Economic Modeling Components

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Third Oregon Symposium on
Integrated Land Use and Transport Models

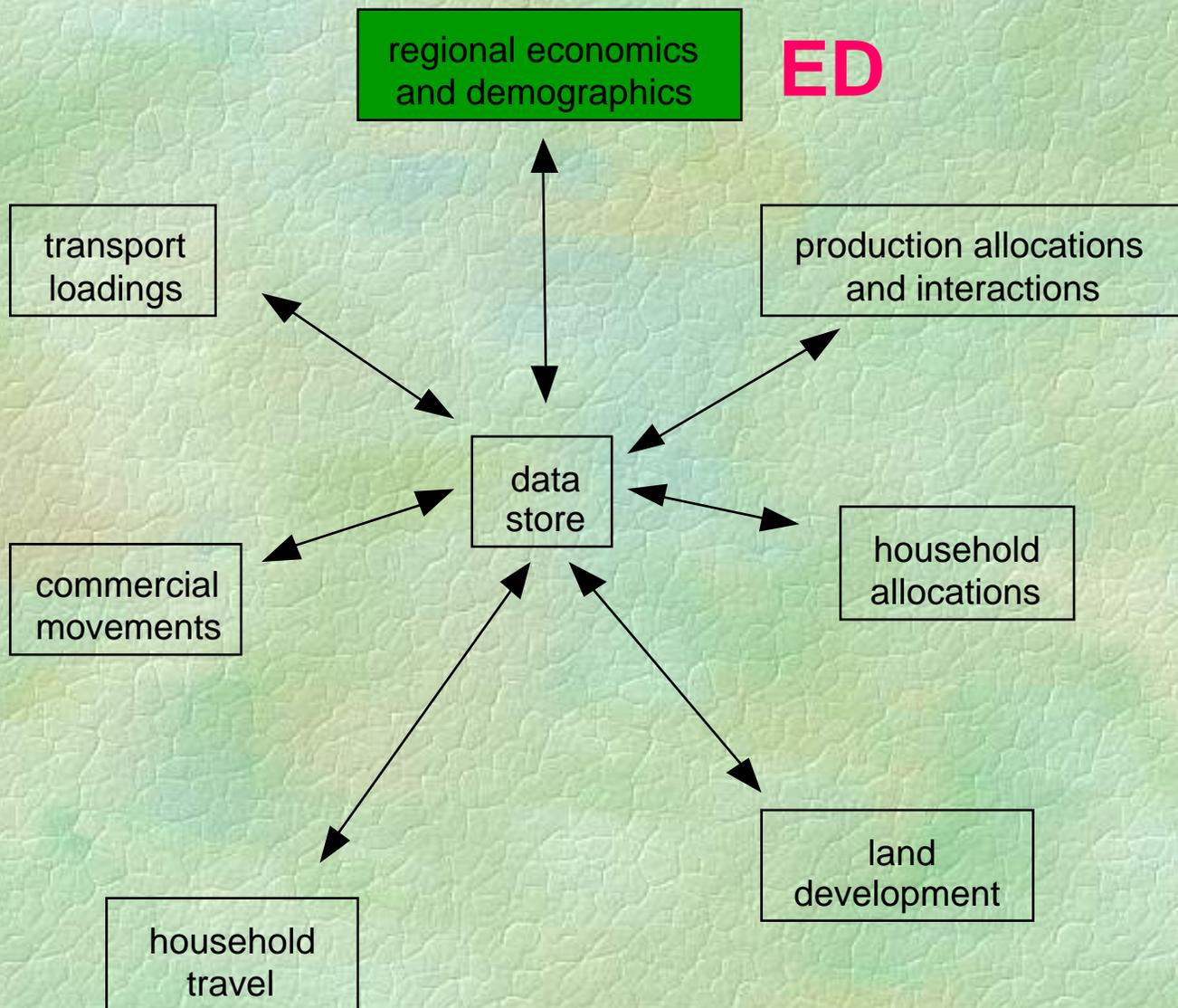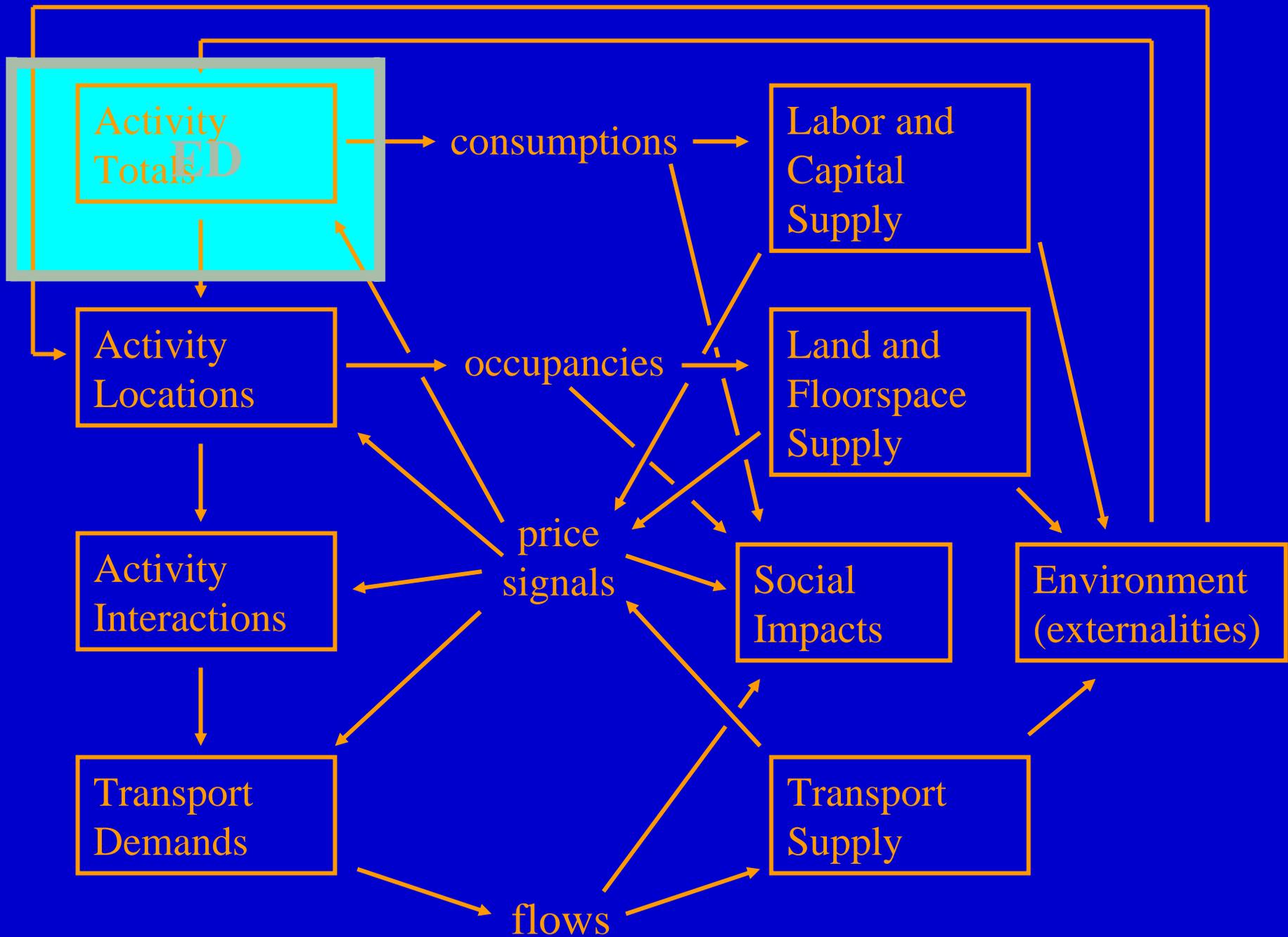Portland OR, USA
23-25 July 2002

