Climate Migration and Demographic Amplification

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Focus on Sea-Level Rise

- 40% of the US population lives in a coastal community
  - Coastal communities are among the most rapidly growing areas in the US and across the world.

- Sea-level rise tends to dominate our understanding of climate migration.

Study	At-risk to what?
Ericson et al 2006[62]	"challenges to human occupancy"
Strauss et al 2015[6]	“implicated”
Hauer et al 2016[42]	“could lead to… population movements”
Desmet et al 2019[10]	“will be displaced”
Hinkel et al 2014[11]	“displace existing people”
Barnard et al 2019[63]	"increasingly at risk of displacement"
McGranahan et al 2007[7]	“encouraged to move away from the coast”
Nicholls et al 2011[64]	“forced displacement”
Curtis & Schneider 2011[2]	“increased vulnerability to… displacement”
Neumann et al 2015[5]	“possible displacement”

Background and Overview

- Many studies model climate migration generally, and SLR driven migration specifically.

- However, these attempts have two drawbacks:
  - 1) They lack a demographic amplification where climate migrants alter the demographic forcing (ie further mortality, fertility, and migration) in both their origins and destinations.

    Fertility effect - Young migrants could start families in their new destinations, shifting potential offspring from origins to destinations.

    Gravity effect – Migration could shift nonclimate-related migrants from some origins to some destinations. Need more doctors, waiters, engineers, construction workers, etc. in destinations.

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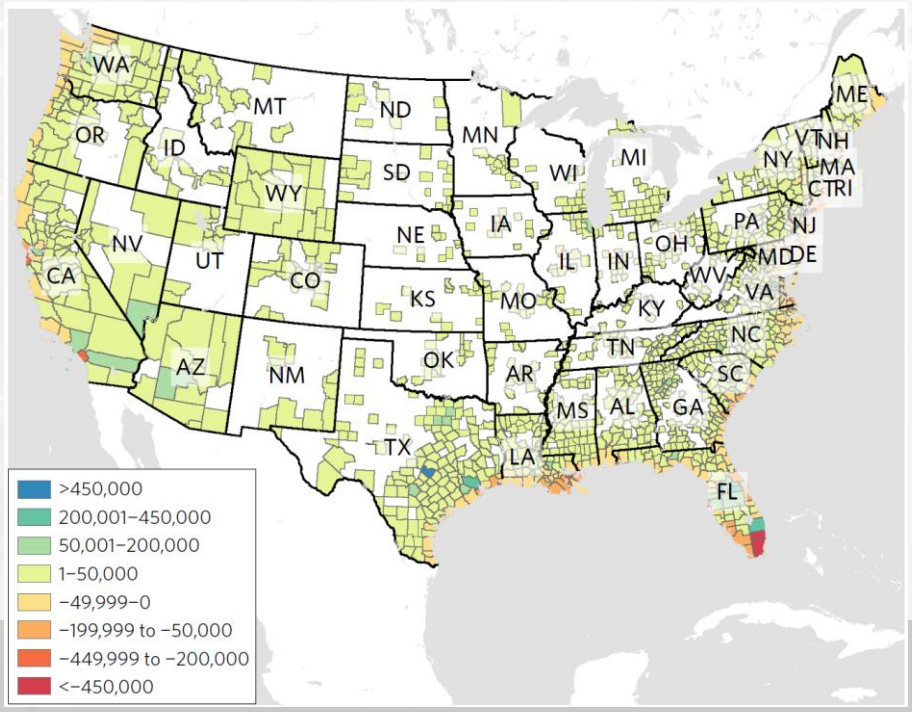
Background and Overview

- In typical climate migration models, migrants are simply removed from populations and added to other places. Just rearranging the same population across space without consideration for other population processes.



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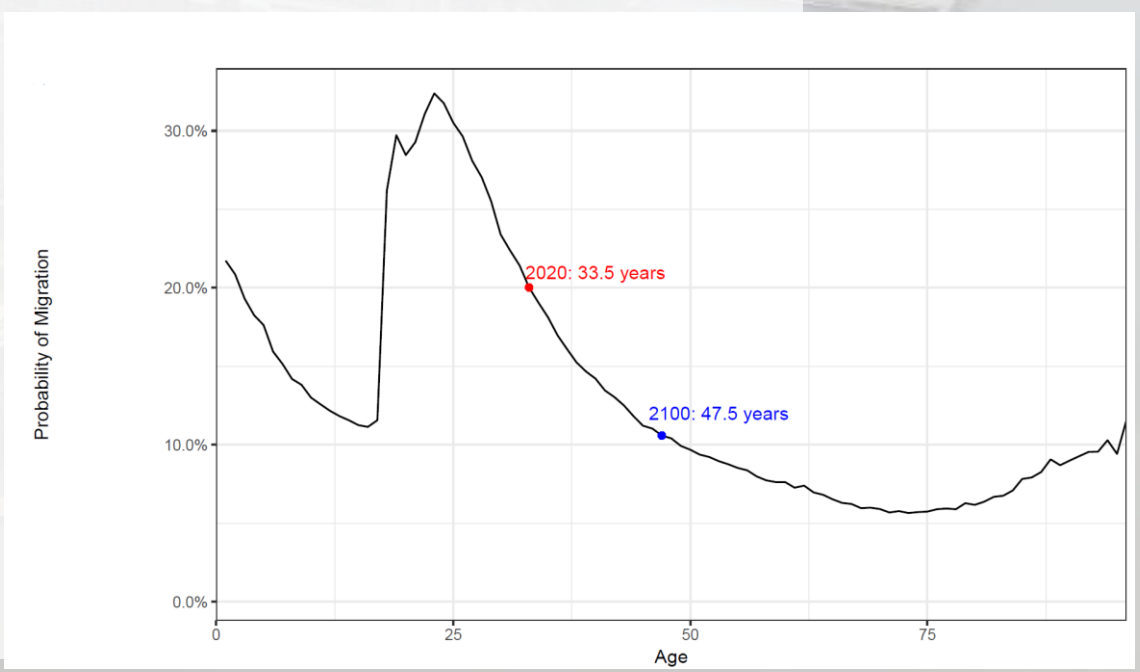
Background and Overview

