Climate Change Effects on Ecosystem Services and Human Health

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The Ecology of Disease

Olaf Hajek

By JIM ROBBINS
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Asclepius, a serpent coiled three times around a stick

The Bowl of Hygeia The cup symbol of medicinal potion with the serpent of wisdom.

THE HIPPOCRATIC OATH

I swear by Apollo, Physician and Asclepius and Hygeia and Panaceia and all the gods and goddesses, making them my witnesses, that I will fulfill according to my ability and judgment this oath and this covenant.

- Hygeia represented a public health model that focused on prevention in the context of public interest.

Austin Texas
EPA, CDC, R6, R9, CDPH, NGO, Austin gov't

Plus:
Phil Gordon
Shannon Jones
Patrick Kelly
Kim Knowlton
Otis Latin
Ester Matthews
Mike McGeehin
Linda Rudolph
Richard Wade
Hal Zenick

Desirable characteristics of the integrated tool

- Temporally and spatially explicit
- Predicts effects of natural resources and human health / well being decisions on each other.
- Provides framework for considering multiple health and eco outcomes
- Provides framework for considering effects of external drivers, e.g. climate change
- Provides framework for assessing cost / benefits of potential decisions

HYGIEA

- HYGEIA makes use of the MIMES framework and model libraries

- is a model in forecasting the effects of climate change on human health and health-environment interactions.

- is developed with using the effect of heat waves on people in Austin Texas as a case study.

What is the MIMES?

MIMES

the Multiscale Integrated Models of Ecosystem Services

- is a dynamic GIS system designed to address the magnitude, dynamics, and spatial patterns of ecosystem service values.

- uses an integrated suite of models coupled through an interaction matrix.
  - The matrix allows a MIMES case study to pass information among surveys, Geographical Information Systems (GIS), and process knowledge for developing fully functional spatial dynamic models.

- considers multiple ecosystem goods and services simultaneously and aims to explore their tradeoffs, and responses to multiple, potentially interacting, environmental and human drivers.

- allows users to understand the long-term sustainability of ecosystem services under different scenarios of human action

