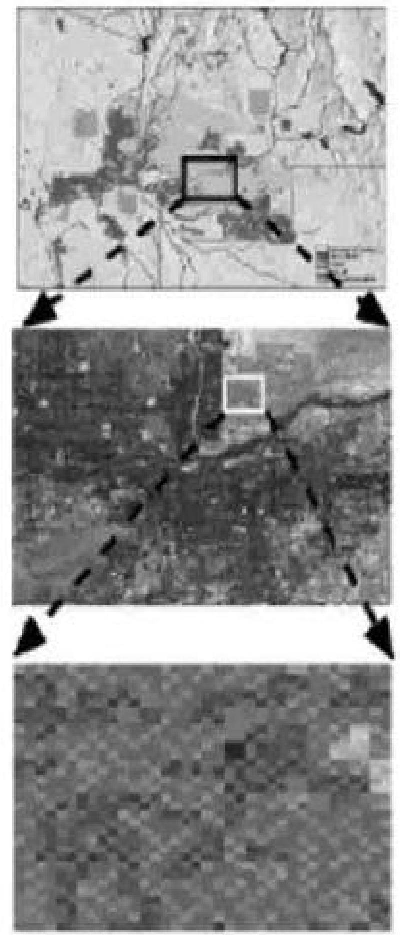
# A Plan 9 Approach to Hierarchical Patch Dynamics

John (EBo) David

IWP9 2010 Seattle, WA

# Many Problems are Inherently Multiscale

| Scale | Major Characteristics |
|---|---|
| Regional Landscape | • Composed of different types of local landscapes<br>• Heterogeneous in ecosystem structure and function<br>• Characterized by the dominant biome and land use pattern at the regional scale (e.g., an urbanized desert region vs. an agricultural grassland region) |
| Local Landscape | • Composed of different land use and land cover types<br>• Heterogeneous in ecosystem structure and function<br>• Characterized by dominant land use types, such as urban landscapes, rural landscapes, agricultural landscapes, and natural desert landscapes |
| Local Ecosystem | • Relatively homogeneous vegetation-soil complexes<br>• Readily detectable from air photos and remote sensing data (e.g., Landsat TM images)<br>• Largely corresponding to Anderson et al.'s (1976) Level II classes |



Wu & David (2001)

