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Using transportation networks to inform valuation of water quality changes for saltwater recreation on Cape Cod, MA

Northeast Arc Users Group

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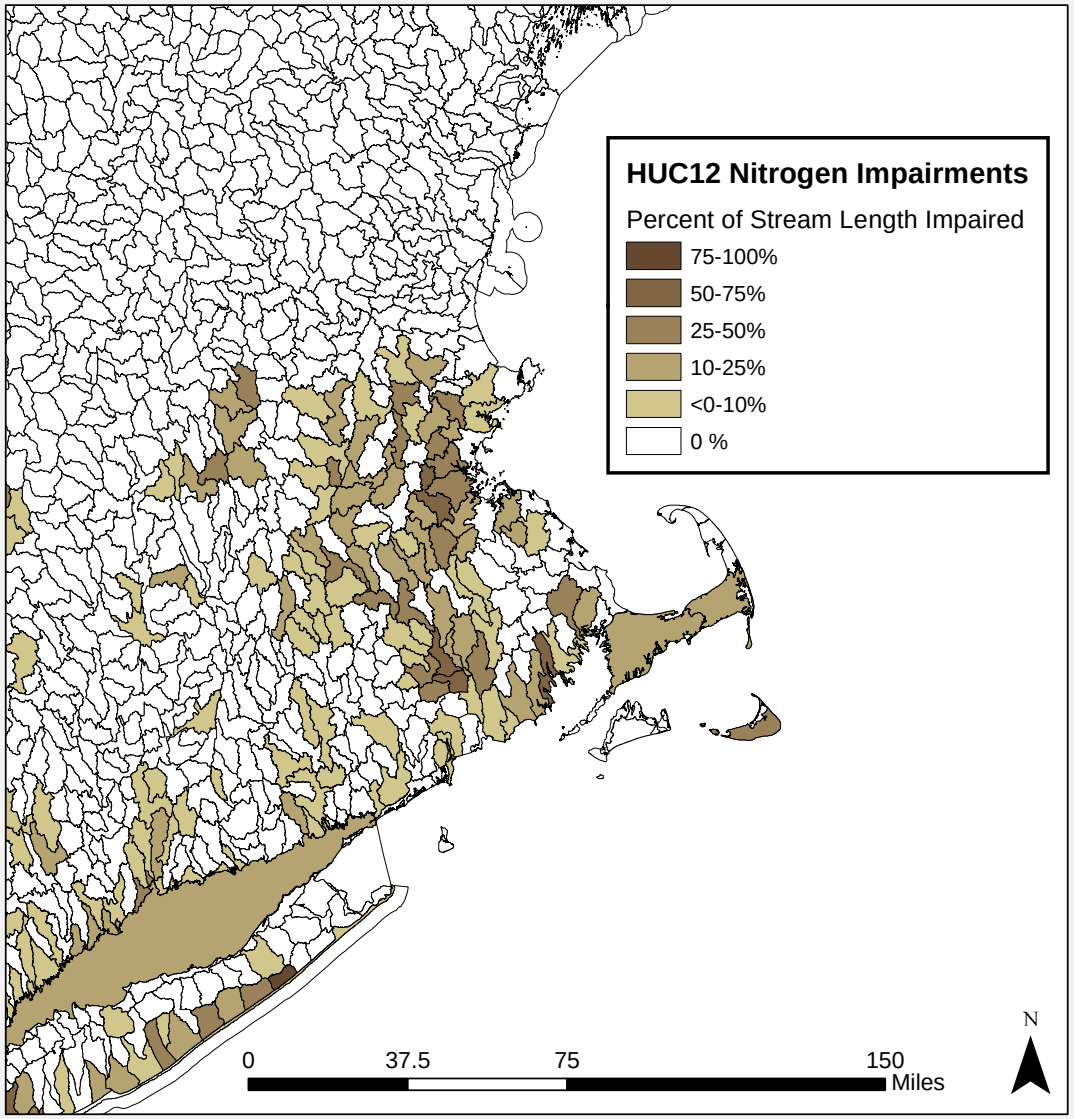
Policy Questions – Cost Benefit Analysis

- Clean Water Act (CWA) Water Quality (WQ) improvements
- Benefits are often hard to quantify

