



NEW ENGLAND COMPLEX SYSTEMS INSTITUTE
solving problems of science and society

Geographical Social Interaction Patterns and their Usage

Leila Hedayatifar

leila@necsi.edu

www.necsi.edu

www.endcoronavirus.org

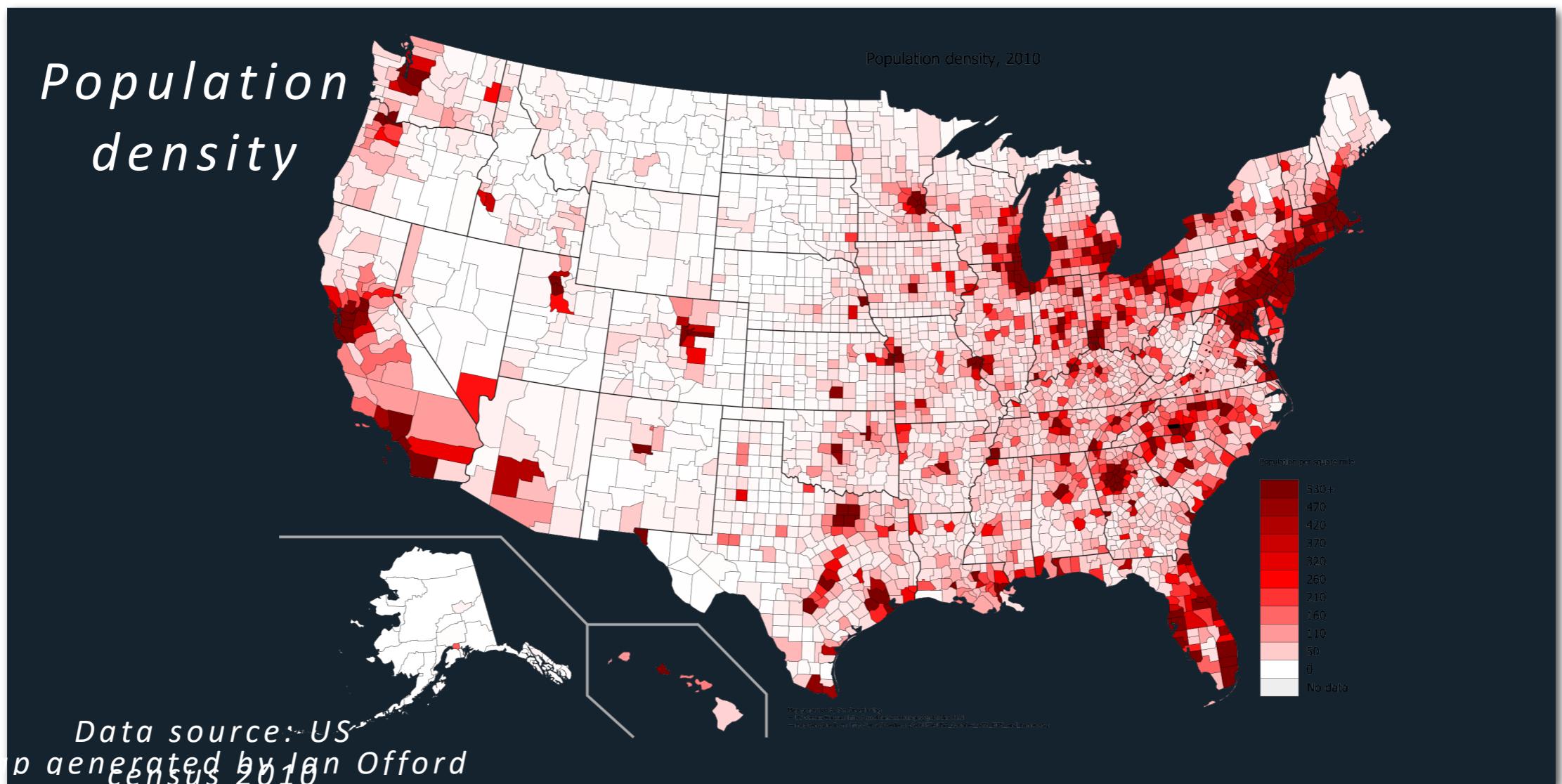
Societies are highly connected



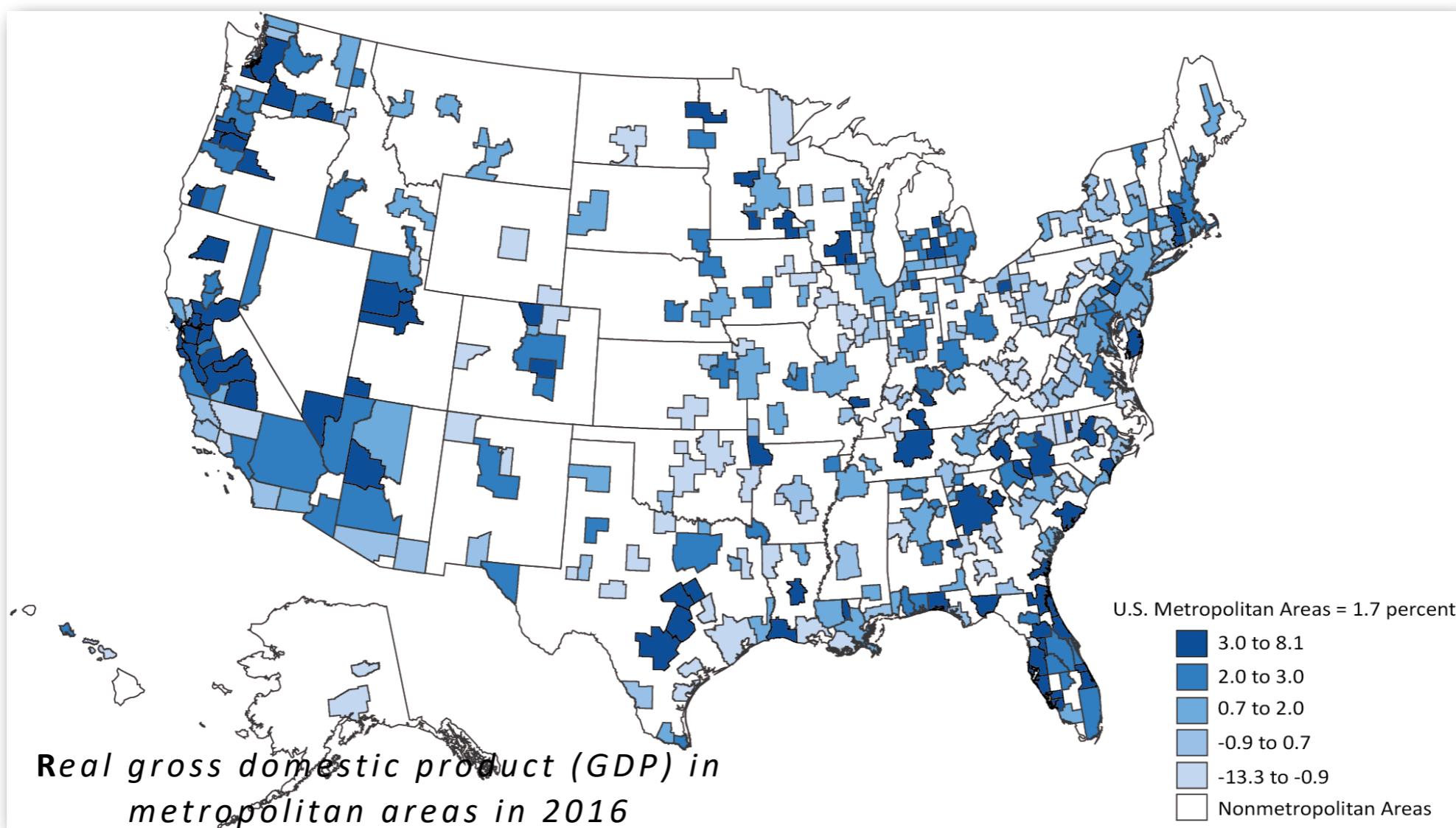
Created by Alfredo J. Morales

Societies are polarized and fragmented

Structure of societies is heterogeneous



Structure of societies is heterogeneous



<https://howmuch.net/articles/gdp-by-metro-2017>

https://www.bea.gov/newsreleases/regional/gdp_metro/2017/gdp_metro0917.htm

Importance of Geographical Social Patterns

- Spread of innovation
- Changes in business and culture
- Development of regional and national events
- Flow of information
- Spread of disease

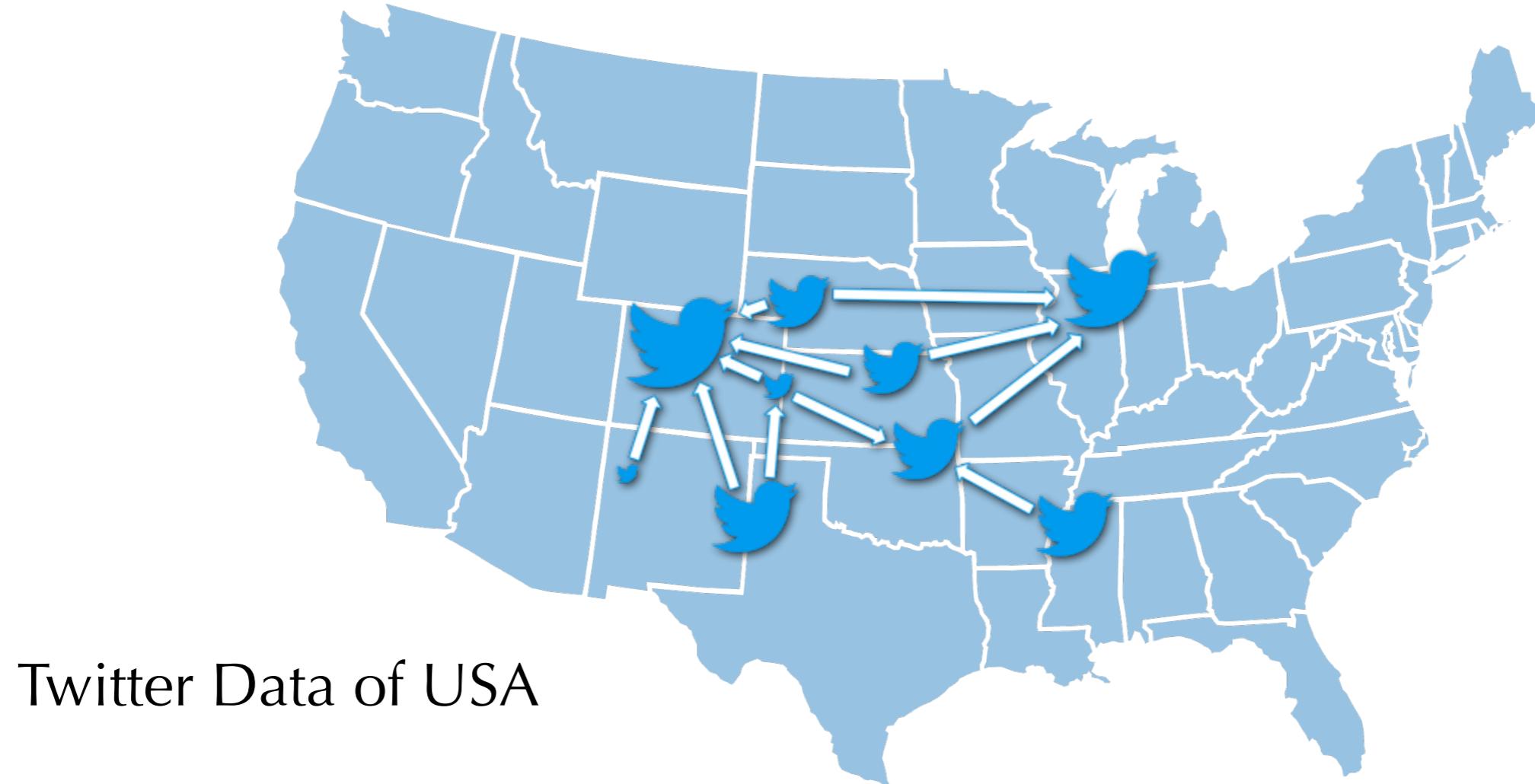
Mobility Patterns

Mobility patterns can be characterized in three overarching concepts:

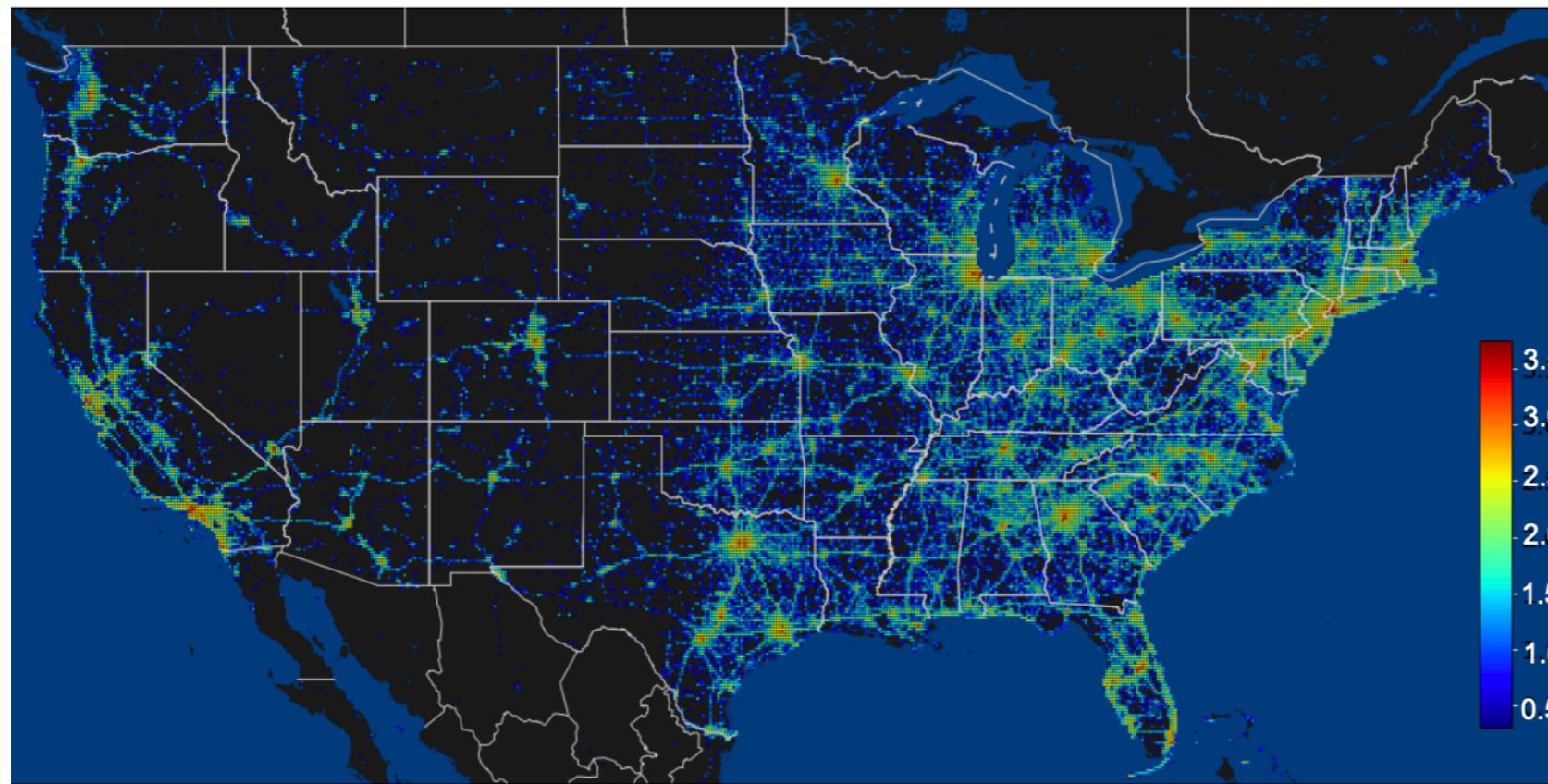
- Short distance movements (grocery shopping, walking)
- Medium distance movements (travel to neighborhood cities for job or fun)
- Long distance movements (travel to other cities for vacation or visiting families).

Combination of these habits in a **self-organized manner** form multi-scale movement patterns.

