THE UNIVERSITY OF MANITOBA

INVESTIGATIONS OF THE SEVERITY, EXTENT, TYPE AND TREATMENT OF COPPER DEFICIENCY IN BEEF CATTLE IN NORTHWESTERN MANITOBA

BY

ROBERT ANDREW DRYSDALE

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ABSTRACT

Drysdale, Robert, Andrew, M.Sc., The University of Manitoba, May, 1979. Investigations of the Severity, Extent, Type and Treatment of Copper Deficiency in Beef Cattle in Northwestern Manitoba. Major Prof; Thomas J. Devlin.

Blood serum, forage and soil samples were collected from beef cattle of forty-four herds in the North West agricultural region of Manitoba. Copper deficiency was identified in all herds and related to low copper and/or excessive molybdenum in the pasture forages. The forages also indicated a potential zinc and manganese deficiency in cattle at these locations. The low concentrations of copper, zinc and manganese in the forages were attributed to low content of copper and zinc and to low availability of copper, zinc and manganese in the soil. Parenteral administration of copper glycinate at the start of the pasture season was insufficient to affect weight gains or to maintain normal serum copper values during the grazing period.

A soil and forage survey was undertaken in the agriculturally productive area of the North West region. Differences in nutrient concentrations were identified among forage types. The forage analyses confirmed potential primary deficiencies of copper, zinc and manganese in relation to cattle production. Elevated molybdenum levels were identified in legumes throughout the region and in grasses confined to the soils derived from the shale bearing Ashville, Favel, Vermillion River and Riding Mountain Geologic Formations.

Supplementation of copper, zinc and manganese is indicated for cattle in northwestern Manitoba and other areas of the province with similar geologic factors.

I. INTRODUCTION

Prior to 1910, occurrences of an ailment of grazing cattle were reported in the Thunder Hill district of northwestern Manitoba. The symptoms were similar to those attributed to molybdenosis, or secondary copper deficiency reported by Ferguson et al (87) in England, Barshad (16), Britton and Gross (30) in the United States, and Alcroft (2) in New Zealand. In 1950, Cunningham (53,54) confirmed the ailment reported in Manitoba to be molybdenosis, responsive to copper therapy. His findings were substantiated by Smith (182) and Findlay (89).

The severity of copper deficiency in the affected areas of this region of Manitoba increased during wet pasture seasons. The summer of 1973 was typical of this phenomenon, but the incidence of copper deficiency appeared to have spread to new areas within the region. This was attributed to increased cognizance of the disorder. A survey by rural veterinary practitioners and staff members of the Manitoba Department of Agriculture located copper deficient cattle in many areas within the region. In addition, results from a preliminary geochemical survey of the region, by the University of British Columbia became available. Results from this and subsequent studies (76) indicated that conditions of potential copper deficiency of cattle existed throughout a much larger area than was previously anticipated.

In the spring of 1974, staff members of the Manitoba Department of Agriculture and the University of British Columbia met with rural veterinary practitioners from the North West Region. Funding became available through the Manitoba Department of Agriculture Animal Industry

Branch, Veterinary Services Branch and North West Regional Division, the Manitoba Youth Secretariat and the University of British Columbia, Geological Sciences Department. In May of 1974, an investigation of the severity, extent and treatment of copper deficiency of cattle in the region was initiated. Subsequent investigations funded by the Manitoba Department of Agriculture North West Regional Division and Veterinary Services Branch, and the Manitoba Youth Secretariat were instituted during 1975, 1976, 1977 and 1978. The results of these studies, in part, are documented in this dissertation.

II. LITERATURE REVIEW

1. Definitions of the Disease

Primary or simple copper deficiency is caused by uncomplicated deficiency of copper in the diet. Indicators in cattle (57) are anemia, unthriftyness, poor growth, lameness and reduced reproductive and milk producing capacities. The hair coat is rough and staring and may show loss of coloration. Calf growth is impaired with increased incidence of bone abnormalities and fracture. Ataxia, seen as a loss of muscular control, has been observed after exercise.

Secondary copper deficiency is caused by the involvement of molybdenum and/or sulfate causing reduced availability or retention of dietary copper. The only objective sign distinguishing simple and complicated copper deficiency in cattle is an acute seasonal scouring condition (57). The animals scour profusely while on lush spring and fall pasture and may become extremely debilitated. During midsummer, when pasture growth is less rapid, scouring ceases and body condition is regained to some extent.

In sheep, copper deficiency is also observed as "stringy" or "steely" wool as described in Australia (7). The effects of copper deficiency of the ewe are usually seen in the lamb, which may be affected by osteoporosis or ataxia associated with regional myelin degeneration or hypomyelination. Osteoporosis seems to occur in cases less depleted than those involving ataxia. Hypomyelinating ataxia occurs as enzootic neonatal ataxia (21, 116) or as delayed swayback (57) which develops between 3 weeks to 4 months of age. The signs of copper deficiency of sheep are usually more severe in cases of secondary deficiency.

2. Geographic Occurence of the Disease

The first citing of naturally occurring copper deficiency was that of "salt sick" cattle of Florida by Neal et al (154) in 1931. The condition was identified in Holland in 1933 by Sjollema (177) and in Western Australia by Bennetts and Chapman (22) in 1937. In 1938, Ferguson, Lewis and Watson (86) identified the "teartness" of pastures in Sommerset, England, to be due to their molybdenum content and thus initiated copper therapy as a cure for molybdenosis (88).

Other investigators have identified the incidence of bovine copper deficiency in New Zealand (57), Sweden (100), Ireland (155), Wales (63), France (127); in parts of California (16, 30), Oregon (160), Nevada (79), and Hawaii (195) in the United States, and in the province of Ankavan, Armenia in the United Soviet Socialist Republics (124).

In Canada, primary and secondary copper deficiencies have been found in Manitoba (182, 89, 54, 76), Ontario (28), British Columbia (147) and very recently in eastern Saskatchewan (186, 31). Conditions similar to those in Manitoba have been found in North Dakota (41). Areas of South Dakota and Minnesota are experiencing a deficiency situation but the causal conditions are only now under investigation (132, 161).

3. The Essentiality and Requirement of Molybdenum

Molybdenum has been found to be a constituent of the metaloflavoprotein enzymes xanthine oxidase (214, 68), aldehyde oxidase (123), and sulfite oxidase (49). The first two of these enzymes are involved in the electron transport chain by interacting with cytochrome c (133, 93) as the electron acceptor. Molybdenum is present at the substrate binding site of these enzymes (164). Xanthine oxidase is required for the oxidation of the purines xanthine and hypoxanthine to uric acid in the rat and chick (105, 129). Aldehyde oxidase catalyses the oxidation of aldehyde and various nitrogen containing heterocyclic aromatic compounds (123) and hypoxanthine (164). Sulfite oxidase is involved in the oxidation of sulfite to sulfate in the mammalian metabolism of sulfur amino acids and sulfur-containing compounds.

The essentiality of dietary molybdenum has been demonstrated only in the chick and rat (105, 48, 120). No required dietary level has been established for these species due to the use of tungsten to establish a deficiency state. The requirement of molybdenum by sheep has been studied (81, 175). Sheriha et al, 1962 (175) concluded that if required, the dietary requirement was less than 0.01 ppm for sheep. A dietary requirement for molybdenum has not been established for ruminants but is required for the healthy growth of pasture legume forages.

4. The Essentiality and Requirement for Copper

Copper has been known as an essential element since the works of Neal et al (154) in 1931 and Sjollema (177) in 1933. Copper is a constituent of the enzymes tyrosinase, ascorbic acid oxidase, phenol oxidase, uricase and cytochrome oxidase. The functional changes of these enzymes under deficiency situations have been reviewed by Adelstein and Vallee (1). Research on the requirements and metabolism of copper has been reviewed by Underwood (202).

Values for the requirement of available copper for the ruminant animal are difficult to assign due to interfering dietary factors. The basic requirement of copper for cattle is accepted at 10 parts per million (ppm) in the dry ration (145, 188, 57, 45, 210) when dietary molybdenum and sulfur are less than 1.0 ppm and 0.10% respectively. Whenever molybdenum levels exceed 1 ppm, the absolute levels of copper and molybdenum, and the copper to molybdenum ratio, must be considered. In such cases, a dietary ratio of 4 parts copper to 1 part molybdenum is desirable (210). Thus the requirement of cattle for copper is accepted as follows in Manitoba:

TABLE 1. Required level of copper in relation to molybdenum in the diet.

Dietary level of Mo, ppm D.W.	Required level of Cu, ppm D.W.
0-1	10
1-3	12
4	16
5[a]	20

[a] for levels of dietary molybdenum greater than 5 ppm, refer to the literature review on supplementation of copper.

For sheep, the dietary requirement for copper is accepted as 4 to 6 ppm for British breeds and 6 ppm for Merino sheep (202). Under moderate intakes of calcium carbonate, molybdenum, or sulfur, the dietary requirement is increased as high as 10 milligrams (mg) per day or 10 ppm in the diet.

In summary, the dietary requirement of cattle and sheep for copper, under Manitoba conditions, may only be adequately estimated when both copper and molybdenum analyses are available. This is in agreement with Miltimore and Mason (146).

5. Body Levels of Molybdenum and Copper

a). Molybdenum

Molybdenum levels in the body are higher in the liver and kidneys than in other organs (196, 105) but accumulation in the liver is not excessively high (202). Levels do not change appreciably with age, and species differences are small (204). Molybdenum levels in the hair (59), bones and liver (66) are influenced by dietary molybdenum levels. Normal liver molybdenum levels of 2 to 4 ppm may increase to 25 to 30 ppm in cattle and sheep on high molybdenum rations (203). Tissue molybdenum levels are decreased by dietary inorganic sulfate and sulfur-containing amino acids (60, 61, 142). Tungsten may also decrease tissue molybdenum levels (9, 64, 65).

Normal values for whole blood molybdenum for cattle and sheep grazing pastures normal in copper and low in molybdenum are 2 to 6 Ug/dL (57, 72) or 0.02 to 0.06 Ug/ml. This level rose to 60 to 80 Ug/dL in young cattle and to 240 to 340 Ug/dL ml in ewes when fed a ration of 30 ppm molybdenum. Dick (7) noted that over 70% of the blood molybdenum was present in the erythrocytes under normal conditions. Increases were due to increases of the plasma fraction. Scaife (171) showed that molybdenum from both fractions of the blood was a readily dialyzeable anion, probably molybdate.

The molybdenum content of milk is normally 10 Ug/l or 0.01 ppm (108). The content of cows milk has been raised from 73 Ug/l to 371 Ug/l by adding 500 milligrams molybdenum daily to the diet (9). Ewes grazing pastures of 13 ppm molybdenum showed a value of 980 Ug/l molybdenum in their milk (110). These researchers found a reduction from 1,043 Ug/l to 137 Ug/l molybdenum after 3 days, in ewes grazing pastures of 25 ppm molybdenum when dosed with 23 grams of sulfate per day. The molybdenum in milk of cows grazing normal pastures is bound to xanthine oxidase (102) and is proportional to the xanthine oxidase activity. Rapid increases in molybdenum values of milk do not show a corresponding increase in xanthine oxidase activity (101).

b). Copper

The distribution of copper in tissues varies with species, age, and copper intake. Under normal conditions, copper concentrations tend to be correspondingly higher in the liver and brain than in other tissues (40, 150). In ruminants, the capacity for storage of hepatic copper can be very high (55), and closely reflects the dietary copper levels, with and without supplementation (83).

The generally accepted values for liver copper concentrations of cattle and sheep are given in TABLE 2. Under Manitoba conditions, the deficient liver copper level was defined as 40 ppm dry weight for adult cattle, in agreement with Claypool et al, 1975 (47). The deficiency level for newborn calves was defined as 55 ppm dry weight as set by Cunningham (56).

TABLE 2. Liver copper level in relation to dietary copper status (56).

Species	Age & Cu Treatment	No. of Animals	Cu ppm dry weight Average	Range
Sheep	newborn, normal diet	27	168	74-430
	newborn, deficient diet	29	14	4- 34
	mature, normal diet	44	599	186-1374
	mature, deficient diet	35	27	7-106
Cattle	newborn, normal diet	41	381	143-655
	newborn, deficient diet	20	55	8-109
	mature, normal diet	23	200	23-409
	mature, deficient diet	41	11.5	3- 32

Copper values in the hair range from 10 to 47 ppm. There appears to be no relationship between species or color to copper content (96, 8). Van Koetsveld (207) reported an average value of 10 ppm copper with values below 8 ppm having been associated with deficiency symptoms. O'Mary et al (159) found that hair of Hereford cattle ranged from 10 to 31 ppm copper and that differences were not attributable to color but to season and time of sampling. In Manitoba, the normal value of copper in the hair of cattle and wool of sheep has been accepted as 7 to 10 ppm.

Copper in the blood of cattle is present in three basic forms. Firstly, erythrocyte hemocuprein is a blue low-molecular weight (35,000) protein with 2 atoms of copper per molecule (0.34% Cu) in the cupric form (135). The plasma copper fractions are the ceruloplasmin and "direct reading copper" protein-bound forms. Ceruloplasmin is an $\alpha 2$-globulin of molecular weight of 151,000 with 8 atoms of copper per molecule (111). It is an oxidase enzyme catalyzing the oxidation of various polyphenols (111) and biological compounds (139, 97). The amount of ceruloplasmin copper exchanged per day is relatively small compared to intake. In mammalian species ceruloplasmin copper represents approximately 80% of the plasma copper while representing only a negligible portion in avian species (185, 217). Highly significant correlations between plasma, serum and whole blood copper levels and ceruloplasmin activity have been drawn (151, 200). Direct reading copper is named for its direct reaction with dithizone. It is nondialyziable and loosely bound to a serum protein, probably albumin (35, 217). The balance of the plasma copper fraction is comprised of the copper containing enzymes: trosinase, laccase, ascorbic acid oxidase, cytochrome oxidase, monoamine oxidase, δ-aminolevulinic acid dehydrase and dopamine-β-hydroxylase (90).

Generally, the normal range for serum copper has been accepted as 0.8 to 1.2 Ug/ml (181, 20). Values below 0.6 Ug/ml have indicated a deficiency for cattle and sheep (202, 63) with values below 0.5 Ug/ml demonstrating severely deficient liver copper levels in cattle (47).

The blood copper levels of sheep are greatly influenced by pregnancy, parturition and disease. Blood copper parameters have been shown to decline during pregnancy in housed (36) and grazing (4, 37) ewes and increase to premating levels approximately one month post partum. Howell et al (112) found that blood copper values rose to very high levels approximately one week post partum and then fell to normal. They found the blood copper values of lambs to be low at birth with an increase to normal adult levels within one week. This finding was confirmed by McDougall (153). In the case of calves, Bingley and Dufty (24) reported whole blood and plasma copper levels of newborn calves to be significantly lower and erythrocyte copper levels to be significantly higher than their mothers.

Variations in blood copper parameters have arisen with the incidence of disease (152, 19, 168) in cattle and sheep. Infestation with internal parasites have been shown to cause depressed copper values (152, 29). Low blood copper values had been attributed to (162) but were later found to be coincidental with Border disease in sheep (14).

The normal copper level in milk is thought to be approximately 0.6 Ug/ml (52) for cattle. For sheep, values of 0.2 to 0.6 Ug/ml fall to 0.04 to 0.16 Ug/ml several months post partum (18). For both species copper values of colostral milk are substantially higher than in later milk (202). Cattle grazing copper deficient pastures have shown milk copper levels of 0.01 to 0.02 Ug/ml (18). Very little response has been shown in milk copper levels to supplementation of ewes (191), cows and goats (82) on already adequate diets. However, Dunkley et al (78) showed a four week elevation of milk copper levels in cows parenterally injected with 300 milligrams copper as glycinate. There was no mention of dietary copper levels in this study.

6. The Diagnostic Reliability of Copper Parameters in Serum

The parameter of total serum copper may not be adequate for the diagnosis and treatment evaluation of copper deficient animals in terms of potentially available copper in the serum. Investigators with sheep (74, 75) and cattle (46) have hypothesized the presence of a copper-molybdenum complex at the serum level similar to that found at the rumen level. Dowdy and Matrone (74, 75) observed that this copper-molybdenum complex had a Cu:Mo ratio of 4:3 and could exist in vivo.

The copper in this complex was biologically unavailable to pigs and sheep. Marcilese et al (136) compared the effects of dietary sulfate alone with molybdenum plus sulfate in the diets of sheep. They found that when molybdenum plus sulfate was added to the diet, the uptake of injected radiocopper by the liver was reduced and that ceruloplasmin synthesis was impaired. This postulated a copper-molybdenum-sulfate complex at the serum level. Recent electron paramagnetic resonance studies by Huisingh and Matrone (114) have shown, however, that the serum Cu^{+2} cation becomes bound to serum proteins and the molybdate remains as a free anion in proximity to that protein. They have proposed that dietary molybdate and sulfate together affect copper transport into and out of the tissues, particularly the liver, by mobilizing copper stores. This increases the total serum copper level. They have also proposed that molybdate plus sulfate inhibits synthesis of copper storage complexes and ceruloplasmin (136). This means that this mobilized copper, shown as an increase in total serum copper level, may be only slightly available to the animal.

In summary, under conditions of molybdate plus sulfate inter-action on copper metabolism, there is merit to the use of the total serum copper plus ceruloplasmin activity criteria in diagnosing copper deficiency. This may explain why deficiency symptoms persist in a herd when the total serum copper levels are apparently adequate, especially when sulfate and molybdate analyses are unavailable. Unfortunately, rapid post-sampling oxidation of ceruloplasmin makes this serum parameter unreliable under field conditions, unless special precautions are taken.

7. Metabolism of Molybdenum and Copper and the Effects of Interrelated Minerals

a). Molybdenum

Under normal conditions, molybdenum is well absorbed from the diet. The hexavalent water soluble forms of sodium and ammonium molybdate, and the water soluble molybdenum of fresh herbage are well absorbed by cattle (88). When fed in large amounts, insoluble compounds such as molybdenum trioxide and calcium molybdate, but not molybdenum disulfide, are well absorbed (84). The active site and mechanism of molybdenum absorption are unknown (204).

On low dietary sulfate, the major route of molybdenum excretion is via the urine in monogastrics (176, 156, 169) but not in cattle (208) or sheep (72, 171). By increasing the dietary level of sulfate from 0.1% to 0.3% in sheep, the amount of molybdenum excreted via the urine increased from 3.0 to 4.6% to 50 to 54% of intake. This effect of sulfate on molybdenum metabolism is very specific in sheep and has been shown to be as effective from endogenous as from dietary sources of sulfate (72, 171, 51).

Dick (72) explains the influence of sulfate on molybdenum absorption and excretion by the interference of inorganic sulfate with, and when concentrations are high enough, the prevention of molybdenum transport across membranes. This is hypothesized to increase molybdenum excretion through the rise in the sulfate concentration of the ultra filtrate of the renal glomerulus following high sulfate intakes. This in turn impedes or blocks reabsorption of molybdenum through the renal tubule. The mechanism of this postulated interference may be due to the similarities between the molybdate and sulfate anions (141).

Very high molybdenum intakes have been reported to give rise to increased phosphorus excretion with accompanying lameness, abnormal joints, osteoporosis and high serum phosphatase levels (66). This may lead to increased incidence of calving difficulties and reduced or absent libido in young bulls. Thomas and Moss (192) have demonstrated damage of the interstitial cells and germinal epithelium of the testes of such animals.

b). Copper

The site of copper absorption has not been demonstrated but is thought to be in the small intestine (45). Ingested copper is rather poorly absorbed in most species (27, 50) and very little is known about the mechanism of copper absorption. A copper-binding protein has been demonstrated in the duodenal mucosal cells of the chick (184) but not in other species.

Absorbed copper is stored in liver and may reach very high levels in ruminants. Copper is excreted via the urine and actively from the liver via the bile (202). The absorption and retention of copper by cattle and sheep is greatly influenced by interrelated dietary factors.

The absorption of dietary copper is reduced under conditions of high dietary intakes of calcium carbonate and sulfide (71). The calcium carbonate reduces the absorption of copper by raising the intestinal pH (71, 134). Dietary sulfur above 0.1% has been found to increase the formation of an insoluble copper sulfide complex in the rumen and intestines (188). The latter finding has also been confirmed in swine (27).

The copper of fresh herbage has been shown to be less available than the equivalent dry herbage or hay (103). Mills (143) has shown the greater part of the copper component in fresh herbage to be in the form of as neutral or negatively charged complexes. Mills has postulated that copper may be transported through the intestinal mucosa both as an ion and in the form of complexes as found in herbage. This postulation is supported by Kirchgessner et al (122) who have shown that the affinity of copper ions for inorganic and organic ligands in food can reduce the rate of absorption, depending upon the size and stability of the resultant complexes.

Several organic and inorganic factors have been shown to decrease the utilization of dietary copper. Davis et al (67) have demonstrated a reduction in the assimilation of copper by phytate. Van Campen and Gross (206) showed that high dietary levels of ascorbic acid significantly reduced the retention of copper by depressing intestinal absorption, rather than by increasing excretion. Zinc and cadmium both decrease the utilization of copper as summarized by Mills (144) and Starcher (184). Zinc, cadmium, copper and mercury are mutually antagonistic elements which are competitively absorbed at binding sites on a protein, believed to be of the metallothionein type located in the liver, kidney and duodenal mucosa (144). Thus increases in dietary levels of zinc, cadmium and mercury may directly influence the absorption and excretion of copper. Iron and manganese have been shown to be competitively absorbed with copper in the intestinal mucosa, thus reducing its availability to the animal (201).

The two dietary factors which most influence the absorption and utilization of dietary copper are molybdenum and sulfur. Sulfur reduces the absorption of copper by formation of insoluble copper sulfide (188), as previously discussed. Molybdenum interferes with both the absorption of copper and its retention in the liver (202). Matrone (140) has suggested that molybdenum reduces copper absorption by the formation of a copper-molybdenum complex referred to as cupric molybdate ($CuMoO_4$). Cunningham (57) and Dick (71) have shown that the deleterious effects of molybdenum and sulfate upon copper utilization are increased when both are administered together. This has suggested the formation of a cupric thiomolybdate complex. Molybdenum, sulfur and molybdenum plus sulfur all decrease the utilization of copper by the animal. The present hypotheses concerning the interactions of these nutrients are complex and are discussed in section 8 below.

8. <u>The Copper-Molybdenum-Sulfate Interaction and its Influence on Absorption, Metabolism and Excretion of Copper in Ruminants</u>

Dowdy and Matrone, 1968, studied the copper-molybdenum-sulfate reaction in ruminants (74, 75). They observed the formation of an insoluble precipitate at neutral pH. Dowdy et al (73) later showed this precipitate to be lindgenite, $2CuMoO_4 \cdot Cu(OH)_2$, which previous workers had referred to as cupric molybdate or the Cu-Mo complex. Dowdy and Matrone (74, 75) were unable to explain the role of sulfate in the copper-molybdenum interaction. They found that the resultant complex was absorbed and transported by the body but was unavailable for ceruloplasmin synthesis. Huisingh and Matrone (114) have postulated models of the action of sulfur in the Cu-Mo interaction.

One model has suggested the unavailability of copper at the rumen level to be due to (a) the formation of cupric molybdate and (b) the precipitation of cupric sulfide (113). As a result of in vitro studies

(94) which showed an inhibition of the sulfate to sulfide reaction by molybdenum in rumen cells, Huisingh and Matrone proposed that molybdenum could alleviate high dietary sulfate induced copper deficiency by blocking the formation of cupric sulfide from copper plus sulfate. Using a dietary level of 50 ppm molybdenum and either sodium sulfate or methionine as a sulfur source, they showed that molybdenum inhibited sulfide formation from sulfate but increased the production of sulfide from methionine.

A more current model of the Cu-Mo-S interrelationship by Huising and Matrone (141) is based on in vivo intestinal loop studies. Molybdenum and sulfate have been observed to interact at (a) the site of enzyme activity, such as molybdate inhibition of sulfate reduction by inhibiting the enzyme ATP-sulfurylase, and at (b) the site of membrane transport, such as intestinal absorption and renal tubule reabsorption, as postulated by Dick (69, 72). Due to the high degree of similarity of the molybdate (MoO_4^{-2}) and sulfate (SO_4^{-2}) oxy-anion (both have $2\pi d$ bonds and sp^3 configurations) chemical parameters, Huising and Matrone have hypothesized:

a) both molybdenum and sulfate are transported across membranes by a carrier.

b) both anions use the same carrier.

c) sulfate can replace molybdate on the carrier.

d) when sulfate replaces molybdate on the carrier at the site of reabsorption in the renal tubule, then molybdate excretion via the urine is increased.

Using the intestinal loop technique, they found that not only sulfate but other Group VI oxy-anions, such as selenate and chromate interfered with molybdate absorption, but Group V phosphate did not. The proposal of a competitive absorption-transport mechanism is supported by the findings of Cardon and Mason (39). This interaction of similar Group VI oxy-anions may offer an explanation to the study by Sheriff and Rankin (174) of a precipitant selenium deficiency, believed to be due to high dietary sulfate.

A brief summary of the effects of dietary molybdenum and sulfate on body copper levels, as found by Huising and Matrone (114), is given in Figure 1. When sheep are fed a copper deficient diet, molybdate or sulfate alone always decreases the plasma, liver and kidney copper level and serum ceruloplasmin activity. When both molybdate and sulfate are added to a copper deficient diet, plasma copper is increased without a corresponding increase in ceruloplasmin activity. There is mobilization and subsequent depletion of body copper stores with an increased urinary excretion of copper (137). In respect to liver copper status, if the animals are receiving adequate dietary copper, then molybdate plus sulfate appears to decrease the level of copper in the liver, but at a reduced rate, leading to a higher retention of liver copper than in comparably deficient animals (114). This supports the hypothesis that molybdate plus sulfate impairs the transport of copper into or out of the liver by impairing the membrane transport system.

Copper Parameters

	Plasma	liver	ceruloplasmin	kidney	urine
MoO_4	⇩[a]	—	↓	—	
SO_4	↓	↓	↓	↓	
MoO_4+SO_4	⇧	↓⇧[b]	↓	⇧	⇧

FIGURE 1. Copper Parameters
Summary of the effect of molybdate, sulfate and molybdate plus sulfate on copper metabolism.
[a]If the diet contains adequate or excess copper, then no change in plasma copper may be observed.
[b]If the diet contains adequate or excess copper, then liver copper values decrease. If the diet is copper-deficient, then the liver copper values are higher for the molybdate plus sulfate than the copper-deficient control animals.

9. The Availability of Molybdenum and Copper

The uptake of molybdenum and copper by the animal depends on the respective contents and availabilities from dietary sources. These factors are dependent upon the geochemistry and soil factors affecting the uptake of these nutrients by plants. This section is a review of factors affecting the uptake, content and availability of molybdenum and copper in plant and animal systems.

a). Molybdenum

Elevated levels of molybdenum have been documented in soils (182) and forages (54) in northwestern Manitoba. In 1973, Doyle and Fletcher (76) initiated a study of the geochemistry of this area of Manitoba. Using stream sediment sampling techniques (195, 212, 194), they demonstrated elevated soil molybdenum levels from a very large area within the North West agricultural region of Manitoba. They later found problems associated with elevated molybdenum values to extend beyond the boundaries of that agricultural region of the province.

The availability of soil molybdenum to plants depends on the molybdenum content of the soil, and the factors affecting the movement of soil molybdate into solution as molybdate in solution is readily available for uptake by plants. The availability of molybdate is greatly reduced when it is adsorbed to the soil particle surface, through reaction with iron or aluminum. Maximum anion adsorption to soil particles (and subsequent least availability) coincides with the pK of the appropriate acid. Soil molybdate availability to plants thus increases from a low near pH4 to a high near pH8 (15, 158). These findings were substantiated by Thompson et al (193) who showed increases of herbage and topsoil molybdenum contents from soils of pH5.8 to pH7.8.

Results of the survey of Doyle and Fletcher (76) confirmed the results of Oddy (157) in the Swan and Valley River basins of Manitoba. These elevated soil molybdenum values were generally located in the shales of the Ashville, Favel and Vermillion River mormations. High soil molybdenum values were associated with the strongly acidic (pH5.1) shale derived Keld Association and alluvial Edwards Association soil units. Despite high soil molybdenum values, molybdenum concentrations of forages from these soils tended to be lower than forages from adjacent mildly to strongly alkaline (pH7.5 to 8.5) soils. Their survey of the moderately alkaline (pH7.9) Kenville Soil Series, within the molybdenum toxic area studied by Cunningham (54), revealed that only background levels of soil molybdenum lead to elevated forage molybdenum values in the order of 4.4 ppm. Thus the levels of molybdenum in forages may be strongly influenced by soil pH and somewhat independent of the molybdenum content of a particular soil type.

Other factors have been shown to influence the availability of soil molybdenum to forages. The availability is increased with the application of phosphate, hydroxyl and vanadate (95, 148, 215), by a decrease in organic matter (149) and by limiting of acid soils (211). Increased availability has also been attributed to increased soil moisture (76, 54, 182) corresponding to periods of lush pasture growth. Sulfate and ammonium ions have been shown to depress soil molybdenum availability (149).

The level of molybdenum in forages is greatly influenced by the type of forage. Legumes concentrate molybdenum as it is used to catalyze nitrogen fixation through nitrogen reduction with cyano complexes (26, 172). Grass forages do not concentrate molybdenum but grasses grown in conjunction with legumes may show a higher molybdenum concentration than grasses grown alone. This is due to an increase in topsoil molybdenum attributable to biological turnover of the legume species. This process is greatly increased when pastures are burned off and elemental molybdenum is released to the topsoil.

The availability of forage molybdenum to the ruminant animal is greatest when the forage is fed as a high moisture pasturage (202). The availability of molybdates in dried herbage appears greatly reduced compared to fresh forages.

b). Copper

The availability of soil copper is influenced by several factors

(32). Soil copper is most soluble under acid conditions. As the pH increases, copper and other cations are oxidized to insuluble hydroxides or oxides of low solubility. The monovalent cation of copper is more available than the divalent form and is promoted by conditions of low oxygen and high moisture in the soil. Soil cations also form complexes of reduced availability with organic matter substrates. Copper deficiency on high organic matter soils in the United States has been partly attributed to such complexes (160). Under normal soil conditions, forage copper content is fairly directly related to soil copper content.

The availability of copper to the animal depends upon the amount of available copper in the forage. Improved pasture forage species are generally higher in copper content than native forage species. The copper of dried herbage is more available than the copper of fresh or high moisture herbage (103, 143). The availability of copper from forages is also greatly influenced by interrelated minerals in the diet as previously discussed.

10. Copper Deficiency in Ruminants

A number of disorders have been associated with copper deficiency in ruminants. These disorders arise from an inadequate intake or from a depletion of body reserves of copper. The severity and extent of deficiency disorders varies with species and with the requirement of individuals within a species. Most often the fast growing young or high producing adult animals are first to succumb as their requirements for copper are greatest. Signs include anemia, depressed growth in spite of adequate feed, bone disorders, apigmentation and abnormal keratinization of hair or wool, nervous disorders, reduced reproductive performance, cardiovascular failure and gastrointestinal scours.

Copper deficient anemia in cattle and ewes is hypochromic and macrocytic; in lambs, it is hypochromic and microcytic (202). Copper is involved in the transport and utilization of oxygen. In sheep, blood copper levels of 0.12 Ug/ml have been found to limit hematopoiesis and a deficiency of copper has been related to the failure of erythrocyte maturation (125, 17). Ceruloplasmin has been shown to be the ferroxidase catalysing the ferrous (Fe^{2+}) to ferric (Fe^{3+}) reaction for uptake by transferrin for transport to receptor sites including haemoglobin (91, 92). Copper, and iron, are also part of the enzyme cytochrome c oxidase which is responsible for introducing oxygen into the oxidative segment of energy production. The heme group and copper ions bind the oxygen, reduce it with electrons from cytochromes of the hydrogen electron transport system, and convert this reduced oxygen to water (42, 92).

Deficient copper intakes lead to reduced tissue copper levels and subsequent reduced enzyme activity. With reduced enzyme activity, especially in the cytochrome enzymes, there is a reduction of body function and production. Young animals born to such dams are often weak poor-doers with reduced liveability.

Copper plays an essential role in the enzymes cytochrome oxidase and amine oxidase, necessary for structural integrity of disulfide linkages in collagen and elastin (25, 33), and in bone mineralization (98). Copper deficiency is reflected by degenerative changes in connective tissues and such changes are believed to account for abnormalities of gait, with arching of the back (66, 113, 205), and abnormal bone development of the distal growth plates of the metacarpus and metatarsus (179). Sheep and cattle grazing copper deficient pastures have shown osteoporosis with ease of fracture (21, 47, 145) and an increase in phosphorus excretion (66).

Pigmentation and keratinization of hair and wool are disrupted during copper deficiency. Apigmentation, or achromotrichia is attributed to the failure of the tyrosine to melanin reaction (70). This reaction is catalysed by the polyphenol oxidases which contain copper (165). Improper keratinization during copper deficiency results in a rough staring hair coat and "steely" or "stringy" wool of reduced crimp and tensile strength (138). These characteristics are dependent upon the integrity of the disulfide linkages of keratin and the alignment of the keratin fibrillae in the fibers. Both are adversely affected during copper deficiency (138). Copper also affects the arrangement of the polypeptide chains in keratin synthesis (34).

Swayback and enzootic neonatal ataxia have been attributed to copper deficiency (131). The condition is usually seen only in sheep but has been reported in goats and swine (202). Animals affected at birth may be ataxic or completely paralysed. Delayed swayback is characterized by progressive incoordination of the hind limbs, a stiff and staggering gait, and swaying of the hind quarters. In very mild cases, symptoms of ataxia may be noted only when the lambs are excited. Considerable research has been completed in the dietary, clinical, pathological and biochemical aspects of swayback (11, 12, 13, 37, 38, 131, 167, 189, 216). Copper deficient ataxia stems from a loss of cytochrome oxidase activity as a result of the failure of the synthesis of the heme prosthetic group (209). This inhibition of aerobic metabolism leads to a decrease in phospholipid, causing a reduction in myelin synthesis (115) and subsequent ataxia.

Reduced reproductive capacity and cardiovascular disorders have been attributed to copper deficiency in cattle. Deficient cattle show depressed or delayed estrus (5, 207) and increased neonatal mortalities (145). The incidence of "falling disease" or acute heart attack is also noted (23). Leigh (130) attributes this myocardial degenerative change to a loss of cytochrome oxidase activity resulting in extensive changes in myofibrillar and mitochondrial morphology and distribution.

Diarrhea has been associated with low blood and tissue copper levels (5, 23) and with high molybdenum intakes (54, 87). Fell et al (85) observed a decrease in epithelial cytochrome oxidase and mitochondrial lesions in the small intestines, and partial villus atrophy in the duodenum and jejunum of copper deficient steers. These morphological changes were correlated to copper-responsive diarrhea.

11. Supplementation with Copper

Supplementation of cattle and sheep with copper is achieved by several methods. The most widely used method is by the addition of copper salts, usually copper sulfate, to the loose mineral or salt supplements offered to the animals. The practice of dosing or drenching the animals with soluble copper salts is practiced effectively in Australia and New Zealand. Supplementation by means of topdressing of pastures with fertilizers containing copper salts has proven effective for cattle but has led to copper toxicity in sheep. The most recent method of supplementation is by the use of injectable copper supplements. These copper complexes release copper to the animal over a period of time dependent upon the nature of the injectable carrier base.

Drenching of cattle and sheep with copper salts provides a rapid temporary remedy in severely copper deficient situations. Cunningham (57) recommends supplying a weekly dosage of 3.5 grams of copper sulfate for cattle with molybdenum scours. For the prevention of swayback in lambs, a drench of 1.5 grams of copper sulfate should be administered to the ewe at least seven weeks prepartum. In lambs susceptible to delayed swayback, ataxia will not develop if the lambs are dosed with 35 milligrams of copper sulfate twice weekly from birth. Ferguson and co-workers (86, 87) found that drenching with 2 grams per cow and 1 gram per calf of copper sulfate per day was effective in the treatment of severe molybdenum induced scours. This treatment was continued until normal body copper levels were regained. This is in keeping with the recommendations by Cunningham (53) of 2 to 4 grams of copper sulfate per day as therapy for severely affected animals until recovery is complete, then 1 to 2 grams per day as long as exposed to the deficiency. One half to one gram copper sulfate per day is recommended for slightly to moderately affected cows and calves. This method of supplementation requires considerable manpower and handling of animals. In Manitoba, this type of supplementation is best suited for therapeutic treatment of deficient animals. It is not practical on a herd basis for either a therapeutic or a preventative basis.

Topdressing pastures with copper sulfate or its equivalent in other copper ores, has been effective in increasing forage copper levels (47, 166). On peat soils, annual fall topdressing with 5 pounds of copper sulfate per acre (4.5 kg/ha) has been found effective in increasing forage copper levels from 4 to 6 ppm to approximately 10 ppm, without excessive copper accumulation (62). On non-peat soils, Underwood (202) has reported that an application of 5 to 7 pounds copper sulfate per acre (4.5 to 6.3 kg/ha) has increased the forage copper content from deficient to adequate levels for cattle for several years. Where pasture land was too rough or semi-forrested, aerial application using aircraft has been found economic and effective (7). This method of supplementation is of limited advantage on strongly calcareous soils due to the poor absorption of copper by plants (97). Due to the low proportion of ranchers in Manitoba that regularly fertilize their pastures, and the high proportion of calcareous soils in the copper deficient area, this method of supplementation is limited. It should be noted that the phosphate fraction of some fertilizers may be contaminated with molybdenum. It is not known whether this contamination influences forage molybdenum concentrations.

Under range conditions in Manitoba, a more practical method of copper supplementation is by the addition of copper salts to the loose mineral or salt supplements offered to cattle. Powdered copper sulfate (25% active copper) is added to the loose salt at a level of 0.5, 1.0 or 2.0 percent copper sulfate (57, 202) or its equivalent in other copper salts. These levels represent an active copper content of 1250, 2500, or 5000 ppm copper respectively and are offered to the cattle under slight, moderate, or severely deficient conditions, as defined by blood and/or liver copper levels. When the cattle are placed on their winter hay feeding program, these levels are reduced by half (53). This is due to the lower availability of molybdenum and the increased availability of copper in dried herbage. At 60 to 90 days prepartum, the supplementary levels should be returned to the higher levels to avoid depletion of the dam's copper reserves by the fetus. Levels of 0.5 to 1.0 percent copper sulfate in salt may be offered to copper deficient sheep (202) (see restrictions below), but only during the grazing period. Supplementation at these levels during the winter feeding period may be toxic to sheep. Cupric sulfate may be added to the loose mineral rather than the salt supplement, but the active copper content in the mineral must be taken into account.

Supplementation with copper in the loose mineral or salt has several restrictions. These supplements are to be consumed at a rate of approximately 30 to 90 grams (1 to 3 ounces) per head per day by cattle. In some areas of Manitoba, consumption of salt and mineral supplements by cattle is insufficient or too irregular to provide adequate supplementation. This is due to the natural salinity of pastures or water supplies. Also, these supplements are inadequately consumed by calves under the age of 5 to 6 months. Thus, this method of supplementation has definite restrictions for cattle in Manitoba. In respect to sheep, this method of supplementation is effective only if a regular check is maintained on the intake to ensure that the safe dose rate of 225 grams (8 ounces) of copper sulfate per 1000 sheep per week is not exceeded (99).

A considerable amount of work has been conducted on the availability of copper from several oral supplements. Results from two studies (43, 128) showed that copper sulfate, nitrate and chloride were relatively equal in availability and utilization. Copper carbonate was found to be poorly retained and cupric oxide, as needles and powder, cuprous oxide as powder and metallic copper in the form of copper wire were poorly absorbed. Copper sulfide was largely unavailable and remained in the intestinal tract (188). Work by Suttle (187) has shown the actual biological availability of copper supplements to be only 4 to 11% of the administered dosage. This study is in agreement with the value of 8.6% by Smith et al. (180).

In areas where intakes of copper by grazing animals must be assured, the most convenient form of supplementation is by the use of injectable copper supplements. Two such supplements are copper glycinate[a,b] in an oil base and copper calcium ethyldiaminetetraacetate (EDTA, edetate)[c] in a water miscible base. Both are administered subcutaneously in the loose folds of the brisket area or

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[a]Cumol brand copper glycinate, 60 mg Cu/cc
Cutter Laboratories
Fourth and Parker
Berkeley, California, U.S.A. 94170

[b]Copperjec brand copper glycinate, 120 mg Cu/tube
ICI Tasman Vaccine Limited
33 Whakatiki St.
Upper Hutt, New Zealand

[c]Coprin brand copper calcium edetate, 100 mg Cu/syringe
Glaxo Group Limited, Export Supplies Division
166 High Halborne
London, U.K., WCIV 6PD

along the side of the neck. There is an irritant inflammatory response to both of these supplements with the oil base products being more severe. Injection of these supplements into the muscle tissue may lead to a large necrotic abscess and subsequent trimming losses at slaughter (6). Another injectable supplement is copper methionate[(d)] in an aqueous base. This supplement is administered by deep intramuscular injection. This product is readily available to the animal and is rapidly absorbed. The irritant swelling at the intramuscular injection site is reduced, but may be very severe when administered subcutaneously. Studies by Cunningham (58) showed that the cupric-bis-8-hydroxyquinoline 5-7 disulphonic acid salt of tetra diethylamine showed no local reaction when injected either subcutaneously or intramuscularly into sheep as an aqueous solution or as a create. This compound had no advantage over copper glycinate for use in cattle. He also found that copper citrate was unsuitable for parenteral administration in sheep. Lamand et al. (126) found copper oxide in purified olive oil to cause only a slight reaction when administered intramuscularly.

Injectable supplements are administered at 3 to 6 month intervals at levels of 120 to 240 milligrams active copper for adult cattle and 30 to 40 milligrams for adult sheep. Calves under 300 pounds are treated with 60 milligrams copper and very young calves with 30 milligrams (6, 178, 202). Swayback is prevented in lambs by admini-

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[d]Copavet brand copper methionate, 20 mg Cu/cc
C-Vet Limited
Minister House, Western Way
Bury St. Edmunds, Suffolk, U.K. IP33 3SU

stration of a single injection of 40 to 50 milligrams copper in mid-pregnancy (3, 99, 104) or immediately prior to mating (190) when infertility due to copper deficiency is suspected. Please refer to the review on toxicity for reservations on injectable copper supplementation for sheep.

Injectable supplements have several advantages over other supplemental methods. They assure that a specific dosage is received by all animals, which is most important when sheep are concerned. They reduce the inconvenience and frequency of treatment under range conditions. The utilization of injected supplements is not impaired by dietary sulfide and molybdenum (190) interactions in the gut. Therefore, the biological availability of injectable copper supplements may be superior to that of oral supplements.

12. Copper Toxicity

Ruminants lack a control mechanism to restrict absorption and liver storage of copper when ingested in levels exceeding the requirement. For this reason, copper poisoning may be a serious problem when supplementing cattle and particularly sheep. Chronic copper poisoning has three definite stages (152). The first is the accumulation of copper in the tissues with no symptoms or abnormal blood values. The second is defined by whole blood copper values in the range of twice that of normal with increased plasma bilirubin, serum glutamic oxalo acetic acid transaminase (SGOT), and lactic dehydrogenase values (170, 200). The third stage is referred to as the hemolytic crisis and is usually initiated by a stress of transportation, handling, or change of environment. Signs are abdominal pain, dullness, increased thirst, generalized icterus and hemoglobinuria. Blood values show increased methemoglobin, decreased hemoglobin and glutathione and increased blood copper levels from 5 to 8 times normal values. This is the result of degeneration of the liver cells and release of copper into the blood. The indicators of acute copper poisoning (56) include enteritis, inflammation, diarrhea, and endocardial hemorrhages indicative of a corrosive poison. Tissue copper levels are not increased as greatly as in chronic copper poisoning.

There appears to be a differential susceptibility of cattle and sheep to copper poisoning. Todd (197) is of the opinion that adult bovines are more resistant than sheep and young calves. Cattle are relatively resistant to chronic copper toxicity (106) while sheep are fairly sensitive. Acute toxicity is a problem in both cattle and sheep.

Literature reports of chronic copper poisoning of cattle show intakes of 200 to 300 milligrams of actual copper per day to be safe (56) but a daily intake of 454 milligrams to be toxic over a five month period (198). Total rations containing 72 and 115 ppm of copper have been found to be toxic (173), while a ration of 50 ppm copper was found safe for calves (213). Todd and Gribben (199) have reported high blood copper values, with reduced hemoglobin, in cattle consuming a diet of 200 ppm copper, or an effective intake of 3.3 grams copper per day. This is far over the 5 gram per day of copper sulfate (1.25 grams copper) toxic limit set by Kidder (121). Chapman et al. (44) found levels of up to 12 grams copper sulfate (3 grams copper), administered in a gelatin capsule, to be non-toxic to cattle.

When this level was administered as a drench, toxicity occurred. This difference was attributed to the lower absorption of copper sulfate when fed in the crystalline form (43).

The margin between safe and toxic dietary levels of copper supplementation in sheep is very narrow. Dietary levels of 40 to 50 ppm copper have been acutely toxic (163, 170). Levels of 11 to 12 ppm copper in the concentrate were found to cause chronic toxicity when fed at a high level in conjunction with alfalfa hay of normal molybdate and sulfate status (109).

Haemolytic crises have arisen in sheep of normal (117) and deficient (118) status when copper calcium edatate was administered at the recommended dose of 50 milligrams copper during midpregnancy. This supplement provides rapid absorption of copper, and in turn, increases the risk of copper poisoning. By reducing the dosage to 30 milligrams copper, this danger is avoided, while still providing adequate supplementation for a 6 month period under conditions where ordinary supplementation is required (58). Toxicity arises in housed sheep more frequently than in grazing sheep. This presumably is due to the higher availability of copper and lower availability of molybdenum in dried as opposed to fresh herbage. In cases where liver levels of sheep are potentially lethal, a daily intake of 100 milligrams molybdenum is recommended for prevention and treatment of copper poisoning (45).

13. Copper Residue Levels After Supplementation

Little work has been done on residue levels of copper in animals slaughtered for human consumption. With respect to sheep, hemolytic crisis occurs before the liver levels exceed the normal range of 186 to 1374 ppm dry weight cited by Underwood (202). Sheep receiving 50 milligrams of copper parenterally as copper calcium edatate, which developed hemolytic crisis, demonstrated liver and kidney copper levels of 200 to 700 ppm and 25 to 100 ppm dry weight respectively (118, 119). Sheep that developed chronic copper toxicity from consumption of high levels of concentrate showed a liver level of 1326 ppm D.W. (109). Chapman et al. (44) demonstrated increases in liver copper levels of beef cattle supplemented with 0.5 to 8.0 grams of copper sulfate daily as a gelatin capsule. Liver levels rose from 180 ppm to 500 ppm wet weight (540 to 1500 ppm D.W.). Liver copper levels of beef cattle parenterally treated with copper glycinate, and receiving a grain supplement containing 48 ppm copper (240 mg Cu/day), increased only to normal values while grazing on pastures deficient in copper and excessive in molybdenum (77). Supplementation of deficient cattle with copper should not increase liver copper levels excessively if the supplementation is kept within the recommended levels.

