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Selenium Content of Forage and Hay Crops in the Pacific Northwest[1]

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ABSTRACT

A map illustrating the Se content of forage and hay crops in different sections of the Pacific Northwest was prepared, based on analyses of crop samples. The primary criterion used in mapping was to delineate areas where forage and hay crops generally contain insufficient Se to meet requirements of lambs and calves, and thus prevent white muscle disease (WMD) and other Se-responsive diseases. The minimal requirement may vary from 0.03 to 0.10 ppm Se in the diet, depending upon the diet level of vitamin E and possibly other substances. Under normal livestock management practices, WMD is common when forages and hay contain less than 0.10 ppm Se and the incidence is greater at lower Se levels. The western half of Washington and Oregon and part of northern California comprise an extremely low Se area. The eastern half of Washington, northern Idaho, extreme western Montana, and the northeast corner of Oregon comprise a low Se area. Most of the remaining portion of the Northwest may be considered as variable in Se, with farm-to-farm variations common, but some small areas of adequate Se were found and mapped.

Additional index words: **white muscle disease, trace elements, animal nutrition, plant composition.**

LIVESTOCK losses from Se-responsive diseases are common in the Pacific Northwest. White muscle disease (WMD), the most common of these diseases, afflicts calves and lambs, causing serious economic losses. The occurrence of WMD is related to Se deficiency in animal feeds (7). This Se deficiency is related to the availability of Se in soils on which animal feeds are grown, which in turn depends upon the geologic nature and parent material of the soils (8) and to a lesser extent upon fertilizer and other practices. The minimal diet level required to prevent WMD is from 0.03 to 0.10 ppm Se depending upon the diet level of vitamin E and possibly other substances (1). However, under normal livestock management practices WMD is common where forages and hay contain less than 0.10 ppm Se and the incidence is greater at lower Se contents. Therefore, many consider that 0.10 ppm Se in plants is the critical level for preventing WMD.

Selenium is not known to be essential for plant growth, but its concentration in forage and hay crops is important to animal health. Plants may contain from none to several thousand ppm of Se depending upon the plant species, the soil, and the soil parent material. Extensive information about Se toxicity to animals resulting from ingesting plants containing from five to several thousand ppm Se is available (10). The geographic regions where Se toxicity is likely are also well characterized. In contrast, comparatively little is known about regions where plants contain too little Se to prevent WMD. A map showing the Se content of crops in the United States (5) is now available, but it lacks sufficient detail for the Pacific Northwest where livestock losses from WMD are heavy, and of important economic impact.

This paper presents the Se content of forage and hay crops in the Pacific Northwest and discusses Se content of these crops in relation to feeding, grazing, and Se-injecting practices.

MATERIALS AND METHODS

Sampling locations were selected throughout the Pacific Northwest to represent particular areas such as drainage basins, plateaus, and different geologic regions. Locations where contamination was possible from industrial concerns, cities, feedlots, and construction were avoided. Care was exercised to sample locations that represented the surrounding region. The initial part of the study was conducted simultaneously with a national mapping project for which sampling criteria are described (5). The final portion of the study was conducted in a special effort to provide more detailed information for the Pacific Northwest where livestock losses are great and represent important economic losses.

Alfalfa was selected as the key plant for sampling because of its wide use as both forage and hay, and because it is grown throughout the Northwest. Where alfalfa was not available, grasses, other legumes, or grass-legume mixtures were sampled. At some locations separate samples were collected from alfalfa and other species for comparing Se content of species.

Each sample was composed of the upper 6 to 10 inches of tops from at least 10 different plants representing one or more acres of land at each location. The clipped plant tops were placed in cloth bags, taken to the laboratory, dried at 50 C, and ground to pass through a 1-mm sieve. The Se concentration was determined fluorometrically (2).

RESULTS AND DISCUSSION

The Se content of 361 forage and hay samples from the Northwest varied from 0 to 1.24 ppm, but only two samples contained more than 1 ppm. Two-thirds of the samples contained less than 0.10 ppm – the level considered by many as the minimal requirement to protect calves and lambs from WMD (5). Thus, this study provides convincing evidence that much of the animal feed produced in the Northwest contains too little Se to protect livestock from WMD.

Alfalfa contained about the same amount of Se as red clover and grasses at the same location. This observation agrees with a recent detailed study of the variation in Se content among plant species (4). Thus, the species sampled to represent particular locations were relatively unimportant.

The variation in Se content of forage and hay crops produced in different sections of the Northwest is illustrated by the map presented in Fig. 1. The number of samples collected from each area and the proportion of them falling into various Se concentration ranges are presented in Table 1 associated with the map. The areas mapped are defined as:

Very low Se – less than 0.10 ppm in more than 95% and less than 0.05 ppm in more than 80% of the samples

Low Se – less than 0.10 ppm in more than 80% and less than 0.05 ppm in more than 60% of the samples

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Table 1. The distribution of samples falling into various mapping categories of Fig. 1.

