# Pasture Improvement in Eastern Canada 

BY TIIE<br>Committee in Charge of Pasture Investigations, Central Experimental Farm, Ottawa

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## The Co-operation of the Pasture Committee of the Ontario Agricultural College, <br> Guelph, Ontario.

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# PASTURE JMPROVEMFNT IN EASTERN CANADA 

BY THE

## Committee in Charge of Pasture Investigations

## CENTRAI, EXPERIMENTAL FARM, OTTAWA



## INTRODUCTION

Successful live stock and dairy farming are largely dependent on the adequate production and utilization of good pasture, as it is a source of highly nutritious fodder for live stock in a relatively cheap and convenient form.

The importance of pasture in Eastern Canada, both with respect to the extent of the area it occupies and its economic value, has been greatly underestimated. It is probably the most neglected crop grown on the farm and too often it consists of the roughest and most unproductive, weed and brush infested areas. Moreover, pasture fertilization has seldom been considered and little or no attention has been paid to grazing management.

In recent years a greater realization of the economic possibilities of pasture lands has developed, and the pasture problem is at last receiving the attention it rightly deserves, by both the farmer and the investigator. Increased effort is now being made through the co-operation of experimental stations, agricultural institutions, and fertilizer firms, to improve the pasture situation in Eastern Canada.

## Importance of Pasture in Eastern Canada

The importance of pasture in Eastern Canada is clearly indicated by the relatively large acreage devoted to it as compared with several other commonly grown crops. Table 1 shows the total area of occupied agricultural land in Canada and the total acreage of grain, hay, and pasture lands. These figures are based on the records of the Seventh Census of Canada, 1931.

TABLE 1.-ACREAGE OF PASTURE COMPARED WITH HAY AND GRAIN IN CANADA

| Province | Total occupied agricultural land | Grain | Hay | Pasture |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | Improved | Natural | Total |
|  | acres | acres | acres | acres | acres | acres |
| Prince Edward Island. | 1,191,202 | 196,640 | 235, 022 | 242,195 | 35,264 | 277,459 |
| Nova Scotia... | 4,302, 031 | 105,089 | 420,816 | 168,303 | 744, 971 | 913,274 |
| New Brunswick | $4,151,596$ | 281,988 | 593,247 | 294,687 | 238,855 | 531,542 |
| Quebec. | 17,304,164 | 2,034,880 | 3,764, 957 | 2,600,757 | 1,430, 974 | 4,031,731 |
| Ontario. | 22,840,898 | 4,968,977 | 3,710,747 | 2,943,567 | 3,460,398 | 6, 403,965 |
| Total-Eastern Canada. | 49,789,891 | 7,586,574 | 8,724,789 | 6,247,509 | 5,910,462 | 12,157,971 |
| Manitoba. | 15, 131, 685 | 5,432,820 | 295, 642 | 411, 924 | 3,601,644 |  |
| Saskatchewan | 55, 673,460 | 21,752,661 | 173,488 | 712,371 | 15,755, 179 | 16,467,550 |
| Alberta. | 38, 977,457 | 11,321,676 | 296,993 | 524,586 | 15,960,335 | 16,484,921 |
| British Columbia | 3,541,541 | 172,034 | 192,714 | 115,326 | 1,347,377 | 1,462,703 |
| Total in Canada. | 163,114,034 | 46,265,765 | 9,683,626 | 8,011,716 | 42, 574,997 | 50, 586,713 |

It will be seen that the area devoted to pasture in Eastern Canada constitutes some $12,157,971$ acres, which is approximately one-quarter of the total area of occupied agricultural land, whereas grain and hay represent only 14 and 17 per cent, respectively.

## NUMBER OF GRAZING ANIMALS

According to the Seventh Census of Canada in 1931, there were, in Eastern Canada, $6,946,038$ cattle and sheep distributed as shown in table 2. These represent the two principal classes of grazing animals. Expressed in terms of
animal units, the number of grazing animals in Eastern Canada represents a total of $3,802,462$. If horses and swine were included in this estimate, the total number would be considerably greater.

TABLE 2.-NUMBER OF GRAZING ANIMALS BY PROVINCES IN EASTERN CANADA

| Province | Cattle | Sheep | Calculated animal units* |
| :---: | :---: | :---: | :---: |
| Prince Edward Island. | 101,383 | 78,478 | 84, 135 |
| Nova Scotia.......... | 221,001 | 196,344 | 191,631 |
| New Brunswick | 210,45C | 143,677 | 174,490 |
| Quebec.. | 1,707,449 | 773,684 | 378,167 |
| Ontario. | 2,509,217 | 1,044,355 | 1,974,039 |
| Total for Eastern Canada. | 4,749,500 | 2,196,538 | 3,802,462 |

* Animal unit-For basis of calculation of animal unit see discussion, page 16.


Pasture is a very important farm crop. In the five provinces of Eastern Canada, in 1931, there were $12,157,000$ acres of pasture as compared with $7,586,000$ acres in grain and $8,724,000$ acres in hay. Notwithstanding this large acreage, the pasture crop is very much neglected. It is the object of this bulletin to suggest economical methods of pasture improvement, based on the results of experimental work.

## ACRES OF PASTURE PER ANIMAL UNIT

In table 3 is shown a summary, by provinces, of the acreage in pasture, the number of animal units, and the number of acres of pasture per animal unit.

TABLE 3.-ACRES OF PASTURE PER ANIMAL UNIT

| Province | Total acres in pasture | Total animal units on pasture | Acres of pasture per animal unit |
| :---: | :---: | :---: | :---: |
| Prince Edward Island. | 277,459 | 84,135 | $3 \cdot 30$ |
| Nova Scotia. | 913,274 | 191,631 | $4 \cdot 77$ |
| New Brunswick | 531,542 | 174,490 | $3 \cdot 05$ |
| Quebec. | 4,031,731 | 1,378,167 | $2 \cdot 93$ |
| Ontario. | 6,403,965 | 1,974,039 | $3 \cdot 24$ |
| Eastern Canada. | 12,157,971 | 3,802,462 | $3 \cdot 20$ |

On the above basis, $3 \cdot 20$ acres of land are required, on the average, to provide pasture for each animal grazing unit in Eastern Canada. This does not take into consideration the areas of hay aftermath and annual crops which are devoted to pasture. With these considered, the area per animal unit would be considerably higher. It has been found that on some improved pastures it is possible to carry one or more animal units on one acre of land throughout the grazing season. This would indicate that there is room for considerable improvement in Eastern Canada pastures.

## Cost of Producing Pastures as Compared with Other Field Crops

Hitherto, very little information has been published regarding the relative importance of pasture from a cost of production standpoint as compared with the cost of producing other field crops. However, a comparison can now be made as a result of the introduction of a suitable method of determining the productive capacities of pastures.

Table 4 shows the cost of producing pasture as compared with six commonly grown farm crops at the Central Experimental Farm, Ottawa, based on the average yields for 1932 to 1935 . The digestible protein and total digestible nutrients (T.D.N.) are taken with the permission of the Morrison Publishing Company, Ithaca, New York, from "Feeds and Feeding," 20th edition, by F. B. Morrison.

TABLE 4.-YIELD AND COST OF PRODUCING CROPS-1932-35, OTTAWA

| Crop | Yield per acre |  |  | Analysis (per cent) |  |  | Cost per acre | Cost per ton |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Field cured | Dry | Total digestible nutrients | $\underset{\text { matter }}{\text { Dry }}$ | Moisture free basis |  |  |  |  |
|  |  |  |  |  | Digestible protein | Total digestible nutrients |  | $\begin{aligned} & \text { Dry } \\ & \text { matter } \end{aligned}$ | digestible nutrients |
|  | tons or bu. | tons | tons |  |  |  | \$ cts. | \$ cts. | \$ cts. |
| Blue grass pasture (fert.). | $6 \cdot 10$ | $1 \cdot 67$ | $1 \cdot 20$ | $28 \cdot 7$ | $15 \cdot 3$ | $71 \cdot 7$ | 956 | 572 | 797 |
| Alfalfa hay........... | $3 \cdot 92$ | $3 \cdot 09$ | $1 \cdot 72$ | $78 \cdot 8$ | $11 \cdot 7$ | $55 \cdot 6$ | 1934 | 626 | 1124 |
| Clover hay. | 3.06 | $2 \cdot 42$ | 1.42 | $79 \cdot 1$ | $7 \cdot 9$ | 58.8 | 2016 | 833 | 1420 |
| Timothy hay. | 2.90 | $2 \cdot 21$ | $1 \cdot 17$ | $76 \cdot 3$ | $3 \cdot 3$ | $52 \cdot 9$ | 1593 | 721 | 1361 |
| Corn silage.... | $18 \cdot 37$ | $3 \cdot 87$ | $2 \cdot 56$ | 21.07 | $4 \cdot 6$ | $66 \cdot 1$ | 4434 | 1146 | $17 \cdot 32$ |
| Mangels... | 24.00 | $2 \cdot 26$ | $1 \cdot 75$ | $9 \cdot 4$ | $10 \cdot 6$ | $77 \cdot 6$ | 5078 | 2247 | 29.02 |
| Barley (grain) | $45 \cdot 2$ | $0 \cdot 98$ | 0.85 | $90 \cdot 4$ | $9 \cdot 3$ | $87 \cdot 0$ | 2193 | 2238 | 2580 |
| Oats (grain). | $61 \cdot 5$ | 0.95 | 0.75 | $91 \cdot 1$ | $9 \cdot 4$ | 78.5 | 2109 | 2220 | 2812 |

The cost of blue grass pasture per acre and the cost per ton of dry matter and total digestible nutrients, have been lower than for any of the crops with which it is compared, even though the yields have been less. These yields of blue grass were obtained from pasture on relatively fertile soil.

A uniform charge of $\$ 4.50$ for rent of land has been made for all crops. It might be pointed out that pasture land is often less valuable than land used for other crops and if a lower rental charge were applied to pasture based on the possibility of its lower capacity to produce, the cost would be lower accordingly. Hay, with its comparatively low labour requirements, is also relatively cheap to produce. Other crops are somewhat more costly.

The figures presented in table 4 for oats and barley are based on the production of grain only. If the value of straw is included the cost per ton of dry matter and total digestible nutrients is considerably lower. In the case of barley, the cost of grain and straw per ton dry matter is $\$ 12.86$ and the cost of total digestible nutrients $\$ 18.79$; with oats the total cost per ton dry matter is $\$ 11.71$ and $\$ 18.80$ per ton total digestible nutrients.

Straw is relatively high in dry matter and moderately high in total digestible nutrients. However, it is not particularly satisfactory for feed, and it is felt that the comparison of barley and oats with other crops on the basis of grain only, provides a more suitable relationship.

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Where such yields as 18.37 tons per acre of corn and 24 tons per acre of mangels can be produced, although their cost per acre is very high, the cost per ton of dry matter or total digestible nutrients is relatively low as compared to oats and barley. Pasture still remains, however, the least expensive crop to grow.


Weeds may become troublesome in poorly managed pastures. Dandelions are common in many localities. The upper photograph shows a fertilized area clipped with a lawn mower with many dandelions present; the lower photograph shows a similar area adjoining but grazed by sheep. Proper fertilization, efficient grazing management, and mowing to prevent weeds from forming seeds, assist considerably in controlling weeds in pastures.

## TYPES OF PASTURE IN EASTERN CANADA

## Permanent Pastures

Permanent pastures are those which are utilized over a number of years without reseeding. Usually such pastures soon revert to the grasses and other plants which occur naturally in a given district. Such areas are left as permanent grazing lands for various reasons. It may be that the land is too rough and stony to permit cultivation. Often the land is comparatively infertile and cannot be used economically for the production of cultivated crops. It may also be located so far from buildings or markets that its use for anything but permanent pasture would be unprofitable.

There are two main types of permanent pasture; those which have never been broken and those which have at some time been broken and seeded and then, for economic or other reasons, have been allowed to remain in permanent pasture.

## Pasture in a Crop Rotation

The acreage of cultivated pasture in Eastern Canada is not nearly so extensive as that of permanent grass land. It is often advisable, however, to grow pasture in a rotation, all the crops of which may be used for grazing or, in a regular farm rotation one field of which is utilized each year for pasture purposes. Such pastures usually produce higher yields than permanent pastures because of the fact that more productive cultivated plant species may be grown.

## Annual or Supplementary Pasture

Annual or supplementary pastures are used to provide feed when permanent or rotation pastures have been injured by drought or winter killing. Annual crops may be seeded in the spring of the year to provide pasturage several weeks later. They are very useful in supplementing the regular pasture during the midsummer season which in many sections is characterized by dry, hot conditions which check the growth of the regular pasture plants. The principal crops used for annual or supplementary pasture are as follows: oats, Sudan grass, peas, barley, sorghum, millet, fall rye, rape, kale, sweet clover, Hubam clover. These crops are seeded alone or in a mixture, depending upon the soil type and moisture conditions.

## CLIMATIC, SOIL AND PLANT VARIATIONS

## Regional Variation in Eastern Canada

In the Canada Year Book for 1936, the Dominion Bureau of Statistics reports that Eastern Canada comprises a total land area of $599,818,240$ acres. Much of this area is not suited for agriculture, being too rough in topography or unfavourable climatically. There are, however, $1,29,650,190$ acres of potential farm land of which only $49,789,891$ acres are at present occupied. Visualizing the very large area which is involved it is obvious that regional variations occur which make recommendations of a specific nature very difficult.

## Climatic Conditions

Considerable variation occurs in the climate of Eastern Canada. The more easterly provinces of Prince Edward Island, Nova Scotia and New Brunswick are affected by their proximity to the Atlantic ocean and are less subject to extremes of temperature. The annual precipitation is somewhat higher in this area and also in Quebec, than farther inland in the province of Ontario.

Table 5 shows the precipitation as recorded at Dominion Experimental Farms located in various parts of Eastern Canada.
TABLE 5．－AVERAGE MONTHLY PRECIPITATION AT DOMINION EXPERIMENTAL FARMS IN EASTERN CANADA

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＇TABLE 6．－MEAN MONTHLY TEMEPRATURE（DEGREES FAHRENHEIT）AT DOMINION EXPERIMENTAL FARMS IN

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It will be observed that the highest precipitation recorded at any of the stations was at Charlottetown, P.E.I., where the average annual rainfall was $42 \cdot 01$ inches. Cap Rouge in Quebec also recorded a high precipitation of 41.98 inches per year. Ste. Anne de la Pocatière in Quebec, received an average rainfall of 33.80 inches which is considerably lower than at Cap Rouge. Similar variations in precipitation occur in Ontario. The rainfall at Ottawa was $34 \cdot 25$ inches which is relatively high while at Harrow in southwestern Ontario, it was only $24 \cdot 06$ inches, the lowest of any of the Eastern Canada stations.

Mean Temperatures at Dominion Experimental Farms in Eastern Canada
The mean annual temperature was highest at Harrow in Ontario. Both the summer and winter temperatures in this section were higher than in other localities in Eastern Canada. The lowest temperatures in both winter and summer were recorded at Kapuskasing in Northern Ontario. At Ottawa in Eastern Ontario, the winter months were comparatively cold while the spring and summer months from April to September, were warmer than at any of the stations excepting Harrow.

With such variations in climatic conditions, therefore, there are naturally corresponding variations in pasture production and methods of management. The comparatively cool temperatures during the growing season in the more easterly provinces together with higher rainfall and more uniform distribution of rain tend to provide conditions more favourable for pasture production than are found in Ontario and parts of Quebec.

## Soil Conditions

Great variations also occur in the soil conditions and these may have a decided influence upon pasture production. Heavy clay loam soils are more retentive of moisture and fertility and are generally more suitable for pasture crops than are light soils. Wide differences occur in the fertility of soils, and the proper fertilizer treatment may vary for each different type of soil. Low, moist land may be utilized for pasture to better advantage than for almost any other crop. This does not mean, however, that pastures will do best on wet land, and consideration must be given to drainage when planning for profitable pasture production.

Topography influences the procedure to be followed. Certain lands are too rough, rocky, and heavily wooded for use as pasture. Such should be used for the production of wood and timber, if possible. Other lands are too rough to permit of cultivation but may produce some pasture. These areas must of necessity be treated in a different manner than land which can be cultivated.

Certain soils in Eastern Canada are strongly acid in reaction and require applications of lime to lessen acidity to the point where desirable plant species thrive to the best advantage. This is particularly so when legumes such as alfalfa and clovers are included in the pasture mixture. Many soils are naturally deficient in phosphoric acid, and others have become low in the available supply of this element through continued cropping or pasture; on such soils the application of phosphatic fertilizers, such as superphosphate or basic slag, gives marked beneficial results. Light soils as well as peat and muck lands may also be lacking in available potash. Soils of low fertility are often associated with a low nitrogen and organic matter content, and the application of a nitrogenous fertilizer or manure in addition to a dressing of mineral fertilizers may be required to promote satisfactory growth of the herbage particularly when grasses predominate.

In table 7 the analyses of soils collected from pasture experimental areas at the Central Experimental Farm, Ottawa, Ontario, and the branch stations at Fredericton, N.B., and Ste. Anne de la Pocatière, Quebec, are given. The
TABLE 7.-ANALYSES OF PASTURE SOILS

| Location | Type ofsoil | Previous fertilizer treatment | Depth | Loss of ignition (organic matter etc.) | Nitrogen | Phosphoric acid |  | Exchangeable |  |  | Acidity pH |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  | Total | Readily soluble (available) (Ruhnke method) | $\begin{gathered} \text { Lime } \\ (\mathrm{CaO}) \end{gathered}$ | Magnesia (MgO) | $\begin{gathered} \text { Potash } \\ \left(\mathrm{K}_{2} \mathrm{O}\right) \end{gathered}$ |  |
| Riffe Range field, Ottawa, Ont. |  |  |  | p.c. | p.c. | p.c. | p.c. | p.c. | p.c. | p.c. |  |
|  | Heavy clay | Unfertilized. | $\begin{aligned} & 0-2 \\ & 2-6 \\ & 0-6 \\ & 6-12 \end{aligned}$ | $\begin{aligned} & 9 \cdot 95 \\ & 7 \cdot 39 \\ & 8 \cdot 17 \\ & 5 \cdot 69 \end{aligned}$ | $\begin{aligned} & 0 \cdot 391 \\ & 0 \cdot 250 \\ & 0 \cdot 294 \\ & 0 \cdot 166 \end{aligned}$ | $\begin{aligned} & 0 \cdot 244 \\ & 0 \cdot 159 \\ & 0 \cdot 185 \\ & 0 \cdot 206 \end{aligned}$ | $\begin{aligned} & 0.052 \\ & 0.054 \\ & 0.053 \\ & 0.054 \end{aligned}$ | $\begin{aligned} & 0.582 \\ & 0.629 \\ & 0.613 \\ & 0.655 \end{aligned}$ | $\begin{aligned} & 0 \cdot 105 \\ & 0 \cdot 110 \\ & 0 \cdot 108 \\ & 0 \cdot 134 \end{aligned}$ | $\begin{aligned} & 0.057 \\ & 0.030 \\ & 0.039 \\ & 0.013 \end{aligned}$ | $\begin{array}{r} 5 \cdot 94 \\ 6 \cdot 16 \\ \hdashline 6.33 \end{array}$ |
|  | Heavy clay | Nitrogen each year for 4 yrs. Minerals applied twice (1929-30). | $\begin{aligned} & 0-2 \\ & 2-6 \\ & 0-6 \\ & 6-12 \end{aligned}$ | $\begin{array}{r} 11 \cdot 04 \\ 7.76 \\ 8 \cdot 70 \\ 3 \cdot 63 \end{array}$ | $\begin{aligned} & 0.462 \\ & 0.298 \\ & 0.349 \\ & 0.072 \end{aligned}$ | $\begin{aligned} & 0 \cdot 294 \\ & 0 \cdot 301 \\ & 0.295 \\ & 0.216 \end{aligned}$ | $\begin{aligned} & 0.047 \\ & 0.045 \\ & 0.046 \\ & 0.037 \end{aligned}$ | $\begin{aligned} & 0.791 \\ & 0.688 \\ & 0.722 \\ & 0.621 \end{aligned}$ | $\begin{aligned} & 0 \cdot 111 \\ & 0 \cdot 116 \\ & 0 \cdot 113 \\ & 0 \cdot 147 \end{aligned}$ | $\begin{aligned} & 0.159 \\ & 0.023 \\ & 0.068 \\ & 0.026 \end{aligned}$ | $\begin{gathered} 5 \cdot 62 \\ 5 \cdot 60 \\ .5 \cdot 80 \end{gathered}$ |
| Prescott Highway field, Ottawa, Ont. | Heavy clay | Unfertilized | $\begin{aligned} & 0-7 \\ & 7-20 \end{aligned}$ | $\begin{aligned} & 7 \cdot 09 \\ & 4 \cdot 67 \end{aligned}$ | $\begin{aligned} & 0 \cdot 17 \\ & 0 \cdot 06 \end{aligned}$ | $\begin{aligned} & 0 \cdot 24 \\ & 0 \cdot 18 \end{aligned}$ | $\begin{aligned} & 0.034 \\ & 0.062 \end{aligned}$ | $\begin{aligned} & 0 \cdot 497 \\ & 0 \cdot 630 \end{aligned}$ | $\begin{aligned} & 0.077 \\ & 0.098 \end{aligned}$ | $\begin{aligned} & 0.020 \\ & 0.026 \end{aligned}$ | $\begin{aligned} & 6 \cdot 15 \\ & 6 \cdot 65 \end{aligned}$ |
|  | Light sandy loam | Unfertilized | $\begin{aligned} & 0-7 \\ & 7-20 \end{aligned}$ | $\begin{aligned} & 7 \cdot 19 \\ & 3 \cdot 95 \end{aligned}$ | $\begin{aligned} & 0 \cdot 20 \\ & 0 \cdot 09 \end{aligned}$ | $\begin{aligned} & 0 \cdot 12 \\ & 0 \cdot 11 \end{aligned}$ | $\begin{aligned} & 0.005 \\ & 0.004 \end{aligned}$ | $\begin{aligned} & 0 \cdot 181 \\ & 0 \cdot 074 \end{aligned}$ | $\begin{aligned} & 0.014 \\ & 0.007 \end{aligned}$ | $\begin{aligned} & 0.009 \\ & 0.008 \end{aligned}$ | $\begin{aligned} & 6 \cdot 00 \\ & 6.05 \end{aligned}$ |
| Experimental Station, Ste. Anne de la Pocatiere, Que. | Gravelly loam. | Unfertilized | 0-6 | $9 \cdot 14$ | $0 \cdot 30$ | $0 \cdot 23$ | 0.003 | $0 \cdot 200$ | $0 \cdot 031$ | $0 \cdot 002$ | $5 \cdot 40$ |
| Experimental Station, Fredericton, N.B. | Sandy loam | Nitrogen each year for seven years. Mineral every second year for six years. | $\begin{aligned} & 0-2 \\ & 2-4 \\ & 4-6 \\ & 0-6 \end{aligned}$ | $\begin{aligned} & 8 \cdot 93 \\ & 7 \cdot 39 \\ & 6 \cdot 45 \\ & 7 \cdot 59 \end{aligned}$ | $\begin{aligned} & 0 \cdot 32 \\ & 0 \cdot 24 \\ & 0 \cdot 20 \\ & 0 \cdot 25 \end{aligned}$ | $\begin{aligned} & 0 \cdot 15 \\ & 0 \cdot 12 \\ & 0 \cdot 13 \\ & 0 \cdot 13 \end{aligned}$ | $\begin{aligned} & 0.006 \\ & 0.004 \\ & 0.003 \\ & 0.004 \end{aligned}$ | $\begin{aligned} & 0 \cdot 254 \\ & 0.224 \\ & 0.213 \\ & 0.230 \end{aligned}$ | $\begin{aligned} & 0.011 \\ & 0.004 \\ & 0.004 \\ & 0.006 \end{aligned}$ | $\begin{aligned} & 0.012 \\ & 0.003 \\ & 0.001 \\ & 0.005 \end{aligned}$ | $6 \cdot 60$ $6 \cdot 75$ 6.75 |

data show the great variations which may exist in the plant food constituents of soils.

