CHAPTER 3

IMPACT OF DAIRY AND SWINE AMENDMENTS ON TURF SOIL QUALITY: EVALUATING SOIL QUALITY WITH MULTIPLE INDICATORS

3.1. ABSTRACT

Golf courses are only as sustainable as their weakest natural component, which is often soil quality. This study was conducted to assess the impact of swine and dairy compost on turf soil quality as well as quantify various soil quality indicators to assist in turf management decisions. During the spring/summer of 2000 swine and dairy compost was applied at three rates on both constructed greens planted with Putter creeping bentgrass (*Agrostis palustris*) and tee boxes planted with a perennial ryegrass (*Lolium perenne*) at Colbert Hills Golf Course (Manhattan, KS) on a monthly basis. Soil samples were collected 15 days after each application. Soil quality indicators monitored included physical, chemical and biological soil properties such as: bulk density, porosity, cation exchange capacity, base saturation, pH, organic carbon content, microbial biomass and mineralizable nitrogen and carbon. Indicator values were used to develop a composite soil quality rating.

Even over a short period of time, the application of swine and diary compost influenced a few chemical properties. Cation exchange capacity on the high-sand green more than doubled under both applications of swine and dairy compost. Electrical conductivity increased under all treatments in the high-sand green and in all treatments except the swine 1x treatment in the tee box soils. The influence of the compost on other chemical properties as well as physical and biological properties was difficult to assess

due to limits imposed on the experimental design and other management practices such as fertilizer and pesticide applications.

The use of a multiple indexing system proved useful in the evaluation of multiple soil quality indicators. Spider/radar graphs are an important tool to assist golf course superintendents to not only evaluate soil quality, but also to evaluate the status of other environmental ecosystems. Further research on the establishment of control limits and the usefulness of soil properties to monitor soil quality will help to strengthen the use of spider/radar graphs as an index to measure multiple indicators of environmental quality.

3.2 OBJECTIVE

The objectives of this study were to:

1. Monitor the impact dairy and swine compost amendments would have on high-sand golf greens and tee boxes

And

2. Assess the status of multiple soil quality indicators by producing a soil quality index using spider/radar graphs.

3.3 MATERIALS AND METHODS

3.3.1 Site Description

The experimental site was located at Colbert Hills Golf Course in Manhattan, Kansas. One golf green and three tee boxes located on the par 3 - research course were used for the study. The putting green, located on the second hole (see Figure 3.1), was planted with Putter creeping bentgrass (*Agrostis palustris*). The first two tee boxes were located on the third hole (see Figure 3.2, 3.3) and were planted with a perennial ryegrass (*Lolium perenne*). The 3rd tee box was located on the fourth hole (see Figure 3.4), and was also planted with a perennial ryegrass. The green soil was a 100% sand mixture with 70 to 80% of the particles ranging between 0.25 to 1.00 mm in size. All three tee box soils were textured as a loam/silt loam. The construction of the golf course required the removal of the native prairie grass and the original A-horizon, and in some areas into the subsoil. Sand and topsoil were imported from areas around Kansas and were prepared following USGA regulations for green and tee box construction.

The green area was divided to accommodate five treatments of animal waste compost. The five treatments were: swine 1x, swine 2x, dairy 1x, dairy 2x, and untreated ($x = 24$ kg 100 m^{-2}). The same five treatments were distributed on the three tee box areas. Compost was applied using a drop applicator during the 2nd week of each month from May to October 2000. Figures 3.5 and 3.6 outline the treatment areas for the green and tee boxes respectively. The dairy and swine amendments were provided by Bion Technologies in Clayton, North Carolina. Chemical analyses of both amendments were performed by Bion Technologies and the Kansas State Soil Testing Lab and are listed in Table 3.1. The differences in values reported between the two testing facilities may be from the methods used, sample preparation, or materials tested. The methods or exact conditions in which the materials were tested were not obtained from the supplier.