- Migration propensity has a well-known age gradient. The US and global populations are expected to age this century.

- Without capturing these important demographic dynamics, we likely understate the demographic implications of climate change and climate migration.



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Background and Overview

- We built a database of all major environmental displacement events in the US since 1980.
  - Built a statistical model to predict migration from this database.

- We built a demographic model to project population change at the US county-level for multiple scenarios of sea-level rise.

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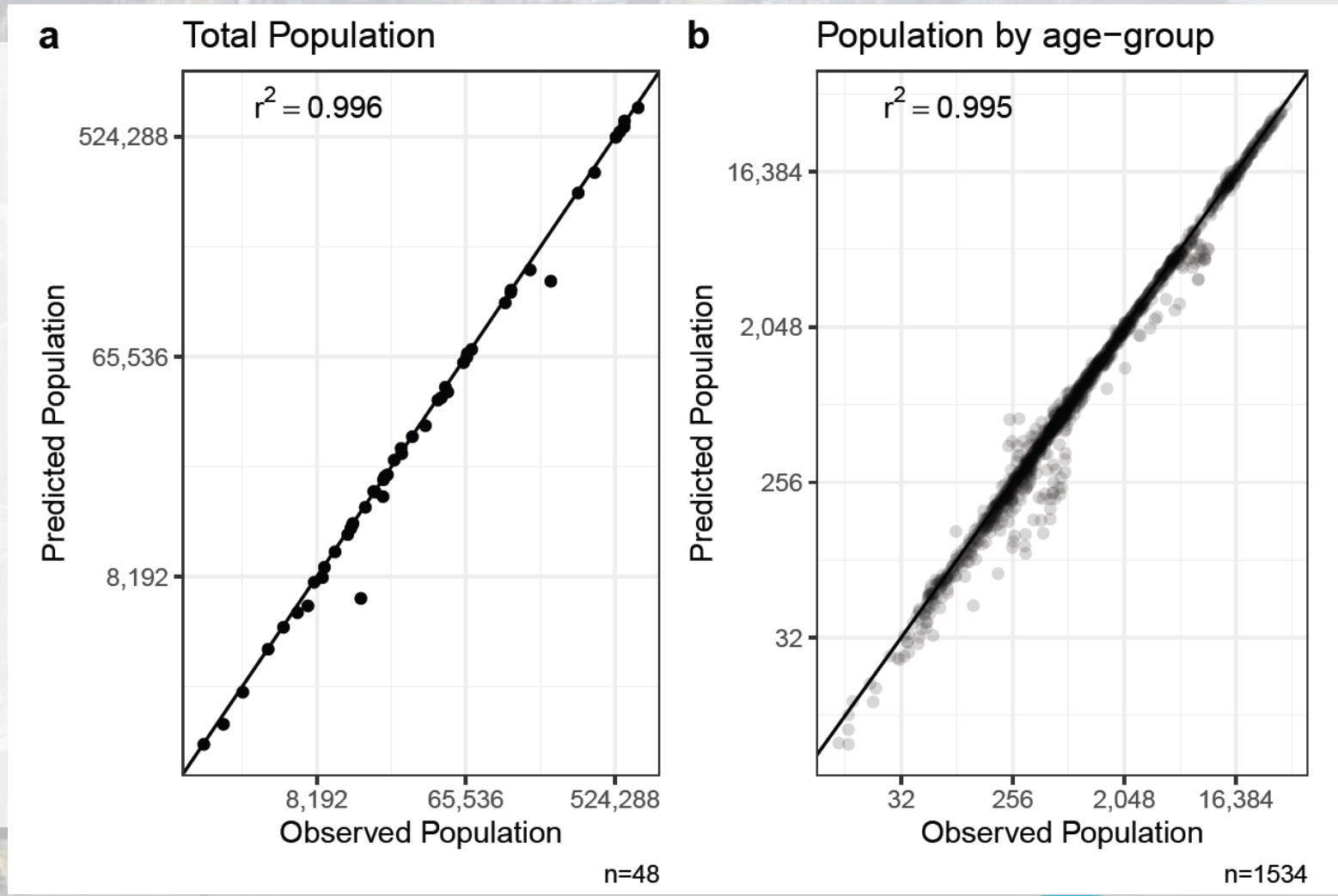
How well does our statistical model perform?

