Highlights from CEGIS & Penn State Multiscale Research on USGS Topographic Mapping

Cynthia A. Brewer
Geography, Pennsylvania State University

NGTOC Graphics TEM, November 2013
Highlights from CEGIS & Penn State Multiscale Research on USGS Topographic Mapping

Collaborators...
Paulo Raposo, Elaine Guidero
Geography, Pennsylvania State University

Lawrence V. Stanislawski, U.S. Geological Survey,
Center of Excellence for Geospatial Information

Barbara P. Buttenfield
Geography, University of Colorado—Boulder

NGTOC Graphics TEM, November 2013
Bob’s question about a 100K product...
Ortho image, Land cover, Hillshade
Understanding Web
Mercator projection

Scale differences across U.S. latitudes

“18K”
Google level

Alaska

“36K”
Google level

CONUS

“72K”
Google level

Whole US

“144K”
Google level

Alaska

Whole US

CONUS
Understanding Web Mercator projection

Scale differences across U.S. latitudes
<table>
<thead>
<tr>
<th>Type of map</th>
<th>5K-10K</th>
<th>11-25</th>
<th>26-50</th>
<th>51-100</th>
<th>101-250</th>
<th>251-500</th>
<th>501-1M</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topo</td>
<td>1</td>
<td>20</td>
<td>11</td>
<td>23</td>
<td>23</td>
<td>10</td>
<td>13</td>
<td>173</td>
</tr>
<tr>
<td>Zoning</td>
<td>3</td>
<td>20</td>
<td>13</td>
<td>24</td>
<td>24</td>
<td>17</td>
<td></td>
<td>127</td>
</tr>
<tr>
<td>Soils</td>
<td>0</td>
<td>12</td>
<td>35</td>
<td>27</td>
<td>14</td>
<td>13</td>
<td></td>
<td>104</td>
</tr>
<tr>
<td>Pop'n</td>
<td>9</td>
<td>31</td>
<td>26</td>
<td>20</td>
<td>14</td>
<td></td>
<td></td>
<td>88</td>
</tr>
</tbody>
</table>

Percent of total changes by scale range

NACIS, October 2007

with Jess Acosta
Three Research Highlights

• Adding importance attribute(s) for feature elimination through scale
  – e.g. minor roads, small towns, ponds, pruned tributaries

• Design for varied background lightness...
  – e.g. label contrast, contrast between layers within multi-layer lines

• Partitions for differential density during processing
  – e.g., fewer labels but more roads retained within dense urban area
## Elimination decisions in ScaleMaster

### Caching scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>24K</th>
<th>36K</th>
<th>72K</th>
<th>100K</th>
<th>144K</th>
<th>250K</th>
<th>289K</th>
<th>580K</th>
<th>1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>20K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>700K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Hydrography
- **Hydro areas**
  - C-
- **Hydro lines**
  - C-L-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-

### Physical
- **Hillshade**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **Contour**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **Summit**
  - C-
- **Wooded**
  - C-

### Transportation
- **Freeway/Highway/Ramp**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **Collector/Local/Service/4WD**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **Rail**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **Airport**
  - C-

### Cultural
- **EMS/Hospital**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **Church/Locale/School**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **Neighborhood (GNIS point)**
  - L-
  - L-
  - L-
  - L-
  - L-
  - L-
  - L-
  - L-

### Administrative
- **Incorporated Place**
  - L-
  - L-
  - L-
  - L-
  - L-
  - L-
  - L-
  - L-
- **Minor Civil Division**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **County**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **Federal Land**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
- **National/State**
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
  - C-
Remove features for multiscale mapping

Of 94 changes in draft ScaleMaster:

- 30% label changes (including removing labels)
- 26% symbol changes
- 14% geometry changes (not yet applied to all themes)
- 31% content changes

**Content and label removal are 39% of design decisions** in this draft multiscale mapping (20K to 1M)
24K design at 750K

750K design

1:750,000
Scale ranges
geometrically increasing breaks

24K
40K
60K
100K
150K
250K
400K
630K
1M

LoD goal:
Level-of-Detail database for each range

For example, show 200K map midway through range
Example of road thinning and labeling

Iowa sample area, 1:200,000
Thin Road Network tool, ArcGIS 10.1
The start...

24K roads shown at 200K, dense and sparse partitions from simplified TIGER Urbanized Areas, U.S. Census Bureau
200K: All roads thinned for average starting density (11km)
Calculate thinning level using inverted Radical Law...

200K: Sparse partition, 17km min length, Thin Road Network
Calculate thinning level using inverted Radical Law...

