Sustainability Metrics and Mapping Tool for Environmental Assessment of Rail Infrastructure in Illinois

Webcast at the Center for Urban Transportation Research, USF
December 11, 2014

Ning Ai, Ph.D.
Assistant Professor, Dept. of Urban Planning and Policy
Research Assistant Professor, Inst. for Environmental Science and Policy

Urban Transportation Center
UNIVERSITY OF ILLINOIS AT CHICAGO
COLLEGE OF URBAN PLANNING & PUBLIC AFFAIRS
Outline

• Project Overview
• Illinois Rail Context
• Research Methodology
• Highlights of Ongoing Research
  – Sustainable rail assessment metrics
  – Location-specific modeling and data integration
  – Web mapping tool under development
• Summary
Project Overview

• Objective
  – Increase the effectiveness and efficiency of environmental impact assessment of rail infrastructure

• Approach
  – Integrated system view
  – Location-specific modeling
  – One-stop GIS database
  – Interactive web interface

• Team Members
  – Project Lead: Ning Ai
  – Graduate Research Assistants
    • Marcella Bondie (Urban Planning)
    • Anthony Grande (Urban Planning)
    • Sol (Shuo) Ma (Computer Science)
    • Shi Yin (Computer Science)
Expected Use of the Research Results

• Pre-NEPA review
• Streamlining rail planning process
• Identification of high priority and sensitive areas for sustainable rail planning and management
• Environmental advocacy
• Public engagement
Challenges of Rail Infrastructure Management in IL

Chicago Area Railroad Freight Trains per Day
(Map 1 of 2)

Legend
- 0
- 1 to 3
- 4 to 6
- 7 to 12
- 13 to 24
- 25 to 36
- 37 to 60
- > 60

Railroad (See Map 2)

Map shows rail line ownership based on 2011 National Transportation Atlas Database published by the U.S. DOT's Bureau of Transportation Statistics.

Regulatory Context of Rail Infrastructure Management

• National Environmental Policy Act
• Passenger Rail Investment and Improvement Act
• Moving Ahead for Progress in the 21st Century
• Clean Air Act
• Clean Water Act
• National Historic Preservation Act
• Archeological Resources Protection Act
• Wilderness Act
• Resource Conservation and Recovery Act
• Noise Control Act
• Occupational Health and Safety Act

Note: This represents a partial list only.
Sustainable Rail Assessment Framework: General Structure

- **Category**
  - Transit rail
  - Commuter passenger rail
  - Freight rail

- **Metric**
  - Performance vs. Output

- **Spatial & Non-Spatial**
  - GIS Interface
  - Spreadsheet

- **Tiered Metrics**
  - Tier 1: Required or Commonly Used
  - Tier 2: Advanced Assessment

- **Benchmark data (work in progress)**
  - National & Regional
  - Best Practice
## Sustainability Checklist: Transit Rail

(Tier I – Spatial)

<table>
<thead>
<tr>
<th>DOT Goal</th>
<th>Strategy</th>
<th>Metric</th>
<th>Legislation or Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Improve rail safety performance</td>
<td>Passenger fatality and injury rate</td>
<td>MAP-21; OSHA; FRSA; 49 CFR B; DOT Strategic Plan 2012 - 2016</td>
</tr>
<tr>
<td></td>
<td>Avoid natural hazard areas</td>
<td>Acres in high flood hazard area</td>
<td>Flood Disaster Protection Act</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acres in high seismic hazard area</td>
<td>49 CFR 41 Seismic Safety</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acres in historical tornado hazard area</td>
<td>Disaster Mitigation Act (PL 106-390)</td>
</tr>
<tr>
<td>Environmental Sustainability</td>
<td>Reduce air emissions</td>
<td>Pounds of greenhouse gases emitted per capita-mi</td>
<td>MAP-21</td>
</tr>
<tr>
<td></td>
<td>Protect high-quality wetlands and water resources</td>
<td>Acres on or near wetlands or water resources</td>
<td>Clean Water Act; Fish and Wildlife Coordination Act; Illinois Interagency Wetlands Policy Act</td>
</tr>
<tr>
<td></td>
<td>Protect high-quality habitat for threatened and endangered species, and species of concern</td>
<td>Acres on or near critical habitat</td>
<td>Endangered Species Act; Illinois Endangered Species Act</td>
</tr>
<tr>
<td></td>
<td>Protect high-quality natural &amp; agricultural landscapes</td>
<td>Acres on or near natural and agricultural lands</td>
<td>Farmland Protection Policy Act; Illinois Farmland Preservation Act; Illinois Natural Areas Preservation Act</td>
</tr>
</tbody>
</table>
# Sustainability Checklist: Transit Rail
(Tier I Spatial – Cont’d)