- is a sophisticated and transferable system that allows researchers to upload improved models and datasets while simultaneously allowing model users to calculate the dynamics of ecosystem services, their links to human quality of life, and their sustainability under various management scenarios.
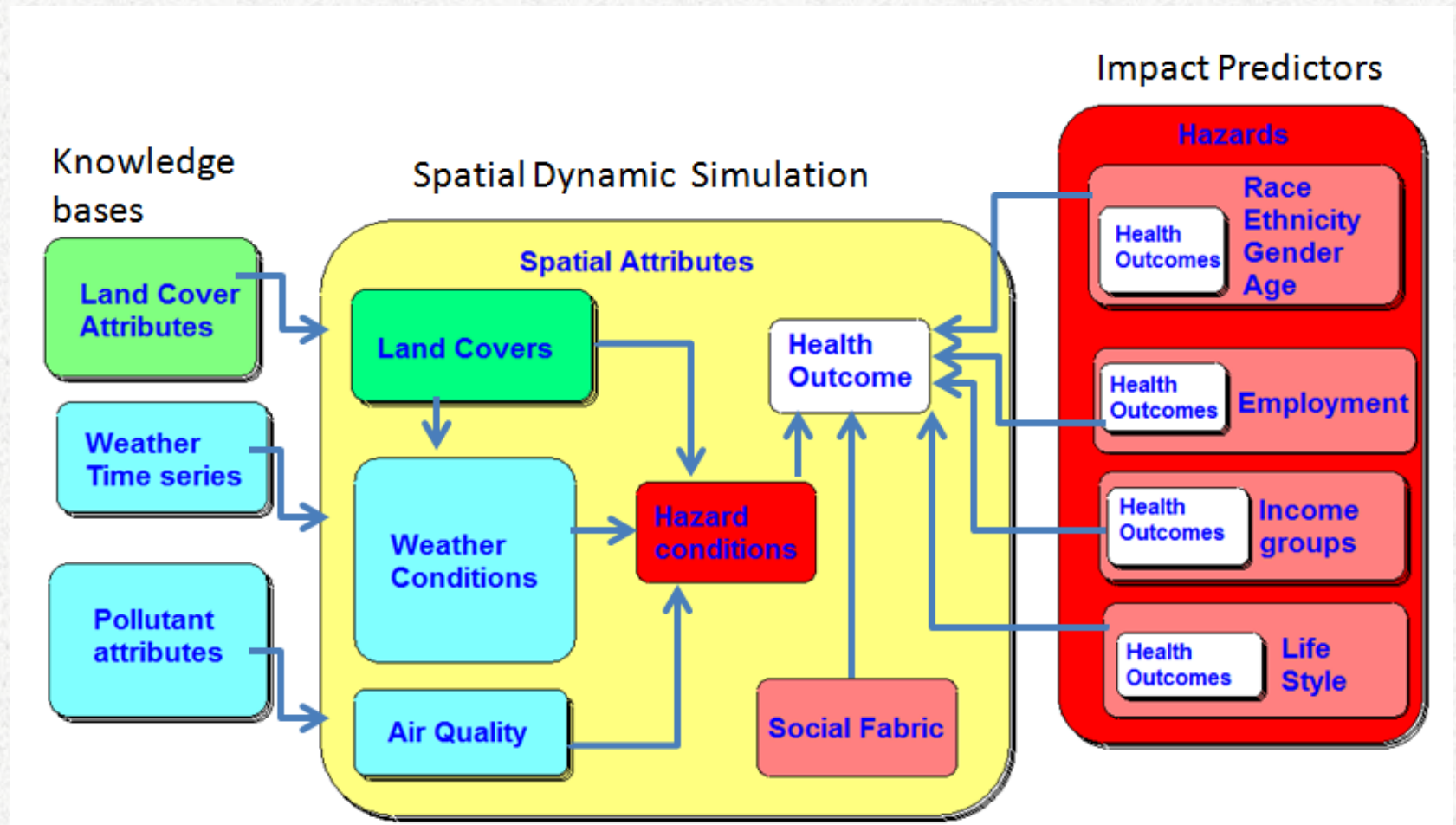
MIMES
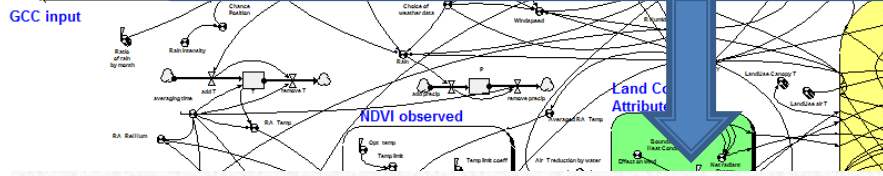## The Multi-Scale Integrated Model of Ecosystem Services
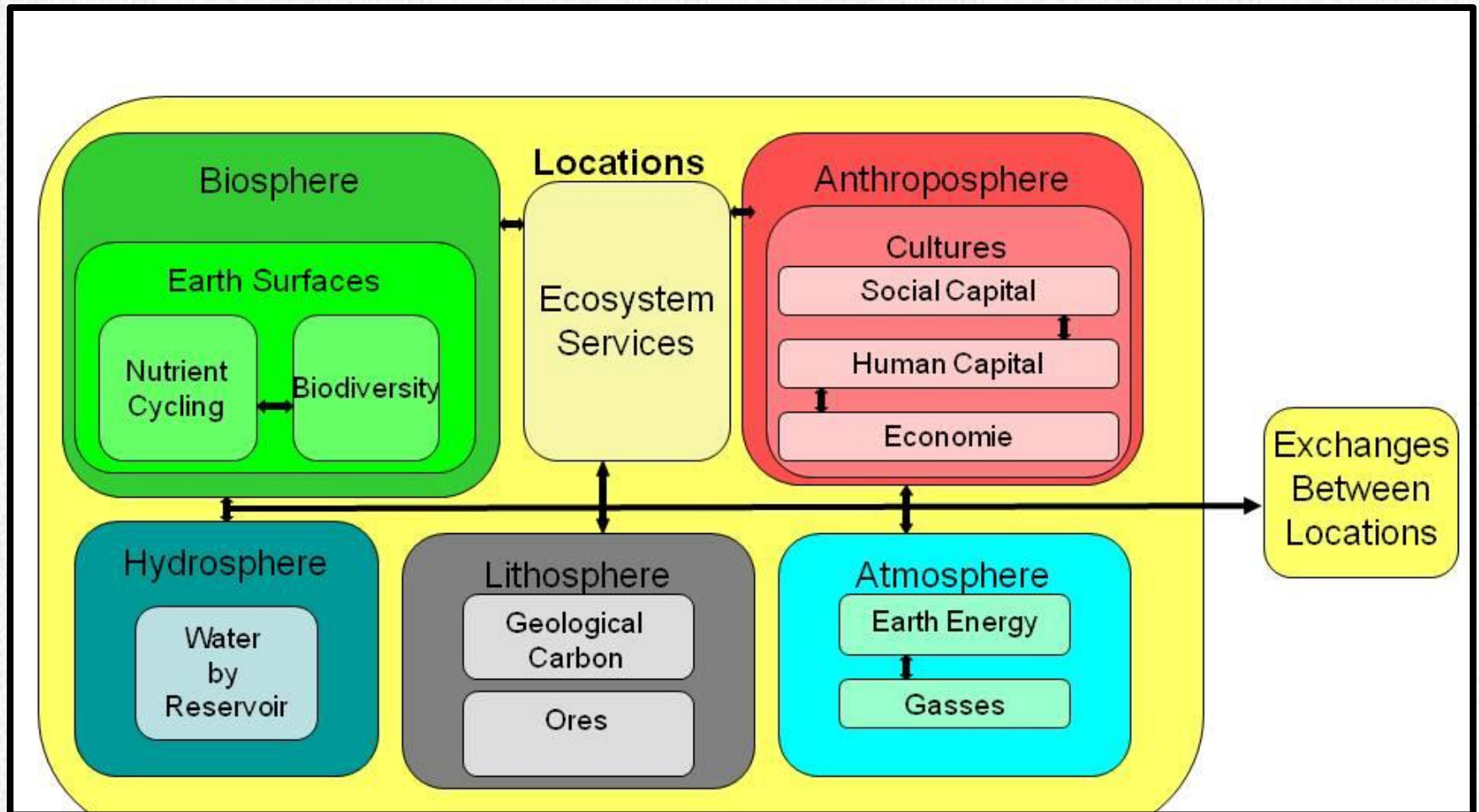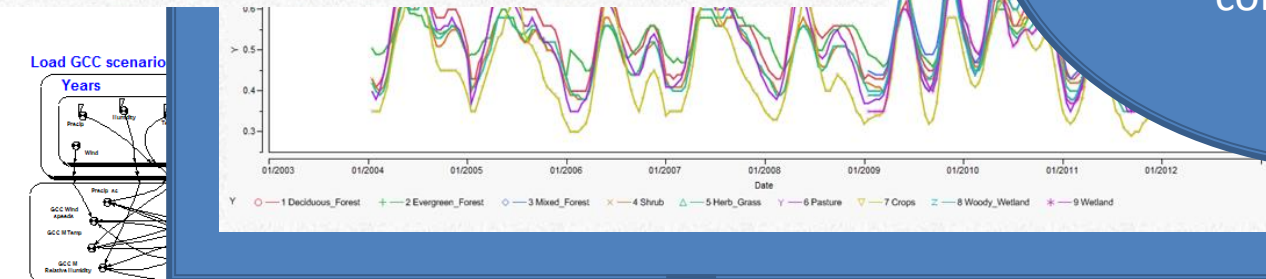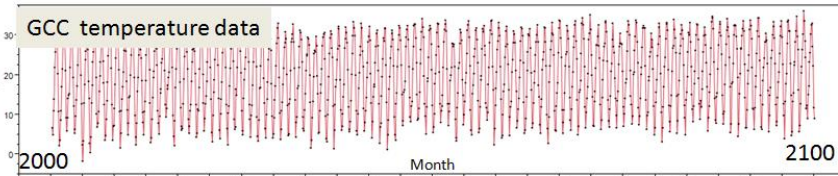
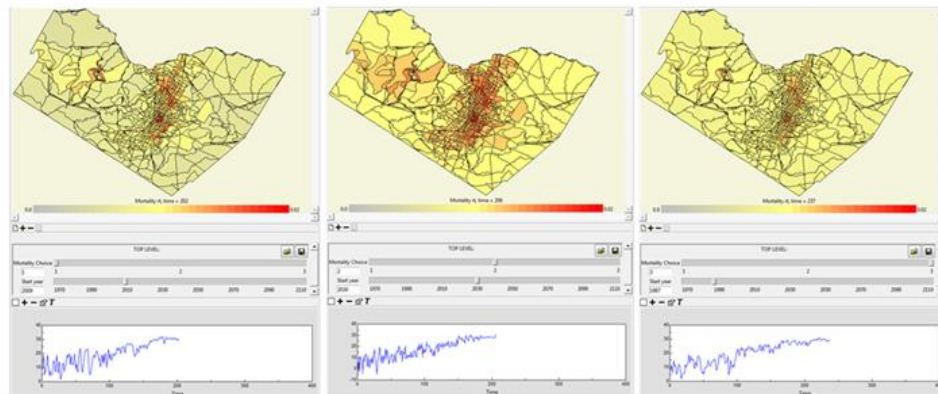- What is HYGEIA?