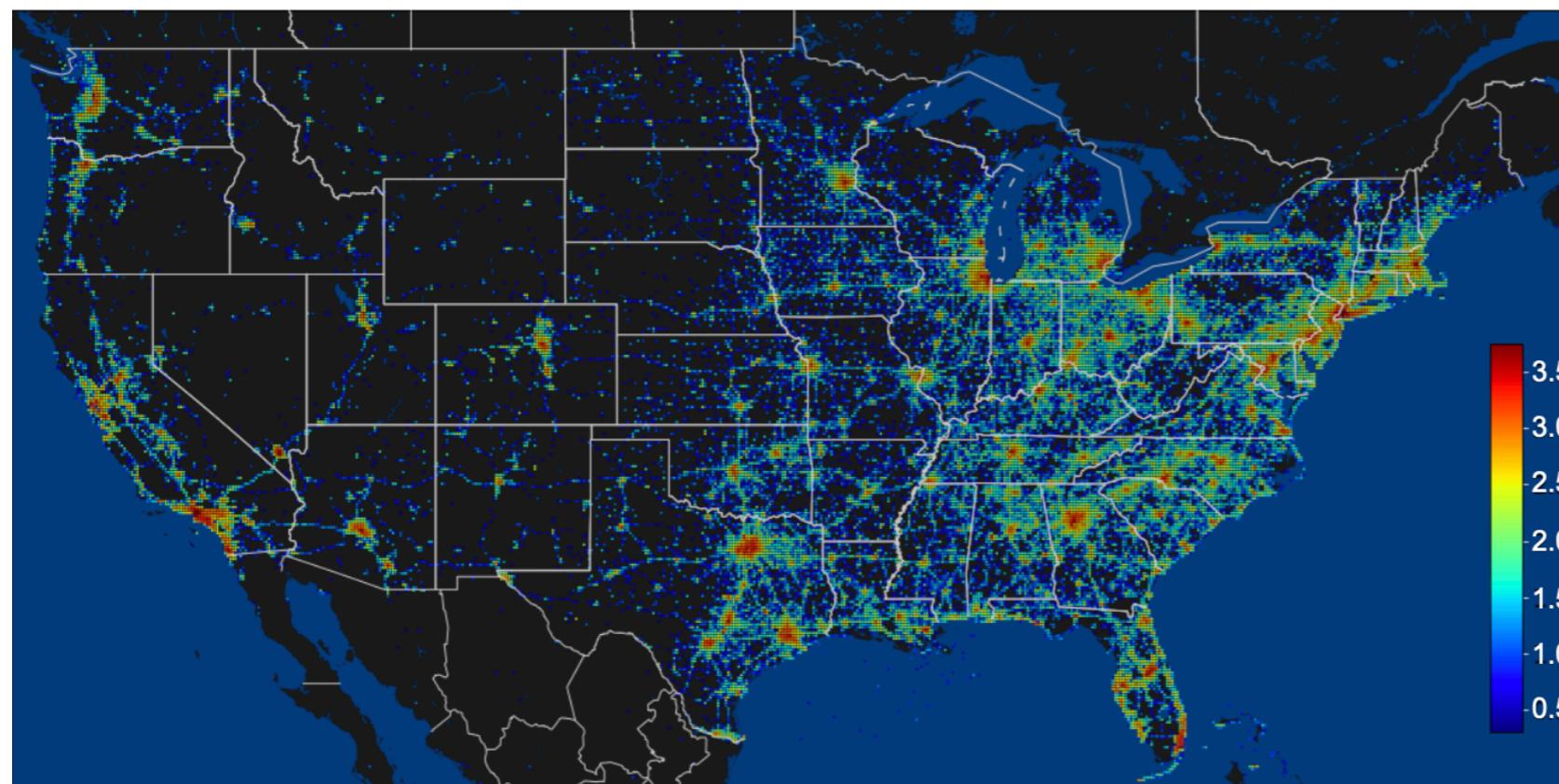
Adaptability of communication and mobility patterns



Hedayatifar L, Rigg RA, Bar-Yam Y, Morales AJ. 2019 US social fragmentation at multiple scales. J. R. Soc. Interface 16: 20190509. <http://dx.doi.org/10.1098/rsif.2019.0509>

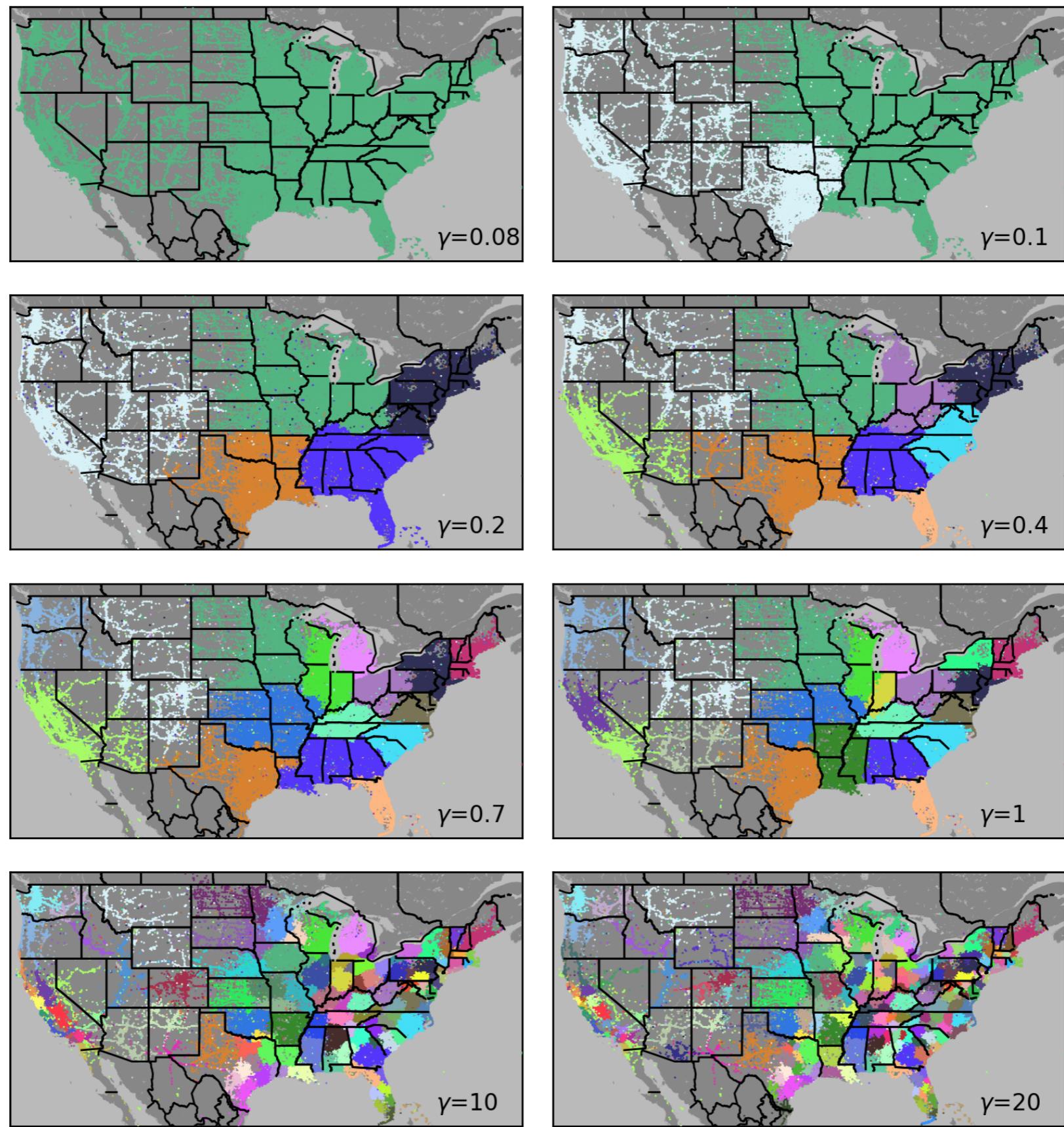


Mobility network

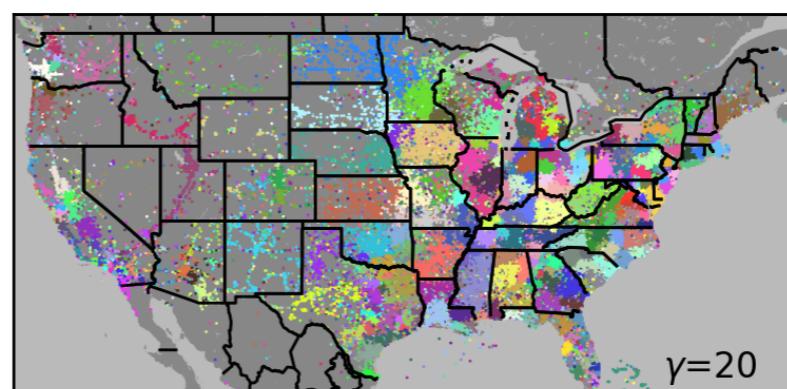
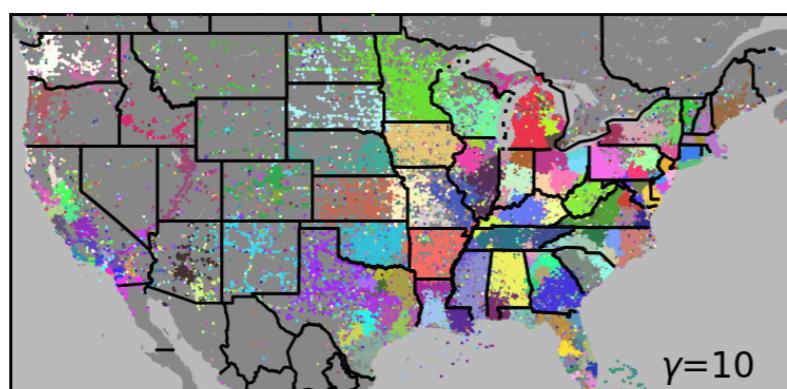
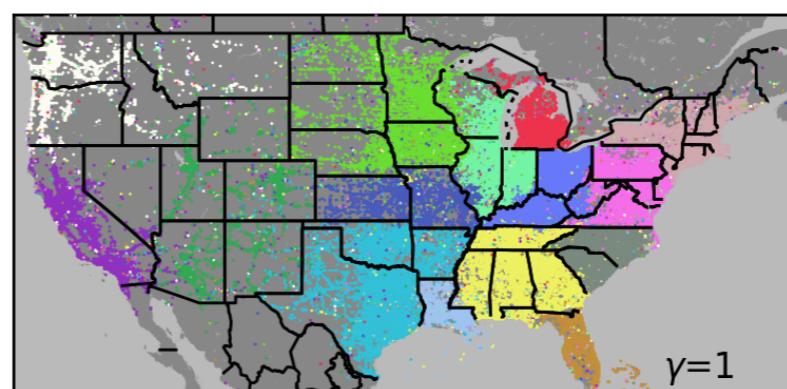
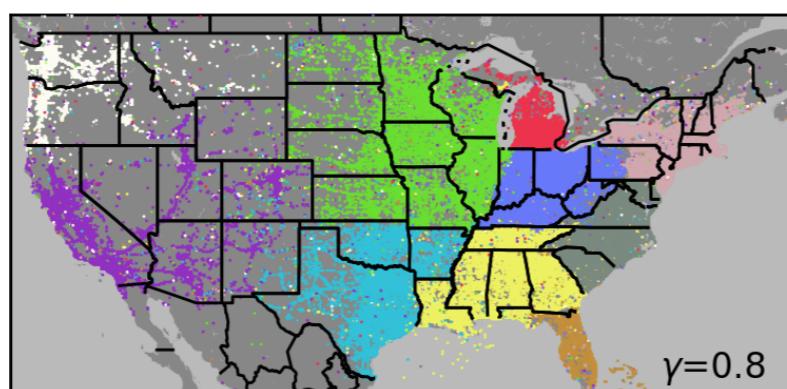
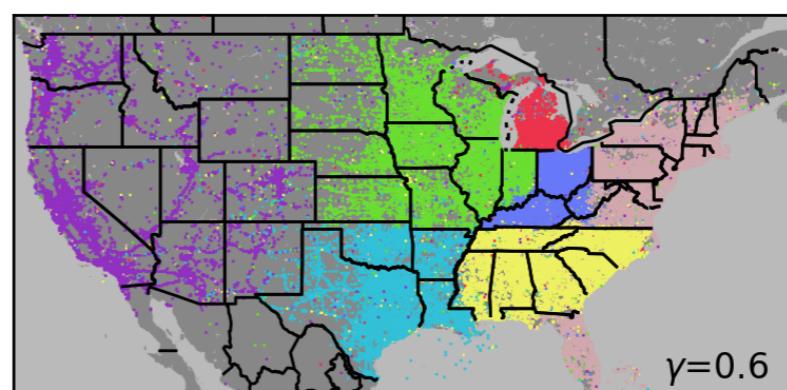
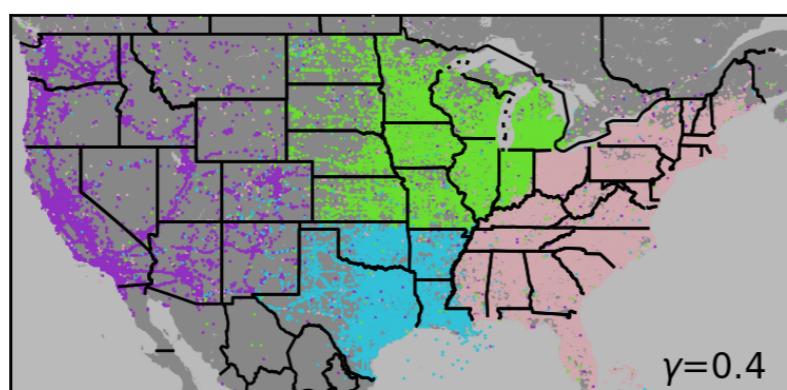
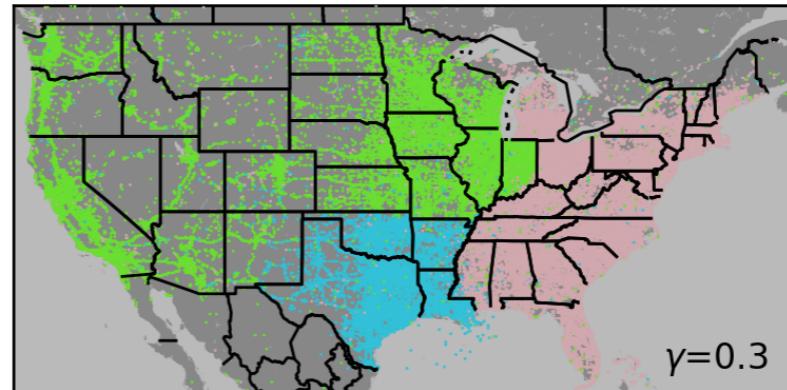
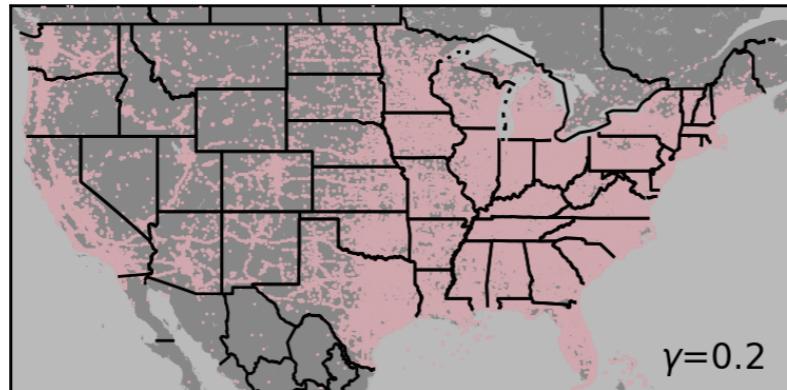