## Spatial Indicators

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Livable Communities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improve rail accessibility</td>
<td>Population density within a half-mile of rail transit station</td>
<td>USEPA Guide to Sustainable Transportation Performance Measures (2011)</td>
</tr>
<tr>
<td></td>
<td>Employment density within a half-mile of rail transit station</td>
<td>USEPA Guide to Sustainable Transportation Performance Measures (2011)</td>
</tr>
<tr>
<td>Locate stations and service frequency</td>
<td>Percentage of minority individuals within service area of station</td>
<td>Title VI; 49 CFR 21; FTA C 4702.1B</td>
</tr>
<tr>
<td>frequency equitably throughout service area</td>
<td>Percentage of low-income households within service area of station</td>
<td>Title VI; 49 CFR 21; FTA C 4702.1B</td>
</tr>
<tr>
<td></td>
<td>Percentage of service reductions in low-income or minority communities</td>
<td>Title VI; 49 CFR 21; FTA C 4702.1B</td>
</tr>
<tr>
<td>Avoid disproportionate adverse impacts to</td>
<td>Acres within or near low-income or minority community area</td>
<td>Uniform Relocation Assistance and Real Property Acquisition Act; EO 12898; 49 CFR 24</td>
</tr>
<tr>
<td>minority and low-income populations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protect cultural and recreational resources</td>
<td>Acres on or partitioning national trails or other greenways</td>
<td>National Trails System Act; Land and Water Conservation Fund Act</td>
</tr>
<tr>
<td></td>
<td>Acres on or near parks and recreational land</td>
<td>49 USC 303 Sec. 4(f); Land and Water Conservation Fund Act</td>
</tr>
<tr>
<td>Protect community cohesion</td>
<td>Acres on or near historical or cultural areas</td>
<td>National Historic Preservation Act; 49 USC 303 Sec. 4(f); Archeological and Historic Preservation Act; American Indian Religious Freedom Act; Illinois Historic Preservation Act</td>
</tr>
<tr>
<td></td>
<td>Acres partitioning residential or commercial districts</td>
<td>NEPA; Passenger Rail Investment and Improvement Act; Illinois Highway Code</td>
</tr>
</tbody>
</table>
# Sustainability Checklist: Transit Rail
(Tier I Non-Spatial)

<table>
<thead>
<tr>
<th>DOT Goal</th>
<th>Strategy</th>
<th>Metric</th>
<th>Legislation or Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>State of Good Repair</strong></td>
<td>Maintain rail assets in a state of good repair</td>
<td>Percentage of rail assets evaluated as adequate condition or better</td>
<td>DOT Strategic Plan 2012 - 2016</td>
</tr>
<tr>
<td></td>
<td>Perform sustainable economic investment in rail</td>
<td>Capital funds expended per vehicle revenue mile</td>
<td>RTA Subregional Peer Report (2011)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Operating cost per passenger mile</td>
<td>RTA Subregional Peer Report (2011)</td>
</tr>
<tr>
<td><strong>Livable Communities</strong></td>
<td>Improve rail access for limited-mobility passengers</td>
<td>Percentage of passenger rail stations compliant with ADA</td>
<td>American Disabilities Act; 49 CFR 37</td>
</tr>
<tr>
<td></td>
<td>Reduce road traffic congestion</td>
<td>Average daily number of congested hours of weekday travel</td>
<td>Haghshenas, et al. Urban sustainable transportation indicators for global comparison. Ecological Indicators (2012)</td>
</tr>
<tr>
<td></td>
<td>Provide high-quality service for all passengers</td>
<td>Percentage of &quot;very satisfied&quot; survey responses</td>
<td>FRA Metrics and Standards for Intercity Passenger Rail Service (2009)</td>
</tr>
<tr>
<td></td>
<td>Provide all stakeholders with opportunity for meaningful input on projects and operations</td>
<td>Number of public meeting attendees and comments</td>
<td>NEPA; EO 13045; EO 13175</td>
</tr>
<tr>
<td><strong>Economic Competitiveness</strong></td>
<td>Increase rail mode share</td>
<td>Mode share of trips</td>
<td>USEPA Guide to Sustainable Transportation Performance Measures (2011)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transit rail system passenger miles per capita</td>
<td>DOT Strategic Plan 2012 - 2016</td>
</tr>
</tbody>
</table>
## Sustainability Checklist: Transit Rail

(Tier I Non-Spatial – Cont’d)

