



Forest Road Geographic Information System (GIS) Data Collection Process and Summary of Road Data

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Introduction

This report has two purposes; the first is to describe the process used by Minnesota Forest Resources Council (MFRC) staff to merge forest road geographic information system (GIS) data received from forest land managers. This process was initiated by the MFRC Northeast Regional Landscape Committee and extended by the North Central Regional Landscape Committee. It involved the participation of numerous forest management groups.

The second purpose is to provide a brief summary of the forest road GIS data collected. It compares the densities of five different road classes (Interstate / Trunk Highways, County Highways, Township Roads, All Season Forest Roads, and Seasonal Forest Roads) for the counties where forest road data was collected.

Forest Road Data Collection and Merging Processes

In April 2000, the MFRC Northeast Landscape Coordination Working Group developed a initial plan to coordinate road projects (http://www.iic.state.mn.us/finfo/roads/forest_rds_proposal.htm). In order to coordinate forest road projects this plan called for forest management entities to share their forest road GIS data. By June 2001 data had been merged together from the following entities: Department of Natural Resources - Division of Forestry (DNR-Forestry), Lake County Land Department, Potlatch, St.Louis County Land Department, Superior National Forest, and UPM-Blandin.

In February 2001, the MFRC North Central Regional Landscape Committee began the process of collecting forest road GIS data (http://www.iic.state.mn.us/finfo/roads/draft_project_plan.doc). The data was collected and merged with the Northeast data in November 2001. Additional data was collected from: Becker County Land Department, Beltrami County Land Department, Cass County Land Department, Chippewa National Forest, Crow Wing County Land Department, and Hubbard County Land Department. After the data was collected and merged, it was distributed back to the entities providing data. Table 1 lists who provided data for each county.

Table 1. Listing of entities providing data for each county.

Counties	Groups Providing Data			
	<i>County Land Department</i>	<i>Department of Natural Resources</i>	<i>Private Industrial (UPM-Blandin and/or Potlatch)</i>	<i>US Forest Service</i>
Aitkin		X	X	
Becker	X	X	X	X
Beltrami	X	X	X	
Carlton		X	X	
Cass	X	X	X	X
Clearwater		X	X	
Cook		X		X
Crow Wing	X	X	X	
Fillmore		X		
Goodhue		X		
Houston		X		
Hubbard	X	X	X	X
Itasca		X	X	X
Kanabec		X	X	
Koochiching		X	X	X
Lake	X	X	X	X
Lake of the Woods		X		
Mahnomen		X		
Mille Lacs		X		
Morrison			X	
Olmsted		X		
Pennington			X	
Pine		X	X	
Polk			X	
Red Lake			X	
Roseau		X		
Sherburne		X		
St. Louis	X	X	X	X
Stearns		X		
Todd			X	
Wabasha		X		
Wadena		X	X	
Winona		X		

Several basic steps were taken to merge the data into one GIS coverage. First, the data from every entity had to be made compatible. The spatial data was converted to the same projection (UTM-Zone 15; Nad 83; units meters) while the tabular information in each data set was converted to similar attribute names and codes. Appendix A summarizes the standard tabular format used. It is important to note that each entity's data contained only

certain common attributes. It was extremely rare that an entity would have detailed attributes for their forest roads.

Data overlap was another major issue when merging the data. Several entities had forest road data for multiple ownerships that they had obtained through older GIS datasets. The major issue was that they had not coded the roads they managed versus the roads that were managed by other entities. The four exceptions to this problem were Chippewa National Forest, DNR-Forestry, Superior National Forest, and UPM-Blandin. These four GIS databases represented roads that only these agencies managed and did not contain miscellaneous data. In order to merge the data and reduce overlapping data, these four datasets were first combined. Then additional road data was merged if a road was not entirely within 200 feet of the original data combined.

It is important to note that this forest road data had not been thoroughly collected and cleaned. Because all forest road data has not been collected, it is very likely additional forest roads are not included in this data set. Also, since this data has not been thoroughly cleaned, it overestimates the roads it represents. This is evident in roads that clearly overlap other roads. There is also the over estimation of forest roads due to roads in the database that no longer exist (for example from vegetation regeneration over the unused road).