Local Applications – Cape Cod

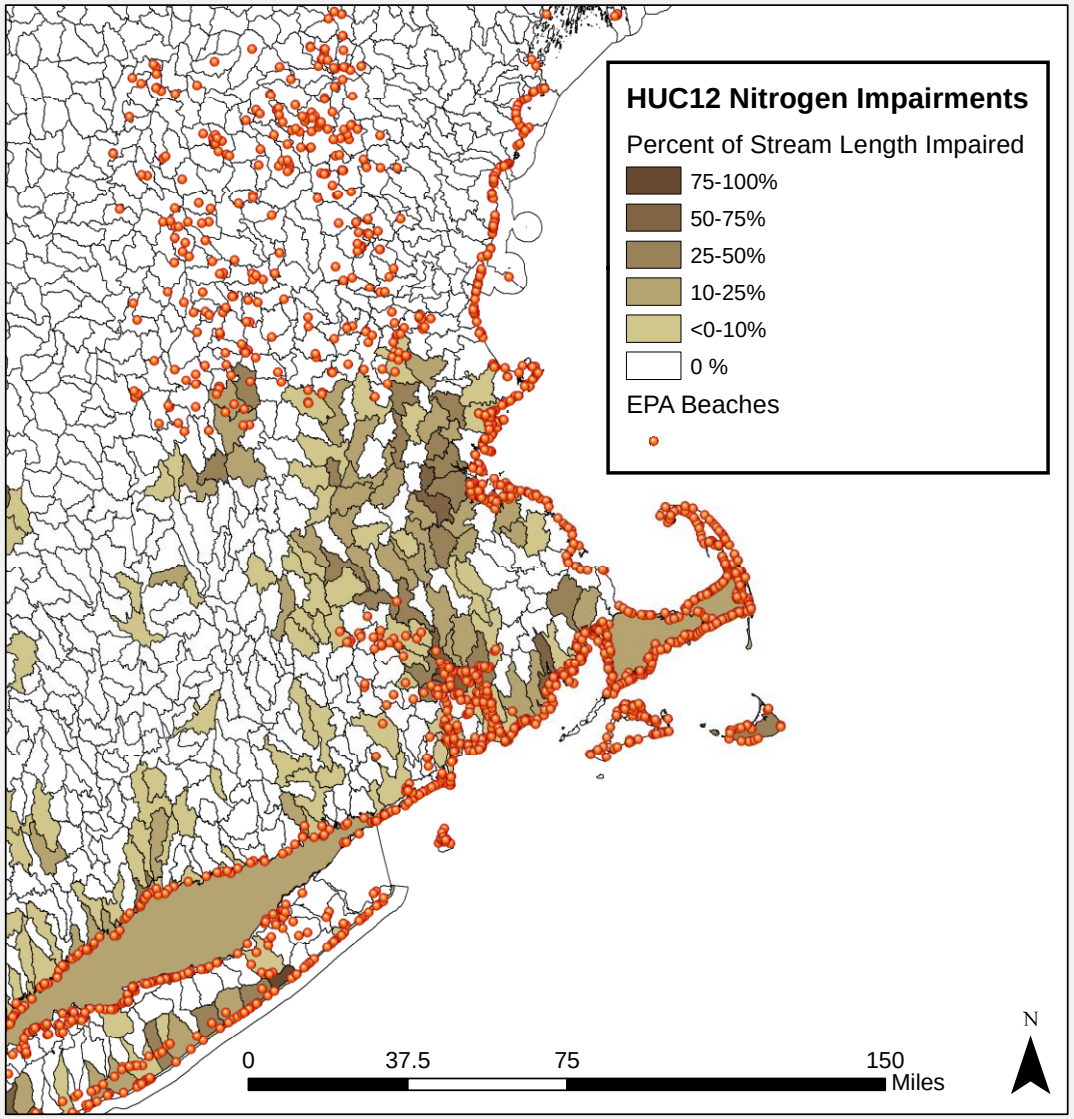
- Cape Cod is exploring ways to meet nutrient reduction requirements in their 208 plan update



Data can be found at:
enviroatlas.epa.gov/

Local Applications – Cape Cod

- Cape Cod is exploring ways to meet nutrient reduction requirements in their 208 plan update
- Water based recreation is important to Cape Cod's tourism based economy



Data can be found at:
http://tinyurl.com.h8tcu5m

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Benefits - Pieces of the Puzzle

- How many people/trips are affected by a WQ improving policy?
  - *Participation*- What water-based activities do people do?
  - *Effort*- How many trips do they take?
  - *Site choice*- Where and why?
- What is a trip worth?
  - What is the value of a current trip?
  - How does this value change as a result of the WQ improvement under consideration?

