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

Chad Skally
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Acknowledgements


For More Information

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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.

<table>
<thead>
<tr>
<th>Counties</th>
<th>Groups Providing Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>County Land Department</td>
</tr>
<tr>
<td>Aitkin</td>
<td>X</td>
</tr>
<tr>
<td>Becker</td>
<td>X</td>
</tr>
<tr>
<td>Beltrami</td>
<td>X</td>
</tr>
<tr>
<td>Carlton</td>
<td>X</td>
</tr>
<tr>
<td>Cass</td>
<td>X</td>
</tr>
<tr>
<td>Clearwater</td>
<td>X</td>
</tr>
<tr>
<td>Cook</td>
<td>X</td>
</tr>
<tr>
<td>Crow Wing</td>
<td>X</td>
</tr>
<tr>
<td>Fillmore</td>
<td>X</td>
</tr>
<tr>
<td>Goodhue</td>
<td>X</td>
</tr>
<tr>
<td>Houston</td>
<td>X</td>
</tr>
<tr>
<td>Hubbard</td>
<td>X</td>
</tr>
<tr>
<td>Itasca</td>
<td>X</td>
</tr>
<tr>
<td>Kanabec</td>
<td>X</td>
</tr>
<tr>
<td>Koochiching</td>
<td>X</td>
</tr>
<tr>
<td>Lake</td>
<td>X</td>
</tr>
<tr>
<td>Lake of the Woods</td>
<td>X</td>
</tr>
<tr>
<td>Mahnomen</td>
<td>X</td>
</tr>
<tr>
<td>Mille Lacs</td>
<td>X</td>
</tr>
<tr>
<td>Morrison</td>
<td>X</td>
</tr>
<tr>
<td>Olmsted</td>
<td>X</td>
</tr>
<tr>
<td>Pennington</td>
<td>X</td>
</tr>
<tr>
<td>Pine</td>
<td>X</td>
</tr>
<tr>
<td>Polk</td>
<td>X</td>
</tr>
<tr>
<td>Red Lake</td>
<td>X</td>
</tr>
<tr>
<td>Roseau</td>
<td>X</td>
</tr>
<tr>
<td>Sherburne</td>
<td>X</td>
</tr>
<tr>
<td>St. Louis</td>
<td>X</td>
</tr>
<tr>
<td>Stearns</td>
<td>X</td>
</tr>
<tr>
<td>Todd</td>
<td>X</td>
</tr>
<tr>
<td>Wabasha</td>
<td>X</td>
</tr>
<tr>
<td>Wadena</td>
<td>X</td>
</tr>
<tr>
<td>Winona</td>
<td>X</td>
</tr>
</tbody>
</table>

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.

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

*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.