- Performance is very good!



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Demographic Model

- Our demographic model predicts migration to/from every US county until 2100.

- We made 3 population projections:

"Climate agnostic"

"Only migration"

"Full Demography"

$$\text{Base} \qquad : \mathbf{P}_{t+1}^{Base}$$

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Results

- SSP1 = Sustainability
- SSP2 = Middle of the Road

RCP		SSP1	SSP2	SSP3	SSP4	SSP5
8.5	SLR Amount (meters) Migrants (millions) Demographic Amplification (millions)					
4.5	SLR Amount (meters) Migrants (millions) Demographic Amplification (millions)					
2.6	SLR Amount (meters) Migrants (millions) Demographic Amplification (millions)					

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RCP		SSP1	SSP2	SSP3	SSP4	SSP5
8.5	SLR Amount (meters) Migrants (millions) Demographic Amplification (millions)			0.79 [0.52 - 1.2]		
4.5	SLR Amount (meters) Migrants (millions) Demographic Amplification (millions)			0.59 [0.36 - 0.93]		
2.6	SLR Amount (meters) Migrants (millions) Demographic Amplification (millions)			0.5 [0.29 - 0.82]		

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Results

- SSP1 = Sustainability
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RCP		SSP1	SSP2	SSP3	SSP4	SSP5
8.5	SLR Amount (meters)			0.79 [0.52 - 1.2]		
	Migrants (millions)					
	Demographic Amplification (millions)					
4.5	SLR Amount (meters)			0.59 [0.36 - 0.93]		
	Migrants (millions)		1.5 [0.63 - 4.1]			
	Demographic Amplification (millions)		15 [10 - 26]			
2.6	SLR Amount (meters)			0.5 [0.29 - 0.82]		
	Migrants (millions)					
	Demographic Amplification (millions)					

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Results

- SSP1 = Sustainability
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RCP		SSP1	SSP2	SSP3	SSP4	SSP5
8.5	SLR Amount (meters)			0.79 [0.52 - 1.2]		
	Migrants (millions)					3.4 [1.3 - 10]
	Demographic Amplification (millions)					28 [17 - 53]
4.5	SLR Amount (meters)			0.59 [0.36 - 0.93]		
	Migrants (millions)		1.5 [0.63 - 4.1]			
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	Migrants (millions)					
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	Migrants (millions)					3.4 [1.3 - 10]
	Demographic Amplification (millions)					28 [17 - 53]
4.5	SLR Amount (meters)			0.59 [0.36 - 0.93]		
	Migrants (millions)		1.5 [0.63 - 4.1]	0.84 [0.36 - 2.3]		
	Demographic Amplification (millions)		15 [10 - 26]	8.6 [5.7 - 15]		
2.6	SLR Amount (meters)			0.5 [0.29 - 0.82]		
	Migrants (millions)					
	Demographic Amplification (millions)					

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Results

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RCP		SSP1	SSP2	SSP3	SSP4	SSP5
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	Migrants (millions)		1.5 [0.63 - 4.1]	0.84 [0.36 - 2.3]	1.2 [0.51 - 3.3]	2.2 [0.96 - 6.2]
	Demographic Amplification (millions)		15 [10 - 26]	8.6 [5.7 - 15]	12 [8 - 21]	23 [15 - 41]
2.6	SLR Amount (meters)			0.5 [0.29 - 0.82]		
	Migrants (millions)	1.2 [0.55 - 3.5]	1.2 [0.54 - 3.4]		0.96 [0.44 - 2.8]	1.8 [0.82 - 5.1]
	Demographic Amplification (millions)	14 [9.7 - 24]	14 [9.5 - 24]		11 [7.6 - 19]	21 [15 - 37]