14. Interrelated Minerals Influenced by Copper Supplementation

Copper is antagonistic to several elements (80). Two such elements which are of concern are zinc and iodine. Increasing the intake of copper through the use of salt or mineral supplements could antagonize a potential deficiency situation of these two minerals. Therefore, the use of iodized salt is necessary when orally supplementing with copper. Also, when supplementing in areas where forage zinc levels are low, or deficient, supplementary zinc should be given in conjunction with copper. Appropriate levels of zinc supplementation are 1/2 pound zinc oxide per 100 pounds salt (0.40% zinc) when forage levels are 30 to 50 ppm zinc, and 1 pound zinc oxide per 100 pounds salt (0.80% zinc), when forages contain less than 30 ppm zinc (210).

III. INVESTIGATIONAL PROCEDURES

A. The 1974 Copper Deficiency Study

In the spring of 1974 a large scale study was initiated in the North West agricultural region of Manitoba. The objects of this study were to assess the severity and apparently increased extent of copper deficiency in beef cattle within the region. The efficacy of an injectable copper supplement, as glycinate, was also to be assessed.

1. Field Investigations

a). Description of the Study Area

i). Location and Extent - The North West agricultural region (Figure 2) extends from township (Twp) 19 northward to Twp 44 and from range 11 west (Rge 11W) diagonally along the western shores of Lakes Manitoba and Winnipegosis, westward to Rge 29W at the Saskatchewan border. The region also includes the Local Government District of Consul lying between Twp 53 and Twp 57 and Rge 25W and Rge 29W. This encompasses an area of approximately 3 million hectares (ha) (11,700 square miles). Approximately 1.5 million hectares (6000 square miles) is agriculturally productive.

ii). Geography - Doyle and Fletcher (76) described the region as descending from the western bounded escarpment plateau into the Swan and Valley River basins and eastern lowlands of post-glacial Lake Agassiz. The well drained plateau and escarpment area consists of shale bearing moderately calcareous till with predominantly Orthic Grey Luvisol (Typic Cryoboralf)[a] soils. The relatively poorly drained

[a]United States equivalent to Canadian nomenclature.

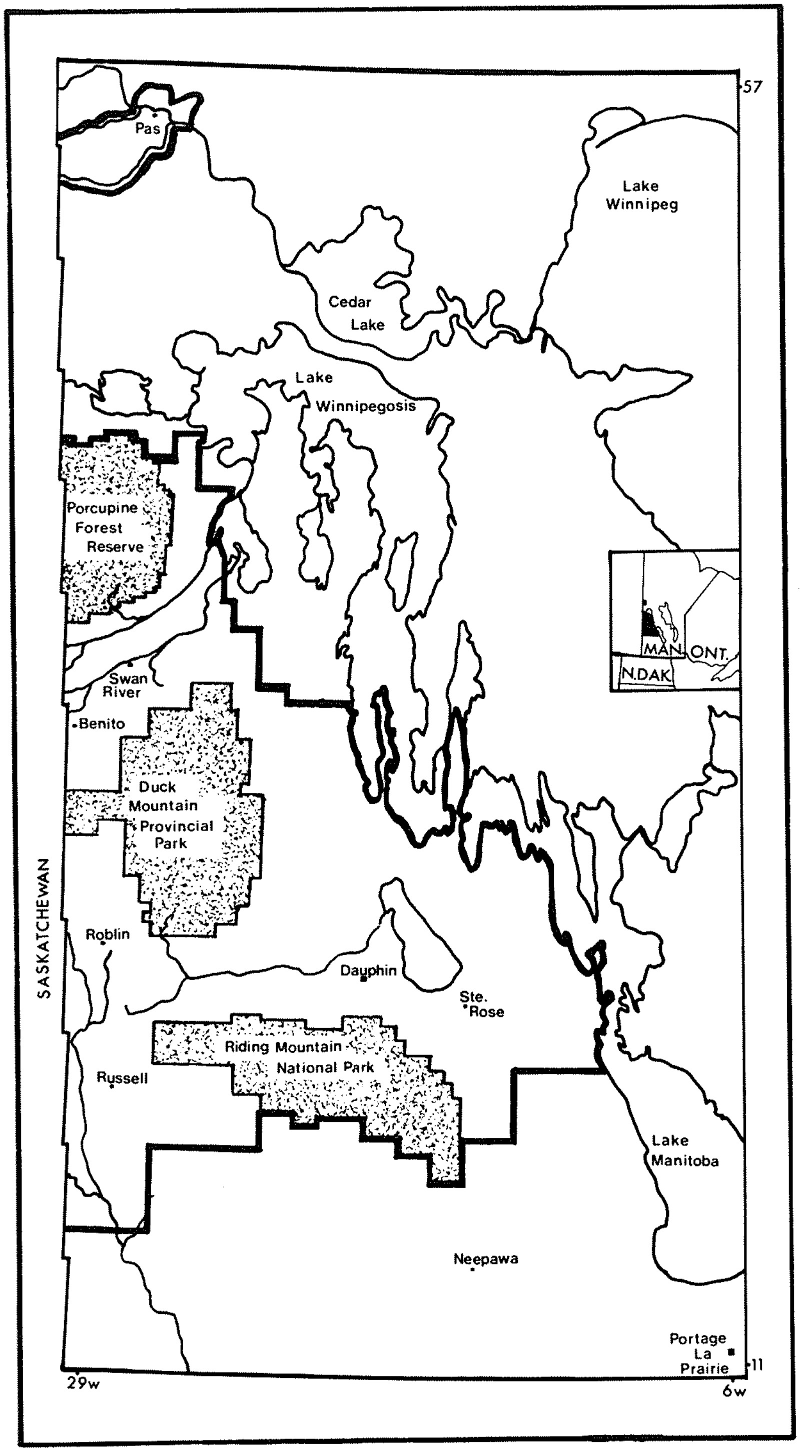

FIGURE 2. North West agricultural region of Manitoba.

river basin and lowland regions consist of a complex mixture of sand, silt and clay deposits with glacial till and recent alluvium. Soils in these areas consist of Regosols (Entisols), Gleyed Rego Black Chernozems (Aquic Halpoboralfs) and Orthic Dark Grey Luvisols (Mollic Cryoboralfs). The comparatively fertile Swan and Valley River basin areas are intensively farmed. The less productive soils of the eastern lowlands and steeply sloping western escarpment areas are utilized for mixed farming and livestock production. The frost free period ranges from 128 days in the southerly portions to 114 days in the most northern areas. Annual rainfall in the region varies from 470 to 495 millimeters with 228 to 271 mm occurring during the growing season. Due to the very rapid drop in elevation from the Riding, Duck and Porcupine Mountains, incidences of high rainfall cause a rapid run-off situation into the Swan and Valley River basins. During such periods subsequent inundation of the eastern lowland region is not uncommon, causing difficulties in agricultural production.

b). Sampling and Treatment Procedures

Thirty-one herd locations were sampled from all areas within the North West region. These herds were chosen by rural veterinary practitioners and agricultural representatives on the basis of location, accessibility and facilities for testing and owner co-operation. In addition, thirteen more herds were surveyed at the end of the pasture season. These herds were chosen from specific "problem" soil formations suspected of promoting elevated forage molybdenum levels.

i). Animal Investigations - The thirty-one test herds included in the deficiency study were sampled and allotted to treatments in May and June of 1974 and resampled at the end of the pasture season. Four of these herds were retreated and sampled again after 90 days on pasture. Two of these four herds were resampled at 30 day intervals on pasture.

Treatment and sampling were achieved by the use of a portable weigh-scale squeeze chute.[a] All test animals were identified (Appendix I) as cow plus corresponding calf units (cow-calf units) or as a single animal yearling unit. The animal units were alternately allotted to either the non-treated control or treated group as they were driven up the handling chute. The treated group of animals were parenterally injected with a copper supplement,[b] subcutaneously into the side of the neck. All animals were weighed and a sample of hair and blood were taken for copper determination. The hair was clipped from the area of the scapula and thoracic vertebrae, placed in a labelled plastic twist-tie bag and stored for future reference. Blood was drawn from the jugular vein and placed in stoppered glass tubes for serum separation.

ii). Soil and Forage Investigation - Samples of soil and forage were taken from the test herd pastures and from potential problem herd locations in the region. Sample sites within a pasture were located

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[a]Silver King Products, Heldenbrand and Son Mfg. Co., 1012-14 South Agnew, P.O. Box 82367, Oklahoma City, Oklahoma, USA, 73108.

[b]Cumol brand copper glycinate, Cutter Laboratories, Berkeley, California, USA, 94710, containing 60 mg active copper per ml. Dosage 60 mg per calf, 120 mg per animal over 500 lb (225 kg).

in an area representative of that pasture. At each sampling location, a soil probe was sunk to a depth of 15 cm (6 inches). This sample was placed in bucket A. The probe was then sunk to 60 cm (24 inches) and that sample placed in bucket B. Replacing the probe, a 5 meter cord attached to the probe was used to designate a 10 meter circle. Six subsite 0 to 15 cm soil samples were drawn from the circumference of this circle. These six samples were placed in bucket A. Samples of forage were taken from within the sampling circle with careful attention to avoid root or rain-splash soil contamination. These forage samples were placed in bucket C. The material from each bucket was mixed thoroughly and a representative sample placed in a labelled paper container for air drying.

2. <u>Laboratory Investigations</u>

a). <u>Sample Preparation</u>

i). <u>Animal Samples</u> - The initial and final body weight values were used to calculate weight gains for the cows, calves and/or yearlings at each of the thirty-one test herd locations. Body weight values were not recorded for the thirteen additional fall survey herds.

All blood samples for copper determination were processed within 48 hours of sampling. The samples were allowed to clot and the serum to separate. The clots were removed with wooden applicator sticks and the resultant serum was spun in a Sorvall centrifuge, model GLC-1 equipped with swing bucket omni carriers, at a relative centrifugal force of 477 for 8 minutes. The serum was either decanted or pipetted into labelled plastic snap-cap containers to await analysis. All hair samples were stored for reference if required after analysis of the serum samples was completed.

ii). Soil and Forage Samples - The air dry soil samples were ground in a mortar and pestle to an approximate minus 80 mesh (177 micron) fineness. These samples were then stored in labelled plastic twist-tie bags. The air dry forage samples were ground in a stainless steel mill fitted with a one millimeter screen. The ground samples were stored in labelled twist-tie plastic bags.

b). Analytical Methods

i). Serum and Hair Samples - The serum samples from this survey were analysed for total copper by the Feed Analysis Laboratory of the Manitoba Department of Agriculture. Analysis was completed by diluting a 2 milliliter alloquot of serum with 2 milliliters of deionized water, mixing and aspirating directly into a Perkin-Elmer model 403 atomic absorption spectrophotometer. The hair samples taken during this survey were not analysed for copper content. Due to the difficulties of preanalytical cleaning of the hair, it was felt that the information derived from this parameter would not warrant the analytical cost and time expenditures.

ii). Soil and Forage Samples - The soil and forage samples were for copper, zinc, iron, manganese and molybdenum by the Department of Geological Sciences, University of British Columbia, Vancouver. The samples were wet-ashed by using a nitric-perchloric acid digestion (76). Molybdenum was determined by a modified dithiol (107) colorimetric procedure. The analyses for copper, zinc, iron and manganese were completed with a Lectron AA-4 atomic absorption spectrophotometer, corrected for background absorption.

3. Statistical Analysis

The effect of treatment with parenteral copper supplementation on changes in body weight and serum copper level was determined by the covariance F-test of adjusted means in a one-way classification (183). This analysis (Appendix I) of variance was selected as it adjusted for the large variation in the initial body parameter values, thus avoiding bias to changes in those values during the test period. The initial body parameter values were designated as "X" and the change over time values as "Y". These values were used to calculate the corrected sums of squares and cross products for the total, treatment and error variations and the corresponding reduction due to regression values. These values, in turn, were used to calculate the sums of squares (SSr), mean squares (MSr) and resultant F-ratio values for the deviations from regression.

This analysis was completed for the cows, calves and/or yearlings at each herd location. The cows and calves of each cow-calf unit were analysed separately, as opposed to a single unit, in an attempt to isolate any possible differences in efficacy of the injectable supplement on the two different production phases.

B. THE 1975 AND 1976 SOIL AND FORAGE SURVEYS

Preliminary results from the 1974 Copper Supplementation Study indicated a copper deficiency problem in cattle throughout the study region. For this reason a soil and forage survey program was initiated with the Department of Geological Sciences, University of British Columbia and the Department of Plant Science, University of Manitoba. The objects of this survey were to define the type and potential severity of copper deficiency in the North West region in terms of forage copper and molybdenum levels. An attempt would also be made to correlate forage micronutrient levels to specific soil types or associations in an effort to establish deficiency patterns. These could be used as diagnostic tools for predicting deficiency problem areas.

1. Field Investigations

a). Description of the Study Area

i). Location and Extent - In 1975, approximately 1 million hectares agriculturally productive land in the study region was surveyed. The survey encompassed an area from Rge 19W to 29W by Twp 23 to 34 plus Rge 25W to 29W by Twp 35 to 38. These areas are covered by the Swan River, Grandview and Rossburn Soil Survey Reports plus an area lying between the northern border of the Grandview Soil Survey map, following a northwesterly direction along the west shore of Lake Winnipegosis, to the easterly border of the Swan River Soil Survey map area. The remaining agriculturally productive area of the region was surveyed in 1976. This included three areas including firstly, an area from Rge 11W, along the westerly shores of Lakes Manitoba and Winnipegosis, to Rge 18W by Twp 21 to 33, secondly, an area covering Rge 24W to 29W by Twp 37 to 42, and thirdly the Local Government District of

Consul from Rge 25W to 29W by Twp 53 to 56. These areas correspond to areas on the West Lake, Ste. Rose, Grahamdale, Swan River and Pasquia Soil Survey Reports.

ii). Geography - The area surveyed in 1975 represents the well drained western escarpment and Swan and Valley River basin areas. This area is steeply to gently sloping land based on shales, silts and sands of the Jurassic and Cretaceous formations of the Mesozoic period. The 1976 study area roughly corresponds to the more poorly drained eastern lowland region of glacial Lake Agassiz. This area is based on Jurassic shales, sandstone and limestone of the Mesozoic period and Middle and Upper Devonian limestone and domolite formations of the Palaeozoic period.

b). Sampling Procedures

i). Selection of Sample Sites - The sampling sites were selected at random at a frequency of 3 sites per township of 36 square miles. They were located on pasture or hayland and at a minimum distance of 50 meters from any road allowance to reduce road-dust contamination and subsoil disturbance. The sample location was selected within a pasture area to represent the immediate area in terms of topography, overburden and soil type. Each sampling site was located on Canada Survey and Soil Survey maps. Their location was identified in terms of township, range and section and in terms of Universal Transverse Mercator (UTM) Grid.

ii). Soil and Forage Samples - The sampling procedure used in the 1975 and 1976 surveys was that used in the 1974 study except that the forage samples were divided into legume and non-legume fractions. Field notes were made at each site (Appendix I). These notes contained information on site number, location in terms of township, range, section and UTM grid, soil type and parent material, forage composition and sample identification. In the 1976 survey, the sample data sheet used in 1975 was altered to include recording of analytical data and thus assist in consolidation of information. All samples were identified by year, project code, site number and consecutive sample number. For example, sample 75-NWM-17-50 is translated to 1975, North West Manitoba, Site No. 17, Sample No. 50 (each sample number is unique). Each site location and number was marked on Canada Survey and Soil Survey maps. These maps then provided the UTM co-ordinate, soil type and parent material information for the data sheets. The surveys were completed between approximately June 15 and August 15 of each year.

2. Laboratory Investigations

a). Sample Preparation

i). Soil Samples - All soil samples were air dried and stored in paper containers. Funding became available in 1977 and 1978 for analysis of the 870 soil samples taken during these two surveys. The samples were passed through a minus 10 mesh (2 mm) nylon sieve[a]. One

[a]Nitex monofilament nylon screen, Tetko Inc., distributed by B and S.H. Thompson and Co. Ltd., 235 Montpellier Blvd., St. Laurent, Montreal, Quebec, H4N 2G3.

half of each sieved sample was placed in a labelled twist-tie plastic bag for organic matter and pH determinations. The second fraction was ground in a high speed stainless steel blender and passed through a minus 80 mesh (177 micron) nylon sieve[a]. This fraction was stored in a labelled twist-tie plastic bag for determination of copper, iron, zinc, manganese and molybdenum.

ii). Forage Samples - All forage samples were allowed to air dry in the paper sampling bags. The samples were ground in a stainless steel mill fitted with a one millimeter screen, as was done in 1974. The ground samples were divided into duplicate fractions and stored in labelled twist-tie plastic bags. One duplicate fraction was sent to the Department of Geological Sciences, University of British Columbia, Vancouver, for determination of copper, iron zinc, manganese and molybdenum. The other duplicate was sent to the Department of Plant Science, University of Manitoba, Winnipeg, for calcium, phosphorus, magnesium, potassium and nitrogen determinations.

b). Analytical Methods

i). Soil Samples - Analysis of the soil samples from these surveys started in 1977 and continued, as budgetary funding became available until 1979. The minus 80 mesh fraction of soil from each sample was analysed for copper, iron, zinc, manganese and molybdenum according to the analytical methods outlined in the 1974 Copper Deficiency Study.

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[a]Nitex monofilament nylon screen, Tetko Inc., distributed by B. and S.H. Thompson and Co. Ltd., 235 Montpellier Blvd., St. Laurent, Montreal, Quebec, H4N 2G3

The minus 10 mesh sample fractions were used to determine the organic matter and pH determinations. Organic matter was determined from the weight loss incurred during ashing in a muffle furnace at 500 degrees Celsius for 3 hours. Soil pH was determined by saturating 10 grams of sample with 10 milliliters of distilled water in an 85 ml paper cup. The suspension was stirred 4 times at 10 minute intervals using a disposable plastic rod. The pH was measured after the suspension had settled for 30 minutes using a Metrohm Herisau pH meter. Preparation of organic soils required the addition of up to 40 ml of distilled water to fully saturate the 10 gram sample. After saturation of these samples of organic soils, the above procedure was followed.

ii). Forage Samples - Analysis of the forage samples from these surveys started in 1975 and was completed in 1977. The methods of determining copper, iron, zinc, manganese and molybdenum by the University of British Columbia were the same as those outlined for the 1974 Copper Deficiency Study. The analytical methods for determination of calcium, magnesium, potassium, phosphorus and nitrogen by the University of Manitoba were those of the Association of Official Analytical Chemists (10). Calcium, magnesium and potassium were determined using a Perkin-Elmer model 303 atomic absorption spectrophotometer corrected for background absorption. Phosphorus was determined colorimetrically using a Bausch & Lamb Spectronic 20 colorimeter. Nitrogen was determined by the Kjeldahl procedure.

3. Statistical Analysis

The resultant analyses from the forage samples taken during the 1975 and 1976 surveys were subdivided into three groups: legumes, native grasses and improved grasses within each year. The mean, standard deviation and range were calculated for each element, within each forage type, within each year. A Student-Newman-Keul (183) test of means (Appendix I) was run between forage types within elements, within each year. Elements were not compared between years as the areas surveyed did not represent distinctly different areas, and it was felt that any differences between survey areas would be more attributable to a year effect rather than an area effect. Within the 1975 survey, molybdenum determinations were divided into two groups for each forage type based on sample site location. Mean molybdenum values east and west of the eastern boundary of the Ashville Geological Formation were compared, within forage types, by a Student-Newman-Keul test of means. This represented a comparison of forages grown on molybdeniferous calcareous shale parent material to those grown on calcareous limestones, sandstone and recent sedimentary and alleuvial deposit parent materials, without any complicating year effects.

The soil analyses from these surveys were not completed in time for publication with this dissertation. A summary and statistical analysis of the soil analyses between soil depths and between geologic areas will be published separately.

IV. RESULTS AND DISCUSSION

A. The 1974 Copper Deficiency Study

The body parameter values for each herd location administered with injectable copper are listed in Appendix IIA. The serum copper values of the additional herds tested in the fall of 1974 are given in Appendix IIB. Appendix IIC contains the monthly change in serum copper value during the grazing season for two herds that were treated at zero and 90 days on pasture. The forage and soil analyses from locations surveyed in 1974 are listed in Appendix IID.

Several major findings can be drawn from these results. Firstly, that the average serum copper values for the cows and calves were 0.56 Ug/ml and 0.68 Ug/ml respectively in the spring of 1974 (TABLE 3). Both these values are within the range considered subnormal for cattle and indicate a potential widespread deficiency problem. Secondly, the serum copper value for the cows was considerably lower than that for the calves. This may be a reflection of the dam sacrificing her reserves of copper for the benefit of the calf or a difference in the utilization of dietary or endogenous copper. Thirdly, the serum copper levels of the cattle on pasture in the North West region tended to remain fairly constant or decline over the grazing period. This suggests a possible deficiency of available copper in the forages in this region. This is substantiated by the results in Appendix IIC where the control animals demonstrated a general decline in serum copper level during the pasture season. Fourthly, the serum copper values of cattle grazing pastures in the

TABLE 3. Summary of mean body weight (kg) and serum copper (Ug/ml) responses of cattle, with and without copper supplementation, grazing copper deficient pastures in northwestern Manitoba.

Production Type	Number of animals			Body weight response			Serum copper response		
	Total	Control	Treated	Initial	Control	Treated	Initial	Control	Treated
1. Herds subjected to treatment at 0 days on pasture (herds 1 to 27).									
	Eastern Lowlands (herds 1 to 8)								
Cow	194	95	99	454.5	21.3	24.5	0.55	0.10	0.17
Calf	194	95	99	63.1	133.5	132.5	0.68	-0.01	0.12
	Valley River Basin (herds 9 to 18)								
Cow	216	107	109	426.0	58.0	53.8	0.50	-0.10	0.02
Calf	160	79	81	67.9	124.6	121.0	0.65	-0.13	0.02
Yearling	9	4	5	270.4	88.5	92.1	0.47	0.03	0.21
	Swan River Basin (herds 19 to 27)								
Cow	152	72	80	453.5	66.3	72.3	0.61	-0.21	-0.07
Calf	152	72	80	71.3	140.9	138.8	0.66	-0.28	-0.07
Yearling	9	4	5	322.0	107.7	104.3	0.70	-0.45	-0.40

Continued ....

TABLE 3 (Continued)

Production Type	Number of animals			Body weight response			Serum copper response		
	Total	Control	Treated	Initial	Control	Treated	Initial	Control	Treated
	Mean response of herds treated at 0 days on pasture								
Cow	562	274	288	443.3	47.4	54.2	0.55	-0.06	0.05
Calf	506	246	260	67.1	132.9	130.9	0.66	-0.12	0.03
Yearling	18	8	10	296.2	98.1	98.2	0.59	-0.21	-0.10
2. Herds subjected to treatment at 0 plus 90 days on pasture (herds 28 to 31).									
	Valley River Basin								
Cow	48	25	23	410.8	54.2	41.6	0.73	-0.09	0.07
Calf	48	25	23	56.0	136.4	137.3	0.89	-0.21	-0.10
Yearling	22	11	11	230.5	145.0	144.5	0.65	-0.22	0.08
	Regional mean values at start of test								
Cow	610	299	311	440.7			0.56		
Calf	554	271	283	66.1			0.68		
Yearling	40	19	21	260.1			0.62		

Continued ....

TABLE 3 (Continued)

Production Type	Number of animals			Body weight response			Serum copper response		
	Total	Control	Treated	Initial	Control	Treated	Initial	Control	Treated
3. Herds subjected to fall sampling only (herds 32 to 44)									
	Valley River Basin (herds 43 to 44)								
Cow	99						0.44		
	Swan River Basin (herds 32 to 42)								
Cow	109						0.53		
Calf	107						0.51		

Eastern Lowlands area did not demonstrate this generalized regional decline in serum copper value (TABLE 3) to the same degree. This suggests that the forage copper deficiency situation may not be as severe in this area as in the Swan and Valley River basin areas.

1. Forage and Soil Analyses

The forage analyses shown in Appendix IID show a widespread primary and/or secondary (due to molybdenum) deficiency of copper in terms of cattle production. The levels of zinc and manganese are also below that required by cattle. The allowances for cattle of zinc and manganese are accepted as 30 to 50 ppm and 20 to 40 ppm (45, 210) respectively.

The soil analyses in Appendix IID indicate that the low forage levels of copper and zinc are a function of relatively low levels of these elements in the soil. The low levels of these elements in the forages is accentuated by the reduced availability of these cations from the soil due to the calcareous nature of the soils in the study area. This is substantiated by the very low levels of manganese in the forages compared to the content of the corresponding soil samples.

2. Body Weight Response to Supplementation

The statistical analyses of the body weight gains at each herd location are given in Appendix IIIA. The covariance F-test of adjusted means was used to test the significance of the effects of injectable copper on body weight gain in cattle grazing copper deficient pastures in the study area. A summary of the statistical analyses by herd and by animal type is given in TABLE 4.

The administration of injectable copper, as glycinate, at zero or zero plus 90 days on pasture, did not influence body weight gains in the cattle of this study ($P<0.10$). Only six of sixty-four herd groups showed a significant response to supplementation. Two of these groups (cows in herds 17 and 31) were negative responses, one of which was supplemented twice on pasture. There was no trend in a significant effect of supplementation relative to copper status of either the animal or forage at these herd locations. Therefore, these six herd groups probably represent the 10 percent (Type I) error due to chance alone. In summary, the level of supplementation, either at zero or zero plus 90 days on pasture, was inadequate to show a body weight response when administered parenterally to copper deficient cattle grazing pastures deficient in copper.

3. Serum Copper Response to Supplementation

The statistical analyses of the serum copper responses to parenteral administration of copper are listed in Appendix IIIB. Again, the covariance F-test of adjusted means was used to test for significance of response. A summary of the statistical analyses by herd and by production group is given in TABLE 4. Thirty of sixty-four herd groups showed a significant ($P<0.10$) response to treatment. All of these responses were positive. A positive response was interpreted as an increase in serum copper value when the value of the control group was constant, or increasing, during the grazing period. For herd groups in which the serum copper value of the control group declined during the grazing period, a positive response was interpreted as a reduction in this decline in serum copper value.

TABLE 4. Summary of herd group responses using the covariance F-test of adjusted means for effects of injectable copper supplementation on body weight gain and change in serum copper level in cattle grazing copper deficient pastures in northwestern Manitoba.

		Body weight response			Serum copper response		
Herd	Location	Cow	Calf	Yearling	Cow	Calf	Yearling
1	Eddystone	+	+		+	+[e][1]	
2	Ste. Rose	+	+		-	+	
3	Dauphin	+	-		+	+	
4	Rorketon	-	+		+	+[c]	
5	Winnipegosis	0	-		+[d]	+	
6	Garland	-	-		+[b]	+[e]	
7	Pine River	-	+		+	+[a]	
8	Camperville	+[a]	-		+	+	
9	Gilbert Pl.	+			+[e]		
10	Gilbert Pl.	+	+		+[c]	+[c]	
11	Grandview	-	+		+[e]	+[e]	
12	Grandview	-	+		-	+	
13	Shortdale	-	0		+	+	
14	Roblin	+	-		+	+[b]	
15	Roblin	-	-	+	+[e]	-	+[c]
16	Roblin	-	-		+[a]	+	
17	Roblin	-[a]	-		+[e]	+[d]	
18	Silverton	+	+		+	+[c]	
19	Benito	+	+		+	+	
20	Benito	-	+		+	+	
21	Kenville	+	-		+[e]	+	
22	Swan River	0	+		+	+	
23	Swan River	-	-		+[a]	+[e]	
24	Minitonas	-	+	-	+	+[a]	+[a]
25	Minitonas	+[e]	+[c]		+	+	
26	Renwer	+[d]	+		0	+	
27	Bellsite	+	-		+	-	
28[2]	Gilbert Pl.	+	-		+[b]	+	
29	Grandview	-	+	-	+[d]	+[e]	+[e]
30	Roblin	-	-		-	+[b]	
31	Roblin	-[a]	+		+[b]	+[a]	

[1a] defined as significantly different response (P<0.10), [b](P<0.05), [c](P<0.025), [d](P<0.01), [e](P<0.005) of the treated versus the control group at that herd location.

[2] Herds 28 to 31 supplemented at 0 and 90 days as opposed to 0 days on test only.

The administration of injectable copper showed responses in all herd group production types and in groups of slight, moderate and severely deficient copper status. There was no evidence of trends between response to treatment and either initial serum copper level of the herd groups or copper status of the forages at the herd location. This is because the serum response cannot be meaningfully related to the initial serum copper status, as this value does not reflect the status of the grazing animal between the initial and final test dates. Also, the forage analyses reflect the total nutrient concentrations of those samples on the sampling dates, and do not reflect fluctuations in total or available nutrient levels, especially molybdenum, with rainfall or forage type.

A possible explanation why supplementation did not give a more uniform response for different production groups, and for different locations, is that the amount of supplementation administered was inadequate to achieve this trend. The parenteral supplement was sufficient to maintain a significantly positive response in almost 50 percent of the herd test groups, but was insufficient to maintain improved serum copper levels, until the end of the test period, in the remaining groups ($P<0.10$). The serum response to treatment in these remaining groups may well have shown a response during the test period, but once the supplement was depleted, the serum level of these animals would return to or near the level of the control animals. This is substantiated by the test results of the herds treated at zero plus 90 days and blood sampled every 30 days on pasture (Appendix IIC). The control groups in these herds declined in serum copper level over the grazing period. The groups of treated animals demonstrated a slower decline in copper status with recovery by 30 days after the 90 day treatment. The administered supplement was partially effective in reducing the decline in serum copper of cattle grazing copper deficient pastures, but was ineffective in increasing serum copper levels to normal and maintaining these levels throughout the grazing period. This is supported by the total lack of normal serum copper values at the end of the test period.

B. The 1975 and 1976 Soil and Forage Surveys

1. Soil Analyses

The analyses of the soil samples from the 1975 and 1976 surveys were not completed by the end of 1978. A summary of these values will be published separately from this dissertation. The summary will investigate differences in micronutrient levels between sample depths and between major geologic areas of northwestern Manitoba.

2. Forage Analyses

The key to site locations and sample description for the 1975 survey is given in Appendix IVA. The corresponding key for the area surveyed in 1976 is given in Appendix VA. The forage analyses from the 1975 and 1976 survey areas are contained in Appendices IVB and VB respectively. The statistical analyses of the forage nutrients between forage types, within areas, are summarized in Appendices IVC and VC. The analyses of variance for molybdenum levels of the different forage types, between major geologic areas of northwestern Manitoba, are given in Appendix IVC. A summary of the analyses from the 1975 and 1976 survey areas, indicating differences in nutrient concentrations between forage types (Student-Newman-Keul test of means), is compiled in TABLE 5 below. TABLE 6 contains a breakdown of the molybdenum concentrations, within forage types, between areas east and west of the major geologic boundary lying between the Ashville and Swan River Formations.

The summary of nutrient levels of forages in TABLE 5 indicate major differences among forage types. These differences are, in general, expected for these nutrients. The major point that can be drawn from TABLE 5 is that the mean levels of several nutrients are deficient in terms of cattle production (210). The results from both surveys indicate a primary deficiency of copper and zinc in all types, a primary deficiency of manganese in improved grasses and legumes, and a secondary copper deficiency, in legumes. The molybdenum concentrations of grasses were consistently higher for both native and improved grasses in the 1975 survey area than in the 1976 survey area. Since there was insufficient overlap of survey areas, a between year effect on forage molybdenum concentrations could not be assessed. The 1975 survey area, however, did encompass areas on both sides of a major geological boundary lying between the Ashville and Swan River Geological Foundations (76). TABLE 6 shows the molybdenum concentrations of grasses to be significantly higher in both native ($P<0.05$) and improved ($P<0.01$) grasses in the area west of this boundary. This may explain the apparently less severe copper deficiency situation of the Eastern Lowlands area noted in the 1974 study.

The primary deficiencies of copper, and zinc in the forages are

TABLE 5. Analysis of nutrients between forage types within survey areas of northwestern Manitoba[1].

	1975 Survey Area				1976 Survey Area			
	n	$\bar{x}$	sd	range	n	$\bar{x}$	sd	range
Copper (ppm)								
Native grass	36	5.13a[2]	1.31	1.8- 7.3	58	4.91aA	2.70	1.4- 12.0
Improved grass	299	5.50a	1.48	1.8- 12.4	96	5.83aB	2.23	2.1- 12.6
Legume	114	7.86b	2.03	2.9- 13.4	73	10.24b	3.43	4.0- 25.8
Iron (ppm)								
Native grass	36	118.83A	85.72	31.3-392.9	57	155.21a	91.02	52.6-640.6
Improved grass	299	102.38A	76.60	34.2-443.4	94	130.43ab	52.71	46.7-611.8
Legume	114	103.82A	80.86	29.8-617.2	71	109.93b	57.95	46.7-271.2
Manganese (ppm)								
Native grass	36	50.13a	38.33	1.9-143.5	58	45.75aA	37.66	6.5-176.6
Improved grass	299	29.61b	17.49	2.2-109.2	96	36.45aB	24.35	7.2-135.4
Legume	114	18.27c	7.48	7.0- 48.6	73	20.77b	9.15	7.2- 41.7
Molybdenum (ppm)								
Native grass	36	1.79aA	1.06	0.4- 5.0	58	0.87a	0.39	0.4- 2.0
Improved grass	299	3.88aB	4.52	0.2- 42.0	96	2.43b	2.89	0.4- 16.0
Legume	114	5.88b	7.30	0.0- 64.0	73	5.30c	3.56	0.8- 20.0

Continued ....

TABLE 5 (Continued)

	1975 Survey Area				1976 Survey Area			
	n	$\bar{x}$	sd	range	n	$\bar{x}$	sd	range
<u>Zinc (ppm)</u>								
Native grass	36	19.43A	6.57	8.9- 36.7	58	24.93A	11.42	9.1- 63.6
Improved grass	299	18.82A	5.48	6.5- 46.5	96	22.20aA	7.66	8.3- 55.0
Legume	114	20.09A	6.71	7.3- 48.7	73	32.09b	16.84	12.4-126.1
<u>Nitrogen (%)</u>								
Native grass	36	1.21a	0.35	0.75-2.14	58	1.63a	0.68	0.71-3.58
Improved grass	299	1.40b	0.39	0.77-4.11	94	2.11b	0.78	0.85-4.75
Legume	107	2.73c	0.54	1.14-4.32	69	3.70c	0.89	1.57-5.62
<u>Phosphorus (%)</u>								
Native grass	36	0.13a	0.06	0.05-0.31	58	0.15a	0.11	0.05-0.82
Improved grass	299	0.19b	0.07	0.05-0.38	94	0.19b	0.08	0.07-0.41
Legume	109	0.22c	0.07	0.07-0.50	69	0.24c	0.12	0.07-0.78
<u>Calcium (%)</u>								
Native grass	36	0.27A	0.06	0.15-0.45	58	0.45A	0.19	0.18-1.47
Improved grass	300	0.29aA	0.09	0.15-1.14	94	0.48aA	0.23	0.19-1.74
Legume	109	1.31b	0.38	0.14-2.20	69	1.91b	0.66	1.56-3.07

Continued ....

TABLE 5 (Continued)

	1975 Survey Area				1976 Survey Area			
	n	$\bar{x}$	sd	range	n	$\bar{x}$	sd	range
<u>Magnesium (%)</u>								
Native grass	36	0.18A	0.06	0.09-0.31	58	0.24A	0.13	0.04-0.99
Improved grass	300	0.16aA	0.05	0.05-0.38	94	0.28aA	0.13	0.08-0.81
Legume	109	0.34b	0.12	0.08-0.70	69	0.51b	0.28	0.22-1.80
<u>Potassium (%)</u>								
Native grass	36	0.60a	0.31	0.23-1.55	58	0.90a	0.61	0.20-2.62
Improved grass	300	0.79b	0.38	0.23-2.26	94	1.23b	0.67	0.23-3.24
Legume	109	1.39c	0.45	0.22-2.47	69	1.75c	0.77	0.12-3.65

[1]Air dry basis, 90% DM.

[2]Means followed by the different letter are significantly different; capitals $P<0.05$; small letters $P<0.01$.

TABLE 6. Molybdenum concentrations of different forage types between areas east and west of the eastern boundary of the Ashville Geological Formation in northwestern Manitoba[1].

	1975 Survey Area			
	n	$\bar{x}$	sd	range
Native Grass				
East	23	1.40A[2]	0.69	0.4- 4.0
West	13	2.48B	1.28	1.2- 5.0
Total	36	1.79	1.07	0.4- 5.0
Improved Grass				
East	48	1.70a	1.25	0.6- 8.0
West	251	4.29b	4.80	0.2-42.0
Total	299	3.88	4.52	0.2-42.0
Legume				
East	15	4.87	1.93	1.6- 8.0
West	99	6.03	7.79	0.0-64.0
Total	114	5.88	7.30	0.0-64.0

[1] ppm, air dry 90% DM

[2] Means followed by different letters are significantly different; capitals $P<0.05$; small letters $P<0.01$.

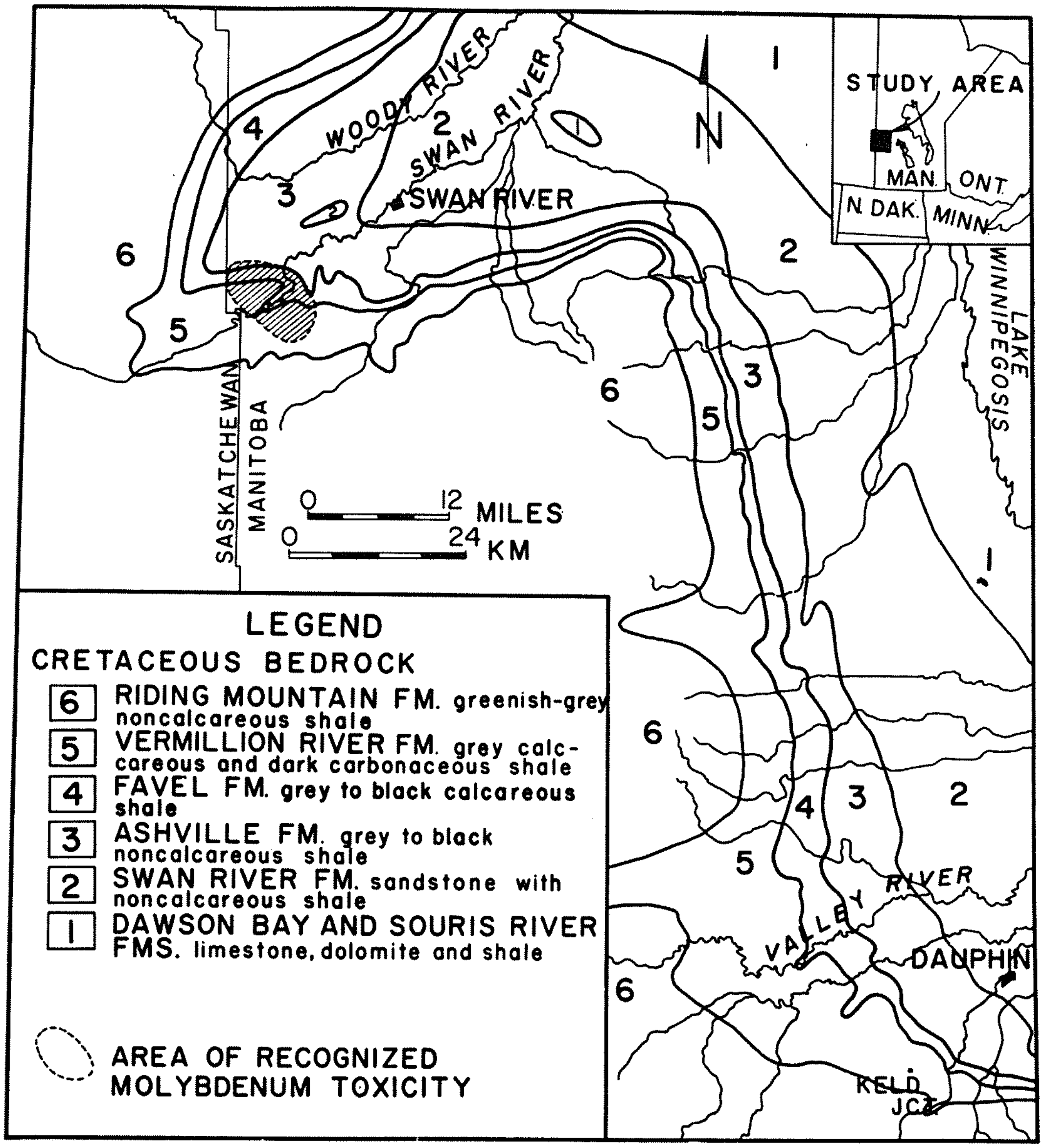

FIGURE 3. Bedrock geology of the 1975 soil and forage survey area (from Doyle and Fletcher, 76).

probably due, in part, to low concentrations in the soil, as indicated in the soil analyses in Appendix IID. These deficiencies are also likely due, in part, to reduced availabilities of copper, zinc and manganese from the calcareous soils (32) in the survey areas. The elevated molybdenum concentrations of legume forages are due to their action of concentrating absorbed molybdates for utilization in nitrogen fixation. The elevated molybdenum levels of grasses in the area west of the Swan River Formation (Figure 3) can be related to elevated soil molybdenum levels derived from the shale bearing parent materials of the Ashville, Favel, Vermillion River and Riding Mountain Geologic Formations (157, 76). These elevated soil molybdenum levels are generally confined to soils derived from these formations and are not found in the area comprised of the Swan River, Amaranth, Reston, Melita, Waskada, Ashern, Elm Point, Winnipegosis and Dawson Bay Formations of the Eastern Lowlands, which are derived from limestone and sandstone parent materials devoid of shales, with two exceptions. These exceptions are, firstly, along stream beds where alluvial action and, secondly, in areas of glacial sediment shift action, has carried molybdeniferous soils or shale material into nonmolybdeniferous areas. There may also be an effect of phosphate fertilizers, contaminated with molybdates, in the more intensively farmed areas west of the Swan River Formation. There is no estimate of the significance of this factor at this time.

V. SUMMARY AND CONCLUSIONS

1. Serum analyses from 44 herds of beef cattle identified a situation of widespread copper deficiency throughout the North West agricultural region. The severity of deficiency ranged from slight to severe (below 0.5 Ug/ml) in the herd test groups.

2. Forage analyses demonstrated low copper and/or elevated molybdenum levels in the forages at these test herd locations in relation to cattle production.

3. Forage analyses also identified a potential situation of primary zinc and manganese deficiency in cattle due to low concentrations of these nutrients in pasture forages.

4. Analyses of corresponding soil and forage samples indicated that the low level of copper and zinc in forages were probably due to low nutrient concentrations in the soil. The low forage concentration of manganese, and to some extent copper and zinc, has been attributed to low cation availability from calcareous soils.

5. The parenteral administration of injectable copper as glycinate to grazing cattle, at a dosage of 60 mg copper per calf and 120 mg copper per animal over 225 kg, at zero or zero and 90 days on pasture, did not affect body weight gain ($P<0.10$). Supplementation was sufficient to maintain a positive serum response in approximately half the herd test groups over the grazing season ($P<0.10$), but was inadequate to increase serum copper levels to normal and to maintain these levels throughout the pasture period.

6. A major soil and forage survey was undertaken to identify the type, severity and extent of copper deficient pastures affecting cattle in northwestern Manitoba. The forage analyses from the survey areas identified differences ($P<0.01$) in nutrient concentrations among forage types.

7. The forage analyses confirmed primary deficiencies of copper, zinc and manganese required for cattle production. Elevated forage molybdenum levels, sufficient to cause a potential secondary copper deficiency in cattle, were identified in legumes throughout the survey areas, and in grasses located on soils derived from the shale bearing Ashville, Favel, Vermillion River and Riding Mountain Geologica Formations.

8. The geological factors associated with nutrient imbalances in the North West region extend into all agricultural regions of Manitoba. The extent of possible nutrient imbalances in these areas requires identification.

VI. RECOMMENDATIONS

1. The dosage of injectable copper may have to be increased to twice the level administered in the 1974 study or administered at 30 day intervals until the animal reaches normal copper status and then administered at 90 day intervals as long as the animal is grazing deficient pastures.

2. The low concentrations of forage copper, zinc and manganese define the need for additional supplementation of these nutrients for more efficient cattle production. Supplementation may be carried out by adjusting the levels of active copper, zinc and manganese to 0.25%, 0.80% and 0.31% respectively (210) in the free choice mineral supplement. In areas of molybdenum toxicity, the copper level may be raised to 0.50% while the cattle are on affected pastures. This mineral may be added to the grain supplement at a level of one percent, providing that no other sources of supplemental copper, zinc or manganese are added to the ration formulation.

3. For production systems where mineral supplementation is impractical, injectable supplements are indicated. A concerted effort is required to legalize such supplements for use in Manitoba.

4. Estimates of the true availabilities of forage micronutrients under the conditions present in northwestern Manitoba are indicated.

5. Estimates of the losses in cattle production due to the potential deficiencies of copper, zinc and manganese identified in this study are required.

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Appendix I

Sample information sheets, illustrations of copper deficiency and analyses of variance

Figure 1. Sampling data sheet for the 1974 copper deficiency study.

OWNER'S NAME ______________________________ Page ____ of ____

TIME OF SAMPLING __________________________

HERD LOCATION: Sec. ______ Twp. ______ Rge. ______

Cow Calf Unit		Age	Ear Tag No.	Wt.	Hair Sample No.	Treat-ment (ml.)	Not Treated (check)	Breed
A	Cow							
B	Calf							
A	Cow							
B	Calf							
A	Cow							
B	Calf							
A	Cow							
B	Calf							
A	Cow							
B	Calf							
A	Cow							
B	Calf							
A	Cow							
B	Calf							
A	Cow							
B	Calf							
A	Cow							
B	Calf							

Figure 2. 1975 soil and forage survey data sheet.

SITE # SAMPLER DATE

LOCATION
TOWNSHIP RANGE SECTION

UTM EAST NORTH

SOIL PARENT MATERIAL

SOIL MAP UNIT

SITE DRAINAGE

FORAGE COMPOSITION

GENERAL COMMENTS

SOIL SAMPLES SAMPLE #	DEPTH (IN)	TEXTURE	COMMENTS

FORAGE SAMPLES SAMPLE #	TYPE	COMMENTS

Figure 3. 1976 soil and forage survey data sheet.

SITE # ______________ DATE ______________________

LOCATION: TP _______ RGE _______ SEC _______

UTM: EAST ______________ NORTH ______________

SOIL PARENT MATERIAL: ____

SOIL MAP UNIT: ____

SITE DRAINAGE: ____

FORAGE COMPOSITION: ____

SOIL SAMPLES:

SAMPLE #	DEPTH (IN)	TEXTURE

FORAGE SAMPLES: Analysis

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo

SAMPLE #	N	K	P	Ca	Mg	

Comments:

FIGURE 4. A 3 month old calf demonstrating signs of severe copper deficiency. Note the rough hair coat, enlarged leg joints, stiffness in the hind legs and general unthriftyness.

FIGURE 5. A cow demonstrating severe scouring associated with molybdenum induced copper deficiency.

Table 1. Covariance F-test of adjusted means for a one-way classification.

1. Derive corrected sums of squares and products for total, treatment and error sources of variation.

2. Calculate the reduction due to regression "Red." for total and error variations by Red.$=(\Sigma xy)^2/ x^2$.

3. Calculate the deviation sums of squares for total and error variations by SSr $= \Sigma y^2 -$ Red.

4. Derive SSr for treatment by SSr total - SSr error.

5. Calculate MSr for treatment and error variation and F ratio.

Source	df	Σx^2	Σxy	Σy^2	Red.	Deviations from regression		
						df	SSr	MSr
Treatment	2	73.0	145.8	293.6				
Total	29	665.9	731.2	1,288.7	802.9	28	485.8	
Error	27	592.9	585.4	995.1	578.0	26	417.1	16.04
F = 2.14						2	68.7	34.35

Table 2. Student-Newman-Keul's test of ordered means.