<table>
<thead>
<tr>
<th>Township Range</th>
<th>Interstate / Trunk Highways</th>
<th>County Highways</th>
<th>Township Roads</th>
<th>All Season Forest Roads</th>
<th>Seasonal Forest Roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>136280</td>
<td>0.0%</td>
<td>100.0%</td>
<td>82.9%</td>
<td>89.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>161370</td>
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<td>100.0%</td>
<td>90.8%</td>
<td>100.0%</td>
<td>89.0%</td>
</tr>
<tr>
<td>159340</td>
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<td>0.0%</td>
<td>70.7%</td>
<td>95.8%</td>
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<tr>
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<td>98.1%</td>
<td>0.0%</td>
</tr>
<tr>
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<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>102050</td>
<td>100.0%</td>
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<td>97.9%</td>
<td>58.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td>42320</td>
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</tr>
<tr>
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<td>100.0%</td>
<td>100.0%</td>
</tr>
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<td>0.0%</td>
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<td>92.6%</td>
</tr>
<tr>
<td>57090</td>
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<td>50.2%</td>
<td>80.0%</td>
<td>55.2%</td>
</tr>
<tr>
<td>53120</td>
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<td>100.0%</td>
<td>97.3%</td>
<td>91.9%</td>
<td>83.0%</td>
</tr>
<tr>
<td>63170</td>
<td>0.0%</td>
<td>100.0%</td>
<td>67.7%</td>
<td>80.6%</td>
<td>86.9%</td>
</tr>
<tr>
<td>69210</td>
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<td>99.4%</td>
<td>100.0%</td>
<td>95.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>55210</td>
<td>100.0%</td>
<td>100.0%</td>
<td>87.0%</td>
<td>100.0%</td>
<td>91.0%</td>
</tr>
<tr>
<td>48150</td>
<td>100.0%</td>
<td>100.0%</td>
<td>0.0%</td>
<td>100.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>48160</td>
<td>98.9%</td>
<td>99.3%</td>
<td>98.2%</td>
<td>87.5%</td>
<td>0.0%</td>
</tr>
<tr>
<td>47180</td>
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<td>97.6%</td>
<td>0.0%</td>
</tr>
<tr>
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<td>93.0%</td>
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<td>0.0%</td>
</tr>
<tr>
<td>137290</td>
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<td>100.0%</td>
<td>88.0%</td>
<td>80.0%</td>
<td>56.7%</td>
</tr>
<tr>
<td>58250</td>
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<td>55.2%</td>
<td>81.6%</td>
<td>100.0%</td>
</tr>
<tr>
<td>59260</td>
<td>100.0%</td>
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<td>89.0%</td>
<td>88.5%</td>
<td>0.0%</td>
</tr>
<tr>
<td>144360</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
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<td>0.0%</td>
<td>29.4%</td>
<td>76.4%</td>
<td>0.0%</td>
</tr>
<tr>
<td>148250</td>
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<td>86.1%</td>
<td>53.5%</td>
<td>75.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>151260</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>150300</td>
<td>100.0%</td>
<td>100.0%</td>
<td>92.0%</td>
<td>85.1%</td>
<td>100.0%</td>
</tr>
<tr>
<td>152300</td>
<td>100.0%</td>
<td>100.0%</td>
<td>84.7%</td>
<td>95.7%</td>
<td>50.8%</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>99.9%</strong></td>
<td><strong>95.9%</strong></td>
<td><strong>84.8%</strong></td>
<td><strong>90.3%</strong></td>
<td><strong>87.0%</strong></td>
</tr>
</tbody>
</table>
Table 4. Density of roads by county.

<table>
<thead>
<tr>
<th>County</th>
<th>Total Road Density</th>
<th>Interstate / Trunk Highways</th>
<th>County Highways</th>
<th>Township Roads</th>
<th>All Season Forest Roads</th>
<th>Seasonal Forest Roads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aitkin</td>
<td>0.90</td>
<td>0.13</td>
<td>0.25</td>
<td>0.36</td>
<td>0.13</td>
<td>0.03</td>
</tr>
<tr>
<td>Becker</td>
<td>1.54</td>
<td>0.11</td>
<td>0.40</td>
<td>0.54</td>
<td>0.43</td>
<td>0.07</td>
</tr>
<tr>
<td>Beltrami</td>
<td>1.31</td>
<td>0.09</td>
<td>0.33</td>
<td>0.32</td>
<td>0.54</td>
<td>0.03</td>
</tr>
<tr>
<td>Carlton</td>
<td>1.61</td>
<td>0.21</td>
<td>0.55</td>
<td>0.39</td>
<td>0.45</td>
<td>0.02</td>
</tr>
<tr>
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<td>2.08</td>
<td>0.11</td>
<td>0.30</td>
<td>0.30</td>
<td>1.36</td>
<td>0.01</td>
</tr>
<tr>
<td>Clearwater</td>
<td>1.09</td>
<td>0.09</td>
<td>0.34</td>
<td>0.31</td>
<td>0.31</td>
<td>0.04</td>
</tr>
<tr>
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<td><strong>0.35</strong></td>
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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 the 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).
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

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<th>Valid Values</th>
<th>Description</th>
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