Outline
Describe First Two Aggregate Modules

- **ED:** Regional Economics and Demographics
    - Framework
    - Inputs
    - Outputs

- **PI:** Production Allocation and Interaction
    - Framework
    - Inputs
    - Outputs

- Conclusions

Model Framework
Regional Economics and Demographics

ED: Overview

- provides regional control totals for production, employment, income, imports, exports, and in- and out-migration

- relies on an exogenous forecast of national economic conditions

- incorporates input-output structure of regional economy

- runs before all other components in each model year

- supplies control totals, but does not otherwise interact with current-year operations of other model components

ED: Framework

Forecast From External National Econometric Model (e.g., DRI Trendlong)

External Regional Models

North	South	East

Regional Model

Consumption Demand

Output

Investment Demand

Input-Output Structure

Employment

Government Demand

Incomes

Employment-Related Migration

Trade Model

North	South	East	Rest of World

ED: Inputs

- National econometric forecast (e.g., DRI Trendlong)

- Results from prior year's Land Developer module (LD)

- Results from prior year's Auto Ownership component

ED: Outputs

- Control totals for output, employment, and incomes by sector
- Trade flows with three external regions (north, south, and east) and rest of world, by sector
- Employment-related in- and out-migration
- Other migration, including family members traveling with employment-related migrants, is handled in the Household Allocation module (HA)

Extra-Regional Models

- Simple econometric models of regions to the north, south, and immediately east of Oregon

- Implemented as sets of simultaneous equations predicting output by major sector

- Rely on exogenous national forecast

- Estimated simultaneously, before regional model

Regional Model

- Final Demand for goods and services by the regional economy
- Production by each industry in the region
- Employment and Labor Income by each industry in the region
- Non-Labor Income
- Labor Force Participation

Regional Model: Demand

- Consumption Demand
  - Non-Durable Goods
    - Function of population, US non-durable consumption per capita, prices, incomes, and unemployment rate
  - Motor Vehicles
    - Function of auto ownership, population, US motor vehicle consumption per-capita, prices, incomes, and unemployment rate
  - Other Durables
    - Function of population, US other durable consumption per capita, prices, incomes, and unemployment rate
  - Services
    - Function of population, US services consumption per capita, prices, incomes, and unemployment rate

Regional Model: Demand

- Investment Demand
  - Residential structures
    - Function of developer activity, incomes, interest rates, prices, and proportion of stock more than 30 years old
  - Non-residential structures
    - Function of developer activity, output, interest rates, and prices
  - Investment in equipment is not explicitly modeled
    - No data

Regional Model: Demand

- State and Local Government Demand
  - Educational operating expenses
    - Function of population and portion of population that is between the ages of 5 and 24
  - Non-Educational operating expenses
    - Function of population, incomes, and unemployment rate
  - Construction
    - Function of population and lagged construction expenditures

Regional Model: Production

- Production by Sector
  - One equation per sector
  - Production in each sector is a function of:
    - production in each of the other sectors times the appropriate input-output coefficient
    - plus the final demand components times their estimated coefficients
  - Equations for all sectors are solved simultaneously, along with the final demand components

Regional Model: Employment

- Employment by Sector
  - A function of output for that sector, prior period employment (to account for slow adjustment), and change in national labor productivity from exogenous national forecast

- Labor income by Sector
  - A function of output and employment for that sector and regional unemployment

Regional Model: Other Output

- Non-Labor Income
  - A function of population, national per-capita non-labor income, and the ratio between regional and national unemployment rates
- Labor-Force Participation
  - A function of the rate of change in national labor-force participation, lagged labor-force participation, and the ratio of regional employment growth to national employment growth
  - Needed for Migration component

Regional Model: Estimation

- Coefficients estimated for the State of Oregon because data are available

- Estimated coefficients are applied to the Model Region (Oregon plus surrounding counties in Washington, Idaho, Nevada, and California)

Trade Model

- Gross trade flows derived from input-output relationships and output levels

- Works like the production allocation component to allocate trade by sector to external regions, using forecasts of output in other regions from extra-regional models

ED: How It Runs

- Solves Equations
  - Equations and their parameters are inputs
  - Can solve independent equations and blocks of simultaneous equations
  - Independent equations may be non-linear
  - XML format devised for equations and parameters
  - Equations are "data", so can change without recoding model