It is observed in table 7 that the surface two inches of the Rifle Range field, Ottawa, and the Fredericton pasture soils are considerably richer in total nitrogen and available potash than the underlying soil.

Of the four locations, the fertilized soil in the Rifle Range field, Ottawa, is much the richest in plant food and the data reflect the influence of the fertilizer applied. The surface six inches of this soil contains 0.35 per cent of nitrogen, 0.046 per cent of available phosphoric acid, 0.068 per cent of available potash, and is high in available lime. These figures indicate that the soil is of high fertility. The unfertilized soil is also well supplied with these soil constituents.

The two soils of the Prescott Highway field, C.E.F., Ottawa, were collected from the same field. The heavy clay soil collected from the east end of the field is much richer in available mineral constituents than the light, sandy loam of the west end. It may be mentioned that considerably larger yields of pasture herbage have been obtained from the east end of the field than from the west end.

The soil of the Fredericton station is well supplied with nitrogen and organic matter, but the data indicate a somewhat low content of mineral plant food. Exceptionally good yields of herbage have resulted from the application of a complete fertilizer at this station.

The soil of the Ste. Anne de la Pocatière station appears to be well supplied with plant food with the exception of readily soluble or available phosphoric acid. The data indicate that it is moderately acid. Applications of phosphatic fertilizers and ground limestone have proved of benefit to this pasture.

## Variations in Native Species Affecting Pastures

Closely associated with the climatic and soil conditions affecting the productivity of pastures are the variations in plant species. Plant species inventories, therefore, become necessary for a thorough understanding of the factors affecting pasture productivity.

These plant species inventories are obtained by means of botanical surveys which have been conducted on the various experimental farms in order to determine what plant species are present on pasture lands. The results of these surveys also offer a means of recording the effects of cultural, fertility and management experiments on the pasture flora. Moreover, a knowledge of the pasture species indigenous to a district, is of value as a means of deciding what new or improved species might be most satisfactorily introduced.

In such a survey on eight different experimental stations in Eastern Canada some 250 species of plants have been recorded, and of this number, as many as 150 have been found at one station. As a general rule the more fertile pasture lands comprise fewer species, numbering about 10 to 15 including both pasture plants and weeds.

The species dominating Ontario pastures is Kentucky blue grass. Red top and red fescue are the most prevalent grasses in Quebec while brown top is more common in the Maritime Provinces. However, where soil amendments are applied to correct acidity, the trend of change is from the more acid tole-ant plants to Kentucky blue grass.

The presence of certain plants in the pasture may often be taken as $\mathfrak{a}$ reliable indication of the condition of the pasture. Pastures in the Maritime Provinces while consisting largely of brown top, are converted readily to Kentucky blue grass and other species when fertilizing and liming have improved the level of fertility. At the same time such weeds as the hawkweed may be considerably reduced. On extremely poor soils the cover may consist chiefly of poverty grass accompanied by such weeds as everlasting 50977-3
and, in other instances, by moss. On the gravelly and shallow soils in the Ottawa district, Canada blue grass and silvery cinquefoil may make up almost the entire stand, and in certain depressed and moist areas, creeping bent may take possession.

When pastures are reverting to a natural state after having been broken and reseeded, a distinct succession of species may be observed. At first, the vegetation will consist of the cultivated species introduced in the seeding, together with some plants which have survived the breaking and cultivation. Seeds of weeds common to arable lands which have been lying dormant in the soil, may germinate following the breaking. These may include such weeds as the foxtails, mustard, red root pigweed and lambs' quarters. Moss, pasture weeds and other species which receive a set-back by the ploughing, will find their way back, increasing gradually from year to year. Short lived plants like red clover, and poorly naturalized plants which may have been sown, thin out after a year or two. By a process of natural selection, therefore, the pasture returns to its former state, or if assisted by fertilizers and controlled grazing, to some improvement upon that state. That the composition of pasture herbage undergoes change with fertilizing, liming and better managemeni, has been well proved by botanical surveys, the rapid elimination of weeds being very noticeable.

Briefly, some of the lessons learned from the botanical survey may be listed as follows:

1. In practically all stands of vegetation some improvement can be effected by fertilizing, liming, or manuring, and in certain cases the response has been rapid and well marked.
2. Grasses respond to complete fertilizers to a greater degree than do legumes and most weeds.
3. Legumes are less dependent on nitrogen than are grasses and may be suppressed by the application of nitrogenous fertilizers.
4. Couch grass responds strongly to fertilizers, and especially to nitrogen. It is also stimulated rather than suppressed, by the tillage operations involved in reseeding pastures.
5. Rotational grazing is little, if any, different from continuous grazing in its effects upon the vegetation. The tramping of stock or the absence of it, however, makes a great difference. The use of the mowing machine to keep the grass short and promote fresh leafy growth favours some species more than others, and especially encourages the rapid development of white clover.
6. White clover with proper fertilization and grazing management can increase very rapidly. It may vary considerably from year to year with changes in weather conditions.
7. Ox-eye daisy and orange hawkweed are examples of weeds which diminish under fertilization.

## Poisonous Plants in Pastures

Any weed, to the extent that it occupies ground to the exclusion or crowding of grasses, clovers, and other more useful species, is a detriment to the pasture. However, weeds which are also unwholesome or definitely poisonous need especially to be taken into account. In general, animals may be expected to shun the less wholesome herbage, but this does not necessarily follow. At times, hunger will make an animal less discriminating; or, in a close admixture of species, injurious plants are not easily avoided.

About ten per cent of the plants recorded in eastern pasture surveys have properties more or less harmful, but less than ten plants altogether are responsible for the greater part of all losses. Those which are merely acrid and irritant to mucous membranes, like the buttercup, milkweed, and the seeds of the mustard, are ordinarily refused. Poison ivy, so virulent on the human
skin, appears to be eaten with impunity by cows. Bracken, so far as Canadian experience goes, has only affected horses, and then only on British Columbia ranges. Other species found on these pastures occur too sparingly to be a source of much danger, although they may be in abundance in swamps or along water courses to which animals have access. Water hemlock, sheep sorrel, and false hellebore, in some regions, may abound in proximity to pastures; and Indian tobacco, a typical weed occurring under pasture conditions, may occasionally exist in appreciable amounts. One of the most frequently occurring poisonous species of the pasture area itself, especially if moist, is field horsetail, which, in common with several other horsetails less given to pasture invasion, is responsible for more of the obscure horse troubles than is usually realized. Ill effects, other than actual poisoning, are sometimes experienced also, from such weeds as wild barley, due to the awns which penetrate the tissues of the mouth or eyes, resulting in ulcerations. In many cases, these troublesome or poisonous plants may be removed by hand, or, if the growth is too thick, the heavily infested areas should be fenced off. A small amount of labour spent in this way will be repaid many times by the increased healtis of the animals and the fact that losses are avoided.

## PASTURE IMPROVEMENT INVESTIGATIONS BY THE DOMINION EXPERIMENTAL FARMS

Pasture improvement investigations are being conducted at the Central Experimental Farm, Ottawa, and at the following points in Eastern Canada: Lennoxville, Ste. Anne de la Pocatière, Cap Rouge, and nineteen Illustration Stations in Quebec; Fredericton and eight Illustration Stations in New Brunswick; Kentville, Nappan and eleven Illustration Stations in Nova Scotia; Charlottetown and seven Illustration Stations in Prince Edward Island; and at the Harrow and Kapuskasing stations in Ontario.


To obtain grass yields on grazed, experimental fields, cages, one square yard in area, are used to protect areas to be clipped with a lawn mower or specially equipped tractor mower. The cages are moved to a new area after each clipping and a sufficient number are used to obtain representative yields from each field.
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## Methods of Obtaining and Recording Pasture Production

Specially equipped lawn mowers or tractor plot mowers have been developed for obtaining grass yields from small cage-protected areas in grazed fields. These cages are located in sufficient numbers to obtain representative yields from each area. These protected areas are clipped and the cages moved to new locations at intervals as required. In this way clippings are made on areas which have previously been grazed and thus simulate pasture conditions and provision is made for a randomized sampling of the vegetation. The weights of grass are recorded for each clipping and samples are taken for chemical analyses. The total weight of grass recorded represents one means of measuring the productivity of the pasture for the season.

Methods of determining the results of experiments have also been adopted so that the animal carrying capacities of the pasture and gains in body weight or milk of grazing animals may be compared on a uniform basis.

## BASIS OF CALCULATING THE ANIMAL UNIT CARRYING CAPACITY

Total Digestible Nutrients.-The carrying capacities of pastures are calculated from the total digestible nutrients produced by the pastures. These in turn are determined on the basis of the total digestible nutrients required for the body maintenance of a given animal and those required for production, be it milk or gain in live weight. If no supplementary feeds are fed, the total digestible nutrients will be those which the animal has secured from grazing. If supplementary feeds are fed, the total digestible nutrients from the feeds are subtracted from the gross total digestible nutrients and the difference is that which has been furnished by the pasture.

Animal Unit.-The conversion of the total digestible nutrients furnished by the pasture into "carrying capacity" necessitates the use of a convenient unit. In practice, it is customary to designate a mature milking cow as one head. A 1,000 pound milk cow producing 25 pounds of four per cent milk daily is therefore selected as one unit. Such a cow requires daily, for maintenance and production, 16 pounds of total digestible nutrients. This amount is, therefore, considered equivalent to a carrying capacity of one "Animal Unit," and it remains the same irrespective of the class of live stock used. The method of calculation is to divide the total digestible nutrients per acre by the number of grazing days multiplied by 16 . This converts the results to a standard unit called the "Animal Unit Carrying Capacity per Acre." Since the length of the pasture season varies considerably the results are made comparable by adjusting them to a standard grazing season of 150 days which is the average length of the pasture season in Eastern Canada.

In order to apply this system, it is necessary to determine the digestible nutrient requirements of the various classes of stock, whether it be dairy cattle, beef cattle or sheep. Allowance must also be made for animals in gestation or nursing their young. Once the requirements are determined and the calculations made, it is possible to compare the carrying capacities of different pastures on a standard basis even although various classes of animals have been used.

Standard Animal Equivalent.-Although this method is necessary to compare properly the productivity of different pastures when different kinds of stock are being used, it is sometimes desirable for practical purposes to express these units in terms of a "standard animal" of the class or species desired. In the selection of a "standard animal " one cow weighing 1,000 pounds giving

25 pounds of four per cent milk daily is taken as a standard milch cow, one heifer averaging 600 pounds in weight for the season and gaining 1.2 pounds a day as a standard heifer; one steer averaging 700 pounds in weight during the season and gaining 1.67 pounds a day as a standard steer; and one 130pound nursing ewe with her lamb averaging 50 pounds for the season and gaining 0.4 pounds daily, as a standard sheep.

The daily nutrient requirements of these animals are then calculated and by taking 16 pounds of total digestible nutrients as a unit, it is possible to express the digestible nutrient requirements of each animal as a fraction of this unit, thus:
$1 \cdot 0$ animal unit- 1 cow weighing 1,000 pounds and giving 25 pounds of four per cent milk per day.
0.5 animal unit- 1 dairy heifer averaging 600 pounds and gaining 1.2 pounds daily.
0.6 animal unit- 1 steer averaging 700 pounds gaining $1 \cdot 67$ pounds daily.
0.2 animal unit- 1 nursing ewe averaging 130 pounds with her lamb averaging 50 pounds and gaining 0.4 pound a day.

## Fertility Experiments on Pastures

Experiments in pasture improvement by the Dominion Experimental Farms first took the form of preliminary fertilizer trials. Since that time the investigational work in this field has rapidly increased at the Central Experimental Farm, Ottawa, and at a number of Dominion Experimental Stations in Eastern Canada. The experiments now in progress include investigations with regard to the economical use of manure and commercial fertilizers, fertilizer formulae, rates and dates of application, and other points connected with pasture fertility.

## FERTILIZER VERSUS NO FERTILIZER ON DOMINION EXPERIMENTAL FARMS

Experiments have been laid down at six Dominion Experimental Farms in Eastern Canada, using two areas of two to four acres each. One area has been fertilized with a complete fertilizer; the other has received no fertilizer. The fertilizer although slightly different at some of the farms, has been composed chiefly of 100 to 200 pounds of sulphate of ammonia applied annually in the early spring with 300 pounds of superphosphate and 75 pounds of muriate of potash applied every four years. The object of these experiments was to determine if commercial fertilizers applied to pastures would bring about economical increases in pasture productivity.

Each of the areas has been grazed by live stock and the productivity of the pasture measured by grass clippings on replicated yard-square areas and by animal carrying capacity and production on the whole area. The results of this experiment are presented in table 8.

Whether measured by grass clippings or by animal carrying capacity, the results show marked increases due to fertilizers at all stations. Calculated on a percentage basis the increases in the dry matter of the grass amounted to $52 \cdot 5$ per cent on the sheep pasture at Ottawa, $37 \cdot 6$ per cent on the steer pasture at Ottawa, $227 \cdot 5$ per cent at Ste. Anne de la Pocatière, $19 \cdot 5$ per cent at Lennoxville, $135 \cdot 2$ per cent at Fredericton, $51 \cdot 2$ per cent at Nappan, and 221.2 per cent at Kentville. Variations in climatic conditions as indicated in tables 5 and 6 , and differences in the fertility of the soils as presented in table 7, together with slight variations in the rates of fertilizers used will account for the variable response to treatments at the different stations.
IABLE 8.-GRASS YIELDS, ANIMAL CARRYING CAPACITY AND RETURN VALUES PER ACRE ON FERTILIZED AND UNFERTILIZED

| Station | Fertilizer treatment | Year's average |  | $\left\|\begin{array}{c} \text { Class } \\ \text { of } \\ \text { livestock } \end{array}\right\|$ | Cost of fertilizer | Yield of grass |  | Total digestible nutrients | Carrying capacity grazing season 150 days |  | Return values |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Grass yields | Animal production |  |  |  |  |  |  |  |  | Return |
|  |  |  |  |  | Average for period | Green | Dry matter |  | $\left\lvert\, \begin{gathered} \text { Animal } \\ \text { units } \end{gathered}\right.$ | Area per head | $\begin{gathered} \text { in } \\ \text { weight } \end{gathered}$ | of gain | cost of fertilizer |
| Ottawa. | Not fertilized................... | 4 | 6 | Sheep... | $\begin{gathered} \text { Scts. } \\ 0 \end{gathered}$ | $\begin{aligned} & \mathrm{lb} . \\ & 7,763 \end{aligned}$ | lb. <br> 2,316 |  | lb. 718.4 | No. $0 \cdot 29$ | acres $0 \cdot 65$ | lb. $92 \cdot 0$ | $\begin{gathered} \text { \$ cts. } \\ 691 \end{gathered}$ | $\begin{gathered} \$ \text { cts. } \\ 691 \end{gathered}$ |
|  | $100 \mathrm{lb} .$, A.S. ${ }^{1}$, spring, 50 lb . June, annually, 300 lb . Sup. ${ }^{2}, 75 \mathrm{lb}$. M. of P. ${ }^{3}$ every 4 years | 4 | 6 | Sheep..... | 399 | 12,202 | 3,532 | 1,187.5 | $0 \cdot 48$ | $0 \cdot 39$ | $152 \cdot 0$ | 1142 | 743 |
| Ottawa. | Not fertilized. | 5 | 5 | Steers... | 0 | 8,538 | 2,428 | 916.3 | 0.38 | $1 \cdot 60$ | $156 \cdot 3$ | 781 | 781 |
|  | $\left\lvert\, \begin{gathered}100 \mathrm{lb} ., \text { A.S., annually, } 300 \mathrm{lb} \\ \text { Sup., } 75 \mathrm{lb} \text { M. of P., every } 4 \\ \text { years..................................... }\end{gathered}\right.$ | 5 | 5 | Steers.... | 271 | 12,523 | 3,342 | 1,275•3 | $0 \cdot 53$ | $1 \cdot 14$ | $217 \cdot 5$ | 1088 | 817 |
| Ste. Anne de la la Pocatiere... | Not fertilized. | 3 | 6 | Dairy heifers... | 0 | 2,247 | 759 | $677 \cdot 3$ | $0 \cdot 28$ | $1 \cdot 82$ | 98.8 | 593 | 593 |
|  | 100 lb A.S., spring, 100 lb . June, annually, 300 lb . Sup., 75 lb . M. of P., every 3 years. | 3 | 6 | Dairy heifers... | 609 | 10,491 | 2,486 | 1,403•5 | $0 \cdot 58$ | $0 \cdot 88$ | $204 \cdot 8$ | 1228 | 620 |


| Station | Fertilizer treatment | Year's average |  | $\begin{gathered} \text { Class } \\ \text { of } \\ \text { livestock } \end{gathered}$ | Cost of fertilizer | Yield | Grass | Animal units | Average cost 2upplementary feeds per year | Milk production | Value at 90 c . per 100 lb . | Return over cost of fertilizer and supplementary feed |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Grass | $\begin{gathered} \text { Animal } \\ \text { pro- } \\ \text { duction } \end{gathered}$ |  | $\begin{aligned} & \text { Average } \\ & \text { for } \\ & \text { period } \end{aligned}$ | Green | $\underset{\text { matter }}{\text { Dry }}$ |  |  |  |  |  |
| Fredericton.. | Not fertilized.... | 3 | 4 | Cows and heifers..... | \$ cts. 0 | $\begin{aligned} & \text { lb. } \\ & 10,842 \end{aligned}$ | $\begin{aligned} & \text { lb. } \\ & 3,096 \end{aligned}$ | No. 0.82 | $\begin{aligned} & \$ \text { cts. } \\ & 1012 \end{aligned}$ | lb. <br> 3,455 | $\begin{array}{cc} \$ & \text { cts. } \\ 31 & 10 \end{array}$ | $\begin{aligned} & \$ \text { cts. } \\ & 2098 \end{aligned}$ |
|  | 100 lb . N.S. ${ }^{4}$ spring 50 lb . June annually 350 lb . Sup., 100 lb . M. of P . every 2 years. | 3 | 4 | Cows and heifers..... | 590 | 38,318 | 7,182 | $1 \cdot 36$ | 1688 | 5,682 | 5114 | 2836 |
| Lennoxville. | Not fertilized.. | 4 | 0 | Beef steers... | 0 | 15,808 | 3,530 |  |  | ........ |  |  |
|  | 100 lb . A.S., spring 100 lb . June annually 300 lb . Sup., 75 lb . M. of P . every 4 years. | 4 | ......... | Beef steers.... | 369 | 18,401 | 4,217 | . . . . . . . |  |  |  |  |
| Nappan.. | Not fertilized. | 3 | ......... | Dairy cattle.. | 0 | 3,591 | 803 | .......... | ........ | ......... | ...... | ....... |
|  | 100 lb . A.S., annually 300 lb. Sup., 75 lb . M. of P. every 4 years. | 3 |  | Dairy cattle.. | 340 | 5,071 | 1,214 |  |  |  |  |  |
| Kentville.. | Not fertilized............. | 3 | .......... | Dairy cattle.. | 0 | 3,476 | 953 | .......... | .......... | ......... | ......... | .......... |
|  | Complete fertilizer. | 3 |  | Dairy cattle.. | 430. | 11,172 | 3,061 |  |  |  |  |  |

${ }^{4}$ Nitrate of soda.
${ }^{3}$ Muriate of potash.
${ }^{2}$ Superphosphate.
${ }^{1}$ Sulphate of ammonia.