How many trips where?

Access Points From:

- EPA
- Health Department
  - ➢ Closure Data
- MORIS
- Towns
  - ➢ Participation Data

Python Toolbox for combining:
github.com/jbousquin/Py_FancyJoin

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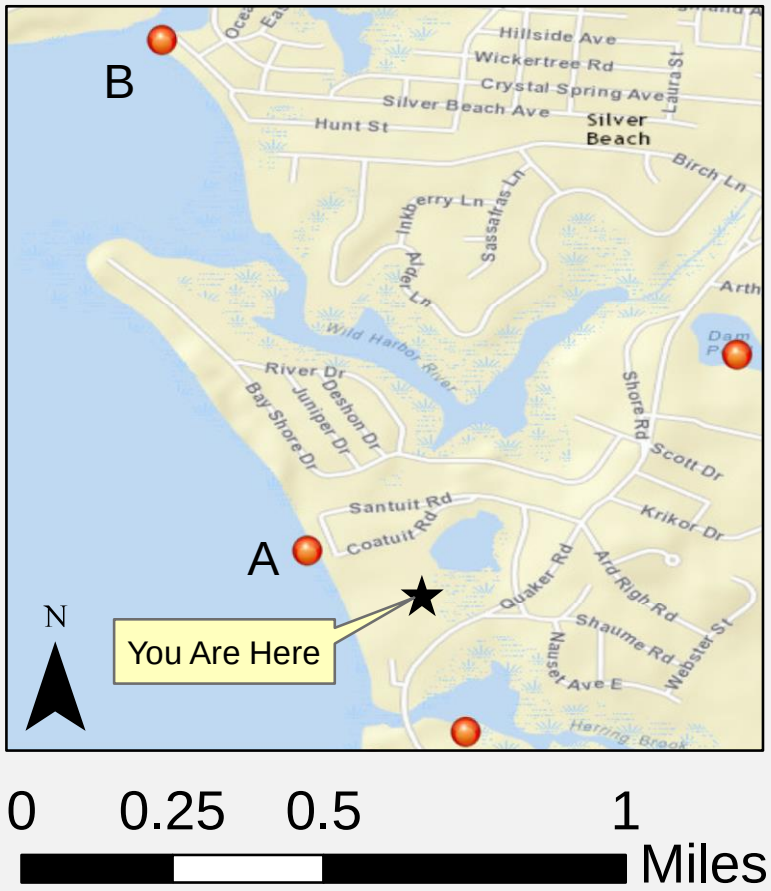
What is a trip worth?

- Travel Cost (WTP: Willingness to Pay)
  - The value of a "beach day" is equal to the cost
    - Travel distance
    - Opportunity cost of travel time

What is a trip worth?

- Travel distance

Beach	Distance (Euclidean Miles)	Cost ($0.54)
A	0.2	$0.11
B	1.0	$0.54



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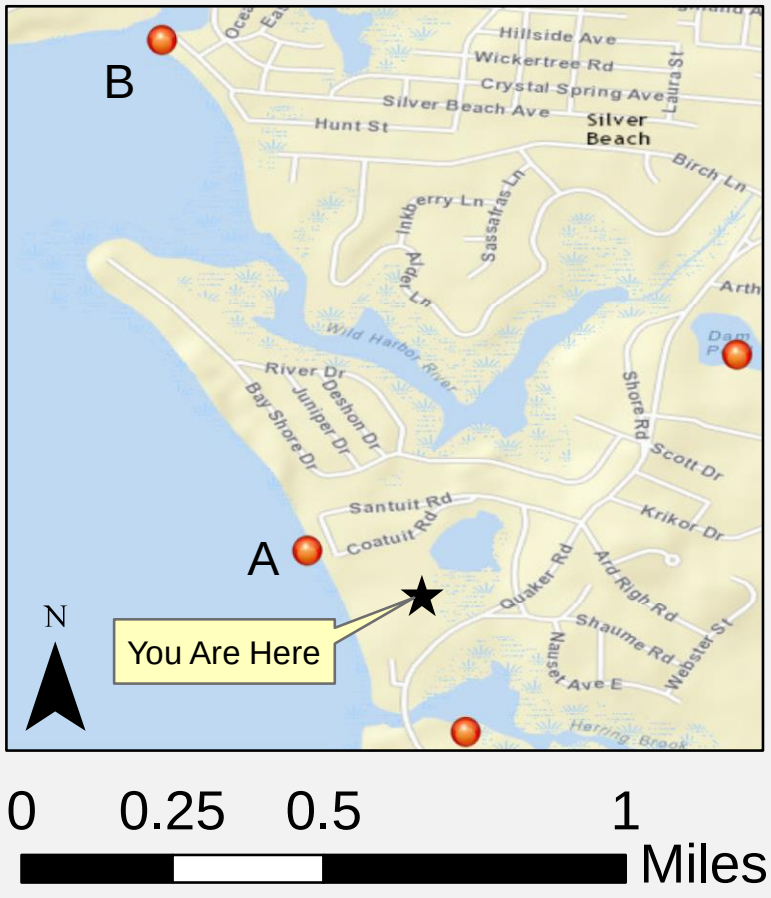
  Wage * Travel Time