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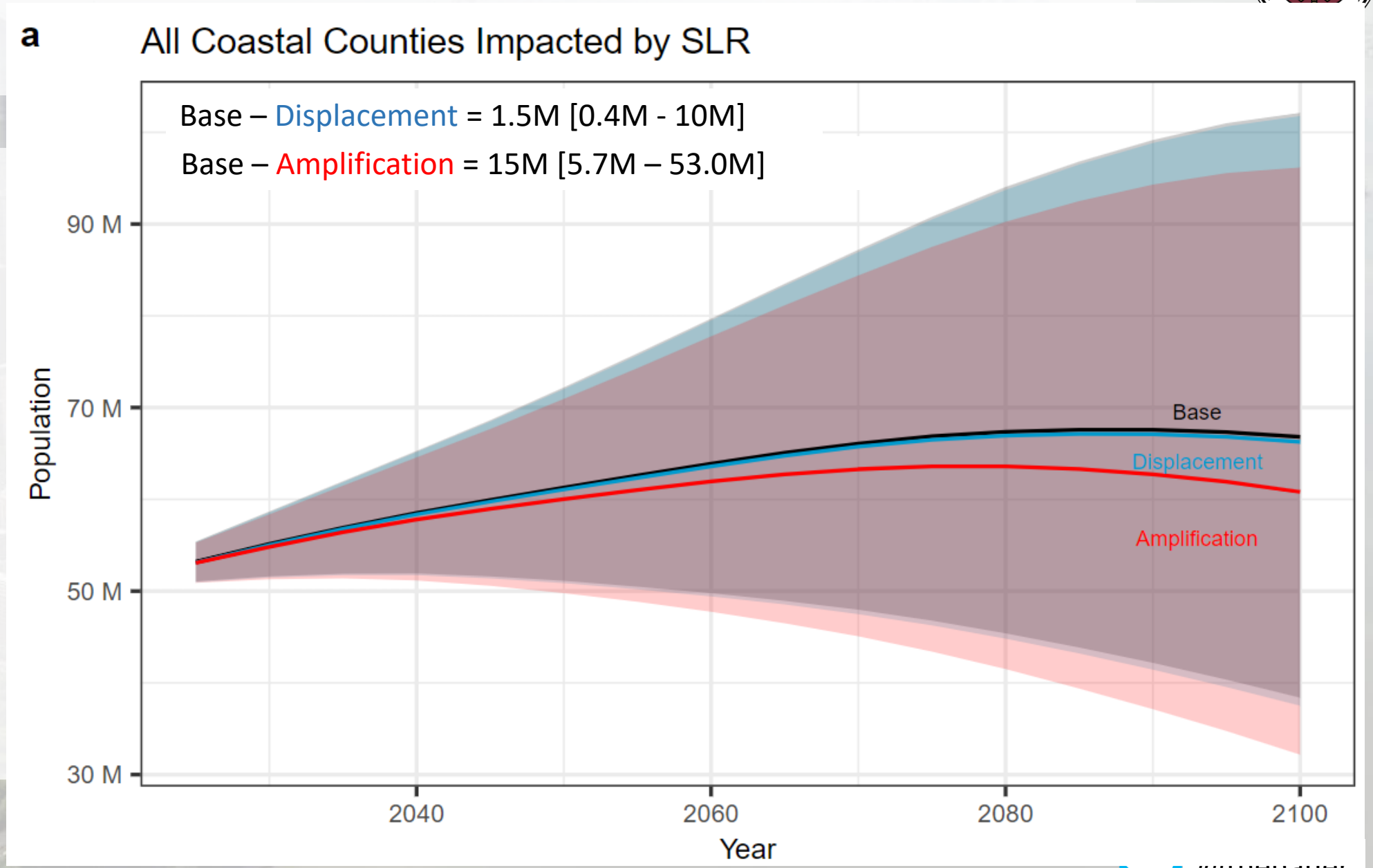
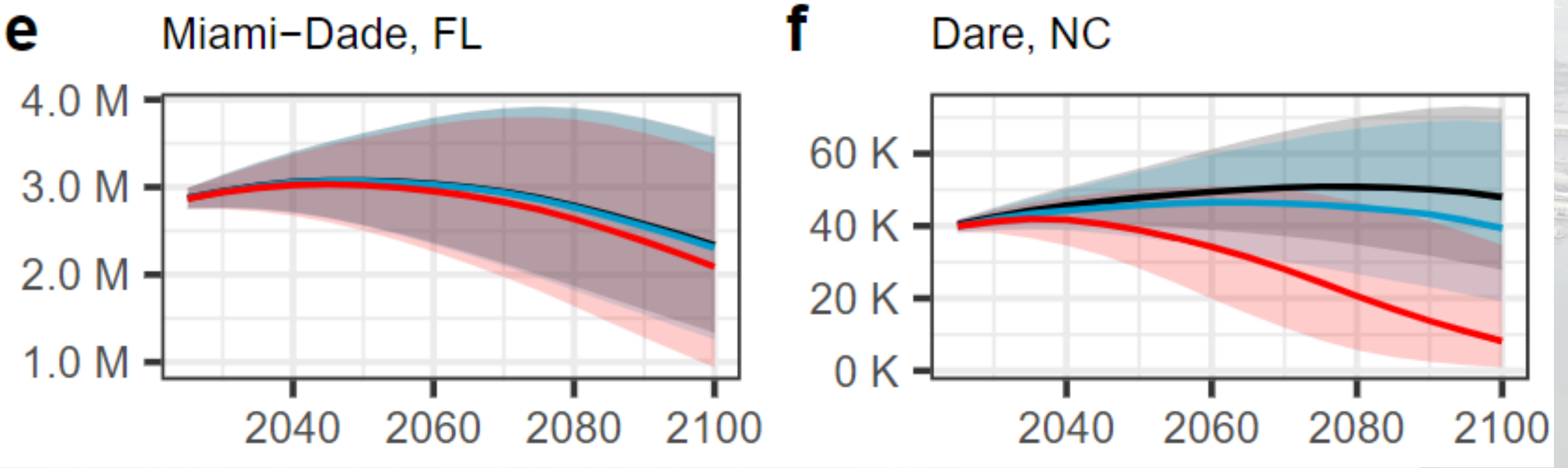
Results

10x effect!



Results



It doesn't take much sea-level rise to have a major demographic amplification.

RCP4.5-SSP2 = 28k displacements buts 250k fewer residents in Miami.

RCP4.5-SSP2 = 8.5K displacements but 39.8k fewer residents in Dare.