The results based on animal production show a similar trend. At Ottawa the fertilized sheep pastures produced an average increase in carrying capacity of $65 \cdot 5$ per cent, and the steer pastures an increase of 39 per cent, while at Ste. Anne de la Pocatière where dairy heifers were used an increase of 107 per cent was obtained.

At Fredericton, similar experiments have been carried on for a number of years using dairy cattle, but due to differences in fertilizer application and in the manner of recording the data, the results based on animal production, cannot be directly compared with those of the other stations. At Ottawa and Ste. Anne de la Pocatiere calculations were based on the discussion regarding animal units and total digestible nutrients on page 16 of this bulletin. At Fredericton, however, the animal units were calculated as follows:-

1 cow $=1$ animal unit.
1 heifer over 800 pounds $=1$ animal unit.
1 heifer under 800 pounds $=0 \cdot 75$ animal unit.
On this basis the fertilization of pasture resulted in an increase of $65 \cdot 9$ per cent.

In estimating the financial returns a value of $7 \cdot 5$ cents a pound was allowed for lamb gains, 5 cents for the steer gains and 6 cents for the dairy heifer gains. At Fredericton milk was valued at 90 cents per 100 pounds. This represents the average market price for the years during which the experiments were conducted. The cost of the fertilizers is based on the average price of each ingredient during the same years.

At all stations, the increase in the return value on the fertilized areas has been high enough to pay the cost of the fertilizer, and leave a slight margin of profit. This profit has amounted to 52 cents per acre at Ottawa on sheep pasture 36 cents on steer pasture and 27 cents at Ste. Anne de la Pocatiere where dairy heifers were used.

At Fredericton, the fertilized pasture has given an outstanding production and has shown a profit of $\$ 7.38$ per acre over the cost of the fertilizer. This is considerably higher than that obtained at Ottawa and Ste. Anne de la Pocatiere, and may be accounted for by the fact that the climatic conditions at Fredericton are more favourable, that the fertilizer applications were heavier and that milch cows were used for grazing.

In addition to increases in actual productivity as measured by grass yields and animal carrying capacity, certain other advantages may arise from the use of fertilizers. For instance, the quality of the herbage has been improved by reducing the weeds and encouraging better and more productive species of pasture plants. It has also been observed that the fertilized pastures have come into productivity from 10 to 15 days earlier in the spring than the unfertilized pastures and growth has been maintained several days longer in the dry period of mid-summer.

It may be seen, therefore, that under most conditions where economy of land is an important factor, it is possible to increase the productiveness of pasture lands by the application of fertilizers, thereby making it possible to decrease the pasture area and make available more land for other farm crops.

## RESULTS OF FERTILIZER TESTS ON ILLUSTRATION STATIONS IN EASTERN CANADA

In addition to the experiments to determine the value of commercial fertilizer for pastures on Dominion Experimental Farms, a large number of tests have been conducted on Illustration Stations throughout Eastern Canada. The first of these tests was undertaken in 1924 at several stations in the province of Nova Scotia. By 1932 the project had expanded, and work was under way in each of the eastern provinces.

On several of the stations in the Maritime Provinces and Western Quebec, the farm land is practically all under cultivation and a systematic crop rotation is followed. Hence in these districts pasture is largely provided from two- or three-vear-old meadows. Crops of oats, peas and vetch, millet, corn, and the aftermath of meadows are used as supplementary feed when the production is low on the regular pastures in late July and early August.

In Eastern Quebec where permanent pasture fields have been seriously depleted in plant food, large areas are required to provide sufficient feed to maintain herds. At a number of the stations in New Brunswick, Nova Scotia, and Prince Edward Island, scrub growth of spruce and balsam have taken possession of pasture lands which have become impoverished by continuous cropping and pasturing. Many are so depleted in soil fertility that they have but little carrying capacity.

In these tests, a total of 117 comparative trials have been conducted in the four eastern provinces. The fertilizer treatments have varied slightly but in all cases a complete fertilizer, supplying approximately 24 pounds of nitrogen, 56 pounds of phosphoric acid and 50 pounds of muriate of potash per acre, has been used as an initial application. In most cases an additional application of nitrogen has been applied in the intervening years with complete fertilizer repeated in two to four years.

All areas have been grazed by milch cows, and the carrying capacity has been based on an animal unit, as represented by one milch cow grazing for a season of 122 days. The results presented in cow grazing days, carrying capacity and increase in milk production due to fertilizers, are shown by provinces in table 9.

TABLE 9.-AVERAGE RESULTS OF FERTILIZER TRIALS ON ILLUSTRATION STATIONS IN FOUR PROVINCES

| Provinces in which stations are located | No. trials | Grazing days per acre |  | Carrying capacity per acre |  | Increase in milk production per acre due to fertilizer |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Check | Fertilized | Check | Fertilized |  |
|  |  | days | days | animals | animals | lb. |
| Prince Edward Island | 18 | $53 \cdot 8$ | $82 \cdot 2$ | $0 \cdot 44$ | 0.67 | $587 \cdot 0$ |
| Nova Scotia.. | 27 | 70.7 | $130 \cdot 1$ | $0 \cdot 58$ | 1.07 | $995 \cdot 3$ |
| New Brunswick. | 27 | 63.5 | $112 \cdot 3$ | $0 \cdot 52$ | 0.92 | 1,032.5 |
| Quebec.......... | 45 | $55 \cdot 3$ | $108 \cdot 6$ | $0 \cdot 45$ | $0 \cdot 89$ | 893.5 |

In Nova Scotia the production has been somewhat higher than in the other provinces on both fertilized and unfertilized pasture. The carrying capacity has been increased by fertilizer applications from 0.58 animals per acre to 1.07 animals, and the increase in milk production has been $995 \cdot 3$ pounds per acre. In New Brunswick the increase in milk production due to fertilizers was slightly higher than in Nova Scotia. In Quebec and Prince Edward Island the treatments, while not so effective, nevertheless have been beneficial.

## RATES OF APPLYING COMMERCIAL FERTILIZER FOR PASTURE

An experiment was started at Ottawa in 1931 on a 30 -year-old permanent pasture sward with the object of determining the most economical rate of applying commercial fertilizers for pastures. Four fields of four acres each were used. Field 1 received no fertilizer. Field 2 received a " light" application of fertilizer consisting of 50 pounds of sulphate of ammonia annually and 300 pounds of superphosphate every four years for the years 1931 to 1934. In 1935
this treatment was changed to an application of 600 pounds of superphosphate to be applied every four years. Field 3 received an application of fertilizer at a " medium " rate consisting of 100 pounds of sulphate of ammonia annually and 300 pounds of superphosphate and 75 pounds of muriate of potash every four years. Field 4 received a " heavy " application of fertilizer consisting of 200 pounds of sulphate of ammonia applied annually and 450 pounds of superphosphate and 100 pounds of muriate of potash every four years.

The fields have been grazed by beef steers and heifers throughout the entire period. Yields of grass have been obtained by clipping small cage-protected areas, and animal carrying capacity and gains have been recorded. The results are shown in table 10.

TABLE 10.-THE EFFECT OF DIFFERENT RATES OF APPLYING COMMERCIAL FERTILIZERS FOR PASTURES GRAZED WITH STEERS AT OTTAWA

| Returns | $\underset{\text { fertilizer }}{\stackrel{\text { No. }}{\text { N }}}$ | Light application of fertilizer | Medium <br> application of fertilizer | Heavy application of fertilizer |
| :---: | :---: | :---: | :---: | :---: |
| Grass Yields (4-Year Average)- |  |  |  |  |
| Green weight, lb | 8,562 | 10,277 | 12,516 | 13, 904 |
| Dry matter, lb . Animal Production (5-Year Average)- | 2,540 | 2,929 | 3,465 | 3,894 |
| Total digestible nutrients lb.... | 868.0 | 1,105.7 | 1,273•0 | 1,404•3 |
| Carrying Capacity (Grazing Season 150 Days)- |  |  |  |  |
| Animal units No............. | $0 \cdot 36$ | $0 \cdot 46$ | 0.53 | $0 \cdot 59$ |
| Area required per head, acre.. | $1 \cdot 69$ | $1 \cdot 33$ | $1 \cdot 15$ | 1.04 |
| Returns per Acre- |  |  |  |  |
| Average cost of fertilizers................... $\S$ | 148.0 | 139 | 2.69 | 4.86 |
| Gain in live weight.... 1 ................ lb | 148.0 | 188.5 | 217.0 | 239.5 |
| Value of gain at $\$ 5$ per 100 lb ................ \& | 740 | $9 \cdot 43$ | $10 \cdot 85$ | 11.98 |
| Return over cost of fertilizer................ \$ | 740 | 804 | $8 \cdot 16$ | $7 \cdot 12$ |

Increased yields of grass were obtained from all three rates of fertilizer used. The most economical increase, however, was made from the medium fertilizer application. This average increase of 925 pounds of dry matter was obtained at a cost of $\$ 2.69$ which is equivalent to $\$ 5.72$ per ton, while the increase from the light fertilizer cost $\$ 6.94$ per ton, and from the heavy fertilizer $\$ 7.06$ per ton increase.

Similar responses were recorded in the animal carrying capacities. The increased rates of fertilizers have in each case produced increases in carrying capacities and decreases in the areas required per head. Although the greatest gains were made by the animals on the heavily fertilized pasture, the most economical returns were obtained where the medium application was used.

Rates of Applying Nitrogenous Fertilizers.-An experiment was begun in 1933 with the object of determining the amount of nitrogen which is most suitable to apply for pasture. This experiment was conducted at Ottawa, on deep, moderately heavy clay loam with an abundance of humus. The land had been in grass for several years and the dominant vegetation was meadow foxtail, although Kentucky blue grass, red clover and timothy were also present in varying proportions. Dandelion, yarrow and buttercup were the principal weeds. Triplicate plots, $1 / 200$ acre in area, were used. Each plot received a fertilizer application consisting of 300 pounds of 16 per cent superphosphate and 75 pounds of muriate of potash per acre once every three years. Each year nitrogen in the form of nitro-chalk ( 16 per cent nitrogen) has been applied at
varying rates. The average yields per acre of dry matter and protein as determined from grass clippings from the plots are presented in table 11.

TABLE 11.-RATES OF APPLYING NITROGEN (OTTAWA)

| Rate of applying nitro-chalk per acre | 1933 | 1934 |  | 1935 |  | 3-year average | 2-year average |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\underset{\text { matter }}{\text { Dry }}$ | $\underset{\text { matter }}{\underset{\text { Dry }}{ }}$ | Protein | $\begin{aligned} & \text { Dry } \\ & \text { matter } \end{aligned}$ | Protein | $\begin{aligned} & \text { Dry } \\ & \text { matter } \end{aligned}$ | Protein |
|  | lb . | lb. | lb . | lb . | lb. | 1 b . | 1 b . |
| No fertilizer. | 1,598 | 1,371 | 308 | 1,475 | 320 | 1,481•3 | 314 |
| 160 pounds. | 1,945 2,103 | 1,608 1,746 | 369 414 | 1,601 1,860 | 323 <br> 368 | $1,718 \cdot 0$ $1,903 \cdot 0$ | 346 392 |
| 480 pounds. | 2,244 | 1,928 | 468 | 2,335 | 498 | 2,169.0 | 483 |

Yields of both dry matter and protein have increased consistently with each increase in the amount of nitrogen applied. The increase in yield has not been very great, however, on the average, and an increase of 185 to 266 pounds of dry matter or 46 to 91 pounds of protein is not sufficient to justify the use of double the amount of nitrogen.

Rates of Applying Nitrate of Soda at Fredericton, N.B.-An experiment was begun at Fredericton, N.B., in 1929 in which minerals alone have been compared with minerals plus varying amounts of nitrate of soda. The application of minerals in every instance has been 300 pounds of superphosphate and 100 pounds of muriate of potash. The yields have been recorded by clipping the plots several times during the season to resemble pasture conditions and are presented in table 12 as an average for seven years.

TABLE 12.-YIELDS OF GRASS FOLLOWING VARIOUS RATES OF APPLYING NITRATE OF SODA AT FREDERICTON, N.B.

| Treatment | Dry matter period 7 -year average |
| :---: | :---: |
|  | 1 b . |
| Check, no fertilizer | 1,938 |
| Minerals alone. | 2,607 |
| Minerals plus 100 lb . nitrate of soda. | 2,963 |
| Minerals plus 150 lb . nitrate of soda. | 3,136 |
| Minerals plus 200 lb . nitrate of soda. | 3,049 |

While minerals alone increased the yield 34.5 per cent increases of 52.9 and 61.8 per cent were obtained from the use of 100 and 150 pounds per acre respectively of nitrate of soda. At 200 pounds per acre no greater increase was obtained than where 150 pounds were applied, suggesting that the amount of this nitrogenous fertilizer to apply under these conditions is limited to about 150 pounds per acre.

## COMMERCIAL FERTILIZER FORMULAE EXPERIMENTS

On Plots Cut for Hay.-It has been shown that beneficial results may be obtained from the use of commercial fertilizer applications. A knowledge of the most suitable mixture of fertilizer to use is very important. In order to obtain information in regard to the most suitable formulae, experiments have been conducted at several Dominion Experimental Farms in Eastern Canada.

Beginning in 1931 a number of treatments were laid down on an old Kentucky blue grass sward at Ottawa. The plots were cut twice during the year and the yields recorded. The average yields for the five-year period, 1931 to 1925 , are presented in table 13.

TABLE 13.-YIELD OF HAY FROM VARIOUS FERTILIZER TREATMENTS AT OTTAWA

| Fertilizer Treatment | Yield of dry matter |
| :---: | :---: |
|  | Ib. |
| 1. Check, no fertilizer.............. | 1,307 |
| 2. 100 lb . sulphate of ammonia annually. | 1,803 |
| 3. 300 lb . superphosphate every 4 years. | 1,581 |
| 4. 75 lb . muriate of potash every 4 years | 1,330 |
| 5. 50 lb . sulphate of ammonia annually. 300 ib . superphosphate every 4 years. | 16,09 |
| 6. 100 lb . sulphate of ammonia annually |  |
| 300 lb . superphosphate and 75 lb . muriate of potash every 4 years. | 2,033 |
| 7. 200 lb . sulphate of ammonia annually. 450 lb . superphosphate and 100 lb . muriate of potash every 4 years. | 2,175 |

This experiment, although conducted on ungrazed plots, shows a definite trend in favour of complete fertilizer. Superphosphate or muriate of potash used alone, produced very little effect. Some response is shown to sulphate of ammonia alone.

Commercial Fertilizer Formulae Plots in Grazed Field.-In 1933 a project was begun in a grazed field in which commercial fertilizers of different formulae were applied on strips of $1 / 50$ acre each running across the field. The production of grass was recorded by clipping cage-protected yard-square areas on each treatment with a lawn mower, every three weeks. The fertilizer formulae which are prosented in the accompanying table were based on an application of 600 pounds of a 4-12-6 fertilizer mixture applied in 1934. The results for the years 1934,1935 and 1936 are presented in table 14.

TABLE 14.-YIELD OF GRASS FROM FERTILIZER FORMULAE TREATMENT OTTAWA

| Treatment | Yield of dry matter per acre |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 1934 | 1935 | 1936 | 3-year average |
|  | lb. | 1 l . | 1 b . | $l \mathrm{lb}$. |
| Check, no fertilizer. | 1,437 | 2,539 | 2,219 | 2,065 |
| Nitrogen group- |  |  |  |  |
| 4-0-0... | 2,522 | 3,529 | 4, 651 | 3,567 |
| 2-12-6. | 1,955 | 3, 351 | 3,549 4,393 | 3, 3233 |
| 4-12-6. | 1,673 | 4,114 | 5,811 | 3,866 |
| 8-12-6. | 2,552 | 6,027 | 6,150 | 4,910 |
| Phosphoric acid group- |  |  |  |  |
| 0-12-0. | 1,213 | 2,652 | 3,815 | 2,560 |
| 4- 0-6. | 1,543 | 4,041 | 2,956 | 3,513 |
| 4-6-6. | 1,737 1,673 | 3,670 4,114 | 4,617 5,811 | 3,341 3,866 |
| Potash group- |  |  |  |  |
| 0-0-6.. | 1,105 | 2,713 | 3,335 | 2,384 |
| 4-12-0. | 2,707 | 4,675 | 5,321 | 4,234 |
| 4-12-6.. | 1,673 | 4,114 | 5,811 | 3,866 |
| 4-12-12. | 2,250 | 5,368 | 6,270 | 4,629 |

Although this experiment has only been conducted for a three-year period it points to certain trends which appear to have some significance. Of the elements applied singly, nitrogen was the most beneficial. The decrease in production following the omission of a single element from the formulae was most noticeable also in the case of nitrogen. Increases in the percentage of nitrogen in the formulae have been followed by corresponding increases in production in all but one instance, namely, where the 4-12-6 mixture was applied in 1934. Increases in production following increased applications of phosphoric acid or potash have not been consistent.

The trend in this experiment to date points to the advisability of using a complete fertilizer. The sward is chiefly made up of Kentucky blue grass which responds to applications of nitrogen. The 8-12-6 mixture has produced the highest average yield with the 4-12-12 also followed by relatively high production. With such high proportion of nitrogen in the one case and potash in the other, it is doubtful if such mixtures would be economical. Except for the first year of the experiment the 4-12-6 mixture has given consistently high yields and is possibly the most economical fertilizer on this blue grass pasture.

## DATE OF APPLYING COMMERCIAL FIRTILIZER FOR PASTCRE

The date of applying commercial fertilizer is of considerable importance. Fertilizers, particularly nitrogen, have been applied early in the spring to promote early growth. Later applications in summer have been applied with the hope of encouraging higher production during the periods of low rainfall and high temperatures experienced in many parts of Eastern Canada.

Summer Applications of Nitrogen.-At three stations in Eastern Canada, nitrogeneous fertilizers have been applied in one, two, three and four successive applications in the spring and summer, to learn which method would produce the most economical yield and maintain a uniform production throughout the growing season. Mineral treatments at the rate of 300 to 350 pounds of superphosphate and 75 pounds of muriate of potash per acre every three years, were applied to all treatments but experiment No. 1 in the Arboretum field at Ottawa.

In the experiment at the Rifle Range, Ottawa, sulphate of ammonia was applied in successive applications, beginning with 100 pounds per acre in early spring, 50 pounds per acre in June and an additional 50 pounds per acre in July. In the Arboretum field, Ottawa, in experiment No. 1, nitro-chalk was applied at the rate of 160 pounds per acre in each of four successive applications, namely, in May, June, July and August. No minerals were applied in this experiment. In experiment No. 2, in the same field, nitro-chalk was applied at the rate of 160 pounds per acre in three successive applications in April, June and July. In this experiment a basic application of superphosphate and muriate of potash was also applied.

At Lennoxville, sulphate of ammonia was applied in one treatment at the rate of 100 pounds per acre in spring and in a second treatment at 100 pounds per acre in the spring plus an additional 100 pounds in June. In the Fredericton experiment, nitrate of soda was used in three applications, the first being 100 pounds per acre in early spring followed by 50 pounds per acre in each of the months of June and July.

TABLE 15.-SUCCESSIVE SUMMER APPLICATIONS OF NITROGEN

| Station | No. of years | Average yield of dry matter per acre |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | $\begin{gathered} \text { Spring } \\ \text { only } \end{gathered}$ | $\left\lvert\, \begin{gathered} \text { Spring and } \\ \text { one } \\ \text { summer } \\ \text { application } \end{gathered}\right.$ | $\left\lvert\, \begin{gathered} \text { Spring and } \\ \text { two } \\ \text { summer } \\ \text { applications } \end{gathered}\right.$ | $\left\lvert\, \begin{gathered} \text { Spring and } \\ \text { three } \\ \text { sumper } \\ \text { applications } \end{gathered}\right.$ |
|  |  | 1 l . | 1 b . | lb . | lb. |
| Ottawa, Rifle Range. |  |  |  |  |  |
| Ottawa, Arboretum, experiment 1 | 4 | 2,027 | 2,396 | 2,600 | 2,622 |
| Ottawa, Arboretum, experiment 2. | 3 | 1,718 | 1,976 |  |  |
| Lennoxville, Que................. | 6 | 1,614 | 1,603 |  |  |
| Fredericton, N.B. | 7 | 2,963 | 3,136 | 3,049 |  |

While some increases in yields have been obtained following successive summer applications of nitrogen, the increases have been so small that they did not pay for the cost of the fertilizer and the time and inconvenience of applying them. Nitrogen no doubt hastens the growth when applied in early spring, but subsequent applications do not increase the growth to any appreciable extent when the weather becomes dry and hot in late June and July.

Frequency of Applying Mineral Fertilizers.-Experiments have been conducted at Ottawa and Fredericton in regard to the frequency of applying minerals. At Ottawa minerals applied annually in amounts equivalent to the same fertilizers applied every four years, have produced approximately the same yields in each case. At Fredericton, minerals applied annually and every alternate year have given higher yields than when applied every four years. In the Fredericton experiment, however, 350 pounds of superphosphate and 100 pounds of muriate of potash have been used for each application. Thus the application in alternate years amounts to double the fertilizing elements and the annual application to four times that applied in the four-year application.

It would appear that minerals if applied in sufficient amounts need only be applied every three or four years.

Fall applications of minerals at Ottawa have given slightly higher yields than spring applications. Where complete fertilizer is applied, the application should be made in the spring. Where minerals only are required, a fall application is advisable.