Beach	Travel Time (Min)	Cost ($25/hr)
A	2	$0.83
B	10	$4.17



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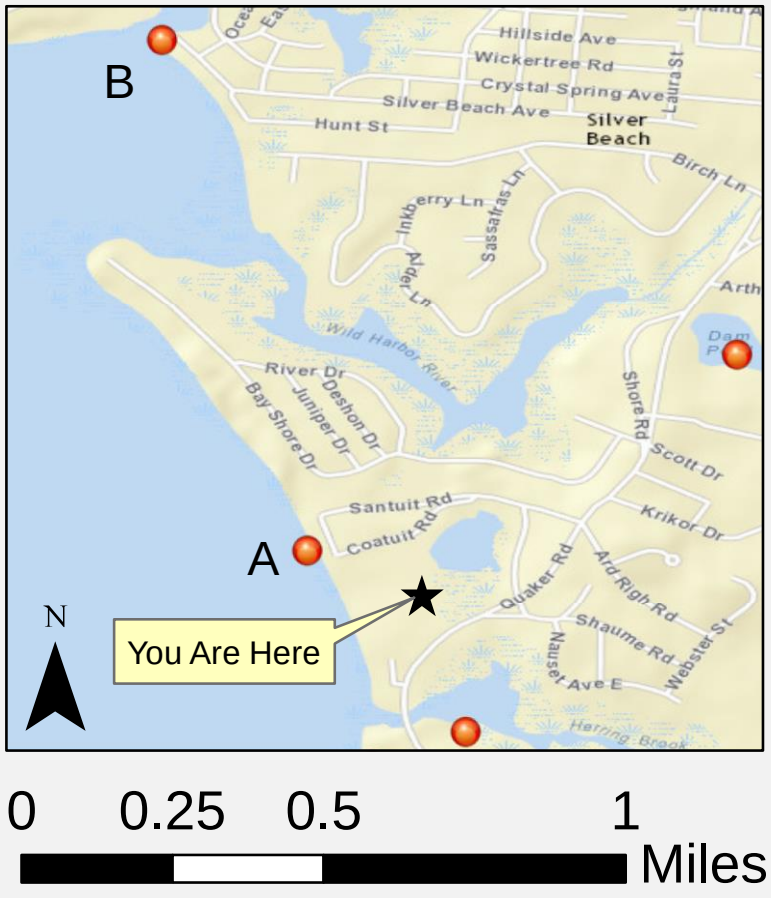
$3.77 difference in WTP



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Site Choice- Which Beach?