HYGEIA Model
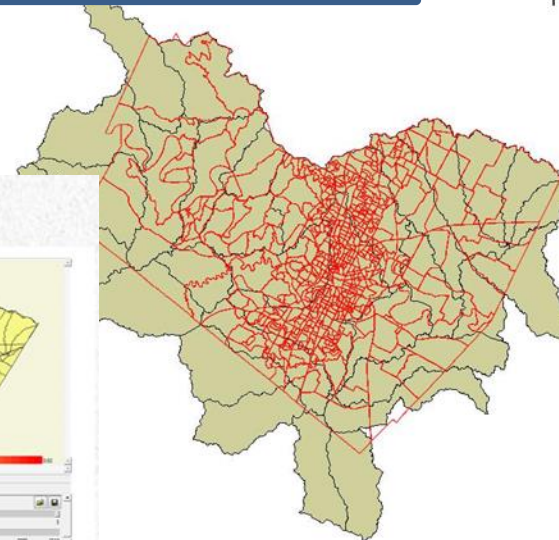
HYGEIA overall model logic

- Determine spatial and temporal variation in hazard exposure

- Analyze spatial variation in population vulnerability to hazards

- Estimate health outcome risk for population groups through hazard exposure and hazard response functions

- Examine how mitigation options may affect health outcomes and their links to other ecosystem services