Figure 1 and Table 2 illustrate the extent of the forest road data collected. For most of the Northern counties more than 90 percent of their area has forest road data collected. A lot of the eastern, central, and southeast counties have less than 50 percent area with forest road data.

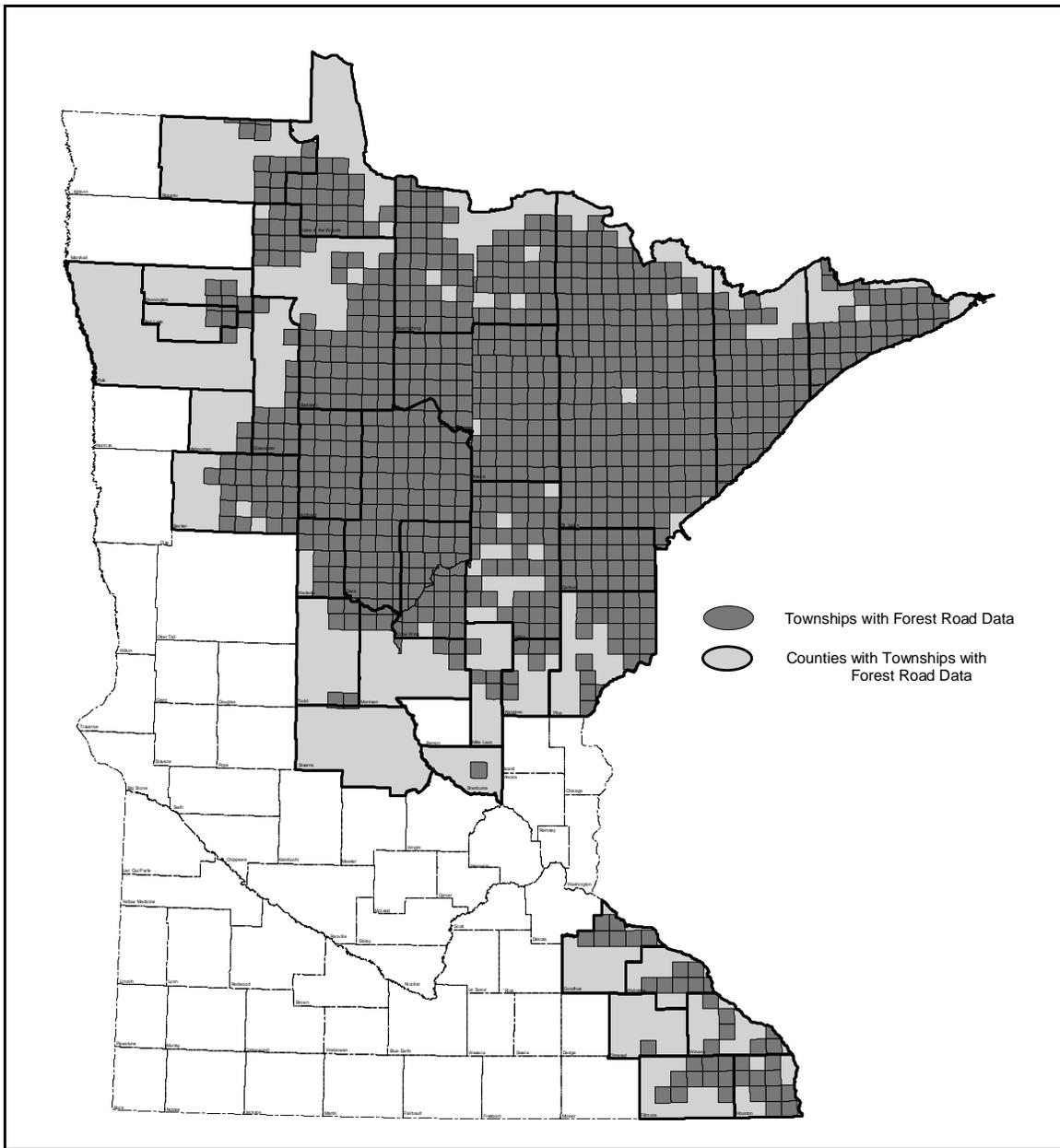


Figure 1. Map of townships and counties with forest road data.