Discrete Choice Model

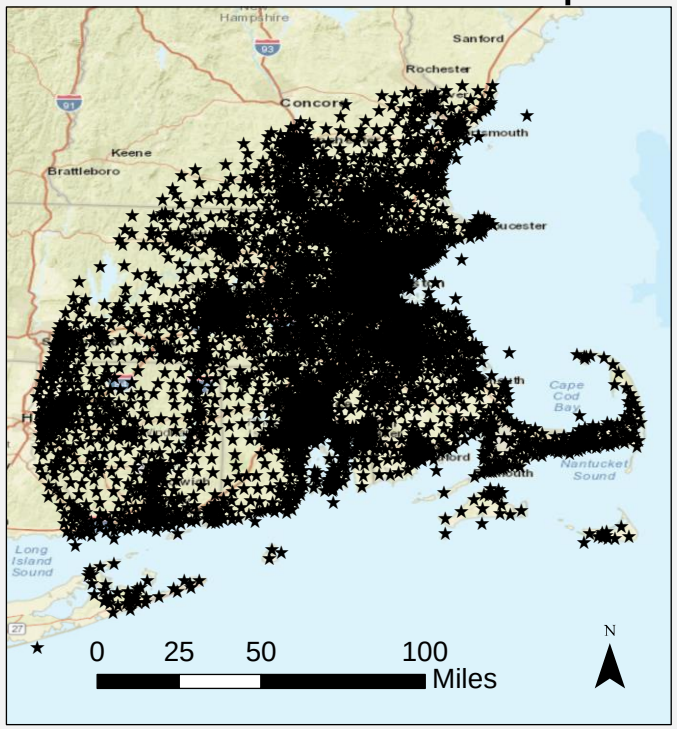
f(travel cost, demographics, beach attributes, etc.)

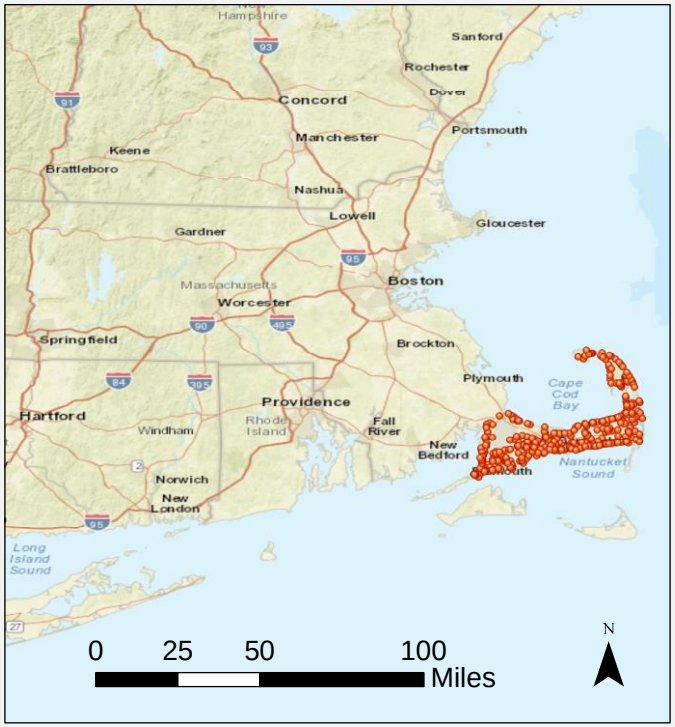
Optimize/Validate Model to Observed Participation

Data set-up

Origin- Block Centroids → Destination- Beach Points

Within 200 Miles of Cape Cod



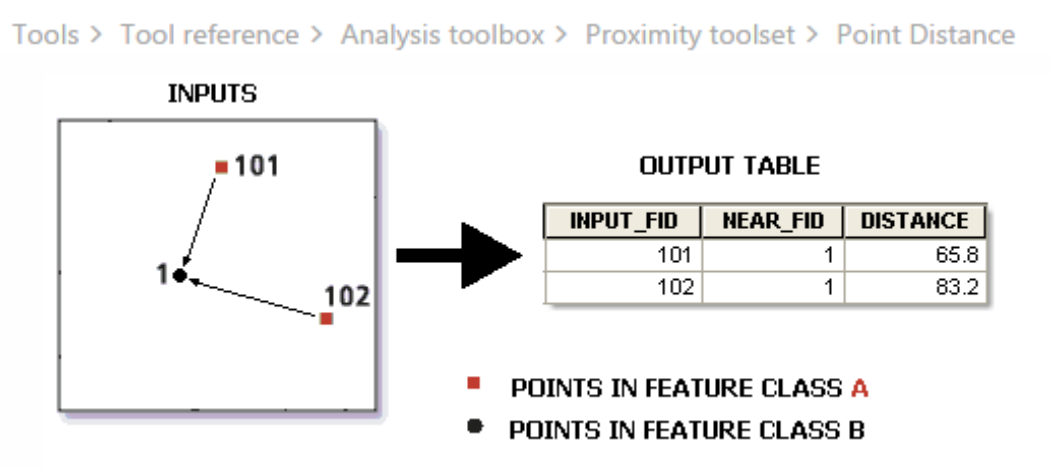


– American Community Survey (ACS)

