



Evaluate the sessions

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Open Source Tools for Spatial Optimization

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**Optimization is about balance:
maximizing an objective within
constraints**

**Optimization is crazy useful. It is a way
to solve many high-impact real world
problems**

**Lots of general open source
optimization tools available, but many
algorithms still need spatialization.**

Points

prime location

Lines

choice path

Areas

elegant configuration

Time

scheduling



GIS is very good at
overlay, measurement,
select, and comparison

10	9	8	9	12	11	12	13
9	8	7	8	10	9	8	12
9	9	8	6	8	7	10	11
10	9	8	7	5	8	9	10
9	8	7	7	4	8	8	11
8	7	5	3	5	6	9	9
4	3	2	4	6	9	7	9
2	1	3	6	7	8	9	10

(a)

↘	↘	↓	↘	↘	↘	↓	↘
→	→	↘	↓	↘	↓	↘	←
↗	↗	→	↘	↓	↘	←	↗
↘	↘	↗	↘	↓	↘	↗	↘
↘	↘	↘	↓	↘	←	↘	←
↘	↘	↓	↘	←	←	←	↘
↘	↓	↘	←	↗	↗	↗	←
→		←	↗	↗	↗	↑	↗

(b)

0	0	0	0	0	0	0	0
0	3	8	1	0	0	5	0
0	0	0	14	0	9	0	0
0	0	0	0	26	0	0	0
0	1	1	0	30	0	2	0
0	1	2	48	11	9	0	0
0	1	57	1	1	0	4	0
0	63	0	0	0	0	0	0

(c)

0	0	0	0	0	0	0	0
0	3	8	1	0	0	5	0
0	0	0	14	0	9	0	0
0	0	0	0	26	0	0	0
0	1	1	0	30	0	2	0
0	1	2	48	11	9	0	0
0	1	57	1	1	0	4	0
0	63	0	0	0	0	0	0

(d)

Optimization

is about balance



You have an objective –

to minimize or maximize something, like
utility, cost, profit, effort, energy

but have constraints –

budget, supply, energy, attention, network,
attention, time



So why not just add optimization to GIS?

Good News. Bad News.

Good. The things that GIS does well are often good enough

Good. Existing GIS covers some optimization cases

Neutral. Optimization requires different thinking

Bad. Many of the problems cannot be solved in reasonable amounts of time. Typically, each addition to the problem creates an exponentially larger computational burden

More Good News!

Good. You are smart & computers are ever faster.

Good. There's also more than one way to approach geospatial problems: Shortcuts (i.e., heuristics) may be used that solve a problem to a near optimum solution – but in a fraction of the time. Use crafty precomputation.

Opportunities! For geospatial analysis, there's lots of workflows & heuristics that still need to be formulated and evaluated.

Opportunities! Many associated open source libraries exist; they just need to be spatially enabled.