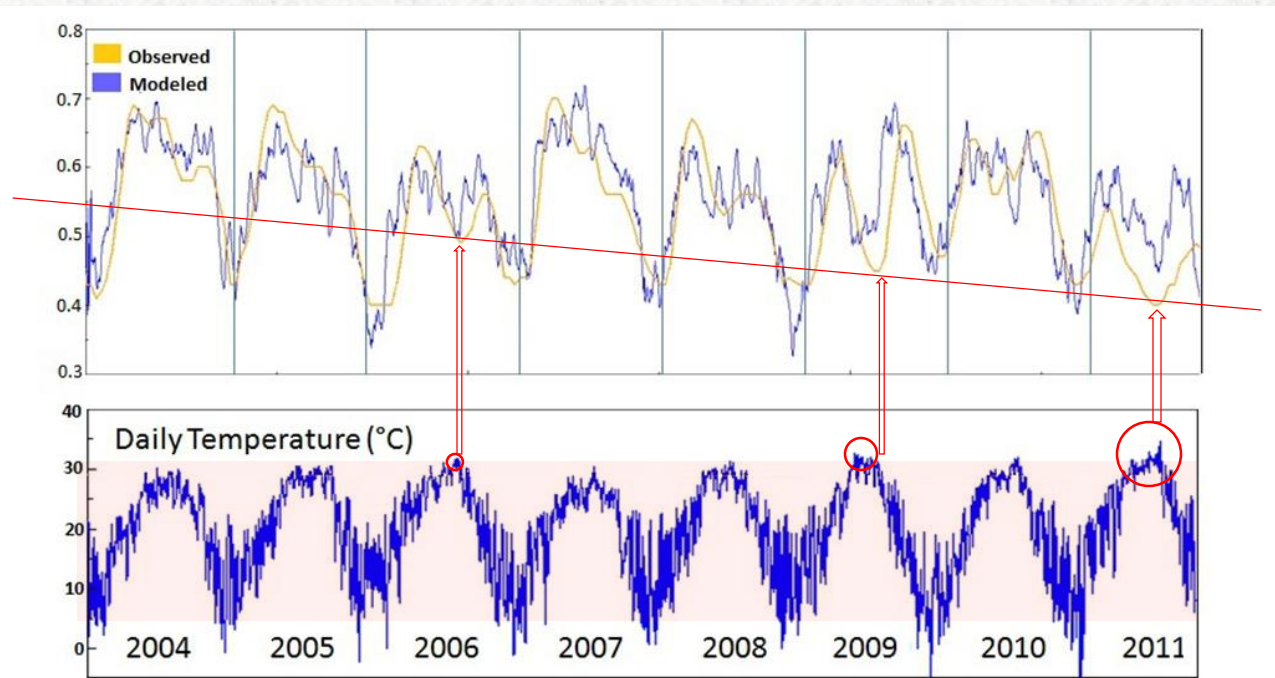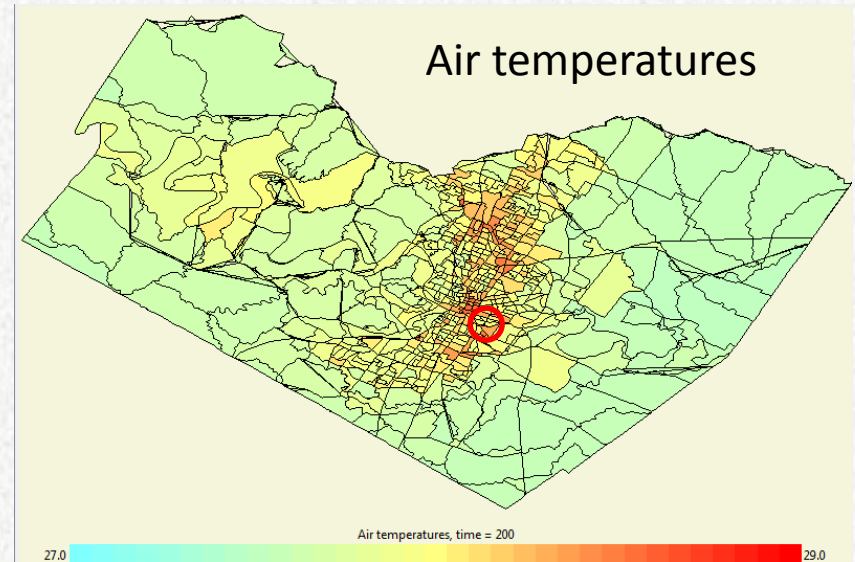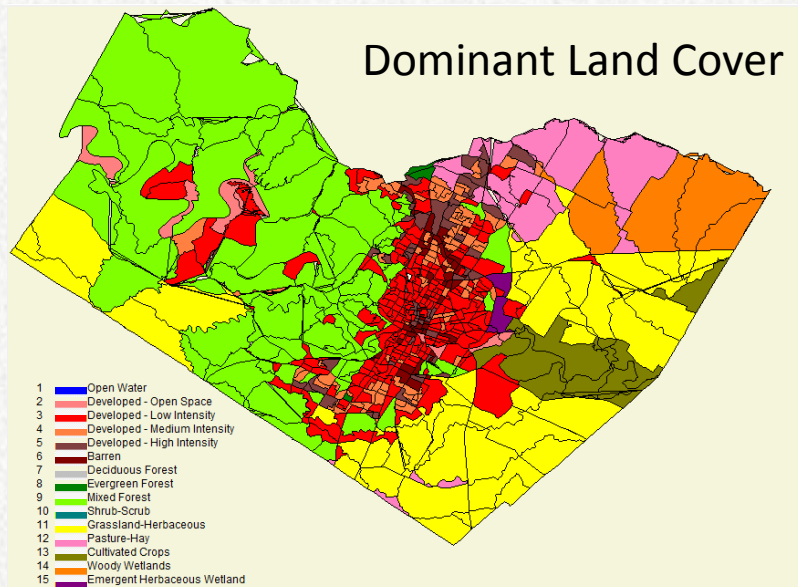# The **NDVI** response to local weather conditions.

Figure 3. Top panel - Observed and modeled NDVI values for Deciduous Forest for Travis County, TX over 2004-2011. Bottom panel - Daily mean temperatures for the same time period.