<table>
<thead>
<tr>
<th>Environmental Sustainability</th>
<th>NON-SPATIAL INDICATORS</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protect wetlands and habitat</td>
<td>Survival rate of nearby wetland plants and habitat</td>
<td>EO 11990; Robin Environmental Consultants <em>California high speed rail ecosystem management plan</em> (2012)</td>
</tr>
<tr>
<td>Prevent growth of invasive species</td>
<td>Percent cover of invasive species</td>
<td>EO 13112; Robin Environmental Consultants <em>California high speed rail ecosystem management plan</em> (2012)</td>
</tr>
<tr>
<td>Protect rare, threatened or endangered plants and animals</td>
<td>Survival rate of protected species</td>
<td>Endangered Species Act; Robin Environmental Consultants <em>California high speed rail ecosystem management plan</em> (2012)</td>
</tr>
<tr>
<td>Increase the share of renewable energy</td>
<td>Percent renewable energy used for operations</td>
<td>International Union of Railways <em>Railway specific environmental performance indicators</em> (2008)</td>
</tr>
</tbody>
</table>
## Sustainability Checklist: Transit Rail
(Tier II - Spatial)

<table>
<thead>
<tr>
<th>SPATIAL INDICATORS</th>
<th>DOT Goal</th>
<th>Strategy</th>
<th>Metric</th>
<th>Legislation or Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Livable Communities</strong></td>
<td>Provide rail facilities and service in transit-dependent communities</td>
<td>Percentage of households without cars</td>
<td>UIC Voorhees Center <em>Transit Equity Matters</em> (2009)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentage of workers commuting &gt;60 min</td>
<td>UIC Voorhees Center <em>Transit Equity Matters</em> (2009)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentage of disabled individuals</td>
<td>UIC Voorhees Center <em>Transit Equity Matters</em> (2009)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentage of elderly individuals</td>
<td>UIC Voorhees Center <em>Transit Equity Matters</em> (2009)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Promote urban infill and minimize greenfield development</td>
<td>Acres built on impervious land cover</td>
<td>USEPA Guide to Sustainable Transportation Performance Measures (2011)</td>
<td></td>
</tr>
</tbody>
</table>
# Sustainability Checklist: Transit Rail

**(Tier II Non-Spatial)**

<table>
<thead>
<tr>
<th>DOT Goal</th>
<th>Strategy</th>
<th>Metric</th>
<th>Legislation or Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Accommodate pedestrians and bicycles</td>
<td>Percentage of grade crossings assessed for pedestrian and bicycle safety</td>
<td>MAP-21; DOT Strategic Plan 2012 - 2016</td>
</tr>
<tr>
<td></td>
<td>Improve transportation affordability</td>
<td>Percentage of household income spent on transportation</td>
<td>USEPA Guide to Sustainable Transportation Performance Measures (2011)</td>
</tr>
<tr>
<td></td>
<td>Increase employment</td>
<td>Number of jobs created per capita-mi</td>
<td>Carpenter, T. The environmental impact of railways (1994)</td>
</tr>
<tr>
<td></td>
<td>Protect community property values</td>
<td>Percent change in property values along rail corridor</td>
<td>Carpenter, T. The environmental impact of railways (1994)</td>
</tr>
<tr>
<td></td>
<td>Reduce urban heat island effect</td>
<td>Percentage of infrastructure with high RFI rating</td>
<td>LEED</td>
</tr>
<tr>
<td></td>
<td>Protect trees and desirable vegetation</td>
<td>Survival rate of protected trees and plants along rail corridor</td>
<td>Illinois DOT D&amp;E 18: Preservation &amp; Replacement of Trees</td>
</tr>
<tr>
<td></td>
<td>Protect wildlife migration corridors</td>
<td>Acres of wildlife corridors fragmented per capita-mi</td>
<td>Robin Environmental Consultants California high speed rail ecosystem management plan (2012)</td>
</tr>
<tr>
<td></td>
<td>Reduce lifecycle waste</td>
<td>Tons of waste generated per capita-mi</td>
<td></td>
</tr>
</tbody>
</table>
Connecting Sustainability Metrics with Spatial Mapping Tools

• Data Needs
• Standards

Spatial Metrics

• Transportation Infrastructure
• Land Use
• Natural Resources
• Demography

Base Data Layers

• Location-specific environmental impacts
• Areas to avoid

Advanced Data Layers
Example: Rail Emission Impact Modeling

Three-Step Analysis

Hot Spot Identification
- Number of trains
- Speed
- Line haul vs. switching operation
- Rail Yards/Stations

Location-Specific Modeling
- Grade-crossing
- Train traffic
- Freight focus
- Tonnage/Carloads
- Fuel efficiency
- Emission factor