Nitrogen.-A number of experiments have been conducted at Ottawa to determine the relative value of different carriers of various fertilizing elements. In 1932 such an experiment was begun in which various sources of nitrogen were compared. Different nitrogenous fertilizers were applied in amounts to supply 25 pounds of nitrogen per acre. All plots except the untreated checks received a uniform application of 300 pounds of superphosphate and 75 pounds of muriate of potash per acre every three years. Yields were obtained by clipping with a lawn mower when the grass was approximately seven inches high. The forms of nitrogen used and the average yields of triplicate plots $(1 / 200)$ acre are presented in table 16.

The differences in yields of dry matter and protein during the four years from the plots receiving the nitrogenous fertilizers show no great variation. Sulphate of ammonia has produced slightly lower yields than other nitrogen carriers. The yields have been higher with all nitrogen carriers than where no nitrogen was applied.

Sources of Phosphoric Acid.-At Fredericton where basic slag and superphosphate were each applied at the rate of 500 pounds per acre every three years, the average yield of dry matter per acre at the end of a six-year period following basic slag was 1,752 pounds, and following superphosphate 1,867 pounds. When applied at the same rate in a complete fertilizer, the yield where basic slag was used was 2,627 pounds per acre, and where superphosphate was applied 2,750 pounds per acre. A similar test on nine Illustration Stations in Nova Scotia (see page 28) gave a three-year average yield of $2,817 \cdot 4$ pounds per acre where superphosphate was used, and $2,734 \cdot 4$ pounds where basic slag was used.

While in each instance superphosphate gave a slightly higher yield, the difference was very slight. The choice of the two carriers must be determined on the basis of their relative cost, either being quite satisfactory from the standpoint of their fertilizing qualities.

TABLE 16.-SOURCES OF NITROGEN FOR PASTURES (OTTAWA)

| Source of nitrogen and rate per acre | Yields per Acre (pounds) |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\frac{1932}{\underset{\substack{\text { Dry } \\ \text { matter }}}{ }}$ | 1933 |  | 1934 |  | 1935 |  | \|average|average |  |
|  |  | Dry matter | Protein | $\underset{\text { matter }}{\text { Dry }}$ | Protein | $\begin{gathered} \text { Dry } \\ \text { matter } \end{gathered}$ | Protein | $\begin{gathered} \text { Dry } \\ \text { matter } \\ 4 \text { years } \end{gathered}$ | Protein 3 years |
| Nitrate of soda, 160 lb . | 2,287 | 2,096 | 410 | 2,297 | 495 | 2,275 | 504 | 2,239 | 470 |
| lb................... | 2,060 | 1,723 | 330 | 2,136 | 485 | 1,973 | 446 | 1,973 | 420 |
| Cyanamid, 125 lb | 1,986 | 2,101 | 431 | 2,264 | 507 | 2,183 | 522 | 2,134 | 487 |
| Nitrate of lime, 160 lb | 2,295 | 1,950 | 371 | 2,222 | 500 | 2,196 | 476 | 2,166 | 449 |
| Nicro-chalk, 160 lb | 2,053 | 2,052 | 423 | 2,012 | 467 | 2,105 | 446 | 2,056 | 445 |
| Urea, 55 lb | 2,215 | 1,868 | 356 | 2,162 | 490 | 2,194 | 481 | 2,110 | 442 |
| No nitrogen........ | 1,728 | 2,059 | 396 | 1,940 | 448 | 1,932 | 456 | 1,915 | 433 |
| Check, no fertilizer | 1,509 | 1,469 | 279 | 2,122 | 476 | 1,312 | 290 | 1.603 | 348 |

THE USE OF LIME ON PASTURES
Experiments have been conducted at several stations to learn the effect of applications of ground limestone on pastures. Two tons of ground limestone per acre have been applied once every four years at all stations except Fredericton where the rate has been one ton every three years. Table 17 shows the yields of grass on limed and unlimed pastures with and without fertilizer.

TABLE 17.-THE EFFECT OF GROUND LIMESTONE ON PASTURES

| Station | Years average | Yield of dry matter pounds per acre |  |
| :---: | :---: | :---: | :---: |
|  |  | Unlimed | Limed |
| No fertilizer applied- |  |  |  |
| Lennoxville, Que. | 5 | 1,634 | 2,100 2 |
| Fredericton, $\mathrm{N} . \mathrm{B}$ | 6 | 1,634 | 1,976 |
| Complete fertilizer applied- |  |  |  |
| Ottawa, Ont. ${ }_{\text {Freder }}$ | ${ }_{6}^{5}$ | 2,000 1,976 | 2,140 2,411 |

The application of ground limestone has given definite results at Lennoxville, Quebec, and Fredericton, N.B. At Nappan and Ottawa lime for pasture has shown little or no beneficial influence.

In 1925 a number of liming experiments were started on the Illustration Stations in Nova Scotia. The plot treatments were as follows:-

Plot 1-2 tons of limestone per acre.
Plot 2-2 tons of limestone plus $\frac{1}{2}$ ton basic slag.
Plot $3-2$ tons of limestone plus $\frac{1}{2}$ ton superphosphate.
Plot $4-\frac{1}{2}$ ton of basic slag.
Plot 5-Check, no fertilizer.
The grass on these plots was cut when growth was completed and the yields from the five plots are presented in the following table:-
TABLE 18.-EFFECT OF LIME AND FERTILIZER ON PASTURE ON THE ILLUSTRATION STATIONS IN NOVA SCOTIA

| Station | Average yield per acre of green grass 3 years-1925, 1926 and 1927 |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | Check, no fertilizer | Lime | Slag | $\begin{aligned} & \text { Lime } \\ & \text { and } \\ & \text { slag } \end{aligned}$ | Lime and superphosphate |
|  | 1 b . | 1 b . | lb. | 1 b . | 1 l . |
| Newport. | $840 \cdot 0$ | 1,153.3 | 4,161.3 | 5,663•3 | 5,556.2 |
| Middle River... | 758.3 | 1,168.3 | 1,175.0 | 1,538.6 | 1,783•3 |
| Christmas Island | $136 \cdot 0$ | $707 \cdot 5$ | $508 \cdot 5$ | $951 \cdot 5$ | 1,019.5 |
| New Glasgow. | 1,823.3 | 3,210.0 | 3,606.5 | 3,490.0 | 3,133.3 |
| Heatherton. | ${ }_{1} 554 \cdot 3$ | $935 \cdot 0$ | 1,806•6 | 2,163.0 | 2,688.3 |
| Kennetcook. | 1,616.6 | 2,433.0 | 3,013.3 | 2,400.3 | 3, $302 \cdot 0$ |
| Musquodoboit | $310 \cdot 0$ | 3,360•0 | 1,080.0 | $960 \cdot 0$ | 1,380.0 |
| Margaree. | $2,603 \cdot 3$ | 2,921-6 | $3,750 \cdot 0$ | 4,413.3 | 4,668.0 |
| Sydney.. | 1,688.3 | 2,094-6 | 2,015.0 | 2,030-0 | 1,825.0 |
| Average 9 stations. | 1,147.8 | 1,664•8 | 2,245.1 | 2,734•4 | 2,817.4 |

It will be observed that lime alone increased the yield somewhat. Slag alone was more beneficial than lime alone, but a mixture of both lime and phosphate give the greatest increase in yield. There appeared to be very little difference in fertilizing value between the superphosphate and slag.

## Management of Pernanent Pastures

The profitable utilization of pastures is dependent on good management. Without good management, pastures cannot be successfully improved nor can optimum returns be expected.

The results of the pasture management experiments conducted at Ottawa and on several other experimental stations are presented herewith.

## rotational versus continuous grazing

Beginning in 1929 experiments were laid down at five Dominion Experimental Stations in Eastern Canada, with the object of learning if a system of rotational grazing is more suitable under Eastern Canadian conditions than pasturing live stock continuously on the same area. The procedure in general, has been to pasture one group of live stock on the field continuously, and another group, in three or four fields, in which they have been rotated from one field to another at weekly intervals, or as often as required depending on the growth of the pasture. All areas have been fertilized with a complete fertilizer made up of 100 to 200 pounds of sulphate of ammonia per acre, applied annually in the early spring and 300 pounds of superphosphate, and 75 to 100 pounds of muriate of potash per acre applied every four years.


This photograph illustrates a comparison between continuous grazing in the large field at the left and rotational grazing in the three fields at the right. In the rotationally grazed field the live stock is moved from one field to another at approximately one week intervals. The results of this experiment show that unless the pasture is divided and watered naturally the slight increase from rotational grazing would scarcely pay for the added cost and inconvenience involved.

The relative production of the pasture has been measured by grass yields from cage-protected yard-square areas clipped at approximately three-week intervals and by grazing with animals, and recording the animal carrying capacity and gains.

Table 19 shows the effects of continuous and rotational grazing on the yield of grass, carrying capacities and returns from pastures at Ottawa, Ste. Anne de la Pocatière and Fredericton. The animal unit carrying capacities at Ottawa and Ste. Anne, are based on the digestible nutrient requirements, while at Fredericton the basis is according to the size and age of animal used.

The rotated pastures have produced slightly higher grass yields, greater carrying capacities and higher returns than did the continuous system of grazing. Further results show that although there were no significant differences in the actual daily gains made by the animals while on the experimental pastures, the rotational grazing provided pasture two or three weeks longer than the continuous grazing. It was also observed that the rotated pastures were cleaner and much more uniformly grazed.

50977-5
TABLE 19.-GRASS YIELDS AND ANIMAL CARRYING CAPACITY ON ROTATIONALLY AND CONTINUOUSLY GRAZED PASTURES

| Station | Treatment | Year's average |  | Class of live stock | Yield of grass |  | Total digestible nutrients per acre | Carrying capacity grazing season 150 days |  | Return per acre |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Grass yield | Animal production |  | Green | $\begin{aligned} & \text { Dry } \\ & \text { matter } \end{aligned}$ |  | $\begin{gathered} \text { Animal } \\ \text { units } \\ \text { per acre } \end{gathered}$ | Area required per head | Gain in live weight | Value of gain ${ }^{1}$ |
|  |  | ycars | ycars |  | lb. | 1 b . | lb. | No. | acres | 1 l . | \$ cts |
| Ottawa. | Continuously grazed Rotationally grazed. | 4 | ${ }_{6}^{6}$ | Sheep. Sheep. | $\begin{aligned} & 12,202 \\ & 14,977 \end{aligned}$ | $\begin{aligned} & 3,532 \\ & 4,235 \end{aligned}$ | $\begin{aligned} & 1,187 \cdot 5 \\ & 1,259 \cdot 0 \end{aligned}$ | $\begin{aligned} & 0.48 \\ & 0.51 \end{aligned}$ | $\begin{aligned} & 0.39 \\ & 0.37 \end{aligned}$ | $\begin{aligned} & 152.2 \\ & 161.5 \end{aligned}$ | $\begin{aligned} & 1142 \\ & 12 \quad 11 \end{aligned}$ |
| Ste. Anne de la Pocaticre | Continuously grazed Rotationally grazed | 3 <br> 3 | ${ }_{6}^{6}$ | Dairy heifers Dairy heifers | $\begin{aligned} & 10,491 \\ & 10,571 \end{aligned}$ | $\begin{aligned} & 2,486 \\ & 3,000 \end{aligned}$ | $\begin{aligned} & 1,403 \cdot 5 \\ & 1,503 \cdot 0 \end{aligned}$ | $\begin{aligned} & 0.58 \\ & 0.63 \end{aligned}$ | $\begin{aligned} & 0.88 \\ & 0.82 \end{aligned}$ | $\begin{aligned} & 204 \cdot 8 \\ & 219 \cdot 4 \end{aligned}$ | $\begin{aligned} & 12 \quad 29 \\ & 1336 \end{aligned}$ |
| Lennoxville. | Continuously grazed Rotationally grazed | $\begin{aligned} & 4 \\ & 4 \end{aligned}$ |  | Stecrs <br> Stcers | $\begin{aligned} & 13,716 \\ & 12,191 \end{aligned}$ | $\begin{aligned} & 3,313 \\ & 3,153 \end{aligned}$ |  |  |  | Milk production |  |
| Fredericton. | Continuously grazed Rotationally grazed | $\begin{aligned} & 3 \\ & 3 \end{aligned}$ | 4 | Dairy cattle. Dairy cattle. | $\begin{aligned} & 38,318 \\ & 36,051 \end{aligned}$ | $\begin{aligned} & 7,182 \\ & 7,283 \end{aligned}$ |  | $\begin{aligned} & 1 \cdot 36^{2} \\ & 1.43^{2} \end{aligned}$ |  | $\begin{aligned} & 5,682 \\ & 6,089 \end{aligned}$ | $\begin{array}{ll} 51 & 14 \\ 54 & 80 \end{array}$ |
| Nappan. | Continuously grazed Rotationally grazed. | 3 3 |  | Dairy heifers Dairy heifers. | $\begin{aligned} & 5,071 \\ & 6.432 \end{aligned}$ | $\begin{aligned} & 1,214 \\ & 1,442 \end{aligned}$ |  |  |  |  |  |

[^0]Under ordinary conditions, it is doubtful whether the adrantages brought about by the rotational system of pasturing are great enough to justify the additional expense involved in putting up extra fences and providing the necessary watering facilities and shelters. However, where natural conditions permit the application of this rotational grazing method at a minimum cost, it may possibly provide for a better utilization of pastures.

## LIGHT VERSUS HEAVY GRAZING

In 1930 an experiment was started at Ottawa involving two areas of blue grass sod one of which has been heavily grazed and one lightly grazed. Both areas have been fertilized with a complete fertilizer and grazed by beef steers and heifers. From a production standpoint there was no significant difference between the two methods of grazing either on the basis of grass production as measured by clippings or by animal carrying capacity and gains. The heavily grazed pasture, however, was more uniformly grazed than where light grazing was practised.


Plots clipped $\frac{1}{2}, 1,2,3$ and 4 inches in height respectively every three weeks, show in an arerage of 4 years results, that plots clipped closely $\frac{1}{2}$ to 2 or 3 inches have produced the highest yields of grass.

## HEIGHT OF CLIPPING EXPERIMENTS

Closely related to the experiment in regard to intensity of grazing, is one in which plots have been cut at different heights. Replicated plots of one yard square were selected on both fertilized and unfertilized permanent pasture. A lawn mower was used to clip the plots at $4-, 3-, 2-, 1$ - and $\frac{1}{2}$ - inch heights, respectively, at intervals of three weeks. The yields of dry matter per acre from these clippings are presented in table 20.

| Plot treatment | Not fertilized | Fertilized |
| :---: | :---: | :---: |
|  | 4-year average lb. of dry matter | 4-year average lb. of dry matter |
| Clipped $\frac{1}{2}$-inch | 1,921 | 2,019 |
| Clipped 1 inch. | 1,628 | 2,012 |
| Clipped 2 inches. | 1,412 | 2,100 |
| Clipped 3 inches. | 1,435 | 1,790 |
| Clipped 4 inches. | 1,356 | 1,569 |

The results indicate that continued close clipping does not reduce the yield of pasture. The yields were higher on the closely clipped plots than on plots clipped at 3 and 4 inches high. This indicates that relatively close grazing is not injurious and may be desirable.

## FREQUENCY OF CLIPPING EXPERIMENTS

Experiments to study the effect of frequency of cutting on the composition and yield of pasture herbage, were conducted at the Central Experimental Farm, Ottawa, during the five-year period 1927-31. The land selected for this investigation had been in grass for many years and the dominant vegetation was meadow foxtail with Kentucky blue grass, red clover and timothy also present. Yarrow, buttercup and dandelion were the principal weeds. The herbage was cut at one-, two-, and three-week intervals. The average dry matter yield and protein content of the herbage during the five-year period is shown in table 21.

TABLE 21.-YIELD AND PROTEIN CONTENT OF PASTURE GRASS AT DIFFERENT FREQUENCIES OF CUTTING (OTTAWA)

| Treatment | Dry matter per acre | Protein per cent | Protein per acre |
| :---: | :---: | :---: | :---: |
| Cut weekly. | lb. 3,100 |  | ${ }^{16} 772$ |
| Cut every 2nd week. | 3,829 | 23.79 | 881 |
| Cut every 3rd week. | 4,046 | $21 \cdot 62$ | 824 |
| Cut as hay with aftermath | 4,792 | $12 \cdot 19$ | 563 |

It will be seen that there was an appreciable decline in the percentage of protein in the herbage with the lengthening of the interval of growth. The most serious decline occurred when the grass was allowed to reach the seed formation stage and was cut for hay. If total yields of protein are the consideration, however, a growing period of from two to three weeks produces the optimum yield of herbage rich in protein and of high digestibility.

Lengthening the growing period to the "seed-formed" stage resulted in increasing the yields of dry matter but not of protein. Further, the coefficient of digestibility of this more mature herbage is much lower than that of young grass.

## Renovating Rough Pastures

An experiment was started in 1933 on a very rough and unproductive pasture typical of those in the district in which the illustration station at South Roxton, Quebec, is located.


Improving rough, rocky unploughable pasture. Ste. Anne de la Pocatiere, Que. Above, pasture land in its natural state. Below, first year after shallow surface cultivation manuring and reseeding; red clover predominates.


The same field as shown on the previous page. The second year after treatment the field is well grazed and productive.

Three representative fields were selected for the test. One field was cleared of brush in the late fall and dragged the following spring to break down mossbanks and unproductive hummocks and an application of 100 pounds of nitrate of soda, 300 pounds of superphosphate, and 100 pounds of muriate of potash, plus $1 \frac{1}{2}$ tons of ground limestone, was made. A second field was prepared in a similar way except that no commercial fertilizer was added but lime only was applied. A third field was left in its natural condition as a check. In 1935 the check field was cleared and fertilized but no lime was added. The results of the experiment are shown in table 22.

TABLE 22.-PRODUCTION ON ROUGH PASTURES AT SOUTH ROXTON, QUEE.

| 'Year | Grazing days per acre |  |  | Carrying capacity per acre |  |  | Milk production per acre |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Check 1933 only | Cleared limed | Cleared limed fertilized | Check 1933 only | Cleared limed | Cleared limed fertilized | $\begin{gathered} \text { Check } \\ 1933 \\ \text { only } \end{gathered}$ | Cleared limed | Cleared limed fertilized |
|  |  |  |  | animals | animals | animals | lb. | lb. | 1 b . |
| $\begin{aligned} & 1933 \ldots \\ & 1934 \ldots \\ & 1935 \ldots \end{aligned}$ | 0 371 722 | 45 65 69 | 60 117 152 | 0 301 592 | 0.37 0.53 0.57 | $\begin{aligned} & 0.49 \\ & 0.97 \\ & 1.25 \end{aligned}$ | $\begin{array}{r} 0 \\ 592 \\ 1,2842 \end{array}$ | $\begin{array}{r} 767 \\ 1,063 \\ 1,251 \end{array}$ | $\begin{aligned} & 1,053 \\ & 1,869 \\ & 2,702 \end{aligned}$ |

[^1]Increases in productiveness and carrying capacities were observed in each succeeding year following the improvement of the pastures due to clearing. The limed and fertilized pasture produced the greatest increases, being changed from
totally unproductive pastures prior to 1933 to pastures capable of providing 152 grazing days, a carrying capacity of 1.25 animals per acre and a milk production of 2,702 pounds per acre.

## Pasture in a Crop Rotation

While permanent pastures provide a convenient and economical source of live stock feed under certain conditions, it may be more profitable in other cases to grow pasture in a regular farm rotation. This will provide for the growth of more productive plant species than those found naturally in permanent pastures.

In 1936 an experiment was begun at Ottawa which illustrates the relatively higher productivity of oats, Sudan grass, clover and timothy when compared with Kentucky blue grass pasture. A three-year rotation of first year, oats or Sudan grass seeded to clover and timothy, second year clover, third year timothy, was laid down for pasture in a field adjoining a permanent sward which had been in Kentucky blue grass pasture for over 30 years. Each area received an application of commercial fertilizer made up of 100 pounds of sulphate of ammonia, 300 pounds of superphosphate, and 75 pounds of muriate of potash per acre. Another area of Kentucky blue grass pasture received no fertilizer and was included in the comparison.

The yields of grass and the animal carrying capacity and returns from the cultivated pastures as well as from the Kentucky blue grass pastures are presented in table 23.

The yield of clover and timothy in the cultivated pasture has been considerably higher than any of the other crops, the average yield of dry matter being $3 \cdot 62$ tons as compared with 0.98 tons for unfertilized Kentucky blue grass, an increase of 269 per cent. Oats and Sudan grass are very succulent crops and produced fair yields of green fodder, but their dry matter yields were only 1.20 and 1.88 tons per acre respectively. The average yield per acre of the three crops in the cultivated rotation based on the acreage of each crop pastured, was $16 \cdot 3$ tons of green crop and 2.93 tons of dry matter per acre. This represents an increase in dry matter of $83 \cdot 1$ per cent over the fertilized and $199 \cdot 0$ per cent over the unfertilized blue grass pasture.

When measured on the basis of the gain in live weight of animals grazing on the pastures, the gain on the non-fertilized Kentucky blue grass pasture was 185 pounds as compared with $242 \cdot 8$ pounds on the fertilized Kentucky blue grass and $395 \cdot 0$ pounds on the cultivated pasture. The increase in favour of the cultivated pasture on this basis is not so great as when measured by grass yields, the gains on the cultivated pasture being only $62 \cdot 7$ per cent higher than the fertilized and 113 per cent higher than the unfertilized Kentucky blue grass pasture. This may be attributed to the more laxative effect of the succulent annual pastures, the greater losses due to tramping and the greater contamination by droppings.