Communication network

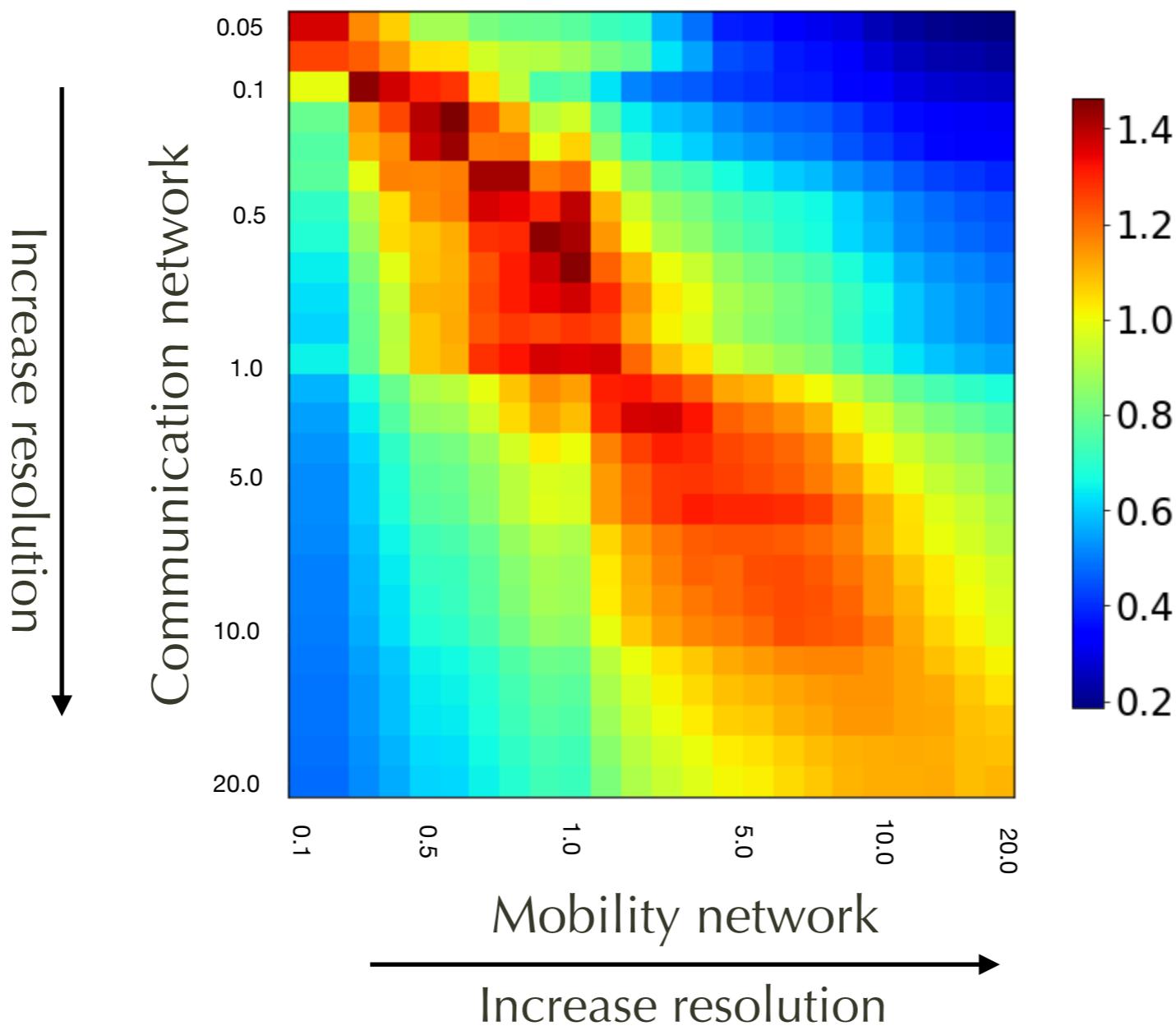
Mobility Network



Communication Network

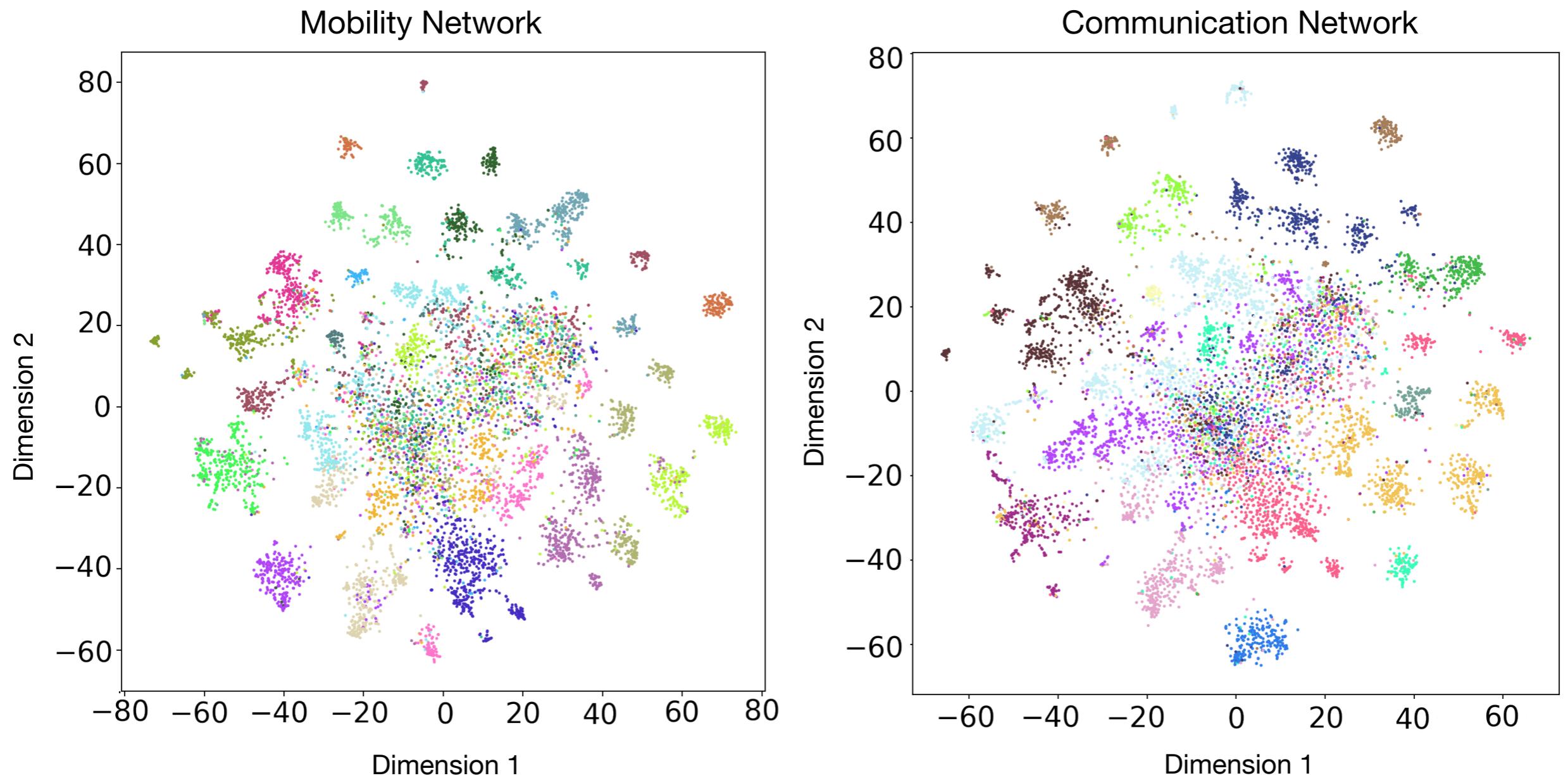


Similarity of the Networks by Communities

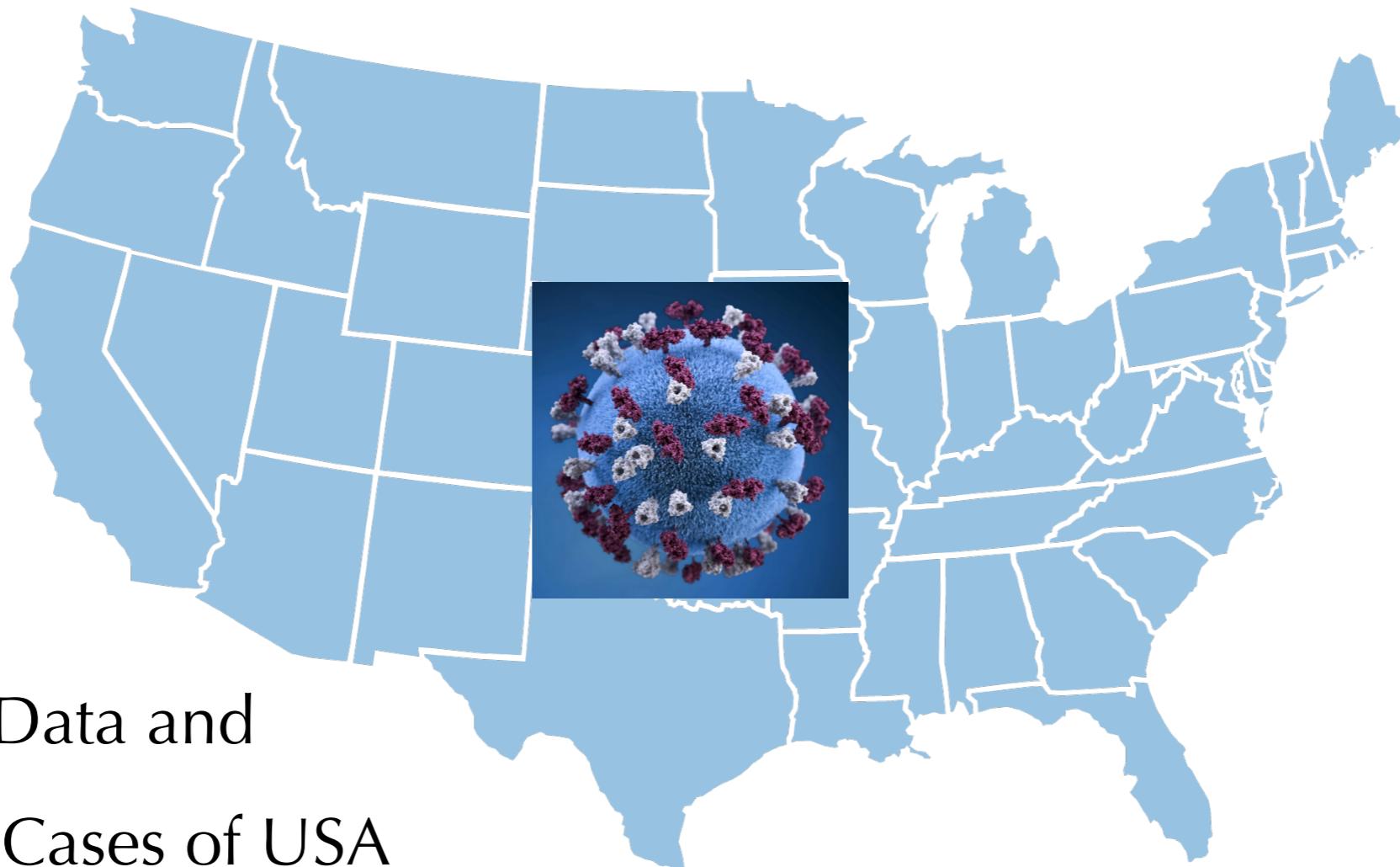


Average of three scores (Purity, Adjusted_Rand and Fowlkes_Mallows) for different values of resolution parameter in both networks.

Content Similarity of Communities



Strategizing COVID-19 Lockdowns Using Mobility Patterns



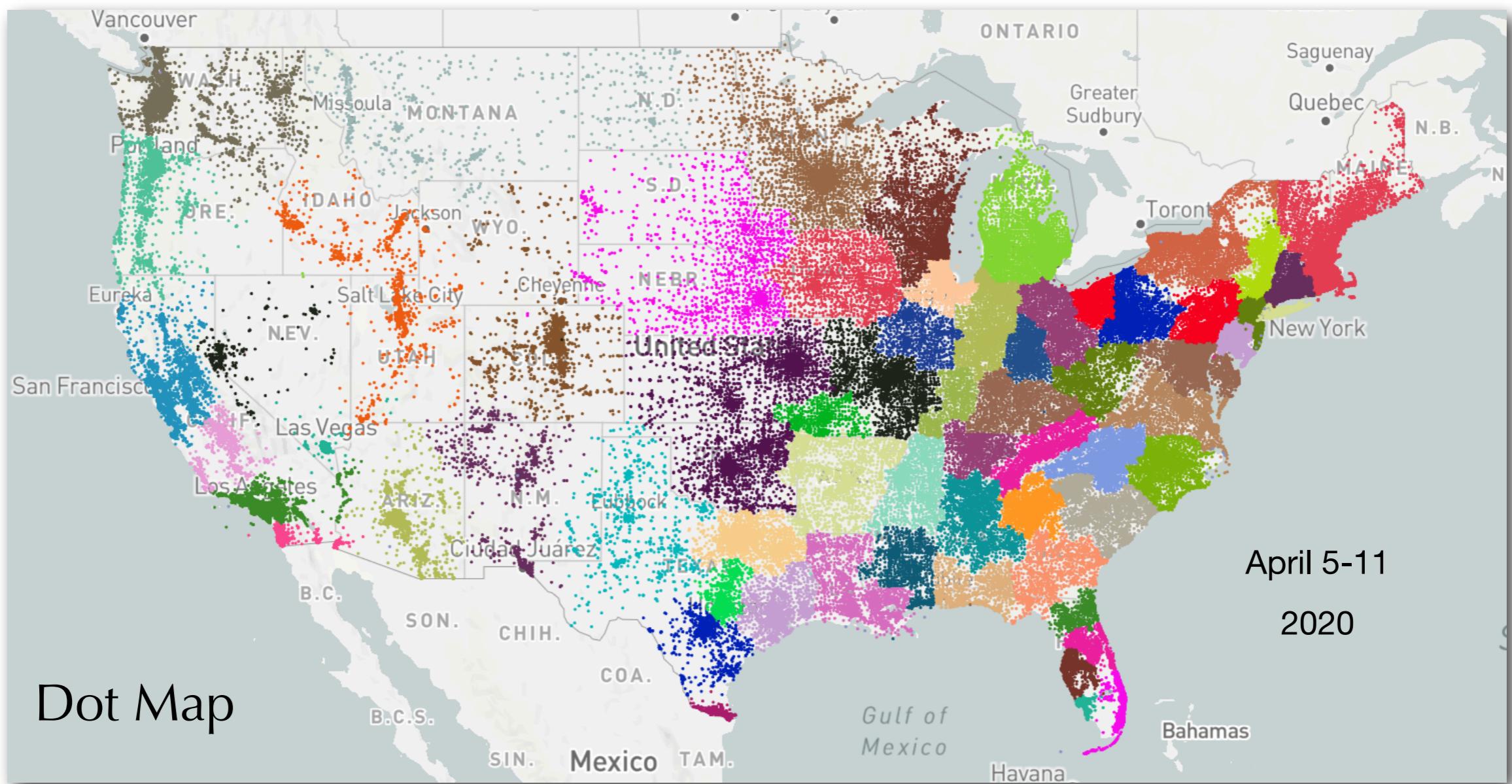
CellPhone Data and
COVID-19 Cases of USA