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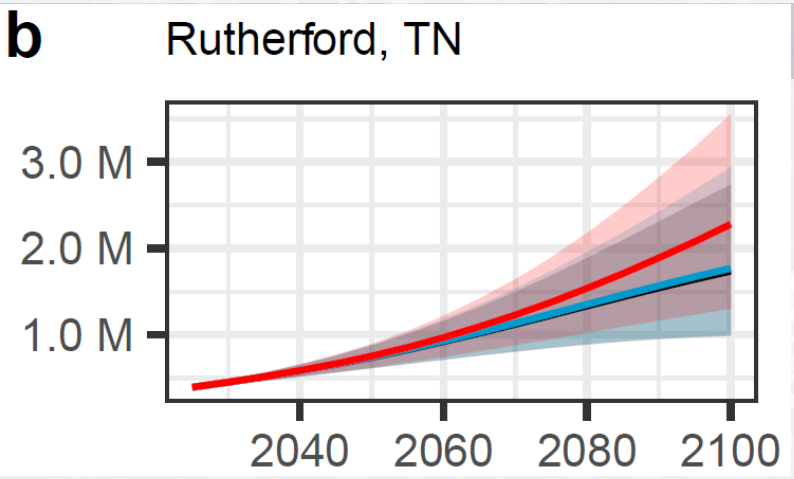
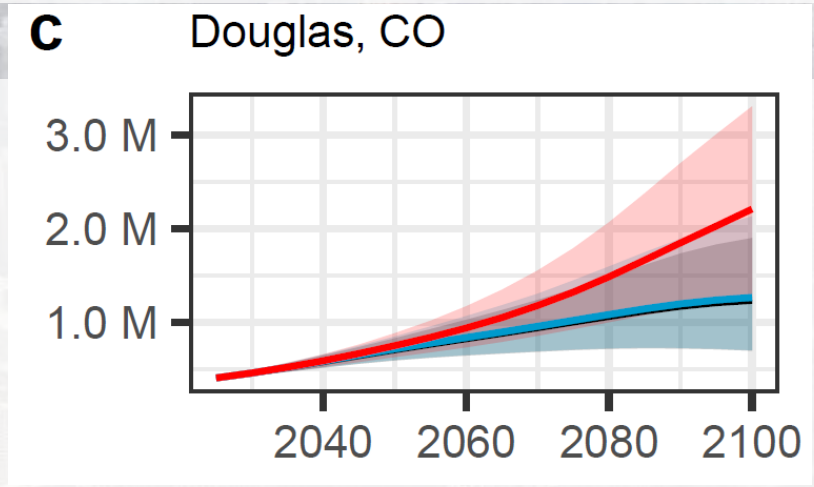
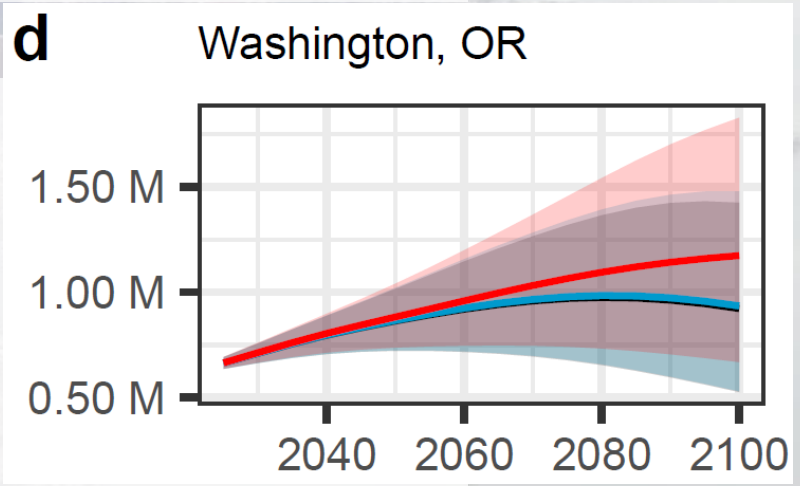
Results







Emergence of Climate Destinations (Nashville, outside Denver and Portland).

Amplification much larger than simple displacement

Rutherford:

Amplification= +245K [78K – 852K]
Displacement= + 34.9K [8.2K – 197K]