Figure 3.1. The green located on the 2nd hole of the research course at Colbert Hills.

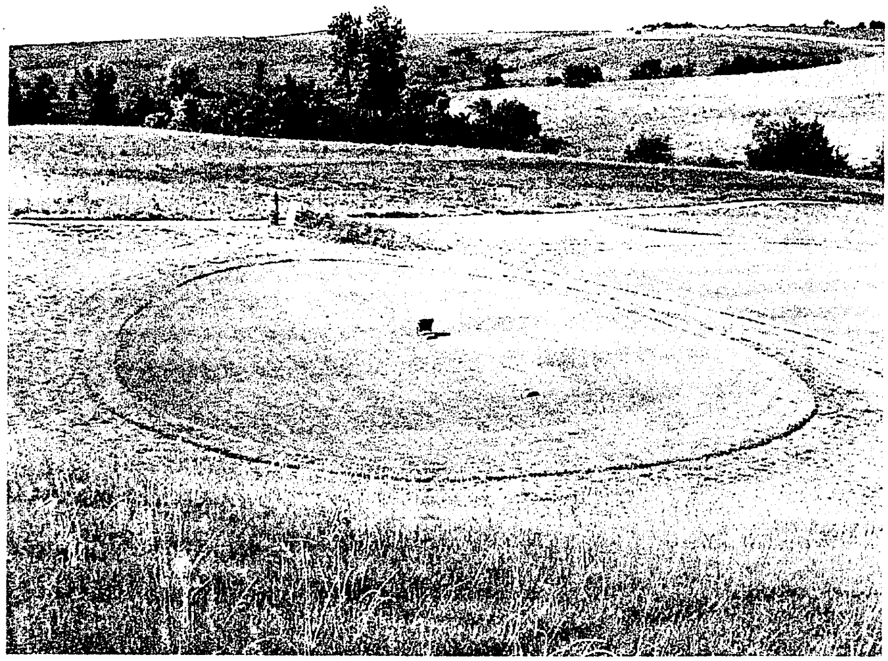


Figure 3.2. The first tee box located on the 3rd hole of the research course at Colbert Hills.

Figure 3.3. The second tee box located on the 3rd hole on the research course at Colbert Hills.