<https://www.endcoronavirus.org/mobility-maps>

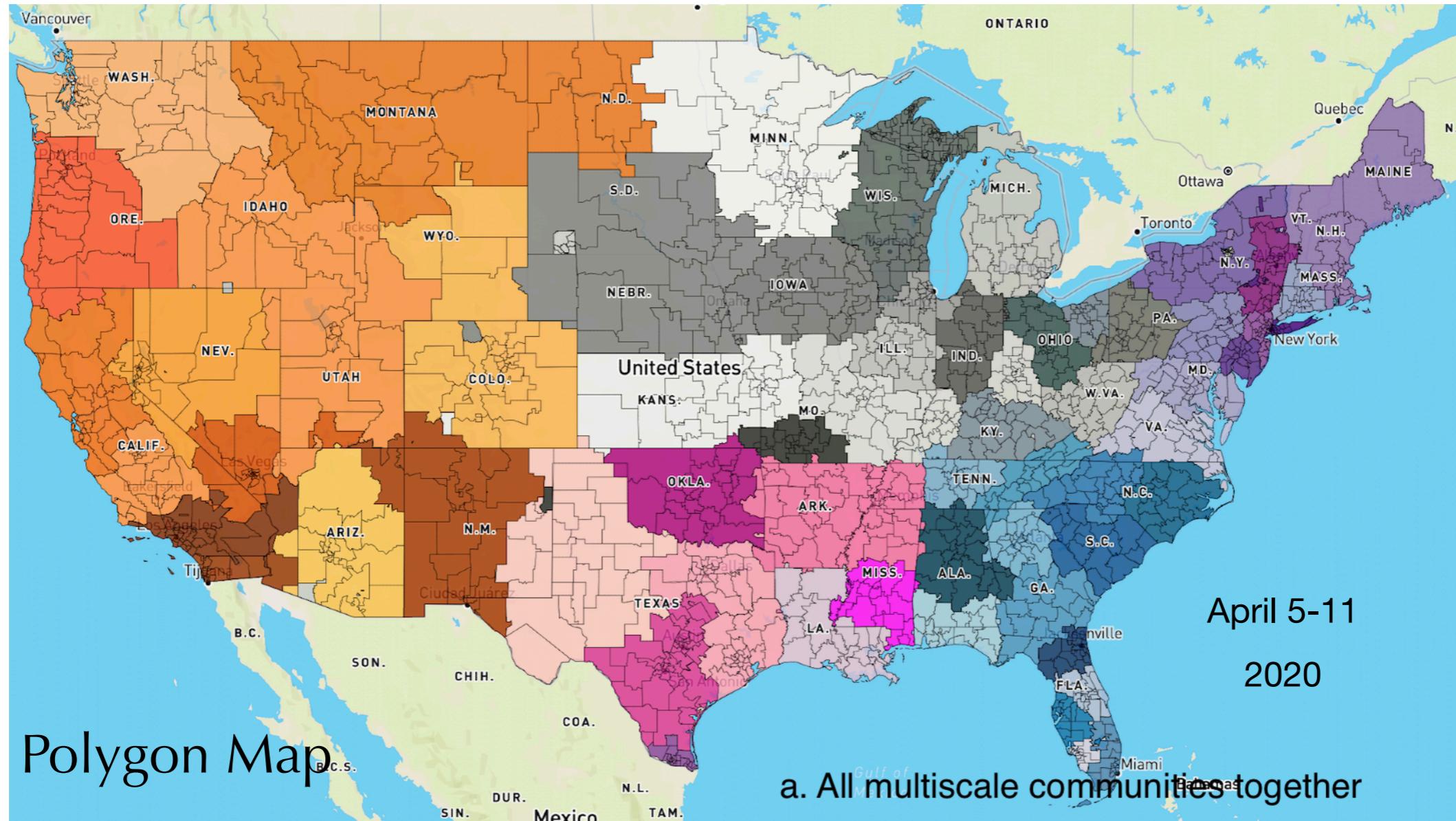


NSF Award Number: 2032536

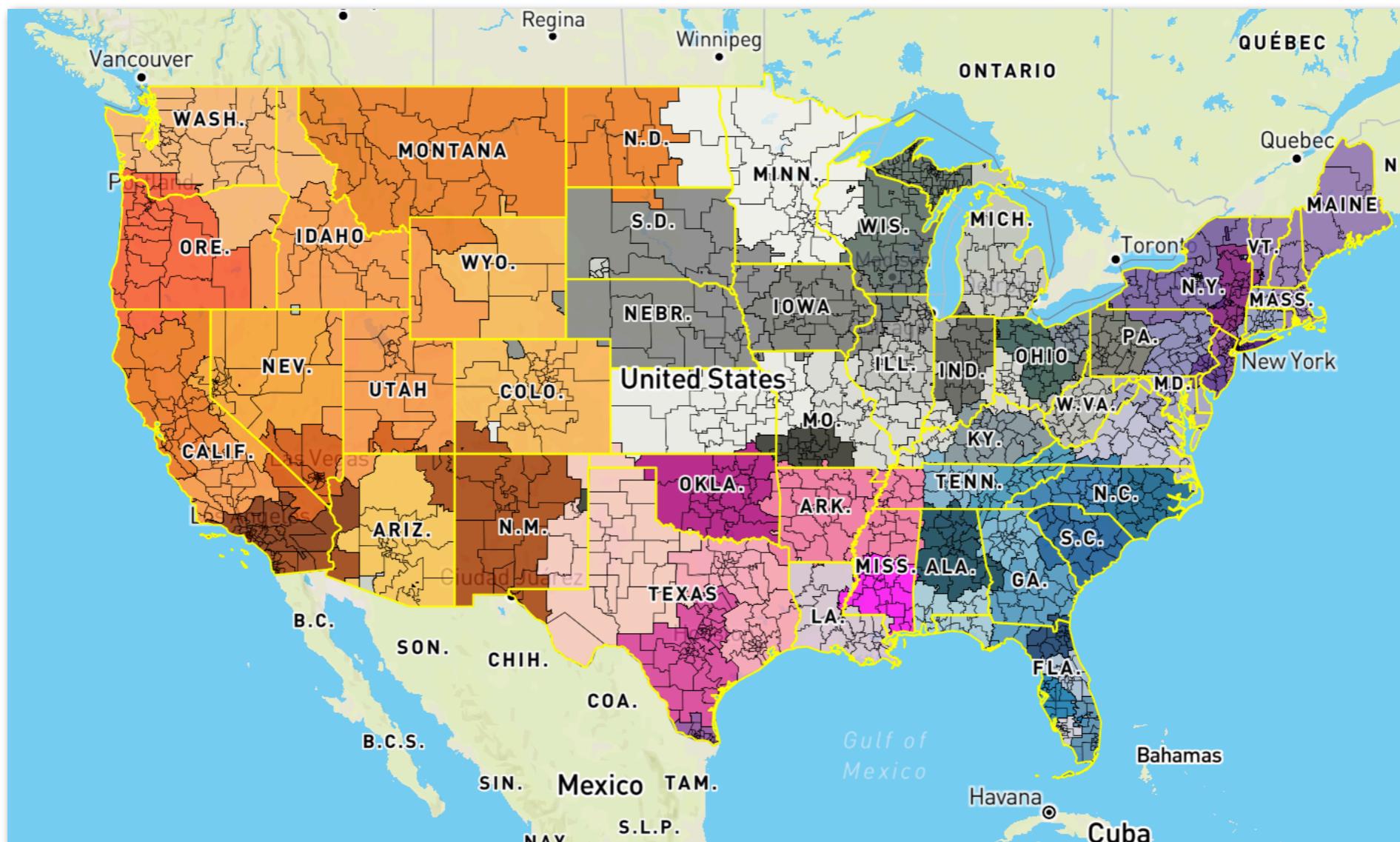
US Mobility Maps



Multi-scale Mobility Patterns

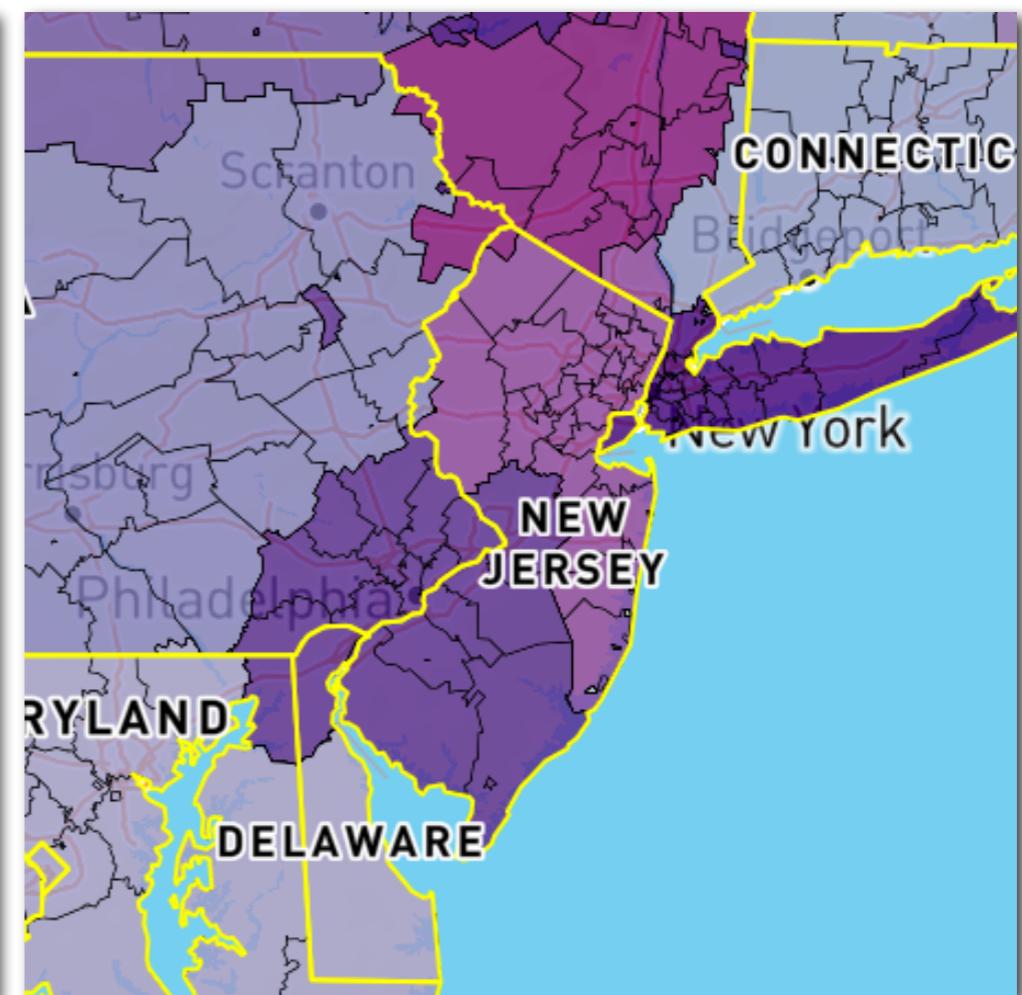
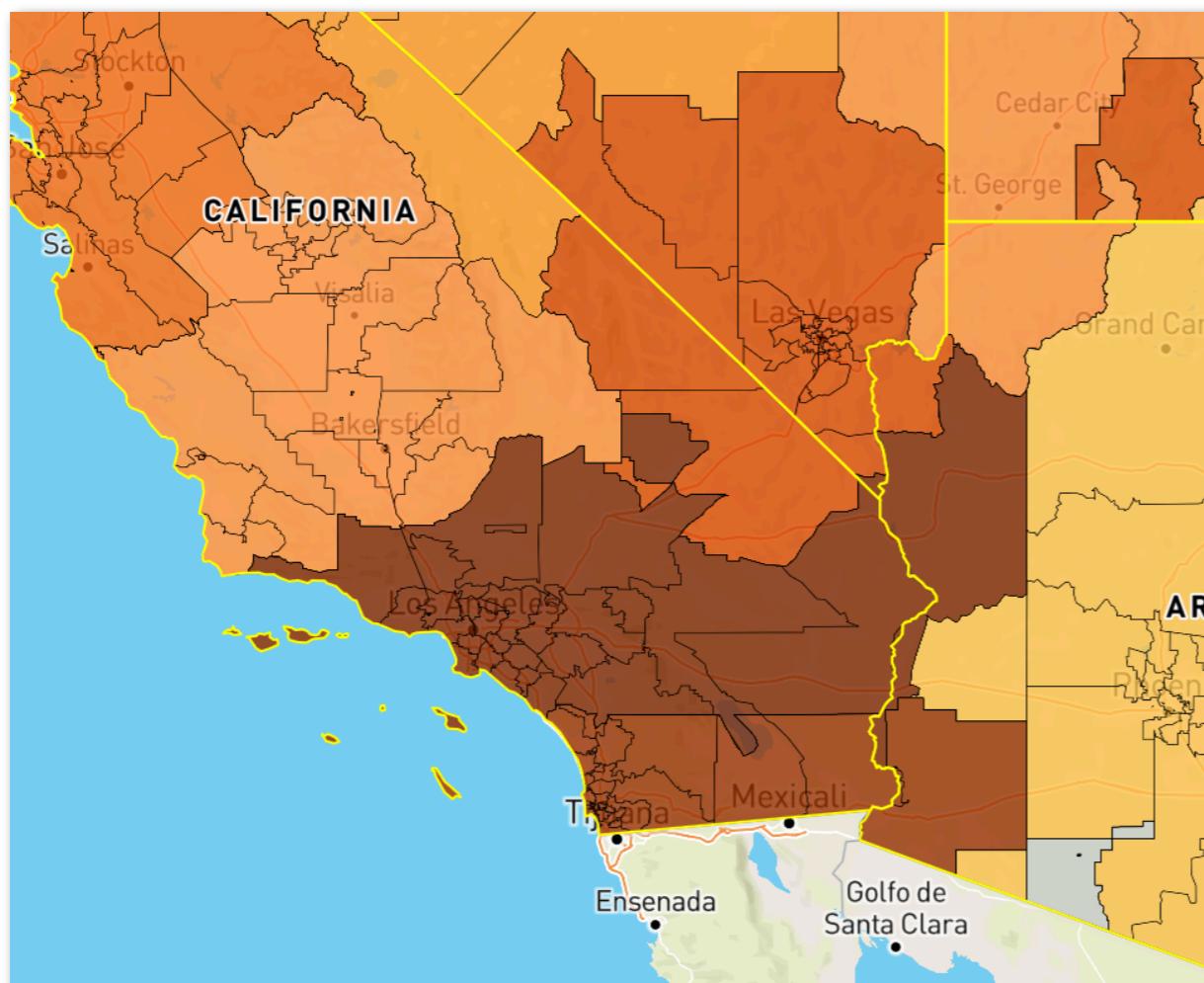