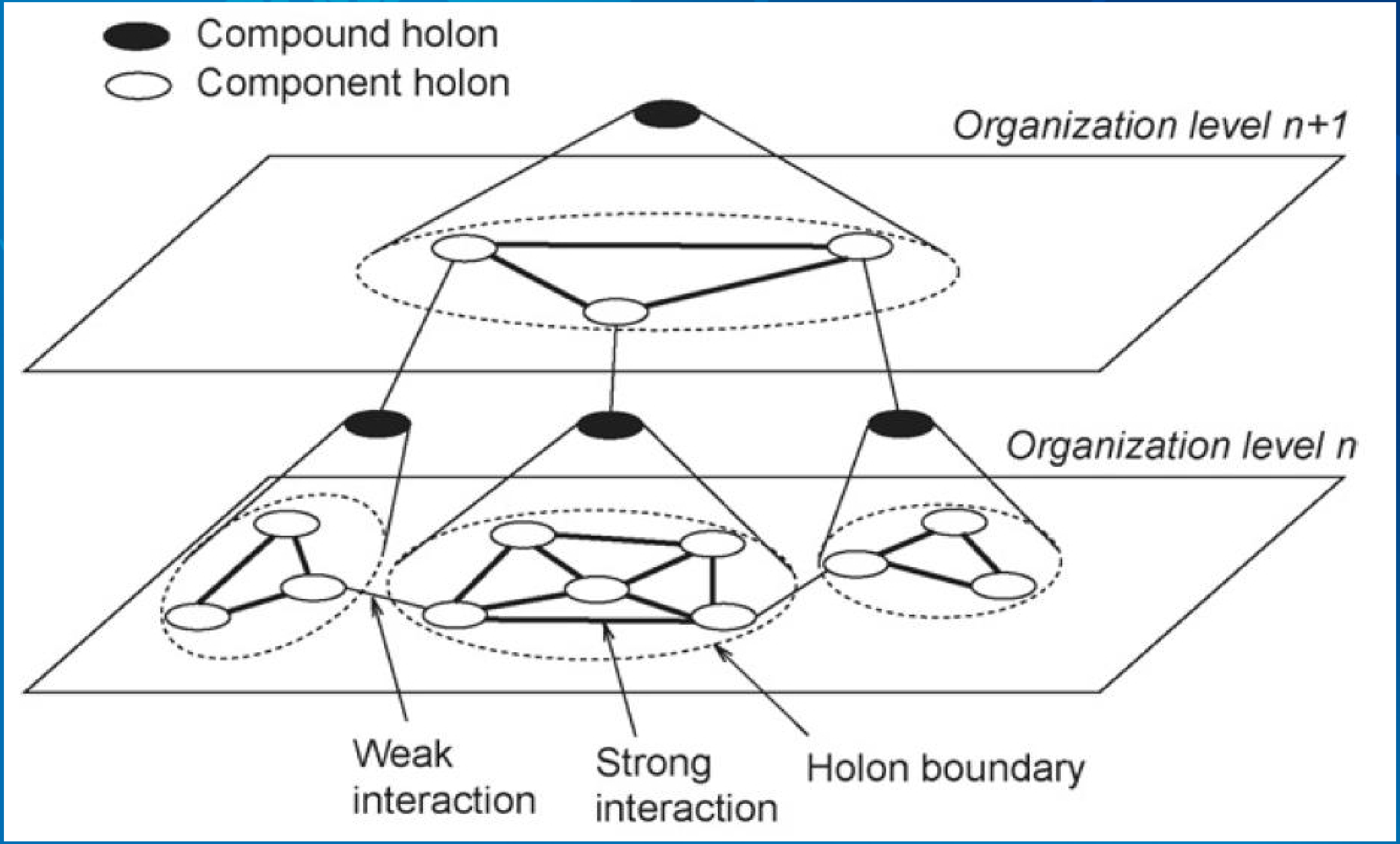
# Hierarchical Patch Dynamics (HPD)

*(Wu and Loucks 1995)*

- **HPD** explicitly integrates **hierarchy theory** with **patch dynamics**, and provides a conceptual and operational framework for linking pattern, process, and scale in heterogeneous landscapes.
- Clean model decomposition allows linking across disciplines as well as scale
- Fully runtime polymorphic