Example Optimization Problems



Routing

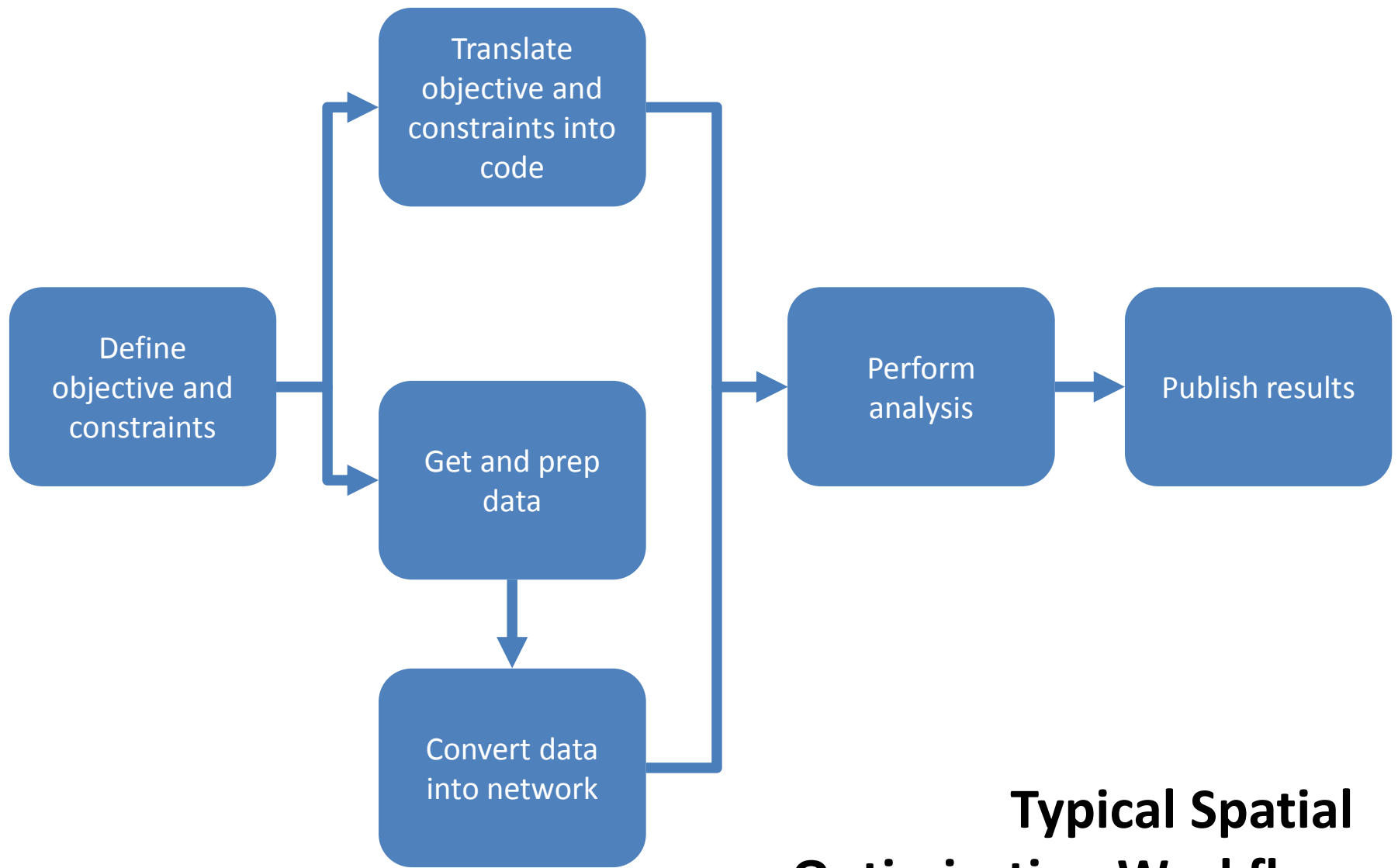
Corridor Location

Classical Transportation (Flows)

Facility Location

Zone configuration

Disruption, Fortification, and Resiliency



**Typical Spatial
Optimization Workflow**

The traditional objective-constraint approach looks like this:

$$\text{Maximize} \quad z = \sum_{i \in I} a_i y_i$$

$$\text{S.T.} \quad \sum_{j \in N_i} x_j \geq y_i \quad \text{for all } i \in I$$

$$\sum_{j \in J} x_j = P$$

$$x_j = (0, 1) \quad \text{for all } j \in J$$

$$y_i = (0, 1) \quad \text{for all } i \in I$$



Code and data: <https://github.com/glennon/redlandspath>

Many, many specialty, open source routing libraries.

- <http://wiki.openstreetmap.org/wiki/Routing>
- http://en.wikipedia.org/wiki/Category:Routing_algorithms
- <http://www.opentripplanner.org>
- <http://pgrouting.org> (extension for PostGIS)
- <http://project-osrm.org> (super fast via contracted hierarchies)

Transportation Extravaganza!

