Comparison of Animal Disposal Sites and Livestock Populations in Minnesota Counties

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Abstract

Determining the animal disposal site capacity of a county is extremely important, especially in the event of a catastrophic emergency. Emergency events can include natural disasters, disease outbreaks, or human induced disasters. This analysis investigates the ability to dispose of large animal carcasses such as cattle, hogs, or sheep by burial in Minnesota counties and compares the respective county livestock populations. An interpretation of county soil surveys was utilized to delineate potential animal disposal sites coupled with the livestock population data by county. GIS was used to control, manipulate, and interpret a significant amount of data for a statewide analysis. This analysis develops a framework for the mitigation, planning, and the siting of animal disposal sites in the event of catastrophic mortality of livestock in Minnesota counties.

Introduction

This analysis was developed to create a framework and a better understanding of livestock populations for mitigation, in the event of an emergency involving catastrophic livestock mortalities. The United States Department of Agriculture (USDA) Farm Service Agency (FSA) is charged with administering multiple emergency management programs that involve livestock and coordinate efforts with other federal and state agencies. Identifying and understanding livestock populations in an emergency situation is extremely valuable on a local and statewide basis.

Animal carcasses can be disposed of in multiple ways. Determining the type of disposal is based on multiple factors, such as cost, environmental concerns, and even public perception (National Agricultural Biosecurity Center (NABCC), 2004). During emergency events, large numbers of animal carcasses may need to be disposed. In the 2001 Foot and Month Disease (FMD) outbreak in the United Kingdom (UK), over 6 million animals needed to be disposed (Scudamore et al., 2002). A major technique of disposing animal carcasses was to bury the carcasses. This was cost effective and could be accomplished in a timely manner, which also helped reduce the spread of disease.

Burying carcasses in animal disposal sites has caused major public concern over public health issues. Water contamination and even dioxin emissions have been identified as health concerns in the UK since the 2001 outbreak of FMD (Scudamore et al., 2002). Burial sites in the UK during the

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2001 outbreak were considered poorly designed and/or constructed. In a subsequent analysis, a USDA Natural Resources Conservation Service (NRCS) standard to mitigate public health and environmental concerns was developed based on the interpretation of soil properties.

Methods

Delineating Animal Disposal Sites

Delineating animal disposal sites can utilize multiple spatial features such as depth to water, soil characteristics, and proximity to structures. These factors can help address public health issues and environmental concerns. This research utilized the Soil Survey Geographic (SSURGO II) layer by county. SSURGO II is a digitized format of the Natural Resources Conservation Service's soil survey. SSURGO II includes both spatial and tabular data. In order to utilize the SSURGO II layer, the Soil Data Viewer 5.1 was employed to interpret both spatial and tabular information.

Soil Data Viewer 5.1 is a simple tool that can be used with or without ArcMap and was developed by NRCS. Soil Data Viewer is a standalone application or an extension used in conjunction with ArcMap 9.x; in this case ArcGIS 9.1 was utilized with the Soil Data Viewer 5.1 extension. The Soil Data Viewer has standardized interpretations to view the complex SSURGO II shapefiles and tabular data that are associated with the respective soil survey. Due to the nature of the analysis in an emergency situation, the Soil Data Viewer defaults for "Catastrophic Mortality, Large Animal Disposal, Pit" parameters were used. This interpretation was based on a NRCS standard (K. Steffen, personal communication, 2007), which yielded no, "Not Limited" soils in Minnesota due to the interaction with the soil type and proximity to the water table.

The Soil Data Viewer utilizes 3 ratings: 1) Not Limited, 2) Somewhat Limited, and 3) Very Limited. The Soil Data Viewer also categorized a forth component of Not Ranked, which was open water according to the soil survey. The ratings are defined by the NRCS rating index. The Not Limited rating has a rating index of 0, the Somewhat Limited rating was greater than 0 and less than 1.0, and the Very Limited rating was 1.0. The Somewhat Limited rating was very extensive within the rating index. Table 1 provides an example from Kittson County in northwest Minnesota. The example identifies the soil features in the SSURGO II tabular data and the rating based the NRCS standard.

Table 1. A sample of the parameters used to define the rating of soils used by the Soils Data Viewer interpretation.