Interesting Facts About the Maps



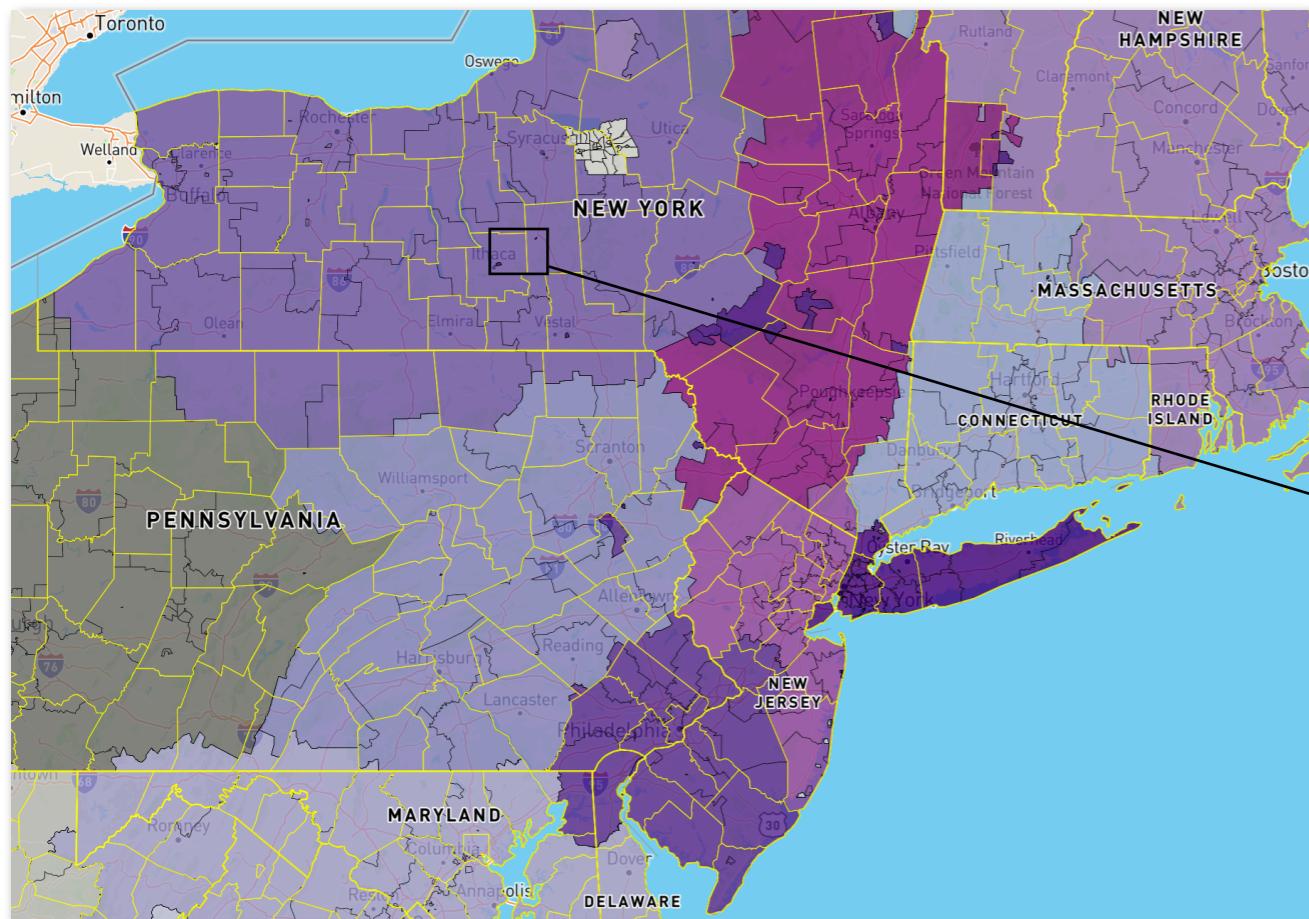
Deviation from administrative borders

Interesting Facts About the Maps



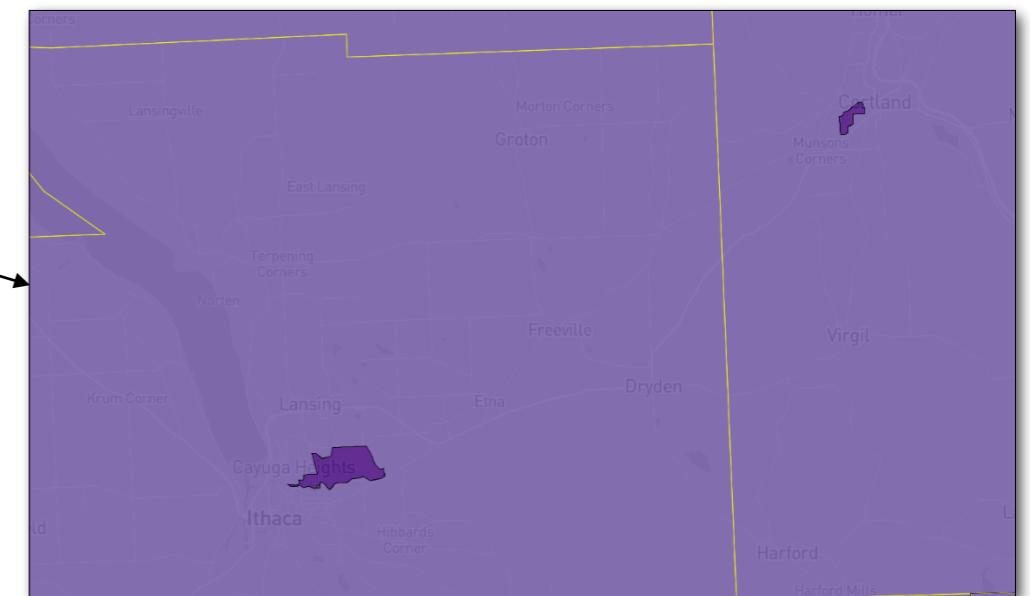
Deviation from administrative borders

Interesting Facts About the Maps



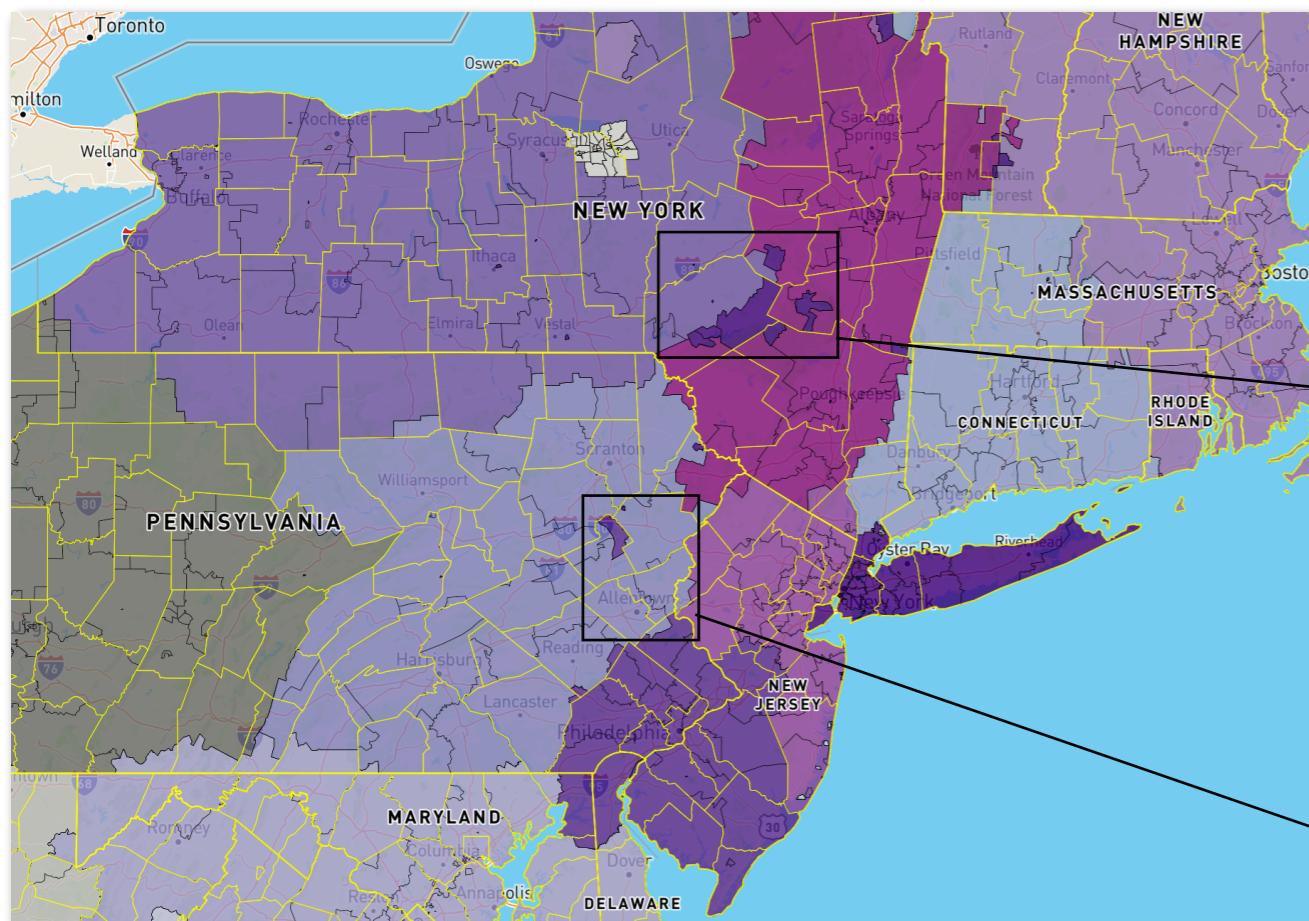
Isolated Communities

Universities



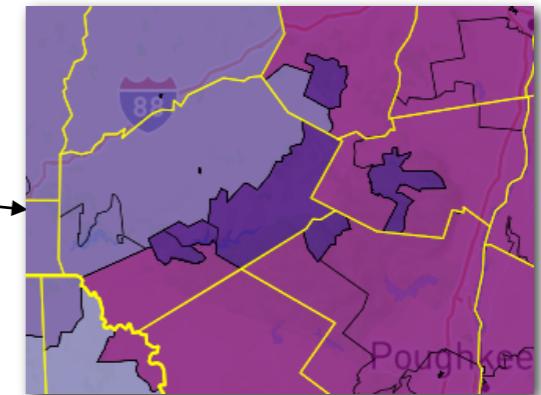
Cornell and SUNY Cortland Universities

Interesting Facts About the Maps

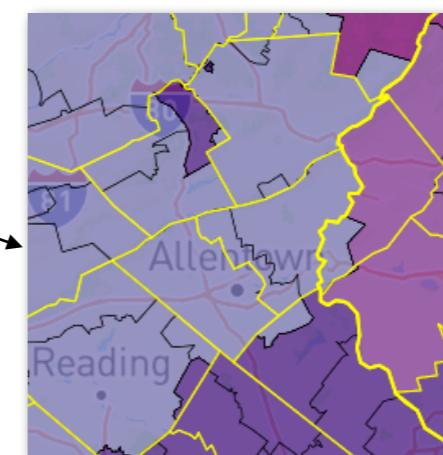


Isolated Communities

Vacation spots

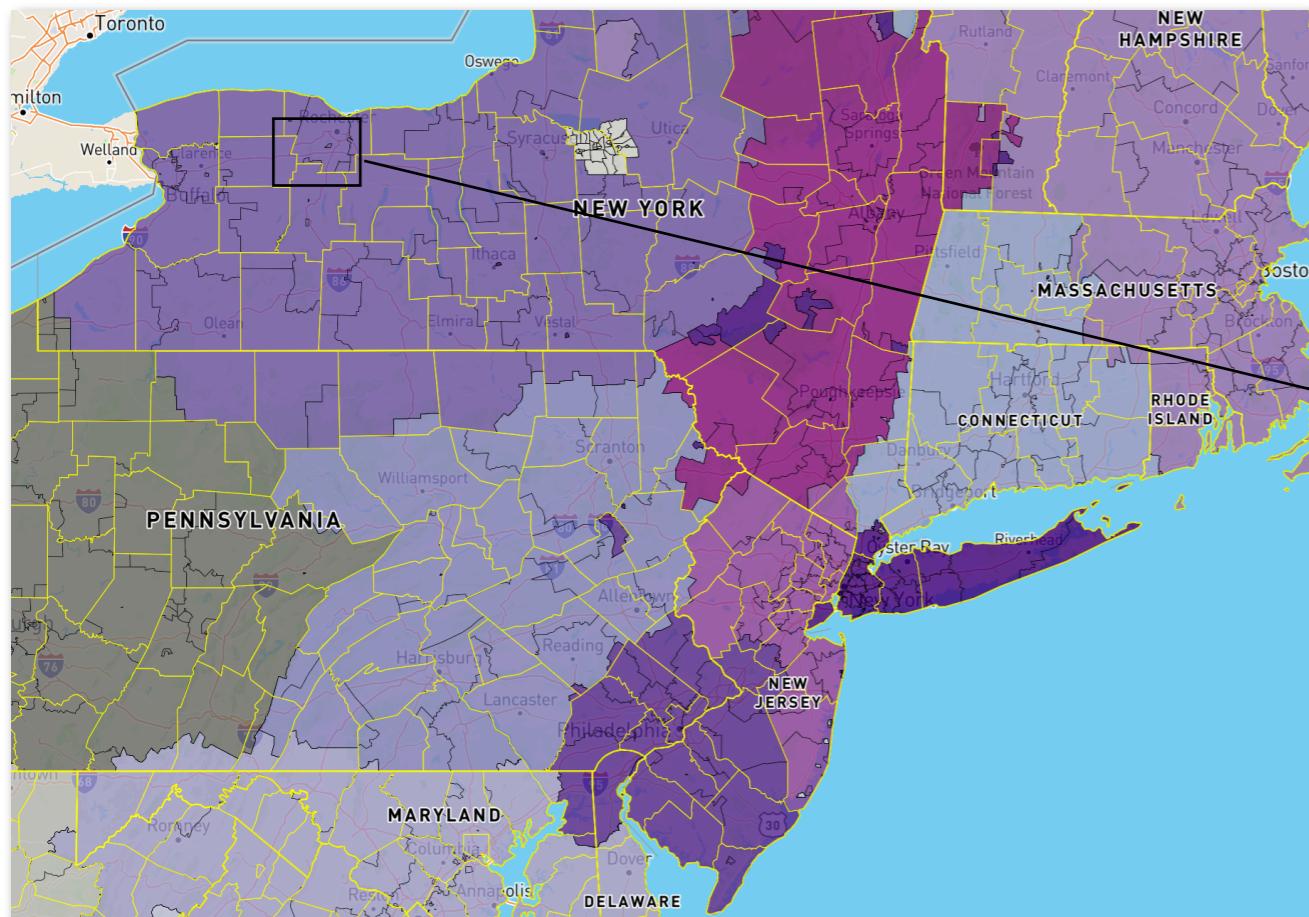


Catskill Mountains



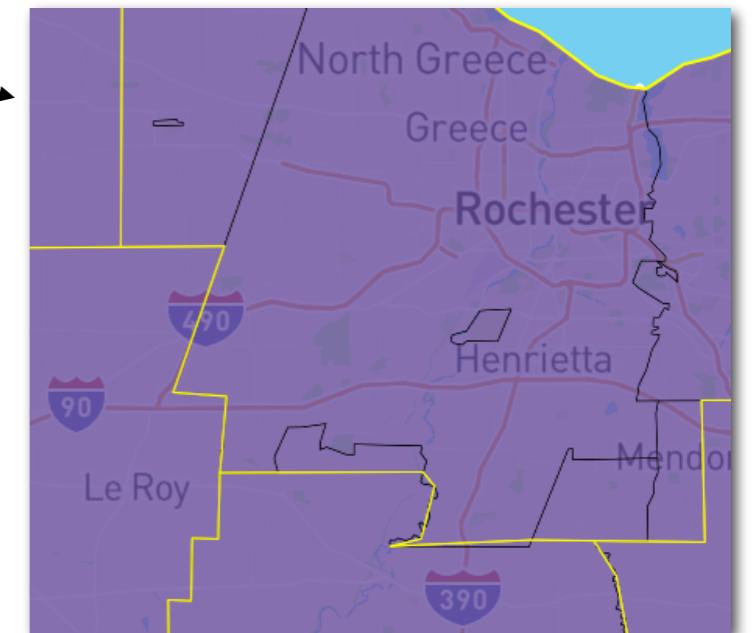
Poconos

Interesting Facts About the Maps