Area	No. of samples	Percent of samples falling in concentration ranges of: ppm 0.00-0.05	0.05-0.10	0.10-0.50	> 0.50
Very low Se	69	81	15	4	0
Low Se	94	61	23	15	1
Variable Se	117	15	37	46	2
Adequate Se	49	2	8	72	18
North Utah - south Idaho - Nevada range	16	94	6	0	0
Fishlake Utah Range	16	56	13	25	6
Total	361				

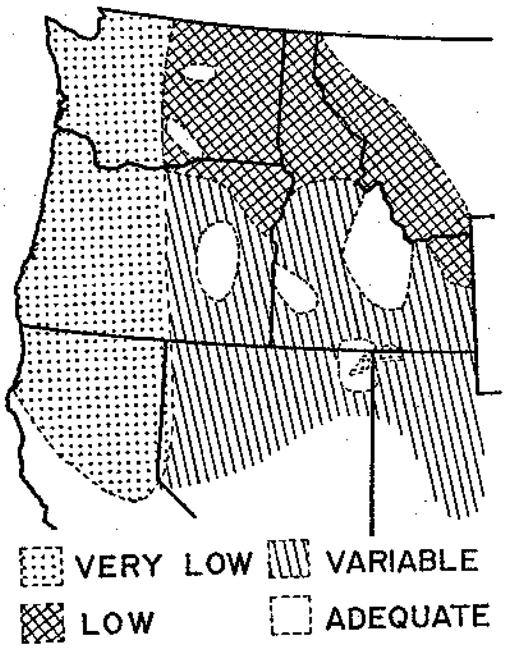

Fig. 1. Selenium content of forages in the Pacific Northwest.

Variable Se — less than 0.10 ppm in 50% of the samples

Adequate Se — more than 0.10 ppm in 90% or more of the samples

In addition to areas mapped on the above basis, several mountain ranges above 7,500 feet in elevation were sampled in detail. These ranges were mapped (Fig. 1) according to the definitions given, but Se concentration distributions are presented separately in Table 1 for some ranges to avoid bias.

The very low Se area of the Northwest includes the western half of Oregon and Washington and extends into northern California (Fig. 1). Essentially all the hay and forage produced in that area contains too little Se to protect livestock from WMD. Most hay and forage samples contained less than half the amount of Se that may be required for this protection. The total Se levels in soils of this area are low (10) because the parent material from which these soils developed contained very little Se (9, 10). Most soils in the area are acid, and Se forms in acid soils are generally less available to plants than those in alkaline soils.

Mountain rangelands above 7,500 feet in elevation in northern Utah, southern Idaho, and northeastern Nevada produce forage very low in Se (Fig. 1). In contrast, the lower rangelands surrounding a portion of these areas produce forage with adequate Se levels. In this area, the soils on higher mountain elevations are formed from (a) geologically old rocks of low Se content or (b) recent volcanic rocks of low Se content. The soil parent materials found at low elevations frequently contain cretaceous or tertiary sediments that normally are somewhat higher in Se content than either older or younger rocks. The general livestock management practice is to graze cattle on the lower lands, generally ranging from 4,000 to 6,000 feet in elevation, in the early spring, the late fall, and sometimes during the winter. The ranges above 7,500 feet in elevation are grazed for approximately 3 months during the summer and early fall. Therefore, livestock in the area would be on Se-deficient feed only about one-fourth of the time, and incidence of WMD is limited in these areas. In contrast, many of the high ranges, as well as the lands surrounding them in western Montana, northern Idaho, and eastern Washington are low Se areas (Fig. 1). Livestock losses in these areas are common as expected because at no time during the year do livestock eat Se-adequate feed.

The high rangeland in the Fishlake National Forest of central Utah produces forage generally lower in Se than surrounding lands, but both the high and surrounding ranges are mapped as variable areas. Livestock losses from WMD in that area depend on where the stock graze, the supplement feeding program, and the Se content of the hay fed on home ranches.

Northern Idaho, extreme western Montana, and most of the eastern half of Washington and the northeast corner of Oregon comprise the low Se area. Livestock production is important in this area, and probably the greatest livestock losses from WMD in the West occur here and in central Oregon. Most ranchers in these areas have lost young livestock from WMD and thus suffered economic losses.

The areas where Se content of forage and hay crops is variable over short distances represent approximately half of the Northwest. WMD does occur in these areas (8), but incidence is lower than on the very low and low Se areas. Apparently, losses in this area depend upon specific locations where feeds are grown, vitamin E levels, and other management practices.

There are several possible explanations for the variability in Se content of crops from farm to farm in the variable Se area. One is that some phosphate fertilizers sold in the West naturally contain small amounts of Se (9 and unpublished data of senior author). Fertilizing alfalfa with these materials may result in the uptake of protective Se levels for one or more growing seasons. It is established that considerable Se may be absorbed by plants from very low Se application rates to the soil (3).

Another explanation for variability is natural depletion. For example, Se-accumulator plants (6) have been observed growing on rangelands near Rome, Oregon. Yet alfalfa collected from irrigated fields contained very little Se. Differences in this area may result from natural depletion of the native Se supply during the 40 to 50 years the lands have been farmed.

Some differences result from differences in soil parent material between cultivated and rangelands.

There are only six relatively small areas of the Northwest where Se content is considered adequate. Even in these areas, some forages and hay contain low Se contents. These areas are along the Yakima River from its mouth upstream for about 150 miles, a small area at the north end of the Columbia Basin in Washington, the Harney Basin in east-central Oregon, an area along the Snake River from Glenns Ferry downstream to the Oregon state line, and an area of the Salmon River and Big and Little Lost River drainages in Idaho. Ranchers in these areas should be aware that some losses from WMD may be expected. In many instances, livestock may get their feed from rangeland outside the area or from hay hauled in from outside areas.

The information provided and illustrated in the map (Fig. 1) should be useful to animal scientists, veterinarians, ranchers, and plant and soil scientists. Many animals are lost to WMD every year because the disease is not recognized by ranchers. The information provided by this study indicates areas where the disease is most likely to occur. Therefore, precautions and protective measures, such as injecting calves and lambs with Se, can be followed. These practices should decrease the livestock losses from WMD.

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