Table 2. Percent of forest road data in counties based on townships with forest road data.

County	Total Area (Square Miles)	Number of Townships with Forest Road Data*	Total Area of Townships with Forest Road Data (Square Miles)	Percent Area of County with Forest Road Data
Aitkin	1,993	48	1,522	76.4%
Becker	1,445	24	865	59.8%
Beltrami	3,055	64	2,087	68.3%
Carlton	875	28	872	99.7%
Cass	2,413	82	2,413	100.0%
Clearwater	1,030	14	487	47.3%
Cook	1,605	44	1,188	74.0%
Crow Wing	1,156	46	1,119	96.8%
Fillmore	862	10	358	41.6%
Goodhue	780	7	246	31.5%
Houston	569	11	353	62.1%
Hubbard	999	30	999	100.0%
Itasca	2,926	96	2,905	99.3%
Kanabec	533	7	216	40.5%
Koochiching	3,152	71	2,413	76.6%
Lake	2,287	62	1,844	80.6%
Lake of the Woods	1,780	25	788	44.3%
Mahnomen	584	2	72	12.3%
Mille Lacs	681	5	133	19.6%
Morrison	1,153	14	237	20.5%
Olmsted	654	1	36	5.5%
Pennington	618	6	153	24.8%
Pine	1,433	24	809	56.4%
Polk	1,999	2	72	3.6%
Red Lake	433	4	96	22.2%
Roseau	1,678	16	422	25.2%
Sherburne	450	1	36	8.1%
St. Louis	6,738	182	6,189	91.9%
Stearns	1,389	2	12	0.9%
Todd	979	7	199	20.3%
Wabasha	549	7	232	42.3%
Wadena	543	13	435	80.2%
Winona	641	8	232	36.2%

*Includes when only part of a township falls within a county.

Road Summarization Methods

This section presents a summary of road density by county. This summary is based on the forest road GIS data collected and 1995 Minnesota Department of Transportation road GIS data. Only the townships with forest road data were analyzed (Figure 1).

Samples of townships were used to estimate the amount of overlap of roads. This is due to the forest road data overlapping with other forest, township, county, and interstate road data. A random sample was taken in a GIS of 27 townships. During the random selection spatial concerns were considered to distribute the samples across the townships. Also, townships sharing the same border were not sampled. If two townships shared the same border, one was randomly removed from the sample. This sample size represents roughly three percent of the total townships with data. Figure 2 maps the location of the sample townships.

For each township the length of miles were measured for any roads that overlapped. This distance was totaled among the following five road classes: Interstate / Trunk Highways, County Highways, Township Roads, All Season Forest Roads, and Seasonal Forest Roads. The total overlap for each class was divided by two (assuming that each mapped road class was 50 percent correct, and 50 percent incorrect) and subtracted from the total miles for that class of road in the township. This was divided by the total miles for that class of road in the township to give the percent of non-overlap miles for each class. Lastly an average was produced for all the townships with road data in them from each class (Table 3).

During the sampling process an additional error was found in the data. All the forest road data provided from Cass County Land Department was double mapped. For every road mapped there was a duplicate in the same spot. The total miles of Cass County Land Department forest road data was 1,776. Half of this distance, 888, was removed from the forest road data for the townships in Cass county.

To calculate the density of roads for each county, data was first summarized at the township level. First, for every township in Cass County the forest road miles were reduced as described above. Then, for each township, the total miles of roads in each road class was calculated. These totals were multiplied by the average non-overlap percent to produce an adjusted total miles for each class by township. Lastly these miles were totaled for each county and divided by the area they represented to produce a density figure (Table 4).