– Includes income & demographics

Method 1: Euclidean Distance

arcpy.PointDistance_analysis(origins, destinations, out_tbl)



Advantages	Disadvantages
• Simple	• Neglects actual travel routes
• Fast (53 sec)	• Travel Time inferred

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Transportation Network Time/Distance

- ArcGIS Network Analyst
- ArcGIS Desktop Service
- ArcGIS Online Service
- OpenStreetMap - OpenSourceRoutingMachine
- Google API

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ArcGIS Network Analyst

- Must set up transportation network
- Can be run using ArcGIS Desktop (arcpy.na)
- Network Analysis using python (UC 2016):

  http://esriurl.com/uc16napy

Advantages	Disadvantages
• Fast	• Requires Network Analyst license
• Local	• Dependent on quality of network

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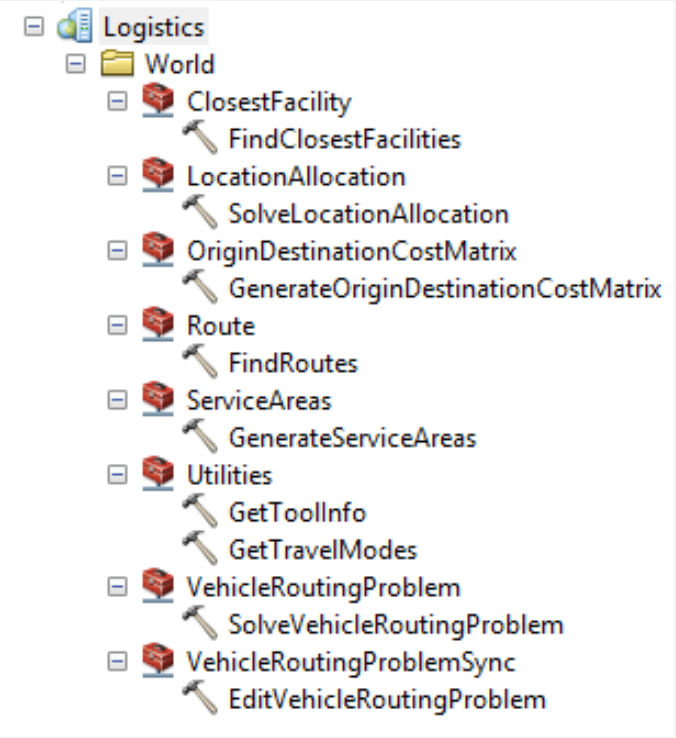
ArcGIS Desktop "Ready-to-use Service"

- Ping network on ESRI cloud
- Requires ArcGIS online account
  - Most services cost credits
- No Network Analyst Extension