2:15 PM - AequilibraE - A free QGIS add-on for transportation modeling

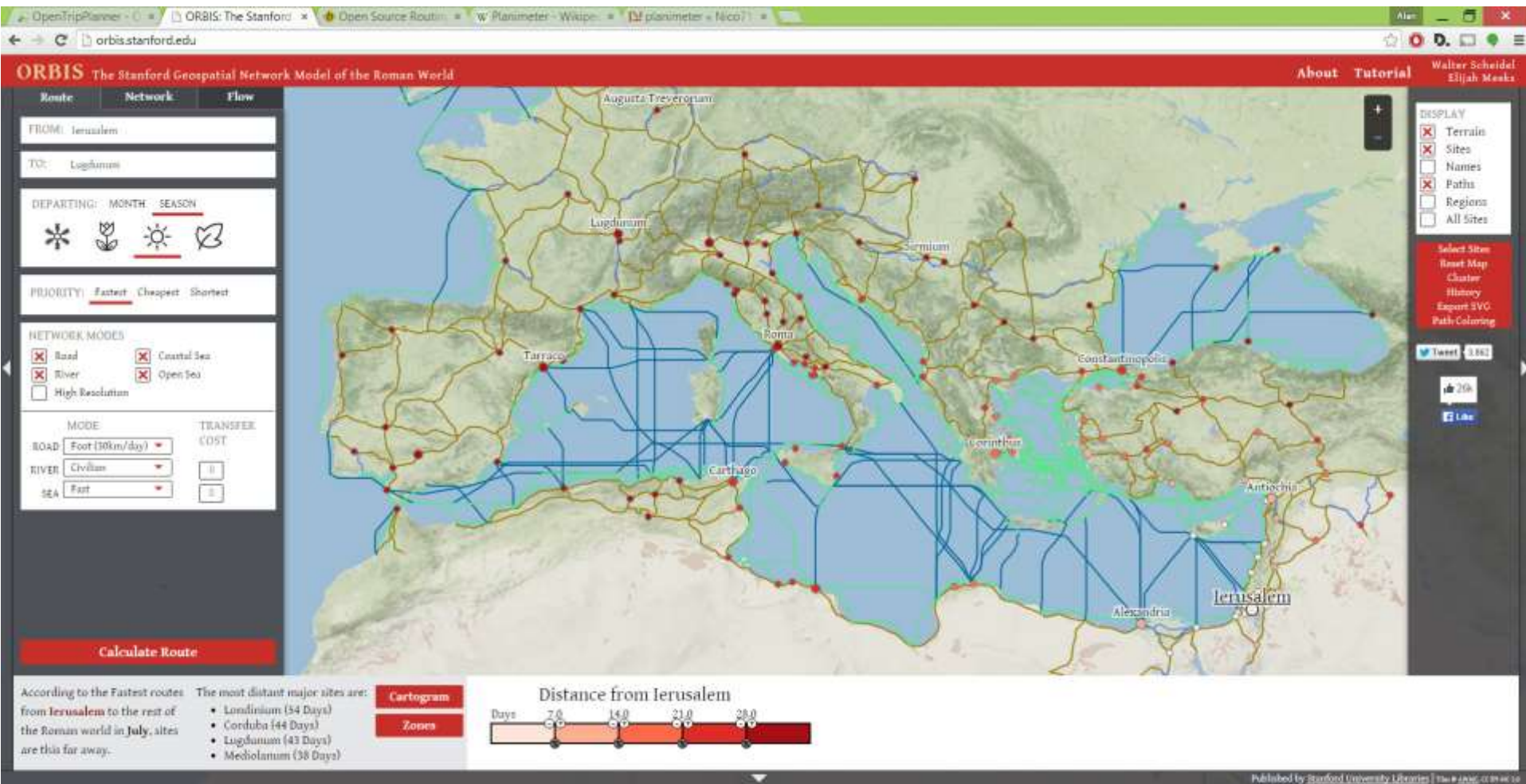
3:00 PM - Which Way Is Inbound? A Journey with SF Muni and Directional Statistics

4:15 PM - Beyond routing with OSRM: Network analysis and complex spatial queries

Corridor Location – ORBIS, Stanford's Geospatial Model of the Roman World; *orbis.stanford.edu*

ORBIS code: https://github.com/emeeeks/orbis_v2

Recast: <https://github.com/memononen/recastnavigation>



Example Optimization Problems



Routing

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Base File

Stan_withMinAcres

Field	Value
S Unit	-
Area	-
Treated	-
Habitat	-
WUI	-
Volume	-

Schedule

Objective Value: 2775176

Layers

☒ Stan (BASEFILE)