The combined cost of fertilization and cultivation on the cultivated pasture amounted to $\$ 8.01$, which is $\$ 5.29$ higher than the treatment on fertilized permanent pasture. The higher return from the cultivated pasture, however, was sufficient to pay for the greater cost. With the animal gains valued at five cents per pound the return over the cost of treatment was $\$ 11.74$ on the cultivated pasture and only $\$ 9.42$ on the fertilized permanent pasture. Both of these pastures produced higher returns than the unfertilized permanent pasture. Furthermore, the cultivated pasture provided a uniform production of excellent quality pasture for 143 out of an estimated standard season of 150 days without necessitating the removal of any of the animals, whereas the fertilized pasture provided grazing for 121 days, only after the number of stock had been decreased considerably. Thus it would seem that where the high cost of land makes
TABLE 23.- YIELD OF GRASS AND ANIMAL CARRYING CAPACITY PER ACRE ON CULTIVATED AND PERMANENT PASTURE,

| Treatment | Class of livestock | Yield of grass |  | Cost of treatment | Total digestible nutrients | Carrying capacity grazing season 150 days |  | Returns per acre |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Green weight | $\underset{\text { Dry }}{\text { matter }}$ |  |  | Animal units | Area required per head | Gains in live weight | Value of gain | Return over cost of treatment |
|  |  | tons | tons | \$ cts. | lb. | No. | acres | lb. | \$ cts. | \$ cts. |
| Non-fertilized Kentucky blue grass pasture | Yearling steers and heifers. | $4 \cdot 0$ | 0.98 | 000 | 1,084•1 | 0.45 | $1 \cdot 35$ | $185 \cdot 0$ | 925 | 925 |
| Fertilized Kentucky bluc grass pasture... | Yearling steers and heifers. | $6 \cdot 5$ | - $1 \cdot 60$ | 272 | 1,423.8 | $0 \cdot 59$ | $1 \cdot 03$ | $242 \cdot 8$ | 1214 | 942 |
| $\begin{gathered} \text { Fertilized pasture in a } \begin{array}{c} \text { Oats and Sudan } \\ \text { three-year rotation } \end{array}\left\{\begin{array}{c} \text { grass. Clover } \\ \text { Timothy. } \end{array}\right. \end{gathered}$ | 2-year old heifers. | $\left.\begin{array}{r}7 \cdot 1 \\ 10 \cdot 2 \\ 20 \cdot 4 \\ 20 \cdot 4\end{array}\right\}^{4} 16 \cdot 3$ | $\left.\begin{array}{l} 1 \cdot 20 \\ 1 \cdot 88 \\ 3 \cdot 62 \\ 3 \cdot 62 \end{array}\right\} .2 \cdot 93$ | Fertilizer 272 Cultural 529 | 2,315•8 | 1.01 | $0 \cdot 63$ | $395 \cdot 0$ | 1975 | 1174 |
|  |  |  |  | 801 |  |  |  |  |  |  |

intensive cultivation necessary and where high-priced products such as milk are produced, it would be economical to maintain a relatively higher yielding cultivated pasture.

## Pasture Species and Seed Mixtures

Among the various species of grasses and legumes that have a wide adaptation when seeded for hay and pasture in Eastern Canada, those which are most extensively used are: timothy, red clover, alsike and alfalfa. Indeed, these are grown almost to the exclusion of all others. They are sometimes grown separately, as in the case of alfalfa, but as a rule a mixture of timothy with one or more of the legumes is preferred.

Mixtures of grasses and legumes have many advantages for both hay and pasture over any one species grown by itself. Some of these advantages may be stated as follows:-

1. Mixtures result in a more uniform stand and higher production. Because many soil conditions are often present in a single field, a mixture composed of several species, each with somewhat different soil requirements, is more likely to cover the area uniformly than is any one species seeded alone.

Mixtures also give a more uniform production throughout the season than pure species, and legumes stimulate the growth of grass by supplying nitrogen which they take from the air.


Pasture plots at the Division of Forage Plants, Central Experimental Farm, Ottawa. Pure species and mixtures of grasses and legumes are grown and are clipped five times each year to simulate grazing to test the productivity, winter-hardiness, adaptability and compatibility of the species. (1) Mixture of timothy, alsike, red clover, alfalfa, orchard grass, meadow fescue and meadow foxtail. (2) Tall oat grass. (3) Common white Dutch clover. (4) Timothy. (5) Mixture of timothy, red clover, alsike, alfalfa, perennial rye grass and red fescue. Note winter-killing of tall oat grass and complete winter hardiness of timothy.

Experiments have shown that mixtures have consistently outyielded pure species. The average yield of 10 cultivated grasses grown separately varied from 1,077 to 2,415 pounds of moisture-free herbage per acre, with an average production of 1,953 pounds, whereas the yield of 10 grass-legume mixtures in the same test varied from 4,016 to 5,712 pounds with an average production of 4,924 pounds per acre.
2. Mixtures of grasses and legumes provide a more balanced feed than either of these alone, since the legumes are higher in protein and mineral content than are the grasses.
3. Mixtures provide a variety of herbage. The less palatable species are often eaten readily when they are grown in a mixture with other palatable grasses and legumes.
4. Legumes in pasture mixtures tend to maintain soil fertility. Deep rooted legumes, such as alfalfa, also resist drought and provide pasture when grasses fail.

In selecting a pasture mixture it is important to keep in mind the suitability of the different grasses and legumes for this purpose, with special reference to: (1) soil and climatic adaptation, (2) compatibility, (3) productivity, (4) palatability, (5) feeding value, and (6) tolerance to grazing. In most parts of Canada it is essential that the plants be winter-hardy and, in some areas, drought resistant also. Cost of seed is another factor that has to be considered.

There are grasses and legumes other than those in common use (timothy, red clover, alsike and alfalfa) that deserve careful consideration from the pasture standpoint. Among the grasses which predominate in the natural or untilled pastures of Eastern Canada are Kentucky blue grass, Canada blue grass, red top, brown top, or colonial bent, and red fescue. Seed of all these is available on the market. Then there are those grasses which are used for pasture most extensively in Northern Europe which include perennial and Italian rye grass, orchard grass, meadow fescue, and tall oat grass. In Western Canada the species commonly grown for both hay and pasture are brome grass, crested wheat grass, and slender wheat grass. Reed canary grass is another species that has been found useful for pasture under certain conditions both in Canada and the United States.

Among the legumes, white clover is of special interest for permanent pastures. Sweet clover is used extensively for pasture alone, but being biennial in habit of growth, it may be considered more properly with the annual crops which are used for temporary or supplementary pastures.

All of the above species are being investigated as to their value for pasture purposes, both as pure species and in mixtures, by the Division of Forage Plants at Ottawa, and by the Dominion Experimental Farms and Stations throughout Eastern Canada. In table 24 are presented the average yields of dry matter of pure species for a period of four years, at Ottawa. The yields were obtained by clipping the herbage five times per season to simulate grazing.

TABLE 24.-AVERAGE YIELDS OF DRY MATTER IN POUNDS PER ACRE OF PURE SPECIES GROWN AT OTTAWA

| Species | Yield | Species | Yield |
| :---: | :---: | :---: | :---: |
| Grasses- |  | Crested Wheat Grass. | 1,615 |
| Timothy. | 2,674 | Italian Rye Grass.... | 1,605 |
| Red Top. | 2,383 | Red Fescue....... | 1,601 |
| Slender Wheat Grass. | 2,351 | Perennial Rye Grass. | 1,077 |
| Meadow Foxtail. | 2,167 | Colonial Bent Grass. | 875 |
| Meadow Fescue. | 2,115 |  |  |
| Reed Canary Grass | 2,110 | Legumes- |  |
| Canada Blue grass. | 2,094 | Alfalfa.. | 5,424 |
| Orchard Grass.... | 1,905 | Red Clover. | 4,443 |
| Commercial Brome Grass. | 1,905 | White Clover (Common) | 3,279 |
| Kentucky Blue grass. | 1,760 | White Clover (Mammoth) | 4,743 |
| Tall Oat Grass. | 1,710 | White Clover (English Wild). | 1,983 |

Owing to the fact that a study of the numerous grasses and legumes for pasture purposes is a relatively recent development in Canada, and because of the great diversity of soils and climatic conditions characteristic of Eastern Canada, our knowledge of pasture mixtures for different areas is still very imperfect. There are a few facts, however, which stand out quite clearly, and, based on the experimental work to date, these will be discussed briefly in the following paragraphs.

## GRASSES

Timothy.-This is the most widely adapted of all the grasses. Yields of timothy have been higher than those of any other species and it is the most palatable grass for all classes of live stock. It grows well in association with clovers and alfalfa, and is very winter-hardy. For these reasons, and because the seed is relatively cheap, timothy should always be used liberally in making up pasture mixtures. The chief disadvantage of timothy as a pasture grass is that it is short lived if grazed closely and that it may be injured permanently by drought.

Kentucky Blue Grass.-This is the dominant species in natural or untilled pastures on non-acid soils. On such grasslands, it is very aggressive and persistent, and competes successfully with most other species. In many parts of Ontario, particularly the southwestern section and in the Ottawa valley, many pastures once seeded to timothy are now composed entirely of Kentucky blue grass. It is characteristic of Kentucky blue grass that it produces an eariy rapid growth for a few weeks only in May and June, after which it matures and remains more or less dormant until revived by fall rains and cooler weather.

Taking the season as a whole, Kentucky blue grass has proved to be relatively unproductive, especially in the older fields and on the less fertile soils. Nor is it as palatable as most other grasses. Live stock will graze it readily in the early stages of growth and later if no other herbage is available, but it is one of the last grasses to be eaten when the animals are given a choice.

When Kentucky blue grass is seeded in a mixture with other species on land to which it is highly adapted, it will crowd out most other species in the space of three or four years. For this reason and because the seed is relatively expensive, it is often advisable to omit this grass in making up pasture mixtures or if it is included, to seed only three or five pounds of seed per acre. On land that is highly adapted to Kentucky blue grass, volunteer seedlings will usually appear in sufficient numbers to provide all the plants that are needed, without including it as one constituent of the mixture.

In association with wild white clover, Kentucky blue grass is more productive and generally more satisfactory than when seeded alone. The spring growth of Kentucky blue grass in Ontario, however, is so rapid, that it is very difficult in practice to secure the degree of close grazing which is necessary to encourage the growth of wild white clover, with the result that clover is suppressed by the blue grass during the flush period of growth. For this reason, and because of hot dry weather which frequently occurs in July and August, wild white clover is often conspicuous by its absence in the blue grass pastures of Ontario.

Canada Blue Grass.-This is the dominant species in certain sections of Ontario. It is better suited than Kentucky blue grass for locations subject to drought, such as are usually found on some of the light sandy and heavy clay soils. As a pasture grass it compares very favourably with Kentucky blue grass in yield and chemical composition, and it is considerably more palatable. Canada blue grass does not form so dense a turf as Kentucky blue grass under conditions at Ottawa, and for this reason wild white clover has persisted better
with Canada blue grass than with Kentucky blue grass. These species, however, exhibit much the same habit of growth in that both reach their maximum development early in the season, production being very much reduced by midsummer.

Red Top.-This grass is of secondary value for pasture purposes. It is sometimes included in mixtures for the purpose of providing good "bottom" in the pasture. Under conditions favourable for red top, it may quickly crowd out all other species, while if the conditions are unfavourable its contribution to the herbage is likely to be unimportant. For these reasons and because it is less palatable and less nutritious than some of the better grasses, the amount of seed used in a given pasture mixture should probably never exceed three pounds per acre.

Colonial Bent (brown top). -This grass is dominant on much of the grassland in the Maritime Provinces, especially those soils which are deficient in lime. Under these conditions it is productive and of fair quality if reasonably well grazed. It is generally associated with some wild white clover which can usually be increased with appropriate fertilization and suitable grazing management.

On land which is well adapted to colonial bent it is never necessary to sow the seed, as the grass grows freely from seed which is present in the soil. On soils which are not highly adapted to this species, it would be unprofitable to include it in the pasture mixture, in view of the fact that better grasses are available, and because the seed, which is valuable for making turf, is high in price.

Red Fescue.-Of the small fescues, including hard fescue, Chewing's fescue, sheep's fescue, and creeping red fescue, the last named is the most important for pasture purposes. Like Kentucky blue grass, Canada blue grass and red top, it is essentially a "bottom" grass. Creeping red fescue when seeded alone has not been especially productive at Ottawa, nor has it been readily eaten by live stock, but in experimental tests, where two or three pounds of seed per acre has been included as one constituent of the pasture mixture, it appears to have much more promise. Used in this way, it helps to thicken up the sward, provides considerable herbage, and is readily eaten along with the more palatable grasses and legumes.

Definite recommendations as to the value of this species must await further experimental work under different conditions and also with respect to the differences between strains, which appear to be rather pronounced. It has been established, however, that genuine creeping red fescue is definitely superior for pasture purposes to hard fescue, Chewing's fescue, or sheep's fescue.

[^2]Italian Rye Grass.-This grass is a quick-growing short-lived perennial that is used extensively both for hay and pasture in European countries where it is highly regarded for semi-permanent pastures. It is frequently included in permanent pasture mixtures, with the object of securing greater productivity during the first and second seasons while the more permanent species are becoming established.

Italian rye grass is not adapted to Eastern Canada because it is usually winter-killed, being considerably less hardy than perennial rye grass. It should not be confused with the latter, which is a much better pasture grass and quite different in habit of growth.

Orchard Grass.-Commonly referred to as "cocksfoot" in Great Britain, this grass is used extensively in European countries for both hay and pasture. Orchard grass makes an early vigorous growth in the spring and is noted for the rapidity with which aftermath is produced after cutting or grazing. The young growth is relished by live stock, but unless the number of animals grazing upon it is sufficient to keep it eaten down, the plants soon become coarse and much less palatable. This constitutes a difficulty in pasture management, especially in Eastern Canada where the growth in May and June is very rapid. In midsummer, on the other hand, when droughty conditions prevail, orchard grass can usually be depended upon to provide some green growth. In dry hot weather it will often be the only grass to produce some fresh green herbage.

Orchard grass possesses greater winter-hardiness than perennial rye grass, but it is not so hardy as it should be for the climatic conditions of Eastern Canada. Occasionally it is severaly injured. This occurs about once in every four years. This might be rather serious if it were seeded alone, but it may be used in mixtures without very much risk. Like other grasses it is better adapted to some soils than to others. In a pasture experiment at Ottawa with dairy cattle, orchard grass has persisted fairly well for three successive winters and its contribution to the herbage, especially during the hot dry weather of midsummer, has been greatly appreciated. This has been the case, also, on some of the eastern experimental farms. While orchard grass has not been highly recommended in Eastern Canada to date, experiments have indicated that it may find a useful place in pasture mixtures where it is adapted to the soil, especially in the drier locations.

Ordinary commercial seed of orchard grass usually results in rather coarse stemmy plants. Improved strains are now available which are much leafier and more suitable for pasture. Among these may be mentioned a very leafy strain produced at the Welsh Plant Breeding Station, Aberystwyth, Wales; also "Akoroa" orchard grass, a regional strain obtained from old pastures in New Zealand. The latter is somewhat more winter-hardy than the former in Eastern Canada and the seed of both commands a considerably higher price than does ordinary commercial seed.

Meadow Fescue.-This is a tall-growing and broad leafed species of fescue which thrives best where moisture is plentiful. It is sufficiently winter-hardy for practical purposes, although it does winter-kill occasionally. Meadow fescue is fairly palatable and grows well in association with other grasses and legumes that are not grazed too closely. Like timothy, it prefers rich, moist soils but does not grow well on sandy land or in dry locations.

On fields which are well adapted to meadow fescue, the addition of three or four pounds of seed per acre to a pasture mixture is often advantageous.

Tall Oat Grass.-This grass is valued in Europe for the early grazing it provides in the spring, but essentially it is a hay rather than a pasture grass. In Eastern Canada, it is not sufficiently winter-hardy to warrant its use in pasture mixtures.

Brome Grass.-In Eastern Canada brome grass has not been used to any extent, but in Western Canada, it is used more widely for hay and pasture than any other species. It is productive under dry conditions, palatable, and high in feeding value. A mixture of 15 pounds of brome grass seed per acre with five pounds of alfalfa is highly recommended for Manitoba, Saskatchewan and Alberta, except in the very dry areas of these provinces. In recent years, brome grass has been reported upon very favourably in the corn belt of United States and in Southern Michigan, which indicates that the brome-alfalfa mixture may have advantages also for Western Ontario.

At Ottawa, brome grass is being tested very thoroughly for hay and pastures, both with and without alfalfa, and in other mixtures. While it has grown exceptionally well as single plants and in inter-tilled rows, the results of plot tests have not been very promising to date. Brome grass is not recommended for Quebec or the Maritime Provinces, and its value for Eastern Ontario is doubtful.

Crested Wheat Grass.-Experimental work with crested wheat grass indicates that this grass is not nearly so well adapted to Eastern Canada as it is to the drier sections of the three Prairie Provinces.

Slender Wheat Grass.-This is another species which is indigenous to Western Canada, where it has been grown extensively for many years. While it grows well also in Ontario, experiments have shown that it is often attacked severely by rust and that it is not otherwise as satisfactory as timothy.

Reed Canary Grass.-A very vigorous grower, this grass is a heavy yielder of both hay and pasture under favourable conditions. It is adapted especially well to wet soils, such as bottom land subject to flooding, and peaty soils. It is perfectly winter-hardy, tolerant of soil acidity, thrives in water for long periods, and the young herbage is readily grazed by live stock. While reed canary grass thrives also on upland soils, it is doubtful whether it will ever be used extensively in preference to timothy and other cultivated grasses. It is highly recommended, however, under conditions where excess of water retards the growth of other grasses. The cost of seed has been in the neighbourhood of $\$ 0.75$ per pound, but considerably lower prices have been quoted during the last two years.

## LEGUMES

The most important consideration in making good pasture is to secure and maintain a satisfactory mixture of grasses and legumes. Without legumes, any of the grasses are relatively unproductive, whereas if legumes are present in sufficient quantity the growth of the grasses associated with them is promoted and the nutritional value of the herbage is greatly improved. It is, therefore, of the greatest importance to select those legumes which are best adapted to the soil and climatic conditions, and then endeavour to maintain them by suitable grazing management, and fertilization where necessary. With respect to pasture, the most important legumes in Eastern Canada are red clover, alsike, alfalfa, white clover, and Ladino or mammoth white clover.

Red Clover.-Red clover is very widely adapted in Eastern Canada. It is commonly grown in a mixture with timothy, as these species thrive particularly well together. In the year after seeding the herbage is composed mainly of clover, but in the second crop year the timothy greatly predominates. Indeed it is usual to find that very little red clover, if any, survives the second winter due to the fact that the red clover used in Eastern Canada belongs to the early double-cut type. This is one of the disadvantages of Canadian red clover as a pasture plant.

In European countries the late single-cut type of red clover is considered to be much better for pasture purposes than the early single-cut type because the plants are leafier and more perennial in habit of growth. Some of these late strains are also more winter-hardy, but unlike Canadian red clover they lack the hairiness of leaf and stem which characterizes most of the red clover grown in America. It is believed that hairiness provides a protection against leaf hoppers and that this is necessary under Canadian conditions, but while there is considerable evidence to support this view, it is by no means certain that hardy types of late red clover could not be used advantageously in some parts of the country to ensure a greater leguminous content in the herbage after the first crop year.

It has been shown also that red clover suppresses the grasses that are seeded with it. This results in a thin sward after the clover has disappeared. In short rotations for hay or pasture this is not a disadvantage but too much red clover seed in permanent pasture mixtures is undesirable.

Alsike.-Alsike is a high-yielding but short-lived legume. Like early doublecut red clover, it is suited only to short rotation pastures. In certain sections of Eastern Canada, more especially in Ontario, alsike largely replaces red clover, and elsewhere it is a common practice to include a couple of pounds of alsike seed in mixtures of timothy and red clover. On certain soils, usually more or less deficient in lime, alsike thrives better than either red clover or alfalfa. For this reason the inclusion of some alsike in the mixture is generally believed to provide a more uniform stand of clover and to increase the yield to a greater or lesser extent depending on its degree of adaptation to the particular soils in which it is being grown.

Alfalfa.-Alfalfa is grown extensively for hay and pasture in Ontario and, to some extent also, in the other provinces of Eastern Canada. Its importance as a forage crop in southwestern Ontario and the Ottawa valley shows that it is highly adapted to these areas. Alfalfa does not thrive on acid soils, and unsuccessful attempts to grow alfalfa are frequently attributable to this fact. A reasonably high state of fertility is required also for best results with this crop and soils which are suitable in this respect, but acid in reaction, can often be made to produce good crops by an application of lime.

Alfalfa has long been regarded as a hay crop primarily but during the last few years its value for pasture has become very evident. More and more of it is being used for this purpose with excellent results. It has been found that alfalfa will persist in pastures much better than was generally believed, provided it is not grazed too closely, and that it produces more herbage than any other pasture plant during periods of drought because of its deep-feeding root system.

As a pasture crop, alfalfa should be grown in a mixture with one or more of the grasses. Grazing animals prefer the mixed herbage, and a mixture of grass and alfalfa is much less likely to cause bloat than alfalfa alone. This is an important consideration since the death losses of animals by bloating on alfalfa have sometimes been serious.

When alfalfa is included in a pasture mixture on good alfalfa soils, not only does it provide the best assurance of pasturage in times of drought, but it raises, also, the general level of production. Experiments at Ottawa have shown that the average yield of all mixtures containing alfalfa has been 5,707 pounds of dried herbage per acre as compared with 4,020 pounds for similar mixtures but without alfalfa. The data are from plots, clipped five times per season to simulate grazing over a period of three years. In a similar comparison, where experimental fields were grazed with dairy cows, the alfalfa mixtures clearly out-yielded those mixtures which did not contain alfalfa.