Impact Analysis
- Existing land use
- Demography

Rail Emission Hot Spots

Data sources: U.S. DOT Bureau of Transportation Statistics, Federal Railroad Administration
Emission Estimates from Freight Rail
- Particular Matter
Community Exposure to Freight Rail Emissions

Overlay map with income

Overlay map with land use

Data sources: U.S. DOT Bureau of Transportation Statistics, Federal Railroad Administration
Web Mapping Tool – Overview

• Publicly accessible at **NURAIL.UIC.EDU**
• Free Tool
• Customizable Data Display
• Customizable Study Area
  – Users can hand draw one point, multiple points, a line, or an area on map
• Optional Buffer Specification
  – Users can specify a buffer distance surrounding the specified area (e.g., 1000 feet, one mile, etc.)
• Summary Data of Interest in Selected Area
Web Interface
Example 1

IDENTIFY ACREAGE OF ENVIRONMENTALLY SENSITIVE LANDS TO BE AFFECTED BY A PROPOSED CORRIDOR
Step 1: Select Habitat Data Layers for Display

1. Select Layers to Show

- **Layers**
  - Transit Routes
  - Rail Infrastructure
    - Intermodal Terminal
    - Grade Crossing
    - Public Transit Facility
    - Railroad Speed
  - Community Profile
    - County Boundary
  - Land Use
  - Safety
    - Rail Safety Performance
    - Natural Hazard Areas
  - Livable Communities
    - Transit Accessibility
    - Cultural Resources
  - Transit Equity
    - Median Household Income
  - Environmental Sustainability
    - Modeled Air Emissions
    - Groundwater
- **Habitat**
  - Bird Presence
  - Critical Habitat
  - Natural Area
  - Riparian Zone
Step 2: Hand Draw a Corridor/Line
Step 3: Choose a Buffer Distance

1. Select Layers to Show
2. Draw Area of Interest
3. Specify Buffering Parameters

**Buffer Distance:**
3

**Buffer Unit:**
Miles

Apply Buffering  Cancel Buffering
Step 4: Retrieve Summary Data

Selected Area:
Area: 66.54940033094927 km²
Length: 37.77144525418259 km

Buffered Area:
Area: 241.67799852973138 km²
Length: 59.82499710241312 km

Note: The numbers here are for illustration purpose only.
Example 2

ASSESS IMPACTS ASSOCIATED WITH RAIL INFRASTRUCTURE AND TRAFFIC IN A SPECIFIC NEIGHBORHOOD
- Potential Interest of the General Public
Step 1: Select Rail Infrastructure Data Layers for Display
Step 2: Hand Draw an Area/Polygon of Interest
Step 3: Proceed without a Buffer

1. Select Layers to Show
2. Draw Area of Interest
3. Specify Buffering Parameters

Would you like to buffer the area?

Yes  No, go to next step

Note: If the shapes you have drawn are points or lines, you need to specify a buffer area in order to let the tool work properly.
Step 4: Retrieve Summary Data

Selected Area:
Area: 3.50319679402023 km²
Length: 7.016899641604823 km

Public Transit Facility

<table>
<thead>
<tr>
<th>id</th>
<th>Station</th>
<th>Street Address</th>
<th>RTS SRVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>SKOKIE</td>
<td>501 DEMPSTER ST</td>
<td>YELLOW LINE</td>
</tr>
</tbody>
</table>

Railroad Speed

<table>
<thead>
<tr>
<th>id</th>
<th>Max Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

Grade Crossing

<table>
<thead>
<tr>
<th>id</th>
<th>Railroad Operating Company</th>
<th>Type of Crossing</th>
<th>Branch or Line Name</th>
<th>Signs / Signals</th>
<th>Day Thru Train</th>
<th>Night Thru Train</th>
<th>Maximum Timetable Speed</th>
<th>Type of Development</th>
<th>Estimate Percent Trucks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>XCTA</td>
<td>3</td>
<td>SKOKIE</td>
<td></td>
<td>99</td>
<td>40</td>
<td>55</td>
<td>4</td>
<td>0.05</td>
</tr>
<tr>
<td>1</td>
<td>XCTA</td>
<td>3</td>
<td>SKOKIE</td>
<td></td>
<td>99</td>
<td>40</td>
<td>55</td>
<td>3</td>
<td>0.08</td>
</tr>
<tr>
<td>2</td>
<td>XCTA</td>
<td>3</td>
<td>SKOKIE</td>
<td></td>
<td>13</td>
<td>40</td>
<td>35</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>XCTA</td>
<td>3</td>
<td>SKOKIE</td>
<td></td>
<td>99</td>
<td>40</td>
<td>55</td>
<td>3</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Note: The numbers here are for illustration purpose only.