200K: Dense partition, 5km min length, Thin Road Network
200K: Roads thinned using both density partitions (5 and 17km)
200K: Labeled roads
200K: Reminder showing all roads is not practical
Ladder thinning choices by scale range

<table>
<thead>
<tr>
<th>scale range</th>
<th>dense road lines</th>
<th>dense label class 1</th>
<th>sparse road lines and labels; dense label class 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M</td>
<td>17</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>630-999K</td>
<td>14</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>400-629K</td>
<td>11</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td>250-399K</td>
<td>7</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>150-249K</td>
<td>5</td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>100-149K</td>
<td>2.5</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>60-99K</td>
<td>1.5</td>
<td>2.5</td>
<td>7</td>
</tr>
<tr>
<td>40-59K</td>
<td>0.5</td>
<td>1.5</td>
<td>5</td>
</tr>
<tr>
<td>24-39K</td>
<td></td>
<td>0.5</td>
<td>5</td>
</tr>
<tr>
<td>24-39K</td>
<td>all</td>
<td></td>
<td>all</td>
</tr>
</tbody>
</table>
Thin road network geoprocessing tool (ESRI ArcGIS 10.1)

Ladder with minimum lengths in km:

<table>
<thead>
<tr>
<th>1M+</th>
<th>all</th>
<th>0.5</th>
<th>1.5</th>
<th>2.5</th>
<th>5</th>
<th>7</th>
<th>11</th>
<th>14</th>
<th>17</th>
<th>23</th>
<th>27</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>630-999K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>400-629K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250-399K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>150-249K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100-149K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-99K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-59K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24-39K</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Populated place labeling
Elimination matters!
# Label sizes by population and map scale

<table>
<thead>
<tr>
<th>Population (thousands)</th>
<th>0</th>
<th>0.5</th>
<th>1</th>
<th>2</th>
<th>5</th>
<th>9</th>
<th>2</th>
<th>30</th>
<th>70</th>
<th>300+</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Map Scale</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>650K-1M</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>500-650K</td>
<td>.</td>
<td>.</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>350-500K</td>
<td>.</td>
<td>.</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>250-350K</td>
<td>.</td>
<td>.</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>170-250K</td>
<td>.</td>
<td>.</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>100-250K</td>
<td>.</td>
<td>.</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>85-100K</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>24-85K</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>14</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>18</td>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>

Details...See Brewer presentation from ICA Commission meeting on Generalisation and Multiple Representation last week aci.ign.fr

Label pattern for incorporated places (C5) only
Multiple road labels with attribute enrichment
Road labeling – multiple names and numbers

**Definition query** on layer to set:
road category
density partition
thinning level

```
"US_LABEL_TYPE" IS NOT NULL AND "gridcode" = 2 AND "visible_m" >= 5000
```
# Visibility (not removed from database)

Single attribute recording last thinning level road segment was visible.
Road labeling – multiple names and numbers

**Definition query** on layer to set:
- road category
- density partition
- thinning level

**SQL query** in Maplex for each label class

**One symbol class, many label classes**
Road labeling – multiple names and numbers

**Definition query** on layer to set:
- road category
- density partition
- thinning level

**SQL query** in Maplex for each label class

![SQL query example](image)
Road labeling – multiple names and numbers

**Definition query** on layer to set:
- road category
- density partition
- thinning level

**SQL query** in Maplex for label class

Python label **expressions** for multiple route numbers

Array 0 = 1st route number in list (all routes)
Array 1 = 2nd route number (2, 3, or 4 route #s)
Array 2 = 3rd route number (3 or 4 route #s)
Array 3 = 4th route number (4 route #s)
1sb = 1 business/bypass shield
2sb = 2 business/bypass shields
Example:

2 U.S. route shields
2 state route shields
‘clean’ name
Allow all, set priority order,
have Maplex place as many as can
<table>
<thead>
<tr>
<th>INTERSTATE</th>
<th>US_ROUTE</th>
<th>STATE_R</th>
<th>COUNTY_R</th>
<th>Importa</th>
<th>US_LABEL</th>
<th>SR_LABEL</th>
<th>CR_LABEL</th>
<th>CLEAN_STREET_NAME</th>
<th>Street_Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Null&gt;</td>
<td>1,23,84</td>
<td>4,38</td>
<td>&lt;Null&gt;</td>
<td>2</td>
<td>3S</td>
<td>2S</td>
<td>&lt;Null&gt;</td>
<td>Plant Ave</td>
<td>Plant Ave</td>
</tr>
<tr>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
<td>&lt;Null&gt;</td>
</tr>
<tr>
<td>&lt;Null&gt;</td>
<td>41,441</td>
<td>25</td>
<td>&lt;Null&gt;</td>
<td>2</td>
<td>2S</td>
<td>2S</td>
<td>&lt;Null&gt;</td>
<td>Hatley St NW</td>
<td>Hatley St NW</td>
</tr>
<tr>
<td>&lt;Null&gt;</td>
<td>41,129</td>
<td>6,100</td>
<td>&lt;Null&gt;</td>
<td>2</td>
<td>2S</td>
<td>2S</td>
<td>&lt;Null&gt;</td>
<td>Hatley St NW</td>
<td>Hatley St NW</td>
</tr>
<tr>
<td>41,123</td>
<td>41,123</td>
<td>6,100</td>
<td>&lt;Null&gt;</td>
<td>2</td>
<td>2S</td>
<td>2S</td>
<td>&lt;Null&gt;</td>
<td>Hatley St NW</td>
<td>Hatley St NW</td>
</tr>
</tbody>
</table>