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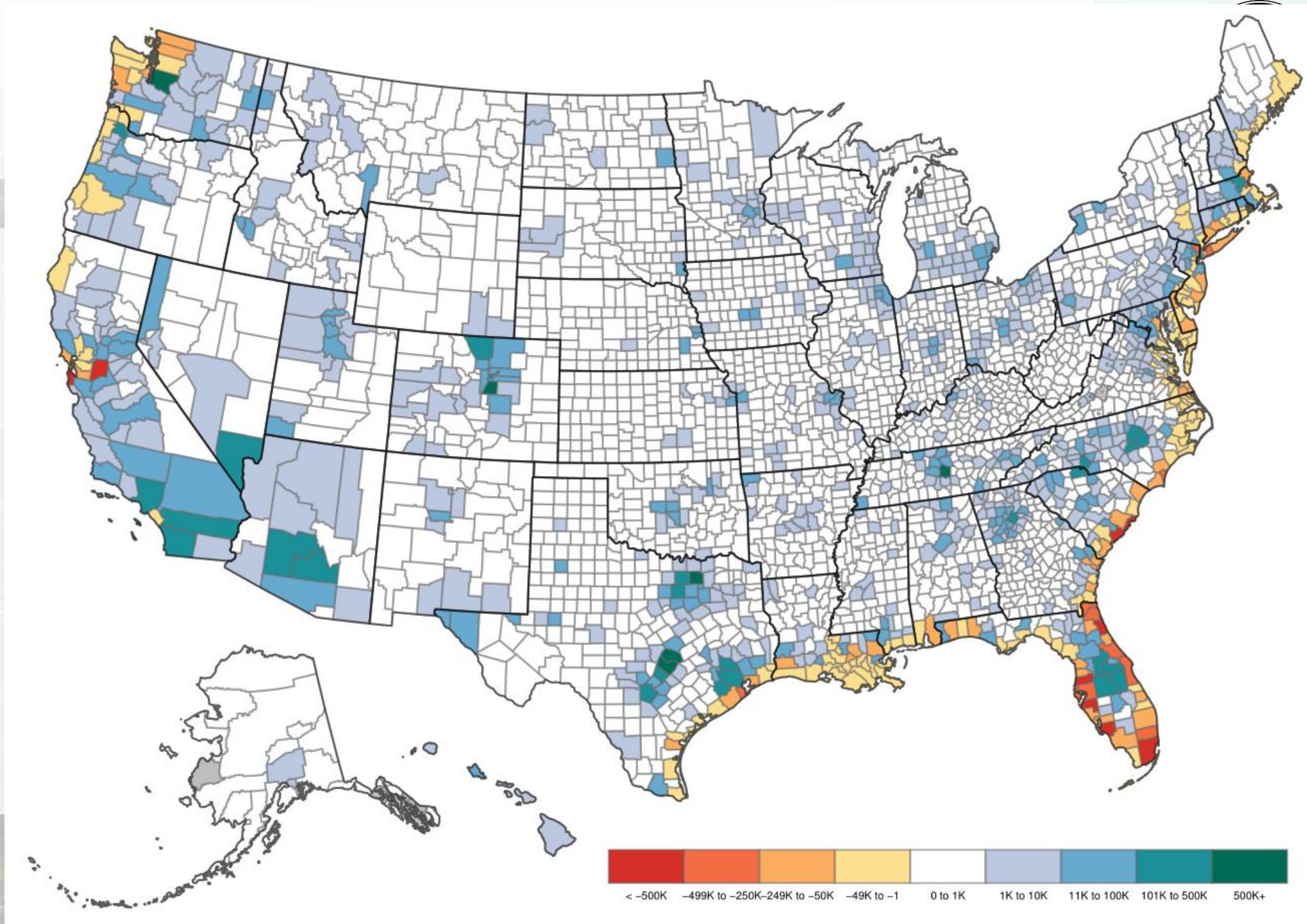
Results

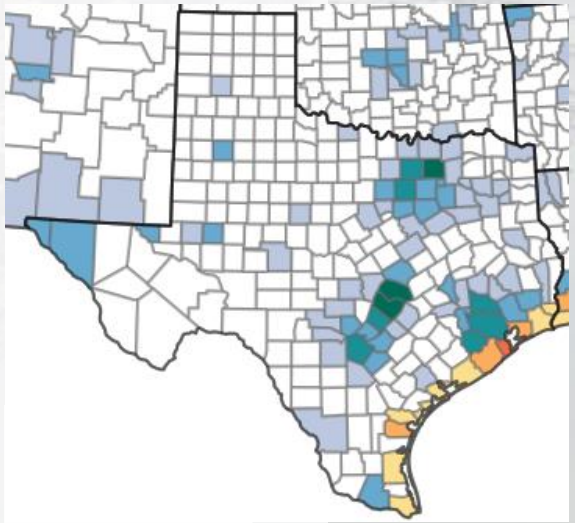
Amplification of both pop decline and growth



Results

Texas = +2.7m [1.9m – 4.2] <- Largest increase for States…

Williamson	=	+1.3m [+0.9m – +1.7m]
Travis	=	+0.7m [+0.5m – +1.1m]
Collin	=	+0.2m [+0.1m – +0.4m]
Galveston	=	-0.2m [-0.1m – -0.3m]
Brazoria	=	-0.1m [-1.5m – -0.01m]
Chambers	=	-0.08m [-0.05m – -0.1m]



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Migration Decision Making

- Why do people move because of climate change?
- They weigh the costs/benefits of a myriad of economic, social, demographic, emotional, and political factors.
- People might migrate in response to
  - Policy incentives
  - Employment opportunities
  - Social/kin networks
  - Socioeconomic reasons