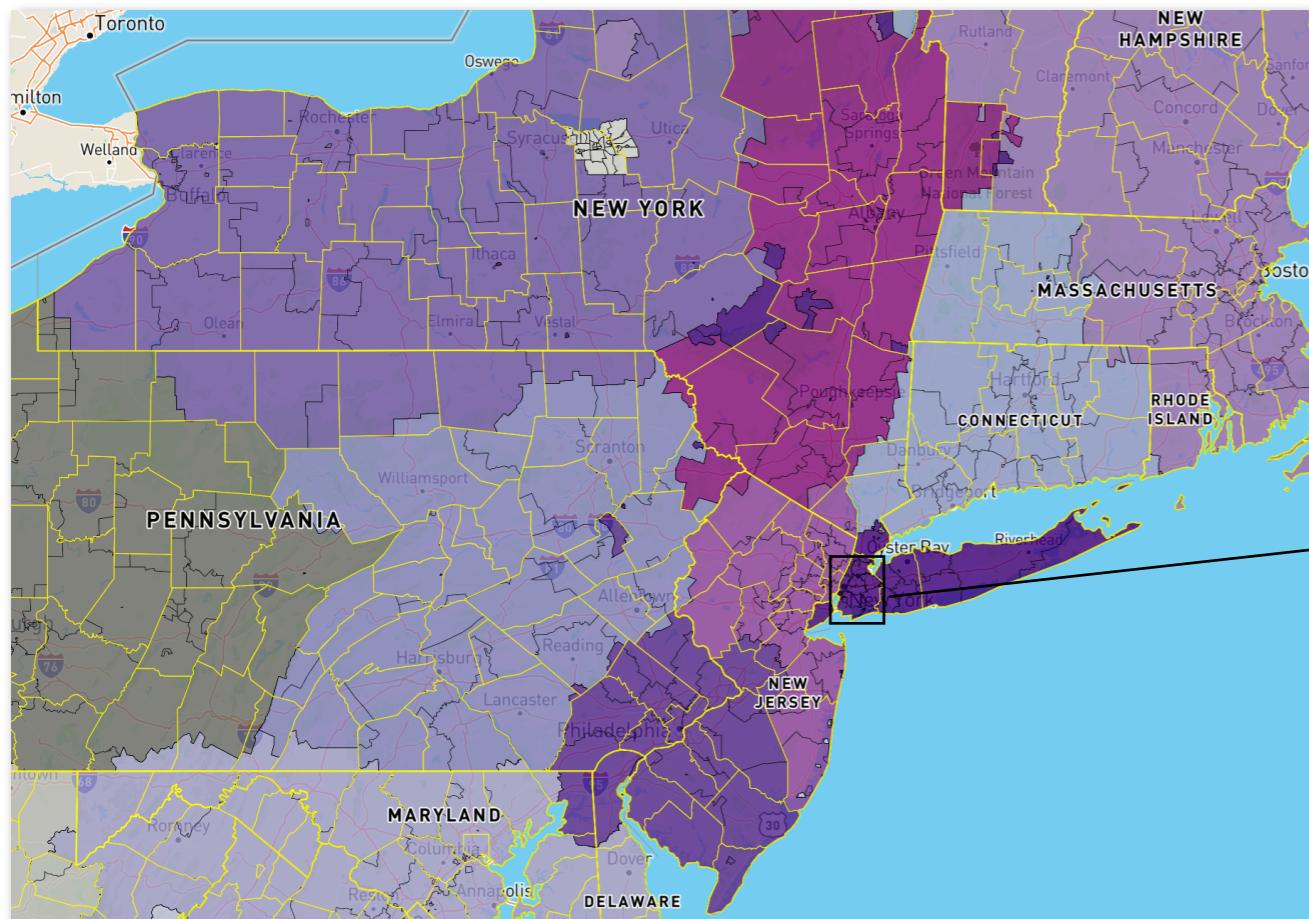


Sub-Communities within Other Sub-Communities

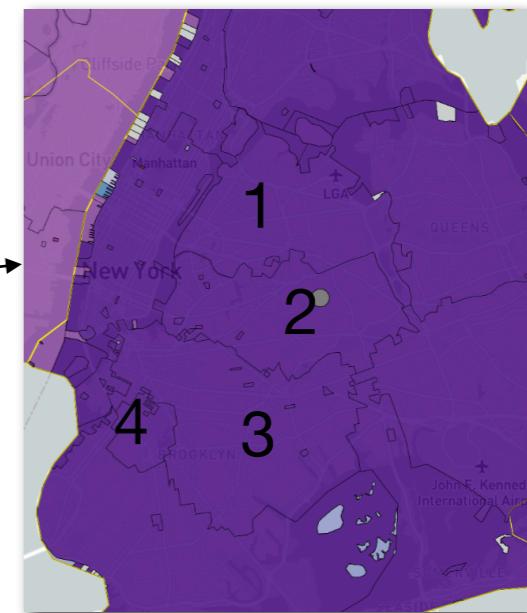
Rochester Institute of Technology



Interesting Facts About the Maps

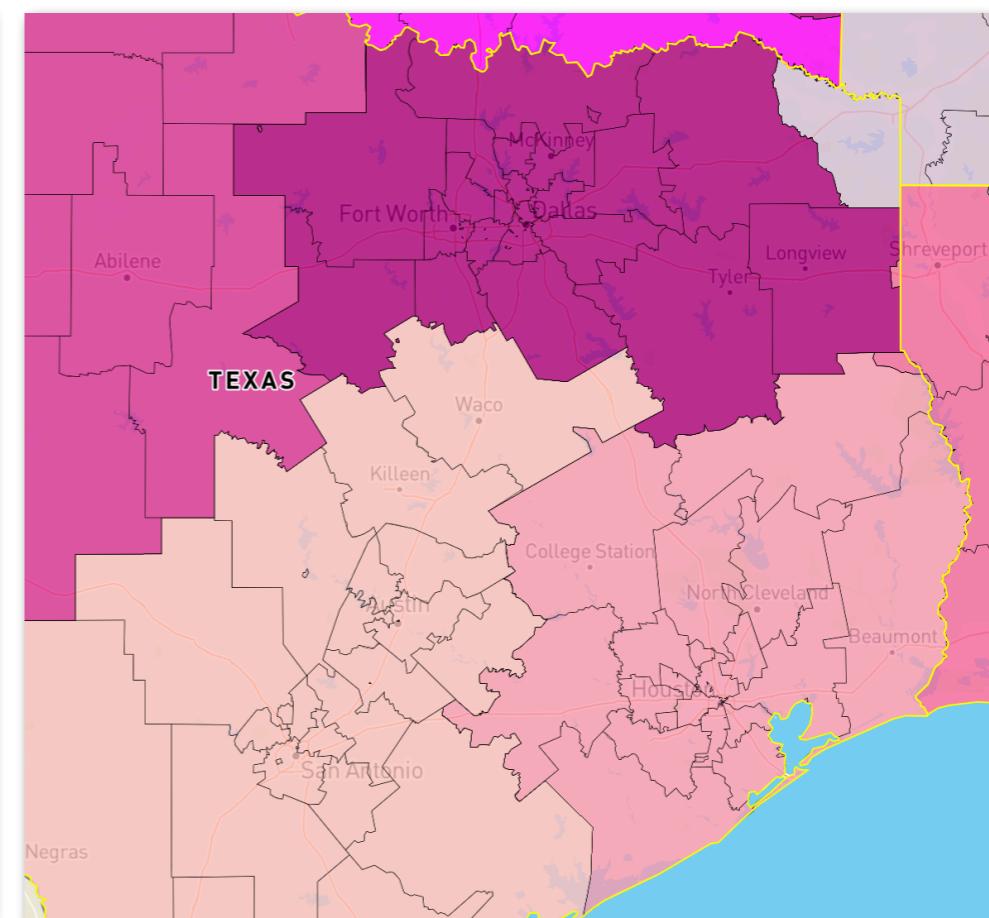
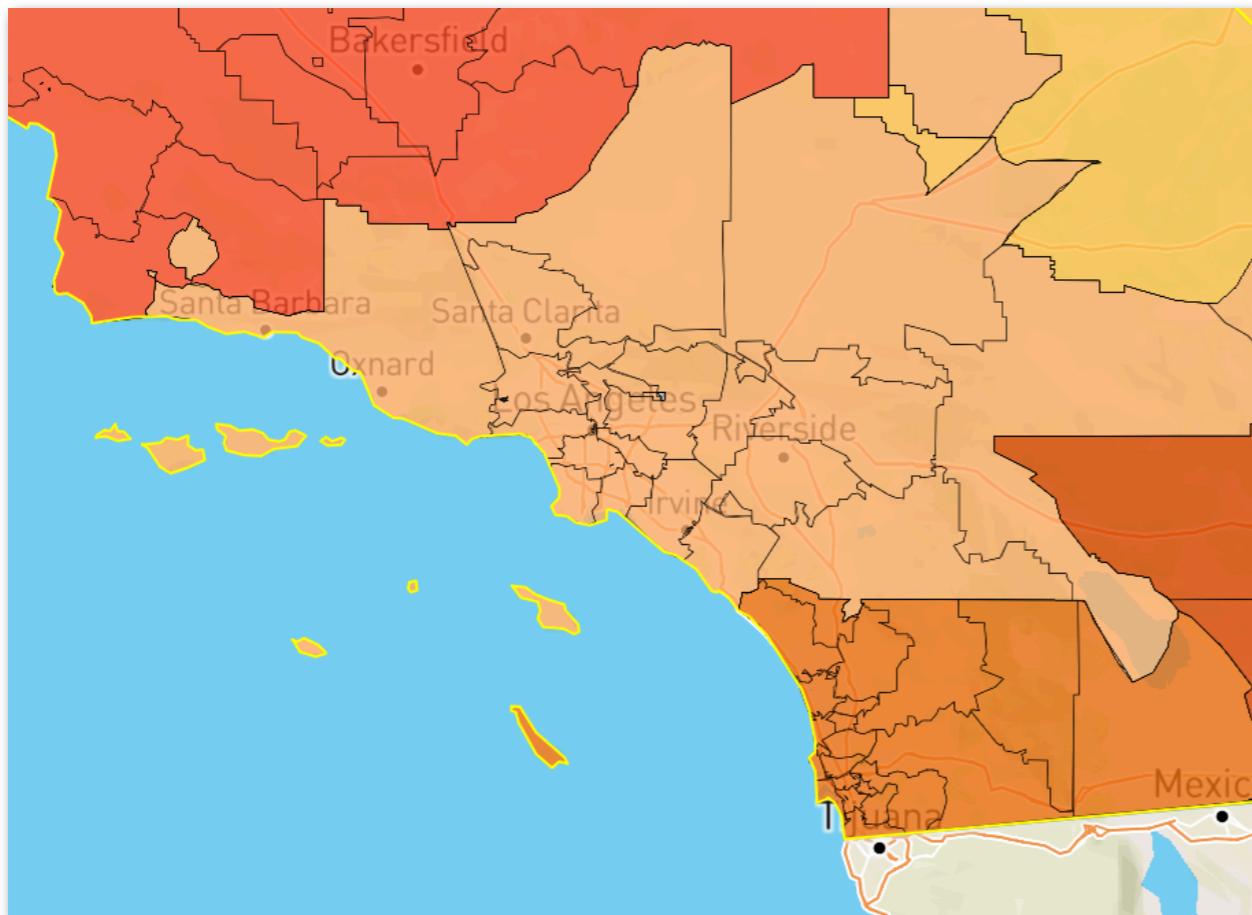


Sub-communities in City areas



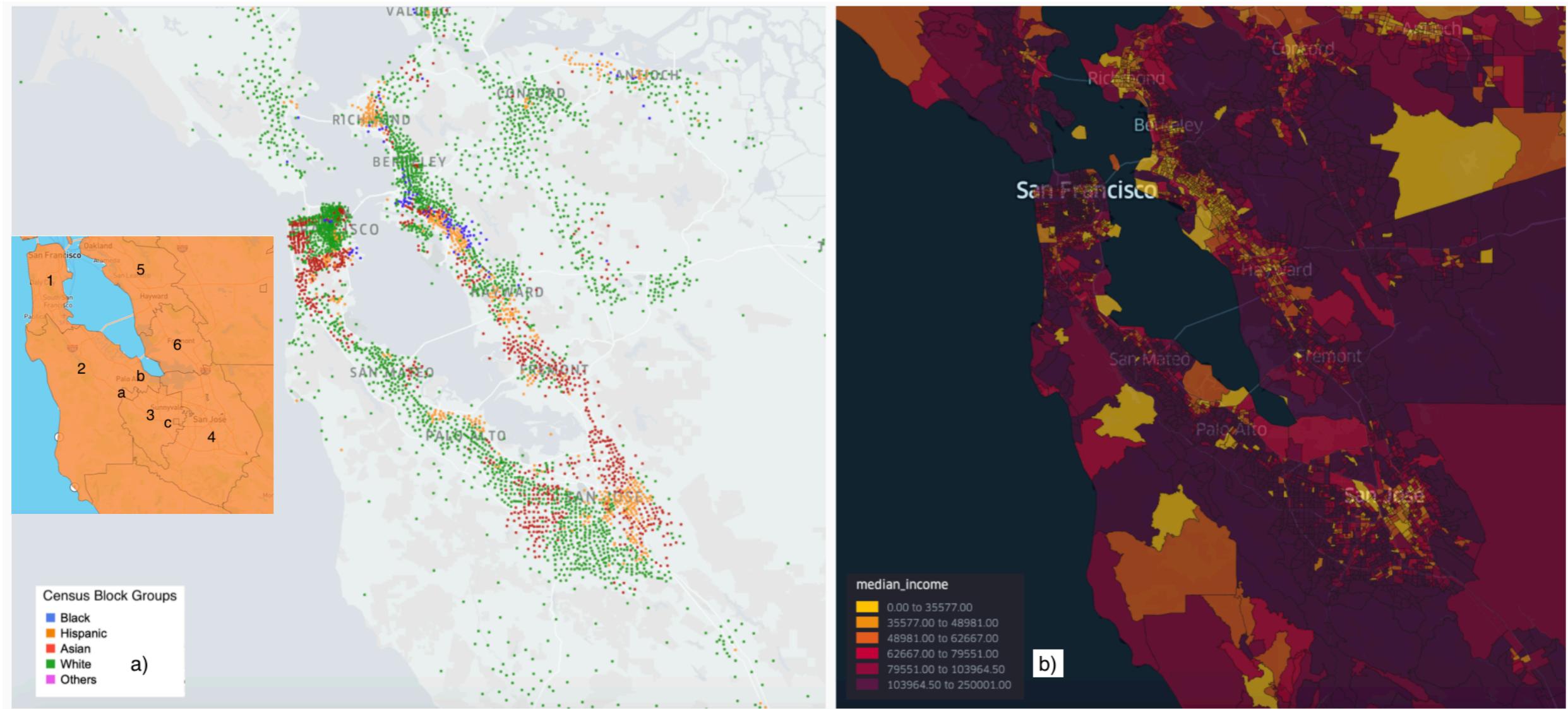
- 1) Areas of Queens
- 2) Northern Brooklyn
- 3) Central Brooklyn
- 4) Around Prospect Park

Interesting Facts About the Maps

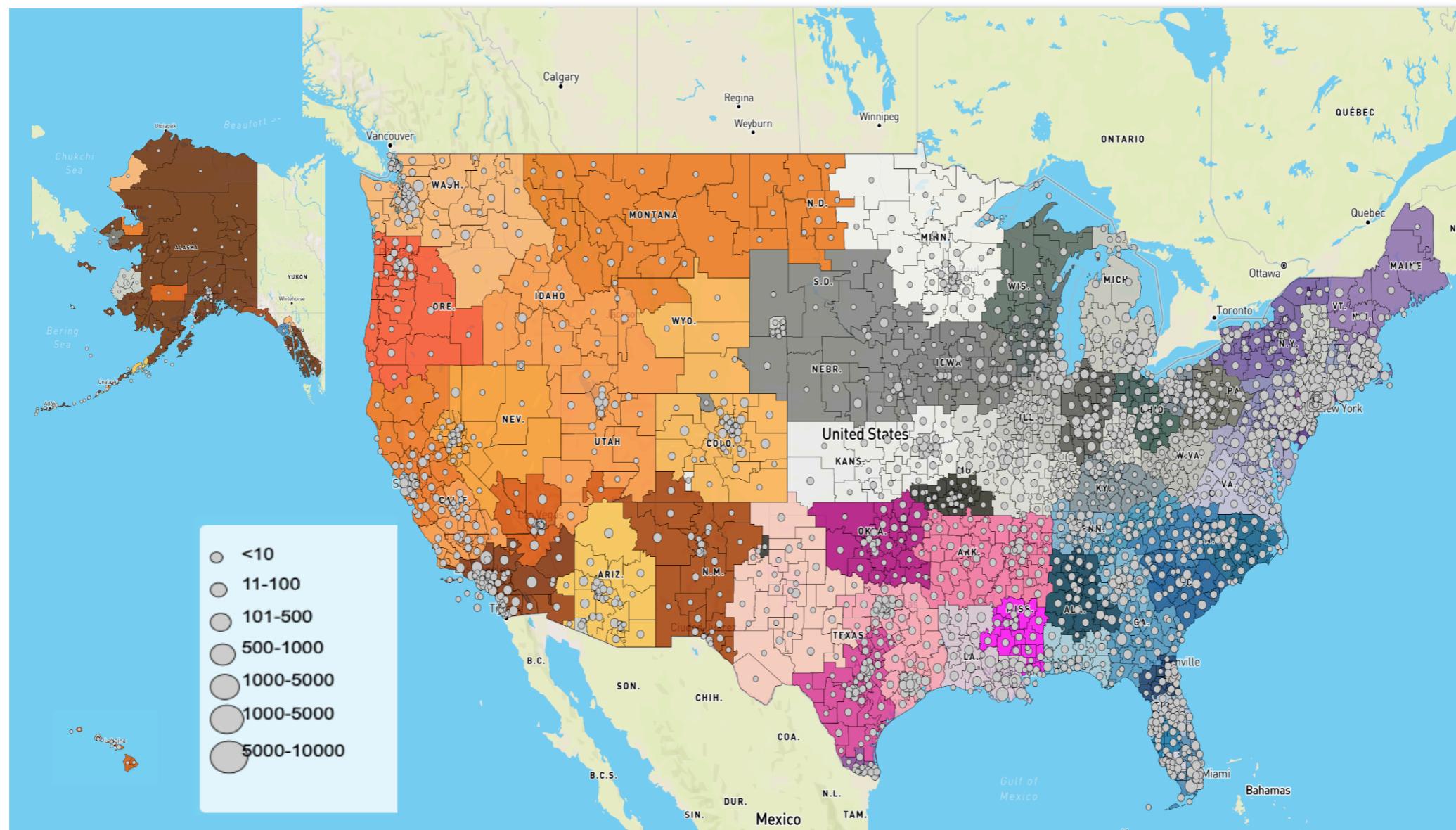


Sub-communities in City areas

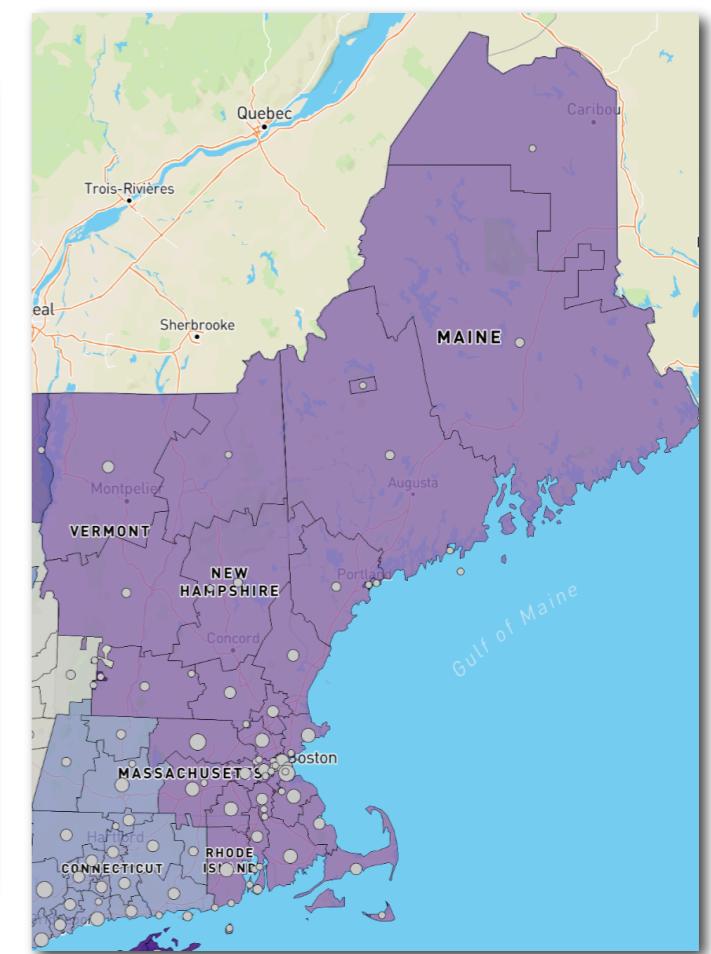
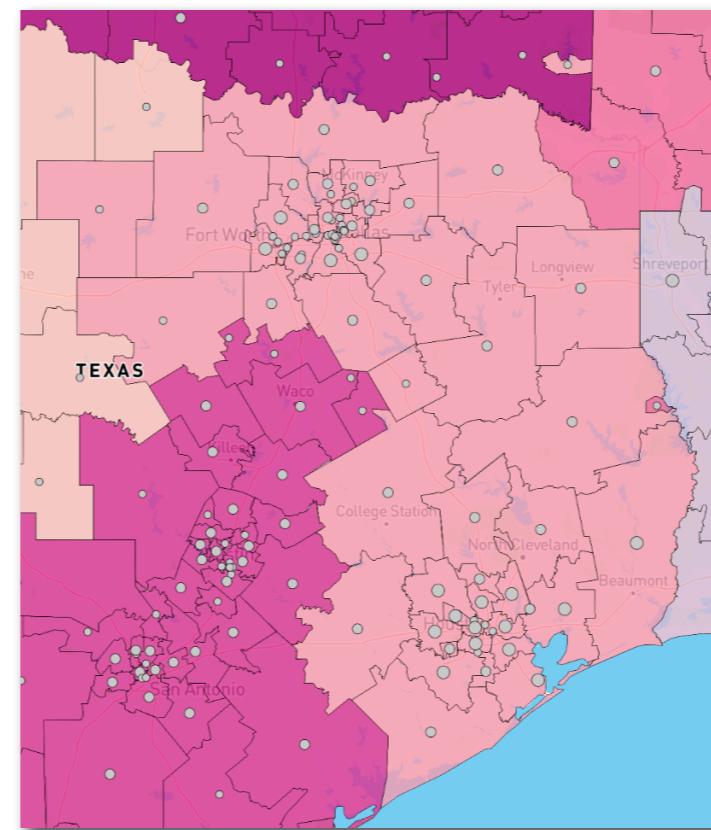
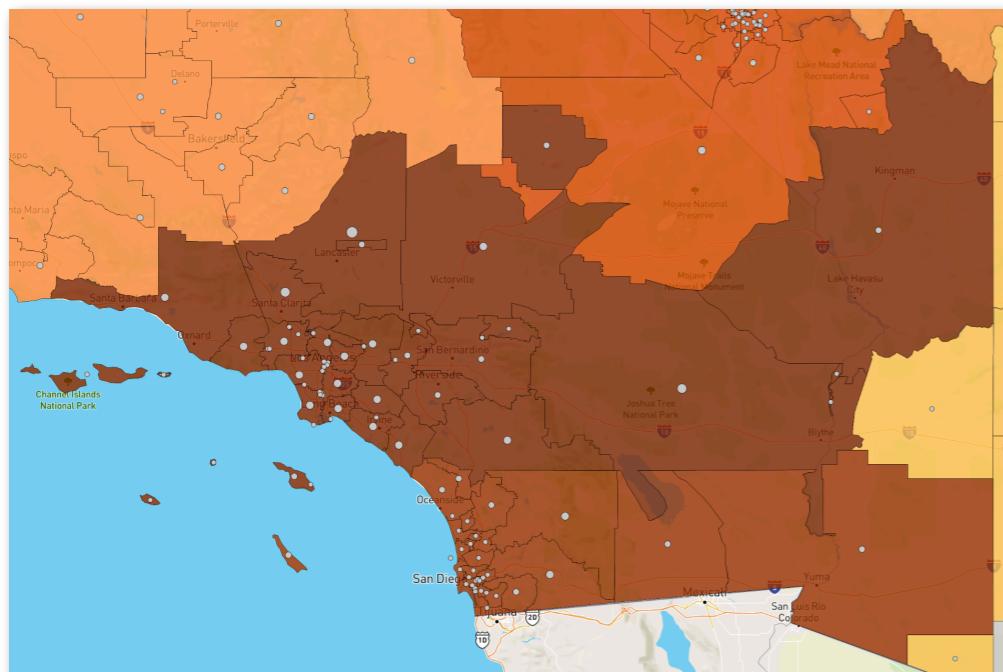
Socio-Economic Characteristics of Communities