**Label Manager**

Label Classes:
- Transport: US Route
  - Array0
  - Array1
  - 1sb
  - cleanname
  - Array2
  - Array3
  - 2sb

- Transport: State Route
  - Array0
  - Array1
  - Array2
  - cleanname
  - Array3

- Transport: County Route
  - Array0

**Expression**

Write a function named `FindLabel` for the selected label. Add fields as parameters to the function.

```python
def FindLabel ([US_ROUTE]):
    arr = [US_ROUTE].split(",")
    return arr[1]
```
Airport elimination through scale with attribute enrichment
### Final Attributes

**FAA** | **GNIS** | **Derived from FAA**
--- | --- | ---
34CO | Sky Ranch Airport | 
RIL | Rifle Municipal Airport | 
GWS | Glenwood Airport | 
FNL | Loveland Airport | 
LMO | Longmont Municipal Airport | 
BDU | Boulder Municipal Airport | 
ASE | Sardy Field | 
CO48 | Barnett's Field | 
APA | Arapahoe County Airport | 
8CO9 | Plane View Airfield | 
AJZ | Blake Field Airport | 
AIB | Hopkins-Montrose County Airport | 
1CO2 | Williams Landing Strip | 
7V2 | North Fork Valley Airport | 
3CO0 | Sky Island Ranch Airport | 
ANK | Salida Airport | 
C24 | Creede Airstrip | 
AFF | Pine Valley Airport | 
C0S | Peterson Field | 
C080 | Fowler Airfield | 
4V1 | Spanish Peaks Airfield | 
1CO5 | Todd Airport | 
7V9 | Las Animas Airport | 
KNN | Roper Field |
<table>
<thead>
<tr>
<th>Scale</th>
<th>Public Major</th>
<th>Public Minor</th>
<th>Private</th>
<th>Heliport</th>
</tr>
</thead>
<tbody>
<tr>
<td>(24K)</td>
<td>all</td>
<td>all</td>
<td>all</td>
<td>all</td>
</tr>
<tr>
<td>(40K)</td>
<td>all</td>
<td>all</td>
<td>all</td>
<td>all</td>
</tr>
<tr>
<td>(60K)</td>
<td>all</td>
<td>all</td>
<td>all</td>
<td>all, but only with [FEATURE_NA] only [FEATURE_NA] on Operations &gt; 0</td>
</tr>
<tr>
<td>(100K)</td>
<td>all</td>
<td>all</td>
<td>all</td>
<td>NOT (&quot;ArptClass&quot; = 'C' AND &quot;Operatio_7&quot; = 0)</td>
</tr>
<tr>
<td>(150K)</td>
<td>all</td>
<td>all</td>
<td>all</td>
<td>4&quot; rectangles</td>
</tr>
<tr>
<td>(250K)</td>
<td>all</td>
<td>all</td>
<td>all</td>
<td>4&quot; rectangles</td>
</tr>
<tr>
<td>(400K)</td>
<td>all</td>
<td>2&quot; rectangles</td>
<td>2.5&quot; rectangles</td>
<td></td>
</tr>
<tr>
<td>(630K)</td>
<td>all</td>
<td>4&quot; rectangles</td>
<td>only [Location_ID] for represented points</td>
<td></td>
</tr>
<tr>
<td>(1Mil)</td>
<td>3.5&quot; rectangles</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Varied background combinations
Vectors with ortho image...through scale (e.g., 1:100,000 and 1:24,000)
White & Contours, Hillshade, Land cover, Image – individual background layers
White & Contours, Hillshade, Land cover, Image – individual background layers
Roads: multi-layer lines

- Connect different road levels and categories
- Contrast with different backgrounds
Roads: multi-layer lines

- Light local roads echo lightness of roads in imagery, providing visual continuation for roads not in database
### Interstate
- **2.0 pt**, **dark red** (137, 68, 68)
- **3.5 pt**, **light red** (245, 122, 122)
- **4.5 pt**, **dark canvas** (186, 170, 153)