Map symbol and soil name	DHS - Catastrophic Mortality, Large Animal Disposal, Pit
50: Cashel, occasionally flooded--------	1.000 Very limited 1.000 Flooding 1.000 Wetness 1.000 (0.395-1.000) Too clayey (Clay content to Too clayey) 1.000 Aquic, Peraquic, Perudic, or Null 0.510 (0.010-1.000) Cutbanks cave 0.500 (0.000-0.998) Shrink-swell (Shrink-swell to Shrink-swell too high) 0.000 Loess or not silty 0.000 Not coarse material 0.000 Fragments not limiting 0.000 Not sandy 0.167 Water gathering 0.000 No permafrost depth limitation 0.000 No ponding limitation 0.000 No slope limitation 0.000 No bedrock depth limitation 0.000 No sodium limitation 1.000 Not aridic environment 0.000 No salinity limitation 0.000 Not too acid 0.000 No cemented pan depth limitation 0.000 No seepage 1.000 Not aridic environment 0.000 Not porous bedrock 0.000 Not sandy 0.000 No organic matter limitation 0.000 No large stone limitation 0.000 No surface stone limitation 0.000 No rock outcrop 0.000 Adsorption

The soils data for Minnesota were extremely large in size. There were approximately 15 Gigabytes of data for all of the SSURGO II layers and tabular data. This was a concern when manipulating and storing the data. Some county shapefiles were in the upwards of 100 – 150 MB, which was also a concern with respect to processing resources and time.

The Soil Data Viewer only created temporary files; a process to export and manipulate the data in an ArcMap session was developed using scripts. Python 2.1 scripts were utilized to increase efficiency in geoprocessing time. Scripting also increased consistency, data integrity, and reduced human error while processing the SSURGO II shapefiles.

To reduce the amount of memory required, hard disk space was conserved by deleting temporary and intermediate data; virtual memory was conserved while scripts were processing by eliminating virtual feature layers.

Not all counties in Minnesota had SSURGO II layers available when this analysis was conducted. Figure 1 identifies the counties in Minnesota that were completed before this analysis was conducted.

Of the 87 Minnesota counties, only 78 had the entire county digitized. Saint Louis County in northeast Minnesota had 3 of the 5 soil surveys completed. Due to the incomplete digitization, Saint Louis County was excluded from the analysis. The remaining counties; Cook, Crow Wing, Fillmore, Isanti, Koochiching, Lake, Pine, and Wabasha, were also excluded because the counties did not have a certified SSURGO II layer or did not have a completed soil survey.

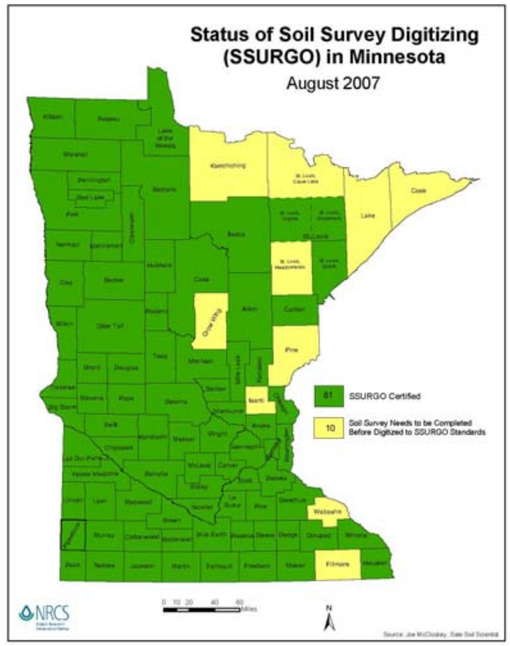

Figure 1. Map of SSURGO II certified counties in Minnesota before the analysis was conducted. This was developed and published by Minnesota NRCS and was obtained from the Minnesota NRCS website.

Calculating Volume Capacity

In order to calculate the capacity of a county to potentially bury animal carcasses, some assumptions were made. The NRCS standard interpretation definition was utilized, and the Somewhat Limited soils were used as acceptable land for an animal disposal site. Once the Somewhat Limited soils were interpreted and delineated, the area for capacity was established by converting the square meters into acres and then square yards. All SSURGO II layers were in their native projection, Universal Transverse Mercator or UTM Zone 14 or 15. Figure 2 identifies the UTM zones for the counties in Minnesota.