White Clover.-Among the important species of pasture plants, white clover occupies a place of unique importance. From a sprinkling of inconspicuous


A wild white clover and grass mixture provides an excellent type of pasture. Wild white clover with (5) Canada blue grass (6) Kentucky blue grass ( $\overline{1}$ ) timothy. Close grazing, and fertilization with superphosphate are essential to promote the growth of wild white clover.
plants it is often possible, by the application of phosphatic fertilizers and appropriate grazing management, to secure a rapid development of the clover to a point where it makes a substantial contribution to the herbage. Where this can be done, the encouragement of wild white clover ranks of first importance on non-arable land as a means of pasture improvement and soil fertility building.

The prevalence of "wild " white clover in England has given a great impetus to pasture improvement. Wild white clover differs from the white Dutch clover of commerce in that it is longer lived, more strongly spreading, and more persistent under close grazing. The seed is obtained from old pastures from which the taller growing and shorter lived types have been eliminated. Strains of wild white clover from different sources exhibit characteristic differences. Seed harvested from old pastures in the county of Kent in England produces plants, with very small leaves, that cling to the ground tightly. This strain is highly regarded in England because of its persistence in permanent pastures. New Zealand wild white clover produces a somewhat taller growth and is more productive than the Kentish strain for at least the first two or three years. Both strains appear to be reasonably winter-hardy in Eastern Canada.

White clover is widely distributed in the natural grasslands of Quebec and the Maritime Provinces. It is less plentiful in Ontario, especially in the southern part of the province, where dry weather in midsummer is unfavourable to its growth. Tests conducted at Ottawa with seed collected from natural grassland in the different provinces of Eastern Canada have shown that much of it is typical of the " wild" type. There is reason to believe that regional strains can be developed that will be superior under local conditions to varieties and strains of foreign origin.

Experiments to determine the place and value of wild white clover are in progress at Ottawa and Dominion Experimental Farms and Stations in Eastern Canada. A few tentative conclusions may be summarized as follows:-

1. Wild white clover in Eastern Canada is of most value in association with the native grasses on non-arable land.
2. Wherever wild white clover thrives naturally in permanent pastures it is likely to be the most important factor in their improvement.
3. An ample supply of phosphates in the soil and close grazing are essential requirements for the best development of wild white clover. It is fairly tolerant of soil acidity but sometimes responds to treatment with lime.
4. The use of wild white clover in seeded pastures that are intended to provide one or two crops of hay is not likely to be profitable because the clover is easily eliminated by shading. If the crop is to be utilized for pasture only, and the soil and climatic conditions are favourable for its growth, wild white clover can be a valuable component of permanent mixtures. The shading effect of other grasses and legumes will be prevented if the herbage is adequately grazed.
5. Experiments at Ottawa have shown that wild white clover in association with different grasses and grass mixtures more than doubled the yields of pasture herbage and produced about five times as much protein per acre as compared with the same grasses and grass mixtures without the clover.

Ladino or Mammoth White Clover.-This is a giant strain of white clover that is giving promising results in experimental tests at Ottawa. It is a perennial tall-growing type with large leaves and strongly spreading stolons. Ladino is quite as winter-hardy as wild white clover but, unlike the latter, it does not persist as well under close grazing. The dense leafy growth produced by this clover tends to suppress the grasses seeded with it, so that its value in mixtures is still problematical. From the tests which have been made, however, it would seem that Ladino may have a very useful place as a pasture legume in Eastern Canada.

## COMPARISON OF DIFFERENT TYPES OF PASTURE MIXTURES AT OTTAWA

It is of some interest to compare the yields of different types of pasture mixtures. Results are available on four fundamentally different mixtures, cut five times per season, for a three-year period. The yields of herbage, in terms of dry matter per acre, for each of the seasons 1934, 1935 and 1936, and the three-year average, are given in table 25.

TABLE 25.-YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT MIXTURES CUT FIVE TIMES PER SEASON

| Mixtures |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |

${ }^{1}$ Kentucky blue grass, red top, and white Dutch clover.
It will be observed that the addition of Kentucky blue grass, red top, and white clover increased somewhat the yields of mixture No. 2 over mixture No. 1 for the first two crop seasons. By the third season the yield of mixture No. 2 was somewhat less than mixture No. 1, due to the fact that Kentucky blue grass had occupied the soil so completely that it began to suppress the timothy and clover.

Mixture No. 3, which was the same as mixture No. 1 with the addition of four pounds of alfalfa seed per acre, had the highest yield throughout. The alfalfa, being a deep-rooted plant, was better able to withstand drought, and persisted in spite of competition with the "bottom grasses" to give a higher yield in 1936 than in 1935. It is interesting to note that the alfalfa was able to survive the clipping treatment for three years.

Mixtures 1, 2, and 3 yielded considerably more than mixture No. 4, thus emphasizing the fact that, in short leas, red clover and alfalfa, especially the latter, are important in securing high yields. If the red clover and alfalfa, however, had been less adapted than the white clover, mixture No. 4 would probably have equalled or exceeded the yields of the other mixtures. Another experiment in which grasses in association with wild white clover were compared with the same grasses alone, showed that the former outyielded the latter more than two to one.

The sharp drop in the yield of mixture No. 4 in 1936 is of special interest. This was due to the disappearance of wild white clover in that year, which in turn was caused by the competition with Kentucky blue grass. This would not have occurred had the blue grass been less aggressive, and could probably have been prevented by very early grazing of sufficient severity to suppress the blue grass while the wild white clover was re-establishing itself in the spring. Although the grass was clipped at a height of approximately one inch and never was allowed to reach a height of more thar five to six inches, the blue grass was able to suppress the clover because of its rapid and vigorous growth before the clover got started.

In order to determine whether more frequent clipping would favourably affect the persistence of wild white clover, one-half of each plot was cut nine
times per season instead of five times. The yields from the "frequently clipped" sections of the four mixtures listed in table 25 are given in table 26.

TABLE 26.-YIELDS OF DRY MATTER IN POUNDS PER ACRE OF DIFFERENT MIXTURES CUT NINE TIMES PER SEASON

| Mixtures |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | 1934 | 1935 | 1936 | Average |
|  |  |  |  |  |

${ }^{1}$ Kentucky blue grass, red top, and white Dutch clover.
It will be seen from a comparison of tables 25 and 26 that mixtures 1, 2, and 3 yielded less and that the yield obtained from mixture No. 4 was slightly greater under more frequent clippings. The more frequent cutting of the plants in the wild white clover mixture apparently was beneficial, and this would indicate the desirability of close grazing for the development of wild white clover. Nevertheless the same sharp reduction in yield occurred in 1936, showing that the more frequent clipping treatment did not ensure the persistence of wild white clover. More frequent clipping throughout the season apparently did not compensate for the need of closer clipping of the Kentucky blue grass at the very early stages of growth. It is believed that similar results and conclusions would have been arrived at had the plots been grazed instead of clipped.

It should be noted, also, that in the case of mixtures 1 and 3 , more frequent clipping greatly reduced the yields in 1935 as well as in 1936. The effect was most pronounced in the mixture containing alfalfa, which goes to show that alfalfa does not tolerate too frequent cutting or too close grazing.

Results obtained from the above experiments are comparable to what might be expected under similar conditions from short leas or a short rotation pasture, where no hay crop is taken. Comparative yields of the different mixtures may be expected to show much less variation in 1937 and future years.

With respect to the nutritive value of the herbage it was found that the average protein content did not vary greatly from 25 per cent, the wild white clover mixture being about 1 per cent higher than the others. This uniformly high protein content was due not only to the leguminous content of the herbage but also the almost equally high protein content of the "frequently cut" grass.

## ANNUAL OR SUPPLEMENTARY PASTURES

Special tests have been made to determine the relative value of different annual crops for supplementary pasture. About 40 different crops and combinations of crops have been compared during the last four years both by clipping the herbage in test plots and by grazing with dairy cows under field conditions. These included varieties of oats, barley, fall rye, and several types and varieties of millet, Sudan grass, early amber cane sorghum, Italian and Wimmera rye grass, Teff grass, soybeans, sweet clover, and several combinations of these crops.

Oats and Sudan grass were found to be the best crops for supplementary pasture. Oats seeded at three bushels per acre between May 20 and 30, or Sudan grass at 30 pounds per acre between June 1 and 10, gave excellent results both from the standpoint of yield and palatability. Cool weather favours the
oat crop, whereas Sudan grass thrives best at relatively high temperatures. These crops were tested also in a mixture of two bushels of oats and 25 pounds of Sudan grass per acre, and seeded about June 1. The results from these tests were very satisfactory. It was concluded that such a mixture combines to a considerable extent the advantages of both crops.

Oats and fall rye seeded together in the spring did not prove to be any better than oats alone, but fall rye seeded about September 1 produced a fair amount of late fall and early spring grazing. The results obtained with fall rye varied considerably, depending upon soil and weather conditions.

Soybeans were not especially satisfactory as a pasture crop, but good results were obtained by seeding soybeans early at 30 pounds per acre in rows about 28 inches apart, and broadcasting Sudan grass between the rows two weeks later. The method of seeding was a disadvantage but apart from this, the crop was very productive and palatable.


Oats and Sudan grass are excellent annual pasture crops. Oats left, Sudan grass right; note seeding of grass and clover in both areas. Both crops are very good nurse crops and pasturing the crops does not damage the new seeding which will provide pasture the following year. A mixture of oats, $1 \frac{1}{2}$ bushels and Sudan grass 15 pounds per acre is recommended when used for a nurse crop. For annual pasture not seeded down the mixture should be oats 2 bushels and Sudan grass 25 pounds per acre.

On land which is suited to sweet clover and alfalfa, either of these legumes, if seeded early in the spring without a nurse crop, will produce a surprising amount of pasturage throughout the fall months of the same season. Grown in this way, these crops are apt to cause bloat unless the grazing is carefully managed.

Sweet clover in a mixture with oats has never been satisfactory as an annual hay crop at Ottawa, apparently because the clover is suppressed by the rapid growth and leafiness of the oats. In Western Canada and parts of Ontario, however, a mixture of oats and sweet clover has frequently been recommended as an emergency hay crop and for pasture. Excellent results have been obtained under certain conditions.

Although a mixture of peas and oats has long been recognized as a very desirable annual hay crop, this combination proved less satisfactory for pasture.

Peas develop much less rapidly than oats in the early stages of growth and therefore the contribution which the peas can make by the time that grazing should begin is relatively unimportant. For this reason, and considering the fact that pea seed is usually expensive, the seeding of peas with oats for jasture is not recommended under most conditions.

In certain seasons when moisture and temperature conditions are favourable, millets and sorghums have been very productive. On the other hand, these crops can be disappointing if they encounter a cool growing season or excessively dry weather. Millets and sorghums are very useful as quick-growing catch crops for hay or as soiling crops, and they may be used for pasture, but in grazing trials with dairy cows the animals showed a decided preference for oats and Sudan grass, and in other respects as well these crops were superior to millets and sorghum. It should be pointed out also that there is some danger of poisoning when animals are grazed on sorghum due to an accumulation of prussic acid in the plants. This is most apt to occur if the plants become stunted by unfavourable conditions for growth, and especially after the plants have been partially frozen.

Italian rye grass seeded with oats showed some promise as a pasture grass in that the ground was always well covered with fresh green herbage during the latter part of the season after the oats had been eaten off. The amount of herbage produced, however, was hardly sufficient to warrant the expense for seed. It is conceivable that under more favourable conditions its use for this purpose might be justified. Wimmera rye grass was less satisfactory than Italian rye grass.

Teff grass proved to be one of the most productive annual grasses in these tests. Unfortunately, it was also the least palatable.

Rape has been tested and found satisfactory for finishing lambs.

## Chemical Composition of Pasture Herbage

In a study of the composition of herbage, the data herein considered are those for protein, fibre, calcium, and phosphorus. The percentage of these constituents in a pasture herbage is affected by the variety of herbage, the stage of maturity and changes in the nature of the herbage brought about by different systems of management as well as fertilization and climatic conditions.

Varicty of Herbage.-In table 27 the composition of a number of the more commonly found species, grown in the same locality, and cut the same number of times per season, is presented. In order to make the data strictly comparable all data are calculated to a water-free basis. The figures given are the average data for three years' work conducted on duplicate plots. The number of cuttings varied from four to five according to the season.

TABLE 27.-CHEMICAL COMPOSITION OF PASTURE PLANT SPECIES (OTTAWA)

| - | $\begin{aligned} & \text { Protein } \\ & \text { (N×6.25) } \end{aligned}$ | Fibre | Calcium | Phosphorus |
| :---: | :---: | :---: | :---: | :---: |
| Grasses- | p.c. | p.c. | p.c. | p.c. |
| Perennial rye grass. | 14.28 | 25.08 | $0 \cdot 78$ | $0 \cdot 50$ |
| Orchard grass.. | $14 \cdot 89$ | 25.25 | $0 \cdot 79$ | $0 \cdot 55$ |
| Timothy..... | $14 \cdot 37$ | 23.39 | $0 \cdot 65$ | $0 \cdot 43$ |
| Kentucky blue | $12 \cdot 28$ | 26.95 | $0 \cdot 62$ | $0 \cdot 44$ |
| Canada blue. . | 13.87 | $25 \cdot 70$ | 0.54 | $0 \cdot 44$ |
| Meadow fescue | $13 \cdot 73$ $14 \cdot 25$ | 25.57 23.75 | 0.79 0.65 | $0 \cdot 52$ 0.49 |
| Reed canary | $14 \cdot 25$ 12.55 | 23.75 27.11 | 0.65 0.75 | $0 \cdot 49$ $0 \cdot 40$ |
| Red top.. | 11.96 | 25.98 | $0 \cdot 74$ | $0 \cdot 38$ |
| Legumes- |  |  |  |  |
| Alfalfa | $24 \cdot 28$ | 20.85 | $1 \cdot 81$ | $0 \cdot 45$ |
| White Dutch clover (common) | $23 \cdot 80$ | 17.23 | $1 \cdot 53$ | $0 \cdot 47$ |
| Wild white clover (English). | 23.79 | 15.95 | $1 \cdot 75$ | $0 \cdot 45$ |
| Alsike....................... | 21.99 | $18 \cdot 66$ | $1 \cdot 59$ | $0 \cdot 45$ |

The data presented show that there are very marked differences in composition between grasses and legumes. The latter are much richer in protein and calcium and lower in fibre than the former. The range in protein for the grasses is, approximately, from 12 to 15 per cent, for the legumes 22 to 24 per cent. The range in calcium for the grasses is approximately from 0.5 to 0.8 per cent; for the legumes 1.5 to 1.8 per cent. In phosphorus content there is no great difference between these grasses and legumes.

Of the grasses the two outstanding varieties, on the basis of chemical composition, are perennial rye and orchard grass; they are high in protein, calcium, and phosphorus. Reed canary grass is characterized by a high protein content. Kentucky blue and red top are both comparatively low in protein.

Of the legumes, alfalfa and wild white clover appear to be slightly better in respect to protein and calcium but the differences among the four legumes listed are not great.

Stage of Maturity.-In the early stages of plant development, root growth leads to heavy withdrawal of nitrogen and mineral matter from the soil. Later, with increased leafage, carbohydrates are rapidly formed, with a consequent lowering of the percentages of protein and ash. Therefore, it will be seen that as sources of protein and mineral matter the early stages of growth are the more valuable.

In table 28 the analyses of certain grasses and legumes show the trends in percentages of protein, calcium, and phosphorus as growth advances towards maturity.

TABLE 28.-COMPOSITION OF GRASSES AND LEGUMES AT DIFFERENT STAGES OF MATURITY (OTTAWA)

| Variety | Stage of maturity | $\begin{aligned} & \text { Date } \\ & \text { of } \\ & \text { cutting } \end{aligned}$ | Data calculated to water-free basis |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Protein (Nx6-25) | Calcium | Phosphorus |
| Sweet clover. |  |  | p.c. | p.c. | p.c. |
|  | Height-6 inches. | 25/5 | 22.56 | $2 \cdot 30$ | $0 \cdot 35$ |
|  | Height-131 ${ }^{\frac{1}{2}}$ inches. | 8/6 | $22 \cdot 81$ | $2 \cdot 18$ | $0 \cdot 36$ |
|  | Height-27 inches. |  |  |  |  |
| Red clover. |  |  |  |  | $0 \cdot 32$ |
|  | 50 per cent blossom. | 16/6 | 16.97 | 1.52 | $0 \cdot 30$ |
|  | 80 per cent blossom..... | 22/6 | 15.37 | $1 \cdot 40$ | $0 \cdot 28$ |
|  | 25 per cent of head brown. | 29/6 | 13.67 | $1 \cdot 36$ | $0 \cdot 25$ |
|  | 80 per cent of heads brown. | 6/7 | $13 \cdot 49$ | $1 \cdot 43$ | $0 \cdot 22$ |
|  | 100 per cent of heads brown. |  |  | $1 \cdot 43$ |  |
| Timothy | Shot blade | 7/6 | 11.42 | $0 \cdot 69$ | 0.31 |
|  | Well headed out. | 16/6 | $10 \cdot 84$ | $0 \cdot 76$ |  |
|  | Almost in bloom. | 22/6 | $9 \cdot 57$ | $0 \cdot 72$ | $0 \cdot 24$ |
|  | Bloom appearing. | 29/6 | 8.52 7.48 | 0.73 0.70 | 0.21 0.18 |
|  | In full bloom............ ${ }_{\text {Well }}$. | $5 / 7$ $13 / 7$ | $7 \cdot 48$ 7.36 | $0 \cdot 70$ 0.67 | 0.18 0.18 |
|  | Well past bloom, seeds still gr |  | $7 \cdot 36$ |  |  |
| Blue grass. | Leaf. |  | 18.79 | $0 \cdot 46$ | 0.31 |
|  | Sheath. |  | $13 \cdot 65$ | $0 \cdot 37$ | $0 \cdot 28$ |
|  | Flower... |  | $8 \cdot 29$ | $0 \cdot 26$ | $0 \cdot 18$ |
|  | Seed shed. |  | $5 \cdot 13$ | $0 \cdot 36$ | $0 \cdot 09$ |
|  | Weathered |  | $4 \cdot 18$ | $0 \cdot 29$ | $0 \cdot 05$ |
| Oats. | Leaf 4-11 inches. |  | $30 \cdot 48$ | 0.91 | $0 \cdot 34$ |
|  | Leaf 7-12 inches. |  | 27.09 | $0 \cdot 64$ | $0 \cdot 33$ |
|  | Shot blade. |  | 18.85 | $0 \cdot 48$ | $0 \cdot 24$ |
|  | Early heading. |  | 13.83 | $0 \cdot 34$ | $0 \cdot 20$ |
|  | Fully headed.. |  | 12.01 | $0 \cdot 37$ | $0 \cdot 17$ |

Fertilization.-The application of fertilizers may affect the composition of herbage. It appears to be true that when a soil is seriously deficient in a plant food element, the application of that element in a readily soluble form will increase its percentage in the plant. On the other hand, it may be assumed that on soils well supplied with the essential elements of fertility the application of plant food does not materially affect the composition of the plant.

Climatic Conditions.-The main climatic conditions affecting the growth of pasture plants are rainfall and temperature. Scanty precipitation accompanied by high temperatures results in hastening maturity and reduces the proportion of leaf to stem.

Since the leaf is richer in protein and phosphorus and lower in fibre than the stem, there is a consequent decline in the desirable constituents.

Drought conditions favour the development and growth of certain weeds -for example, dandelions-and since these are considerably lower in protein than grasses and clovers, the nutritional value of the herbage as a whole is reduced.

## The Feed Value of Pasture Herbage

The material grazed by animals on pasture consists mostly of the leafy parts of immature grasses and legumes. In order to appreciate fully its feeding value, the differences between young growing plants and the same plants when mature must be fully understood. Young plants are very watery and are consequently low in dry matter. The water content of young herbage may vary from 60 to 85 per cent-a very high figure compared with the water content of
the same herbage when mature. Hence, to estimate the nutrients contained in herbage, it is necessary to make the comparison on a water-free basis.

Young plants at the early growing stage are soft and tender. When they approach maturity they become hard and woody, due to an increase in fibre content. The dry matter of young plants is consequently very digestible. According to Morrison, dried pasture herbage from closely grazed pasture will furnish approximately 74.7 per cent digestible nutrients, while the same plants when mature will furnish only 50.5 per cent. As fibre influences the digestibility of the pasture herbage, it is of importance that it be kept down. This may be brought about by preventing the grass from becoming too rank by early and close or frequent grazing.

Protein.-Chemical analyses (see table 28) show that on a dry-matter basis immature blue grass has a protein content of $18 \cdot 79$ per cent. When cut at the "seed shed" stage, its protein content is reduced to $5 \cdot 13$ per cent. The same relationship is found in timothy and other grasses, as well as with mixed legumes and grasses. Immature herbage can, therefore, be classed as a protein-rich feed. Were it not for its high fibre content it could be called a concentrate. The high protein content of immature herbage is very important in stock feeding.. Animals grazing on young pasture not only receive a liberal supply of protein, but also a protein of good quality. Young herbage constitutes, therefore, a fairly well balanced ration for growing stock and makes possible the use of farm-grown grains to supplement pasture for milk production.

Minerals.-The most important minerals in live stock feeding are calcium and phosphorus. These are present in large amounts in young herbage. For instance, blue grass cut at the leaf stage showed a phosphorus content of 0.31 per cent as against 0.09 per cent at the "seed shed" stage. Likewise, the calcium content was 0.46 per cent at the growing stage and 0.36 per cent when the grass was mature. Variations are bound to appear, due to soil fertility, season, and precipitation. Acid soils or soils leached by heavy rains are generally poor in calcium and the grass grown on these soils may be deficient in this mineral. The mineral content of the herbage is generally at its peak in the spring, diminishing as the plants mature. In time of drought, phosphorus deficiency is always more severe than when there is plenty of moisture. As calcium and phosphorus are necessary for all animals, especially cows in milk and growing stock, these factors must be kept in mind, and supplementary mineral mixtures supplied to the animals if any deficiency becomes evident.