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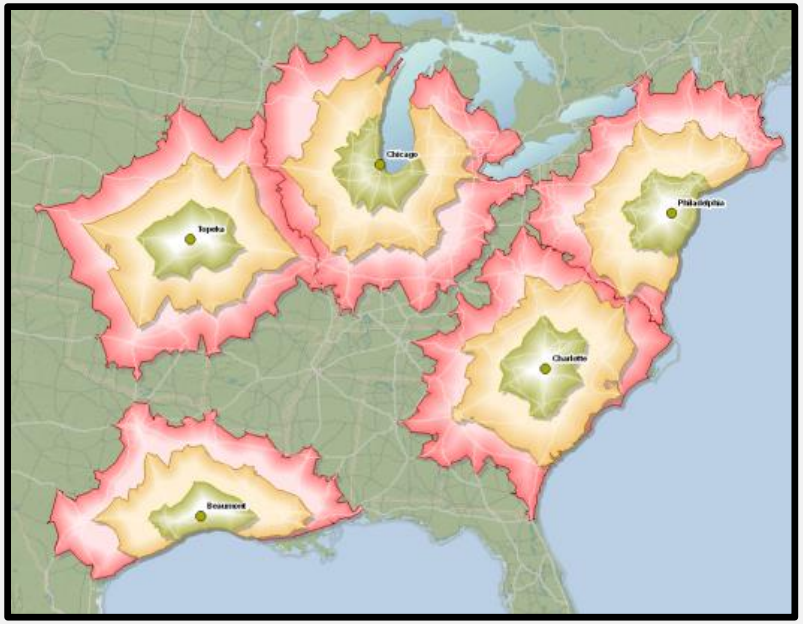
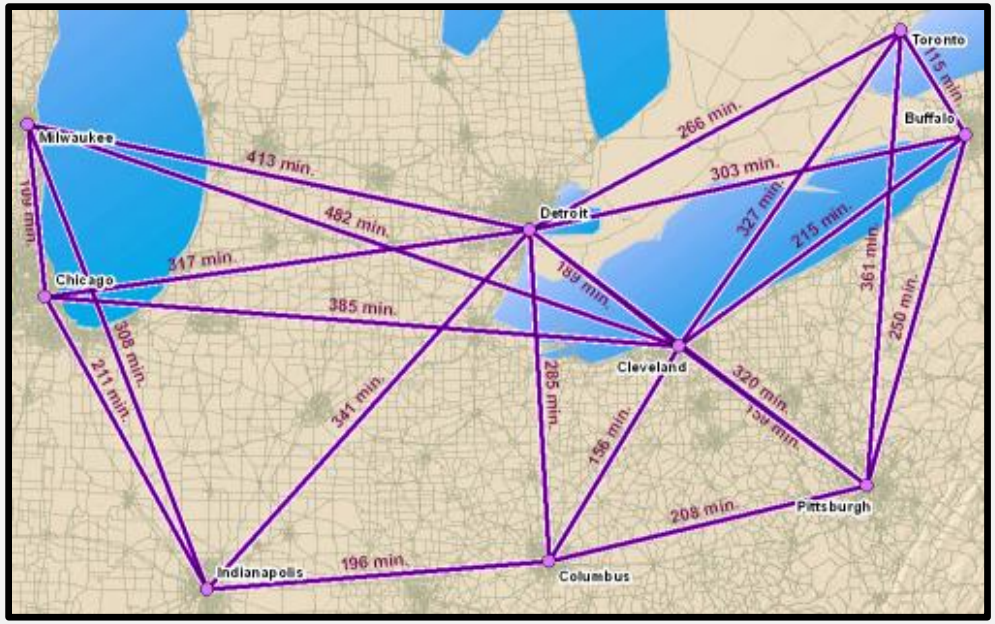
Services via Desktop

Service Areas



Origin-Destination Cost Matrix



Origin-Destination Cost Matrix

Destination Rank	Total Time (Minutes)	Total Distance (Kilometers)	Origin OID	Destination Name	Destination OID
1	80.284497	112.996539	1	ELECTRIC AVENUE	87
2	81.103471	118.889339	1	Queen Sewell Pond	16
3	82.139149	119.347598	1	SCENIC PARK	67
4	84.687527	122.298333	1	Jefferson Road	137

2,897,208 Results

Recommended Documentation: http://tinyurl.com/j7bhaxr

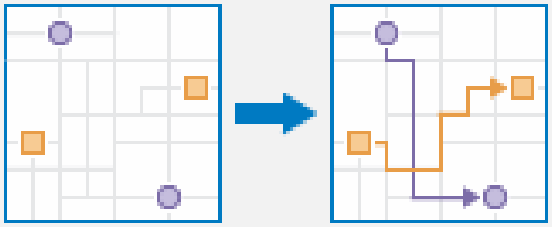
Advantages	Disadvantages
• Reasonably fast	• No geometry
• No credits (for now)	• In beta
• No extension required	• 200x200 (OxD) per request
• Uses Here network	• Snap tolerance 12.42 miles
• Traffic Data	