Defining the capacity volume was based on an assumption, which was consistent with the NABCC examples of approximately 9 feet or 3 yards.

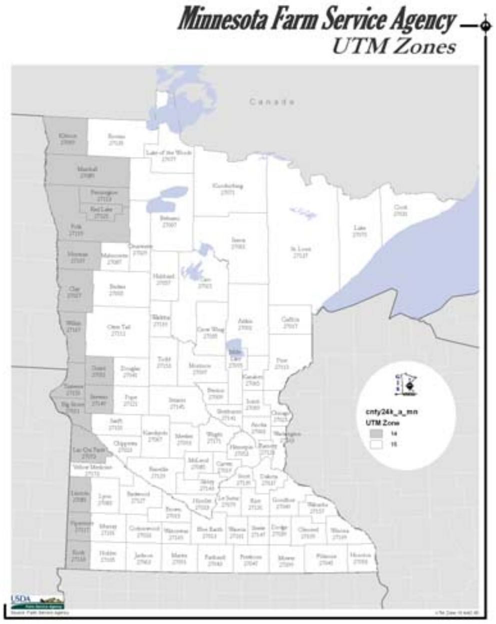

Figure 2. Map of the UTM Zones in Minnesota. The 16 western counties are in UTM Zone 14 and the vast majority of Minnesota is in UTM Zone 15.

This depth goes beyond the observation of the soil surveys, however, was generally accepted according to the Soil Data Viewer report of the interpretation. The 3 yard depth was assumed over the entire extent of the Somewhat Limited soils area for ease of calculation. The depth assumption disregards the size of the area, no matter how small the extent. No contiguous soils were merged together or dissolved during the analysis. Each soil polygon and soil type remained singlepart polygons. The volume capacity was calculated using the following equation, derived from the NABCC examples.

ac = county summarized acres of Somewhat Limited soils

4,840 was used as the conversion factor for acres to square yards

x = county capacity volume in cubic yards

3 yards depth was assumed for the entire pit

x = ac * 4,840 * 3yd

Utilizing Livestock Tabular Data

USDA National Agricultural Statistics Service (NASS) collects agricultural data directly from producers about agricultural prices and yields. Livestock head count data was available for most counties in Minnesota. In order to effectively utilize NASS data, it was broken down into a common unit, animal units. According to the Minnesota Department of Agriculture (MDA), animal units are approximately 1,000 lbs of a particular production type or species. Essentially, animal units are a factor of the number of head of a particular species. In effect, it takes more head of turkeys to equate the same animal unit of a horse.

The NASS data was obtained from the Quick Stats website for the years 2006 to 2007. The data utilized only provided limited numbers and species within Minnesota counties. This analysis examined three general categories of livestock: cattle, hogs, and sheep.

Calculating animal units was straight forward; each species factor was obtained from the MDA website, Animal Unit Calculation Worksheet. Cattle were calculated by the number of head in each county multiplied by a factor of 1.0. Hogs were multiplied by a factor of 0.35 and sheep were multiplied by a factor of 0.1. Finally, all three species were added together in the common animal unit to obtain the total.

Calculating Livestock Volume

The three categories utilized in this analysis were made up of multiple classifications. The cattle category included cattle and calves combination, cattle on feed, and milk cows and production. The hog category included hogs and pigs and hogs-farrowings. The sheep category consisted of the sheep inventory. This terminology was used by NASS to classify and categorize livestock populations. Each of the grouped classification for cattle and hogs were combined equally to develop a simplistic calculation for populations within each of the three categories. Poultry, although a significant factor in Minnesota agriculture, was not used in this analysis because the data was not readily available for poultry by county.

According to NABCC estimates of the volume required to dispose of a single mature cattle carcass requires between 1.2 and 3.5 cubic yards. In this analysis an assumed average of 2.91667 cubic yards was used to calculate the volume for each animal unit. This assumption was derived from the animal unit factor of 1 head of cattle was equal to 1 animal unit.