Might operate in concert or independently from each other

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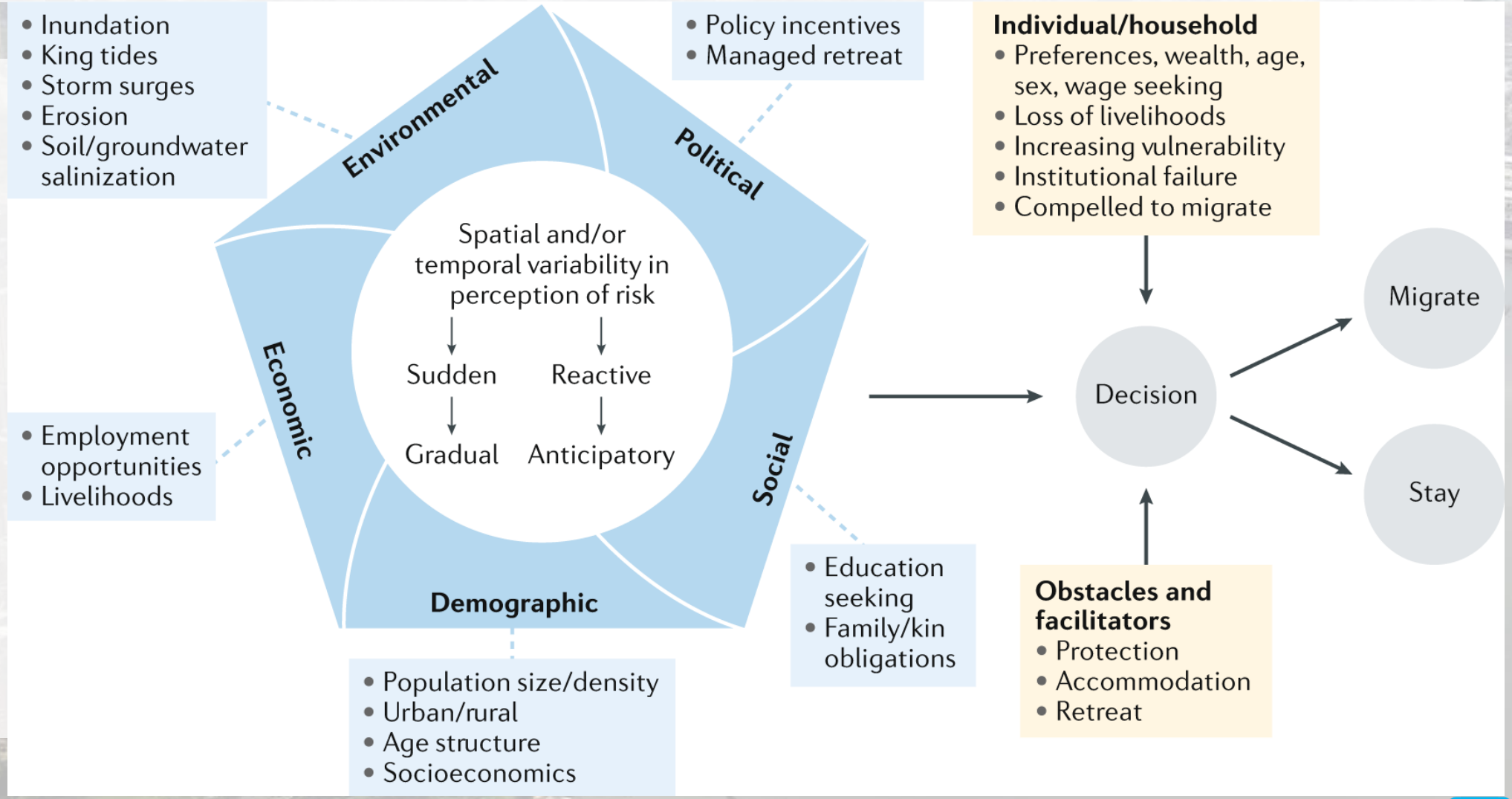
Migration Decision Making



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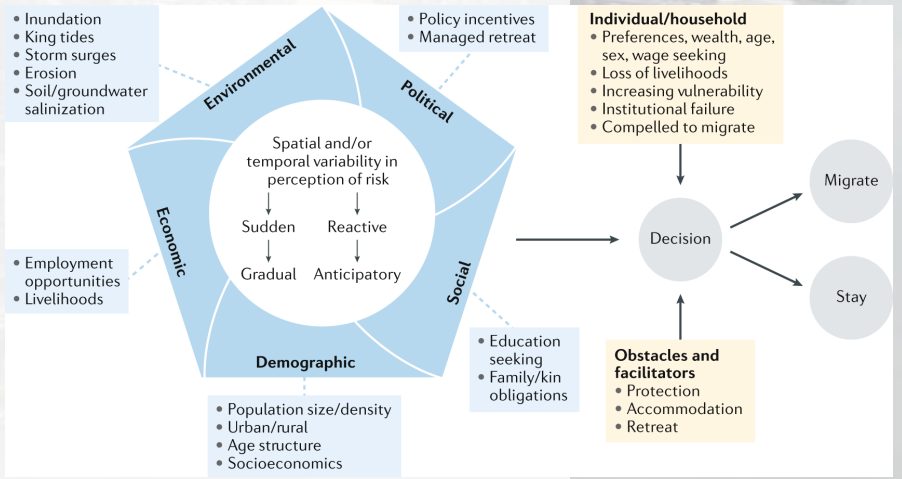
Migration Decision Making

- When does migration occur?
  - Property Damage due to storm surge (Environmental)
    - Preference for temperatures (Environmental)
  - Home buyouts (Political).
  - Close to retirement age (Demographic).
  - Desire to move closer to grandkids (Social).
  - Can’t afford damage from the next storm (Anticipatory)



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Migration Decision Making

- Five principles govern the destinations of environmental migrants:
  1. "Immobility paradox"
     - People want to stay, even if they should move.
  2. Gravity Law of migration.
     - People move to nearer, larger destinations.
  3. Increased wages or human capital lead to migration.
     - Higher levels of human capital are more likely to move and move farther.
  4. People follow pre-existing social and kin ties.
     - People move to places they're familiar with, within their social networks.
  5. Increased social and cultural capital are attractive in destinations.
     - It's not just economics.