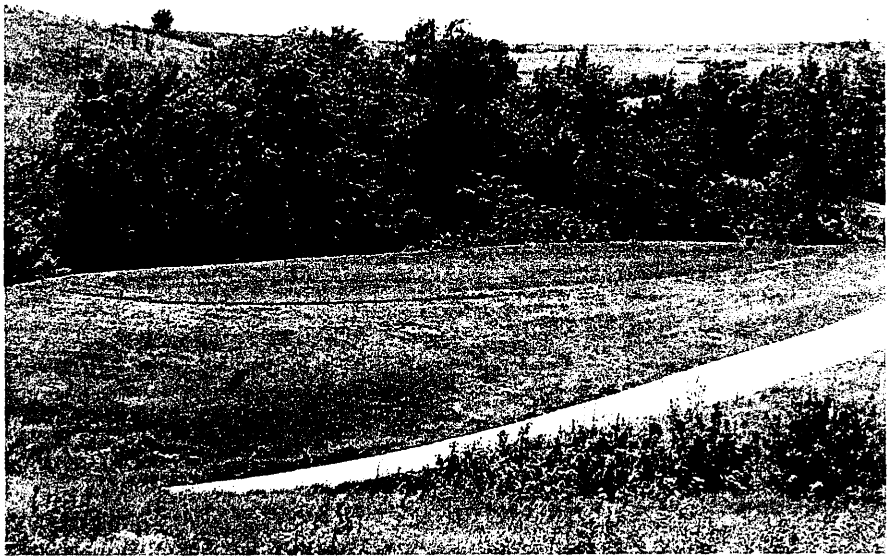
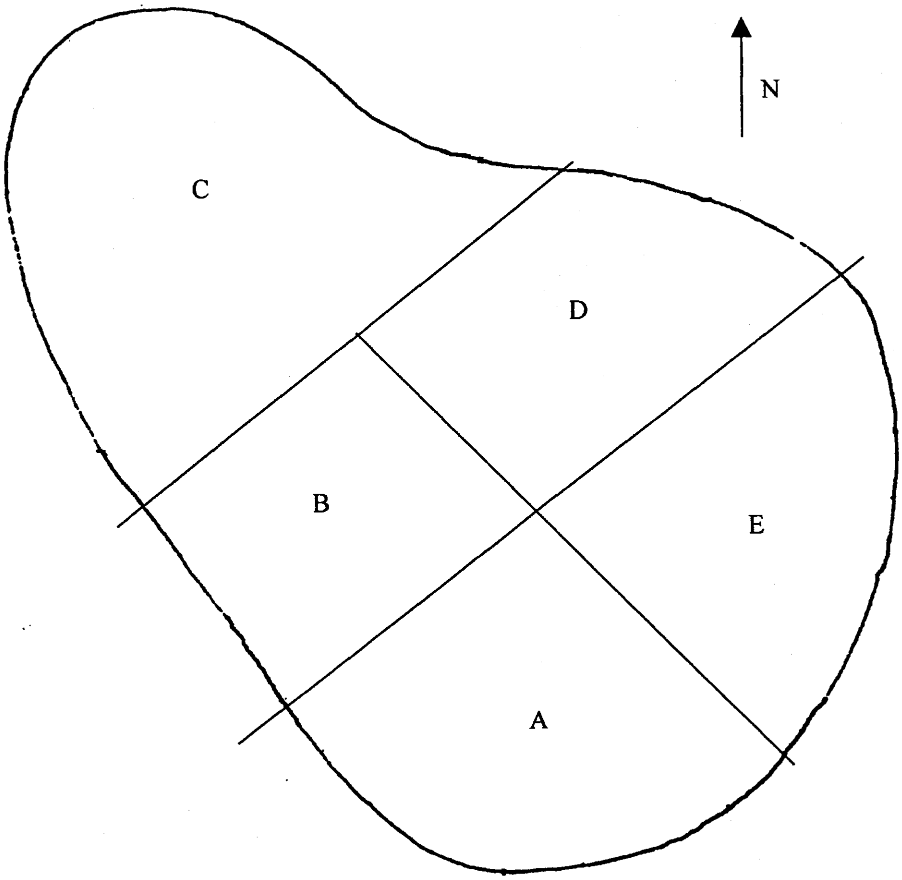


Figure 3.4. Tee box on the 4th hole on the research course at Colbert Hills.

Colbert Hills Golf Course
Par 3 – Research Course
Research Hole – 2nd Green



Section A
Treatment: Untreated
Area: 140 m^2

Section B
Treatment: Swine 2x
Area: 80 m^2

Section C
Treatment: Swine 1x
Area: 160 m^2

Section D
Treatment: Dairy 2x
Area: 120 m^2

Section E
Treatment: Dairy 1x
Area: 93 m^2

Figure 3.5. Diagram of 2nd Green on the research course at Colbert Hills. Diagram is not to scale

Colbert Hills Golf Course
Par 3 – Research Course
Research Holes – Tee Boxes #3 and #4