Results

Soil Capacity

Minnesota yielded 5,192,398 acres of Somewhat Limited soils. Table 2 identifies the amount of acres of the Somewhat Limited soil rating by county. Of the analyzed counties, counties with a capacity greater than zero were listed.

Figure 3 presents an overview of Somewhat Limited soils point density in Minnesota by acre.

Table 2. Somewhat Limited Soils by county in acres. Counties with a capacity of zero and excluded counties are not listed.

County Name	Somewhat Limited Soils	County Name	Somewhat Limited Soils
Aitkin	65,782	Meeker	32,804
Anoka	9,182	Mille Lacs	148
Becker	165,673	Morrison	27,990
Beltrami	144,933	Mower	34,835
Benton	77	Murray	29,309
Big Stone	58,769	Nicollet	13,500
Blue Earth	15,772	Nobles	12,216
Brown	8,667	Norman	24,997
Carlton	138,251	Olmsted	137,681
Carver	25,472	Otter Tail	367,667
Cass	232,794	Pipestone	15,698
Chippewa	83,270	Polk	117,804
Chisago	61,272	Pope	147,365
Clay	96,528	Ramsey	8,768
Clearwater	126,956	Redwood	14,394
Cottonwood	111,350	Renville	14,064
Dakota	59,673	Rice	64,448
Dodge	7,608	Rock	57,837
Douglas	159,108	Scott	30,850
Faribault	19,974	Sherburne	2,424
Freeborn	39,857	Sibley	10,183
Goodhue	139,815	Stearns	189,913
Grant	95,572	Steele	16,568
Hennepin	37,178	Stevens	80,457
Houston	109,522	Swift	55,984
Hubbard	92,163	Todd	148,366
Itasca	276,180	Traverse	20,296
Jackson	18,583	Wadena	6,513
Kandiyohi	90,978	Waseca	16,039
Lac Qui Parle	138,090	Washington	50,515
Le Sueur	31,906	Watonwan	2,849
Lincoln	35,653	Wilkin	19,884
Lyon	175,100	Winona	150,667
McLeod	22,018	Wright	57,142
Mahnomen	135,166	Yellow Medicine	155,683
Martin	27,652		

Figure 3 identifies the general location at a small scale of the Somewhat Limited soils throughout the state. Figure 4 identifies the Somewhat Limited soil density within each county and normalized by county area. The entire state combined yields of 75,393,618,960 cubic yards of volume capacity within the Somewhat Limited soils rating.

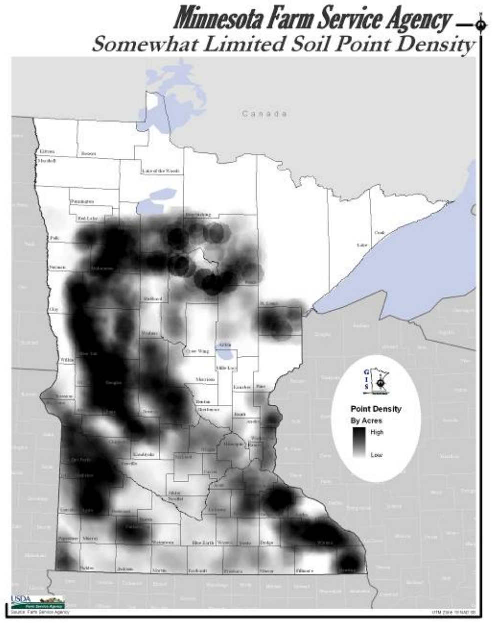

Figure 3. Somewhat Limited Soil Point Density by Acres. The darker shading indicates a higher density of Somewhat Limited soils by acre.