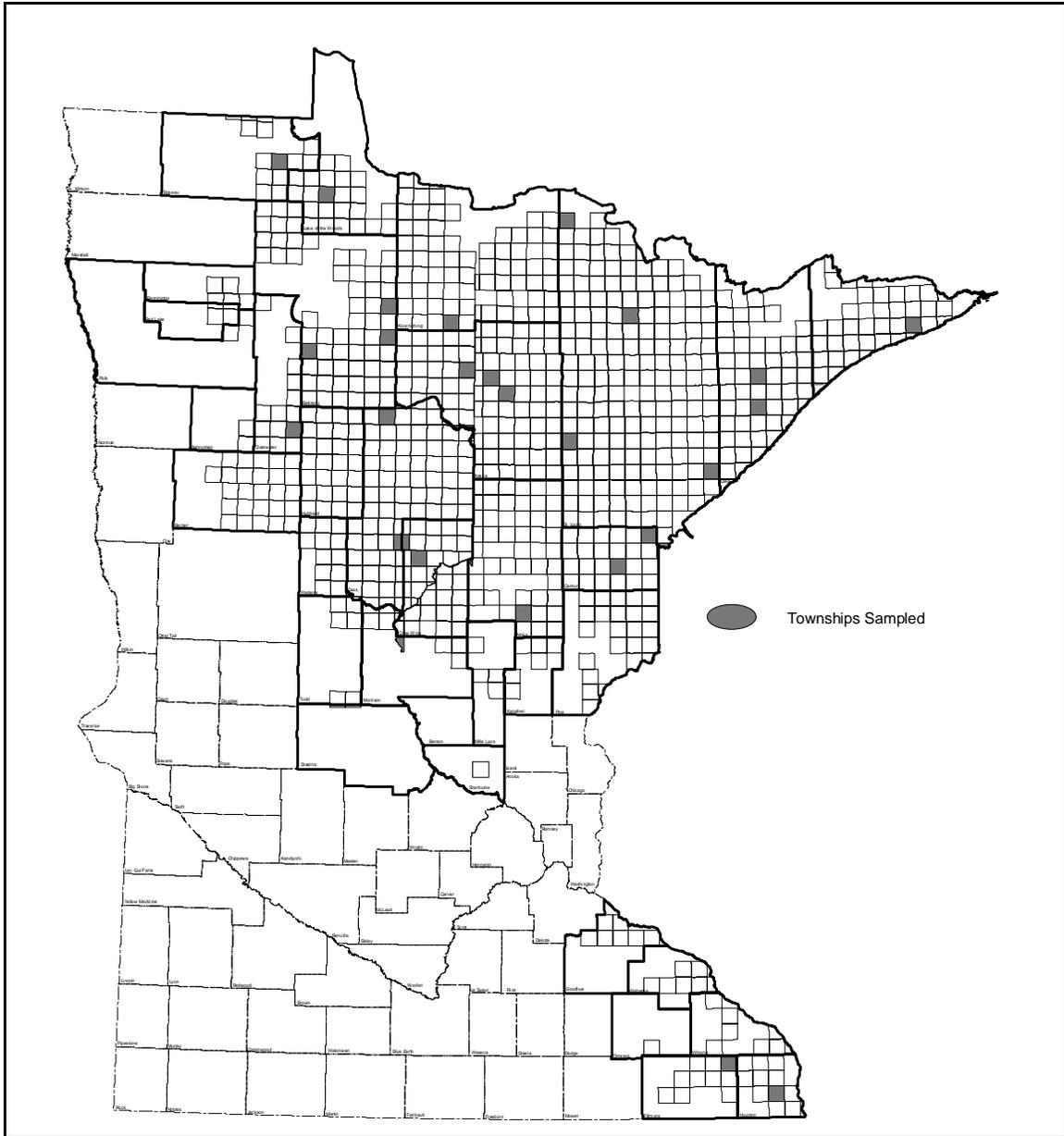


Figure 2. Location of sample townships.

Table 3. Percent of non-overlap road miles by sample townships.