Vegetation effects on temperature

Dominant Land Cover

1	Open Water
2	Developed - Open Space
3	Developed - Low Intensity
4	Developed - Medium Intensity
5	Developed - High Intensity
6	Barren
7	Deciduous Forest
8	Evergreen Forest
9	Mixed Forest
10	Shrub-Scrub
11	Grassland-Herbaceous
12	Pasture-Hay
13	Cultivated Crops
14	Woody Wetlands
15	Emergent Herbaceous Wetland

Air temperatures

Air temperatures, time = 200

27.0   29.0
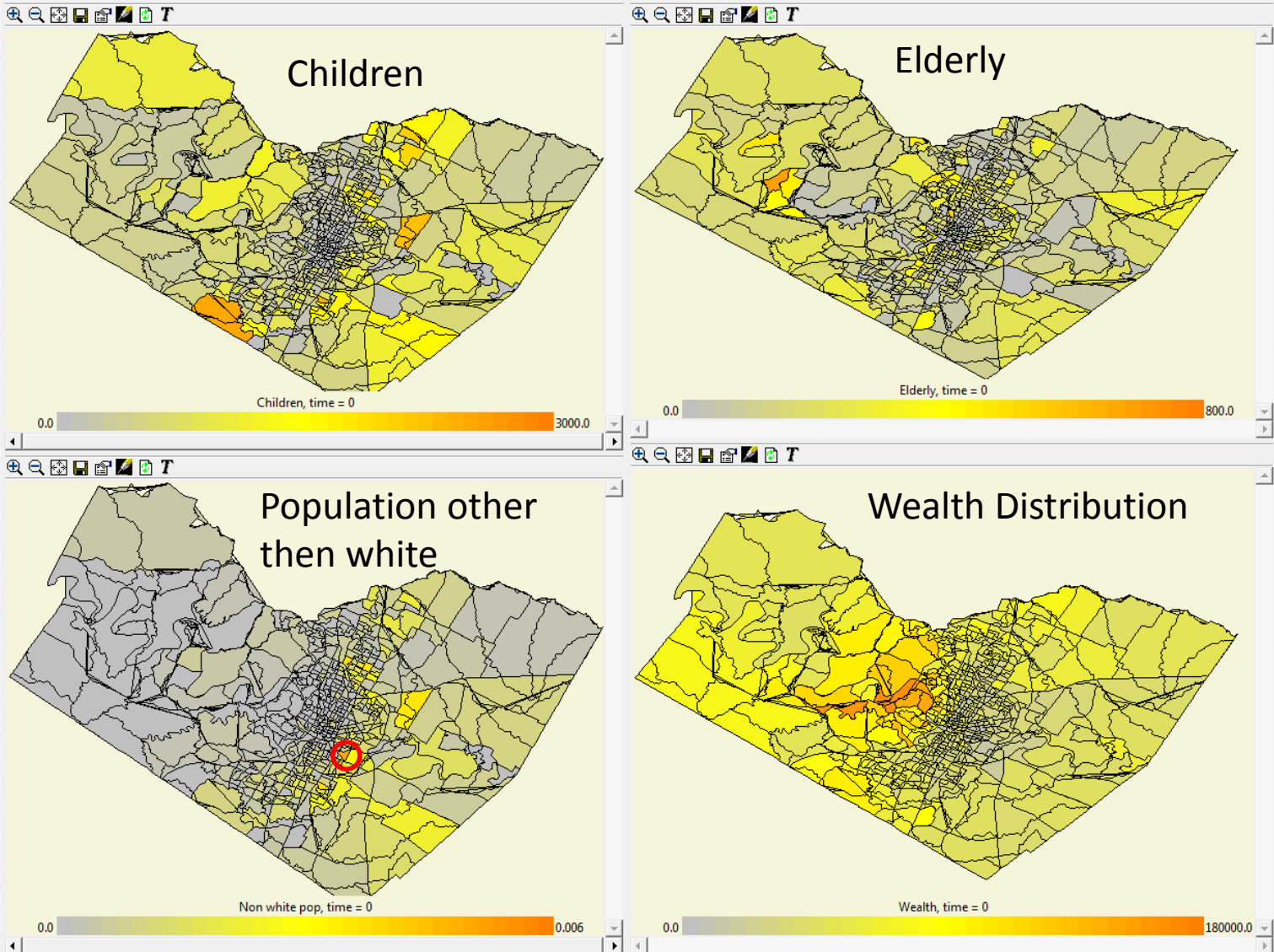
June 7, 2011:
Model surface temperatures ranged from 39.9 to 45.7 °C, with a mean of 43.1 °C. Corresponding Landsat-derived surface temperatures spanned a somewhat larger range from 34.6 to 51.4 °C, with a mean of 42.4 °C.