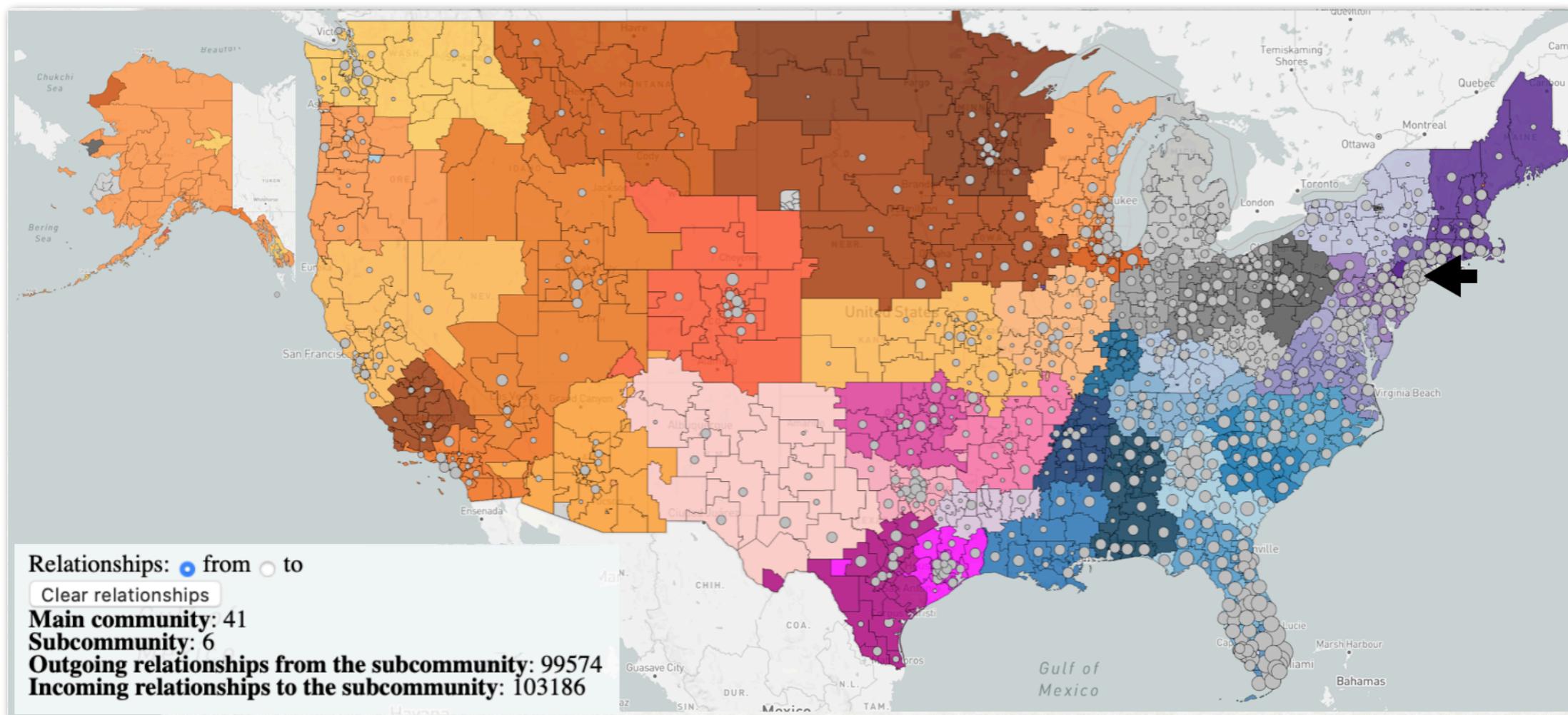
COVID-19 Risk Exposure in Mobility Patches



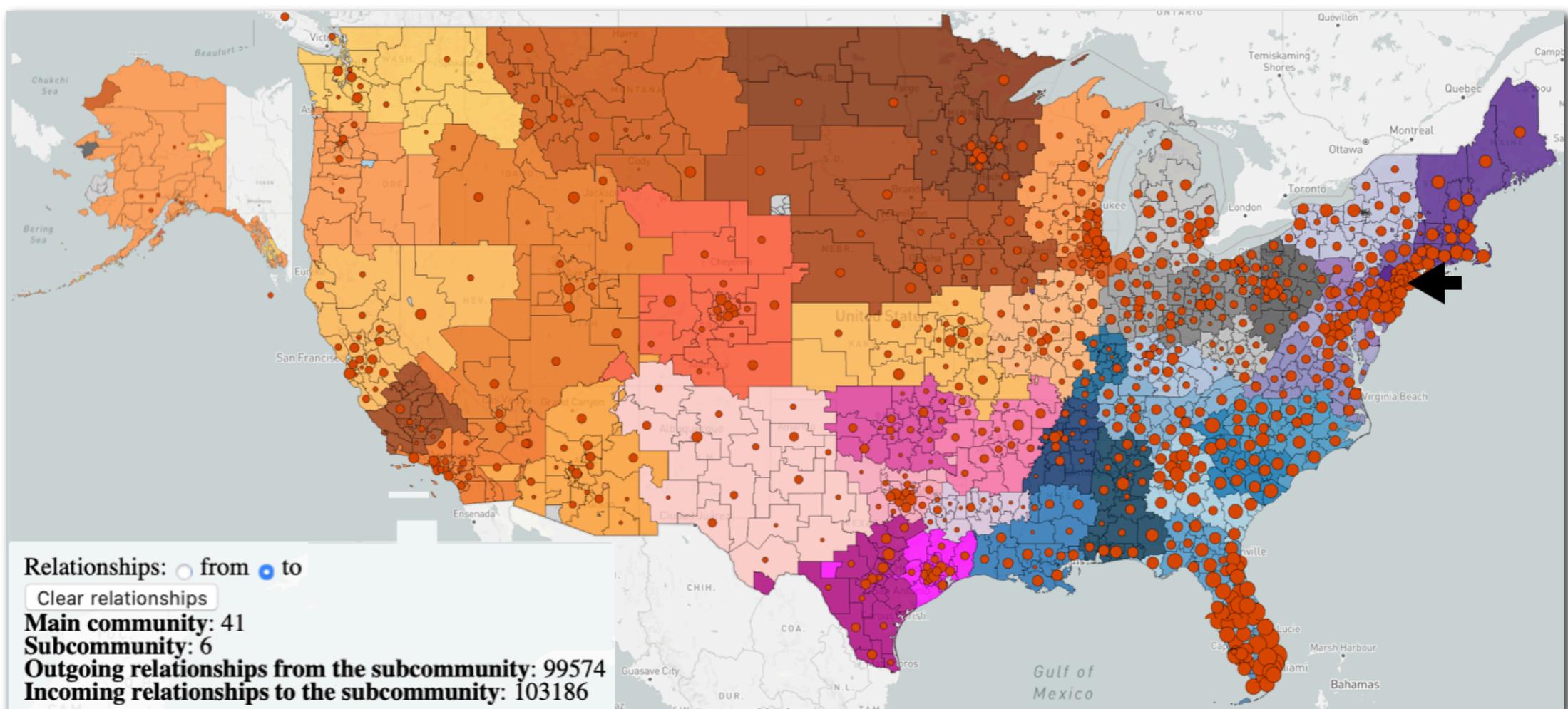
COVID-19 Risk Exposure in Mobility Patches



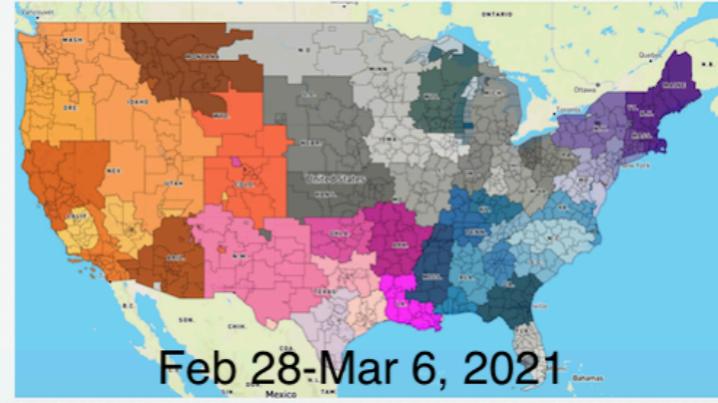
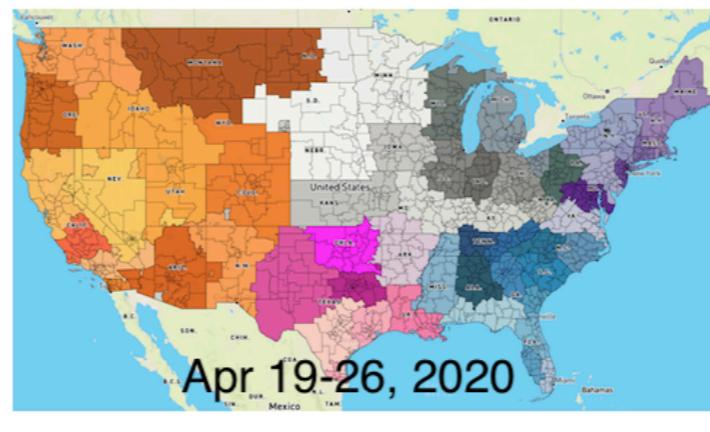
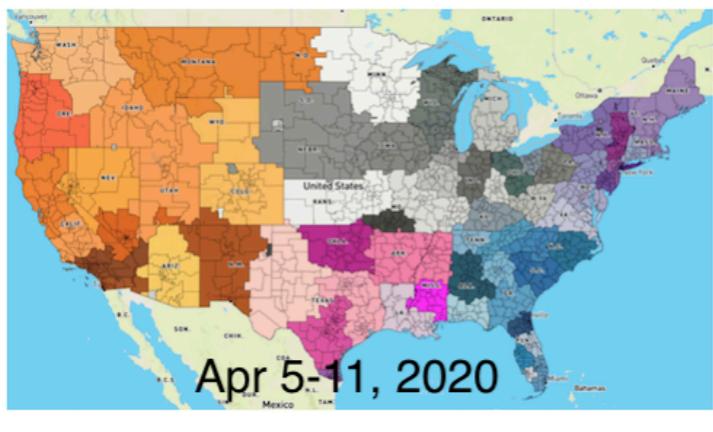
Relationships between Communities