# Hierarchy Theory
*(Simon 1962)*

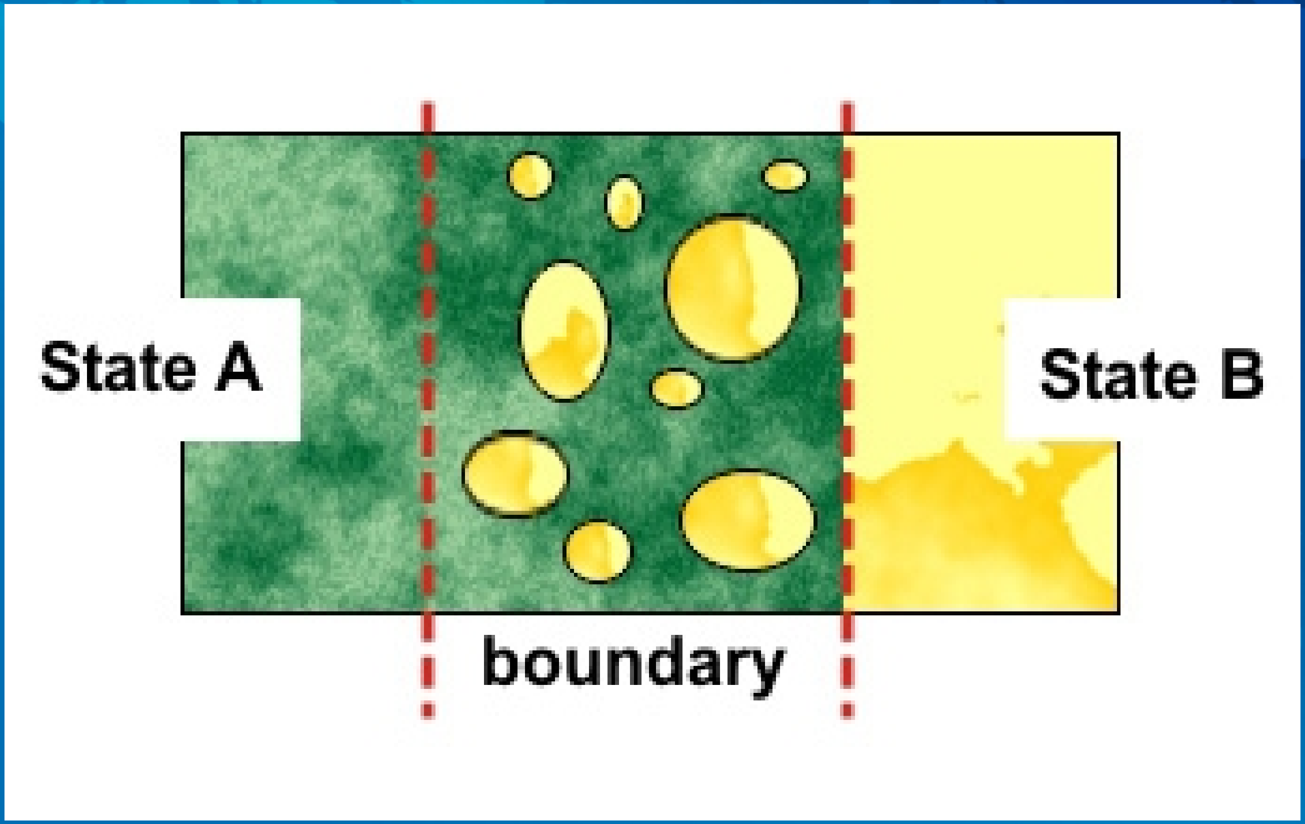
- Focuses on top-down constraints and driving functions




Cedric Ratez, et al. (2007)

# Patch Dynamics
*(Pickett and White 1985)*

- Focuses on spatial configuration and heterogeneity

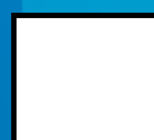



Sevelleta LTER

# Unit-models, Transport-models and Neighborhoods

Unit-models:

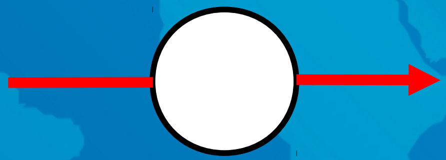
- Model a semi-closed system
- Know nothing about the outside world
- Contain state information
- Typed



# Unit-models, Transport-models and Neighborhoods

Transport-models:

- Used to connect two unit-models
- Stateless by convention
- Connectivity defined by neighborhood rules
- Directed arc defined by model types



# Unit-models, Transport-models and Neighborhoods

Neighborhoods:

- Implicit (4-cell, 8-cell)
- Explicit
- Anisotropic

# Examples:

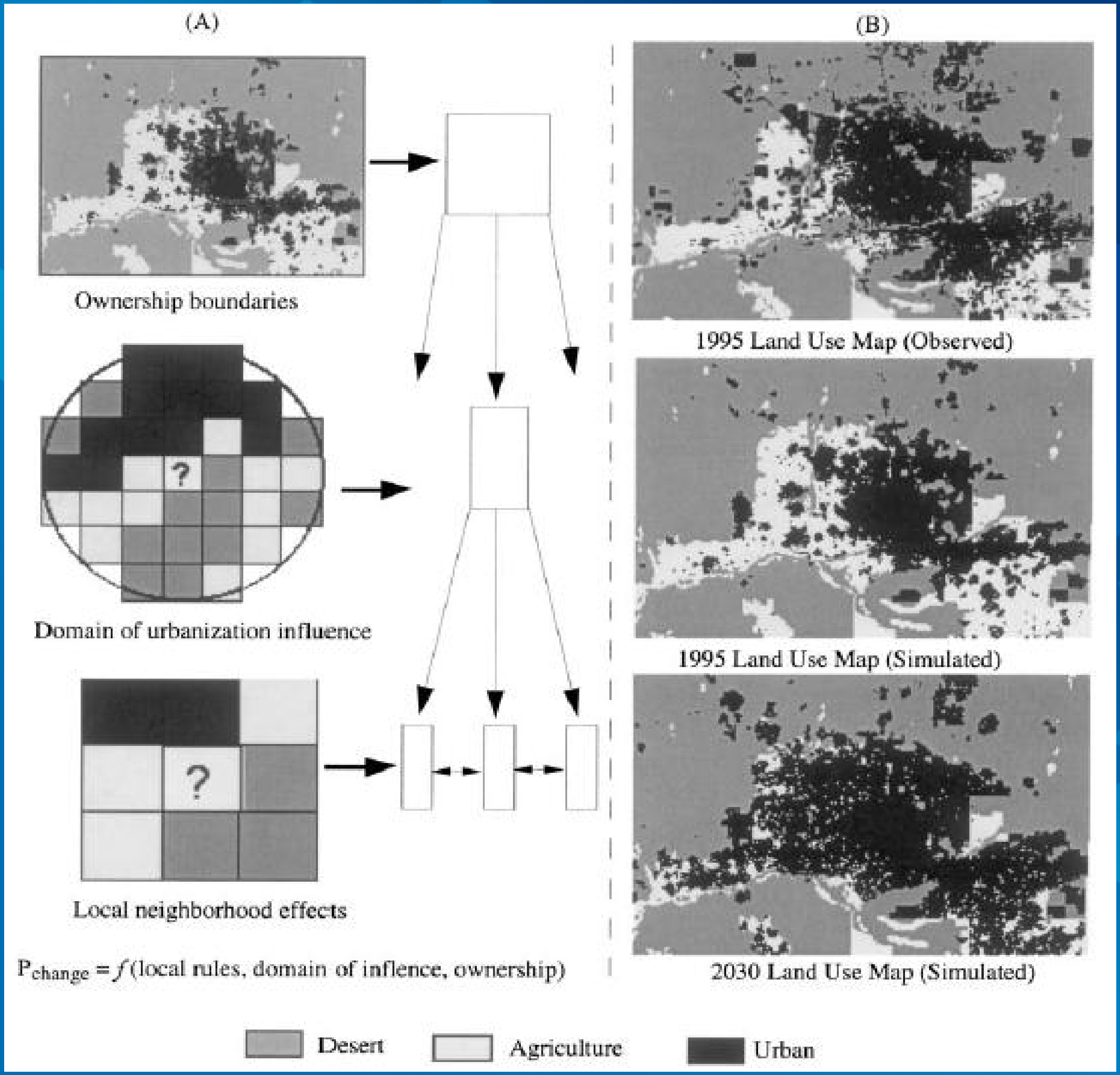
Urban growth modeling with Cellular Atomata