Examples within the Social Fabric
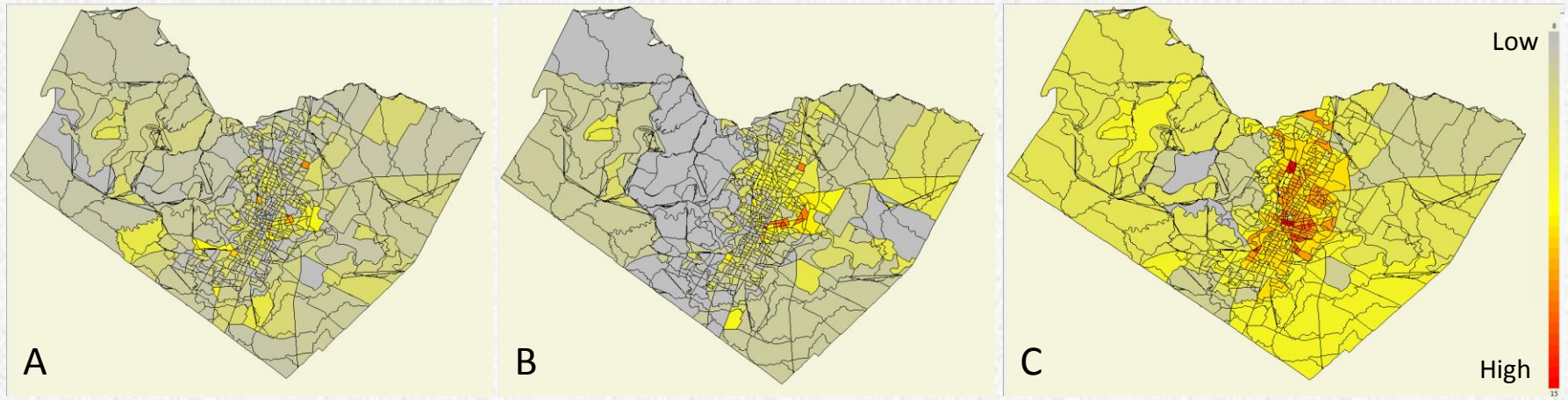
Spatial distributions of heat vulnerability measures for Travis County TX:

- (A) HYGEIA cardiovascular risk estimate;

- (B) a vulnerability index based on age, ethnicity, population density, social isolation, impervious surfaces, and remote sensed surface temperatures (Houghton et al. 2012);

- (C) the Heat Vulnerability Index (HVI) developed by Reid et al. (2009)