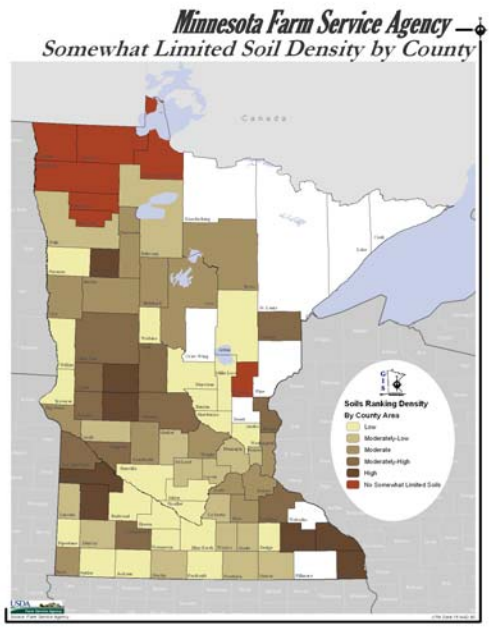

Figure 4. Somewhat Limited Soil Density by County area. The darker shades of brown indicate a higher density of Somewhat Limited soils normalized by the county area in acres. White counties have no data. The red counties indicate counties with no Somewhat Limited soils.

The following seven counties yielded no capacity at all: Kittson, Lake of the Woods, Marshall, Pennington, Red Lake, Roseau, and Kanabec Counties. The aforementioned counties have no capacity to bury any livestock mortalities utilizing the Somewhat Limited soils rating.

Livestock Volume

The populations are extremely dramatic between species. Cattle, Figure 5, had the largest number of animal units and are dispersed throughout the state in 83 counties. Hogs, Figure 6, are second when it comes to the number of animal units in 53 counties; however, hogs had a significantly higher concentration in the southern part of the state along the Iowa border. Sheep, Figure 7, have a small number of animal units and are dispersed unevenly across the state in 66 counties. Figure 8, identifies the sum of all three categories of animal units.

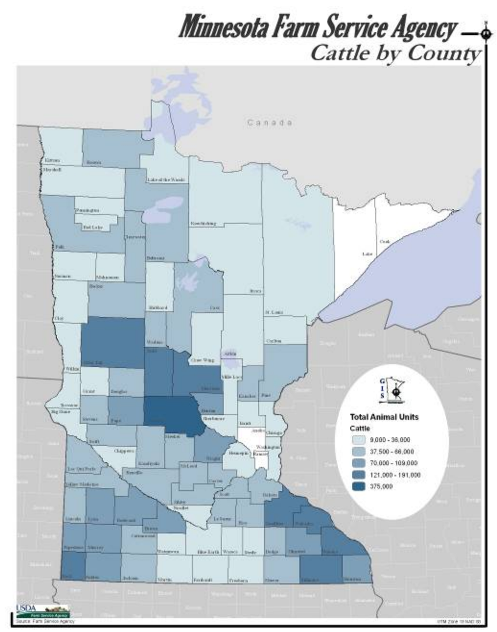

Figure 5. Cattle by County indicates the total number of cattle animal units by county. The darker the shade of blue the higher the cattle population is in animal units.

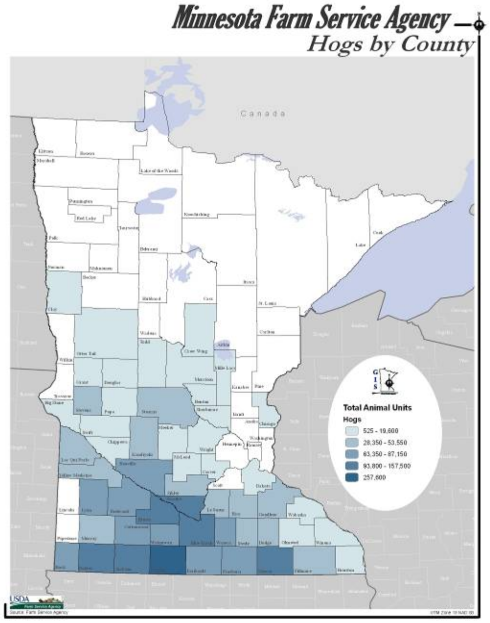

Figure 6. Hogs by County indicates the total number of hog animal units by county. The darker the shade of blue the higher the hog population is in animal units.