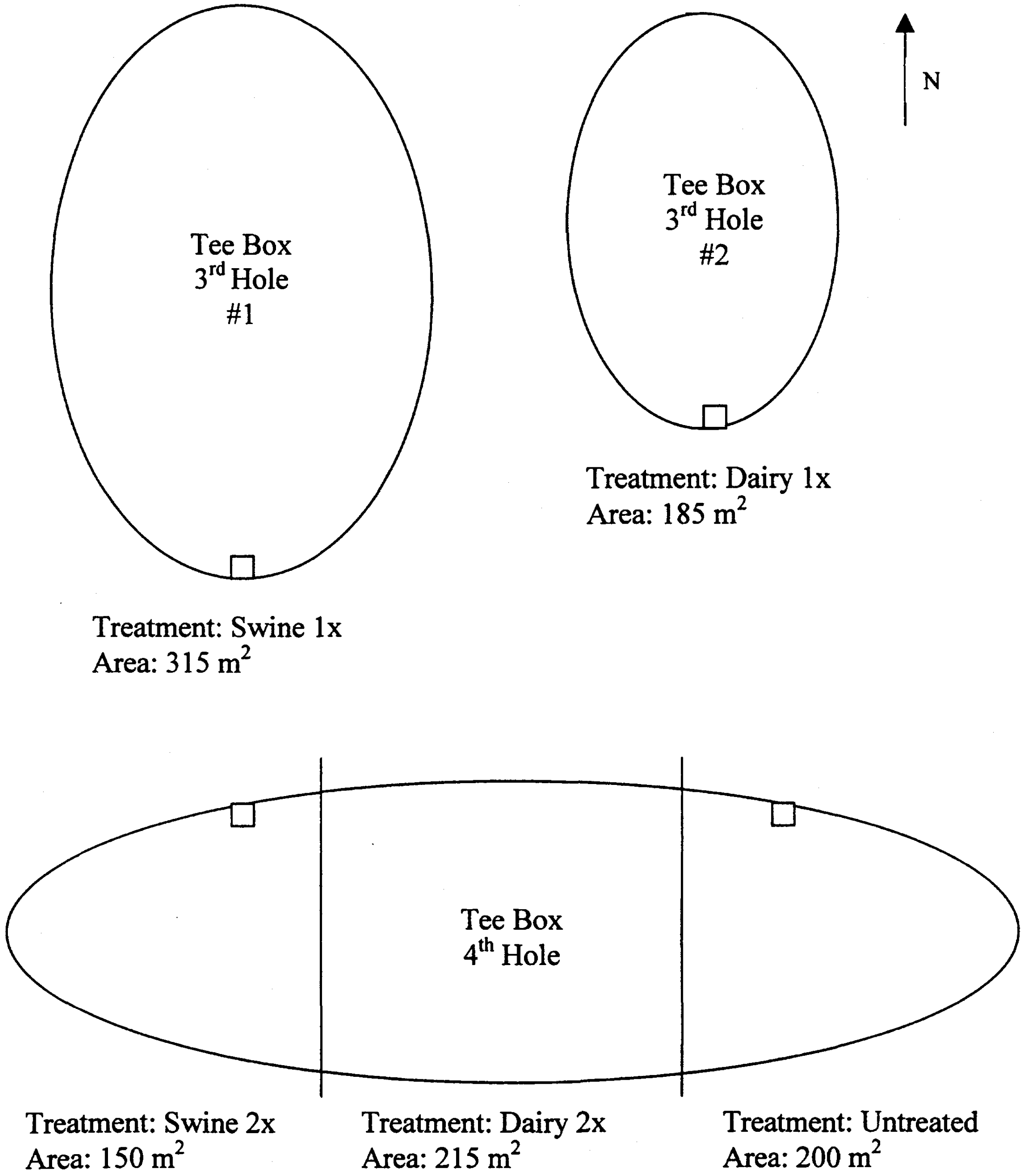


Figure 3.6. Diagrams of Tee Box soils on the 3rd and 4th hole of the research course at Colbert Hills. Diagram is not to scale

3.3.2 Soil Sampling and Analysis

Soil cores were collected monthly, approximately fifteen days after compost application. Three sets of 5 to 7 (15-21 total) 5-cm x 5-cm cores were removed from random locations in each treated area using an AMS slide hammer sampler. The thatch was removed and each core was divided into an upper and lower 2.5-cm sub sample cores. An additional three cores were removed for bulk density analysis. The sampling holes were filled with USGA standardized sand and covered with the thatch removed from the samples. Each of the three sets of soil cores were then split again into two sub-sets. One subset was dried and ground for chemical analysis and the other subset was sieved using a 4.75 mm sieve and kept in 5° C cold storage for microbial analysis. Microbial analysis was performed within 10 days of sample collection. The soil analyses performed and methods used for each soil quality indicator are referenced in Table 3.2.