1. Derive mean square error from one-way analysis of variance.

2. If the variation due to treatment is significant then order the treatment means by size and calculate the differences between ordered means.

3. The test statistic Wr is defined as:

$$q_{r,\alpha,v}\sqrt{\frac{\text{MS error}}{2}\ \frac{1}{n_i} + \frac{1}{n_j}}$$

where q is the value from the Q table at r number of ordered means, level of significance, and v degrees of freedom for error. The corrected n value is used due to the large difference in treatment numbers (n).

4. Differences between means larger than the test statistic are significant.

Appendix II

Results of the 1974 Copper Supplementation Trial

"X" is defined as the initial body parameter in terms of weight or serum copper level.

"Y" is defined as the change in parameters by the termination of the trial period.

Appendix IIA

Summary of Body Weight and Serum Copper Data

All data is in terms of complete cow calf units. If any information was absent from any unit then that unit was omitted.

Herd 1 74-05-17/74-10-10

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					Cow				
2	850	105	0.64	0.06	1	905	225	0.60	0.02
4	910	165	0.82	-0.12	3	1070	85	0.56	0.22
6	1025	50	0.76	0.34	5	985	35	0.60	0.12
8	1030	0	1.18	0	7	920	80	0.60	0.22
10	920	95	0.74	-0.02	9	1180	25	0.60	0.32
12	1135	50	0.76	0.02	11	895	65	0.76	0.02
18	1080	-5	0.86	0.10	13	885	75	0.62	0.12
20	1275	-35	0.78	-0.12	15	820	155	0.60	0.08
22	1195	85	0.76	-0.2	17	765	110	0.82	-0.02
24	1180	-5	0.84	-0.06	19	925	75	0.74	0.18
26	1300	-25	0.76	-0.10	21	1215	25	0.82	-0.10
28	1060	50	0.58	0.06	23	1155	95	0.74	+0.20
30	860	65	0.60	0.02	27	1220	20	0.82	-0.12
32	1190	20	0.78	0	29	1440	-15	0.76	-0.06
34	1205	-55	0.68	0.02	31	1150	75	0.70	-0.04
36	1050	75	0.78	0.02	33	1170	35	0.92	-0.06
38	1105	120	0.70	0.02	35	955	55	0.56	0.12
40	1100	125	0.68	-0.02	37	1355	45	1.06	-0.30
42	1325	35	0.74	-0.10	41	1015	105	0.70	0.10
44	940	60	0.86	-0.06	43	960	90	0.70	-0.02
$\bar{x}$	1086.8	48.8	0.77	-0.01		1049.3	73.0	0.71	0.05

Herd 1 74-05-17/74-10-10

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Calf					Calf				
2	185	295	0.64	0.16	1	170	295	0.96	0
4	150	235	0.92	0.02	3	150	335	0.58	0.42
6	130	300	0.78	0.12	5	100	285	0.70	0.24
8	140	305	0.66	0.22	7	80	245	0.82	0.08
10	175	300	0.84	0.02	9	265	380	0.50	0.34
12	165	325	0.84	-0.06	11	150	270	0.70	0.18
18	165	275	0.74	0.16	13	145	290	0.90	-0.06
20	225	445	0.54	0.12	15	125	255	0.76	0.22
22	170	355	0.62	0.24	17	145	245	0.70	0.32
24	140	275	0.72	0.08	19	180	300	0.86	0.28
26	140	320	0.74	0.06	21	155	275	0.80	0.18
28	125	295	0.54	0.14	23	195	275	0.30	0.68
30	105	290	0.90	-0.18	27	155	260	0.76	0.18
32	115	185	0.84	-0.22	29	155	325	0.78	0.16
34	160	340	0.74	-0.08	31	140	315	0.76	0.18
36	180	345	0.64	0.12	33	140	310	0.72	0.12
38	160	315	0.64	0.22	35	140	300	0.88	-0.20
40	155	320	0.56	0.20	37	190	260	0.82	-0.10
42	135	450	0.64	0.04	41	100	280	0.98	-0.18
44	190	300	0.58	0.08	43	210	330	0.66	0.08
$\bar{x}$	155.5	313.5	0.71	0.07		154.5	291.5	0.75	0.16

Herd 2 74-05-10/74-10-10

CONTROL

Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow				
6	1170	65	0.54	0.06
10	1050	40	0.38	0.22
14	860	100	0.54	0.12
16	705	50	0.54	0.30
18	655	-75	0.62	0.42
20	635	50	0.52	0.12
30	1035	90	0.58	0.38
32	880	15	0.36	0.50
34	890	40	0.48	0.54
40	925	115	0.20	1.06
$\bar{x}$	808.5	49.0	0.48	0.37

TREATED

Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow				
1	1160	0	0.56	0.02
5	800	130	0.42	0.42
7	645	40	0.60	0.28
9	815	55	0.44	0.24
11	960	45	0.48	0.24
13	645	50	0.60	0.20
17	925	60	0.60	0.16
19	965	65	0.30	0.32
21	795	110	0.64	0.20
25	995	5	0.28	0.72
29	665	95	0.58	0.52
21	785	55	0.56	0.16
33	825	195	0.56	0.30
35	745	80	0.60	0.10
43	1085	90	0.46	0.42
$\bar{x}$	854.0	71.7	0.51	0.29

Herd 2 74-05-10/74-11-29

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Calf				
6	80	320	0.96	-0.36
10	120	375	0.98	-0.16
14	145	275	0.50	0.36
16	85	190	0.78	0.10
18	75	95	0.92	0.08
20	105	150	1.00	-0.14
30	145	285	0.78	0.42
32	110	325	0.90	0.32
34	100	275	0.76	0.34
40	105	250	0.64	0.14
$\bar{x}$	107.0	254.0	0.82	0.11

Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Calf				
1	125	345	0.80	-0.04
5	75	220	0.64	0.16
7	75	275	1.14	0.12
9	115	275	0.56	0.26
11	80	305	0.78	0.04
13	110	225	0.58	0.08
17	145	300	0.68	0.18
19	75	290	0.44	0.48
21	105	285	0.86	-0.10
25	75	275	0.98	-0.26
29	75	185	1.10	0.02
31	85	305	1.00	-0.10
33	85	195	0.96	-0.20
35	115	270	0.82	0.08
43	105	280	0.80	0.10
$\bar{x}$	96.3	268.7	0.81	0.04

Herd 3

74-05-13/74-12-10

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					**Cow**				
2	935	70	0.46	0.22	1	1010	200	0.76	-0.10
4	1140	65	0.54	0.14	3	1000	140	0.78	-0.10
6	1115	110	0.54	-0.02	5	950	135	0.38	0.22
8	935	190	0.54	-0.04	7	910	200	0.68	-0.08
10	1020	130	0.46	0.10	9	915	185	0.68	-0.06
12	1025	105	0.56	-0.16	11	1150	155	0.68	-0.04
14	1040	205	0.56	-0.10	15	830	130	0.50	0.14
16	925	185	0.62	0.10	17	960	220	0.46	0.24
18	1100	125	0.62	0.00	19	850	160	0.46	0.24
20	960	130	0.44	0.28	21	1065	25	0.46	0.04
22	1050	80	0.56	-0.06	23	895	105	0.44	0.52
24	935	190	0.30	0.60	25	1000	115	0.52	0.48
26	1190	150	0.70	0.20	27	1165	220	0.84	-0.10
28	1025	110	0.48	-0.02	29	925	125	0.40	0.22
$\bar{x}$	1028.2	131.8	0.53	0.09		973.2	151.1	0.57	0.12

Herd 3

74-05-13/74-12-10

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Calf					Calf				
2	105	345	0.68	-0.30	1	180	440	1.02	-0.24
4	175	330	0.82	-0.16	3	165	370	0.92	-0.12
6	170	430	0.86	-0.52	5	140	290	0.84	-0.24
8	155	345	0.76	-0.16	7	215	410	0.88	0.02
10	150	325	0.66	0.18	9	105	380	0.92	-0.20
12	200	405	0.76	0.06	11	150	320	0.86	0.00
14	185	420	0.74	-0.34	15	165	350	0.70	0.12
16	170	390	0.74	-0.12	17	115	285	0.92	-0.10
18	165	355	1.10	-0.62	19	145	305	0.82	-0.14
20	170	320	0.78	0.04	21	120	455	0.66	-0.06
22	185	430	0.64	0.00	23	130	300	0.72	0.14
24	135	345	0.78	0.42	25	90	420	1.12	0.14
26	115	360	0.86	0.18	27	335	425	0.62	0.10
28	145	320	1.06	-0.38	29	80	325	0.76	0.12
$\bar{x}$	158.9	365.7	0.80	-0.12		152.5	362.5	0.84	-0.03

Herd 4

74-06-25/74-11-01

	CONTROL					TREATED			
	Body Weight (lb)		Serum Cu (Ug/ml)			Body Weight (lb)		Serum Cu (Ug/ml)	
Unit No.	X	Y	X	Y	Unit No.	X	Y	X	Y
<u>Cow</u>					<u>Cow</u>				
2	1000	80	0.64	-0.14	1	900	40	0.64	0.04
6	735	70	0.50	0.06	7	880	70	0.62	0.12
8	905	85	0.70	0.0	9	920	120	0.84	-0.10
12	900	180	0.20	0.0	11	950	20	0.62	-0.10
18	955	105	0.76	-0.16	15	835	115	0.64	0.04
24	1000	115	0.56	-0.10	17	930	105	0.44	0.12
$\bar{x}$	915.8	105.8	0.56	-0.06		902.5	78.3	0.63	0.02
<u>Calf</u>					<u>Calf</u>				
2	225	275	0.78	-0.20	1	225	275	0.64	-0.04
6	130	210	0.66	-0.02	7	160	200	0.68	0.10
8	185	235	0.68	-0.14	9	225	195	0.60	0.18
12	120	150	0.92	-0.30	11	195	255	0.60	-0.06
18	235	195	0.66	0.02	15	155	235	0.68	0.06
24	190	215	0.70	0.02	17	155	225	0.46	0.04
$\bar{x}$	180.8	213.3	0.73	-0.10		185.8	230.8	0.61	0.06

Herd 5

74-05-14/74-10-10

	CONTROL					TREATED			
Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)		Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)	
	X	Y	X	Y		X	Y	X	Y
Cow					Cow				
2	1020	65	0.70	0.06	1	1005	95	0.80	0.80
4	1215	-5	0.54	0.06	3	955	145	0.52	0.10
6	850	160	0.58	0.04	5	1285	65	0.52	0.24
8	1030	35	0.66	-0.02	9	1120	-60	0.54	0.24
12	870	-20	0.58	0.14	11	1025	65	0.62	0.16
14	1075	135	0.58	0.08	13	840	-5	0.52	0.28
16	1245	5	0.58	0.04	15	1165	110	0.60	0.12
18	1330	70	0.58	0.10	17	1095	-70	0.60	0.16
20	1160	5	0.56	0.02	19	1165	125	0.58	0.20
22	1055	30	0.64	0.32	21	1190	120	0.72	0.12
24	1095	30	0.64	-0.06	25	1190	35	0.64	0.12
28	1245	30	0.66	0.06	27	960	105	0.58	0.14
30	950	225	0.70	-0.08	29	1165	35	0.54	0.08
$\bar{x}$	1087.69	58.85	0.62	0.06		1176.92	58.85	0.60	0.21

Herd 5 74-05-14/74-10-10

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Calf					Calf				
2	130	310	0.70	0	1	135	325	0.86	-0.02
4	115	300	0.74	-0.08	3	100	230	0.84	-0.18
6	145	280	0.60	0.04	5	95	295	0.94	-0.04
8	125	295	0.62	0.10	9	115	275	0.74	-0.04
12	155	340	0.74	-0.40	11	120	300	1.20	-0.46
14	75	210	0.86	-0.14	13	130	320	0.86	-0.16
16	90	245	0.70	0.08	15	100	265	1.06	-0.32
18	110	275	0.82	-0.04	17	110	265	0.86	0.14
20	100	290	1.58	-0.86	19	115	305	0.72	0
22	140	280	0.68	0.04	21	100	250	0.78	0.02
24	125	290	2.64	-1.92	25	95	270	0.78	-0.06
28	120	280	0.76	0.02	27	100	260	0.78	-0.14
30	120	290	1.08	-0.32	29	120	270	0.62	-0.24
$\bar{x}$	119.23	283.46	0.96	-0.27		110.38	279.23	0.87	-0.12

Herd 6

74-05-15/74-11-07

Unit No.	CONTROL Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	TREATED Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					Cow				
2	825	100	0.22	0.48	1	865	195	0.20	0.24
4	930	125	0.20	0.12	3	765	170	0.24	0.46
6	885	105	0.20	0.24	7	875	135	0.24	0.40
8	850	175	0.18	0.30	9	785	140	0.24	0.40
10	1115	40	0.22	0.28	11	1240	65	0.22	0.52
12	820	170	0.14	0.28	13	870	180	0.14	0.42
14	985	130	0.14	0.46	15	1170	100	0.14	0.44
16	1175	60	0.20	0.26	17	770	165	0.18	0.46
18	960	240	0.14	0.44	19	960	65	0.22	0.42
20	1000	200	0.20	0.38	25	800	110	0.30	0.22
26	875	225	0.20	0.22	27	1220	-20	0.20	0.44
28	745	185	0.24	0.26	29	965	90	0.20	0.44
32	900	135	0.24	0.42	31	1050	200	0.14	0.46
36	1075	100	0.20	0.38	37	895	-20	0.22	0.44
40	1090	100	0.20	0.38	39	900	95	0.18	0.26
$\bar{x}$	948.67	139.33	0.19	0.33		942.0	111.33	0.20	0.40

Herd 6 74-05-15/74-11-07

	CONTROL					TREATED			
	Body Weight (lb)		Serum Cu (Ug/ml)			Body Weight (lb)		Serum Cu (Ug/ml)	
Unit No.	X	Y	X	Y	Unit No.	X	Y	X	Y
Calf					**Calf**				
2	160	370	0.18	0.28	1	180	330	0.40	0.10
4	170	355	0.18	0.28	3	110	315	0.28	0.12
6	110	305	0.22	0.34	7	195	380	0.18	0.54
8	115	305	0.20	0.16	9	170	380	0.12	0.42
10	130	355	0.40	0.22	11	135	255	0.14	0.60
12	95	345	0.26	0.02	13	150	360	0.14	0.48
14	105	275	0.22	0.16	15	135	370	0.30	0.16
16	115	355	0.08	0.26	17	110	320	0.32	0.32
18	110	365	0.54	-0.20	19	190	340	0.44	0.28
20	150	330	0.54	0.02	25	150	350	0.18	0.44
26	120	300	0.20	0.08	27	165	425	0.18	0.38
28	170	435	0.20	0.24	29	110	265	0.14	0.56
32	85	295	0.56	0	31	110	275	0.10	0.40
36	135	325	0.30	0.14	37	125	280	0.12	0.52
40	120	330	0.50	-0.02	39	105	315	0.10	0.60
$\bar{x}$	126.0	336.3	0.31	0.13		142.67	330.67	0.21	0.39

Herd 7 74-05-14/74-10-02

CONTROL					TREATED				
Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)		Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)	
	X	Y	X	Y		X	Y	X	Y
Cow					Cow				
4	855	75	0.78	-0.22	1	855	-105	0.72	-0.22
6	1085	-185	0.94	-0.08	3	860	-110	0.50	0.06
10	1200	-240	0.66	0.24	5	1115	-315	0.76	0.14
16	1055	-35	0.80	0.02	7	1120	-195	0.58	-0.12
18	1050	10	0.72	-0.02	9	1100	-100	0.60	0.18
22	895	-95	0.62	-0.02	13	885	35	0.80	0.16
28	1080	-180	0.56	-0.18	29	1085	-185	0.66	0.18
32	1060	-225	0.74	-0.18	31	1135	-310	0.38	0.26
34	1085	-160	0.52	-0.02	33	1055	-180	0.60	0.36
44	1165	-245	0.66	-0.16	35	1065	-145	0.48	0.10
46	1100	-365	0.74	-0.04	37	1060	-310	0.58	0.14
48	1075	-215	0.74	0.04	45	1080	-250	0.82	0
50	1215	-415	0.64	0.06	47	1180	-250	0.70	-0.18
$\bar{x}$	1070.77	-175.0	0.70	-0.04		1045.77	-186.15	0.63	0.08

Herd 7 74-05-14/74-10-02

Unit No.	CONTROL Body Weight (lb)		CONTROL Serum Cu (Ug/ml)		Unit No.	TREATED Body Weight (lb)		TREATED Serum Cu (Ug/ml)	
	X	Y	X	Y		X	Y	X	Y
Calf					Calf				
4	130	250	0.74	-0.22	1	165	255	0.74	-0.08
6	120	265	0.78	0.12	3	95	265	0.20	0.52
10	100	260	0.80	0.14	5	180	335	0.74	0.22
16	130	185	0.72	0.10	7	160	260	0.24	0.22
18	125	190	0.72	0.20	9	205	280	0.30	0.52
22	120	225	0.72	0	13	145	245	0.64	0.24
28	115	235	0.66	-0.04	29	115	270	0.60	-0.02
32	160	190	0.30	0.36	31	185	300	0.46	0.42
34	145	215	0.54	0.10	33	135	265	0.38	0.50
44	200	290	0.20	0.40	35	160	215	0.64	0.16
46	85	195	0.70	0.10	37	175	240	0.40	0.32
48	140	205	0.62	-0.08	45	120	220	0.58	0.54
50	100	225	0.76	-0.26	47	115	260	0.70	0.04
$\bar{x}$	128.46	225.38	0.64	0.07		150.38	262.31	0.51	0.28

Herd 8 74-05-16/74-10-25

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
<u>Cow</u>					<u>Cow</u>				
2	1110	-70	0.42	0.06	15	840	55	0.54	-0.06
10	765	75	0.60	-0.02	17	935	130	0.54	0.06
14	1025	-65	0.60	0.04	23	900	35	0.50	0.08
22	950	-10	0.58	-0.04					
$\bar{x}$	962.5	-17.5	0.55	0.01		891.67	73.33	0.53	0.03
<u>Calf</u>					<u>Calf</u>				
2	225	280	0.58	-0.04	15	80	240	0.88	-0.18
10	90	225	0.92	-0.16	17	195	195	0.52	0.38
14	195	305	0.92	-0.26	23	100	170	0.82	0.08
22	170	290	0.64	0.14					
$\bar{x}$	170.0	275.0	0.77	-0.08		125.0	201.67	0.74	0.09

Herd 9 74-05-05/74-11-20

Unit No.	CONTROL Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	TREATED Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					Cow				
1	1200	80	0.48	-0.16	1	765	255	0.56	0.02
2	550	135	0.64	-0.30	2	1040	120	0.28	0.00
3	825	150	0.68	-0.40	4	1230	220	0.52	0.08
5	650	95	0.40	-0.26	5	1050	250	0.46	-0.32
6	825	135	0.50	-0.28	8	1020	120	0.30	-0.04
7	765	370	0.40	0.36	9	1260	155	0.50	0.10
9	755	300	0.60	0.00	10	955	215	0.68	0.10
10	735	40	0.52	-0.20	11	750	185	0.86	0.02
11	780	-40	0.54	-0.32	12	975	165	0.34	0.18
12	725	55	0.60	-0.18	13	1240	110	0.58	0.08
13	730	110	0.82	-0.40	14	870	180	0.38	-0.16
15	740	195	0.92	-0.76	15	1000	35	0.46	-0.22
16	1065	20	0.36	-0.14	16	1190	-110	0.50	-0.12
17	970	-10	0.40	-0.14	17	1090	-10	0.58	-0.36
18	700	225	0.54	-0.32	18	985	100	0.56	-0.14
20	840	110	0.64	-0.16	19	745	265	0.46	0.10
22	1300	25	0.76	-0.38	21	745	5	0.70	-0.40
23	1160	-50	0.30	-0.08	22	850	45	0.40	0.24
26	1025	-25	0.66	-0.42	23	1000	185	0.66	-0.28

Herd 9 74-05-05/74-11-20

	CONTROL					TREATED			
Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)		Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)	
	X	Y	X	Y		X	Y	X	Y
Cow					Cow				
27	1075	40	0.48	-0.10	25	1040	130	0.48	-0.06
28	1130	-5	0.40	-0.18	26	975	110	0.54	-0.24
29	885	25	0.42	-0.16	27	1150	-55	0.56	-0.14
30	1210	180	0.40	-0.10	29	900	-10	0.34	-0.14
31	900	50	0.42	-0.20	30	990	40	0.44	-0.18
32	1065	35	0.40	-0.14	31	1255	80	0.64	-0.30
33	1200	40	0.54	-0.28	32	1280	-20	0.22	-0.02
34	1025	90	0.48	-0.34	33	1235	-35	0.66	-0.26
35	880	155	0.34	-0.16	35	740	250	0.44	-0.24
$\bar{x}$	918.21	90.36	0.52	-0.22		1011.61	107.14	0.50	-0.10

Herd 10 74-06-24/74-10-29

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					**Cow**				
2	815	90	0.36	0.16	1	895	105	0.36	0.30
4	1180	30	0.36	0.06	3	960	-25	0.26	0.38
6	1120	80	0.34	0.00	5	920	100	0.26	0.60
8	810	45	0.36	-0.02	7	710	135	0.42	0.24
$\bar{x}$	981.25	61.25	0.36	0.05		871.25	78.75	0.33	0.38
Calf					**Calf**				
2	180	135	0.76	-0.24	1	200	120	0.54	0.30
4	190	195	0.48	0.02	3	140	185	0.76	0.14
6	180	105	0.28	-0.08	5	200	220	0.28	0.52
8	170	150	0.44	-0.14	7	200	115	0.58	0.22
$\bar{x}$	180.0	146.25	0.49	-0.11		185.0	160.0	0.54	0.30

Herd 11 74-05-09/74-10-28

	CONTROL					TREATED			
Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)		Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)	
	X	Y	X	Y		X	Y	X	Y
Cow					Cow				
4	1070	85	0.50	-0.26	1	925	25	0.40	-0.10
6	1040	75	0.50	-0.14	7	1030	60	0.28	0.18
8	1010	55	0.32	0.04	9	1035	105	0.40	-0.10
10	875	100	0.60	-0.18	11	700	120	0.46	0.18
12	955	65	0.28	0.14	17	1015	245	0.48	0.04
14	1135	20	0.44	-0.08	19	970	80	0.22	0.26
16	905	175	0.44	-0.04	21	800	30	0.60	0.10
18	840	195	0.40	0.04	23	945	125	0.32	0.08
20	895	125	0.34	-0.04	25	940	70	0.28	0.32
22	1020	190	0.84	-0.38	27	900	185	0.28	0.26
24	850	110	0.48	-0.04	29	1095	45	0.68	0.16
26	890	125	0.30	-0.06					
28	680	140	0.58	-0.12					
$\bar{x}$	935.77	112.31	0.46	-0.09		941.36	99.09	0.40	0.13

Herd 11 74-05-09/74-10-28

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Calf					Calf				
4	175	340	0.58	0	1	125	340	0.40	0.02
6	210	305	0.84	-0.40	7	120	300	0.60	-0.02
8	130	280	0.70	-0.36	9	105	365	1.50	-0.86
10	135	300	0.78	-0.20	11	135	370	0.64	-0.10
12	95	335	0.76	-0.22	17	160	420	0.48	0.12
14	135	375	0.78	-0.38	19	95	310	0.88	-0.12
16	170	315	0.54	-0.04	21	100	330	0.76	0
18	140	325	0.78	-0.24	23	130	270	0.68	-0.10
20	155	320	0.50	-0.04	25	150	325	0.90	0.10
22	185	370	0.84	-0.38	27	90	320	0.58	0.22
24	160	295	0.80	-0.30	29	120	380	0.76	0.04
26	155	290	0.62	-0.34					
28	130	330	0.50	-0.04					
$\bar{x}$	151.92	321.54	0.69	-0.23		120.91	339.09	0.74	-0.06

Herd 12 74-05-27/74-11-19

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					**Cow**				
2	1025	170	0.48	-0.02	1	920	105	0.60	-0.02
4	1255	95	0.52	0.18	3	1000	125	0.40	0.16
6	900	110	0.40	0.02	5	900	170	0.54	0.02
8	1040	105	0.56	0.10	7	1180	105	0.54	0.06
10	1230	120	0.40	0.14	9	1050	140	0.32	0.12
12	1155	175	0.40	0.10	11	975	185	0.62	-0.06
14	1040	195	0.36	0.18	13	1040	135	0.74	-0.18
16	1000	25	0.56	0.08	15	1110	150	0.48	-0.10
20	1060	130	0.22	0.12	17	1125	50	0.50	0.10
22	830	90	0.32	0	19	935	65	0.34	0.16
					21	875	55	0.30	0.16
$\bar{x}$	1053.5	121.5	0.42	0.09		1010.0	116.82	0.49	0.04
Calf					**Calf**				
2	105	285	0.58	-0.02	1	135	330	0.68	0
4	140	300	0.66	0.02	3	125	245	0.16	0.44
6	145	345	0.68	-0.10	5	125	285	0.60	0.10
8	155	295	0.60	-0.12	7	165	295	0.72	0.02
10	130	360	0.72	-0.08	9	185	300	0.46	0.26
12	115	305	0.64	-0.04	11	125	270	0.62	0.02
14	125	280	0.48	0.10	13	165	330	0.60	0.04
16	165	230	0.64	0.32	15	155	250	0.76	-0.10
20	95	185	0.84	-0.16	17	140	290	0.46	0.24
22	75	225	0.98	-0.64	19	120	245	0.88	-0.22
					21	80	270	0.64	-0.10
$\bar{x}$	125.0	281.0	0.68	-0.07		138.18	282.73	0.60	0.06

Herd 13 74-05-22/74-11-19

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Cow					Cow				
2	640	435	0.74	-0.18	1	775	195	0.52	-0.08
4	1040	210	0.66	-0.36	3	970	135	0.68	-0.28
6	810	180	0.44	-0.26	5	800	250	0.66	-0.08
8	875	210	0.78	0.06	7	1000	225	0.66	-0.18
10	775	250	0.70	-0.16	9	1075	165	0.68	-0.04
12	890	220	0.66	-0.16	11	950	280	0.60	-0.14
14	1060	230	0.66	-0.26	13	920	205	0.66	-0.20
16	775	210	0.60	-0.30	15	860	275	0.62	-0.04
18	675	250	0.74	-0.22	17	960	215	0.70	-0.26
20	655	275	0.74	-0.32	19	890	285	0.58	-0.12
$\bar{x}$	819.5	247.0	0.67	-0.22		920.0	223.0	0.64	-0.14
Calf					Calf				
2	150	370	0.90	-0.12	1	120	295	0.80	-0.04
4	155	355	0.62	-0.10	3	65	320	1.00	-0.54
6	120	300	0.56	-0.04	5	115	300	1.14	-0.42
8	145	365	0.90	-0.18	7	175	355	0.64	-0.14
10	90	275	0.80	-0.04	9	130	310	0.90	0
12	125	360	1.02	-0.62	11	145	385	0.82	-0.08
14	90	300	0.82	-0.26	13	130	330	0.66	0.04
16	90	295	0.80	-0.20	15	140	325	0.80	-0.20
18	125	310	0.76	-0.08	17	120	295	0.90	-0.12
20	110	305	0.86	-0.42	19	150	325	0.86	-0.12
$\bar{x}$	120.0	323.5	0.93	-0.21		129.0	324.0	0.85	-0.16

Herd 14 74-05-17/74-10-24

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					Cow				
2	1010	225	0.56	-0.30	1	590	240	0.44	-0.14
4	855	130	0.36	0.12	3	875	205	0.54	0.12
6	825	135	0.56	-0.12	5	855	210	0.60	-0.30
8	880	155	0.52	-0.14	7	1050	175	0.66	-0.26
10	1130	95	0.58	-0.20	9	1195	230	0.58	-0.12
12	1270	165	0.60	-0.20	11	665	205	0.54	-0.28
14	1030	195	0.56	-0.18	13	805	170	0.52	0.08
16	970	180	0.56	-0.20	15	1160	115	0.48	-0.18
$\bar{x}$	996.3	160.0	0.54	-0.15		899.4	193.8	0.55	-0.14
Calf					Calf				
2	120	345	0.64	-0.44	1	100	280	0.56	-0.22
4	170	350	0.42	-0.26	3	150	320	0.60	-0.02
6	135	320	0.72	-0.52	5	260	340	0.22	-0.02
8	140	365	0.48	-0.26	7	165	375	0.64	-0.30
10	165	280	0.56	-0.24	9	110	385	0.68	-0.10
12	190	380	0.56	-0.34	11	125	300	0.42	-0.20
14	150	370	0.78	-0.36	13	180	415	0.46	-0.10
16	140	315	0.68	-0.42	15	150	290	0.78	-0.54
$\bar{x}$	151.3	340.6	0.61	-0.36		155.0	338.1	0.55	-0.19

Herd 15 74-05-21/74-10-09

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Cow					Cow				
2	950	135	0.58	0.06	1	950	80	0.28	0.20
4	800	160	0.36	0.10	3	680	135	0.16	0.32
7	925	185	0.36	0.06	8	900	165	0.44	0.16
9	1050	70	0.68	-0.04	10	1105	35	0.36	0.22
11	735	80	0.54	-0.16	12	1285	85	0.42	0.14
13	930	120	0.40	-0.06	14	710	140	0.34	0.12
15	1155	60	0.26	-0.16	16	1075	105	0.50	-0.04
17	935	90	0.42	0	18	775	75	0.34	0.30
19	1025	100	0.50	-0.04	20	710	160	0.60	0.10
21	755	125	0.32	0.02	22	1000	115	0.66	0.02
$\bar{x}$	926.0	112.5	0.44	-0.02		919.0	109.5	0.41	0.15

Herd 15 74-05-21/74-10-09

	CONTROL					TREATED			
	Body Weight (lb)		Serum Cu (Ug/ml)			Body Weight (lb)		Serum Cu (Ug/ml)	
Unit No.	X	Y	X	Y	Unit No.	X	Y	X	Y
Calf					**Calf**				
2	200	285	0.38	0	1	90	295	0.92	-0.24
4	135	185	0.52	-0.08	3	65	185	0.60	0.10
7	140	195	0.80	-0.32	8	170	215	0.94	-0.34
9	290	230	0.32	0.12	10	180	205	0.36	0.24
11	135	175	0.82	-0.14	12	170	255	0.90	-0.16
13	180	215	0.16	0.40	14	95	160	0.92	-0.24
15	150	245	0.54	0	16	240	210	0.32	0.40
17	195	195	0.30	0.32	18	150	200	0.54	0.10
19	210	210	0.52	0.18	20	190	205	0.16	0.44
21	190	245	0.32	0.10	22	195	215	0.62	0.12
$\bar{x}$	182.5	218.0	0.47	0.06		154.5	214.5	0.63	0.04
Yearling Heifers					**Yearling Heifers**				
23B	650	235	0.60	-0.06	23A	555	195	0.58	0.20
24B	725	190	0.38	0.12	24A	595	190	0.36	0.22
25B	575	195	0.60	0.02	25A	600	190	0.48	0.20
27B	535	160	0.56	0.04	26A	530	210	0.36	0.16
					27A	600	230	0.34	0.28
$\bar{x}$	621.3	195.0	0.54	0.03		576.0	203.0	0.42	0.21

Herd 16 74-05-21/74-12-11

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					Cow				
4	915	100	0.80	-0.04	7	800	100	0.60	0.18
10	1150	90	0.92	-0.16	9	1040	75	0.62	0.10
12	1050	115	0.60	0	11	1145	30	0.60	0.18
14	800	160	0.82	-0.14	13	900	110	0.66	0
16	870	95	0.84	-0.02	15	940	95	1.02	-0.08
18	980	55	0.72	-0.04	17	870	140	0.76	0.12
20	880	155	0.74	0.06	19	920	70	0.62	-0.02
$\bar{x}$	949.3	110.0	0.78	-0.05		945.0	88.6	0.70	0.07
Calf					Calf				
4	210	310	0.78	-0.08	7	170	310	0.76	-0.04
10	140	305	1.12	-0.48	9	115	300	0.82	-0.02
12	150	290	0.62	0.06	11	215	420	0.80	-0.04
14	290	285	0.60	0.18	13	125	245	0.66	0.02
16	165	360	0.78	0.06	15	140	290	0.80	0.30
18	165	355	0.88	-0.32	17	145	270	0.90	0.10
20	235	345	0.82	0.06	19	130	260	0.84	-0.14
$\bar{x}$	193.6	321.4	0.80	-0.07		148.6	299.3	0.80	0.03

Herd 17 74-07-04/74-10-11

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					**Cow**				
2	750	85	0.62	-0.06	1	915	-25	0.28	0.44
4	1000	50	0.30	0.10	5	730	50	0.26	0.38
6	1105	75	0.22	-0.02	7	820	95	0.82	-0.14
8	840	60	0.20	0.10	9	970	-10	0.26	0.28
12	1215	10	0.30	-0.10	11	880	60	0.24	0.34
14	975	45	0.54	0	15	870	5	0.20	0.18
18	580	135	0.40	0.24	17	725	75	0.40	0.30
26	905	70	0.70	-0.22	19	860	100	0.18	0.26
30	650	90	0.30	-0.08	21	720	55	0.30	0.16
					23	800	60	0.30	0.30
					25	675	95	0.40	0.38
					27	750	75	0.16	0.22
$\bar{x}$	891.1	68.9	0.40	0.0		809.6	44.6	0.32	0.26
Calf					**Calf**				
2	300	185	0.38	0.22	1	115	140	0.48	0.16
4	175	175	0.34	0.12	5	130	155	0.44	0.28
6	150	120	0.56	-0.06	7	160	140	0.50	0.26
8	200	225	0.44	0.16	9	260	215	0.24	0.40
12	215	175	0.76	0.10	11	115	130	0.52	0.04
14	240	195	0.54	0.02	15	135	105	0.50	0.18
18	210	215	0.62	0.08	17	140	120	0.72	0.12
26	400	180	0.62	0.04	19	140	120	0.30	0.26
30	140	140	0.54	-0.24	21	135	175	0.44	0.28
					23	145	125	0.34	0.30
					25	135	145	0.60	0.18
					27	140	110	0.52	0.20
$\bar{x}$	225.6	178.9	0.53	0.05		145.8	140.0	0.47	0.22

Herd 18 74-05-17/74-11-04

	CONTROL					TREATED			
Unit	Body Weight (lb)		Serum Cu (Ug/ml)		Unit	Body Weight (lb)		Serum Cu (Ug/ml)	
No.	X	Y	X	Y	No.	X	Y	X	Y
Cow					Cow				
4	870	110	0.60	-0.12	1	960	185	0.60	0
6	840	155	0.40	-0.02	3	1160	120	0.80	-0.42
8	910	195	0.52	-0.02	7	970	140	0.56	-0.30
12	1175	50	0.78	-0.14	9	1100	185	0.72	-0.06
14	870	180	0.52	-0.22	13	950	160	0.52	-0.18
16	900	240	0.48	-0.06	15	785	140	0.56	-0.22
18	1060	130	0.38	0	17	1025	125	0.56	+0.20
20	840	130	0.56	-0.28	19	810	150	0.62	+0.24
$\bar{x}$	933.1	148.8	0.53	-0.11		970.0	150.6	0.62	-0.09
Calf					Calf				
4	135	360	0.66	-0.1	1	130	265	0.64	-0.24
6	90	225	0.54	-0.2	3	110	260	0.34	+0.16
8	95	225	0.76	-0.06	7	170	330	0.56	+0.30
12	165	235	0.58	-0.24	9	140	255	0.68	-0.08
14	100	230	0.66	-0.18	13	130	295	0.54	+0.02
16	100	275	0.60	-0.22	15	110	340	0.90	-0.14
18	125	335	0.58	-0.10	17	90	275	0.78	+0.06
20	125	245	0.74	-0.26	19	130	245	0.74	-0.14
$\bar{x}$	116.9	266.3	0.64	-0.17		126.3	283.1	0.65	-0.01

Herd 19 74-05-10/74-10-30

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Cow					Cow				
13	1055	15	0.32	0.14	1	870	35	0.28	0.34
14	1120	65	0.26	0.44	2	700	75	0.16	0.34
16	895	-80	0.16	0.38	3	905	95	0.28	0.22
					4	845	-110	0.54	-0.02
$\bar{x}$	1023.3	0.0	0.25	0.32	5	760	30	0.22	0.40
					6	950	150	0.32	0.36
					7	850	60	0.28	0.36
					9	720	140	0.32	0.68
					10	1000	40	0.32	0.56
					$\bar{x}$	844.4	57.2	0.30	0.36
Calf					Calf				
13	190	180	0.72	0.09	1	125	175	0.16	0.68
14	160	270	0.72	0.18	2	125	245	0.22	0.66
16	175	225	0.22	0.44	3	140	300	0.28	0.40
					4	150	245	0.90	-0.32
$\bar{x}$	175.0	225.0	0.55	0.24	5	135	250	0.12	0.50
					6	120	235	0.64	0.16
					7	145	265	0.90	-0.18
					9	100	185	0.44	0.48
					10	150	200	0.44	0.48
					$\bar{x}$	132.2	233.3	0.46	0.32

Herd 20 74-05-16/74-10-24

	CONTROL					TREATED			
Unit	Body Weight (lb)		Serum Cu (Ug/ml)		Unit	Body Weight (lb)		Serum Cu (Ug/ml)	
No.	X	Y	X	Y	No.	X	Y	X	Y
Cow					Cow				
4	1000	120	0.74	-0.20	3	825	125	0.58	0.06
6	750	125	0.60	-0.14	5	1085	5	0.84	-0.22
8	1160	105	0.64	-0.30	9	985	105	0.82	-0.56
10	1040	100	0.72	-0.30	11	1060	110	0.82	-0.08
12	950	50	0.72	-0.30	13	905	30	0.72	0.06
14	1080	110	0.96	-0.30	15	800	120	0.68	0.06
18	875	150	0.70	0.04	19	1020	160	0.78	-0.16
					23	1075	105	0.78	0.16
$\bar{x}$	979.3	108.6	0.73	-0.21		969.4	95.0	0.75	-0.09
Calf					Calf				
4	185	300	0.66	-0.20	3	155	315	0.50	-0.02
6	100	240	0.66	0	5	135	305	0.72	-0.12
8	260	270	0.26	0	9	240	320	0.58	-0.28
10	275	310	0.64	-0.34	11	185	250	0.58	0
12	165	205	0.54	-0.10	13	260	375	0.60	0
14	260	270	0.68	-0.34	15	235	250	0.60	-0.10
18	210	270	0.60	-0.10	19	200	275	0.48	0
					23	250	240	1.16	-0.60
$\bar{x}$	207.9	266.4	0.58	-0.15		207.5	291.3	0.65	-0.14

Herd 21 74-05-15/74-10-24

	CONTROL					TREATED			
	Body Weight (lb)		Serum Cu (Ug/ml)			Body Weight (lb)		Serum Cu (Ug/ml)	
Unit No.	X	Y	X	Y	Unit No.	X	Y	X	Y
<u>Cow</u>					<u>Cow</u>				
1	1345	165	0.66	-0.38	1	1055	225	0.64	-0.28
4	1185	140	0.54	-0.26	3	880	255	0.70	-0.08
6	1085	215	0.72	-0.36	5	1085	255	0.78	0.06
8	1150	135	0.70	-0.50	7	1035	220	0.60	-0.24
10	1130	130	0.84	-0.50	9	1075	150	0.90	-0.30
12	1200	215	0.72	-0.24	11	1275	125	1.00	-0.20
14	1365	100	0.72	-0.26	13	1005	290	0.60	-0.34
16	1275	185	0.72	-0.44	15	1055	200	0.74	-0.04
18	1150	240	0.72	-0.46	17	1115	140	0.70	-0.26
20	920	260	0.66	-0.42	19	905	300	0.74	-0.32
22	885	285	0.86	-0.44	21	1160	180	0.74	-0.40
$\bar{x}$	1153.6	188.2	0.71	-0.39		1058.6	212.7	0.74	-0.22
<u>Calf</u>					<u>Calf</u>				
2	165	385	0.66	-0.50	1	155	335	0.64	-0.18
4	105	370	0.92	-0.70	3	165	350	0.76	-0.40
6	175	365	0.82	-0.44	5	125	245	0.78	0.02
8	205	340	0.66	-0.24	7	195	365	0.60	-0.10
10	125	390	0.94	-0.66	9	195	360	0.82	-0.10
12	155	350	0.72	-0.44	11	225	305	0.62	-0.42
14	100	385	0.92	-0.42	13	140	355	0.82	-0.52
16	185	380	0.72	-0.42	15	180	225	0.22	-0.04
18	160	310	0.72	-0.02	17	125	335	0.66	-0.26
20	145	325	0.62	-0.32	19	155	365	0.66	-0.34
22	80	230	1.02	-0.62	21	145	255	0.46	0.14
$\bar{x}$	145.4	349.1	0.79	-0.43		164.1	317.7	0.64	-0.20

Herd 22 74-05-14/74-10-31

	CONTROL					TREATED			
	Body Weight (lb)		Serum Cu (Ug/ml)			Body Weight (lb)		Serum Cu (Ug/ml)	
Unit No.	X	Y	X	Y	Unit No.	X	Y	X	Y
Cow					Cow				
3	985	225	0.72	-0.18	1	1115	145	0.54	0.04
4	970	60	0.54	-0.16	6	890	120	0.52	-0.16
5	900	100	0.36	0.10	10	1100	65	0.76	-0.12
8	1000	85	0.64	-0.28	12	880	130	0.52	-0.08
9	975	45	0.56	-0.20	13	970	70	0.58	-0.14
11	830	80	0.56	-0.18	14	960	125	0.66	-0.06
15	950	85	0.86	-0.56	17	1035	100	0.36	0.06
16	975	145	0.42	0.04	18	935	150	0.56	-0.22
20	895	175	0.58	0	19	940	95	0.42	0.02
$\bar{x}$	942.2	111.1	0.58	-0.16		980.6	111.1	0.55	-0.07
Calf					Calf				
3	200	370	0.80	-0.22	1	125	345	0.62	-0.04
4	75	250	0.88	-0.68	6	125	340	0.70	-0.44
5	120	370	0.70	-0.30	10	230	405	0.92	-0.12
8	85	280	0.56	-0.30	12	90	275	0.60	-0.16
9	115	290	0.68	-0.36	13	115	340	0.80	-0.22
11	120	290	0.86	-0.58	14	195	310	0.82	-0.24
15	110	235	0.72	-0.54	17	130	290	0.62	-0.16
16	140	340	0.64	-0.06	18	155	305	0.54	-0.14
20	230	370	0.58	0.18	19	120	375	0.56	-0.08
$\bar{x}$	132.8	310.6	0.71	-0.32		142.8	331.7	0.69	-0.18

Herd 23 74-05-13/74-10-08

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
<u>Cow</u>					<u>Cow</u>				
3	1000	220	0.62	-0.24	1	880	280	0.76	0
4	925	250	0.80	-0.10	2	775	235	0.80	-0.12
10	920	225	0.76	-0.08	5	1035	225	0.70	0
11	765	255	0.78	-0.52	6	900	200	1.14	-0.36
12	965	225	0.68	-0.28	7	1045	185	0.84	-0.56
14	850	200	0.86	-0.06	8	960	265	0.76	0.08
16	880	180	0.62	-0.22	9	945	245	0.62	-0.02
20	855	255	0.74	-0.44	13	960	265	0.78	0
24	1060	240	0.80	-0.30	15	810	190	0.90	-0.12
27	665	285	0.86	-0.04	17	880	240	0.88	-0.08
28	805	195	0.84	-0.56	18	860	205	0.78	-0.02
30	980	190	0.78	-0.28	19	1035	205	0.84	0.02
31	970	230	0.80	-0.46	21	1075	295	0.86	-0.34
32	925	245	0.72	-0.04	22	930	210	0.78	-0.26
33	1060	270	0.82	-0.18	23	730	180	0.92	0.12
35	1045	235	0.84	-0.10	25	1040	225	0.84	0.02
36	965	205	0.90	-0.10	26	1110	210	0.80	-0.36
38	975	215	0.84	-0.38	34	1075	195	0.80	0.06
39	900	250	0.78	-0.48	37	810	230	0.90	0.12
					40	850	285	0.82	-0.02
$\bar{x}$	921.6	230.0	0.66	-0.26		934.8	228.5	0.83	-0.09

Herd 23

74-05-13/74-10-08

	CONTROL					TREATED			
	Body Weight (lb)		Serum Cu (Ug/ml)			Body Weight (lb)		Serum Cu (Ug/ml)	
Unit No.	X	Y	X	Y	Unit No.	X	Y	X	Y
Calf					**Calf**				
3	90	250	0.68	0.18	1	155	310	0.68	0.02
4	145	320	0.76	-0.06	2	135	300	0.88	-0.40
10	185	270	0.70	-0.46	5	260	315	0.80	-0.08
11	150	320	0.78	-0.56	6	155	275	1.02	-0.20
12	180	310	0.86	-0.46	7	170	270	0.88	-0.20
14	175	315	0.78	-0.56	8	180	280	0.74	-0.08
16	190	310	0.76	-0.54	9	145	380	0.68	-0.10
20	130	330	1.00	-0.60	13	145	330	0.78	-0.40
24	170	315	0.70	-0.36	15	140	270	0.96	-0.28
27	150	300	1.00	-0.76	17	160	255	0.62	0.14
28	125	200	0.80	-0.52	18	165	310	0.70	-0.06
30	135	325	0.66	-0.06	19	225	340	0.62	0.10
31	165	395	0.82	-0.32	21	170	260	0.80	-0.12
32	150	300	1.10	-0.58	22	105	230	0.78	0.08
33	150	265	0.88	-0.40	23	140	240	0.92	0.08
35	185	340	0.90	-0.38	25	140	240	0.74	-0.26
36	130	295	0.84	-0.14	26	125	295	0.90	-0.50
38	140	335	0.88	-0.50	34	140	295	1.10	-0.34
39	145	325	0.84	-0.34	37	120	250	0.96	-0.20
					40	130	295	0.96	-0.22
$\bar{x}$	152.1	306.3	0.83	-0.39		157.5	282.0	0.83	-0.15

Herd 24

74-05-14/74-11-04

	CONTROL					TREATED			
Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)		Unit No.	Body Weight (lb)		Serum Cu (Ug/ml)	
	X	Y	X	Y		X	Y	X	Y
<u>Cow</u>					<u>Cow</u>				
2	990	190	0.86	-0.58	3	1180	230	0.32	-0.12
4	1050	185	0.90	-0.70	5	1430	120	0.80	-0.60
6	1250	175	0.94	-0.68	7	1310	65	0.48	-0.28
8	1470	140	0.40	-0.26	9	970	160	0.72	-0.48
10	1060	180	0.62	-0.42	11	1160	190	0.58	-0.32
12	1170	165	0.56	-0.36	13	1280	100	0.42	-0.20
14	1270	130	0.44	-0.22	15	1040	220	0.46	-0.28
16	1185	150	0.68	-0.50					
$\bar{x}$	1180.6	164.4	0.68	-0.47		1195.7	155.0	0.54	-0.33
<u>Calf</u>					<u>Calf</u>				
2	155	330	0.46	-0.3	3	75	375	0.70	-0.44
4	180	285	0.28	-0.18	5	240	330	0.56	-0.20
6	165	365	0.70	-0.46	7	150	345	0.90	-0.76
8	160	330	0.28	-0.12	9	180	355	0.70	-0.32
10	120	315	0.94	-0.76	11	215	390	0.32	-0.02
12	145	305	1.04	-0.74	13	165	315	0.52	-0.24
14	105	230	0.64	-0.52	15	145	305	0.64	-0.52
16	135	300	0.62	-0.50					
$\bar{x}$	145.6	307.5	0.62	-0.45		167.1	345.0	0.62	-0.36