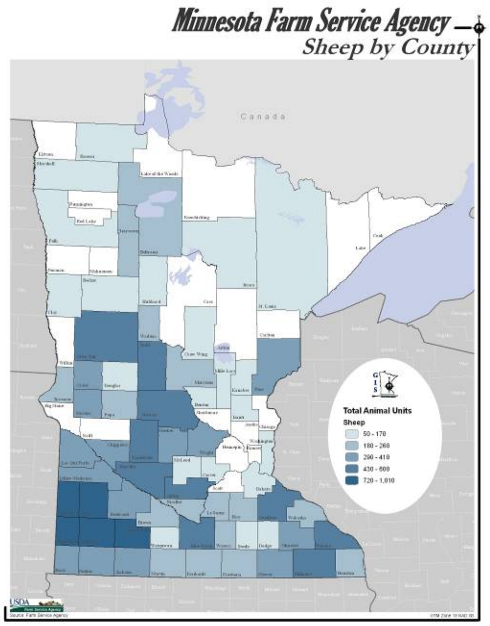

Figure 7. Sheep by County indicates the total number of sheep animal units by county. The darker the shade of blue the higher the sheep population is in animal units.

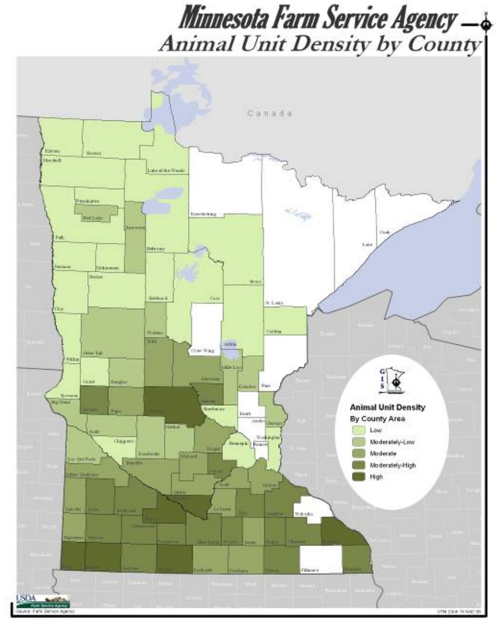

Figure 8. Animal Unit Density by County indicates the total number of all livestock species analyzed of the total animal units by county. The darker the shade of green the higher the livestock population is in animal units. White counties are indicated based on the SSURGO II excluded counties.

The entire state yielded 4,763,300 head of cattle and the same number of animal units. The state total for hogs yielded 6,482,800 head and 2,268,980 animal units. Sheep yielded 204,500 head and 20,450 animal units. The state total of animal units, of the three categories, yielded 7,052,730 animal units. Multiplying the total animal units and the 2.91667 cubic yards factor yielded 20,570,486 cubic yards for the state's livestock volume.

Table 3 identifies the number of animal units by county. Figure 9 identifies the remaining county capacity within the Somewhat Limited soils. Figure 9 identifies the seven counties that have a shortage or no remaining capacity and the excess capacity between the county total capacity and the livestock volume.

Table 3. Livestock by County in Animal Units. All Minnesota counties are listed.

County Name	**Animal Unit**	**County Name**	**Animal Unit**
Aitkin	23,000	Marshall	32,140
Anoka	0	Martin	292,820
Becker	61,110	Meeker	62,910
Beltrami	57,230	Mille Lacs	36,195
Benton	77,510	Morrison	177,055
Big Stone	31,400	Mower	146,800
Blue Earth	184,430	Murray	123,080
Brown	182,450	Nicollet	150,310
Carlton	21,500	Nobles	208,400
Carver	68,295	Norman	18,000
Cass	54,500	Olmsted	120,950
Chippewa	27,790	Otter Tail	200,000
Chisago	25,015	Pennington	19,000
Clay	40,575	Pine	62,810
Clearwater	52,730	Pipestone	73,460
Cook	0	Polk	43,320
Cottonwood	122,070	Pope	98,300
Crow Wing	27,265	Ramsey	0
Dakota	62,200	Red Lake	22,500
Dodge	90,130	Redwood	153,260
Douglas	59,835	Renville	125,800
Faribault	99,980	Rice	94,440
Fillmore	191,550	Rock	199,410
Freeborn	116,870	Roseau	49,610
Goodhue	169,710	Saint Louis	25,110
Grant	15,630	Scott	39,000
Hennepin	14,800	Sherburne	20,460
Houston	117,260	Sibley	90,200
Hubbard	18,640	Stearns	414,330
Isanti	17,630	Steele	70,260
Itasca	18,050	Stevens	115,910
Jackson	132,690	Swift	47,350
Kanabec	43,140	Todd	135,975
Kandiyohi	85,690	Traverse	13,200
Kittson	28,500	Wabasha	133,180
Koochiching	11,000	Wadena	40,730
Lac Qui Parle	66,260	Waseca	96,240
Lake	0	Washington	14,640
Lake of the Woods	9,000	Watonwan	102,840
Le Sueur	66,110	Wilkin	9,000
Lincoln	58,510	Winona	179,720
Lyon	164,570	Wright	84,870
Mcleod	70,350	Yellow Medicine	104,370