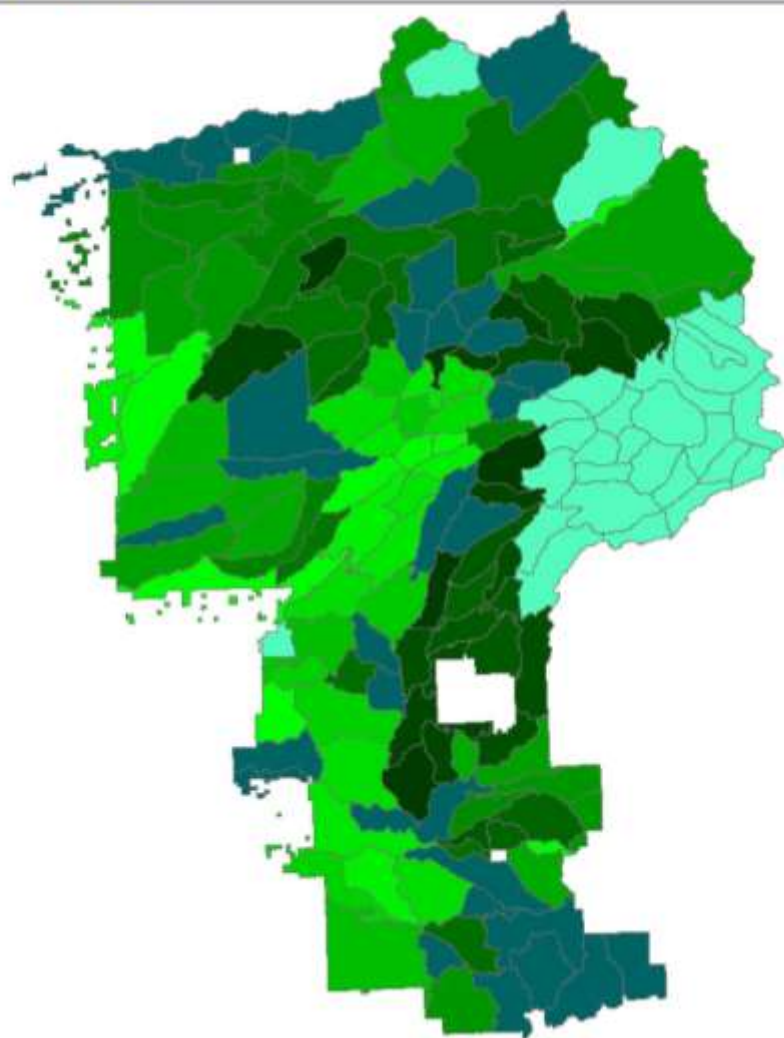
Schedule

Schedule: Stan18889w01r1c

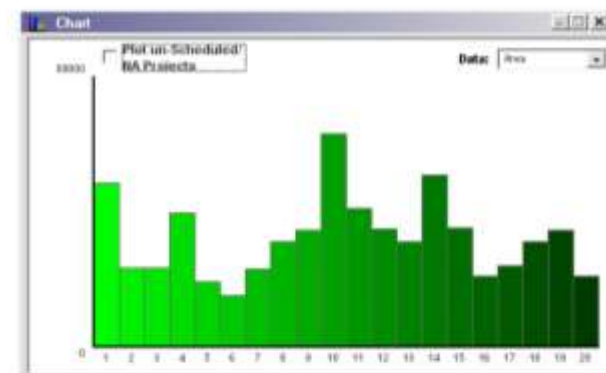
Color: Green

USDA UAS

IFASST - Initial Forest Activities Spatial Scheduling Tool V1.5



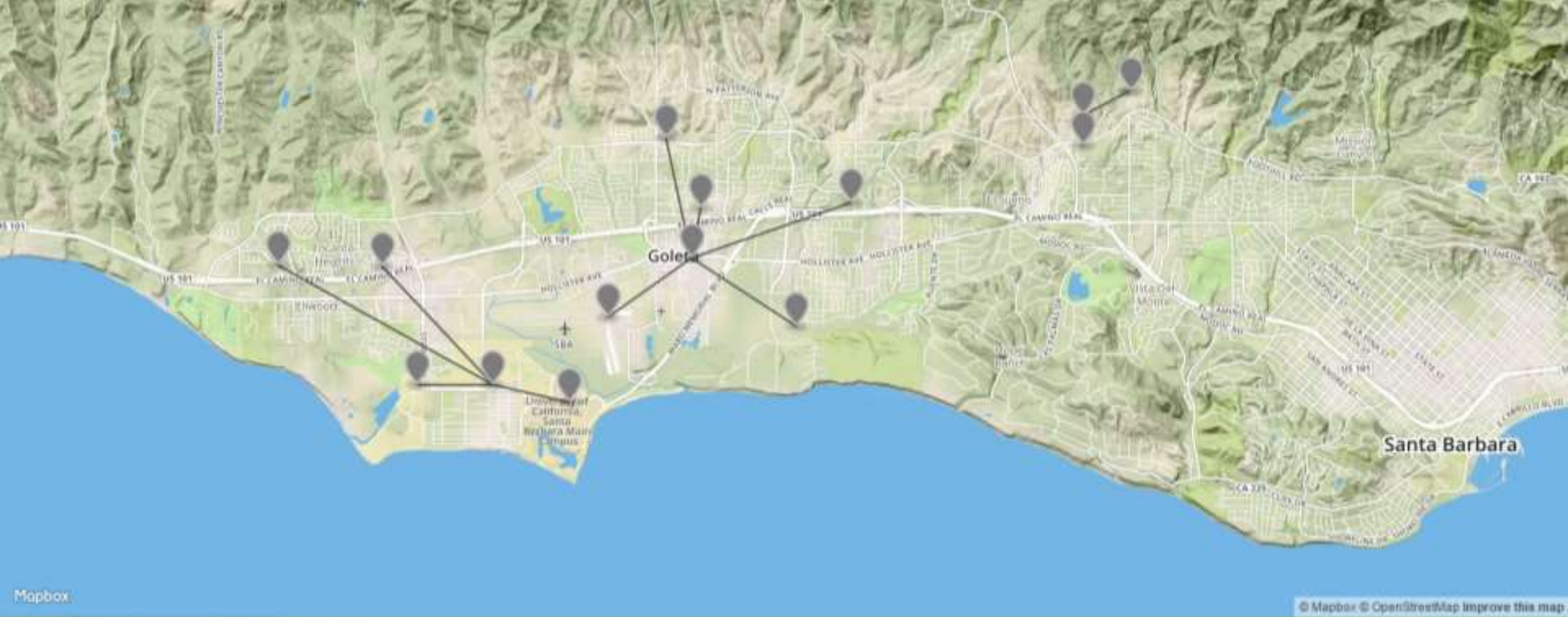
Heuristic						
Description	Weights	Prio Project		Constraints		
Maximize number of project adjacencies	1	\$ Unit		Time Per	Habitat	Revenue
		1	0	1	1200	30000
Maximize # of times at least 1 project is completed in each planning unit period	1	2	0	2	1200	30000
		3	0	3	1200	30000
Maximize treated area	1	4	0	4	1200	30000
		5	0	5	1200	30000
Maximize discounted wildland-urban interface	1	6	0	6	1200	30000
		7	0	7	1200	30000
Evenflow treated acreage	1	8	0	8	1200	30000
		9	0	9	1200	30000
		10	0	10	1200	30000
		11	0	11	1200	30000



Matt Niblett
Timber Harvests
(Mapwindows; MPL License 1.1)

Google Operation Research
Tools (Apache License 2.0)

Gnu Linear Programming Kit
(GNU General Public License 3)



Sample p-median demo

<http://data-doc.geog.ucsb.edu/MapBoxPM4.php>

Other spatial examples within the repo:

<https://github.com/google/or-tools>

**Applied Research on Geographic Information
@arogi**

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