Herd 24 74-05-14/74-11-04

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Yearling					Yearling				
18A	710	190	1.02	-0.84	17A	810	205	0.84	-0.36
20A	675	300	0.86	-0.66	18B	770	200	0.92	-0.42
21A	630	220	0.24	-0.04	19B	700	205	0.74	-0.54
22A	720	240	0.44	-0.26	20B	640	270	0.48	-0.18
					21B	730	270	0.78	-0.48
$\bar{x}$	683.8	237.5	0.64	-0.45		730.0	230.0	0.75	-0.40

Herd 25

74-05-13/74-11-05

	CONTROL					TREATED			
Unit	Body Weight (lb)		Serum Cu (Ug/ml)		Unit	Body Weight (lb)		Serum Cu (Ug/ml)	
No.	X	Y	X	Y	No.	X	Y	X	Y
Cow					**Cow**				
2	1160	140	0.44	-0.06	1	855	275	0.82	-0.16
4	1250	120	0.64	-0.26	3	975	240	0.64	-0.10
6	870	140	0.64	-0.02	5	1050	250	0.62	-0.16
14	1230	120	0.68	-0.20	9	980	230	0.62	-0.14
16	970	100	0.86	-0.26	11	1040	315	0.78	-0.08
					15	1000	135	0.50	-0.18
$\bar{x}$	1096.0	124.0	0.50	-0.16		983.3	240.8	0.66	-0.14
Calf					**Calf**				
2	110	330	0.90	-0.40	1	70	290	0.48	0.26
4	145	340	0.76	-0.28	3	175	335	0.42	0.12
6	140	380	0.58	-0.30	5	165	445	0.26	0.12
14	200	425	0.38	-0.08	9	145	430	0.44	0.02
16	190	360	0.38	0.24	11	135	435	0.42	0.32
					15	140	315	0.42	0.06
$\bar{x}$	157.0	367.0	0.60	-0.16		138.3	375.0	0.41	0.15

Herd 26 74-05-15/74-10-30

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Cow					**Cow**				
2	1095	30	0.30	0.20	1	1375	20	0.26	-0.06
4	1090	55	0.40	0.02	3	885	80	0.14	0.52
6	1015	35	0.22	-0.02	5	830	180	0.14	0.14
8	1080	20	0.26	0.18	7	1180	80	0.42	-0.22
10	1030	30	0.18	-0.08	9	1020	80	0.18	0.32
12	900	50	0.14	0.56					
$\bar{x}$	1035.0	36.7	0.25	0.14		1058.0	88.0	0.23	0.14
Calf					**Calf**				
2	295	285	0.14	0.10	1	290	380	0.12	0.04
4	130	270	0.24	-0.10	3	150	325	0.10	0.32
6	105	320	0.34	-0.06	5	150	285	0.10	0.02
8	175	345	0.20	0.22	7	255	380	0.44	-0.12
10	155	270	0.10	0.08	9	150	340	0.12	0.06
$\bar{x}$	166.7	300.8	0.19	0.08		199.0	342.0	0.18	0.06

Herd 27 74-05-09/74-12-12

	CONTROL					TREATED			
Unit	Body Weight (lb)		Serum Cu (Ug/ml)		Unit	Body Weight (lb)		Serum Cu (Ug/ml)	
No.	X	Y	X	Y	No.	X	Y	X	Y
Cow					Cow				
6	1110	70	0.34	0.08	1	715	125	0.66	-0.10
8	775	60	0.90	-0.52	3	870	100	0.44	0.20
24	925	160	0.30	0.10	11	800	85	0.42	-0.04
26	1110	-125	0.70	-0.10	23	875	230	0.62	-0.40
					27	975	65	0.56	-0.16
$\bar{x}$	980.0	41.3	0.56	-0.11		846.0	121.0	0.54	-0.10
Calf					Calf				
6	125	425	0.50	-0.14	1	80	190	0.80	-0.20
8	115	195	0.70	-0.22	3	100	350	1.20	-0.46
24	165	315	0.70	-0.30	11	150	355	0.74	-0.24
26	125	335	1.40	-0.72	23	175	310	0.70	-0.16
					27	140	340	0.90	-0.60
$\bar{x}$	132.5	317.5	0.83	-0.35		129.0	309.0	0.87	-0.33

Herd 28 | 74-05-09 & 74-08-19/74-10-28

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Cow					Cow				
6	925	160	0.48	0.06	7	1050	50	0.56	0.38
8	1100	75	1.00	-0.08	11	750	85	0.66	0.12
18	1035	125	0.74	0.04	17	975	75	0.78	0.20
20	1240	85	0.66	0.12	19	985	115	0.92	0.06
22	1225	-40	0.86	0.02	23	1010	85	0.74	0.08
24	825	125	0.52	0.10					
26	1325	35	0.78	0.14					
$\bar{x}$	1096.43	80.71	0.72	0.06		954.0	82.0	0.73	0.17
Calf					Calf				
6	170	390	0.52	0.24	7	145	330	0.82	0.06
8	95	275	0.78	-0.10	11	75	340	0.78	-0.16
18	125	320	0.92	-0.30	17	120	310	0.80	0.08
20	90	290	0.92	-0.14	19	115	285	1.04	-0.22
22	80	315	0.92	-0.28	23	120	290	0.70	0.10
24	110	285	0.72	0					
26	105	340	0.74	0.08					
$\bar{x}$	110.71	316.43	0.79	-0.07		115.0	311.0	0.83	-0.03

Herd 29 74-05-29/74-10-29

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	X	Serum Cu (Ug/ml) X	Y	Unit No.	Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Cow					Cow				
4	680	255	0.76	-0.28	1	695	270	0.84	-0.14
6	700	175	0.74	-0.46	5	560	180	0.74	-0.02
8	880	320	0.76	-0.18	7	660	340	0.62	0.10
12	695	305	0.72	-0.18	11	650	275	0.60	0.02
14	770	295	0.60	-0.30	13	610	250	0.90	0.14
$\bar{x}$	745.0	270.0	0.72	-0.28		635.0	263.0	0.74	0.02
Calf					Calf				
4	105	340	1.08	-0.68	1	60	270	1.56	-0.68
6	80	270	1.16	-0.80	5	75	295	0.86	0.12
8	80	200	0.96	-0.38	7	45	290	1.50	-0.82
12	100	265	1.02	-0.56	11	90	290	0.84	-0.06
14	55	215	1.48	-0.94	13	125	300	0.84	-0.06
$\bar{x}$	84.0	258.0	1.14	-0.67		79.0	289.0	1.12	-0.30

Herd 29 74-05-29/74-10-29

	CONTROL				TREATED				
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Yearling & Open Cows					Yearling & Open Cows				
15B	515	370	0.66	-0.44	15A	730	305	0.70	0.16
16B	625	465	0.54	-0.34	17A	350	275	0.90	-0.10
17B	420	305	0.40	-0.22	18A	285	290	0.26	0.40
18B	600	305	0.82	-0.40	19A	540	390	0.72	-0.10
19B	450	350	0.96	-0.18	21A	730	310	0.62	-0.08
20B	230	265	0.38	-0.18	24A	775	350	0.64	0
23B	575	340	0.80	-0.16	25A	600	290	0.44	0.36
24B	385	280	0.34	+0.60	26A	500	250	0.80	0.08
25B	650	290	0.68	-0.46	28A	440	330	0.82	0.04
28B	540	345	0.68	-0.38	29A	515	360	0.80	0.04
10A	275	200	0.42	-0.24	9A	450	355	0.84	0.08
$\bar{x}$	478.64	319.55	0.61	-0.22		537.73	318.64	0.69	0.08

Herd 30 74-05-08/74-12-13

	CONTROL					TREATED			
Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y	Unit No.	Body Weight (lb) X	Body Weight (lb) Y	Serum Cu (Ug/ml) X	Serum Cu (Ug/ml) Y
Cow					Cow				
8	1100	205	0.66	-0.18	5	1250	80	0.66	-0.04
12	810	185	0.56	0.28	15	885	170	0.62	0.06
14	815	115	0.76	-0.16	20	1050	150	0.54	0
18	970	160	0.54	0.06	23	1175	45	0.72	-0.10
$\bar{x}$	923.8	166.3	0.63	0.0		1090.0	111.3	0.64	-0.02
Calf					Calf				
8	150	480	0.76	-0.06	5	190	420	0.80	-0.08
12	110	415	0.64	0.18	15	155	475	0.76	0.12
14	105	435	0.74	-0.24	20	115	325	0.80	0.14
18	200	435	0.66	0.08	23	200	365	0.82	0
$\bar{x}$	141.3	441.3	0.70	-0.01		165.0	396.3	0.80	0.05

Herd 31 74-05-27/74-10-24

Unit No.	CONTROL Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y	Unit No.	TREATED Body Weight (lb) X	Y	Serum Cu (Ug/ml) X	Y
Cow					Cow				
2	880	25	0.86	-0.22	1	985	-10	0.84	-0.12
4	990	145	0.70	-0.18	3	1250	-60	0.74	0.14
6	910	-85	0.76	-0.14	5	1045	-40	0.70	0.38
8	790	75	1.06	-0.28	7	1250	5	0.70	0
10	780	60	0.70	0.04	9	880	55	0.76	0.02
12	950	-30	0.92	-0.30	11	875	25	0.88	-0.10
14	960	90	0.70	0.16	13	950	0	0.70	-0.10
16	830	35	0.86	-0.10	15	900	50	0.62	0.10
18	830	90	0.62	-0.22	17	920	-85	0.86	0.36
$\bar{x}$	880.0	45.0	0.80	-0.14		906.1	-6.67	0.76	0.08
Calf					Calf				
2	235	300	0.76	-0.20	1	115	265	0.84	-0.14
4	120	280	1.10	-0.30	3	145	280	0.76	0.10
6	145	220	0.70	-0.04	5	170	260	0.92	-0.12
8	170	275	0.82	-0.02	7	180	225	0.86	-0.06
10	90	185	0.96	-0.16	9	140	285	0.90	-0.10
12	160	260	0.92	-0.16	11	115	275	0.96	-0.16
14	95	225	1.20	-0.34	13	110	285	0.76	-0.10
16	150	230	0.82	-0.06	15	135	270	0.86	-0.10
18	135	270	0.76	-0.20	17	125	230	0.86	-0.10
$\bar{x}$	144.4	249.4	0.89	-0.16		137.2	263.9	0.86	-0.09

Appendix IIB

Survey of serum copper status of additional herds located on potential problem soils, 1974.

Herd 32 74-10-29

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.66
	3	0.54
	5	0.46
	7	0.46
	9	0.58
	11	0.48
	15	0.52
	17	0.56
	19	0.66

$\bar{x} = 0.536$

Unit No.		Serum Copper Level Ug/ml
Calf	2	0.58
	4	0.32
	6	0.36
	8	0.36
	10	0.48
	12	0.56
	14	0.36
	16	0.46
	18	0.38
	20	0.44

$\bar{x} = 0.429$

Herd 33 74-10-31

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.90
	3	0.56
	5	0.68
	7	0.78
	9	0.76
	11	1.08
	13	0.62
	15	0.56
	17	0.82
	19	0.56
	$\bar{x}$ = 0.732	
Calf	4	0.66
	8	0.52
	10	0.62
	12	0.58
	14	0.52
	16	0.68
	18	0.80
	20	0.56
	$\bar{x}$ = 0.618	

Herd 34 74-11-7

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.42
	3	0.52
	5	0.26
	7	0.36
	9	0.28
	11	0.56
	13	0.64
	15	0.46
	17	0.38
	19	0.38

$\bar{x} = 0.426$

Calf	2	0.34
	4	0.36
	6	0.46
	8	0.24
	10	0.36
	12	0.44
	14	0.62
	16	0.84
	18	0.40
	20	0.36

$\bar{x} = 0.442$

Herd 35 74-11-6

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.90
	3	0.94
	5	1.24
	7	0.66
	9	0.44
	11	0.72
	13	0.44
	15	0.50
	17	0.72
	19	0.86
	$\bar{x}$ = 0.742	
Calf	2	0.74
	6	0.70
	8	0.72
	10	0.68
	12	0.48
	14	0.28
	16	0.74
	18	0.82
	20	0.48
	$\bar{x}$ = 0.626	

Herd 36 74-11-1

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.82
	3	0.24
	5	0.40
	7	0.54
	9	0.54
	11	0.64
	13	0.68
	15	0.62
	17	0.42
	19	0.54
	$\bar{x}$ = 0.544	
Calf	2	0.80
	4	0.50
	6	0.76
	8	0.54
	10	0.34
	12	0.24
	14	0.30
	16	0.56
	18	0.42
	20	0.36
	$\bar{x}$ = 0.482	

Herd 37 74-10-22

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.26
	3	0.30
	5	0.46
	7	0.30
	9	0.32
	11	0.24
	13	0.34
	15	0.58
	17	0.24
	19	0.32
	$\bar{x} = 0.336$	
Calf	2	0.30
	4	0.50
	6	0.34
	8	0.56
	10	0.22
	12	0.34
	14	0.24
	16	0.58
	18	0.24
	20	0.36
	$\bar{x} = 0.368$	

Herd 38 74-11-4

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.78
	3	0.60
	5	0.70
	7	0.70
	9	0.76
	11	0.48
	13	0.58
	15	0.62
	17	0.76
	19	0.74
	$\bar{x}$ = 0.672	
Calf	2	1.00
	4	0.84
	6	0.80
	8	0.68
	10	0.54
	12	0.62
	14	0.86
	16	0.62
	18	0.90
	20	0.74
	$\bar{x}$ = 0.760	

Herd 39 74-11-1

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.60
	3	0.50
	5	0.40
	7	0.72
	9	0.40
	11	0.46
	13	0.54
	15	0.30
	17	0.46
	19	0.52
	$\bar{x}$ = 0.490	
Calf	2	0.40
	4	0.20
	6	0.34
	8	0.62
	10	0.46
	12	0.38
	14	0.66
	16	0.40
	18	0.44
	20	0.30
	$\bar{x}$ = 0.420	

Herd 40 74-11-5

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.40
	3	0.50
	5	0.24
	7	0.40
	9	0.48
	11	0.40
	13	0.50
	15	0.24
	17	0.24
	19	0.60
	$\bar{x}$ = 0.400	
Calf	2	0.76
	4	0.66
	6	0.50
	8	0.66
	10	0.64
	12	0.56
	14	0.64
	16	0.40
	18	0.38
	20	0.50
	$\bar{x}$ = 0.570	

Herd 41 74-10-24

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.82
	3	0.42
	5	0.38
	7	0.42
	9	0.52
	11	0.48
	13	0.46
	15	0.28
	17	0.44
	19	0.40

$\overline{x}$ = 0.462

Calf	2	0.42
	4	0.28
	6	0.28
	8	0.58
	10	0.40
	12	0.32
	14	0.32
	16	0.36
	18	0.36
	20	0.68

$\overline{x}$ = 0.400

Herd 42 74-11-7

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.44
	3	0.66
	5	0.56
	7	0.58
	9	0.32
	11	0.28
	13	0.62
	15	0.47
	17	0.70
	19	0.74

$\bar{x} = 0.532$

Calf	2	0.70
	4	0.34
	6	0.56
	8	0.20
	10	0.52
	12	0.66
	14	0.56
	16	0.60
	18	0.56
	20	0.60

$\bar{x} = 0.531$

Herd 43 74-10-30

Unit No.		Serum Copper Level Ug/ml
Cow	1	0.38
	2	0.56
	3	0.62
	4	0.40
	5	0.62
	6	0.56
	7	0.52
	8	0.50
	9	0.54
	10	0.56
	12	0.64
	13	0.46
	14	0.64
	15	0.46
	16	0.64
	17	0.38
	18	0.38
	19	0.36
	20	0.56
	21	0.52
	22	0.42
	23	0.60
	24	0.48
	25	0.38
	26	0.36
	27	0.50
	28	0.56
	29	0.36
	30	0.48
	31	0.52
	32	0.52
	33	0.28
	34	0.56
	35	0.58
	36	0.40
	37	0.60
	38	0.42
	39	0.52
	40	0.34
	41	0.40
	42	0.48
	43	0.64
	44	0.52
	45	0.36
	46	0.56
	47	0.56
	48	0.52
	49	0.20
	50	0.50

$\bar{x} = 0.488$

Herd 44 | 74-11-6

Unit No.	Serum Copper Level Ug/ml
Cow 1	0.48
2	0.30
3	0.38
4	0.36
5	0.28
6	0.52
7	0.26
8	0.28
9	0.20
10	0.32
11	0.28
12	0.18
13	0.36
14	0.44
15	0.50
16	0.40
17	0.44
18	0.38
19	0.48
20	0.44
21	0.30
22	0.32
23	0.44
24	0.44
25	0.26
26	0.28
27	0.34
28	0.42
29	0.50
30	0.40
31	0.40
32	0.42
33	0.34
34	0.30
35	0.64
36	0.42
37	0.32
38	0.46
39	0.32
40	0.32
41	0.38
42	0.32
43	0.34
44	0.54
45	0.70
46	0.46
47	0.60
48	0.32
49	0.38
50	0.38

$\overline{x} = 0.387$

Appendix IIC

Serum copper levels of herds treated at 0 and 90 days and sampled every 30 days.

Herd 29 - Grandview, Manitoba

Serum copper values, Ug/ml, control group

Unit No.	74/05/29	74/06/24	74/07/29	74/08/27	74/09/24	74/10/29
Cow						
4	0.76	0.74	0.70	0.68	0.66	0.48
6	0.74	0.80	0.56	0.40	0.30	0.28
8	0.76	0.72	0.62	0.50	0.60	0.58
12	0.72	0.78	0.70	0.68	0.70	0.54
14	0.60	0.58	0.38	0.34	0.64	0.30
$\bar{x}$(5)	0.72	0.72	0.59	0.52	0.58	0.44
Calf						
4	1.08	0.74	0.74	0.62	0.58	0.40
6	1.16	1.14	0.66	0.62	0.54	0.36
8	0.96	0.96	0.56	0.50	0.72	0.58
12	1.02	0.68	0.72	0.52	0.50	0.46
14	1.48	0.98	0.56	0.52	0.24	0.54
$\bar{x}$(5)	1.14	0.90	0.65	0.56	0.52	0.47
Yearling						
15B	0.66	0.38	0.42	0.30	0.22	0.22
16B	0.54	0.48	0.46	0.30	0.20	0.20
17B	0.40	0.38	0.44	0.36	0.20	0.18
18B	0.82	1.56	0.70	0.64	0.52	0.42
19B	0.96	0.68	0.70	0.66	0.76	0.78
20B	0.38	0.38	0.44	0.30	0.20	0.20
23B	0.80	0.74	0.70	0.72	0.72	0.64
24B	0.34	0.22	0.24	0.20	0.16	0.94
25B	0.68	0.54	0.60	0.40	0.26	0.22
28B	0.68	0.70	0.60	0.46	0.28	0.30
$\bar{x}$(10)	0.63	0.61	0.53	0.43	0.35	0.41

Herd 29 - Grandview, Manitoba

Serum copper values, Ug/ml, treated group (*designates date of treatment)

Unit No.	74/05/29*	74/06/24	74/07/29	74/08/27*	74/09/24	74/10/29
Cow						
1	0.84	0.88	0.72	0.58	0.80	0.70
5	0.74	0.70	0.64	0.48	0.68	0.72
7	0.62	0.74	0.64	0.52	0.76	0.72
11	0.60	0.68	0.56	0.48	0.66	0.62
13	0.90	0.96	0.92	0.68	0.94	1.04
$\bar{x}$ (5)	0.74	0.79	0.70	0.55	0.77	0.76
Calf						
1	1.56	1.16	0.86	0.80	0.94	0.88
5	0.86	0.96	0.74	0.64	0.94	0.98
7	1.50	0.96	0.62	0.54	0.82	0.68
11	0.84	0.54	0.60	0.64	0.90	0.78
13	0.84	0.76	0.72	0.70	0.94	0.78
$\bar{x}$(5)	1.12	0.88	0.71	0.66	0.91	0.82
Yearling						
15A	0.70	0.86	0.70	0.66	0.82	0.86
17A	0.90	0.86	0.68	0.66	0.82	0.80
18A	0.26	0.84	0.70	0.58	0.76	0.66
20A	0.72	0.66	0.50	0.52	0.68	0.62
21A	0.62	0.80	0.52	0.48	0.60	0.54
24A	0.64	0.70	0.56	0.54	0.66	0.64
25A	0.44	0.88	0.76	0.82	0.90	0.80
26A	0.80	0.72	0.98	0.68	0.86	0.88
28A	0.82	0.70	0.86	0.66	0.78	0.86
29A	0.80	0.70	0.76	0.68	0.78	0.84
$\bar{x}$(10)	0.67	0.77	0.70	0.63	0.77	0.75

Herd 31 - Roblin, Manitoba
Serum copper values, Ug/ml, control group.

Unit No.	74/05/27	74/07/02	74/07/30	74/08/26	74/10/24
Cow					
2	0.86	0.76	0.90	0.76	0.64
4	0.70	0.76	0.90	0.76	0.52
6	0.76	0.66	0.80	0.60	0.62
8	1.06	0.98	1.02	0.84	0.78
10	0.70	0.76	0.84	0.76	0.74
12	0.92	0.84	0.90	0.76	0.62
14	0.70	0.82	1.00	0.94	0.86
16	0.86	0.86	1.06	0.94	0.76
18	0.72	0.58	0.64	0.72	0.40
$\bar{x}(9)$	0.80	0.78	0.90	0.79	0.66
Calf					
2	0.76	0.62	0.70	0.64	0.56
4	1.10	0.74	0.70	0.64	0.80
6	0.70	0.52	0.56	0.60	0.66
8	0.82	0.62	0.78	0.84	0.80
10	0.96	0.70	0.66	0.70	0.80
12	0.92	0.68	0.68	0.74	0.76
14	1.20	0.62	0.58	0.70	0.86
16	0.82	0.68	0.68	0.74	0.76
18	0.76	0.62	0.62	0.68	0.56
$\bar{x}(9)$	0.89	0.64	0.67	0.70	0.73

Herd 31 - Roblin, Manitoba

Serum copper values, Ug/ml treated group (*designates date of treatment).

Unit No.	74/05/27*	74/07/02	74/07/30	74/08/26*	74/10/24
Cow					
1	0.84	0.70	0.78	0.68	0.72
3	0.74	0.94	1.08	0.86	0.88
5	0.70	0.90	0.82	0.86	1.08
7	0.70	0.84	0.90	0.80	0.70
9	0.76	0.90	0.84	0.82	0.78
11	0.88	0.90	0.92	0.94	0.78
13	0.70	0.74	0.74	0.70	0.60
15	0.62	0.78	0.80	0.84	0.72
17	0.86	0.94	0.94	0.94	1.22
$\bar{x}(9)$	0.76	0.85	0.87	0.83	0.83
Calf					
1	0.84	0.52	0.92	0.60	0.70
3	0.76	0.74	0.84	0.66	0.86
5	0.92	0.74	0.80	0.72	0.80
7	0.86	0.62	1.30	0.86	0.80
9	0.90	0.62	0.80	0.72	0.80
11	0.96	0.74	0.72	0.84	0.80
13	0.76	0.66	0.74	0.68	0.66
15	0.86	0.76	0.70	0.80	0.76
17	0.86	0.74	0.70	0.80	0.76
$\bar{x}(9)$	0.86	0.68	0.84	0.74	0.77

Appendix IID

1974 Copper Supplementation Trial

Forage and Soil Survey

1974 Soil and Forage Survey

Key to Sample Location and Description - Forages.

Sample No.	Location Sec.	Twp.	Rge.	Sample Description
1	SW4	26	27	Field 1
2	NW4	26	27	Field 2
3	NE1	25	25	Field 1
4	SE12	25	25	Field 3
5	18	25	22	
6	SW20	24	21	
7	N8	29	29	
8	S21	23	24	
9	SE8	26	18	Field 1
10	SE8	26	18	Field 2
11	S35/N26	28	28	
12	NE18	25	21	Field 1
13	NE18	25	21	Field 2
14	NE22	24	27	Field 3
15	NE19	24	26	Field 1
16	SE30	22	14	Field 1A
17	SE30	22	14	Field 1B
18	SE30	22	14	Field 1C
19	NW1	26	25	Field 1
20	NE2	26	25	Field 2
21	NE11	26	25	Field 3
22	NE11	26	25	Field 4
23	SE26	23	26	
24	NE26	23	26	Alfalfa
25	NE26	23	26	Grass
26	NW26	23	26	Grass
27	NW26	23	26	Alfalfa No. 1
28	NW26	23	26	Alfalfa No. 2
29	S25	23	26	Alfalfa A
30	S25	23	26	Alfalfa B
31	S25	23	26	Grass A
32	S25	23	26	Grass B
33	NE35	23	23	
34	S26	25	28	
35	SE1	26	13	
36	W11	26	13	
37	W2	26	13	
38	SW36	23	17	
39	18	25	22	Second cut
40	NE16	36	25	
41	W6	33	22	
42	SE12	33	23	
43	NW27	35	28	Grass
44	NW27	35	28	Timothy
45	SE29	35	28	Grass
46	NW3	35	29	Alfalfa

Sample No.	Location Sec.	Location Twp.	Location Rge.	Sample Description
47	NW29	35	29	Grass
48	SW15	35	20	Grass
49	S21	35	20	Grass
50	N21	35	20	Grass
51	27	33	15	Grass
52	NW33	27	15	Brome/alfalfa/ quack
53	N28	33	15	Grass
54	17	37	27	Grass
55	S9	37	27	Grass
56	NW4	37	27	Grass
57	S21	23	24	Grass
58	S21	23	24	Alfalfa
59	SE18	36	25	
60	NE5	36	25	
61	6 & 7	34	19	
62	S26	25	28	
63	SW26	25	28	
64	SW2	21	27	
65	SE2	21	27	
66	NE10	21	27	
67	NE10	26	13	
68	14	26	12	
69	E15	26	13	
70	NE27	3	5E	
71	SE17	37	27	
72	4	37	27	
73	W15	35	20	
74	33	27	15	
75	10	33	23	
76	3	33	23	
77	15	35	20	
78	E33	27	15	
79	18	25	21	
80	12	26	13	
81	21	36	25	
82	15	35	20	
83	36	32	23	
84	29	23	17	
85	W34	27	15	
86	18	36	25	
87	9	37	27	
88	SW15	35	20	
89	10	33	23	
90	12	26	13	

Sample No.	Location Sec.	Twp.	Rge.	Sample Description
91	SW15	35	20	
92	12	33	23	
93	SE17	37	27	
94	9	37	27	
95	NW16	35	20	
96	W33	27	15	
97	9	37	27	
98	6	33	22	
99	36	32	23	
100	16	36	25	
101	12	26	13	
102	29	35	29	
103	NW16	35	29	
104	SW3	35	26	
105	NE27	36	28	
106	NW31	34	29	
107	SE16	35	29	
108	SE23	36	27	
109	NW5	37	27	
110	NE36	36	25	
111	NE33	36	24	
112	NE2	36	28	
113	SW34	35	26	
114	NW25	36	27	
115	NE20	36	24	
116	NE6	35	29	
117	SW29	34	29	
118	SW24	20	6	
119	SW5	24	20	

1974 Soil and Forage Survey

Forage analyses in parts per million, dry weight.

Sample No.	Cu	Fe	Mn	Zn	Mo
1	6.5	144.3	41.1	34.6	2.0
2	5.7	138.7	35.8	23.4	3.4
3	6.5	159.1	44.3	24.3	1.4
4	7.2	89.5	21.5	24.1	1.4
5	6.1	74.0	22.9	22.7	1.6
6	5.7	122.2	28.8	20.2	5.0
7	4.6	156.8	26.8	27.1	2.0
8	6.1	160.5	57.7	31.2	0.8
9	6.4	57.3	15.5	21.6	0.8
10	6.4	63.8	17.9	22.3	0.6
11	5.7	153.2	35.4	30.1	0.8
12	5.7	103.9	44.3	29.6	1.4
13	6.1	115.2	28.5	16.7	3.0
14	9.3	142.2	77.3	30.7	1.2
15	8.9	51.8	17.2	22.2	3.4
16	5.7	48.9	19.2	19.0	0.6
17	6.1	42.3	33.6	25.4	0.4
18	4.3	96.6	48.8	13.4	0.8
19	6.4	86.1	31.6	23.5	1.4
20	8.6	153.2	32.3	30.6	2.6
21	5.0	68.9	12.0	16.8	1.0
22	4.6	55.4	21.3	19.3	0.4
23	6.4	52.1	12.7	20.3	0.6
24	5.0	45.2	14.4	26.5	6.0
25	5.7	54.0	12.0	21.2	0.8
26	5.7	52.1	18.5	23.9	1.0
27	2.6	107.5	30.4	24.1	2.0
28	4.2	240.7	21.5	25.7	3.4
29	4.9	58.9	18.5	23.9	2.0
30	4.5	154.7	23.0	29.7	1.8
31	7.8	70.1	26.7	28.6	1.4
32	7.1	67.1	25.6	25.7	1.8
33	14.9	980.0	45.2	37.7	3.6
34	6.5	44.7	21.5	11.7	1.4
35	7.5	86.0	54.4	21.8	1.0
36	7.5	83.4	51.1	18.4	1.8
37	8.4	73.9	51.1	24.5	2.0
38	7.8	67.5	48.9	14.9	3.4
39	3.9	98.9	20.4	19.1	3.4
40	7.9	103.5	34.1	29.0	4.0
41	6.5	58.0	12.5	40.8	2.4
42	4.9	70.9	82.6	34.1	5.0
43	6.1	120.7	120.7	24.1	7.0
44	7.9	75.7	22.2	27.9	4.0
45	11.5	130.1	20.8	26.3	2.4
46	6.1	78.6	25.8	21.3	3.4
47	8.6	81.0	16.1	13.8	9.0
48	8.1	125.5	68.9	26.8	1.4

Sample No.	Cu	Fe	Mn	Zn	Mo
49	5.5	55.9	27.4	20.4	1.8
50	9.7	128.9	27.4	22.0	1.8
51	5.5	128.9	55.6	25.9	1.0
52	5.2	77.4	41.5	18.3	2.0
53	7.1	113.9	38.1	26.6	0.8
54	5.8	79.8	22.9	23.2	5.0
55	7.9	133.0	40.1	26.8	4.0
56	6.5	91.7	20.8	23.5	12.0
57	7.3	56.0	31.4	22.3	0.8
58	4.3	93.9	67.9	27.7	3.0
59	6.1	101.5	31.5	20.7	3.4
60	5.0	62.6	8.2	10.9	2.0
61	7.7	100.1	68.7	19.0	0.6
62	9.3	214.2	67.9	29.0	4.0
63	7.3	79.9	36.1	22.5	2.4
64	6.7	92.7	45.5	21.9	2.6
65	5.3	72.9	29.0	16.3	1.6
66	7.3	47.4	29.4	20.7	2.0
67	6.7	88.1	54.9	21.1	1.6
68	7.3	111.2	66.7	19.2	1.0
69	8.3	70.8	57.7	18.8	0.6
70	8.0	154.4	34.1	18.9	2.6
71	10.8	104.3	36.5	26.8	3.4
72	9.4	98.2	27.2	27.6	2.0
73	6.0	111.2	36.1	24.3	1.8
74	7.7	73.3	32.2	22.3	1.8
75	5.0	64.7	15.3	17.7	4.0
76	6.3	89.0	28.3	13.9	2.4
77	4.0	52.3	27.5	13.8	2.4
78	5.0	85.3	56.1	26.3	1.0
79	8.3	103.0	54.9	28.1	1.4
80	7.3	53.5	25.5	31.3	1.0
81	8.3	73.3	15.3	21.3	5.0
82	5.9	54.8	50.0	21.6	1.4
83	12.1	43.2	13.0	30.2	12.0
84	8.8	64.7	16.2	25.5	3.0
85	5.5	75.5	81.7	26.3	0.6
86	7.8	143.6	20.1	21.9	5.0
87	7.9	114.2	23.6	21.6	2.0
88	11.7	49.0	12.7	33.2	1.6
89	6.5	55.6	42.2	22.3	1.2
90	8.1	58.9	24.6	18.9	1.2
91	10.7	50.6	42.2	29.0	1.8
92	7.5	56.0	30.6	32.1	1.2
93	6.5	81.8	87.7	31.3	0.6
94	8.3	84.0	43.6	20.6	1.4
95	8.8	56.4	19.7	25.0	3.2
96	6.5	83.0	35.9	28.1	0.8
97	15.8	62.5	22.5	33.4	2.4
98	6.5	94.2	20.4	24.6	5.0

Sample No.	Cu	Fe	Mn	Zn	Mo
99	4.2	44.0	15.8	23.7	5.0
100	7.2	115.4	37.2	20.0	5.0
101	8.5	207.5	26.1	34.1	0.6
102	8.3	156.1	24.3	24.3	8.0
103	6.1	177.6	30.7	22.9	0.2
104	10.8	114.7	29.3	26.5	2.0
105	6.1	112.5	12.9	21.3	9.0
106	8.6	110.6	59.0	31.6	10.0
107	10.1	96.9	61.9	26.7	4.0
108	4.3	166.5	33.6	23.2	1.0
109	5.4	86.9	26.8	19.5	3.0
110	7.2	114.1	37.3	36.6	3.0
111	8.3	98.0	30.4	19.6	5.0
112	6.1	155.4	31.5	19.6	3.4
113	5.9	228.3	10.2	29.9	2.6
114	7.2	192.4	37.5	32.3	4.0
115	5.0	89.5	20.4	17.9	1.0
116	3.9	130.3	50.3	19.2	24.0
117	6.5	155.4	64.4	27.1	7.0
118	7.2	127.8	13.0	24.7	0.6
119	4.2	124.5	23.2	17.9	1.0

1974 Soil and Forage Survey

Key to sample location and description - soils.

Sample No.	Location Sec.	Twp.	Rge.	Sample Description
1	18	25	22	0-6"
2				6-24"
3	SW4	26	27	6-24"
4				0-6"
5	NW4	26	27	0-6"
6				6-24"
7	NE1	25	25	0-6" Field 1
8				6-24"Field 1
9				0-6" Field 2
10				6-24"Field 2
11	SE12	25	25	0-6" Field 3
12				0-24"Field 3
13	NE18	25	21	0-6" Field 1
14				6-24"
15				0-6" Field 2
16				6-24"
17	NE19	24	26	0-6" Field 1
18				6-24"
19	NE19	24	26	0-6" Field 2
20				6-24"Field 2
21	NE22	24	27	0-6" Field 3
22				6-24"Field 3
23	N8	29	29	0-6"
24				6-24"
25	S35/N26	28	28	0-6"
26	NE2	26	25	0-6" Field 2
27				6-24"
28	NE11	26	25	0-6" Field 3
29				0-6" Field 4
30	NE11	26	25	6-24
31	NW1	26	25	6-24 Field 1
32	SE8	26	18	0-6"
33				6-24"
34	S21	23	24	0-6"
35				6-24"
36	SW25	24	22	0-6"
37				6-24"
38	SW20	24	21	0-6"
39				0-24"
40	S25	23	26	0-6"
41				6-24"
42	SE26	23	26	6-24"
43	NW26	23	26	0-6"
44				6-24"
45	NE26	23	26	6-24"
46				0-6"

Sample No.	Location Sec.	Twp.	Rge.	Sample Description
47	S25	23	26	6-24"
48	N26	23	26	6-24"
49	SE26	23	26	0-6"
50	NW1	26	25	0-6"
51	S35/N26	28	28	6-24"
52	NE35	23	23	6-24"
53				24-30"
54				0-6"
55	SE8	26	18	24-30"
56	SE30	22	14	0-6" No. 1A
57				6-24"No. 1A
58				0-6" No. 1B
59				6-24"No. 1B
60	SW30	22	14	0-6" No. 1C
61	SE30	22	14	24-30"
62	SE25	22	15	0-6"
63				6-24"
64	SW2	21	27	0-6"
65				6-24"
66	NE10	21	27	0-6"
67				6-24"
68				24-30"
69	SE2	21	27	0-6"
70				6-24"
71	SW26	25	28	0-6"
72				6-24"
73				24-30"
74	S26	25	28	0-6" Center North
75				6-24" Center North
76	S26	25	28	0-6" Center North
77				6-24" Center South
78				24-30" Center South
79	SW5	24	20	0-6"(Keld Area)
80				6-24" " "
81				24-30" " "
82	SW6	24	20	0-6" " "
83				6-24" " "
84				24-30" " "
85	S21	35	20	0-6"
86				6-24"
87	SW15	35	20	0-6"
88				6-24"
89	N21	35	20	0-6"
90				6-24"

Sample No.	Location Sec.	Twp.	Rge.	Sample Description
91	SE12	33	23	0-6"
92				6-24"
93	W26	33	23	0-6"
94				6-24"
95	17	37	27	0-6"
96				6-24"
97	NW4	37	27	0-6"
98				6-12"
99	S9	37	27	0-6"
100				6-12"
101	NE5	36	25	0-6"
102				6-24"
103	SE18	36	25	0-6"
104				6-24"
105	NE16	36	25	0-6"
106				6-24"
107	SW36	23	17	0-6"
108	33	27	15	0-6"
109				6-24"
110	33	28	15	0-6"
111				6-24"
112	NW3	35	29	0-6"
113				6-24"
114	NW29	35	29	0-6"
115	6 & 7	34	19	0-6"
116				6-24"
117	SE29	35	28	0-6"
118				6-24"
119	NW27	35	28	0-6"
120				6-24"
121	NE27	3	5E	0-6" Rosa, Man.
122	NE27	3	5E	6-24" Rosa, Man.
123	NE36-	36	25	0-6"
124				6-24"
125	SW34	35	26	0-6"
126				6-24"
127	SW3	35	26	0-6"
128	NW31	34	29	0-6"
129				6-24"
130	NW25	36	27	0-6"
131				6-24"
132	NE6	35	29	0-6"
133				6-24"
134	SE16	35	29	0-6"
135				6-24"

Sample No.	Location Sec.	Twp.	Rge.	Sample Description
136	NE27	36	28	0-6"
137				6-24"
138	NW5	37	27	0-6"
139	NW16	35	29	0-6"
140				6-24"
141	NE20	36	24	0-6"
142				6-24"
143	SE23	36	24	0-6"
144				6-24"
145	SW29	34	29	0-6"
146				6-24"
147	NE2	36	28	0-6"
148				6-24"
149	NE33	36	24	0-6"
150				6-24"

Soil analyses in parts per million except iron in percent, dry weight.

Sample No.	Cu	Fe	Mn	Zn	Mo*
1	11.7	1.3	464.7	40.8	
2	8.6	1.2	438.3	35.2	
3	11.7	1.5	634.7	85.2	
4	9.0	1.4	566.1	62.0	
5	7.6	1.5	523.7	55.6	
6	9.0	1.7	723.9	51.9	
7	15.2	1.4	377.4	53.7	
8	15.6	1.3	365.8	46.3	
9	15.9	1.5	362.0	46.3	
10	11.4	1.2	327.3	35.2	
11	21.4	2.1	739.4	98.1	
12	19.7	1.5	465.9	57.4	
13	2.8	0.7	219.5	23.1	
14	3.5	0.7	238.7	22.2	
15	3.1	0.7	223.3	20.4	
16	3.1	0.7	204.1	16.7	
17	19.0	1.6	797.1	72.2	
18	24.2	2.9	446.7	90.7	
19	13.8	1.9	577.6	52.8	
20	32.8	3.2	585.3	88.9	
21	16.2	1.4	277.3	69.4	
22	16.2	1.5	104.0	57.4	
23	12.4	0.4	123.2	50.0	1.6
24	15.9	1.2	69.3	55.6	
25	16.1	1.5	869.9	68.3	
26	17.4	1.5	356.4	55.2	
27	14.1	1.5	260.6	45.2	
28	7.4	1.1	206.9	30.1	
29	11.1	0.8	394.7	32.1	
30	6.0	1.0	145.6	24.1	
31	20.8	1.5	352.6	56.2	
32	8.7	0.6	229.9	24.1	
33	7.7	0.6	191.6	15.7	
34	19.5	2.0	1295.3	140.5	
35	19.1	2.9	4752.1	143.5	
36	23.5	1.9	904.4	93.4	
37	19.1	1.4	958.1	48.2	0.8
38	24.8	2.3	1149.7	100.4	
39	19.5	1.5	850.8	54.2	
40	14.1	1.7	919.8	75.3	
41	13.1	1.9	536.5	63.2	
42	7.0	0.8	360.2	22.1	
43	20.1	1.9	942.8	103.4	
44	17.4	2.5	666.8	88.3	
45	19.1	2.7	383.2	84.3	

*No value designates less than 0.8 ppm Mo.

Sample No.	Cu	Fe	Mn	Zn	Mo
46	19.0	1.7	572.8	104.5	
47	9.8	1.2	443.0	42.2	
48	19.3	2.5	3131.3	88.4	0.8
49	9.5	0.7	614.8	35.2	
50	23.9	2.0	534.6	94.5	
51	19.3	1.8	870.6	76.4	
52	19.3	1.7	469.7	58.3	0.8
53	16.5	1.2	527.0	30.2	
54	35.1	2.2	811.5	100.5	
55	7.0	0.5	164.2	13.8	
56	9.8	0.7	274.9	33.2	
57	8.4	0.7	278.8	29.1	
58	6.0	0.6	194.7	19.3	
59	5.3	0.6	171.8	15.6	
60	9.5	1.1	336.0	43.2	
61	4.6	0.7	133.7	12.3	
62	14.1	0.9	420.0	47.7	
63	10.5	0.8	84.0	35.2	
64	13.3	1.4	809.5	62.3	
65	13.0	1.7	748.4	63.3	
66	19.3	1.7	523.2	74.4	
67	15.9	1.7	445.8	72.2	
68	17.3	1.7	457.4	47.5	
69	16.6	1.9	554.3	69.3	
70	16.6	1.9	562.1	62.3	
71	13.8	1.2	503.9	49.5	0.8
72	13.5	1.4	438.0	53.4	1.6
73	16.6	1.3	457.4	55.4	1.6
74	5.9	0.9	317.9	27.7	0.8
75	7.6	0.9	329.5	29.7	0.8
76	10.4	1.0	399.3	45.5	0.8
77	11.0	1.0	407.0	46.5	0.8
78	12.4	1.0	492.3	46.5	1.6
79	43.5	4.8	38.8	68.3	11.6
80	64.5	7.2	19.4	36.6	20.0
81	70.0	7.7	19.4	32.7	24.0
82	13.5	1.1	193.8	75.2	
83	11.0	1.5	182.2	54.4	
84	17.9	1.1	124.0	54.4	2.4
85	9.0	0.8	116.3	23.7	
86	8.3	0.6	170.6	15.2	
87	9.3	0.5	360.5	19.0	
88	2.4	0.4	141.7	11.1	
89	12.2	1.3	192.9	37.5	
90	13.6	1.1	275.5	24.7	
91	12.5	1.3	2637.1	73.0	2.4
92	12.9	1.2	1259.5	46.4	1.6
93	14.6	1.2	602.2	66.1	2.4
94	14.6	1.3	621.9	47.3	0.8
95	13.2	1.7	590.4	49.3	

Sample No.	Cu	Fe	Mn	Zn	Mo
96	14.6	2.2	586.5	57.2	
97	11.5	1.0	366.1	41.4	
98	11.1	1.1	314.9	41.4	
99	8.0	0.9	299.1	22.7	
100	4.5	1.0	145.6	21.7	
101	16.7	1.8	460.5	86.8	
102	18.8	1.9	126.0	45.4	
103	15.3	1.2	519.6	47.3	
104	9.0	0.9	169.3	34.5	
105	12.9	1.4	208.6	46.4	
106	9.0	1.7	267.7	41.4	
107	9.7	0.9	393.6	33.5	
108	12.5	1.0	165.3	44.4	
109	14.3	1.1	281.8	26.4	
110	13.3	1.0	131.2	45.0	
111	7.0	0.7	193.0	19.2	
112	18.2	2.2	1304.7	115.5	1.6
113	20.3	2.9	1158.0	117.5	0.8
114	11.2	1.3	548.1	37.2	0.8
115	6.6	0.8	258.6	19.0	
116	5.9	0.7	177.6	16.6	
117	22.7	2.0	733.4	114.6	
118	25.2	2.5	860.8	90.1	0.8
119	7.7	1.0	509.5	47.0	0.8
120	7.3	1.0	540.4	35.3	
121	3.5	0.6	104.2	14.3	
122	2.8	0.5	96.5	10.4	
123	12.6	1.3	277.9	56.8	
124	7.7	1.1	243.2	33.3	
125	16.1	1.5	409.2	73.4	
126	15.4	1.7	393.7	72.5	0.8
127	13.3	1.3	262.5	43.1	1.6
128	19.6	1.7	795.2	110.6	0.8
129	20.3	2.4	760.4	114.6	0.8
130	8.9	1.1	458.2	54.7	
131	6.3	1.0	375.6	29.9	
132	25.7	2.7	1014.1	144.4	2.4
133	29.0	2.1	837.6	139.3	2.4
134	20.7	2.3	627.2	99.0	0.8
135	21.7	1.5	458.2	80.5	0.8
136	15.5	1.6	540.8	54.7	
137	2.6	0.6	37.6	12.1	
138	3.9	0.3	45.1	13.0	

Sample No.	Cu	Fe	Mn	Zn	Mo
139	11.2	1.4	469.5	44.4	
140	16.5	2.5	4056.3	95.9	1.6
141	7.9	1.6	522.1	30.9	0.8
142	7.2	1.0	214.1	26.8	2.4
143	13.5	1.3	405.6	60.9	
144	11.8	1.3	458.2	51.6	
145	18.1	2.0	1209.4	117.6	2.4
146	12.2	2.4	1029.1	80.5	3.2
147	7.2	0.9	424.4	33.0	
148	4.6	0.8	353.1	27.9	
149	16.5	2.3	3868.5	103.2	1.6
150	7.9	1.3	518.3	36.1	

Appendix III

Covariance F-test of adjusted means in a one-way classification for body weights and serum copper levels of animals surveyed in the 1974 Copper Supplementation Trials. "X" is defined as the initial body value at the commencement of the trials. "Y" is defined as the change in body value by the termination of the trial period.