Table 3.1. Chemical analysis of swine and dairy compost

	Bion Technologies		K-State Soil Testing Lab	
Analysis	Swine	Dairy	Swine	Dairy
Dry Matter (%)	68.12	39.42		
Total Carbon (g C kg^{-1})			227	236
Total Nitrogen (g N kg^{-1})	29.6	9.9	28.6	21.4
Phosphorus ($\mu g\ g^{-1}$)	16500	4900		
Phosphate ($\mu g\ g^{-1}$)	37800	11200		
Potassium ($\mu g\ g^{-1}$)	1000	200	1591	681
Potash ($\mu g\ g^{-1}$)	1200	200		
Calcium ($\mu g\ g^{-1}$)	38600	13300	2235	7780
Magnesium ($\mu g\ g^{-1}$)	6700	700	2534	1366
Sodium ($\mu g\ g^{-1}$)			344	328
Sulfur ($\mu g\ g^{-1}$)	5900	2700		
Electrical Conductivity. (ds m^{-1})			10.9	9.9
Cation Exchange Capacity (cmol kg^{-1})			55	61.1
Fe ($\mu g\ g^{-1}$)	4369	795		
Mn ($\mu g\ g^{-1}$)	521	171		
Zn ($\mu g\ g^{-1}$)	1542	285		
Cu ($\mu g\ g^{-1}$)	330	388		
B ($\mu g\ g^{-1}$)	27	11		
pH	6.8	5.2	6.4	4.7

Table 3.2. Physical, Chemical, and Biological soil quality indicators measured and the referred method.

Property	Method	Reference	Notes
Physical properties			
Soil Texture	Pipette method	Kilmer & Alexander (1949); Soil Survey Laboratory Staff (1996)	
Bulk density	Core method	Blake & Hartge (1986)	
Porosity	Core method	Danielson & Sutherland (1986)	Calculated from bulk density and assumed particle density of 2.65 g cm^{-3}
Soil temperature	Field Method	Taylor & Jackson (1986)	Temperature recorded at surface, 2.5 cm and 7.6 cm depths
Biological properties			
Microbial Biomass C & N	Chloroform Fumigation Incubation Method	Jenkinson & Powlson (1976); Rice et al. (1996) Anderson & Domsch (1978); Horwath & Paul (1994);	Field moisture content used, Soil inoculated with 5 g of same soil after fumigation
Mineralizable C & N		Jenkinson & Powlson (1976); Anderson & Domsch (1978);Horwath & Paul (1994);	Field moisture content used, control not fumigated in MBC used to determine mineralizable C & N
Soil Respiration	Closed Bottle	Alef (1995); Parkin et al. (1996)	48 hour incubation, CO_2 measured 3-6 times, moisture content brought to field capacity
Chemical properties			
Total C & N content	Dry Combustion	Nelson & Sommers (1996); Leco Corp (1995)	CNS-2000, Leco Corp., Furnace temperature at 1350^0 C
Electrical Conductivity	Saturated Paste Method	Whitney (1998); Rhoades (1996)	
Cation Exchange Capacity	Ammonium Ion Replacement	Chapman (1965)	Ammonia extract representing CEC of the sample was analyzed by colormetric procedure on the Rapid Flow Analyzer (RFA-300)
pH	1:1 Water Method	Thomas (1996); Watson & Brown (1998)	
	2:1 $CaCl_2$ Method	Thomas (1996); Watson & Brown (1998)	
Mg, K, Ca	Ammonium Acetate Method	Warncke & Brown (1998)	A low sodium filter paper was used and analysis of
Exchangeable Na	Ammonium Acetate Method	Warncke & Brown (1998)	extracts diluted 1:8 was done by ICP