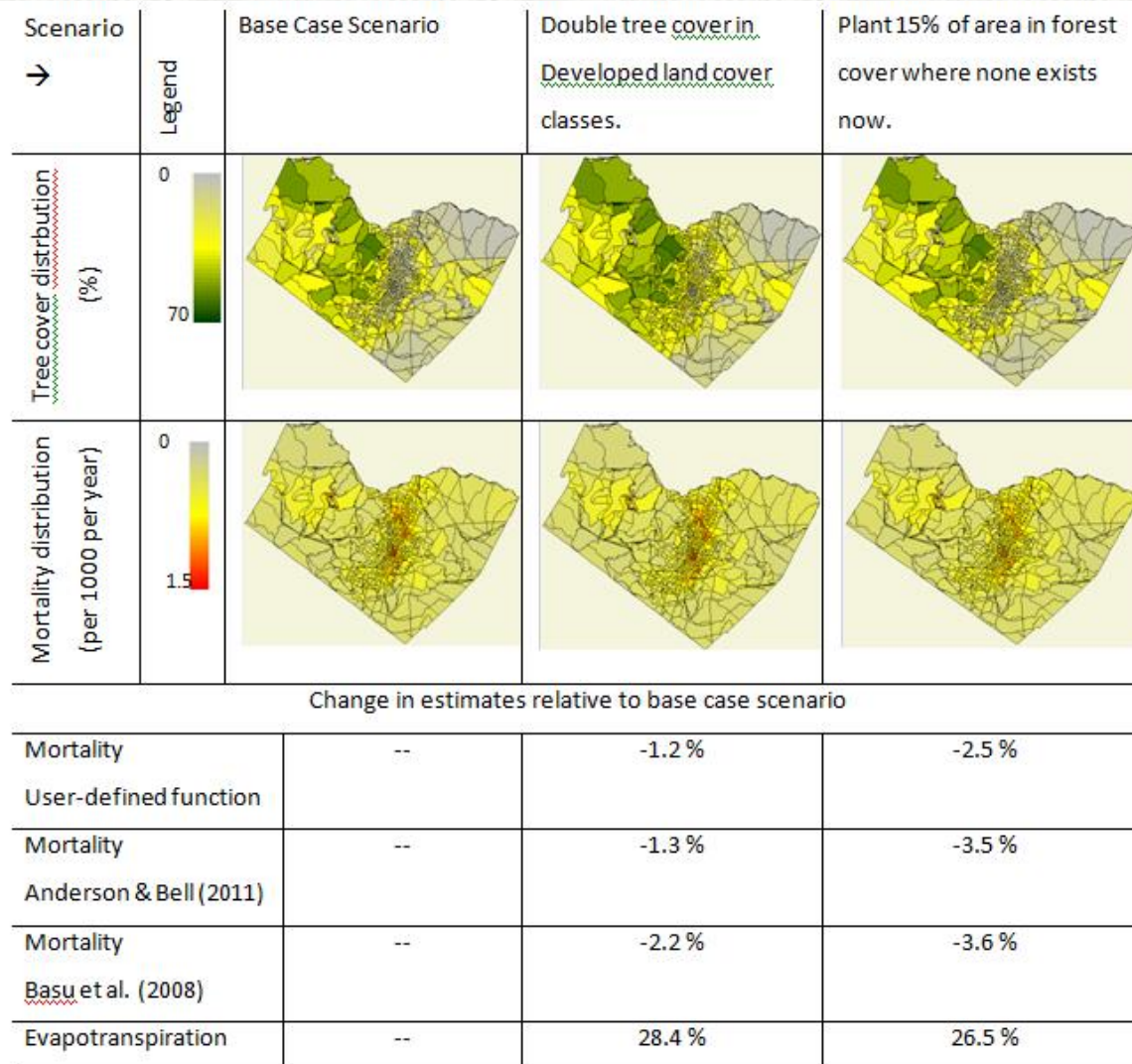# HYGEIA Scenarios

Scenario →	Legend	Base Case Scenario	Double tree cover in Developed land cover classes.	Plant 15% of area in forest cover where none exists now.
Tree cover distribution (%)	0 ⎯ 70			
Mortality distribution (per 1000 per year)	0 ⎯ 1.5			
Change in estimates relative to base case scenario				
Mortality User-defined function		--	-1.2 %	-2.5 %
Mortality Anderson & Bell (2011)		--	-1.3 %	-3.5 %
Mortality Basu et al. (2008)		--	-2.2 %	-3.6 %
Evapotranspiration		--	28.4 %	26.5 %

In Summary

- HYGEIA explicitly links human health & well being with ecosystem services, and examines how they interact within the context of natural resources decision making and climate change.

- HYGEIA has been applied to address the specific issue of climate change induced heat stress on human morbidity and mortality in Austin Texas, but was designed to accommodate many other stressors and their effects.

- HYGEIA predicts outcomes on a temporally and spatially explicit basis (so for instance you can see where and when heat islands occur in cityscapes and can design appropriate mitigation strategies).

- HYGEIA also predicts outcomes for a variety of demographic conditions, e.g. age, race, income level.

- HYGEIA was designed so that it can be applied to any area in the country that has the requisite and standardized data input layers. These include land cover, climate scenarios, and block census data.

- HYGEIA was developed in a participatory setting that included EPA R6 and R9, NHEERL, NCEA, CDC, and various Texas agencies (state and local).