Appendix IIIA

Body weights

Herd 1

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	975	1,460	2.435	6,270	5,830	12,100
Y^2	112,025	159,000	271,025	2,032,700	1,721,650	3,754,350
n	20	20	40	20	20	40
X	21,735	20,985	42,720	3,110	3,090	6,200
X^2	24,003,275	22,633,975	46,637,250	498,250	509,700	1,008,550
XY	966,000	1,413,900	2,379,900	989,650	916,275	1,905,925

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	14,062.5	-9,093.8	5,880.6				
Total	39	1,012,290.3	-220,680.0	122,794.4	48,108.4	38	74,686.0	
Error	38	998,227.5	-211,586.2	116,913.8	44,848.2	37	72,065.6	1,947.7
F ratio = 1.35		NS (P>0.10)				1	2,620.4	2,620.4
Calf								
Treatment	1	10.0	220.0	4,840.0				
Total	39	47,550.0	30,425.0	94,100.0	19,467.5	38	74,686.5	
Error	38	47,540.0	30,205.0	89,260.0	19,191.0	37	70,069.0	1,893.8
F ratio = 2.41		NS (P>0.10)				1	4,563.5	4,563.5

Herd 2

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	490	1,075	1,565	2,540	4,030	6,570
Y^2	49,600	110,575	160,175	711,250	1,109,850	1,821,100
n	10	15	25	10	15	25
X	8,805	12,810	21,615	1,070	1,445	2,515
X^2	8,033,625	11,283,700	19,317,325	119,850	146,225	266,075
XY	470,250	885,200	1,355,450	280,325	393,650	673,975

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	4,213.5	-3,604.0	3,082.7				
Total	24	628,996.0	2,351.0	62,206.0	8.8	23	62,197.2	
Error	23	624,782.5	5,955.0	59,123.0	56.8	22	59,066.5	2,684.8
F ratio = 1.17	NS ($P>0.10$)					1	3,130.7	3,130.7
Calf								
Treatment	1	682.7	-938.7	1,290.7				
Total	24	13,066.0	13,033.0	94,504.0	13,000.1	23	81,503.9	
Error	23	12,383.3	13,971.7	93,213.3	15,763.8	22	77,449.5	3,520.4
F ratio = 2.95	NS ($P>0.10$)					1	4,054.4	4,054.4

Herd 3

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	1,845	2,115	3,960	5,120	5,075	10,195
Y^2	271,125	355,875	627,000	1,894,350	1,885,925	3,780,275
n	14	14	28	14	14	28
X	14,395	13,625	28,020	2,225	2,135	4,360
X^2	14,894,575	13,391,525	28,286,100	363,025	378,475	741,500
XY	1,879,600	2,062,400	3,942,000	821,200	791,425	1,612,625

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	21,175.0	-7,425.0	2,603.6				
Total	27	246,085.7	-20,828.6	66,942.9	1,762.9	26	65,180.0	
Error	26	224,910.7	-13,403.6	64,339.3	798.8	25	63,540.5	2,541.6
F ratio = 0.65 NS (P>0.10)						1	1,639.5	1,639.5
Calf								
Treatment	1	289.3	144.6	72.3				
Total	27	62,585.7	25,117.9	68,202.7	10,080.7	26	58,122.0	
Error	26	62,296.4	24,973.3	68,130.4	10,011.3	25	58,119.1	2,324.8
F ratio = 0.00 NS (P>0.10)						1	2.9	2.9

Herd 4

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	635	470	1,105	1,280	1,385	2,665
Y^2	75,175	45,550	120,725	281,700	324,525	606,225
n	6	6	12	6	6	12
X	5,495	5,415	10,910	1,085	1,115	2,200
X^2	5,081,275	4,895,425	9,976,700	207,475	212,925	420,400
XY	585,650	420,675	1,006,325	237,325	258,775	496,100

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	533.3	1,100.0	2,268.8				
Total	11	57,691.7	1,695.8	18,972.9	49.8	10	18,923.1	
Error	10	57,158.4	595.8	16,704.1	6.2	9	16,697.9	1,855.3
F ratio = 1.20 NS (P>0.10)						1	2,225.2	2,225.2
Calf								
Treatment	1	75.0	262.5	918.7				
Total	11	17,066.7	7,516.7	14,372.9	3,310.6	10	11,062.3	
Error	10	16,991.7	7,254.2	12,104.1	3,097.0	9	9,007.1	1,000.8
F ratio = 2.05 NS (P>0.10)						1	2,055.2	2,055.2

Herd 5

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	765	765	1,530	3,685	3,630	7,315
Y^2	107,975	102,625	210,600	1,055,975	1,022,950	2,078,925
n	13	13	26	13	13	26
X	14,140	14,160	28,300	1,550	1,435	2,985
X^2	15,641,650	15,608,400	31,250,050	190,650	160,525	351,175
XY	780,725	835,850	1,616,575	445,875	403,900	849,775

Variation	df	SSx^2	SSxy	SSy^2	Red.	Deviation from regression: df	SSr	MSr
Cow								
Treatment	1	15.4	0.0	0.0				
Total	25	446,588.5	-48,771.2	120,565.4	5,326.2	24	115,239.2	
Error	24	446,573.1	-48,771.2	120,565.4	5,326.4	23	115,239.0	5,010.4
F ratio = 0.00	NS (P>0.10)					1	0.2	0.2
Calf								
Treatment	1	508.7	243.3	116.3				
Total	25	21,437.2	25,993.5	20,877.9	31,518.2	24	-10,640.3	
Error	24	20,928.5	25,750.2	20,761.6	31,682.8	23	-10,921.2	-474.8
F ratio = 0.59	NS (P>0.10)					1	280.9	280.9

Herd 6

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	3,090	1,670	3,760	5,045	4,960	10,005
Y^2	338,950	252,850	591,800	1,718,575	1,673,050	3,391,625
n	15	15	30	15	15	30
X	14,230	14,130	28,360	1,890	2,140	4,030
X^2	13,713,700	13,666,350	27,380,050	247,750	319,150	566,900
XY	1,926,075	1,498,450	3,424,525	644,950	721,025	1,365,975

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	33.3	1,400.0	5,880.0				
Total	29	570,396.7	-129,928.3	120,546.7	29,595.8	28	90,950.9	
Error	28	570,063.4	-131,328.3	144,666.7	30,254.7	27	84,412.0	3,126.4
F ratio = 2.09	NS (P>0.10)					1	6,538.9	6,538.9
Calf								
Treatment	1	2,083.3	-708.3	240.8				
Total	29	25,536.7	21,970.0	54,957.5	18,901.5	28	36,056.0	
Error	28	23,453.4	22,678.3	54,716.7	21,928.8	27	32,787.9	1,214.4
F ratio = 2.69	NS (P>0.10)					1	3,268.1	3,268.1

Herd 7

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-2,275	-2,420	-4,695	2,930	3,410	6,340
Y^2	628,125	576,450	1,204,575	673,600	906,450	1,580,050
n	13	13	26	13	13	26
X	13,920	13,595	27,515	1,670	1,955	3,625
X^2	15,031,100	14,356,575	29,387,675	224,900	306,825	531,725
XY	-2,564,825	-2,623,525	-5,188,350	379,475	517,100	896,575

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	4,062.5	1,812.5	808.7				
Total	25	269,397.1	-219,776.0	356,766.3	179,294.8	24	177,471.5	
Error	24	265,334.6	-221,588.5	355,957.6	185,054.9	23	170,902.7	7,430.6
F ratio = 0.88	NS (P>0.10)					1	6,568.8	6,568.8
Calf								
Treatment	1	3,124.0	8,861.5	5,261.5				
Total	25	26,316.3	12,632.7	34,065.4	6,064.1	24	28,001.3	
Error	24	23,192.3	3,771.2	28,803.9	613.2	23	28,190.7	1,225.7
F ratio = 0.15	NS (P>0.10)					1	-189.4	-189.4

Herd 8

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-70	220	150	1,100	605	1,705
Y^2	14,850	12,150	36,000	306,150	124,525	430,675
n	4	3	7	4	3	7
X	3,850	2,675	6,525	680	375	1,055
X^2	3,770,450	2,389,825	6,160,275	125,650	54,425	180,075
XY	-96,450	199,250	102,800	192,025	74,225	266,250

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	-84,970.2	-12,101.2	14,144.0				
Total	6	78,042.9	-37,021.4	32,785.7	17,561.9	5	15,223.8	
Error	5	163,013.1	49,122.6	18,641.7	14,802.7	4	3,839.0	959.8
F ratio = 11.9 *(P<0.10)						1	11,384.8	11,384.8
Calf								
Treatment	1	3,471.4	5,657.1	9,219.0				
Total	6	21,071.4	9,282.1	15,385.7	4,088.8	5	11,296.9	
Error	5	17,600.0	3,625.0	6,166.7	746.6	4	5,420.1	1,355.0
F ratio 4.34 NS (P>0.10)						1	5,876.8	5,876.8

Herd 9

Sum	Cow Control	Cow Treated	Cow Total	Calf Control	Calf Treated	Calf Total
Y	2,530	3,000	5,530			
Y^2	496,700	615,100	1,111,800			
n	28	28	56			
X	25,710	28,325	54,035			
X^2	24,682,300	29,467,925	54,150,225			
XY	2,085,925	2,832,900	4,918,825			

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	122,111.2	21,947.3	3,944.6				
Total	55	2,011,274.6	-417,131.3	565,712.5	86,511.6	54	479,200.9	
Error	54	1,889,163.4	-439,078.6	561,767.9	102,050.5	53	459,717.4	8,673.9
F ratio = 2.25		NS (P>0.10)				1	19,483.5	19,483.5

Herd 10

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	245	315	560	585	640	1,225
Y^2	17,425	39,875	57,300	89,775	110,250	200,025
n	4	4	8	4	4	8
X	3,925	3,485	7,410	720	740	1,460
X^2	3,967,125	3,073,125	7,040,250	129,800	139,600	269,400
XY	234,800	257,825	492,625	105,750	116,900	222,650

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	24,200.0	-3,850.0	612.5				
Total	7	176,737.5	-26,075.0	18,100.0	3,847.0	6	14,253.0	
Error	6	152,537.5	-22,225.0	17,487.5	3,238.2	5	14,249.3	2,849.9
F ratio = 0.00 NS (P>0.10)						1	3.7	3.7
Calf								
Treatment	1	50.0	137.5	378.1				
Total	7	2,950.0	-912.5	12,446.9	282.3	6	12,164.6	
Error	6	2,900.0	-1,050.0	12,068.8	380.2	5	11,688.6	2,337.7
F ratio = 0.20 NS (P>0.10)						1	476.0	476.0

Herd 11

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	1,460	1,090	2,550	4,180	3,730	7,910
Y^2	198,200	153,750	351,950	1,354,050	1,282,450	2,636,500
n	13	11	24	13	11	24
X	12,165	10,355	22,520	1,975	1,330	3,305
X^2	11,555,525	9,874,525	21,430,050	310,375	165,800	476,175
XY	1,324,575	1,027,575	2,352,150	635,050	454,675	1,089,725

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
<u>Cow</u>								
Treatment	1	186.4	-440.6	1,040.8				
Total	23	298,783.3	-40,600.0	81,012.5	5,516.9	22	75,495.6	
Error	22	298,596.9	-40,159.4	79,971.7	5,401.2	21	74,570.5	3,551.0
F ratio = 0.26	NS (P>0.10)					1	925.1	925.1
<u>Calf</u>								
Treatment	1	5,731.1	-3,243.5	1,835.7				
Total	23	21,048.6	452.1	29,495.8	9.7	22	29,486.1	
Error	22	15,317.5	3,695.6	27,660.1	891.6	21	26,768.5	1,274.7
F ratio = 2.13	NS (P>0.10)					1	2,717.6	2,717.6

Herd 12

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	1,215	1,285	2,500	2,810	3,110	5,920
Y^2	169,725	170,875	340,600	816,050	888,500	1,704,550
n	10	11	21	10	11	21
X	10,535	11,110	21,645	1,250	1,520	2,770
X^2	11,258,275	11,321,100	22,579,375	163,300	218,200	381,500
XY	1,291,700	1,297,925	2,589,625	356,950	433,525	790,475

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	9,911.8	1,066.8	114.8				
Total	20	269,564.3	12,839.3	42,981.0	611.5	19	42,369.5	
Error	19	259,652.5	11,772.5	42,866.2	533.8	18	42,332.4	2,351.8
F ratio = 0.02 NS (P>0.10)						1	37.1	37.1
Calf								
Treatment	1	910.1	119.3	15.6				
Total	20	16,123.8	9,598.8	35,673.8	5,714.3	19	29,959.5	
Error	19	15,213.7	9,479.5	35,658.2	5,906.6	18	29,751.6	1,652.9
F ratio = 0.13 NS (P>0.10)						1	207.9	207.9

Herd 13

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	2,470	2,230	4,700	3,235	3,240	6,475
Y^2	655,850	520,100	1,175,950	1,057,525	1,056,950	2,114,475
n	10	10	20	10	10	20
X	8,195	9,200	17,395	1,200	1,290	2,490
X^2	6,914,525	8,539,350	15,453,875	149,600	173,800	323,400
XY	1,971,325	2,035,600	4,006,925	395,050	421,500	816,550

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	50,501.3	-12,060.0	2,880.0				
Total	19	324,573.8	-80,900.0	71,450.0	20,164.3	18	51,285.7	
Error	18	274,072.5	-68,840.0	68,570.0	17,290.8	17	51,279.2	3,016.4
F ratio = 0.00 NS (P>0.10)						1	6.5	6.5
Calf								
Treatment	1	405.0	22.5	1.3				
Total	19	13,395.0	10,412.5	18,193.8	8,094.1	18	10,099.7	
Error	18	12,990.0	10,390.0	18,192.5	8,310.4	17	9,882.1	581.3
F ratio = 0.37 NS (P>0.10)						1	217.6	217.6

Herd 14

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	1,280	1,550	2,830	2,725	2,705	5,430
Y^2	216,450	311,400	527,850	936,075	931,575	1,867,650
n	8	8	16	8	8	16
X	7,970	7,195	15,165	1,210	1,240	2,450
X^2	8,097,750	6,811,125	14,908,875	186,550	209,950	396,500
XY	1,278,525	1,365,700	2,644,225	413,200	424,325	837,525

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	37,539.1	-13,078.1	4,556.3				
Total	15	535,298.4	-38,084.4	27,293.8	2,709.6	14	24,584.2	
Error	14	497,759.3	-25,006.3	22,737.5	1,256.3	13	21,481.2	1,652.4
F ratio = 1.88		NS (P>0.10)				1	3,103.0	3,103.0
Calf								
Treatment	1	56.3	-37.5	25.0				
Total	15	21,343.8	6,056.3	24,843.8	1,718.5	14	23,125.3	
Error	14	21,287.5	6,093.8	24,818.8	1,744.4	13	23,074.4	1,775.0
F ratio = 0.03		NS (P>0.10)				1	-50.9	-50.9

Herd 15

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	1,125	1,095	2,220	2,180	2,145	4,325
Y^2	141,075	135,375	276,450	485,400	472,475	957,875
n	10	10	20	10	10	20
X	9,260	9,190	18,450	1,825	1,545	3,370
X^2	8,734,650	8,811,600	17,546,250	353,275	265,775	619,050
XY	1,021,600	963,200	1,984,800	403,725	331,850	735,575

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	245.0	105.0	45.0				
Total	19	526,125.0	-63,150.0	30,030.0	7,579.8	18	22,450.2	
Error	18	525,880.0	-63,255.0	29,985.0	7,608.6	17	22,376.4	1,316.3
F ratio = 0.06 NS (P>0.10)						1	73.8	73.8
Calf								
Treatment	1	3,920.0	490.0	61.3				
Total	19	51,205.0	6,812.5	22,593.8	906.4	18	21,687.4	
Error	18	47,285.0	6,322.5	22,532.5	845.4	17	21,687.1	1,275.7
F ratio = 0.00 NS (P>0.10)						1	0.3	0.3

Herd 15

Sum	Yearlings Control	Treated	Total	Control	Treated	Total
Y	780	1,015	1,795			
Y^2	154,950	207,225	362,175			
n	4	5	9			
X	2,485	2,880	5,365			
X^2	1,564,975	1,662,950	3,227,925			
XY	488,225	584,575	1,072,800			

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Yearling								
Treatment	1	4,550.1	-804.4	142.2				
Total	8	29,788.9	2,780.6	4,172.2	259.6	7	3,912.6	
Error	7	25,238.8	3,585.0	4,030.0	509.2	6	3,520.8	586.8
F ratio = 0.67 NS (P>0.10)						1	391.8	391.8

Herd 16

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	770	620	1,390	2,250	2,095	4,345
Y^2	93,000	62,150	155,150	729,100	647,125	1,376,225
n	7	7	14	7	7	14
X	6,645	6,615	13,260	1,355	1,040	2,395
X^2	6,393,925	6,329,525	12,723,450	279,975	161,500	441,475
XY	716,700	566,850	1,283,550	433,000	321,675	754,675

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	64.3	321.4	1,607.1				
Total	13	164,335.7	-32,978.6	17,142.9	6,618.1	12	10,524.8	
Error	12	164,271.4	-33,300.0	15,535.8	6,750.4	11	8,785.4	798.7
F ratio = 2.18	NS (P>0.10)					1	1,739.4	1,739.4
Calf								
Treatment	1	7,087.5	3,487.5	1,716.1				
Total	13	31,758.9	11,369.6	27,723.2	4,070.3	12	23,652.9	
Error	12	24,671.4	7,882.1	26,007.1	2,518.2	11	23,488.9	2,135.4
F ratio = 0.08	NS (P>0.10)					1	164.0	164.0

Herd 17

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	620	535	1,155	1,610	1,680	3,290
Y^2	52,300	52,775	105,075	296,750	245,550	542,300
n	9	12	21	9	12	21
X	8,020	9,715	17,735	2,030	1,750	3,780
X^2	7,493,900	7,956,475	15,450,375	510,650	271,050	781,700
XY	503,200	414,325	917,525	370,300	254,000	624,300

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	34,183.4	10,191.0	3,038.2				
Total	20	472,745.2	-57,900.0	41,550.0	7,091.4	19	34,458.6	
Error	19	438,561.8	-68,091.0	38,511.8	10,571.8	18	27,940.0	1,552.2
F ratio = 4.20	*(P<0.10)					1	6,518.6	6,518.6
Calf								
Treatment	1	32,686.1	15,944.4	7,777.8				
Total	20	101,300.0	32,100.0	26,866.7	10,171.9	19	16,694.8	
Error	19	68,613.9	16,155.6	19,088.9	3,803.9	18	15,285.0	849.2
F ratio = 1.66	NS (P>0.10)					1	1,409.8	1,409.8

Herd 18

Sum	Cow Control	Cow Treated	Cow Total	Calf Control	Calf Treated	Calf Total
Y	1,190	1,205	2,395	2,130	2,265	4,395
Y^2	200,450	185,775	386,225	586,850	650,025	1,236,875
n	8	8	16	8	8	16
X	7,465	7,760	15,225	935	1,010	1,045
X^2	7,067,325	7,643,550	14,710,875	113,825	131,500	245,325
XY	1,081,700	1,167,625	2,249,325	252,000	287,200	539,200

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	5,439.1	276.6	14.1				
Total	15	223,335.9	-29,667.2	27,723.4	3,940.9	14	23,782.5	
Error	14	217,896.8	-29,943.8	27,709.3	4,114.9	13	23,594.4	1,815.0
F ratio = 0.10		NS (P>0.10)				1	188.1	188.1
Calf								
Treatment	1	351.6	632.8	1,139.1				
Total	15	8,885.9	4,932.8	29,623.4	2,738.3	14	26,885.1	
Error	14	8,534.3	4,300.0	28,484.3	2,166.6	13	26,317.7	2,024.4
F ratio = 0.28		NS (P>0.10)				1	567.4	567.4

Herd 19

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	0	515	515	675	2,100	2,775
Y^2	10,850	76,175	87,025	155,925	502,850	658,775
n	3	9	12	3	9	12
X	3,070	7,600	10,670	525	1,190	1,715
X^2	3,168,450	6,500,950	9,669,400	92,325	159,500	251,825
XY	17,025	433,075	450,100	116,775	280,125	396,900

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	72,002.8	-23,031.9	7,367.4				
Total	11	181,991.7	-7,820.8	64,922.9	336.1	10	64,586.8	
Error	10	109,988.9	15,211.1	57,555.5	2,103.6	9	55,451.9	6,161.3
F ratio = 1.48 NS (P>0.10						1	9,134.9	9,134.9
Calf								
Treatment	1	4,117.4	-802.1	156.3				
Total	11	6,722.9	306.3	17,056.3	14.0	10	17,042.3	
Error	10	2,605.5	1,108.4	16,900.0	471.5	9	16,428.5	1,825.4
F ratio = 0.34 NS (P>0.10)						1	613.8	613.8

Herd 20

Sum	Cow Control	Cow Treated	Cow Total	Calf Control	Calf Treated	Calf Total
Y	760	760	1,520	1,865	2,330	4,195
Y^2	88,150	90,700	178,850	504,425	693,500	1,197,925
n	7	8	15	7	8	15
X	6,855	7,755	14,610	1,455	1,660	3,115
X^2	6,824,225	7,606,725	14,430,950	326,375	359,400	685,775
XY	737,100	727,800	1,464,900	395,675	484,300	879,975

Variation	df	SSx^2	SSxy	SSy^2	Red.	Deviation from regression df	SSr	MSr
Cow								
Treatment	1	366.7	502.1	687.6				
Total	14	200,810.0	-15,580.0	24,823.3	1,208.8	13	23,614.5	
Error	13	200,443.3	-16,082.1	24,135.7	1,290.3	12	22,845.4	1,903.8
F ratio = 0.40	NS (P>0.10)					1	769.1	769.1
Calf								
Treatment	1	0.5	-33.1	2,300.1				
Total	14	38,893.3	8,813.3	24,723.3	1,997.1	13	22,726.2	
Error	13	38,892.8	8,846.4	22,423.2	2,012.2	12	20,411.0	1,700.9
F ratio = 1.36	NS (P>0.10)					1	2,315.2	2,315.2

Herd 21

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	2,070	2,340	4,410	3,840	3,495	7,335
Y^2	425,050	533,300	958,350	1,362,900	1,137,725	2,500,625
n	11	11	22	11	11	22
X	12,690	11,645	24,335	1,600	1,805	3,405
X^2	14,870,850	12,448,025	27,318,875	247,800	306,225	554,025
XY	2,321,050	2,425,625	4,746,675	564,425	575,925	1,140,350

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	49,637.5	-12,825.0	3,313.6				
Total	21	401,046.6	-131,386.4	74,345.5	43,043.3	20	31,302.2	
Error	20	351,409.1	-118,561.4	71,031.9	40,001.3	19	31,030.6	1,633.2
F ratio = 0.17	NS (P>0.10)					1	271.6	271.6
Calf								
Treatment	1	1,910.2	3,214.8	5,410.2				
Total	21	27,023.9	5,092.0	55,069.3	959.5	20	54,109.8	
Error	20	25,113.7	1,877.2	49,659.1	140.3	19	49,518.8	2,606.3
F ratio = 1.76	NS (P<0.10)					1	4,591.0	4,591.0

Herd 22

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	1,000	1,000	2,000	2,795	2,985	5,780
Y^2	138,750	118,600	257,350	890,625	1,003,725	1,894,350
n	9	9	18	9	9	18
X	8,480	8,825	17,305	1,195	1,285	2,480
X^2	8,014,800	8,711,275	16,726,075	179,475	198,825	378,300
XY	943,850	975,325	1,919,175	387,650	433,050	820,700

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	6,612.5	0	0				
Total	17	89,240.3	-3,602.8	35,127.8	145.5	16	34,982.3	
Error	16	82,627.8	-3,602.8	35,127.8	157.1	15	34,970.7	2,331.4
F ratio = 0.00	NS (P>0.10)					1	11.6	11.6
Calf								
Treatment	1	450.0	950.0	2,005.6				
Total	17	36,611.1	38,327.8	24,344.4	40,125.0	16	-15,780.6	
Error	16	36,161.1	37,377.8	22,338.8	38,635.4	15	-16,296.6	-1,086.4
F ratio = -0.47	NS (P>0.10)							

Herd 23

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	4,370	4,570	8,940	5,820	5,640	11,460
Y^2	1,019,350	1,067,100	2,086,450	1,812,100	1,608,450	3,420,550
n	19	20	39	19	20	39
X	17,510	18,695	36,205	2,890	3,150	5,995
X^2	16,324,650	17,706,575	34,031,225	451,100	505,925	957,025
XY	4,017,925	4,275,675	8,293,600	892,200	886,150	1,778,350

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	1,690.3	-192.5	21.9				
Total	38	420,916.7	-5,700.0	37,126.9	77.2	37	37,049.7	
Error	37	419,307.4	-5,507.5	37,105.0	72.3	36	37,032.7	1,028.7
F ratio = 0.02	NS (P>0.10)					1	17.0	17.0
Calf								
Treatment	1	14,170.0	11,944.9	5,761.0				
Total	38	35,485.9	16,742.3	53,073.1	7,899.0	37	45,174.1	
Error	37	21,315.9	4,797.4	47,312.1	1,079.7	36	46,232.4	1,284.2
F ratio = 0.82	NS (P>0.10)					1	-1,058.3	-1,058.3

Herd 24

Sum	Cow Control	Cow Treated	Cow Total	Calf Control	Calf Treated	Calf Total
Y	1,315	1,085	2,400	2,460	2,415	4,875
Y^2	219,575	191,625	411,200	767,400	838,925	1,606,325
n	8	7	15	8	7	15
X	9,445	8,370	17,815	1,165	1,170	2,335
X^2	11,315,625	10,159,900	21,475,525	173,925	212,600	386,525
XY	1,533,600	1,260,550	2,794,150	362,150	403,025	765,175

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	850.0	-528.1	328.1				
Total	14	317,243.3	-56,250.0	27,200.0	9,973.6	13	17,226.4	
Error	13	316,393.3	-55,721.9	26,871.9	9,813.5	12	17,058.4	1,421.5
F ratio = 0.12	NS (P>0.10)					1	168.0	168.0
Calf								
Treatment	1	1,728.6	3,012.5	5,250.0				
Total	14	23,043.3	6,300.0	21,950.0	1,722.4	13	20,227.6	
Error	13	21,314.7	3,287.5	16,700.0	507.1	12	16,192.9	1,349.4
F ratio = 2.99	NS (P>0.10)					1	4,034.7	4,034.7

Herd 24

Sum	Yearlings Control	Treated	Total	Control	Treated	Total
Y	950	1,150	2,100			
Y^2	232,100	269,850	501,950			
n	4	5	9			
X	2,735	3,650	6,385			
X^2	1,875,025	2,681,500	4,556,525			
XY	648,800	833,450	1,482,250			

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Yearlings								
Treatment	1	4,753.5	-770.8	125.0				
Total	8	26,722.2	-7,583.3	11,950.0	2,152.0	7	9,798.0	
Error	7	21,968.7	-6,812.5	11,825.0	2,112.6	6	9,712.4	1,618.7
F ratio = 0.05 NS (P>0.10)						1	85.6	85.6

Herd 25

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	620	1,445	2,065	1,835	2,250	4,085
Y^2	78,000	366,075	444,075	679,125	867,700	1,546,825
n	5	6	11	5	6	11
X	5,480	5,900	11,380	785	830	1,615
X^2	6,118,800	5,826,150	11,944,950	128,825	121,600	250,425
XY	678,800	1,419,625	2,098,425	292,200	317,525	609,725

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	34,619.4	-35,899.7	37,227.3				
Total	10	171,822.7	-37,911.4	56,418.2	8,364.9	9	48,053.3	
Error	9	137,203.3	-2,011.7	19,190.9	29.5	8	19,161.4	2,395.2
F ratio = 12.06		*(P<0.01)				1	28,891.9	28,891.9
Calf								
Treatment	1	950.3	-407.3	174.5				
Total	10	13,313.6	9,972.7	29,804.5	7,470.2	9	22,334.3	
Error	9	12,363.3	10,380.0	29,630.0	8,714.9	8	20,915.1	2,614.4
F ratio = 10.38		**(P<0.025)				1	27,138.2	27,138.2

Herd 26

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	220	440	660	1,805	1,710	3,515
Y^2	8,950	52,000	60,950	547,675	591,250	1,138,925
n	6	5	11	6	5	11
X	6,210	5,290	11,500	1,000	995	1,995
X^2	6,454,650	5,795,550	12,250,200	189,200	216,625	405,825
XY	225,825	423,700	649,525	299,100	349,600	648,700

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	1,442.7	3,220.0	7,186.7				
Total	10	227,472.7	-40,475.0	21,350.0	7,201.9	9	14,148.1	
Error	9	226,030.0	-43,695.0	14,163.3	8,446.9	8	5,716.4	714.6
F ratio = 11.80		**(P<0.01)				1	8,431.7	8,431.7
Calf								
Treatment	1	2,851.2	3,630.2	4,621.9				
Total	10	44,004.5	11,206.8	15,722.7	2,854.1	9	12,868.6	
Error	9	41,153.3	7,576.6	11,100.8	1,394.9	8	9,705.9	1,213.2
F ratio = 2.61		NS (P>0.10)				1	3,162.7	3,162.7

Herd 27

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	165	605	770	1,270	1,545	2,815
Y^2	49,725	89,975	139,700	430,100	496,325	926,425
n	4	5	9	4	5	9
X	3,920	4,230	8,155	530	645	1,175
X^2	3,920,450	3,624,375	7,544,825	71,700	89,125	160,825
XY	133,450	509,000	642,450	169,400	205,300	374,700

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	30,843.9	-24,175.6	14,133.5				
Total	8	155,488.9	-55,255.6	73,822.2	19,636.0	7	54,186.2	
Error	7	124,645.0	-31,080.0	59,688.7	7,749.7	6	51,939.0	8,656.5
F ratio = 0.26	NS (P>0.10)					1	2,247.2	2,247.2
Calf								
Treatment	1	27.2	66.1	160.6				
Total	8	7,422.2	7,186.1	45,955.6	6,957.5	7	38,998.1	
Error	7	7,395.0	7,120.0	45,795.0	6,855.2	6	38,939.8	6,490.0
F ratio = 0.01	NS (P<0.10)					1	58.3	58.3

Herd 28

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	565	410	975	2,215	1,555	3,770
Y^2	72,525	35,800	108,325	710,275	485,925	1,196,200
n	7	5	12	7	5	12
X	7,675	4,770	12,445	775	575	1,350
X^2	8,611,325	4,605,950	13,217,275	91,175	68,675	159,850
XY	565,775	388,500	954,275	250,775	178,125	428,900

Variation	df	SSx^2	SSxy	SSy^2	Red.	Deviation from regression df	SSr	MSr
Cow								
Treatment	1	59,167.2	-534.1	4.8				
Total	11	310,772.9	-56,881.3	29,106.3	10,411.1	10	18,695.2	
Error	10	251,605.7	-56,347.2	29,101.5	12,619.0	9	16,482.5	1,831.4
F ratio = 1.21	NS (P>0.10)					1	2,212.7	2,212.7
Calf								
Treatment	1	53.6	-67.9	85.9				
Total	11	7,975.0	4,775.0	11,791.7	2,859.0	10	8,932.7	
Error	10	7,921.4	4,842.9	11,705.8	2,960.8	9	8,745.0	971.7
F ratio = 0.19	NS (P>0.10)					1	187.7	187.7

Herd 29

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	1,350	1,315	2,665	1,290	1,445	2,735
Y^2	378,100	359,025	737,125	344,950	418,125	763,075
n	5	5	10	5	5	10
X	3,725	3,175	6,900	420	395	815
X^2	2,802,725	2,026,825	4,829,550	36,850	34,975	71,825
XY	1,016,625	844,100	1,860,725	111,625	114,975	226,600

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	30,250.0	1,925.0	122.5				
Total	9	68,550.0	21,875.0	26,902.5	6,980.5	8	19,922.0	
Error	8	38,300.0	19,950.0	26,780.0	10,391.7	7	16,388.3	2,341.2
F ratio = 1.51 NS (P>0.10)						1	3,533.7	3,533.7
Calf								
Treatment	1	62.5	-387.5	2,402.5				
Total	9	5,402.5	3,697.5	15,052.5	2,530.6	8	12,521.9	
Error	8	5,340.0	4,085.0	12,650.0	3,125.0	7	9,525.1	1,360.7
F ratio = 2.20 NS (P>0.10)						1	2,996.8	2,996.8

Herd 29

Sum	Yearlings Control	Treated	Total	Control	Treated	Total
Y	3,515	3,505	7,020			
Y^2	1,169,025	1,134,575	2,303,600			
n	11	11	22			
X	5,265	5,915	11,180			
X^2	2,716,225	3,433,975	6,149,300			
XY	1,743,825	1,899,050	3,642,875			

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Yearlings								
Treatment	1	19,204.5	-295.5	4.5				
Total	21	467,827.3	75,438.6	63,581.8	12,164.7	20	51,417.1	
Error	20	448,622.8	75,734.1	63,577.3	12,785.0	19	50,792.3	2,673.3
F ratio = 0.23 NS (P>0.10)						1	624.8	624.8

Herd 30

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	665	445	1,110	1,765	1,585	3,350
Y^2	115,075	59,825	174,900	781,075	640,875	1,421,950
n	4	4	8	4	4	8
X	3,695	4,360	8,055	565	660	1,225
X^2	3,471,225	4,828,850	800,075	85,625	113,350	198,975
XY	624,275	460,825	1,085,100	250,325	263,800	514,125

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	55,278.1	-18,287.5	6,050.0				
Total	7	189,696.9	-32,531.3	20,887.5	5,578.8	6	15,308.7	
Error	6	134,418.8	-14,252.8	14,837.5	1,511.3	5	13,326.2	2,665.2
F ratio = 0.74	NS (P>0.10)					1	1,982.5	1,982.5
Calf								
Treatment	1	1,128.1	-2,137.5	4,050.0				
Total	7	11,396.9	1,156.3	19,137.5	117.3	6	19,020.2	
Error	6	10,268.8	3,293.8	15,087.5	1,056.5	5	14,031.0	2,806.2
F ratio = 1.78	NS (P>0.10)					1	4,989.2	4,989.2

Herd 31

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	405	-60	345	2,245	2,375	4,620
Y^2	56,425	18,700	75,125	570,675	630,725	1,201,400
n	9	9	18	9	9	18
X	7,920	8,155	16,075	1,300	1,235	2,535
X^2	7,017,000	8,215,175	15,232,175	203,000	174,325	377,325
XY	355,900	-47,325	308,575	333,325	323,850	657,175

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	3,068.1	-6,070.8	12,012.0				
Total	17	876,306.9	470.8	68,512.5	0.3	16	68,512.2	
Error	16	873,238.8	6,541.6	56,500.5	49.0	15	56,451.5	3,763.4
F ratio = 3.20 *(P<.01)						1	12,060.7	12,060.7
Calf								
Treatment	1	234.7	-469.4	938.9				
Total	17	20,312.5	6,525.0	15,600.0	2,096.0	16	13,504.0	
Error	16	20,077.8	6,994.4	14,661.1	2,436.6	15	12,224.5	815.0
F ratio = 1.57 NS (P>0.10)						1	1,279.5	1,279.5

Appendix IIIB

Serum copper values

Herd 1

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.14	1.00	0.86	1.46	3.12	4.58
Y^2	0.23	0.46	0.69	0.42	1.31	1.73
n	20	20	40	20	20	40
X	15.30	14.28	29.58	14.12	14.94	29.06
X^2	12.00	10.52	22.52	10.23	11.63	21.87
XY	-0.14	0.43	0.29	0.83	1.80	2.63

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.026	-0.029	0.032				
Total	39	0.646	-0.343	0.669	0.182	38	0.487	
Error	38	0.620	-0.314	0.637	0.159	37	0.478	0.013
F ratio = 0.72 NS (P>0.10)						1	0.009	0.009
Calf								
Treatment	1	0.017	0.034	0.069				
Total	39	0.755	-0.694	1.200	0.638	38	0.562	
Error	38	0.738	-0.728	1.131	0.718	37	0.413	0.011
F ratio = 13.33 ** (P<0.005)						1	0.149	0.149

Herd 2

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	3.72	4.30	8.02	1.10	0.58	1.68
Y^2	2.16	1.67	3.83	0.73	0.52	1.26
n	10	15	25	10	15	25
X	4.76	7.68	12.44	8.22	12.14	20.36
X^2	2.41	4.11	6.52	6.99	10.41	17.40
XY	1.54	2.03	3.57	0.65	0.03	0.68

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.008	-0.018	0.044				
Total	24	0.327	-0.423	1.250	0.547	23	0.703	
Error	23	0.319	-0.405	1.206	0.513	22	0.694	0.032
F ratio = 0.30 NS (P>0.10)						1	0.009	0.009
Calf								
Treatment	1	0.001	0.005	0.031				
Total	24	0.819	-0.690	1.146	0.581	23	0.565	
Error	23	0.818	-0.695	1.116	0.591	22	0.524	0.024
F ratio = 1.69 NS (P>0.10)						1	0.040	0.040

Herd 3

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	1.24	1.62	2.86	-1.72	-0.46	-2.18
Y^2	0.61	0.78	1.38	1.32	0.28	1.60
n	14	14	28	14	14	28
X	7.38	8.04	15.42	11.24	11.76	23.00
X^2	4.01	4.93	8.94	9.26	10.13	19.39
XY	0.51	0.60	1.11	-1.65	-0.47	-2.12

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.016	0.009	0.005				
Total	27	0.452	-0.469	1.092	0.488	26	0.604	
Error	26	0.436	-0.478	1.086	0.525	25	0.561	0.023
F ratio = 1.88 NS (P>0.10)						1	0.042	0.042
Calf								
Treatment	1	0.010	0.023	0.057				
Total	27	0.499	-0.351	1.431	0.246	26	1.185	
Error	26	0.489	-0.374	1.375	0.286	25	1.089	0.044
F ratio = 2.21 NS (P>0.10)						1	0.096	0.096

Herd 4

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.34	0.12	-0.22	-0.62	0.36	0.26
Y^2	0.06	0.05	0.11	0.15	0.05	0.20
n	6	6	12	6	6	12
X	3.36	3.80	7.16	4.40	3.66	8.06
X^2	2.08	2.49	4.57	3.28	2.27	5.54
XY	-0.24	0.03	0.20	-0.51	0.22	-0.29

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.016	0.017	0.018				
Total	11	0.296	0.336	0.107	0.382	10	-0.275	
Error	10	0.280	0.319	0.089	0.364	9	-0.275	-0.031
F ratio = 0.00 NS (P>0.10)						1	0.000	0.000
Calf								
Treatment	1	0.046	-0.410	0.080				
Total	11	0.131	0.463	0.198	1.639	10	-1.441	
Error	10	0.085	0.873	0.118	8.939	9	-8.821	-0.980
F ratio = 7.53 ** (P<0.025)						1	7.380	7.380

Herd 5

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	0.76	2.76	3.52	-3.48	-1.50	-4.98
Y^2	0.16	1.00	1.17	4.74	0.48	5.21
n	13	13	26	13	13	26
X	8.00	7.78	15.78	12.52	11.28	23.80
X^2	4.96	4.74	9.70	15.90	10.00	25.91
XY	0.45	1.76	2.22	-7.10	-1.49	-8.59

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.002	-0.017	0.154				
Total	25	0.120	0.081	0.691	0.054	24	0.636	
Error	24	0.118	0.098	0.537	0.081	23	0.456	0.020
F ratio = 9.09 ** (P<0.01)						1	0.180	0.180
Calf								
Treatment	1	0.059	-0.094	0.151				
Total	25	4.120	-4.029	4.259	3.941	24	0.318	
Error	24	4.061	-3.935	4.108	3.813	23	0.295	0.013
F ratio = 1.79 NS (P>0.10)						1	0.023	0.023

Herd 6

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	4.90	6.02	10.92	1.98	5.92	7.90
Y^2	1.75	2.53	4.27	0.56	2.73	3.30
n	15	15	30	15	15	30
X	2.92	3.06	5.98	4.58	3.14	7.72
X^2	0.58	0.65	1.23	1.75	0.83	2.58
XY	0.95	1.21	2.16	0.36	1.03	1.37

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.001	0.005	0.042				
Total	29	0.043	-0.021	0.299	0.010	28	0.289	
Error	28	0.042	-0.026	0.257	0.016	27	0.241	0.009
F ratio = 5.34 NS (P<0.05)						1	0.048	0.048
Calf								
Treatment	1	0.069	-0.189	0.518				
Total	29	0.595	-0.663	1.215	0.739	28	0.477	
Error	28	0.526	-0.474	0.698	0.427	27	0.271	0.010
F ratio = 20.52 ** (P<0.005)						1	0.206	0.206

Herd 7

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.56	1.06	0.50	0.92	3.60	4.52
Y^2	0.21	0.44	0.65	0.52	1.55	2.07
n	13	13	26	13	13	26
X	9.12	8.18	17.30	8.26	6.62	14.88
X^2	6.54	5.35	11.89	5.66	3.80	9.46
XY	-0.41	0.58	0.17	0.30	1.51	1.81

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.034	-0.059	0.101				
Total	25	0.383	-0.162	0.637	0.069	24	0.568	
Error	24	0.349	-0.104	0.536	0.308	23	0.506	0.022
F ratio = 2.86 NS (P>0.10)						1	0.063	0.063
Calf								
Treatment	1	0.103	-0.169	0.276				
Total	25	0.949	-0.777	1.281	0.636	24	0.646	
Error	24	0.846	-0.608	1.01	0.437	23	0.568	0.025
F ratio = 3.12 * (P<0.10)						1	0.077	0.077

Herd 8

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	0.04	0.08	0.12	-0.32	0.28	-0.04
Y^2	0.01	0.01	0.02	0.11	0.18	0.30
n	4	3	7	4	3	7
X	2.20	1.58	3.78	3.06	2.22	5.28
X^2	1.23	0.83	2.07	2.44	1.72	4.16
XY	0.01	0.04	0.05	-0.32	0.10	0.42

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.001	-0.001	0.001				
Total	6	0.025	-0.011	0.019	0.005	5	0.014	
Error	5	0.024	-0.010	0.018	0.004	4	0.014	0.004
F ratio = 0.03 NS (P>0.10)						1	0.000	0.000
Calf								
Treatment	1	0.001	-0.007	0.052				
Total	6	0.173	0.455	0.297	1.194	5	-0.897	
Error	5	0.172	0.462	0.246	1.241	4	-0.995	-0.249
F ratio = 0.40 NS (P>0.10)						1	0.099	0.099

Herd 9

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-6.20	-2.70	-8.90			
Y^2	2.32	1.06	3.38			
n	28	28	56			
X	14.64	14.1	28.74			
X^2	8.27	7.65	15.92			
XY	-3.76	-1.53	-5.29			

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.005	-0.034	0.219				
Total	55	1.171	-0.726	1.963	0.450	54	1.513	
Error	54	1.166	-0.692	1.744	0.410	53	1.334	0.025
F ratio = 7.14 ** ($P<0.01$)						1	0.180	0.180

Herd 10

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	0.20	1.52	1.72	-0.44	1.18	0.74
Y^2	0.03	0.65	0.68	0.08	0.43	0.51
n	4	4	8	4	4	8
X	1.42	1.30	2.72	1.96	2.16	4.12
X^2	0.50	0.44	0.95	1.08	1.28	2.36
XY	0.07	0.46	0.54	-0.26	0.54	0.28

Variation	df	SSx^2	SSxy	SSy^2	Red.	Deviation from regression df	SSr	MSr
Cow								
Treatment	1	0.002	-0.020	0.218				
Total	7	0.021	-0.049	0.312	0.116	6	0.195	
Error	6	0.019	-0.029	0.094	0.046	5	0.049	0.010
F ratio = 15.14 ** (P<0.025)						1	0.147	0.147
Calf								
Treatment	1	0.005	-0.041	0.328				
Total	7	0.242	-0.096	0.444	0.038	6	0.406	
Error	6	0.237	-0.056	0.116	0.013	5	0.103	0.021
F ratio = 14.73 ** (P<0.025)						1	0.303	0.303

Herd 11

Sum	Cow Control	Cow Treated	Cow Total	Calf Control	Calf Treated	Calf Total
Y	-1.12	1.38	0.26	-2.94	-0.70	-3.64
Y^2	0.32	0.37	0.68	0.93	0.85	1.78
n	13	11	24	13	11	24
X	6.02	4.40	10.42	9.02	8.18	17.20
X^2	3.07	1.97	5.04	6.46	6.95	13.40
XY	-0.73	0.49	-0.25	-2.23	-1.23	-3.45

Variation	df	SSx^2	SSxy	SSy^2	Red.	Deviation from regression df	SSr	MSr
Cow								
Treatment	1	0.024	-0.080	0.267				
Total	23	0.512	-0.359	0.679	0.251	22	0.428	
Error	22	0.489	-0.279	0.412	0.160	21	0.253	0.012
F ratio = 14.55 ** (P<0.005)						1	0.175	0.175
Calf								
Treatment	1	0.015	0.048	0.157				
Total	23	1.078	-0.844	1.232	0.660	22	0.572	
Error	22	1.063	-0.892	1.075	0.748	21	0.326	0.016
F ratio = 15.78 ** (P<0.005)						1	0.245	0.245

Herd 12

Sum	Cow Control	Cow Treated	Cow Total	Calf Control	Calf Treated	Calf Total
Y	0.90	0.42	1.32	-0.72	0.70	-0.02
Y^2	0.13	0.15	0.28	0.58	0.40	0.98
n	10	11	21	10	11	21
X	4.22	5.38	9.60	6.82	6.58	13.40
X^2	1.89	2.82	4.71	4.83	4.30	9.12
XY	0.38	0.07	0.45	-0.73	0.08	-0.65

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.024	-0.018	0.014				
Total	20	0.323	-0.156	0.195	0.075	19	0.120	
Error	19	0.300	-0.138	0.181	0.063	18	0.117	0.007
F ratio = 0.34 NS (P>0.10)						1	0.002	0.002
Calf								
Treatment	1	0.037	-0.060	0.096				
Total	20	0.574	-0.640	0.980	0.714	19	0.266	
Error	19	0.537	-0.580	0.884	0.628	18	0.256	0.014
F ratio = 0.70 NS (P>0.10)						1	0.010	0.010

Herd 13

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-2.16	-1.42	-3.58	-2.06	-1.62	-3.68
Y^2	0.59	0.27	0.86	0.73	0.57	1.30
n	10	10	20	10	10	20
X	6.72	6.36	13.08	9.32	8.52	17.84
X^2	4.60	4.07	8.67	9.85	7.46	17.31
XY	-1.41	-0.92	-2.33	-1.94	-1.55	-3.49

Variation	df	SSx^2	SSxy	SSy^2	Red.	Deviation from regression df	SSr	MSr
Cow								
Treatment	1	0.007	-0.013	0.027				
Total	19	0.120	0.011	0.220	0.001	18	0.219	
Error	18	0.114	0.024	0.193	0.005	17	0.188	0.011
F ratio = 2.86 NS (P>0.10)						1	0.032	0.032
Calf								
Treatment	1	0.032	-0.018	0.010				
Total	19	1.397	-0.210	0.624	0.032	18	0.592	
Error	18	1.365	-0.193	0.614	0.027	17	0.587	0.035
F ratio = 0.15 NS (P>0.10)						1	0.005	0.005

Herd 14

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-1.22	-1.08	-2.30	-2.84	-1.50	-4.34
Y^2	0.29	0.32	0.61	1.08	0.49	1.57
n	8	8	16	8	8	16
X	4.30	4.36	4.66	4.84	4.36	9.20
X^2	2.35	2.41	4.76	3.03	2.59	5.62
XY	-0.71	-0.61	-1.33	-1.78	-0.95	-2.73

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	3.33	-0.575	0.001				
Total	15	3.40	-0.658	0.283	0.127	14	0.156	
Error	14	0.07	-0.083	0.282	0.095	13	0.187	0.014
F ratio = -2.16 NS ($P>0.10$)						1	-0.031	-0.031
Calf								
Treatment	1	0.014	-0.040	0.112				
Total	15	0.333	-0.237	0.392	0.168	14	0.224	
Error	14	0.319	-0.196	0.280	0.121	13	0.159	0.012
F ratio = 5.33 ** ($P<0.05$)						1	0.065	0.065

Herd 15

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.22	1.54	1.32	0.58	0.42	1.00
Y^2	0.08	0.35	0.43	0.45	0.70	1.15
n	10	10	20	10	10	20
X	4.42	4.1	8.52	4.68	6.28	10.96
X^2	2.11	1.88	3.99	2.61	4.68	7.29
XY	-0.10	0.51	0.41	-0.09	-0.43	0.52