### Routes
- **1.8 pt**, **light red**
- **2.4 pt**, **dark canvas**

### Ramps
- **0.8 pt**, **light red**
- **1.6 pt**, **dark canvas**

### Local Roads
- **1.2 pt**, **light canvas** (234, 229, 224)
  - (RGB of canvas at 30% transp)
- **2.0 pt**, **dark canvas**
Road labels

- Two text fills for light or dark ground
- Double halo
- Higher contrast on inner halo for readability
- Color that melds with roads and surroundings on outer halo
4WD and trail lightness dash

- Light dash on dark background
- Dark dash on light background
Hydrography line lightness “wave”

- Line for perennial
- Dash for intermittent
Hydrography line lightness “wave”
Wave present but not apparent

Wave functions
Stream Tapering

Intermittent dash has subtle wave of lightness levels within dashes for contrast against busy backgrounds.

Top: darker blue (58, 119, 193)
Middle: medium blue (65, 124, 199)
Bottom: lighter blue (77, 134, 209)
Waterbodies

- Outlines are light on dark ground
- Outlines are dark on light ground
- Hydro textures also invert (e.g. swamp)
Lightness
Ross, Kevin, "Ladder versus star: Comparing Two Approaches for Generalization" (3.7MB PDF)
Tyrna, Abbey, "Using Surface Hydrologic Connections to Select or Prune Natural Waterways," 16pp (3.5MB PDF)
Wilmer, James, "National Hydrographic Data: Generalization and "The Principles of Visualization" 30pp (3.1MB PDF)
Smithgall, Mark, "Multi-Representation Database Development Review and Methodology," 11pp (3.8MB PDF)
Raposo, Paulo, "Review of DEM Specialists in the United Kingdom," 16pp (3.5MB PDF)

Citation of these papers would also include detail on the locations of University, University Park.

13. Series of related papers presented at the 2009-2010 Panel discussions:

Buttenfield et al., "Place Still Matters," Proceedings Paper


Presentation at ICC2009 (10MB)


8. Interactive version of ScaleMaster.org available online.

47. Presentations at NACIS, Greenville, SC, November 2008:

46. Presentations and Proceeding Papers at NACIS, Greenville, SC, November 2008:
Proceedings Paper
Presentation 1: Raposo, P. and C. Brewer, "A Case Study of an Interactive Decimation Process to Improve Generalization,
Presentation 2: Raposo, P. and C. Brewer, "A Case Study of an Interactive Decimation Process to Improve Generalization,
Presentation 3: Raposo, P. and C. Brewer, "A Case Study of an Interactive Decimation Process to Improve Generalization,
Presentation 4: Raposo, P. and C. Brewer, "A Case Study of an Interactive Decimation Process to Improve Generalization,

45. ICA Workshop Presentation and Proceedings Paper
Presentation: Raposo, P., C. Brewer, "An Interactive Design of The National Map of the United States,


Presentation 1: Brewer, C., "Multiscale Hydrography" Proceedings Paper
Presentation 4: Raposo, P., and C. Brewer


ScaleMaster is a structured diagram tool for planning and making generalization decisions.

In its rudimentary form, ScaleMaster is a concept diagram that we have used to plan and linked as we continued to develop the idea. The ScaleMaster project was a collaboration involving the following scientists and researchers:

Research assistants at CU Boulder: Chad Schmit, David Hultcrank, et al.
Others contributors include Aileen Buckland, Polly Schaller, and others.

The research work was funded from 2005 through Cooperative Ecosystem Studies Units (CESU) at the University of Colorado at Boulder and University of Colorado at Boulder. ScaleMaster research was initially funded by NASA grant NCC 5-1953.

Additional papers and talks by Buttenfield et al., "Place Still Matters," Proceedings Paper

Presentation 4: Raposo, P. and C. Brewer, "A Case Study of an Interactive Decimation Process to Improve Generalization,
Acknowledgements

USGS funding 2007 to 2013, Lynn Usery, Director, Center of Excellence for Geospatial Information Science (CEGIS), and 2010-11, Mike Cooley

Resources
CEGIS-USGS:

cegis.usgs.gov

Project resources:
ScaleMaster.org

Gould Center, Penn State:
NationalMapping.us

Meridian Lab, Boulder:
greenwich.colorado.edu

Thank you to Penn State RAs...

Katie Meckler, Clare Price, Kevin Sparks, Jay McGilloway, Rick Fourroux, Steve Butzler, Andy Stauffer, Stephen Sylvia, Jim Thatcher, Doug Minnigh, Chelsea Hanchett, Halina Sundy, Rob Roth, Mamata Akella, Jess Acosta

babs buttenfield, Chris Anderson Tarver,
Mike Gleason  CU-Boulder