Bike Trail Planning for Des Moines MPO, Iowa

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Outline

• Project Background
• Project Goal
• Literature Review
• Project Design
• Methodology
• Results
• Conclusion
Project Background

- Inspiration: numerous trails in Aspen, CO
• More than 1,800 miles of biking trails across Iowa State (Iowa DNR)

• Bicycling is one of the most popular outdoor recreation activities in Iowa (Bowels et al., 2011).

• There is a rising demand for cycling in Iowa.
Project Background

- Des Moines has the largest population across Iowa, Des Moines MPO as the big community union in development
Des Moines MPO (Metropolitan Planning Organization):

• A regional transportation planning entity comprised of local communities and transportation agencies in the Des Moines, Iowa, metropolitan region.

• Used to describe the area where its members (16 cities; DART; 3 associate, non-voting cities) are located.
Project Background

• Natural Resources near Des Moines MPO: The Lake Red Rock
Lake Red Rock Area

Lake Red Rock: The largest lake in Iowa

“Originally the city of Red Rock, Lake Red Rock, also referred to as Red Rock Reservoir is a reservoir formed by Red Rock Dam on the Des Moines River, about 55 miles southeast of the city of Des Moines, Iowa.” (Wiki, 2015)
Project Background

Lake Red Rock Sunset

Photo Copyright: knoxvilleia.gov
An active piece of the Iowa Interstate Railroad; will be deactivated when no business demand exists

Railroad deactivated, funding has been being collecting to purchase the corridor to be transitioned into a trail

Deactivated interstate corridor; railbanked and purchased by Jasper County; no development so far

Developed by following highways 14 and G28

*map provided by Iowa Natural Heritage Foundation
Spatial Question

Where are the locations for alternative biking trail routes, based on environmental conservation criteria, to connect Des Moines MPO and the Lake Red Rock?
• The benefit of biking: social, economical, physical and environmental benefits (Badland, et al., 2013; Titze et al., 2013; Giles-Corti et al., 2010; Huy et al., 2008; Bowels et al., 2011)

• Least cost path design for bike trails (Snyder et al., 2008; Ferguson et al., 1998; Bagli et al., 2011)
Literature Review

**Trail criteria** (Snyder et al., 2008):

<table>
<thead>
<tr>
<th>Description</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Bodies with 100 feet buffers around</td>
<td>To reduce the likelihood of trail segments in these areas and their associated riparian impacts</td>
</tr>
<tr>
<td>Wetland with 100 feet buffers around</td>
<td>To minimize human impacts to wetlands</td>
</tr>
<tr>
<td>Public Roads with 100 feet buffers around</td>
<td>To address safety issues</td>
</tr>
<tr>
<td>Existing Trails with 0.6 mile buffers around</td>
<td>For safety and noise issues consideration</td>
</tr>
<tr>
<td>Viewshed</td>
<td>To address the importance of views from trails</td>
</tr>
<tr>
<td>Slope</td>
<td>Reflect bicycler’s preferences in slope; safety concern</td>
</tr>
<tr>
<td>Land Ownership</td>
<td>Minimize conflict with ownership</td>
</tr>
<tr>
<td>Landcover</td>
<td>To balance the natural resource utilization and its conservation</td>
</tr>
</tbody>
</table>
GOAL:

To identify alternative biking trail routes, based on environmental conservation criteria, connecting Northeast Des Moines and the Lake Red Rock.
Project Design: Bike Trail Planning

Environmental Conservation

- Existing Conceptual trail
- Alternative trail
- Comparing Scenarios

- Same weights
  - Rivers
  - Wetland
  - Roads
  - Trails
  - Slope
  - Land cover

- Different weights
  - Rivers
  - Wetland
  - Roads
  - Trails
  - Slope
  - Land cover

25 scenarios

Suggested trail
Methodology

Preprocessing
• Set up Study Area
• Set up Criteria
• Acquire Necessary Data

Geoprocessing
• Data Analysis
• Obtain the Least Cost Paths
• Multiple Scenarios

Review and Compare
• Review the least cost paths
• Review paths in multiple scenarios
• Compare paths
Study Area

Des Moines
Altoona
Mitchellville
Prairie City
Monroe
Polk County
Jasper County
Marion County
Red Rock Lake
Study Area: the four sections

- Altoona-Mitchellville
- Mitchellville-Prairie City
- Prairie City-Monroe
- Monroe-Red Rock Lake

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The Spatial Environmental Conservation Criteria

Alternative biking trail routes are desired to be located:

• Away from the rivers and wetlands;
• Away from roads and existing trails;
• Occupy conservation and recreation land;
• Where land cover is barren/fallow, and avoid structures;
• In a required slope range.
<table>
<thead>
<tr>
<th>CRITERION</th>
<th>SCALE</th>
<th>1 (least cost)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (most cost)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100' buffer of rivers</td>
<td>Areas outside the buffer</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Areas within the buffer</td>
<td></td>
</tr>
<tr>
<td>100' buffer of wetlands</td>
<td>Areas outside the buffer</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>Areas within the buffer</td>
<td></td>
</tr>
<tr>
<td>0.6 mile buffer of trails</td>
<td>Areas outside the buffer</td>
<td>NA</td>
<td>Areas within the buffer</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>100' buffer of roads</td>
<td>Areas outside the buffer</td>
<td>NA</td>
<td>Areas within the buffer</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Conservation &amp; recreation land</td>
<td>Areas within the land</td>
<td>NA</td>
<td>Areas outside the land</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Slope</td>
<td>0 - 3 (%)</td>
<td>4 - 5 (%)</td>
<td>6 - 8 (%)</td>
<td>9 - 10 (%)</td>
<td>11 - 100(%)</td>
<td></td>
</tr>
<tr>
<td>Land cover</td>
<td>Barren/Fallow</td>
<td>Cut hay Roads/Impervious</td>
<td>Grass 1, Grass 2, Corn, Soybeans, Shadow/No Data</td>
<td>Coniferous forest, Deciduous short, Deciduous medium, Deciduous tall</td>
<td>Water, Wetland, Structure</td>
<td></td>
</tr>
</tbody>
</table>

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## Data Acquired

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LAYER NAME</th>
<th>TYPE</th>
<th>SOURCE</th>
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<tr>
<td>Waterbodies</td>
<td>Rivers_50, Rivers_63, Rivers_77, Waterbody, Major_lakes, Major_rivers</td>
<td>vector</td>
<td>Iowa DNR</td>
</tr>
<tr>
<td>Wetlands</td>
<td>Designated_wetlands_setback, NWI_2002</td>
<td>vector</td>
<td>Iowa DNR</td>
</tr>
<tr>
<td>Public roads</td>
<td>iowa_roads</td>
<td>vector</td>
<td>Iowa DNR</td>
</tr>
<tr>
<td>Existing trails</td>
<td>Trails, Trails_so_2012</td>
<td>vector</td>
<td>Iowa DNR, Iowa DOT</td>
</tr>
<tr>
<td>Slope</td>
<td>DEM_3M_I_77, DEM_3M_I_63, DEM_3M_I_50</td>
<td>raster</td>
<td>Iowa DNR</td>
</tr>
<tr>
<td>Land ownership</td>
<td>Cons_rec_lands_public, iowa_gap_stewardship, DNR_lands</td>
<td>vector</td>
<td>ISU Mirror of Iowa DNR</td>
</tr>
<tr>
<td>Land cover</td>
<td>HRLC_2009_77, HRLC_2009_63, HRLC_2009_50</td>
<td>raster</td>
<td>Iowa DNR</td>
</tr>
</tbody>
</table>

- **XY Coordinate System**: NAD_1983_UTM_Zone_15N
- **Projection**: Transverse_Mercator
- **Cell Size**: 15m*15m
Applied to Rivers, Wetlands, Trails, Roads, Conservation & Recreation Lands

Clip → Buffer → Polygon to Raster → Reclassify

Applied to Slope
Clip → Slope → Reclassify

Applied to Landcover
Clip → Reclassify

Weighted Sum → Cost Path
Cost Distance
Data Analysis: GIS Model Builder
The Least Cost Path
Section 1: Altoona-Mitchellville

Legend
- Blue circle: Start point in Altoona
- Yellow circle: End point in Mitchellville
- Dotted line: Existing Conceptual Route

Start point in Altoona
End point in Mitchellville
Existing Conceptual Route

0 0.5 1 2 3 4
Miles

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Reclassified Layers
Section 1: Altoona-Mitchellville

River with 100’ Buffer

Wetlands with 100’ Buffer

Altoona

Mitchellville

Altoona

Mitchellville

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Reclassified Layers
Section 1: Altoona-Mitchellville

Trail with 0.6 Mile Buffer

Landcover

Altoona

Mitchellville

Altoona

Mitchellville

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Reclassified Layers
Section 1: Altoona-Michellville