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.005	-0.028	0.155				
Total	19	0.357	-0.151	0.341	0.064	18	0.277	
Error	18	0.352	-0.123	0.186	0.043	17	0.143	0.008
F ratio = 15.90 ** (P<0.005)						1	0.134	0.134
Calf								
Treatment	1	0.128	-0.013	0.001				
Total	19	1.284	-0.028	1.100	0.001	18	1.099	
Error	18	1.156	-0.015	1.098	0.000	17	1.098	0.065
F ratio = 0.01 NS (P>0.10)						1	0.001	0.001

Herd 15

Sum	Yearling Heifers Control	Treated	Total	Control	Treated	Total
Y	0.12	1.06	1.18			
Y^2	0.02	0.23	0.25			
n	4	5	9			
X	2.14	2.12	4.26			
X^2	1.18	0.94	2.12			
XY	0.04	0.44	0.49			

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Yearling Heifers								
Treatment	1	0.027	-0.045	0.074				
Total	8	0.103	-0.071	0.098	0.048	7	0.050	
Error	7	0.076	-0.026	0.024	0.009	6	0.016	0.003
F ratio = 13.08 ** ($P<0.025$)						1	0.034	0.034

Herd 16

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.34	0.48	0.14	-0.52	0.18	-0.34
Y^2	0.05	0.10	0.15	0.38	0.12	0.51
n	7	7	14	7	7	14
X	5.44	4.88	10.32	5.60	5.58	11.18
X^2	4.29	3.54	7.83	4.66	4.48	9.14
XY	-0.30	0.28	-0.02	-0.64	0.15	-0.49

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.022	-0.033	0.048				
Total	13	0.226	-0.123	0.147	0.067	12	0.080	
Error	12	0.203	-0.090	0.099	0.040	11	0.059	0.005
F ratio = 3.91 * ($P<0.10$)						1	0.021	0.021
Calf								
Treatment	1	0.000	-0.001	0.035				
Total	13	0.216	-0.222	0.498	0.229	12	0.269	
Error	12	0.216	-0.221	0.463	0.227	11	0.236	0.021
F ratio = 1.54 NS ($P>0.10$)						1	0.033	0.033

Herd 17

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.04	3.10	3.06	0.44	2.66	3.10
Y^2	0.15	1.05	1.20	0.17	0.69	0.86
n	9	12	21	9	12	21
X	3.58	3.80	7.38	4.80	5.60	10.40
X^2	1.68	1.54	3.23	2.70	2.80	5.50
XY	-0.10	0.79	0.69	0.19	1.14	1.33

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.034	-0.110	0.335				
Total	20	0.633	-0.389	0.751	0.240	19	0.511	
Error	19	0.599	-0.280	0.395	0.131	18	0.265	0.015
F ratio = 16.75 ** ($P<0.005$)						1	0.246	0.246
Calf								
Treatment	1	0.023	-0.059	0.154				
Total	20	0.346	-0.204	0.399	0.120	19	0.279	
Error	19	0.323	-0.145	0.245	0.065	18	0.181	0.010
F ratio = 9.78 ** ($P<0.01$)						1	0.098	0.098

Herd 18

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.86	-0.74	-1.60	-1.36	-0.06	-1.42
Y^2	0.17	0.45	0.61	0.27	0.22	0.49
n	8	8	16	8	8	16
X	4.24	4.94	9.18	5.12	5.18	10.30
X^2	2.36	3.11	5.47	3.32	3.56	6.88
XY	-0.50	-0.50	-1.00	-0.86	-0.16	-1.02

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.030	0.005	0.001				
Total	15	0.205	-0.085	0.454	0.035	14	0.419	
Error	14	0.174	-0.090	0.453	0.047	13	0.406	0.031
F ratio = 0.40 NS (P>0.10)						1	0.013	0.013
Calf								
Treatment	1	0.000	0.005	0.106				
Total	15	0.249	-0.104	0.366	0.043	14	0.323	
Error	14	0.249	-0.108	0.261	0.047	13	0.214	0.016
F ratio = 6.68 ** (P<0.025)						1	0.110	0.110

Herd 19

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	0.96	3.24	4.20	0.71	2.86	3.57
Y^2	0.36	1.48	1.83	0.23	1.93	2.16
n	3	9	12	3	9	12
X	0.74	2.72	3.46	1.66	4.10	5.76
X^2	0.20	0.91	1.10	1.09	2.58	3.67
XY	0.22	0.90	1.12	0.29	0.50	0.79

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.007	0.005	0.004				
Total	11	0.106	-0.090	0.363	0.076	10	0.287	
Error	10	0.099	-0.095	0.359	0.091	9	0.269	0.030
F ratio = 0.61 NS (P>0.10)						1	0.018	0.018
Calf								
Treatment	1	0.022	-0.018	0.015				
Total	11	0.904	-0.922	1.101	0.940	10	0.162	
Error	10	0.883	-0.904	1.086	0.926	9	0.161	0.018
F ratio = 0.05 NS (P>0.10)						1	0.001	0.001

Herd 20

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-1.50	-0.68	-2.18	-1.08	-1.12	-2.20
Y^2	0.42	0.43	0.85	0.29	0.46	0.75
n	7	8	15	7	8	15
X	5.08	6.02	11.10	4.04	5.22	9.26
X^2	3.77	4.58	8.35	2.46	3.74	6.20
XY	-1.12	-0.59	-1.71	-0.69	-1.01	-1.71

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.003	0.013	0.062				
Total	14	0.136	-0.094	0.535	0.064	13	0.470	
Error	13	0.133	-0.107	0.472	0.085	12	0.387	0.032
F ratio = 2.57 NS (P>0.10)						1	0.083	0.083
Calf								
Treatment	1	0.021	0.004	0.001				
Total	14	0.483	-0.352	0.432	0.256	13	0.176	
Error	13	0.462	-0.356	0.431	0.274	12	0.157	0.013
F ratio = 1.43 NS (P>0.10)						1	0.019	0.019

Herd 21

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-4.26	-2.40	-6.66	-4.78	-2.20	-6.98
Y^2	1.74	0.72	2.47	2.46	0.86	3.32
n	11	11	22	11	11	22
X	7.86	8.14	16.00	8.72	7.04	15.76
X^2	5.69	6.17	11.86	7.10	4.82	11.92
XY	-3.08	-1.75	-4.83	-3.96	-1.57	-5.54

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.004	0.024	0.157				
Total	21	0.224	0.009	0.449	0.000	20	0.449	
Error	20	0.221	-0.015	0.292	0.001	19	0.291	0.015
F ratio = 10.33 ** ($P<0.005$)						1	0.158	0.158
Calf								
Treatment	1	0.128	0.197	0.303				
Total	21	0.626	-0.537	1.110	0.461	20	0.649	
Error	20	0.498	-0.340	0.807	0.232	19	0.575	0.030
F ratio = 2.45 NS ($P>0.10$)						1	0.074	0.074

Herd 22

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-1.42	-0.66	-2.08	-2.86	-1.60	-4.46
Y^2	0.53	0.12	0.66	1.48	0.39	1.88
n	9	9	18	9	9	18
X	5.24	4.92	10.16	6.42	6.18	12.60
X^2	3.23	2.80	6.03	4.68	4.38	9.07
XY	-1.04	-0.41	-1.45	-2.22	-1.13	-3.35

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.006	-0.014	0.032				
Total	17	0.296	-0.271	0.417	0.249	16	0.168	
Error	16	0.290	-0.258	0.385	0.229	15	0.156	0.010
F ratio = 1.19 NS (P>0.10)						1	0.012	0.012
Calf								
Treatment	1	0.003	-0.017	0.088				
Total	17	0.247	-0.228	0.772	0.211	16	0.561	
Error	16	0.244	-0.212	0.684	0.184	15	0.500	0.033
F ratio = 1.82 NS (P>0.10)						1	0.061	0.061

Herd 23

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-4.86	-1.84	-6.70	-7.42	-3.02	-10.44
Y^2	1.79	0.83	2.62	3.85	1.08	4.93
n	19	20	39	19	20	39
X	12.54	16.52	29.06	15.74	16.52	32.26
X^2	9.05	13.84	22.89	13.28	14.00	27.28
XY	-2.84	-1.62	-4.46	-6.43	-2.76	-9.19

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.269	0.265	0.261				
Total	38	1.240	0.533	1.473	0.299	37	1.244	
Error	37	0.971	0.268	1.212	0.074	36	1.138	0.032
F ratio = 3.36 * (P<0.10)						1	0.106	0.106
Calf								
Treatment	1	0.000	-0.006	0.559				
Total	38	0.593	-0.557	2.137	0.524	37	1.613	
Error	37	0.593	-0.552	1.578	0.513	36	1.064	0.030
F ratio = 18.55 ** (P<0.005)						1	0.548	0.548

Herd 24

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-3.72	-2.28	-6.00	-3.58	-2.50	-6.08
Y^2	1.96	0.90	2.86	1.99	1.24	3.24
n	8	7	15	8	7	15
X	5.40	3.78	9.18	4.96	4.34	9.30
X^2	3.95	2.22	6.16	3.62	2.89	6.50
XY	-2.77	-1.40	-4.17	-2.67	-1.79	-4.46

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.068	-0.070	0.072				
Total	14	0.545	-0.496	0.465	0.451	13	0.014	
Error	13	0.477	-0.425	0.392	0.380	12	0.013	0.001
F ratio = 1.00 NS						1	0.001	0.001
Calf								
Treatment	1	0.000	0.000	0.031				
Total	14	0.738	-0.693	0.772	0.652	13	0.120	
Error	13	0.738	-0.693	0.741	0.652	12	0.090	0.008
F ratio = 4.08 * (P<0.10)						1	0.031	0.031

Herd 24

Sum	Yearlings Control	Treated	Total	Control	Treated	Total
Y	-1.80	-1.98	-3.78			
Y^2	1.21	0.86	2.07			
n	4	5	9			
X	2.56	3.76	6.32			
X^2	2.03	2.94	4.97			
XY	-1.55	-1.55	-3.10			

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Yearlings								
Treatment	1	0.028	0.013	0.007				
Total	8	0.532	-0.443	0.483	0.370	7	0.114	
Error	7	0.504	-0.457	0.477	0.414	6	0.063	0.011
F ratio = 4.86 * (P<0.10)						1	0.051	0.051

Herd 25

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.80	-0.82	-0.90	-0.82	0.90	0.08
Y^2	0.18	0.12	0.30	0.39	0.20	0.60
n	5	6	11	5	6	11
X	2.50	3.98	6.48	3.00	2.44	5.44
X^2	1.65	2.71	4.35	2.01	1.02	3.03
XY	-0.47	-0.53	-1.00	-0.69	0.37	-0.31

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.948	-0.535	0.167				
Total	10	0.537	-0.471	0.225	0.413	9	-0.188	
Error	9	-0.411	0.064	0.059	-0.010	8	0.069	0.009
F ratio = 2.99 NS (P>0.10)						1	-0.026	-0.026
Calf								
Treatment	1	0.102	-0.166	0.269				
Total	10	0.343	-0.351	0.595	0.359	9	0.236	
Error	9	0.241	-0.185	0.326	0.142	8	0.184	0.023
F ratio = 2.29 NS (P>0.10)						1	0.053	0.053

Herd 26

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	0.86	0.70	1.56	0.48	0.32	0.80
Y^2	0.39	0.44	0.84	0.14	0.12	0.26
n	6	5	11	6	5	11
X	1.50	1.14	2.64	1.12	0.88	2.00
X^2	0.42	0.32	0.73	0.25	0.24	0.50
XY	0.17	0.04	0.22	0.05	-0.01	0.04

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.001	0.000	0.000				
Total	10	0.100	-0.158	0.616	0.250	9	0.367	
Error	9	0.099	-0.158	0.616	0.254	8	0.363	0.045
F ratio = 0.09 NS (P>0.10)						1	0.004	0.004
Calf								
Treatment	1	0.000	0.001	0.001				
Total	10	0.132	-0.107	0.200	0.087	9	0.114	
Error	9	0.131	-0.107	0.200	0.087	8	0.112	0.014
F ratio = 0.12 NS (P>0.10)						1	0.002	0.002

Herd 27

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-0.44	-0.50	-0.94	-1.38	-1.66	-3.04
Y^2	0.30	0.24	0.53	0.68	0.69	1.37
n	4	5	9	4	5	9
X	2.24	2.70	4.94	3.30	4.34	7.64
X^2	1.51	1.50	3.01	3.19	3.93	7.12
XY	-0.48	-0.33	-0.81	-1.44	-1.54	-2.98

Variation	df	SSx^2	SSxy	SSy^2	Red.	Deviation from regression df	SSr	MSr
Cow								
Treatment	1	0.001	-0.000	0.000				
Total	8	0.298	-0.297	0.436	0.297	7	0.139	
Error	7	0.297	-0.297	0.436	0.297	6	0.139	0.023
F ratio = 0.01 NS (P>0.10)						1	0.000	0.000
Calf								
Treatment	1	0.004	0.001	0.000				
Total	8	0.632	-0.403	0.344	0.257	7	0.088	
Error	7	0.628	-0.404	0.344	0.260	6	0.084	0.014
F ratio = 0.26 NS (P>0.10)						1	0.004	0.004

Herd 28

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	0.40	0.84	1.24	-0.50	-0.14	-0.64
Y^2	0.06	0.21	0.26	0.26	0.09	0.36
n	7	5	12	7	5	12
X	5.04	3.66	8.70	5.52	4.14	9.66
X^2	3.83	2.75	6.58	4.48	3.49	7.98
XY	0.24	0.56	0.80	-0.56	-0.17	-0.73

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.000	0.004	0.036				
Total	11	0.276	-0.101	0.137	0.037	10	0.100	
Error	10	0.276	-0.105	0.101	0.040	9	0.061	0.007
F ratio = 5.68 ** ($P<0.05$)						1	0.039	0.039
Calf								
Treatment	1	0.005	0.005	0.006				
Total	11	0.200	-0.212	0.322	0.224	10	0.098	
Error	10	0.196	-0.217	0.316	0.240	9	0.077	0.009
F ratio = 2.54 NS ($P>0.10$)						1	0.022	0.022

Herd 29

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-1.40	0.10	-1.30	-3.36	-1.50	-4.86
Y^2	0.44	0.05	0.49	2.44	1.16	3.60
n	5	5	10	5	5	10
X	3.58	3.70	7.28	5.70	5.60	11.30
X^2	2.58	2.81	5.39	6.66	6.83	13.50
XY	-1.00	0.07	-0.93	-3.99	-2.29	-6.28

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.001	0.018	0.225				
Total	9	0.089	0.014	0.326	0.002	8	0.324	
Error	8	0.088	-0.004	0.101	0.000	7	0.101	0.014
F ratio = 15.49 ** (P<0.01)						1	0.223	0.223
Calf								
Treatment	1	0.001	-0.019	0.346				
Total	9	0.730	-0.786	1.238	0.847	8	0.391	
Error	8	0.729	-0.768	0.892	0.809	7	0.084	0.012
F ratio = 25.66 ** (P<0.005)						1	0.308	0.308

Herd 29

Sum	Yearlings & Open Cows Control	Treated	Total	Control	Treated	Total
Y	-2.4	0.88	-1.52			
Y^2	1.38	0.36	1.74			
n	11	11	22			
X	6.68	7.54	14.22			
X^2	4.48	5.53	10.01			
XY	-1.73	0.36	-1.37			

Variation	df	SSx^2	SSxy	SSy^2	Red.	Deviation from regression df	SSr	MSr
Yearlings & Open Cows								
Treatment	1	0.034	0.128	0.489				
Total	21	0.823	-0.386	1.634	0.181	20	1.453	
Error	20	0.789	-0.514	1.145	0.335	19	0.810	0.043
F ratio = 15.07	** (P<0.005)					1	0.643	0.643

Herd 30

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	0.00	-0.08	-0.08	-0.04	0.18	0.14
Y^2	0.14	0.02	0.16	0.10	0.04	0.14
n	4	4	8	4	4	8
X	2.52	2.54	5.06	2.80	3.18	5.98
X^2	1.62	1.63	3.25	1.97	2.53	4.50
XY	-0.05	-0.06	-0.11	-0.06	0.14	0.08

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.000	0.000	0.001				
Total	7	0.048	-0.062	0.154	0.080	6	0.075	
Error	6	0.048	-0.062	0.154	0.080	5	0.073	0.015
F ratio = 0.10 NS (P>0.10)						1	0.002	0.002
Calf								
Treatment	1	0.018	0.011	0.006				
Total	7	0.030	-0.021	0.138	0.014	6	0.124	
Error	6	0.012	-0.031	0.132	0.079	5	0.053	0.011
F ratio = 6.73 ** (P<0.05)						1	0.071	0.071

Herd 31

Sum	Cow Control	Treated	Total	Calf Control	Treated	Total
Y	-1.24	0.68	-0.56	-1.48	-0.78	-2.26
Y^2	0.35	0.34	0.69	0.34	0.11	0.46
n	9	9	18	9	9	18
X	7.18	6.80	13.98	8.04	7.72	15.76
X^2	5.88	5.20	11.08	7.41	6.66	14.07
XY	-1.08	0.50	-0.58	-1.44	-0.70	-2.13

						Deviation from regression		
Variation	df	SSx^2	SSxy	SSy^2	Red.	df	SSr	MSr
Cow								
Treatment	1	0.008	-0.041	0.205				
Total	17	0.223	-0.144	0.675	0.094	16	0.582	
Error	16	0.215	-0.104	0.471	0.050	15	0.420	0.028
F ratio = 5.76 ** ($P<0.05$)						1	0.162	0.162
Calf								
Treatment	1	0.006	-0.012	0.027				
Total	17	0.267	-0.153	0.172	0.088	16	0.084	
Error	16	0.261	-0.140	0.145	0.076	15	0.069	0.005
F ratio = 3.30 * ($P<0.10$)						1	0.015	0.015

Appendix IV

1975 Soil and Forage Survey

Appendix IVA

Site location and sample description

1975 FORAGE AND SOIL SURVEY - SITE LOCATION AND SAMPLE DESCRIPTION

*Native grass species

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
1	25	19	26	4276	56717	1	2	3	4
2	25	19	22	4260	56702	5	6	7	8
3	25	19	8	4231	56670	9	10	11	12
4	26	19	14	4288	56774	13	14	15	16
5	27	19	1	4292	56840	17		18	
6	28	19	1	4294	56910	19		20	
7	30	19	13	4298	57141	21	22	23	
8	30	19	21	4260	57150	24	25	26*	
9	29	19	33	4260	57091	27		28	
10	29	19	10	4262	57030	29		30	
11	28	19	22	4262	56962	31	32	33	34
12	27	19	22	4260	56890	35		36	37
13	26	19	15	4260	56780	38	39	40	41

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
14	26	19	8	4230	56757	42	43	44	
15	27	19	6	4212	56850	45		46	
16	28	19	19	4225	56959	47	48	49	
17	29	19	18	4225	57045	50	51	52	53
18	30	19	5	4240	57102	54	55	56	
19	30	20	12	4200	57121	57	58	59	
20	30	20	6	4130	57106	60	61	62	63
21	30	20	10	4170	57122	64		65	
22	29	20	25	4200	57075	66	67	68	
23	28	20	35	4190	56990	69	70	71	72
24	27	20	14	4190	56883	73	74	75	76
25	26	20	2	4190	56743	77	78	79	
26	25	20	23	4190	56703	80	81	82	
27	25	20	9	4155	56668	83	84	85	86
28	25	20	16	4145	56677	87	88	89	90

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
29	26	20	9	4156	56764	91	92	93	
30	27	20	4	4158	56847	94	95	96	97
31	28	20	4	4160	56914	98		99	
32	29	20	3	4167	57007	100	101	102	
33	29	20	5	4133	57005	103	104	105	
34	29	21	2	4083	57007	106	107	108	
35	28	21	27	4080	56970	109	110	111	112
36	28	21	9	4058	56933	113	114	115	
37	28	20	6	4115	56913	116	117	118	
38	27	20	18	4123	56880	119	120	121	122
39	26	20	32	4032	56833	123	124	125	126
40	26	21	24	4096	56792	127	128	129	
41	26	21	20	4050	56804	130	131	132	
42	27	21	13	4098	56882	133		134	135
43	27	21	16	4060	56885	136		137	
44	28	21	18	4020	56950	138		139	140

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
45	27	21	5	4045	56846	141		142*	
46	26	21	8	4030	56763	144	145	146	147
47	25	21	2	4080	56653	148	149	150	151
48	25	21	20	4042	56705	152		153	154
49	25	21	34	4074	56726	155		156	
50	25	22	14	3980	56680	157	158	159	160
51	25	22	17	3942	56692	161	162	163	164
52	25	22	36	4000	56730	165	166	167	
53	26	22	9	3960	56760	168	169	170	
54	26	22	14	3983	56787	171	172	173	
55	26	22	32	3943	56824	174	175	176	
56	27	22	6	3928	56852	177	178	179	
57	27	22	10	3967	56862	180	181	182	
58	27	22	14	3998	56880	183	184	185	
59	25	23	3	3866	56654	186	187	188	189
60	25	23	22	3870	56708	190	191	192	193

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
61	25	23	32	3843	56728	194	195	196	197
62	26	23	4	3852	56757	198	199	200	201
63	26	23	28	3855	56816	202	203	204	
64	26	23	23	3892	56796	205	206	207	208
65	27	23	6	3821	56852	209	210	211	212
66	27	23	9	3863	56871	213	214	215	216
67	27	23	13	3915	56887	217	218	219	
68	28	22	10	3970	56927	220	221	222	223
69	28	22	34	3972	56995	224	225	226	227
70	28	22	24	4010	56966	228	229	230	
71	29	21	16	4054	57040	231	232	233	
72	29	21	21	4056	57060	234		235	
73	30	21	9	4054	57120	236	237	238	239
74	30	21	2	4088	57103	240	241	242	243
75	29	22	25	4008	57072	244	245	246	247
76	29	22	29	3950	57070	248		249	250

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
77	29	22	18	3934	57038	251		252	253
78	26	26	3	3582	56750	170A		171A	
79	26	26	17	3552	56785	172A		173A	174A
80	26	26	5	3644	56752	175A	176A	177A	
81	26	25	12	3705	56772	178A	179A	180A	
82	25	25	25	3715	56720	181A	182A	183A	
83	25	25	10	3682	56675	184A	185A	186A	187A
84	24	25	22	3680	56612	188A	189	190	190A
85	24	25	17	3643	56593	191A	192A	193A	194A
86	24	25	33	3660	56646	195A	196A	197A	198A
87	25	25	19	3622	56707	199A	200A	201A	
88	28	28	17	3352	56960	254	255	256	
89	28	29	10	3270	56978	257	258	259	
90	28	29	27	3266	57026	260	261	262	
91	28	29	36	3310	57047	263		264	265
92	29	29	9	3250	57072	266	267	268	

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
93	29	29	13	3303	57102	269		270	271
94	29	29	35	3290	57140	272		273	274
95	29	28	30	3347	57086	275	276	277	
96	30	28	9	3373	57138	278		279	
97	30	28	20	3367	57172	280		281	
98	30	28	1	3422	57118	282	283	284	
99	29	28	26	3405	57090	285	286	287	
100	29	28	10	3398	57040	288		289	290
101	28	28	33	3367	57012	291	292	293	
102	28	28	13	3422	56970	294	295	296	297
103	27	28	5	3348	56867	298	299	300	
104	27	29	15	3263	56895	301		302	
105	27	29	32	3243	56943	303		304	
106	27	29	26	3285	66935	305		306	
107	27	28	3	3384	56870	307	308	309	
108	27	28	13	3420	56892	310	311	312	

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
109	27	27	4	3470	56867	313	314	315	
110	27	27	16	3463	56902	316	317	318	
111	28	27	9	3475	56947	319		320	321
112	28	27	28	3477	56990	322	323	324	
113	28	27	1	3512	56930	325		326	
114	27	27	13	3521	56890	327	328	329	
115	26	28	19	3337	56812	330	331	332	333
116	26	29	15	3288	56795	334	335	336	
117	26	29	28	3265	56830	337	338	339	
118	26	29	35	3300	56852	340	341	342	
119	26	28	34	3390	56843	343	344	345	346
120	26	28	15	3385	56794	346	347	348	
121	26	27	5	3444	56765	349	350	351	352
122	26	27	13	3510	56790	353	354	355	
123	26	27	28	3467	56830	356	357	358	359
124	25	26	29	3540	56728	360	361	362	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
125	25	26	27	3593	56724	363	364	365	366
126	25	26	10	3572	56676	367	368	369	370
127	24	26	22	3578	56615	371	372	373	374
128	24	26	10	3580	56582	375	376	377	378
129	24	26	18	3528	56595	379	380	381	382
130	25	27	29	3450	56728	383	384	385	
131	25	27	22	3483	56710	386	387	388	
132	25	28	24	3410	56710	389	390	391	
133	25	28	12	3410	56676	392	393	394	395
134	25	27	8	3450	56675	396	397	398	399
135	25	28	30	3335	56727	400	401	402	
136	25	29	22	3282	56722	403	404	405	
137	25	29	10	3288	56685	406	407	408	
138	25	29	1	3320	56672	409	410	411	412
139	24	28	32	3345	56645	413	414	415	416
140	24	28	4	3357	56575	417	418	419	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
141	23	28	29	3350	56545	420	421	422	423
142	23	28	23	3390	56528	424		425	
143	23	28	9	3365	56485	426		427	428
144	22	28	32	3350	56450	429	430	431	
145	23	29	4	3262	56470	432	433	434	
146	23	29	22	3283	56520	435	436	437	
147	23	29	27	3276	56545	438	439	440	
148	24	29	5	3250	56580	441	442	443	
149	24	29	16	3263	56610	444		445	446
150	24	29	32	3252	56650	447		448	
151	24	28	27	3380	56630	449	450	451	
152	24	27	20	3440	56616	452	453	454	
153	24	27	27	3480	56623	455	456	457	
154	24	27	3	3470	56570	458	459	460	
155	23	27	27	3480	56540	461	462	463	
156	23	27	14	3490	56495	464	465	467	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
157	23	27	7	3430	56485	468	469	470	
158	21	29	7	3247	56295	471	472	473	
159	21	29	15	3295	56313	474	475	476	
160	21	29	11	3312	56288	477	478	479	
161	22	29	4	3280	56378	480		481	
162	22	29	13	3320	56404	482	483	484	485
163	22	29	26	3305	56433	486		487	
164	22	28	17	3357	56405	488	489	490	491
165	22	28	11	3412	56390	492	493	494	
166	22	27	30	3447	56432	495	496	497	
167	22	27	15	3495	56407	498		499	
168	22	27	5	3450	56375	500	501	502	
169	21	28	32	3362	56350	503	504	505	
170	21	28	8	3358	56285	506	507	508	
171	21	28	15	3395	56310	509	510	511	512
172	21	27	9	3475	56285	513	514	515	

						SAMPLE NUMBER/DESCRIPTION			
				UTM x 100m		SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
173	21	27	24	3516	56323	516	517	518	
174	21	27	30	3444	56334	519	520	521	
175	21	26	21	3565	56315	522	523	524	
176	21	26	31	3542	56345	525	526	527	528
177	21	26	25	3622	56335	529		530	
178	21	25	26	3697	56334	531	532	533	
179	21	25	16	3665	56305	534	535	536	537
180	21	25	4	3660	56266	538	539	540	541
181	35	27	9	3443	57618	541	542	543	544
182	34	27	27	3476	57568	545	546	547	
183	34	27	16	3467	57540	548	549	550	551
184	34	27	32	3445	57586	552	553	554	
185	34	28	24	3413	57560	555	556	557	
186	34	28	9	3360	57526	558	559	560	
187	34	28	28	3362	57580	561	562	563	564
188	34	29	34	3290	57588	565	566	567	

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
189	34	29	20	3260	57555	568	569	570	
190	34	29	11	3296	57526	571	572	573	
191	37	27	25	3498	57860	574	575	576	
192	37	27	15	3470	57825	577	578	579	
193	37	27	20	3432	57855	560B	561B	562B	
194	37	26	7	3520	57817	563B	564B	565B	566B
195	37	26	15	3570	57830	567B	568B	569B	
196	37	26	27	3563	57865	570B	571B	572B	573B
197	37	25	35	3680	57866	574B		575B	
198	37	25	20	3633	57838	576B	577B	578B	
199	37	25	10	3667	57803	579B	560A	561A	
200	37	24	30	3720	57850	562A		563A	
201	37	24	8	3733	57812	564A	565A	566A	
202	37	24	3	3755	57792	567A	568A	569A	
203	36	24	27	3750	57758	570A	571A	572A	
204	36	24	24	3785	57740	573A	574A	575A	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
205	36	24	17	3718	57730	576A	577A	578A	
206	36	25	11	3678	57717	579A	580	581	582
207	36	25	25	3790	57757	583	584	585	586
208	36	25	28	3640	57767	587	588	589	
209	37	28	8	3334	57825	590	591	592	
210	37	28	24	3400	57845	593	594	595	
211	37	28	29	3340	57872	596	597	598	
212	37	29	27	3280	57868	599	600	601	
213	37	29	15	3276	57833	602	603	604	
214	37	29	4	3252	57810	605	606	607	
215	36	29	29	3244	57773	608	609	610	
216	36	29	24	3300	57750	611	612	613	614
217	36	29	10	3264	57720	615	616	617	
218	33	29	28	3270	57473	618	619	620	
219	33	29	15	3300	57442	621	622	623	624
220	33	29	8	3250	57435	625	626	627	

Site #	Twp.	Rge.	Sec.	UTM x 100m		SAMPLE NUMBER/DESCRIPTION SOIL		VEGETATION	
				E	N	0-6"	6-24"	Grass	Legume
221	32	29	29	3250	57375	628	629	630	
222	32	29	34	3285	57400	631	632	633	
223	32	29	23	3300	57357	634	635	636	
224	36	28	33	3355	57780	637	638	639	
225	36	28	6	3324	57710	640	641	642	
226	36	28	3	3370	57710	643	644	645	
227	36	27	7	3420	57715	646	647	648	
228	36	27	29	3428	57772	649	650	651	652
229	36	27	2	3476	57706	653		654	655
230	36	27	27	3478	57786	656	657	658	
231	36	26	29	3535	57767	659	660	661	662
232	36	26	7	3520	57720	663	664	665	
233	36	26	3	3565	57705	666	667	668	
234	35	25	29	3625	57665	669	670	671	672
235	35	25	33	3637	57680	672	673	674	
236	35	29	32	3240	57687	675	676	677	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
237	35	29	10	3263	57620	678	679	680	681
238	35	28	7	3330	57620	682	683	684	685
239	35	29	23	3285	57665	686	687	688	
240	35	28	29	3327	57680	689	690	691	
241	35	28	14	3375	57642	692	693	694	
242	35	27	30	3420	57680	695	696	697	
243	35	27	23	3473	57660	700	701	702	703
244	35	27	11	3490	57615	704	705		706
245	35	23	23	3880	57642	707	708	709	
246	35	22	20	3920	57642	710	711	712	
247	35	22	30	3900	57657	713	714	715	
248	35	23	28	3834	57655	716	717	718	
249	35	23	15	3848	57632	719	720	721	
250	35	22	22	3953	57640	722	723	724	
251	35	23	34	3860	57670	725	726	727*	
252	36	23	10	3860	57710	728	729	730	

Site #	Twp.	Rge.	Sec.	UTM x 100 m E	UTM x 100 m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
253	36	23	9	3840	57703	731	732	733	734
254	36	23	18	3814	57728	735	736	737	738
255	35	26	3	3565	57600	739	740	741	
252A	35	26	29	3523	57672	730	731	732	
253A	35	26	22	3564	57658	733	734	735	
254A	35	26	5	3522	57605	736	737	738	
263	32	22	31	3916	57380	769	770	771	
264	32	22	16	3953	57330	772	773	774	
265	32	22	28	3947	57363	775	776	777*	
266	33	23	14	3882	57428	778	779	780	
267	33	23	25	3900	57458	781	782	783	784
268	33	23	35	3885	57477	785	786	787	788
269	33	22	4	3950	57405	789	790	791	
270	33	22	17	3936	57428	792	793	794	795
271	33	22	20	3933	57454	796	797	798	
272	33	21	5	4035	57397	799	800	801*	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
273	33	21	16	4054	57428	802	803	804	
274	33	21	15	4070	57434	805	806	807	
274A	30	22	7	3934	57130	808	809	810	811
275	30	22	29	3953	57168	812	813	814	
276	30	22	34	3975	57190	815	816	817	818
277	31	22	9	3955	57220	819	820	821	
278	31	22	29	3938	57266	822	823	824*	
279	31	22	25	3992	57264	825	826	827	
280	31	21	9	4043	57225	828	829	830	
281	31	21	20	4025	57257	831	832	833	834
282	31	21	26	4080	57264	835	836	837*	
283	36	19	30	4207	57795	838	839	840*	
284	36	20	26	4167	57745	841	842	843*	
285	35	19	7	4205	57605	844	845	846	
286	35	20	11	4172	57607	847	848	849*	
287	35	20	10	4143	57607	850	851	852*	853

				UTM x 100 m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
288	35	20	6	4100	57585	854	855	856*	
289	35	21	3	4058	57590	857	858	859*	
290	35	21	7	4000	57600	860	861	862*	863
291	35	23	11	3868	57605	864	865	866*	
292	35	23	10	3856	57605	867		868*	
293	35	23	7	3812	57613	869		870*	
294	35	22	12	3987	57608	871	872	873	874
295	35	22	9	3940	57610	875	876	877*	
296	35	22	4	3930	57596	878	879	880*	
297	34	22	30	3925	57570	881	882	883	884
298	34	23	9	3850	57510	885	886	887*	888
299	34	22	8	3933	57520	889	890	891	892
300	34	23	12	3905	57518	893	894	895	896
301	34	23	25	3910	57560	897	898	899	
302	34	22	29	3935	57555	900	901	902	
303	34	19	30	4213	57560	903	904	905*	

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
304	34	20	23	4183	57545	906	907	908*	
305	34	20	9	4155	57515	909	910	911*	
306	34	20	5	4137	57496	912	913	914	
307	33	20	28	4143	57462	915		916*	
308	33	20	7	4120	57413	917		918*	
309	32	21	24	4094	57353	919		920	
310	32	21	22	4060	57354	921	922	923*	
311	32	21	11	4084	57320	924	925	926*	
312	32	20	29	4127	57363	927	928	929*	
313	32	20	22	4158	57343	930	931	932	
314	32	20	34	4158	57377	933	934	935*	
315	33	20	9	4150	57410	936	937	938*	
316	34	19	18	4210	57527	939	940	941	
317	34	19	6	4210	57495	942		943	
318	33	19	29	4220	57455	944	945	946	947
319	33	19	9	4240	57410	948	949	950*	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
320	33	19	6	4217	57390	951	952	953*	
321	32	19	27	4257	57364	954	955	956*	
322	32	18	15	4266	57333	957	958	959*	
323	32	19	9	4250	57310	960	961	962	
324	31	19	28	4246	57264	963	964	965	
325	31	19	24	4295	57250	966	967	968	
100A	24	19	5	4230	56558	1300	1301	1302	
101A	24	19	14	4276	56590	1303	1304A	1304B	1305
102A	24	19	2	4273	56556	1306	1307	1308	1309
103A	24	20	24	4196	56605	1310	1311	1312	1313
104A	24	20	5	4126	56560	1314	1315	1316*	
105A	24	20	30	4125	56618	1317	1318	1319	1320
106A	24	21	35	4090	56630	1321	1322	1323	
107A	24	23	24	3900	56610	1324	1325	1326	
108A	24	23	8	3835	56582	1327	1328	1329	
109A	24	23	1	3906	56556	1330	1331	1332	

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
110A	24	21	31	4023	56640	1333	1334	1335	
111A	24	21	14	4090	56570	1336	1337	1338	1339
112A	25	24	27	3778	56717	1340	1341	1342	
113A	26	24	11	3786	56773	1343	1344	1345	1346
114A	26	24	4	3755	56763	1347	1348	1349	
115A	25	24	32	3746	56733	1350	1351	1352	1353
116A	25	24	8	3740	56680	1354	1355	1356	
117A	24	24	20	3734	56612	1357	1358	1359	1360
118A	24	24	25	3807	56616	1361	1362	1363	1364

Appendix IVB

Forage analyses:

Analyses of Cu, Fe, Mn, Zn, Mo in parts per million

Analyses of N, K, Ca, P, Mg in percent

FORAGE SURVEY, NORTH WESTERN MANITOBA, 1975

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #1 - Lakeland Clayloam											
3	grass	4.4	113.7	23.8	13.7	2.6	1.18	1.20	0.14	0.39	0.24
4	legume	9.8	106.1	16.1	19.8	5.0	3.52	1.15	0.17	1.52	0.59
Site #2 - Dauphin Clay											
7	grass	4.6	34.2	5.2	14.1	2.4	1.22	1.12	0.12	0.33	0.18
8	legume	6.9	76.8	16.8	18.1	8.0	3.10	1.61	0.14	1.24	0.44
Site #3 - Isafold Assoc.											
11	grass	6.0	76.1	17.5	16.2	3.0	2.00	1.48	0.25	0.34	0.20
12	legume	5.6	60.2	12.9	12.8	3.0	3.04	2.41	0.16	0.80	0.30
Site #4 - Sandy Loam											
15	grass	6.5	91.9	21.7	19.4	4.0	1.55	1.22	0.12	0.27	0.21
16	legume	8.0	76.3	17.2	16.3	4.0	3.06	1.34	0.16	1.05	0.46
Site #5 - Lakeland Loam											
18	grass	6.3	62.5	12.3	12.6	3.0	1.76	1.67	0.18	0.29	0.20

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #6 - Lakeland Loam											
20	grass	4.7	75.8	16.5	14.9	1.0	1.18	1.28	0.09	0.25	0.18
Site #7 - Lakeland Loam											
23	grass	8.0	73.7	17.2	32.0	2.0	2.12	1.78	0.16	0.33	0.20
Site #8 - Isafold Assn.											
26	grass	4.7	55.6	32.6	22.2	1.4	1.15	0.81	0.13	0.25	0.20
Site #9 - Isafold Assn.											
28	grass	8.4	80.8	20.0	31.7	1.6	2.13	1.19	0.09	0.27	0.21
Site #10 - Lakeland Loam											
30	grass	5.8	61.6	11.9	18.1	1.2	1.92	1.53	0.20	0.32	0.19
Site #11 - Gilbert Sandy Loam											
33	grass	5.1	61.2	13.4	20.0	1.6	1.31	0.86	0.13	0.25	0.20
34	legume	8.4	89.3	17.8	26.1	4.0	2.83	1.12	0.20	1.31	0.59
Site #12 - Gilbert Sandy Loam											
36	grass	5.1	46.3	10.1	19.0	0.8	1.34	1.72	0.07	0.29	0.17
37	legume	10.5	78.9	17.5	28.7	5.0	2.70	1.69	0.07	1.19	0.51

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #13 - Lakeland Loam											
40	grass	6.7	200.6	50.0	18.2	1.8	1.62	0.75	0.10	0.44	0.27
41	legume	11.3	93.4	24.5	22.1	6.0	3.49	1.24	0.14	1.58	0.40
Site #14 - Lakeland Loam											
44	grass	4.8	88.2	16.4	15.5	0.4	1.49	0.78	0.17	0.51	0.26
Site #15 - Isafold Assoc.											
46	grass	9.2	443.4	82.4	32.6	0.6	1.70	1.41	0.05	0.34	0.23
Site #16 - Gilbert Sandy Loam											
49	grass	7.0	100.3	10.7	26.7	2.0	1.70	0.50	0.05	0.36	0.24
Site #17 - Isafold Assoc.											
52	grass	7.7	62.9	32.5	20.8	0.8	1.46	1.04	0.13	0.34	0.21
53	legume	9.5	61.7	12.1	23.7	3.0	2.64	1.27	0.01	1.07	0.46
Site #18 - Gilbert Till Substrate											
56	grass	7.0	93.9	19.6	17.7	1.0	1.47	0.79	0.09	0.28	0.20
Site #19 - Selina Sand											
59	grass	6.3	48.8	14.7	15.0	1.2	1.41	1.21	0.17	0.27	0.28

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #20 - Selina Sand											
62	grass	5.3	48.3	9.2	24.6	8.0	1.57	1.88	0.06	0.38	0.16
63	legume	9.8	79.3	19.6	22.1	7.0	2.58	1.30	0.08	2.03	0.34
Site #21 - Garson Complex											
65	grass	4.9	47.4	43.5	14.5	0.8	0.98	0.70	0.06	0.25	0.15
Site #22 - Gilbert Sandy Loam											
68	grass	6.0	57.0	22.1	17.1	1.2	1.33	0.61	0.22	0.32	0.32
Site #23 - Gilbert Sandy Loam											
71	grass	4.2	67.0	6.7	14.7	1.4	0.96	0.89	0.10	0.40	0.30
72	legume	8.8	97.3	15.7	16.2	6.0	2.12	0.62	0.14	1.74	0.60
Site #24 - Gilbert Sandy Loam											
75	grass	4.9	43.8	17.2	15.5	2.0	1.31	1.08	0.33	0.37	0.19
76	legume	7.0	40.1	9.8	14.0	2.4	3.01	1.11	0.22	1.48	0.31
Site #25 - Dauphin Clay											
79	grass	5.6	51.5	9.2	16.3	0.8	1.28	1.44	0.21	0.22	0.21

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #26 - Gilbert Sandy Loam											
82	grass	4.6	67.0	10.7	18.2	1.8	1.38	1.45	0.14	0.32	0.17
Site #27 - Dauphin Clay											
85	grass	4.8	66.4	8.7	14.9	0.4	1.57	1.78	0.24	0.29	0.12
86	legume	8.3	95.9	15.8	35.1	5.0	2.58	2.37	0.26	0.89	0.30
Site #28 - Agassiz Assoc.											
89	grass	5.2	84.4	68.8	25.3	1.0	1.22	1.63	0.18	0.32	0.14
90	legume	10.3	121.4	37.9	48.7	3.0	2.29	1.88	0.19	1.19	0.35
Site #29 - Gilbert Sandy Loam											
93	grass	4.8	53.5	14.4	16.6	1.0	1.30	1.38	0.18	0.32	0.19
Site #30 - Gilbert Sandy Loam											
96	grass	6.2	81.2	22.5	19.6	1.0	1.68	0.76	0.18	0.37	0.25
97	legume	2.9	92.5	16.8	9.1	1.0	3.58	1.10	0.26	1.45	0.69
Site #31 - Gilbert Sandy Loam											
99	grass	5.9	75.6	35.6	18.5	1.2	1.22	0.72	0.12	0.32	0.22

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #32 - Gilbert Sandy Loam											
102	grass	5.2	79.8	17.5	16.9	1.0	1.25	0.81	0.19	0.42	0.24
Site #33 - Gilbert Sandy Loam											
105	grass	5.5	73.8	77.9	24.2	2.0	1.73	0.57	0.12	0.36	0.28
Site #34 - Gilbert Sandy Loam											
108	grass	5.2	47.0	48.7	18.7	1.6	1.07	0.53	0.15	0.28	0.20
Site #35 - Gilbert Sandy Loam											
111	grass	5.5	59.9	30.9	18.9	1.0	1.66	1.20	0.20	0.54	0.27
112	legume	9.7	39.7	19.1	19.4	0.8	3.10	0.66	0.24	2.20	0.51
Site #36 - Isafold											
115	grass	4.1	74.7	19.1	16.8	4.0	1.14	0.57	0.22	0.28	0.17
Site #37 - Isafold											
118	grass	12.4	90.4	32.2	19.2	1.8	1.28	0.70	0.20	0.29	0.17
Site #38 - Gilbert Sandy Loam											
121	grass	5.5	81.6	27.9	17.3	2.0	1.31	1.12	0.16	0.30	0.19
122	legume	9.3	69.2	18.8	24.5	3.0	2.42	1.44	0.34	0.98	0.47

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #39 - Gilbert Sandy Loam											
125	grass	4.5	80.7	14.8	19.6	1.6	1.18	0.60	0.13	0.28	0.22
126	legume	6.9	72.4	16.8	17.0	2.6	2.62	0.52	0.22	1.61	0.65
Site #40 - Gilbert Sandy Loam											
129	grass	6.2	89.5	24.5	19.4	0.4	1.62	1.22	0.23	0.33	0.21
Site #41 - Meharry Clay Loam											
132	grass	4.1	62.2	10.1	16.6	2.4	0.94	0.80	0.18	0.27	0.13
Site #42 - Isafold Stony											
134	grass	5.5	97.8	31.5	25.2	2.0	1.33	1.05	0.19	0.26	0.20
135	legume	7.7	66.9	17.6	23.2	5.0	2.77	1.39	0.21	1.20	0.47
Site #43 - Isafold Stony											
137	grass	4.2	103.8	17.6	13.6	0.6	1.09	0.92	0.15	0.22	0.20
Site #44 - Meharry Clay Loam											
139	grass	4.2	79.4	9.2	12.1	1.0	0.80	0.72	0.13	0.21	0.13
140	legume	8.7	116.3	14.9	18.4	5.0	2.56	1.20	0.14	1.08	0.35

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #45 - Agassiz Assoc.											
142	grass	3.5	89.0	5.4	17.9	1.8	0.75	0.75	0.22	0.15	0.11
Site #46 - Meharry Clay Loam											
146	grass	5.2	89.5	9.5	23.8	1.4	1.49	0.75	0.08	0.48	0.18
147	legume	7.7	304.5	15.9	30.7	12.0	2.67	0.19	0.14	2.16	0.30
Site #47 - Meharry Clay Loam											
150	grass	4.9	122.3	19.3	22.8	3.0	1.09	0.68	0.12	0.32	0.14
151	legume	9.4	85.8	13.6	27.1	20.0	2.72	1.74	0.17	1.69	0.31
Site #48 - Meharry Clay Loam											
153	grass	4.5	84.9	10.9	18.1	4.0	1.17	0.72	0.08	0.29	0.14
154	legume	9.8	66.9	9.5	31.6	6.0	3.20	1.28	0.17	1.29	0.31
Site #49 - Meharry Clay Loam											
156	grass	4.9	132.4	23.1	13.6	2.0	1.00	0.86	0.20	0.35	0.14
Site #50 - Gilbert Sandy Loam											
159	grass	4.1	97.8	31.6	15.5	14.0	1.17	0.81	0.21	0.33	0.15
160	legume	5.9	67.4	16.6	18.1	2.6	2.93	1.48	0.24	1.13	0.19

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #51 - Gilbert Sandy Loam											
163	grass	4.2	230.7	62.4	20.3	3.0	1.06	0.53	0.08	0.30	0.12
164	legume	8.7	66.9	17.6	19.6	3.4	2.75	0.98	0.18	2.11	0.28
Site #52 - Gilbert Sandy Loam											
167	grass	3.5	75.2	14.3	13.6	5.0	1.26	0.49	0.12	0.40	0.14
Site #53 - Gilbert Sandy Loam											
170	grass	5.2	80.8	12.6	17.7	12.0	1.23	0.78	0.17	0.29	0.12
Site #54 - Gilbert Sandy Loam											
173	grass	4.9	138.4	8.1	17.0	1.6	1.30	0.69	0.16	0.36	0.13
Site #55 - Meharry Clay Loam											
176	grass	4.9	60.0	17.6	17.3	7.0	1.36	0.74	0.18	0.26	0.15
Site #56 - Peat											
179	grass	8.7	132.0	52.6	26.5	2.0	1.49	1.15	0.16	0.31	0.24
Site #57 - Dutton Clay Loam											
182	grass	4.9	76.9	13.8	16.2	0.4	1.25	0.71	0.22	0.24	0.14