Township Range Direction	Interstate / Trunk Highways	County Highways	Township Roads	All Season Forest Roads	Seasonal Forest Roads
136280	0.0%	100.0%	82.9%	89.2%	0.0%
161370	0.0%	100.0%	90.8%	100.0%	89.0%
159340	0.0%	0.0%	70.7%	95.8%	100.0%
149350	0.0%	100.0%	93.4%	98.1%	0.0%
104080	100.0%	100.0%	100.0%	100.0%	100.0%
102050	100.0%	100.0%	97.9%	58.8%	100.0%
42320	100.0%	100.0%	99.9%	96.8%	0.0%
62021	0.0%	100.0%	100.0%	100.0%	100.0%
59090	100.0%	0.0%	0.0%	95.2%	92.6%
57090	0.0%	0.0%	50.2%	80.0%	55.2%
53120	0.0%	100.0%	97.3%	91.9%	83.0%
63170	0.0%	100.0%	67.7%	80.6%	86.9%
69210	0.0%	99.4%	100.0%	95.9%	0.0%
55210	100.0%	100.0%	87.0%	100.0%	91.0%
48150	100.0%	100.0%	0.0%	100.0%	0.0%
48160	98.9%	99.3%	98.2%	87.5%	0.0%
47180	100.0%	100.0%	99.1%	97.6%	0.0%
44240	0.0%	100.0%	93.0%	87.2%	0.0%
137290	100.0%	100.0%	88.0%	80.0%	56.7%
58250	0.0%	70.3%	55.2%	81.6%	100.0%
59260	100.0%	51.5%	89.0%	88.5%	0.0%
144360	100.0%	100.0%	100.0%	100.0%	100.0%
145300	0.0%	0.0%	29.4%	76.4%	0.0%
148250	100.0%	86.1%	53.5%	75.9%	0.0%
151260	100.0%	100.0%	100.0%	100.0%	0.0%
150300	100.0%	100.0%	92.0%	85.1%	100.0%
152300	100.0%	100.0%	84.7%	95.7%	50.8%
Average	99.9%	95.9%	84.8%	90.3%	87.0%

Table 4. Density of roads by county.

County	Total Road Density	Interstate / Trunk Highways	County Highways	Township Roads	All Season Forest Roads	Seasonal Forest Roads
Aitkin	0.90	0.13	0.25	0.36	0.13	0.03
Becker	1.54	0.11	0.40	0.54	0.43	0.07
Beltrami	1.31	0.09	0.33	0.32	0.54	0.03
Carlton	1.61	0.21	0.55	0.39	0.45	0.02
Cass	2.08	0.11	0.30	0.30	1.36	0.01
Clearwater	1.09	0.09	0.34	0.31	0.31	0.04
Cook	0.77	0.05	0.21	0.03	0.27	0.20
Crow Wing	2.00	0.16	0.45	0.53	0.85	0.01
Fillmore	1.52	0.25	0.45	0.71	0.04	0.07
Goodhue	1.55	0.29	0.45	0.78	0.01	0.02
Houston	1.38	0.17	0.45	0.64	0.03	0.09
Hubbard	2.41	0.16	0.49	0.54	1.15	0.06
Itasca	1.65	0.12	0.43	0.18	0.72	0.21
Kanabec	1.04	0.17	0.42	0.39	0.04	0.02
Koochiching	0.47	0.08	0.11	0.09	0.12	0.07
Lake	1.55	0.06	0.14	0.08	0.98	0.29
Lake of the Woods	0.47	0.03	0.13	0.10	0.17	0.04
Mahnomen	0.84	0.12	0.22	0.43	0.05	0.02
Mille Lacs	1.04	0.15	0.44	0.34	0.08	0.02
Morrison	1.30	0.14	0.45	0.51	0.21	0.00
Olmsted	2.13	0.40	0.76	0.88	0.05	0.03
Pennington	1.46	0.00	0.96	0.46	0.04	0.00
Pine	1.22	0.11	0.37	0.47	0.18	0.09
Polk	1.24	0.08	0.35	0.77	0.02	0.00
Red Lake	1.72	0.00	0.90	0.70	0.12	0.00
Roseau	0.87	0.02	0.25	0.31	0.06	0.23
Sherburne	2.00	0.00	0.73	1.02	0.24	0.00
St. Louis	1.48	0.09	0.45	0.13	0.38	0.41
Stearns	1.82	0.11	0.60	0.95	0.02	0.13
Todd	1.72	0.22	0.57	0.82	0.12	0.00
Wabasha	1.52	0.26	0.62	0.55	0.06	0.03
Wadena	2.31	0.09	0.80	0.53	0.89	0.00
Winona	1.78	0.40	0.60	0.72	0.04	0.03
Mean	1.42	0.13	0.45	0.47	0.31	0.07
Standard Deviation	0.50	0.10	0.21	0.26	0.35	0.09

Discussion

Across the analyzed counties, the average density of county and township road classes were the highest, followed by the all season forest road class. The lowest average density was in the interstate class and seasonal forest road class.