Vitamins.-Vitamins are necessary for growth, reproduction and the general wellbeing of the stock. Fortunately, with the exception of vitamin D, these are generously supplied in young pasture herbage. As direct sunlight takes the place of vitamin $D$, this is also taken care of, indirectly, when the animals are on pasture. It follows, therefore, that under these circumstances, and since the animals can store a limited amount in the body, they are better prepared to withstand the long winter period after a season on good pasture.

Palatability.-Domestic animals have likes and dislikes, hence the palatability of the pasture herbage is a factor not to be neglected. Palatable feeds are always eaten with relish. The palatability of a pasture will depend on the kind of plants, stage of maturity, climate, and soil conditions. The common grasses and legumes such as timothy, blue grass, alfalfa and clover, have proved satisfactory from the standpoint of palatability, and combinations of these make excellent herbage mixtures. The degree of maturity has an influence on the palatability of pasture grass. Plants that have gone to seed are left for more tender shoots. This is especially noticeable with sheep. Observation, however, reveals that close grazing or early mowing whenever necessary provides for more uniform grazing. New and better growth takes place and the grass which is refused while standing is eaten by the stock when mowed.

Fresh, green herbage grown on good soil constitutes, therefore, a complete well-balanced ration for most classes of live stock. It is high in protein, the tissueforming element; it is fairly rich in total digestible nutrients; it furnishes in sufficient quantity the minerals required for growth; and it contains the vitamins necessary for the development of animals and maintenance of their health.

## RECOMMENDATIONS FOR PASTURE MANAGEMENT AND IMPROVEMENT

The following general recommendations are presented with the reservation that no hard and fast rules can be laid down for so complex a problem as the management and improvement of pastures:-

## Improvement of Rough, Untillable Pastures

Some areas used as pastures are so rough and stony, with thin and irregular deposits of soil, that improvement is impracticable or uneconomical. Such lands may be more useful for reforestation purposes, and where tree growth occurs it might well be protected from grazing animals.


Where pasture lands are rough and untillable they may often be improved by applications of commercial fertilizers. Even on arable land in the Maritime Provinces and parts of Quebec, fertilization and proper grazing management of permanent pasture produce maximum pasturage. In Ontario and parts of Quebec. it is often more economical to plough such land and reseed with high producing species.

Rough Pastures with Sufficient Soil for Plant Growth.-There are many areas of land which are too rough to permit cultivation, but where there is sufficient soil for the growth of pasture plants. Many of these areas have deteriorated through neglect, with a considerable reduction in fertility, a heavy growth of weeds, and the appearance of moss hummocks, brush, and bracken. While extensive improvements on such areas might not prove economical, certain measures to increase the production of pasture herbage may be used with profit.

Removing Shrub and Weed Growth.-It is important in the improvement of these rough areas to eradicate as much of the undesirable growth as possible. The shrub growth should be cut off and removed. Where the land surface is not too rough or irregular this may sometimes be done with a mowing machine,
otherwise a hay scythe or short-bladed brush scythe may be used. For some of the larger shrubs it is necessary to use an axe or mattock to cut them. The most suitable time to cut the shrubs is in the late summer or fall. Weeds should be kept cut so as to prevent the formation of seeds.

Improving the Herbage on Rough Pastures.-On rough land where desirable species of herbage plants are not in evidence, pasture may sometimes be improved by broadcasting grass and clover seed in the very early spring, followed immediately by harrowing with a disk, spike-tooth, or brush harrow. A suitable seed mixture for this purpose might consist of: orchard grass, four pounds; red top, two pounds; timothy, four pounds; white clover, one pound; sweet clover or red clover, six pounds. It should be remembered, however, that success in establishing suitable species of pasture plants is governed more by the fertility and reaction of the soil than by the addition of suitable seed.

Improving Fertility of Rough Pastures.-The fertility of rough pastures may be increased by the judicious application of fertilizers, the kind of fertilizer and rate of application being largely dependent on local soil and herbage conditions, and on the value of the probable increase in production. Pasture swards containing a fairly large percentage of clovers will generally respond to applications of superphosphate at about 400 to 600 pounds per acre once in four years. On such pastures the increased growth of clovers due to superphosphate treatment will usually result in an increase of nitrogen in the soil. Where clovers do not grow readily, nitrogen in the form of sulphate of ammonia applied annually at the rate of 75 to 100 pounds per acre, in addition to the superphosphate, may prove beneficial. On soils low in potash an application of from 50 to 75 pounds per acre of muriate of potash may be applied with the superphosphate. In every case it is advisable to precede the fertilizer treatment of pastures with small-scale trials in order to determine the kind and rate of fertilizer required.

Where manure is available for the treatment of rough pastures, an application of from eight to ten tons per acre once in three or four years should be beneficial, especially when supplemented with a moderate application of superphosphate.

## Permanent Pastures which are Tillable

Many areas of permanent pasture are located on land which is tillable but because of inaccessibility, poor drainage, or labour problems are left permanently in pasture. The productivity of such pastures may be maintained or increased, in many cases, by suitable cultural practices, judicious fertilizer treatments, and careful management. With these pastures, the guiding principle is maximum production with a minimum of expense.

Economic Considerations.-Arable land may be economically left in permant pasture where the net revenue which is secured from the pasture is greater than would be secured by growing cultivated crops. On arable land low in fertility, permanent pasture may result in a larger net revenue than the growing of cultivated crops because of the difference in labour costs in favour of pasture.

In this connection it should be observed that a large percentage of the cost of producing cultivated crops is constant, regardless of the yield which may be secured. Even relatively fertile land may be economically used for permanent pasture.

The foregoing factors which should be fairly well indicated by the price or rental value of the land, will determine largely the methods of pasture management and improvement which can be economically adopted in any particular case. Where land is cheap it may be more profitable to secure extra land for pasture than to attempt intensive improvements, but if land values are high the reverse may be true.

## CULTURAL TREATMENT OF PERMANENT ARABLE PASTURES

The maintenance of permanent arable pastures in good grazing condition may be effected by certain cultural treatments. Mowing to destroy weeds and remove coarse herbage, together with the eradication of shrub growth, will promote more uniform grazing. Spreading animal droppings with a chain or spike-tooth harrow prevents the persistence of small ungrazed areas throughout a pasture. These measures are comparatively inexpensive and may be put into effect during intervals when work on cultivated land is not pressing.

Definite improvement in the sward of permanent arable pastures may sometimes be accomplished by cutting the sod with a disk harrow, especially where a "sod bound" condition exists. It is important that this operation be performed in the early spring before much growth takes place, in order to avoid permanent injury to the herbage, and that sufficient soil moisture be present to facilitate the disking and promote subsequent growth of the sward. This operation may be accompanied by suitable reseeding measures, which are referred to in a later section. On many pastures, work of this nature is beneficial in cases of winter-killing or other damage.

Renovation of old permanent arable pastures may require more drastic cultural treatment than that described above. Where the stand of desirable pasture species has become thin and weeds make up a great percentage of the stand it is usually advisable to plough the area and establish a fresh stand. The land should be ploughed in early August to allow for cultivation necessary for the eradication of weeds. The ploughing may be followed by a thorough disking to break up the sod and then by frequent cultivations with a spring-tooth or a stiff-tooth cultivator until late fall. If manure is available, it should be applied at the rate of ten tons per acre and ploughed in at this time. If no manure is applied it is not necessary to replough in the fall.

Following the summer and fall cultivations the land should be in good shape for reseeding in the spring. It should be disked or cultivated in preparation for the seed bed. If manure has been applied in the previous fall an application of 300 pounds per acre of superphosphate, harrowed in just before seeding, is recommended. If no manure has been applied, a complete fertilizer is likely to be beneficial. A 2-12-6 commercial mixture at the rate of 500 pounds per acre is a good general application and this should be applied boadcast and harrowed in just previous to seeding. A common practice in re-establishing a permanent pasture is to harvest one or two crops of hay before pasturing. If this is done it is desirable to seed a hay and pasture seed mixture with a nurse crop of oats or barley.

## SEED MIXTURES FOR HAY AND PASTURE

Where hay is to be harvested and the land subsequently pastured the following seed mixtures are recommended:-

1. For non-acid or mildly acid soils where alfalfa can be grown successfully:-

| Timothy. | 6 pounds | per acre |
| :---: | :---: | :---: |
| Red clover. | 4 |  |
| Alfalfa. | 4 | " " |
| Alsike | 2 | " " |
| Kentucky or Canada blue grass | 3 | " " |
| Red top | 2 | " " |
| White Dutch clover | 1 |  |


3. For acid soils:-

| Timothy.. | 6 pounds per acre |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Red clover | 6 |  |  |  |
| Alsike | 4 | " | " |  |
| Kentucky or Canada blue grass | 3 | " | : |  |
| Red Top.. . . . . . . . . . . | 2 |  | " | " |
| White Dutch clover | 1 |  | " |  |

Such mixtures as these recommended above will provide one to three years hay and may then be pastured for an indefinite period.


Highly productive, fresh, green pastures are required for the milking herd. A pasture composed of a mixture of timothy, red clover and alfalfa is considered one of the best. Such high producing pasture will enable cows to produce from 30 to 35 pounds of milk per day without.supplementary barn feeding.

Seed Mixtures for Pastures Only.-When establishing a permanent pasture it is often required that pasturage be provided as soon as possible without first harvesting grain or hay crops. Under such circumstances, the preliminary cultivation and fertilization is the same as that for hay and pasture. It is desirable, however, to modify the seed mixture somewhat. The proposed modification in the mixtures as recommended for hay and pasture would increase the timothy to nine pounds per acre rather than six pounds and would decrease the red clover and alsike in each instance by one half.

As pasture in this arrangement is required in the first year, oats seeded at two bushels per acre should be used as the nurse crop. This crop may be pastured when the oats are about six to eight inches in height without injury to
the grass and clover seedlings provided they are not grazed too closely nor too late in the season. A few weeks should be allowed in the fall for the clovers and grasses to make some top growth as a protection in winter. The following season and in subsequent seasons, the area may be pastured and fertilized as recommended for permanent pasture.

Pasture on Tillable Land Where Wild White Clover is Naturally Adapted.In some parts of Quebec and the Maritime Provinces wild white clover grows naturally and where this occurs a very satisfactory type of permanent pasture may be produced. If for any reason the permanent sward has become "run out" it is often advisable to plough and reseed. Cultivation may be carried on as recommended for hay and pasture but the seed mixture sown without a nurse crop may be as follows:-


This mixture should be sown broadcast without a nurse crop on a finely prepared seed bed and the seed covered lightly. Grazing may begin in about eight weeks from seeding and should be sufficient to control weeds and to prevent an excessively heavy growth of grass. The following year grazing should begin as early as possible and the herbage should be kept eaten down closely throughout the season. Subsequent fertilization should be followed on the basis of a permanent pasture.

## MANURE AND FERTILIZER FOR PERMANENT ARABLE PASTURES

While the fertility of pasture soils should not normally decline as rapidly as where cultivated crops are grown, due to the partial return to pasture land of plant nutrients in the animal excreta, the maintenance and increase of pasture productivity may require the application of manure or fertilizer. The following general recommendations may be useful in selecting possible treatments.

Farmyard manure may be used to top-dress permanent pastures, the application being made at about eight to ten tons per acre once in three or four years in the fall, with subsequent harrowing to avoid undue contamination of the herbage. Where pastures are broken up for reseeding a somewhat heavier application may be made in order to promote a vigorous re-establishment of herbage. The foregoing recommendations presuppose supplies of manure in excess of ordinary farm requirements.

Fertilizers are usually preferable to manure for pasture treatment because of their greater economy of labour in application and also their adjustability to varying plant nutrient requirements. The chief obstacle to their use is the cash outlay for their purchase.

The relation between fertilizer formulae and soil and herbage composition is important: only those fertilizer elements should be applied which will bring about economical increases in herbage production. On many pastures phosphoric acid, usually in the form of superphosphate, is the only fertilizer required for economic results. Superphosphate is particularly beneficial in promoting the growth of clovers on soils where these legumes grow naturally. Where clovers do not grow naturally, the use of fertilizers containing nitrogen, such as ammonium sulphate or nitrate of soda, is generally advisable. In addition, potash in the muriate form is usually necessary for sandy soils.

Recommendations as to the composition, rate and time of applying fertilizers for pastures under different soil and herbage conditions are given in table
29. It must be observed, however, that these recommendations are of a general nature, and may require adjustment for individual cases.

TABLE 29.-FERTILIZERS FOR PERMANENT PASTU゙RES

| Character of soil and herbage | Fertilizer materials in pounds per açre |  |  | Alternative treatments |
| :---: | :---: | :---: | :---: | :---: |
|  | Sulphate of ammonia applied annually | Superphosphate 16 per cent every 4 years | Muriate of potash every 4 years |  |
| Grass pasturesClay loam. | 100 | 400 | 50 | $500 \mathrm{lb} .4-12-6$ every 4 years with 100 lb . sulphate of ammonia in the intervening years. |
| Sandy loam. | 100 | 300 | 100 | 500 lb. $4-10-10$ every 4 years with 100 lb . sulphate of ammonia in the intervening years. |
| Mixed grass and clover pasturesClay loam. | - | $\begin{aligned} & 400 \\ & \text { to } \\ & 600 \end{aligned}$ | - | 500 lb . 2-12-6 or $0-16-6$ every 4 years. |
| Sandy loam. | - | $\begin{aligned} & 400 \\ & \text { to } \\ & 600 \end{aligned}$ | 100 | 500 lb . 2-12-10 or $0-12-10$ every 4 years. |

In table 29 pastures have been divided into two general groups: grass pastures and mixed grass and clover pastures. In Ontario and certain districts in Quebec and the Maritime Provinces it is very difficult and in many cases impossible, to permanently establish a stand of white clover mixed with the native grasses and as a result many of these pastures are predominantly grass.

Commercial fertilizers containing nitrogen should be applied under these conditions, as grasses require considerable amounts of this element for maximum growth. Nitrogen may be applied in the form of sulphate of ammonia at 100 pounds per acre annually, or equivalent amounts of other nitrogenous fertilizers such as nitrate of soda or cyanamid, the kind of fertilizer used depending upon the price per unit of available nitrogen.

Phosphoric acid appears to be deficient in most soils and on grass pastures will usually give economical returns when applied every fourth year in the form of superphosphate ( 16 per cent) at the rate of 300 to 400 pounds per acre, or in equivalent amounts of 20 per cent superphosphate, triple superphosphate or basic slag.

Many soils are less likely to be deficient in potash than in nitrogen or phosphoric acid and in some instances little or no potash treatment is required. Where there is a deficiency of this constituent, horvever, an application of 50 pounds of muriate of potash per acre every fourth year should be applied. Sandy scils are likely to be more deficient in potash than the heavier clay soils and might receive an application of muriate of potash as high as 100 pounds per acre.

If desired, commercially mixed fertilizer rather than the various ingredients separately may be purchased, and this is usually advisable if the cost per unit is about the same. An application of 500 pounds per acre of a 4-12-6 mixture, or a 4-12-10 on sandy soils, applied every fourth year with 100 pounds of sulphate of ammonia per acre in the three intervening years is a good general application for grass pastures.

Where wild white clover grows well in association with native grass species, as is the case in parts of Quebec, the fertilizer treatment is somewhat different. As clovers are able to obtain nitrogen from the atmosphere and store it in the nodules on their roots to later enrich the soil, it is probable where the sward is predominantly clover that sufficient nitrogen may be added in this way and thus eliminate the necessity of applying this relatively expensive element. Where clover makes up only a small percentage of the sward or where for some reason the growth of grass is not stimulated by the presence of clover, a light dressing of 50 pounds per acre of sulphate of ammonia is likely to prove beneficial.

Superphosphate encourages the growth of clovers and in mixed grass and clover pastures on the heavier soils an application of 400 to 600 pounds of superphosphate per acre every four years may be the only fertilizer necessary. On sandy soils or where potash is known to be deficient it will be necessary to apply 50 to 100 pounds of muriate of potash per acre every four years. Under some conditions of soil and climate beneficial results may be obtained by more frequent applications of these mineral fertilizers.

Commercially mixed fertilizers may be used on mixed grass and clover pastures, in preference to mixing the separate ingredients at home, if the cost is approximately the same. If this procedure is followed, an application of 500 pounds per acre of a 2-12-6 an 0-16-0 or an 0-16-6 applied every four years is recommended depending on the condition of the sward and the fertility of the soil. On the sandy soils the potash should be increased from six to ten per cent.

Lime for Permanent Arable Pastures.-The reaction of pasture soils, whether acid, neutral or alkaline, not only affects their productivity but determines to a considerable extent the botanical composition of the herbage. Pasture plants, especially alfalfa and red clover, prefer neutral or slightly alkaline soils. Some of the grasses, however, and also wild white clover, will thrive on slightly acid soils. Soil acidity may be corrected by the use of ground limestone, the rate and frequency of application depending on the degree of acidity. On moderately acid soils the growth legumes such as red clover and alfalfa will generally be encouraged by an application of about two tons of ground limestone once in four years. For wild white clover and most grasses, little or no limestone is required.

## MANAGEMENT OF PERMANENT ARABLE PASTURES

Where permanent pasture is an integral feature of the farm economy, it is important to ensure a uniform supply of grazing throughout the growing season. For this reason, the management of pastures, with a view to providing against any temporary shortage of grazing, as well as to securing maximum production, requires careful planning and foresight. The following suggestions will indicate the objects and scope of pasture management.

In order to keep pasture herbage in as palatable and nutritious a condition as possible, close grazing to prevent coarse growth is essential. Under eastern climatic conditions the rate of growth of pasture herbage is not uniform throughout the growing season. Following a rapid rate of growth from early spring to about the middle of June, there is usually a decided decline and relatively slow growth through midsummer, with a slight recovery in the early fall. The method of securing optimum utilization of herbage under these conditions depends on the number of stock carried. Where there is insufficient stock to graze the spring growth of herbage uniformly, mowing the pasture is advisable to prevent a coarse stand of mature plants. Mowing when the grasses are just heading out will promote an aftermath of tender, nutritious herbage. Live stock will consume the mown grass if it is left lying on the field, although they do not relish this coarse material before it is cut.

Where pastures are heavily stocked or winter injury has occurred, it is wise to make provision for supplemental pasture for the midsummer period. This may be provided in the form of aftermath on clover hay meadows, the hay being harvested somewhat earlier than in the customary full-bloom stage. In this connection, it is interesting to note that the superior feeding quality of clover cut in the late bud or early bloom stage will generally offset the loss in the yield of dry matter as compared with clover cut in full bloom. Where clover aftermath is not available, it may be necessary to sow some annual pasture crop, such as oats or Sudan grass.

Rotational Grazing.-This is a phase of pasture management which has gained some prominence in recent years. In this system, the permanent pasture is divided into a number of fields, which are grazed in succession. The advantages of this system are that it offers a more intensive utilization of pasture herbage, provides resting periods for pastures, and allows for a certain amount of preferential grazing by using different classes of live stock. High producing milch cows are turned into the best pastures first, then followed by dry cows, heifers and calves, and finally sheep are turned in to clean up what growth remains. With sheep, rotated grazing may be beneficial in reducing the danger of infestation by parasites. The chief objection to rotational grazing is the cost of extra fencing and watering facilities. In Eastern Canada these additional costs are generally too high, so that the slight increase in productivity secured by rotated grazing is not economical. Where the permanent pasture is naturally divided into a number of fields with good water supply, however, rotational grazing will undoubtedly prove advantageous.

A modified form of rotational grazing which is useful on dairy farms is the provision of one pasture for day and one for night grazing, the latter preferably high in productivity and located near the farm buildings.

## SUPPLEMENTARY AND EMERGENCY PASTURE CROPS

In selecting supplementary or emergency pasture crops, some consideration must be given to the season of the year in which they will provide grazing. Certain species are more adapted than others to individual soil and climatic conditions. Fall rye seeded at two bushels per acre may be used to provide late fall and early spring pasture. Oats seeded alone at three bushels per acre between May 20 and 30 , or Sudan grass at 30 pounds per acre between June 1 and 10, give excellent results.

It has been reported that some poisoning has occurred with animals pasturing on Sudan grass due to the fact that the plant sometimes contains a poisonous substance in the form of prussic acid. While there seems to be considerable difference of opinion as to whether Sudan grass is dangerous in this regard, it is well to take certain precautions with animals grazing on it. Grazing on Sudan grass after the crop has been damaged by frost should be avoided. Live stock should not be turned on to Sudan grass pasture when very hungry but should have access to other feed previously. The danger from poisoning seems to be reduced when the crop is grown on soil high in phosphoric acid. Where this constituent is low, it is advisable to apply superphosphate. Seeding Sudan grass in a mixture with oats is less dangerous than seeding it alone. A very suitable pasture may be obtained by seeding a mixture of two bushels of oats and 25 pounds of Sudan grass per acre about June 1. A similar mixture may also be used as a nurse crop in a crop rotation for pasture but the rate should then be reduced to $1 \frac{1}{2}$ bushel of oats and 15 pounds of Sudan grass. In parts of Ontario a mixture of two bushels of oats and 15 pounds of sweet clover is often recommended. In the Maritime Provinces and Quebec, a mixture of oats at two bushels and peas at one bushel per acre may be satisfactory. Different varieties of millet seeded between 20 and 30 pounds to the acre provide good pasturage for dairy cattle.

There are many other crops that may be useful as emergency pasture, but the above are most commonly used with good results.