Slope Surface

Altoona

Mitchellville

Slope: 0-3%
4-5%
6-8%
9-10%
11-57%

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Miles

0 0.5 1 2 3 4
The Accumulated Cost Surface
Section 1: Altoona-Mitchellville

Weighted Sum

Cost Increases

Cost Decreases

Start point in Altoona
End point in Mitchellville

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The Cost Distance & Direction Surfaces
Section 1: Altoona-Mitchellville

Cost Distance Surface

Cost Direction Surface

Start point in Altoona
End point in Mitchellville

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The Least Cost Path
Section 1: Altoona-Mitchellville

Start point in Altoona
End point in Mitchellville
Existing Conceptual Route
The Least Cost Path

03/30/2015
## Multiple Scenarios
### Section 1: Altoona-Mitchellville

<table>
<thead>
<tr>
<th>Layer Name</th>
<th>original</th>
<th>scenario 1</th>
<th>scenario 2</th>
<th>scenario 3</th>
<th>scenario 4</th>
<th>scenario 5</th>
<th>scenario 6</th>
<th>scenario 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>rivers</td>
<td>x1</td>
<td>x2</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
</tr>
<tr>
<td>wetlands</td>
<td>x1</td>
<td>x1</td>
<td>x2</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
</tr>
<tr>
<td>trails</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x2</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
</tr>
<tr>
<td>roads</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x2</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
</tr>
<tr>
<td>slope</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x2</td>
<td>x1</td>
<td>x1</td>
</tr>
<tr>
<td>landcover</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x2</td>
<td>x1</td>
</tr>
<tr>
<td>conservation &amp; recreation land</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
<td>x1</td>
</tr>
</tbody>
</table>
Multiple Scenarios
Section 1: Altoona-Mitchellville

The Original Least Cost Path

Scenario 1 Least Cost Path
Scenario 2 Least Cost Path
Scenario 3 Least Cost Path
Scenario 4 Least Cost Path
Scenario 5 Least Cost Path
Scenario 6 Least Cost Path
Scenario 7 Least Cost Path

Start point in Altoona
End point in Mitchellville
Existing Conceptual Route

Miles
0 0.5 1 2 3 4

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### Multiple Scenarios : Statistics

**Section 1: Altoona-Mitchellville**

Original Count: 515  
Original Path Cost: 93,973

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>New Count</th>
<th>Count Deviation %</th>
<th>New PathCost</th>
<th>Cost Deviation %</th>
<th>Trail Alignment Change %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>515</td>
<td>0±</td>
<td>103,322</td>
<td>9.9+</td>
<td>4.5</td>
</tr>
<tr>
<td>2</td>
<td>515</td>
<td>0±</td>
<td>101,817</td>
<td>8.3+</td>
<td>49.9</td>
</tr>
<tr>
<td>3</td>
<td>515</td>
<td>0±</td>
<td>103,794</td>
<td>10.5+</td>
<td>49.9</td>
</tr>
<tr>
<td>4</td>
<td>515</td>
<td>0±</td>
<td>102,465</td>
<td>9.0+</td>
<td>53.6</td>
</tr>
<tr>
<td>5</td>
<td>515</td>
<td>0±</td>
<td>105,453</td>
<td>12.2+</td>
<td>55.0</td>
</tr>
<tr>
<td>6</td>
<td>515</td>
<td>0±</td>
<td>116,077</td>
<td>23.5+</td>
<td>44.7</td>
</tr>
<tr>
<td>7</td>
<td>515</td>
<td>0±</td>
<td>117,168</td>
<td>24.7+</td>
<td>53.0</td>
</tr>
</tbody>
</table>
Results
Review of The Least Cost Paths
Section 1: Altoona-Mitchellville
Review of The Least Cost Paths

Section 1: Altoona-Mitchellville
Suggested Route
Section 1: Altoona-Mitchellville
Conclusion

Limitations

• Lack of accuracy of the data
• No sufficient property data for suburban areas
• Viewshed took too much time to complete
• Criteria not particularly tailored for the study area
• No field observation and inventory
• Inevitable data redundancy
Conclusion

Final Remarks on the Geo-Process

• For water bodies and the wetlands, data cannot be set to 'no data' in reclassification. Since they spread across almost everywhere between the starting point and the destination. In stead, a value of relatively high should be set to allow the path go across.

• Z-factor for slope is 0.01. According to DEM value the mean is 28531.90728. And the mean elevation for the State of Iowa is 1100feet. So it is very likely that the number has a unit of centimeter. Thus the factor of 0.01.
Acknowledgements

Professor Monica Haddad
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Josh Obrecht
Professor Kevin Kane
The Department of Landscape Architecture
References