Python Toolbox:
Py_RecDemand/blob/master/GenerateCostMatrix.pyt

ArcGIS Online Services: Connect Origins to Destinations

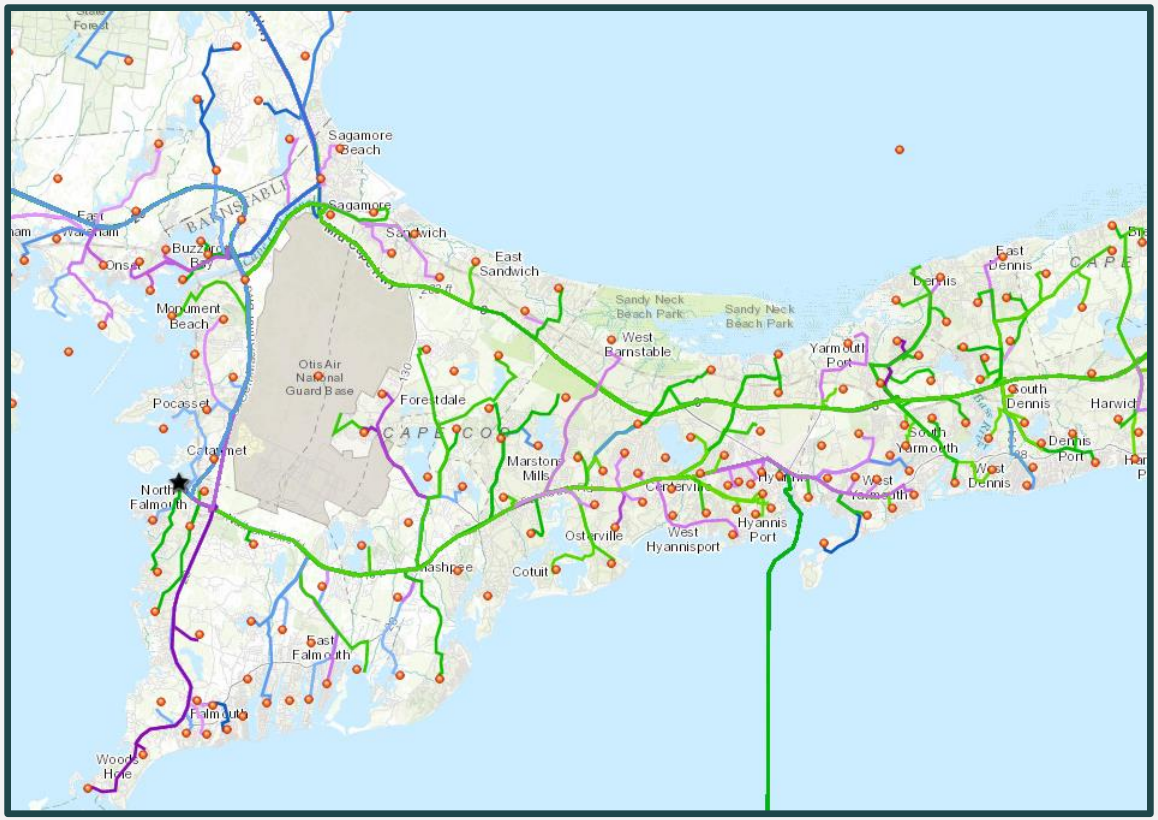
Documentation:

http://tinyurl.com/j5c33uj



Advantages	Disadvantages
• Provides Geometry	• A bit slow
• No extension required	• Could get credit expensive
• Uses Here network	• Requires paired ID
• Traffic Data	• 5,000 pairs per request
• Automatically up online	
• Unassigned O/D are easy to ID	

Connect Origins to Destinations



All Origins to 1 beach in ArcGIS Online for comparisons

Standalone py Script (under development):
Py_RecDemand/connectOriginsToDestinations_API.py

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OpenStreetMap – Open Source Routing Machine

Setup "server" on machine and run offline

Documentation:

http://project-osrm.org/

https://github.com/Project-OSRM/osrm-backend

Python Wrapper:

https://github.com/ustroetz/python-osrm

Advantages	Disadvantages
• Reasonably fast	• Setting up local data
• Free	• OSRM v5 API updating
	• Hard to track errors
	• Doesn't account for traffic

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Google API

Web services > Distance Matrix API

Google Documentation: http://tinyurl.com/hww5q65

Google's Github: http://tinyurl.com/gof472n

Web services > Directions API

Google Documentation: http://tinyurl.com/hpgg2on

2011 SCAUG Paper: http://tinyurl.com/gtd8jcq

Advantages	Disadvantages
• "Free" (no arcpy)	• 2,500 free direction requests /day
• Reasonably Fast	• 50 requests/second
• Traffic Data	
• Good at finding O/D	

Py Script: Py_RecDemand/blob/master/GoogleAPI/TravelTimeGoogle.py

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Early Results

	Calc Time	Traffic Data	Cost
Euclidean Distance	1 Min	NO	Free**
ArcGIS Desktop Service	6-8 Hours	YES	Free**
ArcGIS Online	Days	YES	Credits
OSRM	Hours	NO	Free
Google API	16 Hours*	YES	Free

*Free use restrictions on Google API mean it will take 5 days
** Free with arcpy/ArcGIS

Next Step: Compare calculated distance and times

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Questions

- Github:
  - Slides
  - Scripts

- Email:
  - Bousquin.justin@epa.gov