## Pastures in a Farm Rotation

Where all of the land in a farm is suitable for growing cultivated crops, it may be necessary to allot a portion of it for pastures. The usual practice is to leave hay down for two or more years, depending on the rotation followed, and to use the last year in hay for grazing. In some cases a hay field is divided by a temporary fence, a portion of the field being grazed in the spring and early summer, while the other portion is used for hay. Later any aftermath on the hay portion may be used for late summer pasture.

It sometimes happens that certain sections of the farm are more suitable than others for the production of grain, hay and fodder crops. The areas which are not well adapted for the production of these crops may often be used satisfactorily for pasture crops. Under such conditions it may be advisable to plan the regular farm rotation for the production of winter feed on that


Two-year-old steers are the most suitable for fattening on grass. Such cattle, if carried through the winter in a good growing condition, should gain from 2 to $2 \frac{1}{2}$ pounds per day throughout the subsequent grazing season, and reach a good degree of finish by late summer or early fall.
portion of the farm most suitable for the purpose and on the remainder of the farm design a rotation specifically for pasture. If there is no choice of the location of the pasture rotation from a fertility or production standpoint, it may be located on a utility basis. For instance, pasture for dairy cattle would be more suitable near the buildings, for beef cattle or sheep it might be as satisfactory at the back of the farm away from the buildings.

A rotation to provide grazing throughout the whole summer season could consist of a four-year arrangement of: first year oats and Sudan grass, seeded to clover and timothy (and alfalfa where it will grow well) followed by three years of legume and timothy pasture. In such a rotation, all of the crops may be used for pasture. The second year crop with a large percentage of legume would provide early summer pasture. The third and fourth year crops with a larger proportion of timothy would come in somewhat later. About the middle
of July when the production on the legume and timothy areas is somewhat reduced because of dry, hot weather, the oats and Sudan grass seeded as outlined on page 47 should be ready for pasture. If the crop is grazed when about eight inches high, it will provide good pasture and if not grazed too heavily, the new seeding should not be injured. By the time this annual mixture has been grazed sufficiently, the clover and timothy will have grown again to provide more feed. In addition, the aftermath following the hay in the regular farm rotation could be utilized at this time. The management and treatment of pastures on cultivated land is governed by ordinary cropping practices which are outlined in the Dominion Department of Agriculture bulletin No. 163, "Crop Rotations and Soil Management for Eastern Canada."

## Pasture Utilization by Live Stock

Farm animals on pasture do not all behave alike. Sheep relish and graze very closely the most tender shoots while beef cattle will consume the coarser grasses to better advantage. Heavy milk producers require abundant nutritious pasturage, while the young stock can be maintained on somewhat coarscr herbage. Consequently, different methods of management are necessary.

## DAIRY CATTLE

One of the fundamentals of dairying is liberal feeding. Dairy cows will decline in milk production or lose weight when fed a ration that is insufficient or unbalanced, and in order that they may develop normally, growing stock should receive plenty of feed.

A good milch cow requires a large amount of feed to keep up her production. Cows weighing 1,000 pounds require about 15 pounds digestible nutrients per day to maintain their weight and produce one pound of butterfat. In order to get these nutrients they must consume from 23 to 24 pounds of the dry matter of a balanced ration. Assuming the dry matter in grass to be around 24 per cent, these cows will have to consume 120 pounds of herbage. If optimum milk production is to be obtained, abundant pasturage must be provided. A pasture composed of timothy, clover and alfalfa is considered one of the best. Its production is abundant, and although alfalfa is not the most palatable herbage, its addition to the mixture will generally increase the protein content and provide more green growth in a dry period.

Pasture, either permanent or cultivated, will seldom furnish succulent herbage all summer. In Eastern Canada, pastures are at their peak during late May, June, and the early part of July. Later, growth diminishes partly due to the tendency of the herbage to mature and go into a more or less dormant stage, and partly due to the scant precipitation of Juiy and August. To obviate this tendency, rotational grazing combined with close grazing has been tried out experimentally. This system leads to a better utilization of the grass and stimulates a longer growth period. However, the extra expense for fencing and watering is not offset by the additional profit derived.

When the pasture is abundant, cows giving 30 to 35 pounds of milk will need very little grain to supplement the pasture. However, with heavy producers, or when the pasture is getting low, grain should be fed if milk production is to be kept at a high level and the cows in good condition.

Based on trials in this connection at the Central Experimental Farm, Ottawa, it would seem advisable to feed at least one pound of grain for every four pounds of milk produced over 35 pounds. During the early season, when the grass is young and abundant, a grain ration consisting of equal parts of oats and barley will constitute a satisfactory supplement. With more mature grasses, however, a grain supplement containing 20 per cent linseed oilmeal should be fed if the ration is to be properly balanced.

Annual and aftermath pastures are recommended elsewhere in this bulletin as supplements to permanent pasture. Annual pasture crops, however, are very watery and are likely to be laxative in effect if the cows are allowed to graze continually. A good practice is to start grazing the annual pasture before the regular pasture is too closely cropped and to let the cows graze twice a day on the annual pasture for two or three hours at a time. A better utilization of the feed is obtained in this way, and the pasture can be made to last until an aftermath is ready.


Beef production is economical where land is cheap and natural grazing is abundant. Cattle raised for beef do not require as high quality of herbage as do dairy cattle. Rough, unimproved pasture may be used for the breeding herd provided there is sufficient grass for the cow to raise her calf successfully and keep in good condition.

## BEEF CATTLE

The raising of beef cattle is one of the simplest ways of producing a commodity that may be marketed direct from the farm. Farm beef production is economical where land is cheap and natural grazing abundant, since pasture is essential for economical production. Cattle raised for beef do not require as high a quality herbage as dairy cattle. They will do well on coarser pastures if well supplied with water, salt and shelter.

Beef cows should have good pasture to keep them in a thriving condition and to produce sufficient milk to nurse their calves successfully. At the Central Experimental Farm, Ottawa, the following practice has proved successful: the cows bred to calve in March are wintered in an open shed opening into a yard with a southern exposure. No grain whatsoever is fed before or after calving. Under these conditions the initial milk flow is not in excess of the calves' requirement and very little udder trouble is experienced. When finally the herd goes to pasture and the milk secretion due to good grazing, increases, it is easily taken care of by the calves and rapid growth results. The above method would seem preferable to that of having the cows bred to calve on pasture. As the milk secretion is often in excess of that which the calf is able to consume and as such cows cannot receive proper attention, serious udder trouble may follow.

Early calving has many other advantages in addition to the above mentioned. By the time the cows go to pasture, milk production has started to
decline, but the stimulus of the new grass tends to offset this drop in production. Being older, the calves are better able to take advantage of the more nutritious herbage of the early summer. Weaning is easy due to their age and with the extra development thus obtained the calves can be wintered more cheaply. Furthermore, the cows have more time to get in good calving condition again. In all, the pasture is utilized to the best advantage, which makes production more economical.

In small herds, or on farms where beef and milk production are combined, a different method must be followed. Probably one of the most practical is to milk half of the herd and have the other half nurse the calves, allowing two calves per cow. The calves are generally kept in the barn. They are allowed to suckle twice a day and are fed supplemental feeds. Such a procedure requires better grazing to keep up the milk production. Annual or aftermath pastures may have to be provided and grain fed to the good producers.

Yearlings, which are usually kept over for fattening the following winter, need no special care. A permanent pasture with water and plenty of shade is sufficient. Rough pastures, partly open and partly covered with woods are very satisfactory. The open sections of such pastures provide good grazing in early summer, while the shady portion will provide some good feed during the hot and dry part of the season.

Ordinarily, it is not economical to feed grain. However, if rapid fattening is desired, two or three pounds of grain per head per day may be fed in the fall when the stock are still on pasture. Thus, the young steers will be kept gaining and much time will be saved in getting them on full feed later in their winter quarters. The economy of such a practice will depend on the quality of the pasture, the price of the grain and the market outlook. No rule can be set in this regard and the feeder must decide for himself according to his conditions.

Two-year-old steers are the best to fatten on grass, for having completed their growth they use the grass for the laying on of fat. Fattening steers on pasture has many advantages over fattening in the feed lot, notably in economy of gains, labour and shelter construction. It is, however, more difficult to get a real good finish on cattle on grass, and grass finished cattle almost invariably bring a lower price than grain fed cattle, on a discriminating market. Good quality pasture throughout the entire season is very necessary to secure a high finish on steers on grass alone. This means that the pasture must be on relatively good land, and it is possible that such land might be used to better advantage for the production of feed for the winter finishing of cattle.

Cattle that are to be finished on grass should be carried through the winter in just good growing condition, on an economical roughage ration. Cattle carrying a considerable degree of finish when turned to pasture in the spring may lose in weight at the start of the grazing period. Any such cattle should be grain fed on pasture for a quick finish.

Thin cattle on pasture may gain from two to three pounds per day, on the average, throughout the season. The greatest daily gains are made during the early part of the season, due to general filling up and development of muscular tissue as a result of abundance of fresh green grass. Later in the season, when the grass contains a higher proportion of carbohydrates, there is a greater tendency to lay on fat. Daily gains will be lower at this time, but the quality of the carcass will be improving.

It is obvious that good pasture should be provided throughout the season. Mixed grass pasture followed by annual pastures or hay aftermath, will be found satisfactory. If annual pastures are used, the cattle should have access to the regular pasture at the same time as the annual crops alone are too succulent for best results.

While it is possible to get a high degree of finish on cattle on grass alone, it may sometimes be found advisable to supplement the pasture with grain, particularly in a dry season or on a strong market. A mixture of barley and oats with ten per cent of oilmeal added will usuallly be found satisfactory. The amount to be fed will depend on such circumstances as condition of grass, finish of cattle, price of grain, and prospective market price of cattle.

## HORSES

A pasture of mixed grasses and white clover is ideal for horses and it should be kept closely cropped at all times as horses prefer the short fresh grass and will tend to over-graze some sections and leave others if the whole pasture is not kept closely grazed. In a permanent horse pasture the droppings are usually found in the patches of longer grass and unless the droppings are scattered by use of a harrow or fork these patches become rank and are never cropped down.


A pasture of mixed grasses and white clover is ideal for horses. It should be kept closely grazed at all times as horses prefer short, fresh grass. Pastures are essential for the economical handling of colts, brood mares with foals and idle horses. Horses on light work can be kept in fairly good condition on pasture plus a midday feed of grain.

Pastures are essential for the economical handling of colts, brood mares with foals, and idle horses. Young and idle horses may be turned out fairly early in the spring and brood mares and foals just as soon as the weather permits. If the pasture is luxuriant, care should be taken that the change from stable feeding to pasture is not made too abruptly. Shoes should be removed from all horses permanently on pasture, to avoid injuries from kicking, but care should be taken that their feet are trimmed regularly to ensure keeping them in proper condition.

Horses on light work can be kept in fairly good condition on pasture plus some stable feeding of hay and grain at mid-day, but horses that are on heavy work should receive a complete ration of hay and grain as pasture does not supply enough energy for the day's work. If the heavy working horse is turned to pasture at all, it should only be at night after the regular ration of grain and at least a part of the regular ration of hay has been fed. It is satisfactory to pasture over the week-end without feeding additional grain. Work-horses that are on pasture part time in this way will be a little soft and possibly sweat more
than those that are stabled regularly but this will be more than offset by the tonic value of the grass which is consumed.

## SHEEP

The trend of sheep husbandry in Eastern Canada is toward the production of early grass lambs. For this, early lambing is essential, but it also means more and better pasture in order to keep the lambs growing and fattening rapidly.

Sheep lead all other animals in their ability to utilize pasture, a characteristic which is not always appreciated. Too often, the farm flock is carried through the summer on old pastures and laneways, while the best pasture is reserved for other stock. Rapid gain cannot be expected from sheep treated in this manner.


Sheep lead all other animals in their ability to utilitze pasture. A good sheep pasture should be well drained. Dry, rolling or hilly land is preferable. Fresh, nutritious pasture made up of a mixture of legumes and grass, closely grazed is ideal for sheep.

A good sheep pasture must fulfill certain definite conditions. It must be on a well-drained soil. Swampy fields or those characterized by a heavy soil should be avoided as the excess moisture provides a natural breeding ground for all types of parasites. Whenever possible, dry, rolling or hilly land should be given the preference.

Clean grass is essential for lamb production. A change of pasture from year to year is advisable to curtail parasitic infestation and since sheep do not relish soiled herbage, a succession of pastures throughout the season will result in improved health and more rapid gains.

Most important of all is the need for fresh, nutritious herbage. Mixtures of legumes and grasses such as white, or alsike clover and timothy will provide pasture of this type. At the Central Experimental Farm, Ottawa, lambs reared on pasture such as this, were ready for market a month earlier than comparable lambs raised on old Kentucky blue grass.

The following plan with small variations to suit local conditions is believed to be applicable on most farms where sheep are kept. For the first two or three weeks in the spring a patch of winter rye could furnish early green feed for the nursing ewes. Following this, the main pasture of the rotation, or the permanent pasture can be used for seven or eight weeks. By this time, clover or some other aftermath should be ready. Rape could follow later and it will be found to be very convenient for finishing the lambs which have not already been marketed. Such a succession of pasture would allow for heavy grazing when the herbage is at its best and little grass would be wasted. An acre of such pasture should carry four to five ewes and their lambs. Its inclusion in the main rotation would be a guarantee against parasitic infestation, and in addition, it would furnish continuously the much needed nutritious grass so necessary for an abundant flow of milk from the nursing ewes and for the rapid growth of the young lambs.

If the above plan is followed, mixed grazing, that is the grazing of cattle and sheep together, may be conveniently practised during the major part of the summer. This method is recommended provided the proportion of sheep to


Mixed stocking of pastures with sheep and cattle on the same area results in more uniform grazing and thus a more satisfactory utilization of the pasture.
cattle is not too large. At the Central Experimental Farm, Ottawa, a mixed lot of sheep and steers gave a 30 per cent increase in production over a field grazed with a single class of stock. All animals made good gains and the field was grazed very uniformly. Sheep and cattle probably make the best combination for mixed grazing. Sheep relish the short and tender herbage while cattle will consume the longer and coaiser type of growth. The proportion of sheep to cattle should never be more than four to five ewes and their lambs to one steer or cow.

After the weaning, the ewes need good pasture to regain their condition in preparation for the mating season. This is called "flushing" and it is considered very important by good sheepmen. A timothy aftermath is excellent for this purpose but if one is not available, a stubble field will prove satisfactory. Abundant pasture at this time and all through the fall may save considerable
feed during the winter, since it is known that breeding ewes which enter their winter quarters in good condition require very little grain until near the lambing season.

## SWINE

Although the swine pasture is generally located on a part of the farm which has been given little special attention, it can, when planned and properly cared for, become a real asset. Both perennial and annual crops are suitable for swine pastures, and when it is desired to reduce the possibility of parasitic infestation, a system of pasture rotation is recommended.

Alfalfa and clover are the perennial crops most commonly used. These crops fit into the farm rotation, and provide forage of excellent quality. Where alfalfa can be grown successfully it is an outstanding pasture crop for hogs. Clover is also good, but the pasture season is shorter than with alfalfa.

Of the annual crops, rape, and a combination of oats and peas, or fall rye are the most widely used for pig pastures. Rape will provide excellent succulent feed for late summer and fall. However, if grazed too closely the growth of new leaves will be reduced. In pasturing annual crops the use of a temporary fence is recommended, so that the pigs may graze only a part of the field at a time.

Pastures are most useful for growing feeder pigs, and for the growth and maintenance of breeding stock. Feeder pigs may be pastured from weaning to four months of age, but they should not be expected to procure all their feed from the pasture. To produce the best results a grain mixture of ground oats and barley, along with a protein supplement, should be fed. A good pasture will supply most of the requirements of mature stock. However, to ensure their maintenance, or to improve the condition of the pigs, it is recommended that a grain mixture of equal parts of ground oats and barley be fed in small amounts to mature animals on pasture.

## Hints on General Management of Live Stock on Pasture

## SHELTER

During the hot summer days farm animals often suffer from heat. Relief can be furnished very cheaply by providing some kind of protection or shade. Trees and bushes if present in the pastures are sufficient, but where no natural protection is available, some shelter should be provided. A flat roof put up on posts is satisfactory. Often this temporary shelter may be made of branches or brush cut from an adjacent field. This type is very good for the summer, since it allows the wind to blow under it from all directions. In districts where the stock is left out early in the spring and kept on pasture until late in the fall, a better protection is necessary. An old abandoned barn, shed, or even a temporary shelter with roof and walls on the sides from which the prevailing winds blow will be satisfactory.

## WATER

Stock on pasture should have plenty of good clean water. Polluted streams, swamps, or water holes in which the water is stagnant are detrimental to the health of the stock, and very often are a source of infection for contagious diseases or parasites. A flowing stream where the water is readily accessible to the stock is satisfactory. The safest source, however, is a good well or spring; this water is always clean and is generally better supplied with minerals than is surface water, especially in districts where rainfall is heavy. Troughs, if used, should be cleaned out once in a while before the addition of fresh water.

## SALT AND MINERALS

Salt is necessary to all farm animals whether on pasture or not. Coarse salt is satisfactory, but where the pasture is large or far away from the barn, rock or pressed block salt is sometimes more convenient to use. Iodized salt should be provided whenever there is a doubt as to an adequate supply of iodine in the district.

It is a good practice to distribute the salt at different points in the pasture. Otherwise the stock will soon get the habit of coming regularly to the same place, with the result that the pasture in the vicinity of the salt will be overgrazed and soiled.


Fresh, pure water and shade are primary necessities for a good pasture.
Mineral supplements are often adrisable even if there is no obvious mineral deficiency. They are especially recommended for heavy milkers and growing stock, and for stock on light or rain-leached soils or on soils in a low state of fortility. As the minerale most likely to be deficient are phosphorus and calcium, a mixture of 25 per cent bone meal, 25 per cent limestone and 50 per cent salt will prove quite satisfactory. If the cattle have access to this mixture, additional salt need not be provided.

## BLOATING

Tympanites, commonly called "bloating," is a form of indigestion caused by the distension of the rumen or paunch by the gases of fermentation. In severe cases, if no treatment is applied, the animal may die of suffocation. Bloating is more common with sheep and cattle than with horses. Young, succulent herbage, especially clover and alfalfa, may cause bloating when the stock is not accustomed to it. Clover and alfalfa are especially dangerous after rain, heavy dew or frost. Volunteer oats, second growth alfalfa, and rape are particularly troublesome in their season. That is, there is more trouble from bloating in the late summer and early fall than at other seasons of the year.

As soon as bloating is noticed, something must be done if the animal is to be saved. Exercise, rubbing the animal vigorously to force evacuation of the gases, keeping the animal on a steep incline, head up, to facilitate gas evacuation by way of the mouth, drenching with kerosene and milk, all have proved helpful in mild cases, and may be tried. In most serious cases the rumen is punctured with a trocar and cannula. The puncture is made at the place of greatest distension on the left side of the animal. When the instrument is inserted, the trocar is removed and the cannula left in place to allow the gas to escape.

As with many diseases, prevention is better than cure. Any change of stock from a dry to a green, luscious pasture should be done very gradually. The cattle or sheep should not be allowed to go on such a field when they are very hungry, and they should not be allowed to graze more than one hour the first day. Thereafter, the time of grazing should be increased slowly until the stock is aceustomed to the new grass. A feed of dry hay before putting the stock out will prove uscful. Anything that will improve the general condition of the animal, such as plenty of salt, a sufficiency of other minerals, good condition and good management will help to prevent bloating, as it is often the off-condition animal that is the first to suffer.

## FLIES

Flics are a great somer of amnyance to stock, and eanse lower production. With dairy cows, the nee of sprays makes control possible. With beef cattle and young stock, generally far away from the huidings, control is almost impossible. If there are brush patelies in the field, the animal will find relief by taking shelter in them.

The most disturbing insect, however, is the warble fly. The female of this species, in depositing her eggs on the skin of the animal just back of the shoulder or in the region of the heel, makes life miscrable for the animals. The cattle cannot feed or rest properly because of these flies. This disturbance, therefore, is not conducire to high production in dairy cows nor to good gains in becf cattle, as nearly all their energy is utilized in fighting off the flies. Furthermore, the larvac which come out through the skin on the back of the animal in the spring, leave scars which reduce the value of the hide. The only treatment is to kill the larvae before they emerge from the skin. Instructions on how to treat warbles are given in Pamphlet No. 147, of the Dominion Department of Agriculture, to which the reader is referred.




[^0]:    'Sheep 7.5 cents per pound; dairy heifers 6 cents per pound; milk 90 cents per 100 pounds.
    ${ }_{2}$ The animal carrying capacities at Fredericton are not comparable with those at other stations, as they are based on a different animal unit system (see page 20.)

[^1]:    ${ }^{1}$ Land on former check plot cleared in 1934.
    ${ }^{2}$ Fertilized in 1935.

[^2]:    Perennial Rye Grass.-This is probably the most desirable of the pasture grasses where it can be grown successfully. It is productive, palatable, and thrives in association with wild white clover. Unfortunately, it lacks winterhardiness under the climatic conditions of Eastern Canada. Some strains like the Svalof "Victoria," are considerably more winter-hardy than others, but even this variety is often winter-killed. It has been found, however, that whereas perennial rye grass is frequently injured by low temperatures when growing as single plants and in plots cut for hay, it will often persist without injury under the same conditions when grazed rather closely. It is considered, therefore, that the hardier strains of this grass may prove useful for pasture under certain conditions, as for example: in mixtures seeded for grazing only, in which the rye grass takes the place of a nurse crop. Used in this way, in association with white clover, perennial rye grass at Ottawa has persisted well for three successive winters. There is also the possibility that plant breeders may be successful in developing hardier varieties, in which case this grass would undoubtedly occupy an important place in the pastures of Eastern Canada. The seed of perennial rye grass is relatively cheap.