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #58											
185	grass	5.2	87.4	72.6	29.0	0.8	1.38	0.53	0.11	0.30	0.17
Site #59											
188	grass	5.1	236.1	33.5	22.0	4.0	1.20	1.42	0.09	0.34	0.15
189	legume	9.9	139.8	19.4	29.6	3.0	2.75	1.80	0.22	1.73	0.26
Site #60 - Plainview Clay											
192	grass	8.4	221.7	13.1	18.7	4.0	1.60	0.85	0.24	0.32	0.20
193	legume	7.7	85.3	14.1	25.4	2.6	omitted due to small sample				
Site #61 - Gilbert Sandy Loam											
196	grass	4.0	221.7	42.2	8.1	1.6	0.77	1.07	0.12	0.28	0.11
197	legume	8.2	80.2	17.8	15.0	7.0	2.30	0.89	0.20	1.51	0.22
Site #62 - Gilbert Sandy Loam											
200	grass	3.7	69.9	18.8	10.5	4.0	0.95	0.81	0.08	0.33	0.17
201	legume	8.0	70.3	20.5	19.2	4.0	2.35	0.96	0.13	1.98	0.49
Site #63 - Meharry Clay Loam											
204	grass	7.0	78.6	12.4	21.2	1.2	1.79	1.93	0.15	0.40	0.16

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #64 - Meharry Sandy Loam											
207	grass	4.9	105.9	30.2	9.8	0.6	1.52	1.17	0.20	0.29	0.19
208	legume	6.9	70.8	9.0	12.2	1.6	2.53	1.40	0.24	1.02	0.29
Site #65 - Grifton Assoc., Sandy Loam											
211	grass	8.8	140.7	11.1	34.8	5.0	1.66	0.50	0.13	0.22	0.15
212	legume	10.3	112.8	12.4	28.4	12.0	3.25	1.54	0.19	1.07	0.33
Site #66 - Grifton Assoc., Sandy Loam											
215	grass	5.1	89.6	20.8	20.2	3.4	1.17	0.32	0.23	0.16	0.12
216	legume	9.5	89.2	14.1	14.3	1.4	2.48	1.21	0.18	0.87	0.35
Site #67 - Meharry Clay Loam											
219	grass	5.9	69.9	30.8	15.1	1.2	1.18	0.46	0.21	0.20	0.11
Site #68 - Meharry Clay Loam											
222	grass	3.3	100.6	25.2	11.2	8.0	1.30	0.80	0.23	0.24	0.11
223	legume	5.9	105.9	18.2	14.5	3.4	2.70	0.97	0.34	0.89	0.23
Site #69 - Sand to Fine Sandy Loam											
226	grass	8.1	54.7	22.5	41.7	1.8	2.22	0.75	0.11	0.22	0.14
227	legume	9.1	74.1	20.5	22.2	7.0	2.67	0.95	0.30	1.45	0.32

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #70 - Meharry Clay Loam											
230	grass	8.4	107.4	21.5	22.9	1.0	2.13	0.34	0.63	0.30	0.16
Site #71 - Gilbert Sandy Loam											
233	grass	5.1	58.6	27.1	15.4	1 4	1.06	0.25	0.21	0.21	0.15
Site #72 - Edward Assoc.											
235	grass	5.5	68.8	17.2	14.8	1.2	1.00	0.23	0.24	0.17	0.09
Site #73 - Gilbert Sandy Loam											
238	grass	4.4	90.3	101.2	19.9	1.2	1.71	0.43	0.17	0.23	0.19
239	legume	4.4	45.0	10.6	12.5	5.0	analysis UBC only				
Site #74 - Garson Complex											
242	grass	5.5	47.8	38.7	21.4	2.0	1.34	0.47	0.19	0.37	0.16
243	legume	8.1	73.2	22.2	34.1	0.0	2.48	0.22	0.25	1.51	0.63
243 Rerun	legume					70.0					
Site #75 - Meharry Clay Loam											
246	grass	9.2	110.3	46.3	34.8	1.6	1.80	0.67	0.16	0.24	0.17
247	legume	8.8	90.8	14.6	23.4	4.0	3.03	0.94	0.20	1.14	0.35

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #76 - Leary Assoc.											
249	grass	5.1	73.2	12.2	22.0	1.6	1.58	0.45	0.21	0.30	0.14
250	legume	8.4	97.6	12.6	30.0	1.6	Analysis UBC only				
Site #77 - Meharry Clay Loam											
252	grass	5.1	58.6	36.1	18.7	0.8	1.26	0.54	0.19	0.24	0.15
253	legume	8.0	61.7	24.0	25.0	7.0	2.96	1.23	0.21	1.11	0.29
Site #78 - Rose Ridge Assoc.											
171A	grass	5.9	73.1	40.4	22.1	6.0	1.54	0.39	0.21	0.21	0.16
Site #79 - Onanole Clay Loam											
173A	grass	4.4	84.0	37.4	18.3	5.0	1.22	0.35	0.23	0.15	0.09
174A	legume	12.2	147.2	23.4	31.8	7.0	3.09	1.37	0.31	0.97	0.29
Site #80 - Meharry Clay Loam											
177A	grass	4.8	74.2	44.7	21.4	5.0	1.31	0.27	0.15	0.14	0.08
Site #81 - Meharry Clay Loam											
180A	grass	4.4	52.2	30.4	24.1	1.6	1.34	0.49	0.24	0.19	0.13

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #82 - Meharry Clay Loam											
183A	grass	5.1	69.3	20.5	17.1	1.0	1.86	0.57	0.15	0.22	0.11
Site #83 - Eroded Slopes Complex											
186A	grass	5.9	67.4	42.7	28.6	8.0	1.46	0.44	0.29	0.20	0.12
187A	legume	7.3	68.3	18.5	17.1	3.0	2.85	1.24	0.24	1.09	0.30
Site #84 - Meharry Clay Loam											
190	grass	4.5	123.7	26.5	23.4	0.2					
190A	legume	6.7	65.3	14.6	19.3	1.8	1.26	0.55	0.23	0.23	0.18
Site #85 - Waitville Loam											
193A	grass	4.5	107.4	28.8	13.1	7.0	1.23	1.16	0.23	0.33	0.15
194A	legume	7.4	410.8	48.6	23.1	8.0	2.91	1.62	0.32	1.14	0.36
Site #86 - Rose Ridge Assoc.											
197A	grass	5.2	71.8	49.2	17.8	20.0	1.52	0.51	0.28	0.25	0.17
198A	legume	8.2	80.2	17.8	15.1	7.0	3.09	1.23	0.24	1.49	0.30
Site #87 - Rose Ridge Assoc.											
201A	grass	5.2	40.6	30.4	19.5	10.0	1.46	0.50	0.24	0.20	0.15

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #88 - Erickson Assoc.											
256	grass	5.9	55.1	29.9	15.1	8.0	1.25	0.43	0.18	0.22	0.14
Site #89 - Leary Assoc.											
259	grass	5.9	70.3	71.1	22.9	1.0	1.23	0.48	0.22	0.22	0.16
Site #90 - Silt Loam to Heavy Clay Loam											
262	grass	6.7	112.9	24.3	22.9	2.0	1.63	0.52	0.14	0.22	0.14
Site #91 - Undifferentiated Organic Deposits - Peat											
264	grass	4.9	110.1	39.5	13.8	5.0	1.31	0.65	0.23	0.23	0.15
265	legume	6.7	183.1	26.5	14.2	1.8	1.30	1.66	0.50	1.22	0.28
Site #92 - Waitville Loam											
268	grass	5.6	72.3	29.8	21.4	1.6	1.63	0.59	0.31	0.23	0.18
Site #93 - Loamy Sand to Sandy Loam											
270	grass	5.2	54.6	10.2	20.4	8.0	1.22	0.49	0.25	0.21	0.16
271	legume	5.6	78.2	23.3	18.3	4.0	2.86	1.02	0.43	1.40	0.32

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #94 - Waitville Loam											
273	grass	5.6	66.5	38.1	19.6	9.0	1.25	0.37	0.23	0.21	0.11
274	legume	8.2	61.9	18.8	16.9	5.0	2.91	1.64	0.14	1.35	0.21
Site #95 - Waitville Loam Assoc.											
277	grass	4.2	246.9	27.5	12.1	2.0	0.91	1.23	0.14	0.29	0.11
Site #96 - Waitville Loam											
279	grass	4.5	66.8	59.2	28.9	4.0	2.45	0.77	0.32	0.24	0.16
Site #97 - Rockham Clay Loam											
281	grass	4.9	44.6	26.9	17.4	18.0	1.30	0.55	0.28	0.17	0.13
Site #98 - Waitville Clay Loam											
284	grass	4.5	130.2	19.4	19.2	10.0	1.06	0.47	0.27	0.20	0.13
Site #99 - Waitville Clay Loam											
287	grass	4.5	132.7	28.5	22.4	5.0	1.36	0.47	0.36	0.18	0.14

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #100 - Waitville Loam											
289	grass	5.9	137.7	34.0	24.1	14.0	1.44	0.49	0.36	0.20	0.13
290	legume	6.0	130.2	21.0	18.0	3.0	3.20	1.69	0.36	1.23	0.41
Site #101 - Waitville Loam											
293	grass	5.2	111.1	20.2	16.8	5.0	1.20	0.77	0.22	0.25	0.13
Site #102 - Waitville Loam											
296	grass	4.8	56.9	58.9	17.4	8.0	1.36	0.67	0.27	0.22	0.14
297	legume	5.9	72.6	18.2	13.1	5.0	insuff. sample	1.22	0.25	1.40	0.16
Site #103 - Erickson Clay Loam											
300	grass	6.0	111.9	43.7	23.0	1.0	1.47	0.65	0.25	0.20	0.19
Site #104 - Erickson Clay Loam											
302	grass	4.5	121.8	20.6	15.9	9.0	1.50	0.87	0.27	0.28	0.18
Site #105 - Erickson Clay Loam											
304	grass	4.8	188.1	36.3	15.2	9.0	1.22	0.88	0.20	0.24	0.13

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #106 - Kenville Assoc.											
306	grass	4.5	91.6	23.0	18.9	2.6	1.44	0.60	0.24	0.16	0.16
Site #107 - Eroded Slopes Complex											
309	grass	5.6	73.2	25.3	20.2	0.6	1.66	0.84	0.24	0.29	0.17
Site #108 - Waitville Loam											
312	grass	4.4	62.5	70.2	21.7	3.0	1.36	0.53	0.17	0.22	0.19
Site #109 - Peat											
315	grass	5.1	51.2	50.4	17.3	3.4	1.31	0.77	0.24	0.21	0.14
Site #110 - Peat											
318	grass	4.8	206.8	30.0	19.8	1.8	1.31	0.60	0.20	0.21	0.17
Site #111 - Duck Mountain Complex											
320	grass	5.9	67.4	19.1	18.8	4.0	1.50	0.72	0.19	0.19	0.12
321	legume	8.0	123.8	20.0	27.7	3.4	insuff. sample	1.79	0.37	1.18	0.36
Site #112 - Waitville Loam											
324	grass	5.2	66.8	48.5	20.8	6.0	1.20	0.70	0.27	0.20	0.11

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #113 - Duck Mountain Complex											
326	grass	4.9	141.5	24.7	16.9	4.0	1.31	1.34	0.26	0.18	0.14
Site #114 - Peat											
329	grass	6.6	147.7	39.5	22.5	12.0	1.49	0.57	0.27	0.18	0.16
Site #115 - Erickson Clay Loam											
332	grass	6.2	88.6	28.7	17.8	4.0	1.50	0.90	0.26	0.32	0.09
333	legume	7.4	65.5	15.3	13.1	1.6	2.98	1.41	0.23	1.53	0.37
Site #116 - Erickson Clay Loam											
336	grass	5.9	61.5	35.1	16.0	5.0	1.34	0.63	0.21	0.27	0.07
Site #117 - Erickson Modified Phase											
339	grass	4.1	92.4	9.3	22.5	9.0	1.07	0.74	0.20	0.22	0.07
Site #118 - Erickson Clay Loam											
342	grass	5.9	109.3	25.2	16.6	8.0	1.41	1.41	0.18	0.38	0.10
Site #119 - Bench Lands Complex											
345	grass	6.5	117.3	50.8	14.3	4.0	2.00	1.17	0.15	0.44	0.10
346	legume	7.7	79.8	20.4	10.9	4.0	2.91	1.58	0.17	1.78	0.24

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #120 - Waitville Loam											
348	grass	4.1	97.9	21.0	15.4	5.0	1.10	0.68	0.13	0.29	0.07
Site #121 - Onanole Sandy Loam											
351	grass	3.7	57.1	44.3	15.1	6.0	1.34	0.65	0.19	0.24	0.07
352	legume	7.2	66.5	21.3	23.9	5.0	3.17	1.10	0.29	1.69	0.22
Site #122 - Onanole Clay Loam - Till Substrate											
355	grass	5.5	76.7	34.2	22.1	20.0	1.58	0.77	0.25	0.25	0.08
Site #123 - Waitville Loam											
358	grass	5.1	44.3	30.0	28.7	7.0	1.36	0.56	0.17	0.23	0.05
359	legume	7.3	64.0	14.7	18.3	2.4	3.17	1.82	0.27	1.75	0.15
Site #124 - Erickson Clay Loam											
362	grass	4.4	63.0	24.9	13.9	2.0	1.23	0.72	0.20	0.30	0.07
Site #125 - Rose Ridge Assoc. - Loam to Clay Loam											
365	grass	5.5	66.5	16.8	13.9	5.0	1.57	0.65	0.15	0.27	0.08
366	legume	7.0	50.2	12.1	21.2	3.4	3.30	1.96	0.17	1.64	0.27

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #126 - Waitville Loam											
369	grass	6.9	47.1	12.3	18.6	3.0	1.50	0.61	0.24	0.22	0.05
370	legume	4.4	64.0	26.1	19.3	12.0	2.96	1.44	0.20	1.39	0.14
Site #127 - Waitville Loam											
373	grass	4.5	76.2	33.0	21.2	14.0	1.34	0.84	0.10	0.28	0.06
374	legume	7.3	81.7	28.6	18.3	3.4	2.98	1.50	0.19	1.15	0.17
Site #128 - Waitville Loam											
377	grass	4.8	42.9	28.6	18.0	42.0	1.47	0.10	1.69	0.43	0.09
378	legume	8.9	56.3	16.4	14.4	6.0	3.07	0.20	1.42	1.76	0.19
Site #129 - Waitville Loam											
381	grass	5.2	138.5	19.6	15.4	4.0	1.31	0.62	0.23	0.28	0.08
382	legume	9.5	176.0	25.4	13.5	5.0	2.35	1.53	0.14	1.01	0.31
Site #130 - Eroded Slopes Complex											
385	grass	5.1	215.1	54.0	13.4	4.0	1.28	0.18	0.85	0.24	0.15
Site #131 - Erickson Modified Phase											
388	grass	3.4	101.6	23.1	15.1	3.4	0.95	0.56	0.21	0.15	0.11

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #132 - Erickson Modified Phase											
391	grass	5.2	106.7	26.9	15.4	6.0	1.36	0.63	0.18	0.23	0.13
Site #133 - Erickson Clay Loam											
394	grass	4.1	48.9	19.9	20.6	7.0	1.33	0.65	0.18	0.21	0.14
395	legume	6.5	43.4	19.3	11.8	0.8	2.56	0.79	0.20	1.49	0.55
Site #134 - Waitville Loam											
398	grass	6.9	42.9	18.4	13.3	6.0	1.00	0.51	0.09	0.16	0.09
399	legume	4.1	67.0	13.4	14.3	8.0	2.48	1.44	0.14	1.02	0.35
Site #135 - Erickson Clay Loam											
402	grass	5.2	73.9	15.5	14.4	6.0	1.33	0.65	0.18	0.18	0.12
Site #136 - Erickson Clay Loam											
405	grass	4.3	42.8	50.0	19.0	5.0	1.38	0.60	0.14	0.21	0.14
Site #137 - Erickson Modified Phase											
408	grass	5.0	46.2	27.5	14.7	5.0	1.54	0.71	0.20	0.20	0.13

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #138 - Erickson Modified Phase											
411	grass	5.4	67.4	58.6	23.7	4.0	1.49	0.53	0.09	0.30	0.16
412	legume	8.6	58.7	33.6	18.6	2.6	2.35	0.87	0.16	1.79	0.36
Site #139 - Erickson Clay Loam											
415	grass	5.7	71.3	50.7	18.6	18.0	1.28	0.51	0.21	0.22	0.13
416	legume	6.8	75.6	9.6	12.7	3.4	2.40	1.46	0.23	1.31	0.24
Site #140 - Erickson Clay Loam											
419	grass	5.0	69.1	26.8	14.8	5.0	0.98	0.60	0.17	0.20	0.11
Site #141 - Erickson Clay Loam											
422	grass	5.4	63.1	14.3	17.5	7.0	1.15	0.54	0.17	0.25	0.11
423	legume	8.6	58.7	13.6	18.9	4.0	3.12	1.73	0.22	1.20	0.34
Site #142 - Ericksdale Clay Loam											
425	grass	6.1	75.1	40.4	18.0	2.0	1.55	0.43	0.15	0.18	0.11
Site #143 - Benchlands Complex											
427	grass	5.7	73.4	59.3	16.9	5.0	1.36	0.56	0.15	0.20	0.10
428	legume	7.9	97.2	12.5	17.0	1.4	2.51	1.19	0.18	1.47	0.26

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #144 - Maninghurst Coarse Sandy Loam											
431	grass	3.2	74.7	26.8	14.5	1.6	1.06	0.81	0.09	0.20	0.10
Site #145 - Assiniboine Complex											
434	grass	4.7	99.3	16.4	21.0	0.4	1.44	0.70	0.12	0.15	0.14
Site #146 - Erickson Modified Phase											
437	grass	4.3	76.0	41.1	10.0	3.4	0.98	1.04	0.12	0.19	0.09
Site #147 - Erickson Modified Phase											
440	grass	4.3	139.5	18.6	14.4	1.2	0.91	0.66	0.15	0.20	0.10
Site #148 - Newdale Modified Phase											
443	grass	3.6	118.8	9.6	14.3	0.4	0.93	0.66	0.11	0.16	0.12
Site #149 - Newdale Modified Phase											
445	grass	4.3	76.4	12.1	9.5	3.0	1.02	0.98	0.14	0.18	0.08
446	legume	9.3	241.8	16.8	19.3	2.0	2.48	1.42	0.19	0.81	0.29
Site #150 - Newdale Modified Phase											
448	grass	5.0	104.5	15.7	17.8	7.0	1.09	0.67	0.16	0.21	0.11

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #151 - Erickson Clay Loam											
451	grass	6.4	133.9	38.2	18.6	16.0	1.07	0.68	0.14	0.17	0.10
Site #152 - Waitville Loam											
454	grass	5.0	67.4	28.1	16.3	5.0	1.25	0.65	0.15	0.21	0.12
Site #153 - Waitville Loam											
457	grass	4.4	83.1	22.9	18.5	12.0	1.50	0.63	0.57	0.17	0.13
Site #154 - Waitville Loam											
460	grass	6.7	96.6	23.2	30.8	1.2	1.63	0.61	0.30	0.24	0.17
Site #155 - Waitville Loam											
463	grass	4.3	71.9	16.1	18.7	1.8	1.30	0.50	0.19	0.18	0.11
Site #156 - Erickson Clay Loam											
467	grass	5.3	69.9	31.6	22.0	1.8	1.34	0.60	0.25	0.26	0.14
Site #157 - Newdale Undulating Phase											
470	grass	5.0	54.3	22.1	22.4	5.0	1.50	0.53	0.30	0.20	0.12

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #158 - Newdale Loam to Clay Loam											
473	grass	4.3	74.8	40.0	14.5	1.6	1.15	0.80	0.16	0.23	0.13
Site #159 - Assiniboine Complex											
476	grass	5.0	104.4	20.0	22.6	3.0	1.39	0.53	0.22	0.16	0.10
Site #160 - Newdale Clay Loam - Rolling Phase											
479	grass	7.8	83.4	62.5	22.9	1.6	1.89	0.57	0.28	0.26	0.14
Site #161 - Assiniboine Complex											
481	grass	4.3	87.1	49.8	18.4	1.0	1.49	0.66	0.30	0.21	0.11
Site #162 - Newdale Clay Loam - Undulating Phase											
484	grass	5.0	112.6	37.5	10.6	3.0	1.17	0.59	0.14	0.27	0.11
485	legume	7.1	131.5	17.5	10.0	1.2	2.24	1.19	0.19	1.95	0.27
Site #163 - Maninghurst Coarse Sandy Loam											
487	grass	5.3	82.2	32.3	13.6	1.6	1.31	0.67	0.15	0.35	0.15
Site #164 - Newdale Clay Loam - Undulating Phase											
490	grass	6.7	76.0	37.2	17.6	1.4	1.52	0.54	0.29	0.24	0.13
491	legume	9.2	103.6	11.6	19.0	2.0	2.80	1.78	0.26	1.42	0.22

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #165 - Newdale Clay Loam - Undulating Phase											
494	grass	6.0	95.4	27.4	15.1	2.6	1.15	0.43	0.19	0.24	0.10
Site #166 - Newdale Clay Loam - Undulating Phase											
497	grass	8.2	108.9	77.2	24.7	0.6	1.30	0.60	0.21	0.30	0.17
Site #167 - Erickson Clay Loam											
499	grass	no computer analysis					1.63	0.55	0.28	0.38	0.13
Site #168 - Newdale Clay Loam - Undulating Phase											
502	grass	7.1	113.0	48.8	15.2	1.6	1.41	0.50	0.22	0.25	0.18
Site #169 - Newdale Clay Loam - Rolling Phase											
505	grass	5.3	70.7	50.2	17.7	2.6	1.09	1.20	0.22	0.40	0.11
Site #170 - Newdale Clay Loam - Rolling Phase											
508	grass	6.0	86.3	10.5	16.2	0.8	1.12	0.78	0.07	0.33	0.14
Site #171 - Newdale Clay Loam - Rolling Phase											
511	grass	6.0	95.4	31.6	14.9	1.4	1.49	1.25	0.11	0.32	0.16
512	legume	5.8	88.0	8.8	13.4	2.8	2.06	0.97	0.10	1.61	0.56

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #172 - Newdale Clay Loam - Rolling Phase											
515	grass	4.3	91.7	52.7	16.5	4.0	1.36	0.47	0.28	0.21	0.14
Site #173 - Newdale Clay Loam - Undulating Phase											
518	grass	4.6	131.3	29.8	14.8	10.0	1.23	0.58	0.21	0.29	0.11
Site #174 - Newdale Clay Loam - Rolling Phase											
521	grass	5.4	102.5	43.3	17.8	1.2	1.65	0.59	0.15	0.24	0.16
Site #175 - Erickson Clay Loam											
524	grass	4.4	100.2	11.8	16.4	1.0	1.33	0.84	0.15	0.35	0.16
Site #176 - Erickson Clay Loam											
527	grass	5.5	220.0	39.4	22.4	2.0	1.54	0.82	0.22	0.35	0.18
Site #177 - Waitville Clay Loam											
530	grass	4.6	146.7	27.0	12.9	5.0	1.06	0.74	0.13	0.31	0.12
Site #178 - Erickson Clay Loam											
533	grass	7.9	145.8	45.8	23.0	0.2	2.08	0.94	0.29	0.54	0.24

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #179 - Erickson Clay Loam											
536	grass	6.4	80.0	40.2	16.3	5.0	1.41	0.83	0.26	0.36	0.17
537	legume	7.2	99.6	28.4	12.4	8.0	2.46	1.53	0.23	1.38	0.35
Site #180 - Erickson Clay Loam											
540	grass	4.8	130.5	40.4	16.2	0.6	1.34	0.77	0.31	0.31	0.15
541	legume	6.4	64.2	15.3	9.7	6.0	2.24	1.28	0.22	1.00	0.38
Site #181 - Kenville Series - Silty Clay Loam											
543	grass	5.7	258.3	46.5	14.7	14.0	1.49	0.65	0.27	0.39	0.17
544	legume	5.9	149.1	19.1	13.7	4.0	2.51	1.23	0.31	1.44	0.26
Site #182 - Harlington Till-Substrate Phase Clay											
547	grass	5.0	140.0	16.3	18.9	24.0	0.98	0.69	0.24	0.27	0.11
Site #183 - Duck Mountain Complex											
550	grass	4.4	87.0	27.6	16.9	14.0	0.98	0.63	0.22	0.28	0.12
551	legume	8.2	72.9	9.0	15.3	5.0	3.10	2.00	0.28	1.54	0.29
Site #184 - Davidson Series (Sand)											
554	grass	4.4	80.2	77.9	16.8	2.0	1.26	0.63	0.30	0.27	0.14

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
<u>Site #185</u> - <u>Valley Series - Clay Loam</u>											
557	grass	5.0	51.3	29.5	21.1	1.2	1.68	0.53	0.27	0.23	0.14
<u>Site #186</u> - <u>Substrate Phase Clay Loam</u>											
560	grass	4.3	104.2	11.1	14.4	3.0	1.09	0.64	0.22	0.26	0.14
<u>Site #187</u> - <u>Silty Clay Loam</u>											
563	grass	5.7	64.6	38.1	19.0	4.0	1.55	0.57	0.30	0.30	0.16
564	legume	9.3	67.9	21.1	19.7	2.8	3.25	1.75	0.33	1.77	0.27
<u>Site #188</u> - <u>Silty Clay Loam</u>											
567	grass	4.8	91.9	29.2	15.8	6.0	1.31	0.79	0.28	0.32	0.14
<u>Site #189</u> - <u>Sandy Loam</u>											
570	grass	3.9	116.7	42.0	22.0	2.0	1.73	0.76	0.25	0.27	0.15
<u>Site #190</u> - <u>Gilbert Series</u> - <u>Sandy Loam</u>											
573	grass	3.9	114.6	19.4	15.7	2.6	1.04	0.51	0.18	0.18	0.11
<u>Site #191</u> - <u>Valley Series - Clay Loam</u>											
576	grass	5.0	204.2	18.0	20.6	0.6	1.20	0.31	0.18	0.24	0.14

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #192 - Valley Series - Clay Loam											
579	grass	5.7	100.8	47.2	18.4	4.0	1.23	0.70	0.21	0.37	0.16
Site #193 - Lenswood Series - Fine Sandy Loam											
562B	grass	4.8	61.6	20.3	28.0	9.0	1.57	0.77	0.38	0.26	0.13
Site #194 - Valley Series - Clay Loam											
565B	grass	5.9	89.5	45.4	18.7	0.8	1.60	0.25	0.19	0.17	0.15
566B	legume	8.4	94.4	23.2	17.7	5.0	2.26	1.39	0.20	1.04	0.38
Site #195 - Swanford Series - Very Fine Sandy Loam											
569B	grass	4.4	111.5	28.0	14.7	0.4	1.22	0.48	0.24	0.27	0.18
Site #196 - Fyala Series Clay											
572B	grass	4.4	69.4	11.8	13.5	2.0	1.12	0.68	0.24	0.27	0.14
573B	legume	4.4	68.4	10.2	11.2	1.6	2.05	1.03	0.22	0.81	0.41
Site #197 - Rose Ridge Association Loam											
575B	grass	5.5	107.6	23.5	13.3	3.4	1.70	0.58	0.28	0.37	0.27
Site #197 - Rose Ridge Association Loam											
575B	grass	5.5	107.6	23.5	13.3	3.4	1.70	0.58	0.28	0.37	0.27

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #198 - Valley Series - Clay Loam											
578B	grass	5.1	126.1	14.9	18.5	1.4	1.20	0.70	0.25	0.31	0.20
Site #199 - Plan View Series - Clay											
561A	grass	4.3	134.6	12.5	11.7	3.0	1.17	0.70	0.26	0.31	0.18
Site #200 - Rose Ridge Association Loam											
563A	grass	3.6	92.0	18.1	16.6	1.0	1.12	0.54	0.18	0.23	0.16
Site #201 - Foley Series - Very Fine Sandy Loam											
566A	grass	7.6	56.0	2.2	46.5	1.4	1.46	0.65	0.11	0.33	0.21
Site #202 - Foley Till Substrate Phase											
569A	grass	5.8	80.0	18.1	26.4	2.6	1.25	0.52	0.19	0.24	0.17
Site #203 - Plan View Till Substrate Phase											
572A	grass	6.2	73.0	33.3	29.9	1.0	1.22	0.42	0.21	0.25	0.15
Site #204 - Berlo Series - Fine Sand											
575A	grass	6.5	101.1	33.0	21.9	3.0	1.41	0.65	0.14	0.32	0.23

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #205 - Plain View Series - Clay											
578A	grass	5.4	69.6	26.8	18.0	1.4	1.25	0.52	0.19	0.25	0.15
Site #206 - Berlo Series - Fine Sand											
581	grass	5.8	82.9	22.5	24.6	2.6	1.50	0.44	0.19	0.24	0.14
582	legume	10.0	83.1	14.3	31.3	12.0	2.46	1.67	0.22	0.89	0.32
Site #207 - Plain View Till Substrate Phase											
585	grass	5.8	236.3	18.8	18.3	1.4	1.41	0.49	0.21	0.26	0.16
586	legume	7.4	376.0	33.2	21.4	3.4	2.67	1.12	0.20	0.90	0.39
Site #208 - Agassiz Series - Loamy Coarse Sand											
589	grass	6.3	101.9	29.9	19.1	1.2	1.49	0.60	0.18	0.25	0.18
Site #209 - Shallow Peat											
592	grass	8.0	137.6	17.0	26.8	0.4	1.63	0.72	0.12	0.30	0.19
Site #210 - Lenswood Series - Fine Sandy Loam											
595	grass	6.7	141.2	68.3	14.9	9.0	1.31	0.70	0.19	0.24	0.16
Site #211 - Shallow Peat											
598	grass	7.4	87.4	60.5	19.6	3.4	1.71	0.70	0.16	0.32	0.15

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #212 - Alluvial Complex											
601	grass	7.8	82.2	11.7	14.1	1.8	1.39	0.46	0.18	0.20	0.19
Site #213 - Peguis Till Substrate Phase											
604	grass	9.7	91.8	38.4	18.5	2.0	1.47	0.62	0.18	0.25	0.21
Site #214 - Polson Complex											
607	grass	9.7	83.9	67.4	25.3	1.0	1.71	0.54	0.16	0.44	0.27
Site #215 - Racham Series											
610	grass	7.2	124.4	23.2	20.1	3.0	1.50	0.56	0.20	0.30	0.18
Site #216 - Agassiz Series											
613	grass	9.7	131.6	43.9	14.2	4.0	1.22	0.75	0.19	0.25	0.16
614	legume	7.4	139.0	22.1	16.3	1.8	2.88	1.44	0.23	1.24	0.23
Site #217 - Rose Ridge Association (Loam)											
617	grass	5.9	56.0	31.9	18.0	3.4	1.49	0.62	0.20	0.20	0.19
Site #218 - Duck Mountain Complex											
620	grass	5.1	62.2	35.5	15.4	1.0	1.00	0.76	0.16	0.27	0.17

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #219 - Blackstone Association (Clay)											
623	grass	6.3	69.9	31.2	20.2	6.0	1.18	0.68	0.16	0.24	0.10
624	legume	10.5	69.6	10.1	22.8	6.0	4.05	2.07	0.31	1.76	0.27
Site #220 - Undifferentiated Peat											
627	grass	7.4	55.1	25.7	28.1	1.8	1.58	0.53	0.14	0.20	0.14
Site #221 - Blackstone Association - Clay											
630	grass	no computer analysis					no computer analysis				
Site #222 - Blackstone Association - Clay											
633	grass	no computer analysis					no computer analysis				
Site #223 - Blackstone Association - Clay											
636	grass	no computer analysis					no computer analysis				
Site #224 - Lenswood Series - Fine Sandy Loam											
639	grass	6.7	111.5	13.0	17.6	1.2	1.44	0.69	0.12	0.20	0.16
Site #225 - Plain View Till											
642	grass	5.1	70.5	9.4	25.2	9.0	1.38	0.48	0.19	0.24	0.18

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #226 - Lenswood Series											
645	grass	2.9	96.2	20.6	21.0	1.8	0.95	0.46	0.16	0.16	0.13
Site #227 - Gilbert Series											
648	grass	6.7	140.8	36.8	17.4	0.6	1.38	0.43	0.13	0.25	0.28
Site #228 - Lenswood Series											
651	grass	4.7	310.9	29.0	23.7	0.6	1.20	0.46	0.12	0.29	0.19
652	legume	9.8	244.6	18.8	25.6	14.0	2.86	0.97	0.20	0.94	0.31
Site #229 - Durban											
654	grass	7.1	70.8	27.3	11.6	4.0	1.07	0.48	0.12	0.30	0.20
655	legume	11.2	83.1	16.9	18.5	5.0	2.51	1.37	0.16	1.05	0.29
Site #230 - Gilbert Series											
658	grass	5.1	68.0	38.8	18.8	5.0	1.70	0.62	0.22	0.30	0.16
Site #231 - Fyala Series											
661	grass	4.8	61.3	25.4	17.4	1.4	1.23	0.46	0.20	0.24	0.18
662	legume	8.3	51.4	8.3	23.0	4.0	2.24	1.51	0.18	0.86	0.30

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #238 - Kenville Series											
684	grass	8.5	58.6	54.1	15.1	4.0	1.52	0.67	0.20	0.27	0.17
685	legume	9.7	77.9	21.4	24.5	7.0	3.28	2.00	0.24	1.52	0.35
Site #239 - Plain View Series											
688	grass	7.4	132.9	54.7	17.1	9.0	1.39	0.58	0.22	0.30	0.18
Site #240 - Peguis Series											
691	grass	5.9	210.9	14.8	25.3	0.8	1.74	1.06	0.22	0.26	0.12
Site #241 - Kenville Series											
694	grass	8.5	86.1	58.6	37.1	14.0	1.66	0.89	0.22	0.30	0.19
Site #242 - Valley Series											
697	grass	10.1	94.4	54.4	27.2	4.0	2.01	0.86	0.20	0.37	0.22
Site #243 - Peguis Series (Clay)											
702	grass	4.8	109.5	32.5	16.7	9.0	1.30	0.60	0.23	0.31	0.17
703	legume	12.4	85.2	17.2	23.9	18.0	3.41	2.09	0.28	1.34	0.32
Site #244 - Davidson Series											
706	legume	8.9	92.5	27.8	25.1	2.4	3.74	2.47	0.28	1.75	0.31

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #232 - Foley Series											
665	grass	4.8	118.5	65.1	17.5	2.0	1.28	0.78	0.20	0.25	0.17
Site #233 - Valley Series											
668	grass	4.5	74.3	30.3	16.3	2.6	1.00	0.50	0.11	0.20	0.14
Site #234 - Unclassified											
671	grass	6.2	98.2	15.2	32.3	10.0	1.44	0.55	0.12	0.24	0.14
672	legume	7.7	105.8	10.7	17.4	8.0	2.50	1.25	0.15	1.60	0.25
Site #235 - Unclassified											
674	grass	8.5	74.2	21.7	17.6	3.4	1.25	0.38	0.15	0.24	0.12
Site #236 - Shallow Peat											
677	grass	5.8	68.4	6.5	18.6	1.2	1.25	0.73	0.19	0.25	0.19
Site #237 - Kenville Series											
680	grass	6.2	183.3	56.4	19.2	5.0	1.34	0.52	0.16	0.25	0.13
681	legume	8.7	99.5	27.9	23.2	4.0	3.02	1.71	0.23	2.00	0.28

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #245 - 709	grass	4.6	238.2	34.0	13.9	3.0	0.77	0.27	0.14	0.31	0.16
Site #246 - 712	grass	4.4	105.5	7.8	14.6	5.0	1.42	0.80	0.19	0.30	0.21
Site #247 - 715	grass	7.0	146.1	40.5	29.2	1.8	1.07	0.58	0.12	0.28	0.17
Site #248 - 718	grass	5.1	99.4	26.8	12.8	8.0	1.04	0.69	0.11	0.25	0.11
Site #249 - 721	grass	4.8	64.9	43.0	27.9	0.6	1.62	1.38	0.19	0.70	0.23
Site #250 - 724	grass	5.1	88.0	12.7	16.9	1.2	1.65	0.90	0.23	0.40	0.22
Site #251 - 727	grass	1.8	90.0	12.0	9.2	1.2	0.75	0.53	0.10	0.18	0.11

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #252 -											
730	grass	2.9	66.5	8.1	10.3	5.0	1.14	0.66	0.16	0.22	0.17
Site #253 -											
733	grass	3.7	50.7	12.7	10.4	1.6	1.10	0.61	0.21	0.31	0.22
734	legume	4.4	55.6	14.8	7.3	1.0	1.87	0.65	0.17	1.78	0.33
Site #254 -											
737	grass	3.7	55.6	51.2	14.8	1.6	0.85	0.34	0.12	0.22	0.13
738	legume	8.8	55.2	20.1	18.3	1.4	2.94	1.16	0.26	0.70	0.34
Site #255 - Blackstone Association (Clay)											
741	grass	7.7	95.7	21.4	29.1	4.0	1.50	0.96	0.11	0.54	0.23
Site #252A - Blackstone Association (Clay)											
732	grass	4.4	61.6	11.3	15.6	2.0	1.50	1.59	0.23	0.37	0.20
Site #253A - Blackstone Association (Clay)											
735							1.42	0.19	0.81	0.31	0.19
Site #254A - Blackstone Association (Clay)											
738	grass	8.8	55.2	20.1	18.3	1.4	1.14	0.87	0.16	0.30	0.17

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #263 - Leary Association											
771	grass	6.2	116.0	57.2	22.5	1.4	1.33	0.54	0.13	0.31	0.18
Site #264 - Edwards Association											
774	grass	4.8	94.9	58.6	17.1	1.6	1.23	0.62	0.19	0.28	0.14
Site #265 - Edwards Association											
777	grass	6.6	81.9	15.5	27.7	4.0	1.65	0.70	0.17	0.32	0.14
Site #266 - Edwards Association											
780	grass	4.4	69.8	33.9	16.3	6.0	1.22	0.45	0.14	0.21	0.14
Site #267 - Leary Association											
783	grass	7.4	55.6	20.5	11.9	5.0	1.04	0.43	0.13	0.28	0.14
784	legume	4.4	53.5	18.7	16.4	20.0	2.56	1.15	0.17	1.45	0.28
Site #268 - Edwards Association											
787	grass	4.8	53.5	41.6	17.4	20.0	1.20	0.59	0.19	0.24	0.14
788	legume	8.5	60.4	17.3	16.9	4.0	2.38	1.49	0.16	1.32	0.22
Site #269 - Leary Association											
791	grass	5.4	130.7	24.0	18.8	14.0	1.17	0.60	0.12	0.25	0.15

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #270 - Plainview Clay											
794	grass	3.6	187.9	15.2	17.0	1.6	1.23	0.62	0.18	0.36	0.20
795	legume	6.2	106.2	11.3	22.4	28.0	3.01	0.77	0.25	1.57	0.42
Site #271 - Edwards Association											
798	grass	1.8	93.9	9.2	9.3	5.0	1.09	0.60	0.23	0.33	0.14
Site #272 - Garson Complex											
801	grass	4.0	109.5	81.3	36.7	2.6	1.52	0.54	0.06	0.45	0.21
Site #273 - Selina Sand											
804	grass	9.1	107.0	54.5	19.4	3.0	2.99	1.33	0.21	0.34	0.32
Site #274 - Selina Sand											
807	grass	2.9	94.8	25.8	14.5	2.0	1.02	0.47	0.13	0.26	0.23
Site #274A - Meharry Clay Loam											
810	grass	3.6	81.7	9.5	22.6	1.4	1.39	0.56	0.23	0.22	0.13
811	legume	4.3	37.6	9.2	17.5	1.6	2.32	0.80	0.23	0.89	0.31
Site #275 - Meharry Clay Loam											
814	grass	5.8	257.3	19.8	20.8	3.0	4.11	2.26	0.33	0.29	0.22

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #276 - Meharry Clay Loam											
817	grass	3.3	67.4	39.6	16.3	1.6	1.22	0.90	0.10	0.31	0.15
818	legume	7.6	70.2	10.6	21.9	16.0	2.34	1.08	0.15	1.67	0.50
Site #277 - Rose Ridge Assoc. (Loam to Clay Loam)											
821	grass	4.7	75.2	19.4	21.7	4.0	1.58	1.09	0.18	0.28	0.19
Site #278 -											
824	grass	7.2	72.3	135.1	22.0	1.2	2.05	1.10	0.19	0.21	0.14
Site #279 - Garson Complex											
827	grass	4.3	73.5	15.2	10.7	1.0	1.39	1.27	0.13	0.25	0.16
Site #280 - Garson Complex											
830	grass	4.0	65.3	14.9	19.8	5.0	1.97	1.29	0.29	0.29	0.17
Site #281 - Edwards Association											
833	grass	10.1	53.9	21.2	23.7	2.0	2.66	2.03	0.32	0.35	0.35
834	legume	10.1	29.8	11.3	23.3	10.0	4.13	2.07	0.27	1.28	0.45
Site #282 - Garson Complex											
837	grass	7.2	143.8	34.3	21.5	1.4	2.14	1.55	0.31	0.33	0.22

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #283 -											
840	grass	5.4	137.4	16.8	15.7	2.0	1.34	0.72	0.22	0.25	0.20
Site #284 -											
843	grass	6.6	83.4	104.3	22.8	1.2	1.80	0.82	0.10	0.24	0.12
Site #285 -											
846	grass	6.2	192.4	66.4	27.0	0.8	1.41	0.64	0.11	0.38	0.25
Site #286 -											
849	grass	5.8	294.1	40.3	17.5	1.2	0.91	0.41	0.09	0.33	0.23
Site #287 -											
852	grass	5.0	137.4	21.4	13.1	1.4	0.98	0.47	0.19	0.32	0.31
853	legume	13.4	84.1	18.7	33.1	8.0	3.73	1.16	0.22	1.83	0.63
Site #288 -											
856	grass	5.4	238.2	93.9	13.7	1.2	1.25	0.38	0.07	0.27	0.17
Site #289 -											
859	grass	5.8	110.9	81.6	11.2	1.6	1.20	0.49	0.05	0.26	0.12

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
<u>Site #290</u> -											
862	grass	4.9	78.6	49.4	12.5	3.6	1.15	0.55	0.12	0.23	0.22
863	legume	8.4	91.9	25.2	23.8	64.0	3.41	2.06	0.36	0.70	0.49
863 Rerun						50.0					
<u>Site #291</u> -											
866	grass	4.4	56.7	28.7	20.8	2.0	1.23	0.47	0.16	0.22	0.14
<u>Site #292</u> -											
868	grass	4.9	54.2	143.5	22.7	1.4	1.50	1.37	0.08	0.24	0.09
<u>Site #293</u> -											
870	grass	4.5	64.2	26.6	17.0	4.0	0.85	0.36	0.07	0.24	0.13
<u>Site #294</u> -											
873	grass	5.7	100.5	21.4	18.4	3.0	1.33	0.75	0.16	0.30	0.19
874	legume	7.2	64.2	9.7	14.7	4.0	2.13	1.04	0.17	1.14	0.20
<u>Site #295</u> -											
877	grass	4.2	88.7	99.0	8.9	2.6	0.88	0.24	0.12	0.28	0.13

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #296 -											
880	grass	5.1	69.2	111.1	33.3	1.4	0.88	0.42	0.17	0.27	0.20
Site #297 -											
883	grass	3.8	45.0	7.1	6.5	1.6	0.80	0.42	0.11	0.20	0.15
884	legume	3.8	70.8	16.2	12.2	1.0	2.94	0.92	0.24	0.10	0.30
Site #298 -											
887	grass	2.2	31.3	36.5	15.9	5.0	0.99	0.68	0.17	0.28	0.14
888	legume	6.5	58.1	14.0	17.5	2.0	2.37	1.30	0.17	0.98	0.19
Site #299 -											
891	grass	3.6	62.6	13.3	12.3	1.4	1.12	0.48	0.16	0.33	0.20
892	legume	7.3	91.9	30.5	19.4	9.0	4.32	0.91	0.31	1.64	0.47
Site #300 -											
895	grass	4.5	174.7	13.0	13.0	1.4	1.17	0.65	0.19	0.28	0.15
896	legume	3.3	94.0	7.0	17.9	1.8	3.46	1.29	0.29	0.72	0.34
Site #301 -											
899	grass	4.9	40.6	46.1	16.7	1.2	1.34	0.59	0.17	0.27	0.13

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #302 -											
902	grass	4.9	53.7	10.4	11.3	5.0	1.04	0.43	0.13	0.29	0.17
Site #303 -											
905	grass	7.3	262.7	49.8	29.8	1.6	1.18	0.42	0.14	0.40	0.29
Site #304 -											
908	grass	6.0	138.9	47.7	20.0	0.4	0.98	0.24	0.09	0.24	0.20
Site #305 -											
911	grass	5.7	118.4	23.7	24.8	1.6	1.50	0.45	0.14	0.26	0.22
Site #306 -											
914	grass	3.8	104.4	23.1	10.2	0.8	0.99	0.40	0.12	0.23	0.21
Site #307 -	Selina Sand										
916	grass	3.4	135.9	54.6	20.3	0.6	0.79	0.29	0.05	0.21	0.14
Site #308 -	Garson Complex										
918	grass	4.4	134.9	44.2	20.6	1.0	0.87	0.23	0.05	0.28	0.16

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #309 - Selina Sand, Till Substrate Phase											
920	grass	4.4	132.3	63.1	19.0	1.2	0.79	0.40	0.05	0.27	0.28
Site #310 - Selina Sand											
923	grass	4.5	46.3	97.4	21.0	1.0	1.18	0.43	0.07	0.27	0.19
Site #311 - Selina Series											
926	grass	4.5	40.2	1.9	11.5	4.0	1.20	0.59	0.12	0.31	0.19
Site #312 - Garson Complex											
929	grass	3.4	52.4	16.9	15.9	1.6	0.88	0.37	0.10	0.19	0.13
Site #313 - Garson Complex											
932	grass	6.0	81.3	16.2	21.4	0.8	1.38	0.39	0.17	0.32	0.22
Site #314 - Garson Complex											
935	grass	5.3	70.8	102.3	17.3	1.4	1.17	0.50	0.08	0.23	0.13
Site #315 - Garson Complex											
938	grass	6.0	45.9	30.8	17.7	0.8	1.18	0.49	0.16	0.29	0.18

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #316 -											
941	grass	5.3	198.9	24.2	21.1	0.6	1.36	0.70	0.18	0.32	0.21
Site #317 -											
943	grass	3.8	287.3	14.4	21.8	1.4	1.39	0.35	0.18	0.26	0.20
Site #318 - Edwards Association											
946	grass	6.5	98.1	16.4	20.4	1.0	1.52	0.33	0.12	0.34	0.30
947	legume	9.9	132.6	16.4	26.7	5.0	3.02	1.25	0.20	1.87	0.37
Site #319 - Selina Association - Selina Sand											
950	grass	4.9	340.3	15.7	11.3	1.2	0.87	0.38	0.13	0.30	0.18
Site #320 - Garson Complex											
953	grass	6.8	131.7	44.5	19.7	0.8	1.38	0.44	0.13	0.35	0.28
Site #321 - Edwards Association											
956	grass	6.1	148.5	28.1	31.7	2.0	1.63	0.59	0.11	0.33	0.21
Site #322 - Duck Mountain Complex											
959	grass	5.3	83.1	53.7	21.7	1.6	1.47	0.64	0.12	0.21	0.21

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #323 - Edwards Association											
962	grass	6.5	309.4	18.3	21.0	1.6	1.20	0.54	0.15	0.40	0.22
Site #324 - Agassiz Association											
965	grass	9.9	93.7	31.4	30.3	1.6	3.09	1.16	0.25	0.53	0.38
Site #325 - Isafold Association											
968	grass	5.7	84.0	8.8	26.4	1.2	2.69	0.46	0.08	0.25	0.23
Site #100A - Edwards Association											
1302	grass	4.9	82.6	32.2	14.5	1.4	0.93	0.99	0.35	0.27	0.09
Site #101A - Edwards Association											
1304B	grass	5.2	1044.5	99.0	32.9	12.0	0.64	0.95	0.28	0.28	0.13
1305	legume	11.2	617.2	42.5	30.1	24.0	2.29	2 25	0.35	1.31	0.38
Site #102A -											
1308	grass	2.8	105.6	12.4	17.8	3.0	insuff. sample	1.04	insuff. sample	0.29	0.10
1309	legume	5.9	176.8	17.6	26.1	2.0	2.13	2.40	0.28	0.89	0.34

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #103A - Dauphin Clay Till Substrate Phase											
1312	grass	4.2	314.4	19.7	17.5	0.8	1.00	1.78	0.20	0.41	0.25
1313	legume	6.9	314.4	31.8	31.1	4.0	1.92	2.41	0.18	0.84	0.46
Site #104A - Keld Assoc. Clay Loam to Clay											
1316	grass	5.9	392.9	9.7	19.5	1.4	0.93	1.08	0.09	0.20	0.12
Site #105A - Dulton Clay Loam											
1319	grass	4.2	127.7	19.4	13.9	1.7	1.38	0.92	0.17	0.26	0.14
1320	legume	5.9	260.3	13.2	21.8	10.0	1.70	1.68	0.15	1.00	0.33
Site #106A - Meharry Clay Loam-Deep Phase											
1323	grass	5.6	81.8	8.7	23.2	1.6	1.58	1.27	0.13	0.35	0.18
Site #107A - Dutton Clay Loam											
1326	grass	7.6	255.4	18.8	28.4	0.4	1.95	1.65	0.25	0.29	0.33
Site #108A - Meharry Clay Loam-Deep Phase											
1329	grass	9.4	64.8	32.4	24.0	0.4	2.14	2.11	0.26	0.30	0.23

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #109A - Meharry Clay Loam-Deep Phase											
1332	grass	6.6	122.8	27.6	19.7	2.0	1.55	1.60	0.22	0.26	0.17
Site #110A - Gilbert Sandy Loam											
1335	grass	6.6	147.4	54.4	19.9	0.8	2.14	1.48	0.24	0.35	0.20
Site #111A - Meharry Clay Loam-Deep Phase											
1338	grass	4.9	132.6	10.0	17.9	6.0	1.25	0.96	0.10	0.32	0.15
1339	legume	7.6	106.1	12.4	20.7	16.0	2.85	1.48	0.23	1.01	0.45
Site #112A - Meharry Clay Loam-Deep Phase											
1342	grass	4.2	62.4	11.2	11.5	2.4	1.17	1.63	0.12	0.25	0.21
Site #113A - Gilbert Sandy Loam											
1345	grass	5.2	86.0	27.6	15.4	2.6	1.62	1.78	0.20	0.37	0.15
1346	legume	4.4	33.0	9.2	8.5	2.0	1.97	1.09	0.20	0.87	0.18
Site #114A - Meharry Clay Loam-Deep Phase											
1349	grass	4.4	84.7	52.6	13.3	2.4	1.00	1.52	0.13	0.32	0.16

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #115A - Meharry Clay Loam - Deep Phase											
1352	grass	6.9	108.1	39.7	17.0	1.4	1.84	2.17	0.19	0.31	0.10
1353	legume	9.2	105.4	15.3	16.4	2.0	3.06	1.78	0.18	1.30	0.30
Site #116A - Meharry Clay Loam-Deep Phase											
1356	grass	3.4	106.2	7.0	12.6	2.0	1.07	0.73	0.13	0.21	0.10
Site #117A - Meharry Clay Loam-Deep Phase											
1359	grass	3.4	57.7	12.6	11.6	0.8	1.10	1.88	0.26	0.37	0.11
1360	legume	5.5	143.1	15.2	12.8	0.8	insuff. sample	1.89	insuff. sample	1.08	0.25
Site #118A - Meharry Clay Loam-Deep Phase											
1363	grass	3.7	48.7	17.9	12.4	0.2	1.18	1.46	0.21	0.34	0.13
1364	legume	8.6	73.9	25.7	22.6	5.0	2.46	2.40	0.22	0.87	0.19

Appendix IVC

Analysis of variance for nutrients between forage types and geological areas

Analysis of variance for different nutrients between forage types within the 1975 survey area. *Significant at P<0.005.