When looking at this data it is important to notice that forest roads are not the same as county roads, which are not the same as Interstate roads. Two characteristics of roads that help illustrate this difference is the number of lanes along a road and the material the road is made of. For interstate and county roads, the material used is asphalt, for township and all season forest roads gravel is commonly used, and for seasonal forest roads the main material is soil. The number of lanes for these road classes also varies greatly: four to eight lanes for Interstate roads, four to two lanes for county roads, two lanes for Township roads, and two to one lanes for forest roads.

Figure 4 maps the densities of the road classes by county (see also Table 4). In most counties the highest individual density was of county highways or township roads. In a few counties the density of forest roads and other classes were fairly similar. These counties include: Clearwater, Koochiching, and Lake of the Woods. In some counties the all season forest road class density was higher than other individual road groups, including Beltrami, Cass, Cook, Crow Wing, Hubbard, Itasca, Lake, and Wadena.

Again, it is important to note that this forest road data had not been thoroughly collected and cleaned. Because all forest road data has not been collected, it is very likely additional forest roads are not included in this data set. Also, since this data has not been thoroughly cleaned, it overestimates the roads it represents. This is evident in roads that clearly overlap other roads. There is also the over estimation of forest roads due to roads in the database that no longer exist (for example from vegetation regeneration over the unused road).