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Migration Decision Making

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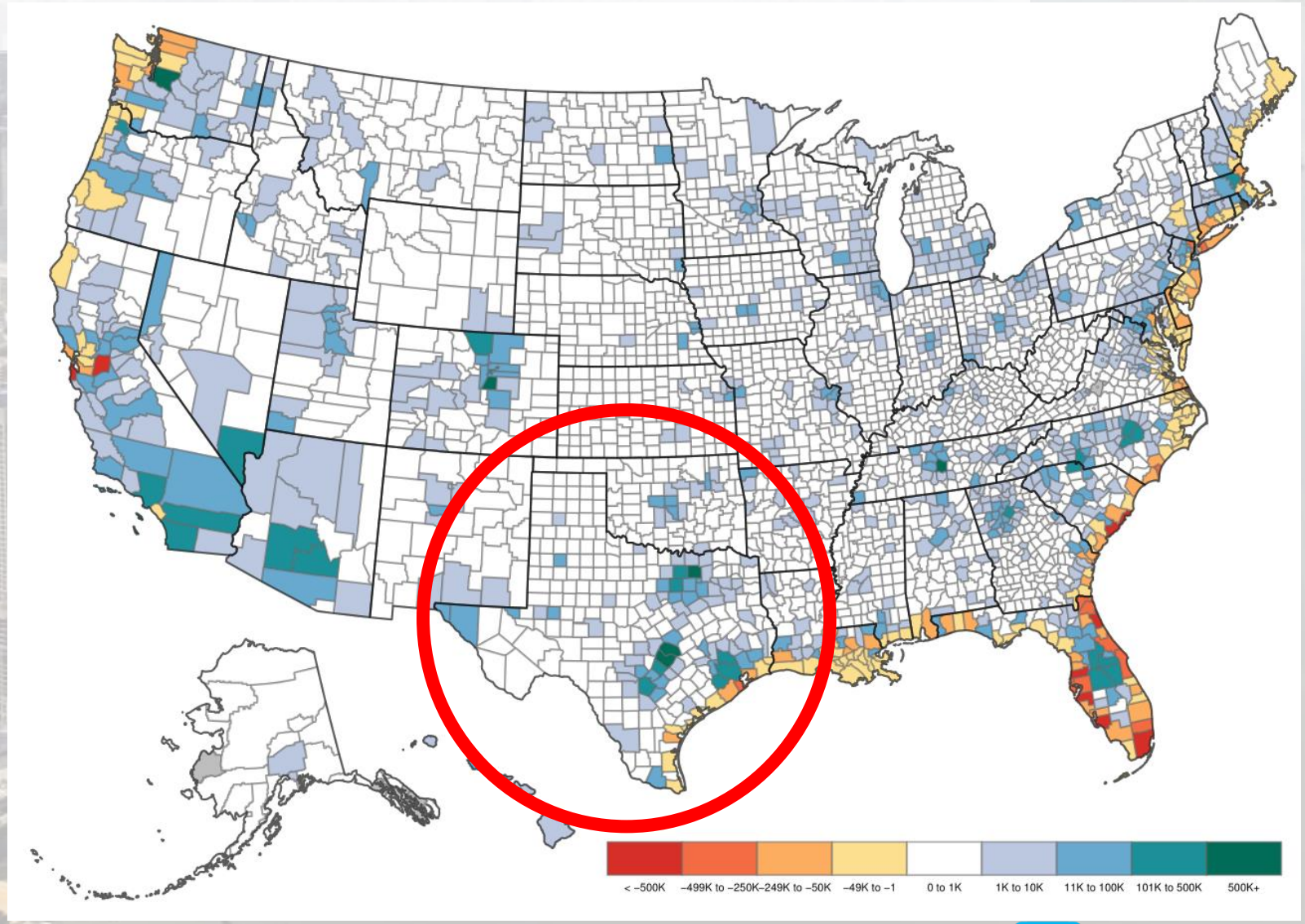
  1. "Immobility paradox"
  2. Gravity Law of migration.
  3. Increased wages or human capital lead to migration.
  4. People follow pre-existing social and kin ties.
  5. Increased social and cultural capital are attractive in destinations.

Lots of reasons why Texas could be a climate migration destination.



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Conclusion

- The amplification of demographic change (further fertility, mortality, and migration) is MUCH larger than just the migration effect ~10x larger!

- Texas sees the largest population increase from this climate migration demographic amplification.

- There are many reasons why Texas might be a climate destination for other climate hazards.

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Thank you!

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