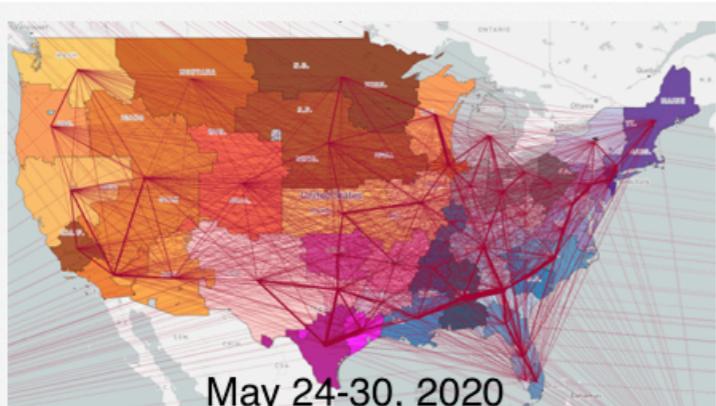
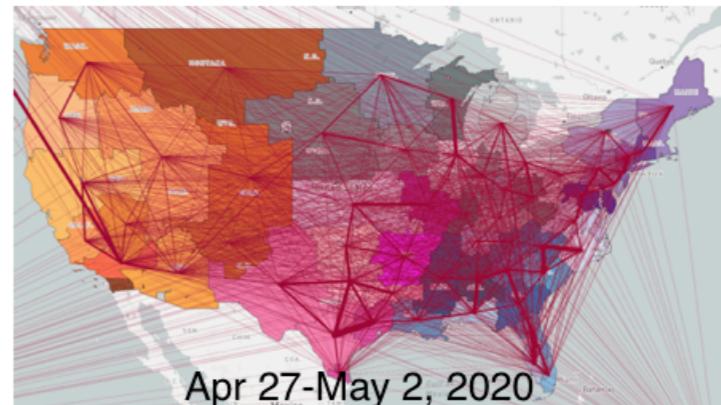
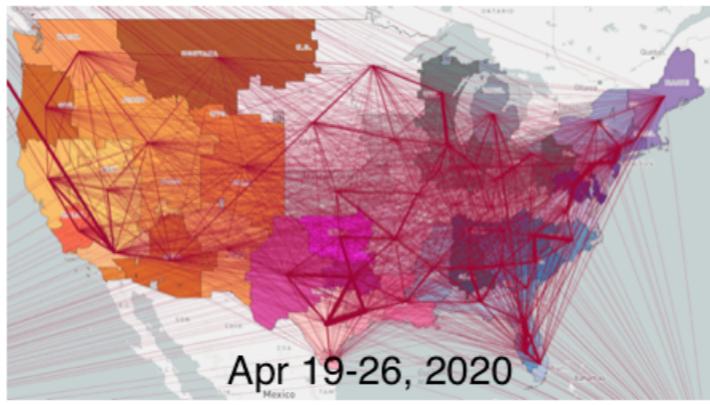
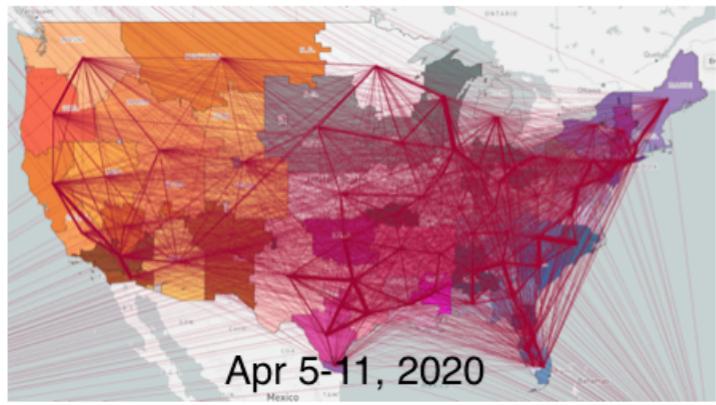
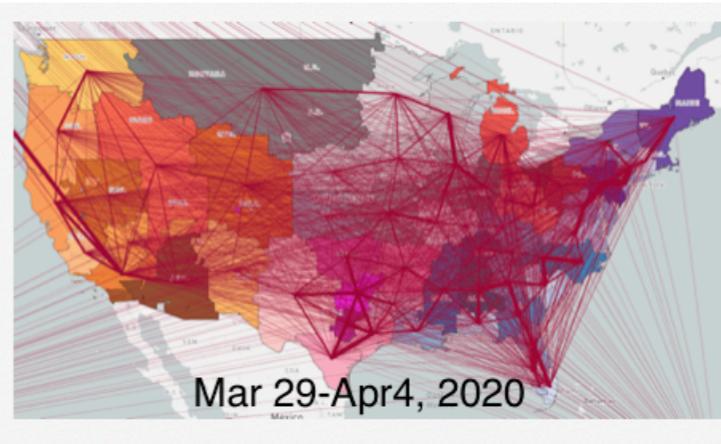
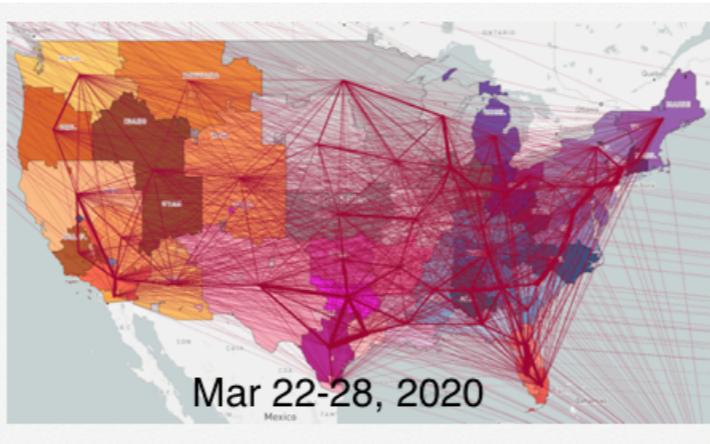
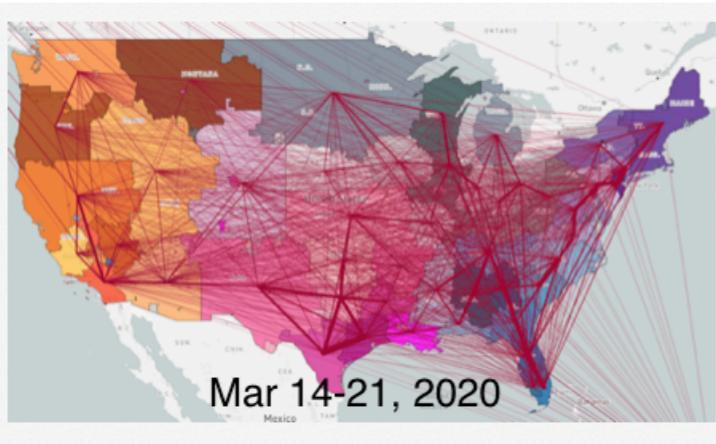
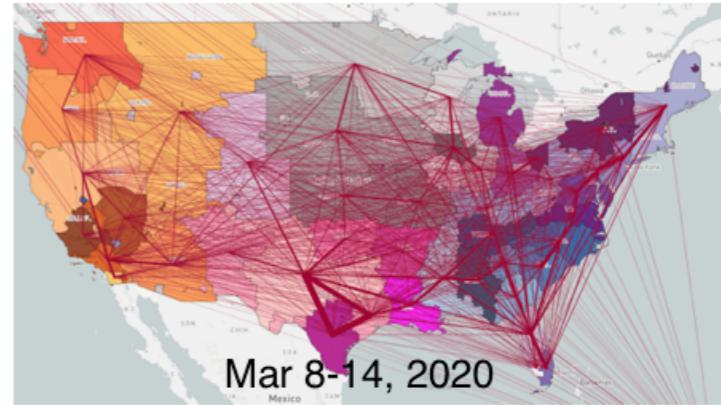
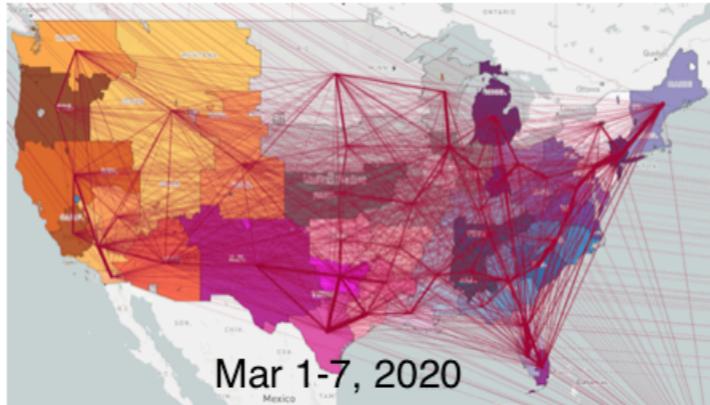
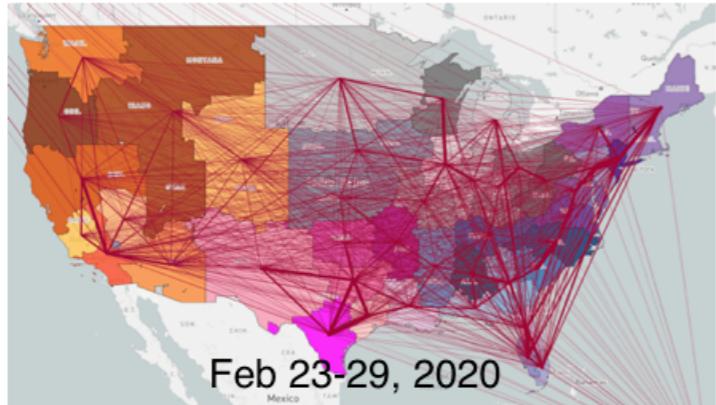
Relationships between Communities



Dynamics of Mobility Patterns

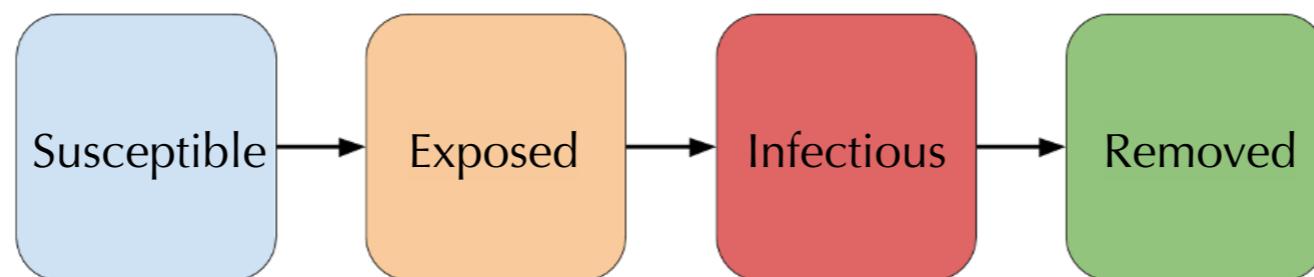


Movements between Communities



COVID-19 Spreading Simulation

SEIR model:



$$\frac{dS_i}{dt} = -\beta \frac{S_i I_i}{N_i} - \eta_i S_i + \sum_j \frac{A_{ij} \eta_j}{k_j} S_j$$

$$\frac{dE_i}{dt} = \beta \frac{S_i I_i}{N_i} - \alpha E_i - \eta_i E_i + \sum_j \frac{A_{ij} \eta_j}{k_j} E_j,$$

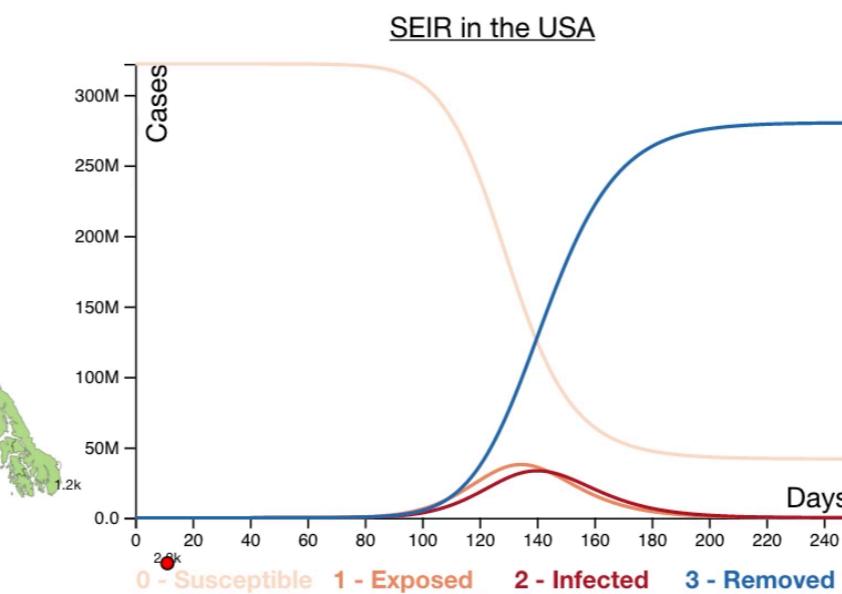
$$\frac{dI_i}{dt} = \alpha E_i - \gamma I_i - \eta_i I_i + \sum_j \frac{A_{ij} \eta_j}{k_j} I_j,$$

$$\frac{dR_i}{dt} = \gamma I_i - \eta_i R_i + \sum_j \frac{A_{ij} \eta_j}{k_j} R_j,$$

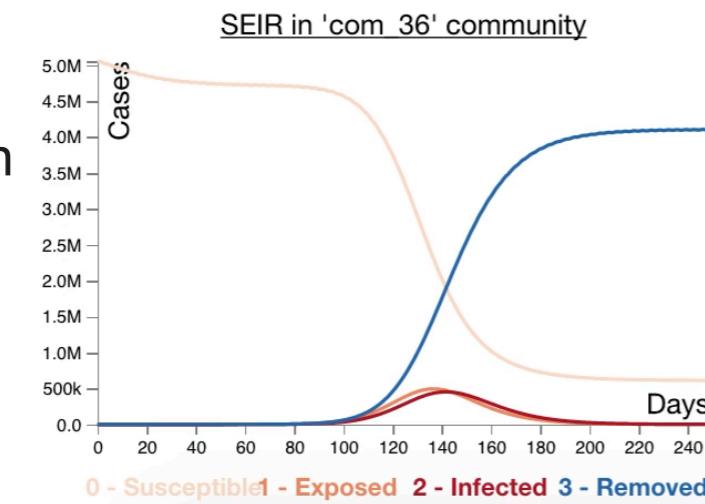
$$\frac{dN_i}{dt} = -\eta_i N_i + \sum_j \frac{A_{ij} \eta_j}{k_j} N_j,$$

COVID-19 Spreading Simulation

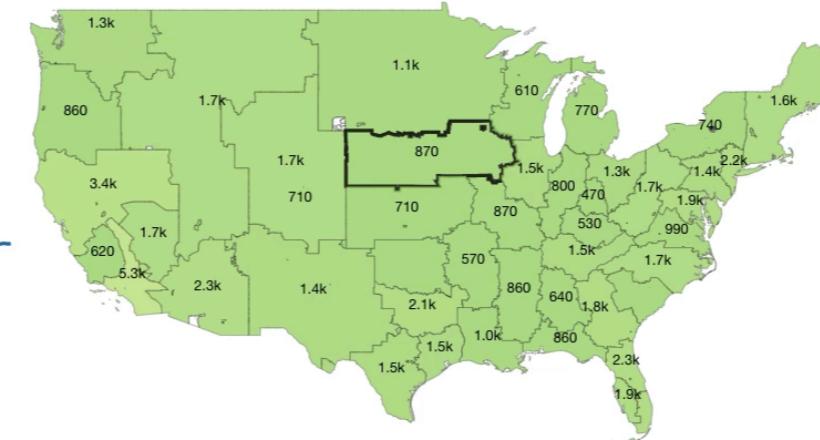
com_4 ▾



Before Lockdown

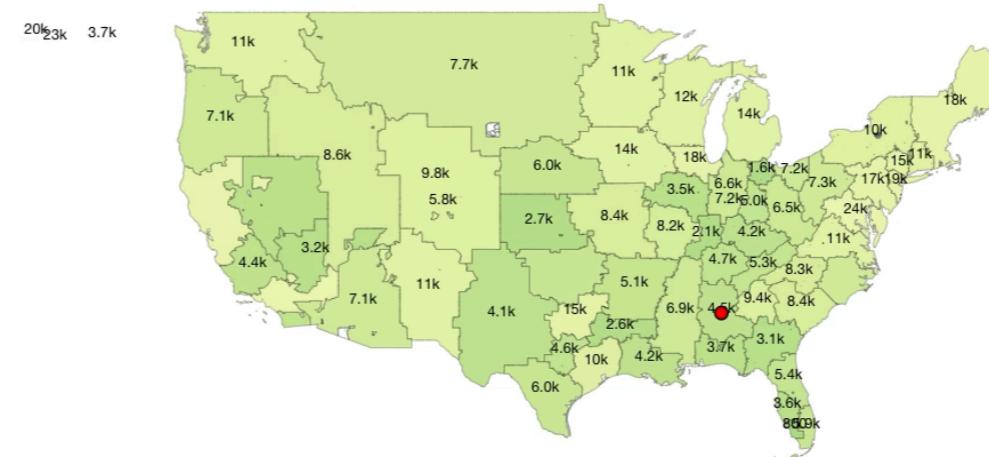
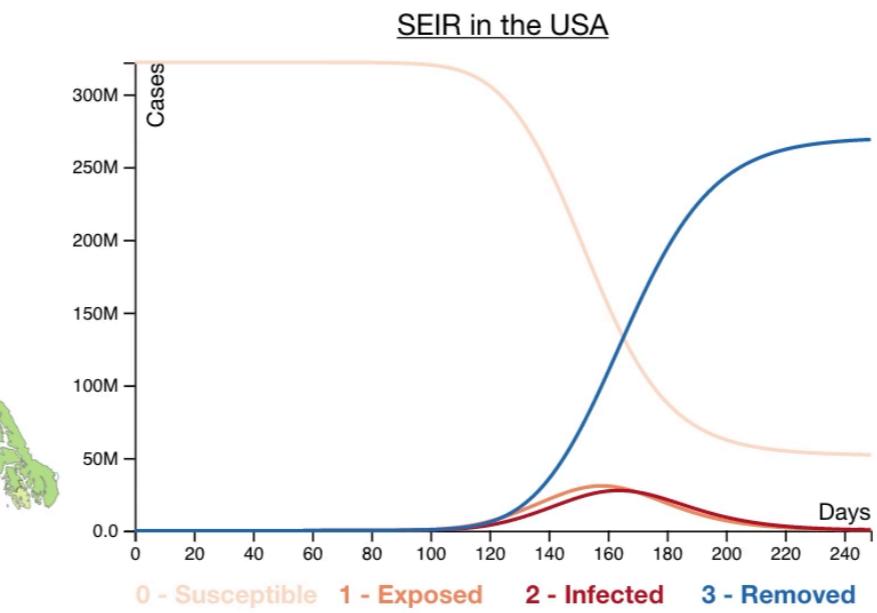
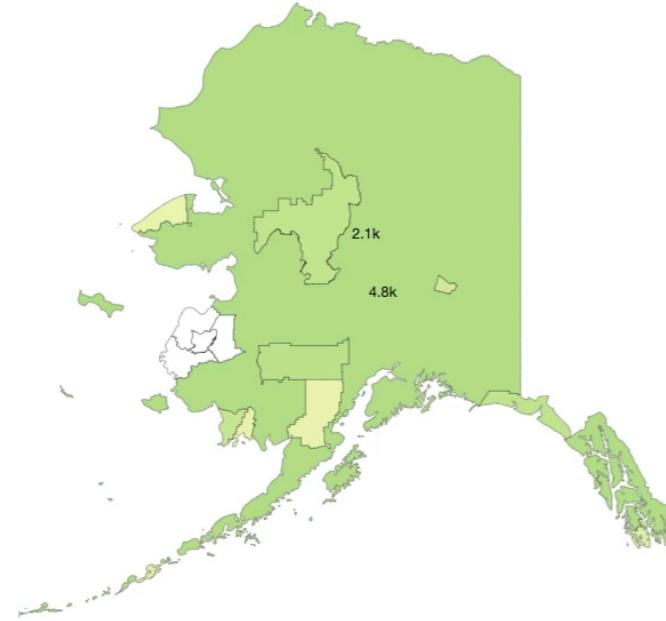


Feb 23- Feb 29



COVID-19 Spreading Simulation

com_0 ▾



During national
Lockdown

March 29-April 04



NEW ENGLAND COMPLEX SYSTEMS INSTITUTE
solving problems of science and society

Leila Hedayatifar

leila@necsi.edu

Thanks!

www.necsi.edu

www.endcoronavirus.org