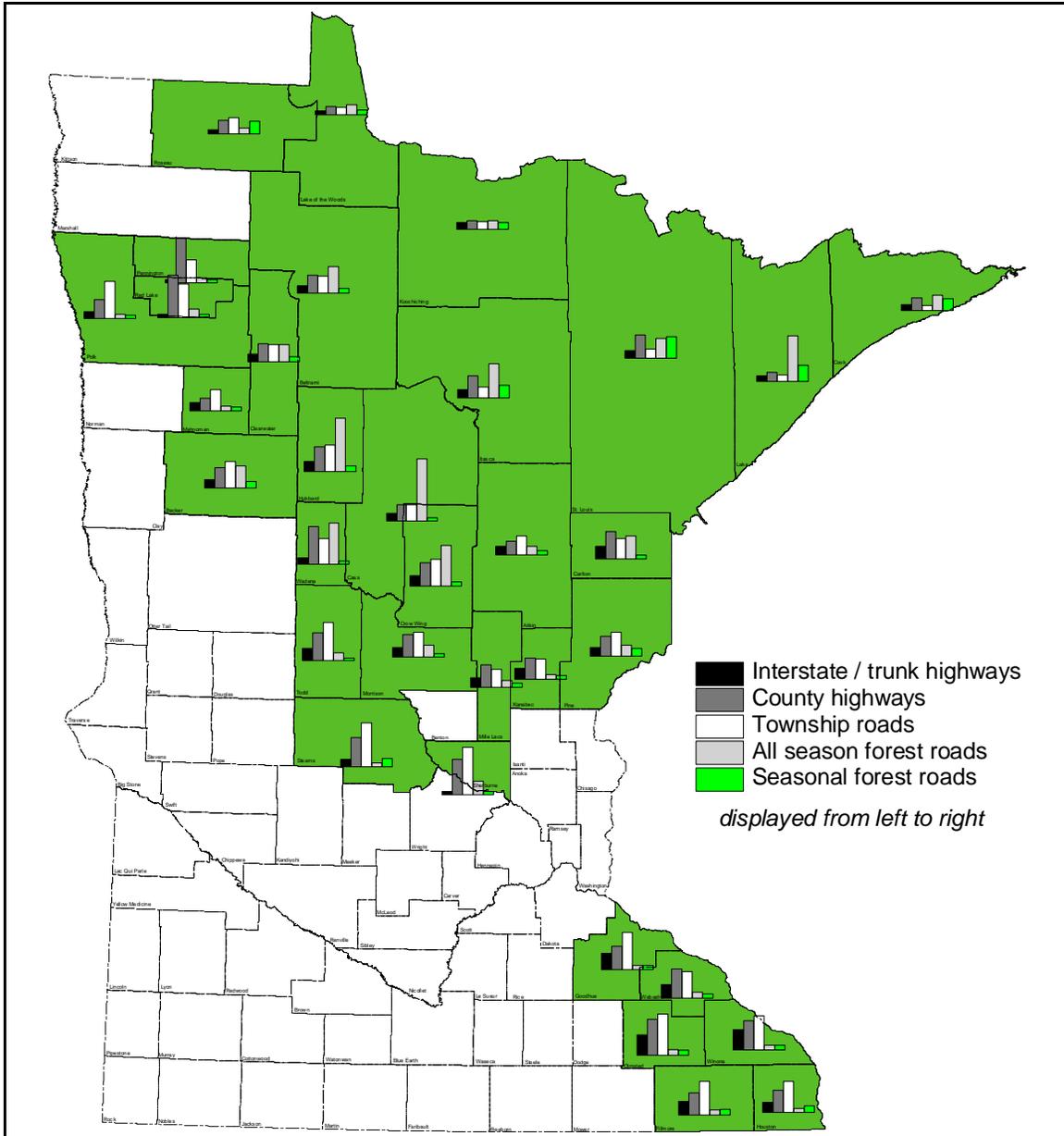


Figure 3. Map of road densities by county (only includes data from townships analyzed in each county, see Figure 1).

Future Direction

In the future, there are many uses for this data from site-level forest management and road layout, to landscape level planning. It provides a way for land managers to communicate what their road systems are and thus increase coordination across ownership boundaries.

Specifically, in the future, development of a road GIS system that is dynamically accessed by all agencies managing forest roads could be very useful. The system would allow managers to easily update their forest road inventories, while systematically allowing other forest managers access to their data. The road GIS system, as a result, can dramatically make the construction and reduction of forest roads more efficient. This would be a complex task requiring use of an Internet or Intranet system. The forest road data collected in this project provides an initial foundation that could be used for this kind of system.

Appendix A. Forest Road Attributes

Attribute Name	Valid Values	Description	Explanation
Name	Alpha numeric string	Name used by agency (up to 20 characters)	
number	Alpha numeric string	Number used by agency (up to 10 characters)	
season_of_use	A	All weather forest road	
	S	Dry summer forest road	
	W	Winter forest road(freeze down)	
type	A	Arterial (MNDOT - local)	Thru road usually connects to Township, County, etc. road
	C	Collector (MNDOT - local)	Serves 1,001 or more acres
	L	Local (MNDOT - local)	Serves less than 1000 acres
status	O	normally open	
	C	normally closed	
	I	Intermitently open	
	P	Permit Required	
lanes	1	number of lanes	One lane = Less than 15 feet of driving surface
	1.5		1.5 lane = 16 - 19 feet of driving surface
	2		Two lane = More than 19 feet of driving surface
cleared_width	0	12 -18'	Average total width cleared of trees
	1	19 - 25'	
	2	26 - 50'	
	3	50 +	
accuracy	H	High	GPS, +/- 20 feet
	M	Medium	Digitized, +/- 80 feet
	L	Low	Estimated from photo, +/- 150 feet
closure_method	G	Gate	
	B	Berm/Ditch	

	R	Rocks	
	N	Natural Vegetation	
	S	Sign/Barricade	
admin_code		Who administers, standard codes and names	Also known as jurisdiction. Who makes decisions on the road.
	1	Forest Service	
	2	DNR-Forestry	
	3	DNR-Wildlife	
	4	County Land Dept.	
	5	Blandin	
	6	Boise-Cascade	
	7	Potlatch	
	8	NIP	
	9	DNR-T&W	
	10	BLM	
admin_name		Who administers (names defined in admin_code)	Also known as jurisdiction. Who makes decisions on the road.
		Forest Service	
		DNR-Forestry	
		DNR-Wildlife	
		County Land Dept.	
		Blandin	
		Boise-Cascade	
		Potlatch	
		NIP	NonIndustrial Private
		DNR-T&W	
		BLM	
admin2_code	Same as admin_code		Use this if there is coop working agreement.
admin3_code	Same as admin_code		Use this if there is coop working agreement.
source	text	DNR, lake county, blandin, etc	Source of data