Fluvial geomorphology linked with alternative vegetation models

Forest fire dynamics

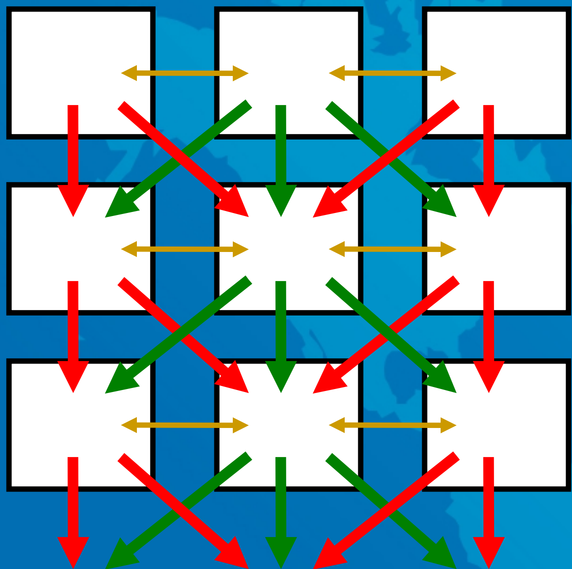
Run-time polymorphism

# Example: Urban Growth (CA)

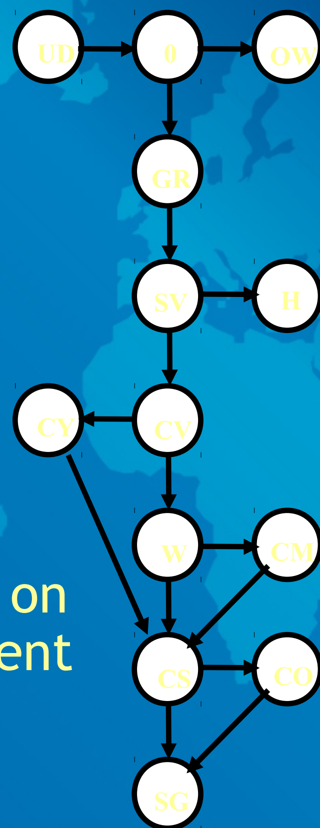



Wu & David 2002

# Example: Linking CA Braided Stream Model Vegetation Succession



- Cellular automata based on routing water and sediment along a regular grid.
- Lateral movement accommodates bank erosion