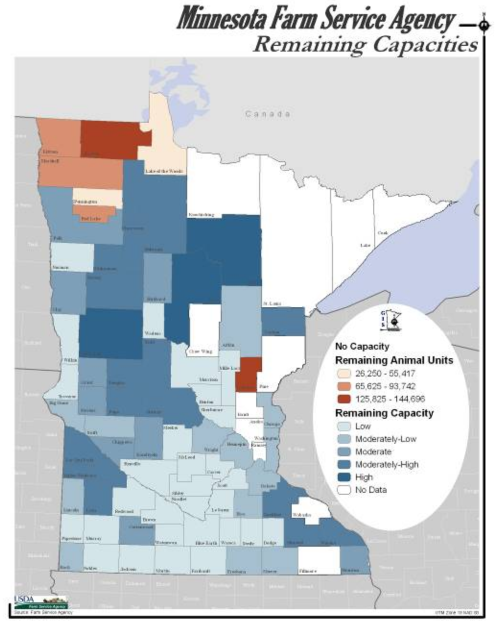

Figure 9. Remaining Capacity by County. The blue shades indicate an excess capacity, in which, to bury livestock animals. The darker the blue indicates a larger capacity. The red shades indicate a shortage of capacity, the darker the red the larger the capacity shortage.

Discussion

The overall analysis was a simplistic comparison of a county's animal disposal site capacity based on the Somewhat Limited rating and three categories of livestock populations.

The data indicated a significant lack of capacity in two large areas of Minnesota. The northwest part of the state was the most extensive area that lacks the ability, in which, to bury its own livestock population. The five county area, Kittson, Marshall, Pennington, Red Lake, and Roseau counties have no soils that are Somewhat Limited. Another area was in the central-eastern part of the state around Benton, Kanabec, and Mille Lacs Counties. These three counties have an extremely low capacity to bury livestock.

The data seemed to indicate that Minnesota, as a whole, does have a significant capacity to bury a large volume of livestock with exception of the aforementioned counties. However, the data was based on the NRCS standard interpretation. Minnesota will need to recalibrate the formula based on the NRCS standard rating index that is more consistent for the local soils to identify the best overall soils in each county and across the state. Recalibration will have to evaluate the rating index in a more in-depth process. Doing so would potentially reduce the amount of capacity in each county; however, revisions would have a more reflective representation of the soils in the environment.

This analysis was based on a limiting single layer. The SSURGO II data is extensive, however, does not take into account the proximity to minor civil divisions, roads, emergency shelters, lakes, or streams. Further analysis will need to be conducted to enrich the framework that has been established. The use of a single layer does allow for national consistency, such as, across state lines. The SSURGO II layers are designed to be similar in structure and data. Utilizing a consistent layer across the country increases the efficiency of the analysis on a statewide basis.

Conclusions

The concepts utilized in this analysis integrate soils as the key component in analytically identifying, on a statewide basis, physically and environmentally sound land that can potentially support an animal disposal site. FSA, along with other federal and state agencies, have the ability to utilize a significant amount of data in a short period of time.

This analysis has developed the necessary SSURGO II interpretation data and scripts, which can be utilized to increase efficiency and consistency for future interpretations of a Minnesota standard. In conjunction with a Minnesota soils interpretation, more in-depth livestock data, such as, feedlot data, and the utilization of other geographic data; a strong analysis can be derived to appropriately define animal disposal sites in the event of an emergency.

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