Source	Copper df	Copper MS	Iron df	Iron MS	Manganese df	Manganese MS	Molybdenum df	Molybdenum MS
Total	448		448		448		448	
Between	2	248.04*	2	4,351.92	2	14,566.37*	2	280.35*
Within	446	2.64	446	6,120.50	446	333.67	446	27.24

Source	Zinc df	Zinc MS	Nitrogen df	Nitrogen MS	Phosphorus df	Phosphorus MS	Calcium df	Calcium MS
Total	448		441		443		444	
Between	2	8,354.31*	2	110.0281*	2	0.1149*	2	43.3585*
Within	446	34.84	439	0.0241	441	0.0046	442	0.0411

Source	Magnesium df	Magnesium MS	Potassium df	Potassium MS
Total	444		444	
Between	2	1.3416*	2	16.6381*
Within	442	0.0058	442	0.1540

Analysis of variance for molybdenum levels of different forage types between areas east and west of the eastern boundary of the Ashville Geological Formation within the 1975 survey area.

*P<0.025, **P<0.005

Source	Native grass		Improved grass		Legume	
	df	MS	df	MS	df	MS
Total	35		298		113	
Between	2	4.82*	2	135.17**	2	8.82
Within	33	0.92	296	19.67	111	54.04

Appendix V

1976 Soil and Forage Survey

Appendix VA

Site location and sample description

1976 FORAGE AND SOIL SURVEY - SITE LOCATION AND SAMPLE DESCRIPTION

*Native grass species

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
1	21	16	32	4539	56338	1	2	3*	
2	21	15	31	4621	56330	4	5	6	
3	21	16	06	4589	56297	7	8	9*	
4	21	15	01	4695	56250	10	11		12
5	21	14	03	4758	56248	13	14	15*	
6	21	13	05	4835	56255	16	17		
7	21	12	05	4932	56247	18	19	20	21
8	21	15	14	4688	56281	22	23	24	
9	21	14	08	4737	56274	25	26	27*	
10	21	14	30	4720	56320	28	29	30	31
11	22	14	08	4727	56371	32	33	34	
12	22	15	11	4684	56372	35	36	37*	
13	22	15	18	4623	56379	38	39	40	41
14	22	16	13	4596	56388	42	43	44	
15	22	16	17	4535	56378	45	46	47	48

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
16	22	17	13	4504	56390	49	50		51
17	22	16	30	4526	56418	52	53	54	55
18	23	16	05	4529	56447	56	57	58	59
19	23	16	17	4531	56488	60	61	62	63
20	23	16	28	4537	56517	64	65	66	
21	24	10	21	5138	56589	67		68	
22	24	10	07	5100	56568	69		70	71
23	24	11	24	5083	56588	72	73	74	
24	24	11	36	5083	56632	75		76	77
25	25	11	11	5069	56654	78		79	80
26	25	11	16	5035	56680	81		82	
27	25	12	13	4989	56678	83			84
28	25	12	02	4968	56640	85		86	87
29	24	12	33	4935	56622	88	89	90	
30	24	11	19	4898	56588	91			92
31	25	12	07	4898	56681	93		94	

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
32	26	13	12	4894	56757	95		96	97
33	26	12	29	4915	56802	98	99	100*	
34	27	12	07	4909	56854	101	102	103	
35	27	12	17	4913	56892	104	105	106*	
36	26	12	05	4918	56735	107		108*	
37	24	13	13	4881	56572	109		110*	
38	24	15	13	4684	56573	111	112	113	114
39	24	14	05	4730	56550	115			116
40	23	14	20	4730	56503	117	118	119	
41	24	14	12	4783	56556	120		121	122
42	24	13	08	4824	56556	123		124*	
43	23	15	22	4646	56514	125	126	127	128
44	24	16	12	4582	56557	129		130	131
45	24	16	07	4505	56558	132		133	134
46	24	17	03	4454	56552	135	136	137	138
47	24	15	21	4630	56607	139	140	141	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
48	24	15	34	4651	56629	142	143	144*	
49	25	15	10	4651	56662	145	146	147*	
50	25	15	27	4652	56704	148	149	150	151
51	26	15	15	4653	56771	152	153	154*	
52	26	15	34	4653	56820	155	156	157*	
53	27	15	04	4636	56850	158	159	160	161
54	27	15	21	4636	56890	162	163	164*	
55	28	15	09	4637	56920	165	166	167	
56	28	15	18	4604	56926	168			169
57	28	15	29	4632	56970	170	171	172	
58	29	15	04	4637	57010	173	174	175	
59	29	15	14	4669	57032	176	177	178	
60	29	16	12	4598	57028	179	180	181*	
61	29	16	22	4556	57049	182		183	
62	29	16	18	4507	57033	184			185
63	29	17	01	4502	57004	186	187	188*	
64	29	17	03	4464	57002	189	190	191*	

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
65	28	17	24	4502	56960	192	193	194*	
66	28	17	10	4465	56932	195		196	
67	28	16	09	4550	56927	197		198	
68	27	16	22	4554	56890	199		200	
69	27	16	03	4554	56836	201		202	
70	25	15	30	4612	56717	203	204	205*	
71	25	15	18	4612	56680	206	207	208*	
72	24	16	21	4538	56612	209	210	211*	
73	25	18	20	4337	56690	212	213		214
74	25	18	22	4358	56703	215	216	217	
75	25	19	25	4305	56717	218	219	220	221
76	26	18	07	4309	56745	222	223	224	225
77	26	18	19	4310	56803	226	227	228*	
78	26	18	21	4349	56803	229	230	231	
79	27	19	13	4305	56875	232	233	234	235
80	28	19	12	4306	56923	236	237	238	
81	28	19	25	4308	56984	239	240	241	242

				UTM x 100m		SAMPLE NUMBER/DESCRIPTION			
						SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
82	29	18	06	4324	57010	243	244	245	246
83	29	18	20	4324	57054	247			248
84	29	18	27	4372	57067	249	250	251	
85	30	18	11	4377	57122	252	253	254*	
86	30	18	27	4373	57170	255	256	257	258
87	31	18	29	4330	57268	259	260	261*	
88	31	18	17	4330	57232	262		263	264
89	30	18	32	4342	57190	265		266	267
90	30	17	17	4432	57131	268		269*	
91	30	17	14	4474	57131	270	271	272*	
92	30	16	18	4510	57131	273	274	275*	
93	30	16	20	4527	57142	276		277*	
94	30	16	26	4576	57172	278		279*	
95	31	16	14	4577	57228	280	281	282*	
96	31	15	30	4606	57260	283		284*	
97	32	15	17	4619	57326	285		286*	

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
98	32	15	29	4621	57361	287		288	289
99	33	15	08	4623	57412	290		291	292
100	33	15	09	4643	57414	293	294	295	
101	33	14	15	4744	57420	296	297	298*	
102	24	18	34	4356	56634	299		300	301
103	24	17	28	4449	56619	302	303	304*	
104	24	17	20	4432	56594	305	306	307	308
105	23	17	21	4440	56506	309	310	311	
106	23	17	16	4448	56479	312	313	314	315
107	24	18	12	4400	56559	316		317*	
108	24	18	16	4344	56576	318		319*	
109	37	29	10	3266	57813	320	321	322	323
110	37	29	30	3232	57866	324		325	326
111	37	29	23	3296	57859	327		328	329
112	37	28	28	3350	57866	330	331	332	333
113	37	28	13	3397	57834	334		335	
114	37	28	09	3347	57813	336		337	338

Site #	Twp.	Rge.	Sec.	UTM x 100m E	UTM x 100m N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	SOIL 6-24"	VEGETATION Grass	VEGETATION Legume
115	38	27	30	3431	57966	339	340	341	342
116	38	28	23	3374	57942	343		344	345
117	38	27	17	3433	57922	346		348	349
118	38	27	26	3482	57954	350		351	
119	37	27	20	3492	57840	353	354	355	356
120	37	27	36	3497	57877	357		358	359
121	38	26	17	3531	57919	360		361	362
122	38	26	33	3547	57967	363	364	365	366
123	39	26	14	3565	58017	367		368	
124	39	25	19	3612	58044	369	370	371	372
125	39	25	25	3678	58045	373		374	375
126	39	25	03	3657	57994	376		377	378
127	38	25	33	3658	57913	379	380	381	382
128	38	25	19	3625	57933	383		384	
129	38	26	11	3578	57915	385		386	387
130	37	25	10	3670	57803	388	389	390	391
131	38	25	10	3673	57912	392		393	
132	37	25	22	3659	57849	394		395	

						SAMPLE NUMBER/DESCRIPTION			
				UTM x 100m		SOIL		VEGETATION	
Site #	Twp.	Rge.	Sec.	E	N	0-6"	6-24"	Grass	Legume
133	37	25	18	3623	57833	396		397	
134	37	26	13	3592	57820	398	399	400	
135	37	26	32	3543	57871	401		402	403
136	42	25	06	3616	58287	404	405	406	407
137	54	28	02	3363	59458	408	409	410 411*	411
138	54	29	36	3290	59545	412	413	414* 416*	415 417
139	53	28	27	3347	59418	418	419		420
140	53	27	31	3390	59432	421	422	423 424*	424
141	54	29	34	3256	59544	425	426	427	428
142 portion of	54 54	28 27	13 18	3385	59485	429	430	431* 432* 433*	
143	54	28	19	3305	59506	434	435	436* 437*	438
144	54	28	09	3335	59468	439	440	442	441
145	55	29	01	3263	59553	443	444	445* 446	
146	55	26	32	3492	59626	447	448	449*	450

Site #	Twp.	Rge.	Sec.	UTM x 100 m E	 N	SAMPLE NUMBER/DESCRIPTION SOIL 0-6"	 6-24"	 VEGETATION Grass	 Legume
147	55	27	35	3443	59635	451	452	453*	454
148	56	25	16	3612	59669	455	456	457* 458	
149	55	27	16/21	3411	59590	459	460	461* 462*	
150	55	27	36	3461	59630	463	464	466*	465
151	55	27	15	3428	59581	467	468	470*	469
152	55	26	29	3487	59613	471	472	473* 475*	474
153	56 56	27 26	01 06	3471	59650	476	477	478* 479*	
154	53	27	31	3401	59442	480	481		482

Appendix VB

Forage analyses:

Analyses of Cu, Fe, Mn, Zn, Mo in parts per million

Analyses of N, K, P, Ca, Mg in percent

Appendix VB

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #1 - Edwards Silt Loam to Silty Clay											
3	grass	6.1	75.0	20.9	25.0	0.6	1.46	1.28	0.17	0.31	0.16
Site #2 - McCreary Assoc. (Very Fine Sandy Loam to Clay Loam)											
6	grass	7.9	133.0	27.9	35.4	3.2	3.78	2.39	0.38	0.38	0.20
Site #3 - Edwards Silt Loam to Silty Clay											
9	grass	6.5	134.5	45.1	23.4	1.0	2.26	1.46	0.22	0.42	0.17
Site #4 - Dauphin Clay, Till Substrate Phase											
12	legume	11.6	76.0	18.7	52.7	5.0	3.9	2.19	0.19	1.94	0.41
Site #5 - Isafold Assoc. (Loamy Sand to Clay Loam)											
15	grass	5.4	95.3	60.9	20.6	0.8	1.47	1.11	0.12	0.45	0.24
Site #6 - Leary Assoc. (Leary Loamy Sand)											
	No sample obtainable										
Site #7 - Lakeland Assoc., Lakeland Loam, Till Substrate Phase											
20	grass	12.6	78.9	49.5	40.4	0.6	3.12	2.48	0.40	0.47	0.44
21	legume	10.5	79.8	24.6	30.9	2.6	5.28	1.30	0.39	2.09	0.50

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #8 - Agassiz Assoc.											
24	grass	3.3	93.4	21.7	22.3	5.0	2.74	3.05	0.30	0.49	0.20
Site #9 - Isafold Assoc.											
27	grass	4.3	72.6	61.3	20.0	2.0	1.73	0.96	0.11	0.45	0.29
Site #10 - Isafold Assoc.											
30	grass	10.8	90.5	38.9	23.6	0.8	4.75	2.43	0.30	0.59	0.34
31	legume	11.9	85.6	24.2	34.5	3.4	4.87	2.20	0.38	2.45	0.45
Site #11 - Isafold Assoc.											
34	grass	7.2	75.0	31.9	20.0	1.8	2.77	1.30	0.30	0.41	0.25
Site #12 - Isafold Assoc.											
37	grass	3.6	124.8	35.2	16.6	1.2	1.97	1.26	0.12	0.35	0.21
Site #13 - Lakeland Assoc.											
40	grass	5.8	94.3	34.1	28.2	1.6	2.77	0.90	0.18	0.36	0.17
41	legume	15.9	74.0	19.8	58.1	11.0	5.62	2.15	0.43	2.07	0.38
Site #14 - Organic Soils											
44	grass	5.0	122.4	19.8	18.2	2.8	2.10	0.93	0.16	0.58	0.21

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #15 - Leary Assoc.											
47	grass	9.8	132.1	78.2	32.3	1.6	3.25	1.26	0.23	0.54	0.27
48	legume	14.4	87.1	35.2	58.1	9.0	5.55	2.00	0.43	1.88	0.31
Site #16 - Erickson Assoc.											
51	legume	11.6	74.0	20.6	40.9	20.0	4.72	2.59	0.37	2.35	0.31
Site #17 - Edwards Assoc.											
54	grass	6.5	90.5	18.3	35.0	7.0	2.58	1.58	0.31	0.40	0.20
55	alfalfa	10.8	95.3	19.1	40.9	7.0	4.34	1.71	0.29	2.82	0.55
Site #18 - Glenhope Series											
58	grass	10.4	123.2	34.2	29.9	1.2	3.18	1.53	0.23	0.19	0.32
59	legume	14.9	76.4	27.3	42.1	12.0	4.34	1.27	0.25	2.75	0.50
Site #19 - Colby Series											
62	grass	11.1	69.1	48.4	24.4	2.8	2.27	1.35	0.18	0.45	0.21
63	legume	15.2	69.1	15.6	37.9	3.8	4.35	1.66	0.31	2.35	0.35
Site #20 - Garrioch Series											
66	grass	8.6	86.8	31.3	20.1	1.2	2.69	2.29	0.17	0.48	0.20

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #21 - Fairford/Inwood Complex - Loam											
68	grass	9.3	192.4	40.8	29.0	1.6	2.77	2.06	0.27	0.53	0.29
Site #22 - Meleb S - Peaty Phase - Loam											
70	grass	4.8	88.4	42.9	20.3	1.8	2.00	1.02	0.18	0.34	0.22
71	legume	11.1	60.8	19.3	34.6	5.6	3.84	1.70	0.20	2.20	0.68
Site #23 - Meleb S - Peaty Phase - Loam											
74	grass	7.3	76.9	77.5	27.1	0.8	2.78	0.52	0.17	0.22	0.23
Site #24 - Fairford/Inwood Complex - Loam											
76	grass	6.9	88.4	13.1	16.5	0.8	2.08	0.67	0.35	0.60	0.60
77	legume	5.9	93.6	16.0	15.2	1.4	3.39	0.60	0.20	1.56	1.30
Site #25 - Clarkleigh S - Loam											
79	grass	6.6	58.7	9.8	16.5	0.8	2.43	1.27	0.21	0.47	0.33
80	legume	12.1	102.4	16.0	15.9	3.0	3.30	0.45	0.16	2.82	1.80
Site #26 - Crane Complex											
82	grass	6.2	74.3	17.1	20.1	1.2	2.59	1.19	0.14	0.40	0.39

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #27 - Fairford/Inwood Complex - Loam											
84	legume	6.9	70.2	12.4	17.3	4.0	3.22	1.14	0.13	2.72	1.10
Site #28 - Clarkleigh Peaty Phase - Loam											
86	grass	7.6	58.2	26.5	24.3	0.8	2.50	0.78	0.18	0.39	0.43
87	legume	6.2	63.9	9.8	12.6	1.6	2.61	1.37	0.12	1.42	0.61
Site #29 - Wentland S Peaty Phase											
90	grass	7.6	71.2	26.9	34.5	0.8	2.46	0.99	0.16	0.35	0.32
Site #30 - Lundar/Isafold Complex											
92	legume	9.0	66.0	10.9	20.8	5.0	3.26	0.77	0.18	1.73	0.81
Site #31 - Lundar/Clarkleigh Complex - Loam											
94	grass	4.8	140.4	26.9	17.1	0.4	1.97	0.73	0.21	0.42	0.36
Site #32 - Lundar Series											
96	grass	6.2	102.4	8.7	24.3	0.8	1.76	1.29	0.15	0.44	0.26
97	legume	10.6	75.5	11.8	23.9	3.0	4.37	1.38	0.25	1.57	0.60
Site #33 - Meleb Peaty Loam/Crane Complex Peat											
100	grass	2.6	54.9	87.1	16.7	1.2	1.20	0.27	0.05	0.22	0.19

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #34 - Lundar/Clarkleigh Complex - Loam											
103	grass	3.8	94.8	51.5	20.8	0.4	1.22	0.23	0.09	0.30	0.29
Site #35 - Isafold/Lundar/Clarkleigh Complex - Loam											
106	grass	2.6	80.4	41.6	19.2	0.4	1.18	0.56	0.12	0.18	0.31
Site #36 - Isafold/Lundar/Clarkleigh Complex - Loam											
108	grass	3.0	202.1	19.5	14.5	0.4	1.12	0.28	0.10	0.25	0.15
Site #37 - Meleb Series - Peaty Phase Loam											
110	grass	1.9	108.8	176.6	13.9	0.4	0.80	0.42	0.05	0.26	0.21
Site #38 - Plum Ridge Series											
113	grass	4.9	83.2	29.4	14.2	3.0	2.05	0.42	0.18	0.41	0.43
114	legume	13.9	77.0	28.3	32.6	5.4	5.22	1.31	0.34	1.48	0.74
Site #39 - Lundar Series											
116	legume	7.5	84.2	9.9	8.3	0.8	2.10	0.64	0.11	1.20	0.68
Site #40 - Plun Ridge Series											
119	grass	3.8	43.3	5.1	9.2	0.4	2.29	1.02	0.20	0.43	0.40

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #41 - Clarkleigh Series											
121	grass	4.1	74.6	14.3	20.5	4.0	1.58	1.00	0.22	0.44	0.32
122	legume	6.4	67.4	16.9	16.1	5.0	3.70	0.82	0.18	1.97	1.01
Site #42 - Lundar Series											
124	grass	2.6	56.3	57.7	13.9	0.8	1.02	0.45	0.07	0.42	0.27
Site #43 - Plum Ridge Series											
127	grass	6.0	68.8	24.2	26.0	1.2	2.56	1.13	0.16	0.39	0.52
128	legume	8.7	69.8	15.8	21.5	3.0	3.54	0.72	0.16	1.33	0.95
Site #44 - Lundar/Glenhope Complex											
130	grass	3.4	67.4	34.5	12.0	1.2	1.55	1.03	0.13	0.44	0.23
131	legume	4.5	46.7	12.1	12.0	5.0	2.86	1.53	0.11	1.93	0.33
Site #45 - Glenhope Series											
133	grass	3.8	46.7	21.0	10.1	1.2	2.01	1.30	0.15	0.51	0.35
134	legume	9.8	73.6	22.8	19.9	6.4	3.23	0.71	0.13	2.12	0.68
Site #46 - Ochre River Series											
137	grass	5.7	202.1	35.3	18.3	4.0	2.16	1.40	0.22	0.60	0.30
138	legume	14.3	79.4	19.1	33.6	8.0	4.10	1.79	0.25	2.40	0.53

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #47 - Plum Ridge Series											
141	grass	2.5	60.1	77.8	12.1	0.4	1.04	0.63	0.08	0.28	0.18
Site #48 - Plum Ridge Series											
144	grass	2.2	132.3	49.3	9.9	0.4	1.07	0.35	0.10	0.25	0.18
Site #49 - McCreary Series											
147	grass	2.5	97.8	43.8	16.8	0.5	1.09	0.62	0.09	0.28	0.22
Site #50 - Methley/Magnet Complex											
150	grass	5.4	94.1	61.3	0.6	16.1	2.93	2.00	0.16	0.42	0.48
151	legume	4.3	94.1	28.1	2.6	14.8	2.98	1.08	0.15	1.47	1.08
Site #51 - Methley/Magnet Complex											
154	grass	7.6	96.7	45.6	27.6	0.8	2.32	1.38	0.15	0.33	0.26
Site #52 - Methley Series											
157	grass	2.5	76.8	27.4	16.5	0.4	1.00	0.49	0.08	0.28	0.18
Site #53 - Glenhope Series											
160	grass	3.6	183.0	44.9	19.4	0.4	1.65	0.71	0.23	0.44	0.35
161	legume	10.1	153.2	28.5	29.6	4.0	4.14	1.70	0.26	1.81	0.76

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #54 - Methley Series											
164	grass	2.5	177.8	45.2	17.3	1.4	1.18	0.37	0.05	0.42	0.24
Site #55 - Lundar/Clarkleigh (Saline) Complex											
167	grass	4.7	142.7	59.5	23.2	2.4	1.82	0.11	0.35	0.19	0.75
Site #56 - Lundar Series											
169	legume	10.5	148.0	23.4	34.7	3.4	3.23	2.01	0.13	2.26	0.52
Site #57 - Colby Series - Saline Phase											
172	grass	4.3	224.8	27.0	25.6	0.6	2.10	0.85	0.11	0.57	0.50
Site #58 - Lundar/Clarkleigh Complex											
175	grass	2.9	481.0	47.5	22.7	0.8	1.25	0.60	0.11	0.38	0.38
Site #59 - Lundar/Clarkleigh Complex											
178	grass	6.5	116.6	51.1	24.7	0.8	2.80	1.58	0.26	0.34	0.30
Site #60 - Clarkleigh Series											
181	grass	3.6	183.0	63.9	28.1	1.2	1.26	0.61	0.06	0.48	0.45

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #61 - Isafold Series											
183	grass	2.5	76.9	15.3	14.5	1.0	0.98	0.34	0.11	0.38	0.70
Site #62 - Isafold Series											
185	legume	11.5	120.3	27.4	40.4	5.0	3.12	1.38	0.12	2.37	0.67
Site #63 - Clarkleigh Series											
188	grass	3.3	287.6	32.1	17.0	0.4	1.18	0.36	0.09	0.46	0.22
Site #64 - Crane Complex											
191	grass	1.8	261.4	157.0	12.5	0.4	1.17	0.32	0.09	0.53	0.32
Site #65 - Eddystone Series											
194	grass	2.9	130.7	64.6	26.1	1.4	1.22	0.34	0.06	0.36	0.20
Site #66 - Isafold Series											
196	grass	5.5	92.0	28.6	19.0	2.0	2.16	0.98	0.19	0.45	0.38
Site #67 - Lundar Series											
198	grass	2.2	108.0	22.2	10.3	1.2	1.09	0.47	0.17	0.40	0.18

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #68 - Lundar Series											
200	grass	2.9	109.0	59.1	13.8	0.6	0.85	0.45	0.10	0.32	0.21
Site #69 - Clarkleigh Series											
202	grass	5.5	93.1	48.3	26.1	1.2	1.76	1.07	0.10	0.40	0.30
Site #70 - Magnet Series											
205	grass	2.2	103.7	23.9	17.1	0.4	0.71	0.20	0.06	0.38	0.99
Site #71 - Wentland Series											
208	grass	2.2	113.3	16.8	12.6	1.2	0.90	0.42	0.08	0.34	0.19
Site #72 - Glenfields Series											
211	grass	3.3	119.7	28.6	22.9	0.6	1.22	0.39	0.12	0.40	0.29
Site #73 - Dauphin Series											
214	legume	8.4	228.8	22.6	13.7	3.6	2.83	0.94	0.13	1.50	0.57
Site #74 - Plumas Series											
217	grass	8.7	191.5	61.9	21.7	1.2	3.79	3.12	0.25	0.62	0.38

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #75 - Weiden Series											
220	grass	4.4	155.9	22.6	15.7	1.2	1.50	0.74	0.15	0.32	0.16
221	legume	9.8	79.8	17.9	24.6	5.6	3.60	0.82	0.19	1.25	0.32
Site #76 - Glenhope Series											
224	grass	3.6	141.0	17.9	16.4	3.0	1.33	0.54	0.11	0.59	0.18
225	legume	8.0	108.0	25.1	13.2	2.8	2.37	0.54	0.09	2.55	0.37
Site #77 - Glenhope Series											
228	grass	5.5	212.8	57.3	39.6	1.0	1.47	1.12	0.17	0.45	0.27
Site #78 - Methley Series											
231	grass	4.7	129.3	38.3	21.7	0.8	1.18	0.83	0.09	0.34	0.29
Site #79 - Glenhope Series											
234	grass	4.0	127.7	16.1	16.7	0.6	1.79	1.28	0.11	0.36	0.26
235	legume	7.6	191.5	13.3	19.3	5.0	2.80	0.98	0.09	1.86	0.90
Site #80 - Glenella Series											
238	grass	3.6	111.7	53.7	10.3	2.0	1.31	1.48	0.11	0.45	0.26

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #81 - Glenella Series											
241	grass	5.8	79.8	17.9	30.4	1.2	2.08	0.83	0.09	0.39	0.29
242	legume	9.5	95.8	16.8	30.4	6.0	2.83	1.56	0.09	2.29	0.66
Site #82 - McCreary Series											
245	grass	4.4	126.1	22.2	13.2	4.4	1.39	1.34	0.12	0.62	0.33
246	legume	9.1	117.7	24.3	22.1	8.0	2.80	0.09	2.40	0.37	1.26
Site #83 - Isafold Series											
248	legume	11.6	88.1	29.7	30.8	1.2	2.62	0.88	0.10	3.07	0.75
Site #84 - Lundar Series											
251	grass	6.5	179.4	16.3	30.4	1.0	2.38	0.83	0.11	0.67	0.41
Site #85 - Glenhope Series											
254	grass	3.6	226.9	32.6	15.6	1.0	1.31	0.60	0.12	0.70	0.37
Site #86 - Methley Series											
257	grass	3.9	98.7	7.2	24.8	2.4	1.57	1.11	0.07	0.56	0.22
258	legume	9.4	253.3	16.3	15.4	4.6	2.29	0.07	1.00	3.23	0.68

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #87 - Weiden Peaty Saline											
261	grass	5.8	102.9	38.0	34.1	0.8	3.17	1.31	0.17	0.54	0.23
Site #88 - Fairford/Inwood Complex											
263	grass	3.3	92.3	18.1	18.0	1.4	1.18	0.62	0.15	0.42	0.20
264	legume	7.2	68.6	8.7	12.4	8.0	2.01	0.96	0.09	1.87	0.43
Site #89 - Fairford/Inwood Complex											
266	grass	2.5	131.9	97.1	10.3	1.2	0.85	0.32	0.05	0.57	0.22
267	legume	7.6	91.3	22.5	13.7	3.0	2.32	0.51	0.09	2.91	0.65
Site #90 - Fairford/Inwood Complex											
269	grass	2.2	221.6	19.9	16.3	2.0	0.80	0.40	0.06	0.51	0.21
Site #91 - Lundar Series											
272	grass	4.7	174.1	22.5	23.4	0.6	2.37	1.43	0.20	0.44	0.28
Site #92 - Fairford/Inwood Complex											
275	grass	2.9	226.9	55.4	24.3	0.6	1.57	0.89	0.07	0.63	0.25
Site #93 - Inwood Series											
277	grass	1.8	211.0	6.5	9.2	1.2	0.80	0.22	0.06	0.52	0.22

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #94 - Meleb Series											
279	grass	2.5	155.6	35.5	16.8	0.6	1.25	0.34	0.10	0.47	0.22
Site #95 - Fairford/Inwood/Meleb (Peaty) Complex											
282	grass	5.8	195.2	30.8	40.2	0.8	2.82	0.79	0.19	0.49	0.36
Site #96 - Marsh Complex											
284	grass	2.9	195.2	16.7	9.8	0.6	0.96	0.43	0.08	0.43	0.32
Site #97 - Lundar/Meleb Complex											
286	grass	5.1	114.5	17.0	20.5	0.8	1.76	0.38	0.09	0.34	0.29
Site #98 - Fairford/Inwood Complex											
288	grass	4.0	189.9	24.6	16.5	0.8	1.58	0.73	0.19	0.45	0.34
289	legume	14.1	89.7	12.7	27.6	4.4	4.91	2.40	0.38	1.58	0.67
Site #99 - Fairford/Inwood Complex											
291	grass	5.0	205.8	30.2	12.3	1.8	1.76	2.05	0.24	0.51	0.39
292	legume	10.7	127.2	17.7	25.0	3.0	3.71	1.50	0.19	1.63	0.61
Site #100 - Meleb Peat/Crane Peat/Meleb Loam											
295	grass	5.0	127.2	108.5	31.0	0.8	2.12	0.63	0.12	0.34	0.19

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #100 -	Meleb Peat/Crane Peat/Meleb Loam										
295	grass	5.0	127.2	108.5	31.0	0.8	2.12	0.63	0.12	0.34	0.19
Site #101 -	Meleb Peat/Fairford Loam/Inwood Loam										
298	grass	1.4	128.3	172.9	11.6	0.8	1.09	0.31	0.05	0.39	0.29
Site #102 -	Clarkleigh Series										
300	grass	7.9	189.5	43.4	18.0	1.0	2.75	0.31	0.26	0.58	0.32
301	legume	7.1	128.3	19.5	13.9	3.4	3.89	1.32	0.18	1.74	0.49
Site #103 -	Glenhope/Glenhope Saline Complex										
304	grass	3.6	99.1	97.5	26.4	0.8	1.57	0.52	0.11	0.48	0.28
Site #104 -	Magnet Series										
307	grass	6.1	90.4	22.1	25.0	3.4	1.84	1.44	0.08	0.39	0.17
308	legume	10.4	92.0	9.2	36.6	6.0	2.94	1.29	0.10	2.71	0.39
Site #105 -	Valley River Series										
311	grass	4.3	112.1	34.9	17.6	0.8	1.49	0.70	0.11	0.55	0.35

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #106 - Edwards Series											
314	grass	7.1	127.2	135.4	23.9	1.6	2.37	1.32	0.18	0.50	0.19
315	legume	13.2	222.0	32.0	27.5	14.0	4.14	2.37	0.24	1.64	0.38
Site #107 - Lundar/Clarkleigh Complex											
317	grass	2.5	95.3	121.4	11.8	1.2	0.77	0.33	0.06	0.49	0.19
Site #108 - Ridgely Series											
319	grass	2.9	117.5	41.6	18.2	1.2	1.20	0.48	0.07	0.49	0.17
Site #109 - Kenville Series											
322	grass	8.2	95.8	23.5	22.5	4.0	2.50	2.25	0.30	0.37	0.19
323	legume	11.8	77.4	23.9	46.3	8.3	2.40	1.38	0.20	0.36	0.16
Site #110 - Meadowbrook Assoc.											
325	grass	5.7	611.8	67.3	22.4	16.0	2.40	1.38	0.20	0.36	0.16
326	legume	12.1	78.5	39.4	32.9	4.0	4.72	2.46	0.32	2.20	0.40
Site #111 - Peguis Till Substrate Phase											
328	grass	4.3	109.9	9.5	17.6	7.0	1.34	0.74	0.16	0.38	0.16
329	legume	9.3	78.5	23.9	19.0	4.0	UBC only				

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #112 - Agassiz Series											
332	grass	2.9	286.9	90.9	16.0	4.0	0.91	0.39	0.14	0.46	0.14
333	legume	5.7	262.6	65.2	16.9	2.0	2.10	0.64	0.20	2.08	0.40
Site #113 - Lenswood Series											
335	grass	4.6	257.1	43.8	14.0	19.1	1.39	1.30	0.25	0.45	0.18
Site #114 - Lenswood Series											
337	grass	6.4	153.2	17.8	19.7	0.8	2.35	1.62	0.20	0.39	0.13
338	legume	5.0	251.6	29.2	22.5	7.0	3.22	1.56	0.24	1.26	0.39
Site #115 - Grifton Assoc.											
341	grass	8.6	56.3	58.0	24.3	2.0	2.96	2.52	0.31	0.37	0.17
342	legume	7.9	65.6	29.6	26.2	3.4	4.14	2.54	0.35	1.96	0.26
Site #116 - Grifton Assoc.											
344	grass	5.0	71.1	22.8	27.3	8.0	1.65	1.56	0.21	0.35	0.16
345	legume	13.6	80.4	20.3	30.5	4.0	4.51	2.76	0.37	2.29	0.30
Site #117 - Malowton Series											
348	grass	5.4	93.0	24.2	16.6	1.2	1.87	1.79	0.15	0.46	0.22
349	legume	4.6	73.8	21.4	21.3	4.4	3.33	2.20	0.15	1.84	0.31

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #118 -											
351	grass	5.4	91.4	29.2	20.3	4.4	2.69	2.03	0.27	0.64	0.17
Site #119 - Lenswood Till Substrate Phase											
355	grass	5.4	180.5	26.7	28.9	4.0	1.68	1.90	0.21	0.30	0.19
356	legume	8.6	112.1	11.8	31.9	4.0	4.75	2.54	0.35	1.89	0.32
Site #120 - Swanford Series											
358	grass	10.4	152.1	29.6	19.0	3.0	2.93	3.24	0.34	0.49	0.24
359	legume	10.0	152.1	32.1	37.0	3.2	3.44	2.44	0.33	1.28	0.41
Site #121 - Valley Series											
361	grass	6.4	147.7	32.1	15.7	3.8	2.24	1.50	0.21	0.42	0.20
362	legume	7.9	101.2	26.4	31.0	4.0	4.70	2.78	0.33	2.03	0.29
Site #122 - Berlo Series											
365	grass	5.7	66.7	8.2	24.0	1.2	1.70	1.13	0.14	0.54	0.24
366	legume	8.6	57.4	12.8	38.8	3.6	UBC only				
Site #123 - Davidson Series											
368	grass	6.1	132.9	43.8	31.9	3.0	UBC only				

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #124 - Pine Ridge Series											
371	grass	4.6	83.7	22.4	13.6	3.8	1.44	0.65	0.21	0.63	0.27
372	legume	6.8	127.5	41.7	22.1	3.0	3.81	1.33	0.38	1.46	0.38
Site #125 - Plainview Series											
374	grass	7.5	162.7	15.9	25.0	2.0	2.29	2.39	0.30	0.42	0.24
375	legume	10.7	66.7	10.6	22.8	12.0	3.78	2.29	0.27	1.93	0.39
Site #126 - Lenswood Series											
377	grass	5.0	74.3	15.2	15.0	1.0	1.39	0.63	0.11	0.50	0.30
378	legume	9.6	85.2	20.2	33.7	1.8	3.10	0.87	0.78	2.55	0.54
Site #127 - Lenswood Series											
381	grass	9.6	93.8	21.9	21.6	1.6	2.82	2.22	0.25	0.45	0.29
382	legume	5.0	81.4	19.8	27.0	6.0	4.13	2.86	0.35	1.87	0.32
Site #128 - Swanford Series											
384	grass	4.6	77.6	9.9	21.6	1.0	1.14	0.28	0.07	0.40	0.23
Site #129 - Fyala Series											
386	grass	4.6	138.3	35.4	15.9	4.0	1.22	0.95	0.17	0.44	0.18
387	legume	10.4	88.9	15.9	27.1	4.0	3.94	1.97	0.30	2.05	0.45

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #130 - Plainview Series											
390	grass	6.8	287.5	31.8	30.5	4.0	2.73	1.61	0.27	0.37	0.21
391	legume	12.1	271.2	21.2	29.6	4.6	3.86	2.13	0.23	1.94	0.45
Site #131 - Swanford Series											
393	grass	8.6	401.4	46.0	20.0	0.8	3.62	1.82	0.24	0.55	0.37
Site #132 - Valley Series											
395	grass	5.4	75.9	21.9	21.4	2.0	2.06	0.99	0.15	0.54	0.30
Site #133 - Valley Series											
397	grass	4.6	133.9	40.7	18.5	8.6	1.92	1.66	0.24	0.54	0.16
Site #134 - Foley Series											
400	grass	9.6	179.0	20.2	33.2	1.6	3.36	1.58	0.24	0.54	0.33
Site #135 - Fyala Series											
402	grass	5.7	77.6	26.5	21.9	1.0	Analysis UBC only				
403	legume	8.9	74.8	15.2	38.7	8.0	Analysis UBC only				

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #136 - Birch River Series											
406	grass	4.3	93.8	37.5	17.9	16.0	1.54	0.57	0.12	0.39	0.08
407	legume	12.1	100.3	23.4	38.7	10.0	4.46	2.29	0.33	2.39	0.25
Site #137 - LePas Drained Phase											
410	tame	3.6	179.0	37.9	22.8	0.8	0.94	0.45	0.12	0.36	0.08
411	native	5.2	145.9	85.8	40.1	0.4	1.66	0.84	0.12	0.52	0.14
Site #138 - LePas Sand Substrate Phase											
414	native	6.3	97.5	60.3	30.9	0.8	2.12	1.22	0.13	0.26	0.11
415	legume	25.8	143.1	23.0	126.1	0.8	3.04	3.65	0.22	0.96	0.22
416	native	6.6	150.1	16.1	30.4	0.8	2.43	2.62	0.19	0.41	0.18
417	legume	10.3	58.4	16.1	40.1	3.8	3.68	2.22	0.20	2.82	0.33
Site #139 - LePas Str. Saline Phase											
420	legume	12.5	245.3	13.9	46.7	6.0	4.83	2.82	0.32	1.55	0.34
Site #140 - Shallow Peat											
423	tame	4.1	221.9	39.1	37.5	0.4	1.25	0.79	0.12	0.43	0.16
424	native	6.3	327.0	38.0	45.0	0.6	1.98	1.20	0.13	0.43	0.15

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #141 - Big Lake Modal Phase											
427	tame	7.0	800.0	39.1	35.3	3.8	2.14	1.05	0.24	0.42	0.15
428	legume	9.2	1302.2	33.6	37.9	3.6	3.90	2.18	0.27	1.07	0.25
Site #142 - LePas Modal Phase											
431	native	11.1	274.5	51.1	30.9	1.0	2.69	2.30	0.32	0.71	0.25
432	native	5.2	192.7	51.9	22.9	1.2	1.79	1.06	0.17	0.54	0.26
433	native	8.1	5080.3	93.2	40.1	0.8	0.80	0.68	0.82	1.47	0.44
Site #143 - LePas Modal Phase											
436	native	6.3	204.4	35.4	46.7	0.8	1.41	0.79	0.12	0.54	0.21
437	native	10.3	198.5	11.7	34.8	0.8	3.58	2.30	0.30	0.92	0.23
438	legume	10.3	198.5	17.2	50.3	7.0	3.53	2.40	0.21	1.64	0.32
Site #144 - Nels Fine Sandy Loam											
441	legume	14.4	268.6	11.3	51.2	4.0	2.72	3.29	0.39	2.12	0.34
442	tame	9.6	729.9	25.6	36.0	1.2	2.24	1.26	0.30	0.41	0.18
Site #145 - Big Lake Modal Phase											
445	native	2.2	52.6	21.9	27.3	0.4	1.44	0.46	0.16	0.47	0.13
446	tame	3.7	70.1	118.7	28.2	0.4	1.22	0.32	0.07	0.39	0.11

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #146 - LePas Modal Phase											
449	native	7.0	89.3	14.6	23.8	1.2	2.05	1.23	0.18	0.52	0.19
450	legume	12.7	96.4	10.1	63.3	18.0	3.97	2.18	0.20	1.74	0.31
Site #147 - LePas Modal Phase											
453	native	6.0	181.4	31.7	24.3	1.8	1.82	1.53	0.25	0.50	0.19
454	legume	12.7	86.7	16.8	38.6	5.0	4.96	2.57	0.36	1.86	0.30
Site #148 - Pasquia Drained Phase/LePas Drained Sand Substr. Phase											
457	native	4.5	66.9	32.4	63.3	0.4	1.92	0.80	0.15	0.49	0.15
458	tame	3.0	77.7	79.4	27.3	0.4	1.34	0.57	0.11	0.33	0.14
Site #149 - Big Lake Modal Phase											
461	native	8.6	187.1	12.7	29.5	0.8	1.66	1.16	0.14	0.36	0.14
462	native	6.0	181.4	17.9	28.2	1.0	1.15	0.78	0.09	0.30	0.12
Site #150 - LePas Modal Phase											
465	legume	11.2	90.7	11.9	57.3	9.6	3.81	2.91	0.26	1.46	0.30
466	native	10.1	97.5	24.9	55.5	1.0	2.56	2.07	0.30	0.38	0.18

SAMPLE #	TYPE	Cu	Fe	Mn	Zn	Mo	N	K	P	Ca	Mg
Site #151 - Big Lake Modal Phase											
469	legume	13.8	56.7	12.3	29.9	3.0	3.58	2.20	0.18	2.46	0.25
470	native	12.0	94.7	9.3	30.4	1.2	2.01	1.29	0.16	0.60	0.14
Site #152 - LePas Modal Phase											
473	(foxtail) native	6.7	90.7	13.1	28.9	0.8	1.41	0.76	0.13	0.26	0.08
474	legume	12.3	249.4	17.5	34.7	3.0	4.22	2.72	0.28	1.30	0.28
475	native	10.1	640.1	29.1	41.6	1.4	2.69	1.62	0.25	0.60	0.21
Site #153 - LePas Drained Phase											
478	native	9.7	198.4	16.0	26.0	0.8	2.91	2.15	0.23	0.41	0.18
479	native	8.2	113.4	16.9	20.4	0.8	2.78	2.17	0.27	0.44	0.19
Site #154 - Shallow Peat											
482	legume	12.0	810.6	27.2	47.7	4.6	4.00	2.16	0.28	2.11	0.58

Appendix VC

Analysis of variance for nutrients between forage types

Analysis of variance for different nutrients between forage types within the 1976 survey area. *(P<0.01) **(P<0.005)

Source	Copper		Iron		Manganese		Molybdenum	
	df	MS	df	MS	df	MS	df	MS
Total	226		221[a]		226		226	
Between	2	574.99**	2	32,405.42*	2	10,676.55**	2	340.05**
Within	224	7.75	219	6,308.09	224	639.32	224	7.65

Source	Zinc		Nitrogen		Phosphorus		Calcium	
	df	MS	df	MS	df	MS	df	MS
Total	226		220		220		220	
Between	2	2,076.10**	2	79.1774**	2	0.1450**	2	49.4108**
Within	224	149.21	218	0.6263	218	0.0105	218	0.1684

Source	Magnesium		Potassium	
	df	MS	df	MS
Total	220		220	
Between	2	1.5016**	2	11.3073**
Within	218	0.0349	218	0.4778

[a]Omitting 1 value of 5,080.3 ppm from the native grasses, 2 values of 800.0 and 729.9 ppm from the improved grasses and 2 values of 1,302.2 and 810.6 ppm from the legumes, which if included would have given biased mean values of 240.12 ± 652.96, 143.65 ± 124.53 and 135.86 ± 170.72 ppm respectively.