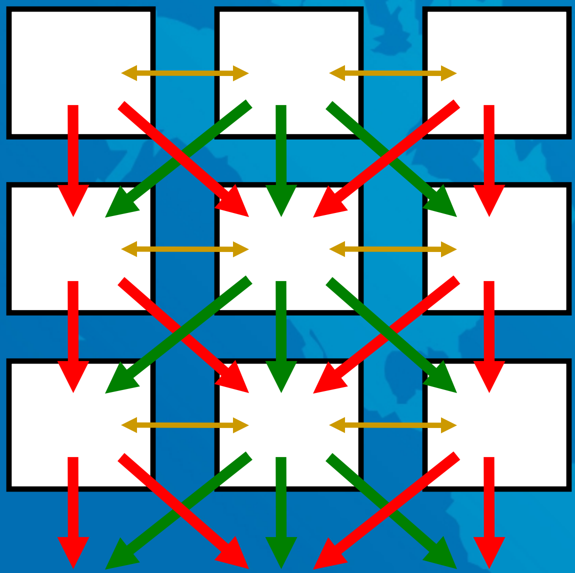


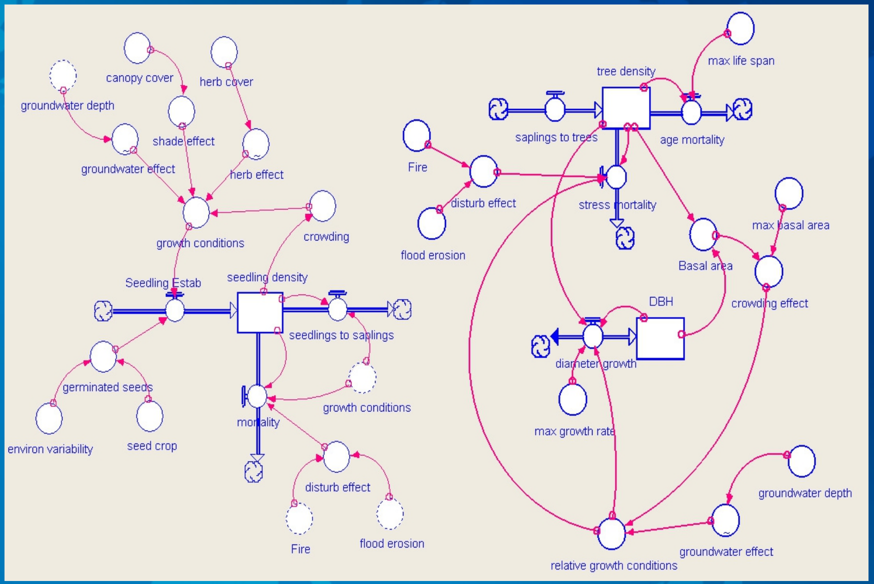

- UD – undisturbed
- 0 – recently disturbed
- OW – open water
- GR – bare gravel
- H – herbaceous wetlands
- SV – popular/willow seedlings on gravel
- CW – willow saplings
- W – mature willow
- CS – cottonwood/poplar with
- shrubs
- CY – young cottonwood
- CO – over-mature cottonwood
- SG – shrubs and grassland

# Example: Linking

# CA Braided Stream Model

# Vegetation Succession



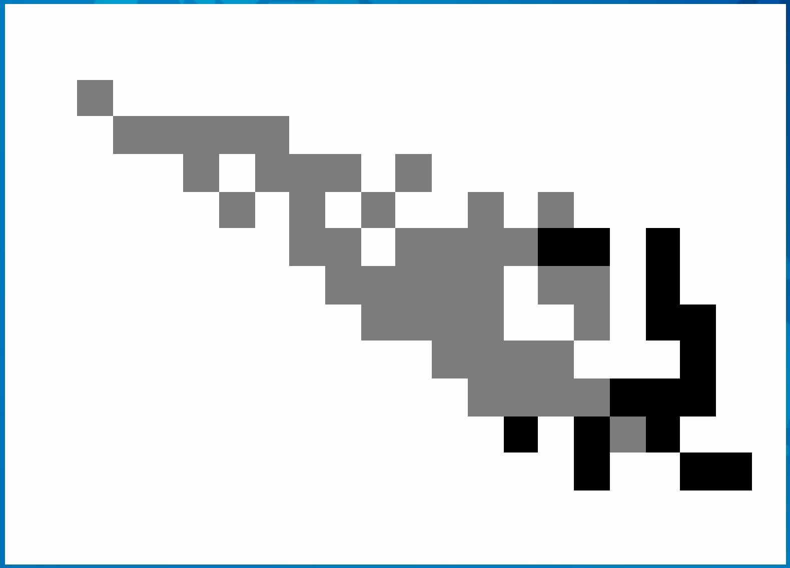



- Cellular automata based on routing water and sediment along a regular grid.
- Lateral movement accommodates bank erosion

- Plant recruitment and growth model
- Non-linear feedbacks to geomorphic processes as a function of stand structure (density and basal area)

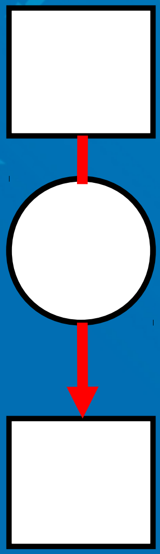
# Example: Fire Dynamics

Anisotropic spread of fire - gray burned, black burning



# Example: Run-time Polymorphism

Overloading models at runtime provides mechanisms to model dynamic hierarchies



Original model

Conversion even cause the unit-model to be decoupled from the system

Temporal transport-model data-mines old unit-model to parameterize new one

New unit-model

## Acknowledgments:

I would like to thank Google for their Summer of Code internship which supported the start of the HPD rewrite using Plan 9 primitives.  Many thanks go to my GSoC mentor Dr. Ron Minnich for all his guidance this summer.