ED: Data Sources

- Historical consumption, production, and employment, data
  - Bureau of Economic Analysis
  - Oregon Employment Division
- Historical population and government expenditure data
  - Census
- Input-Output structure
  - IMPLAN

Model Framework
Production Allocations and Interactions
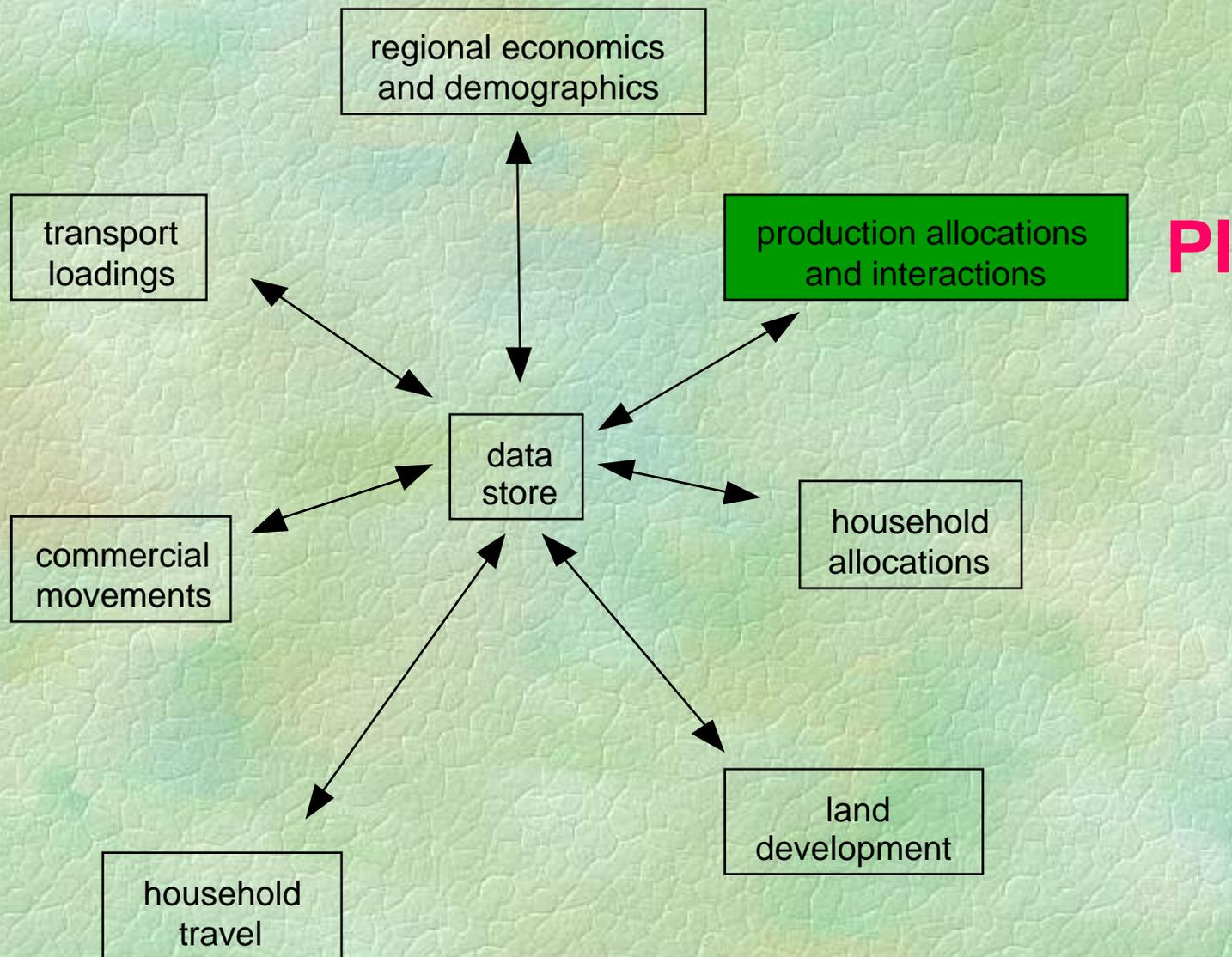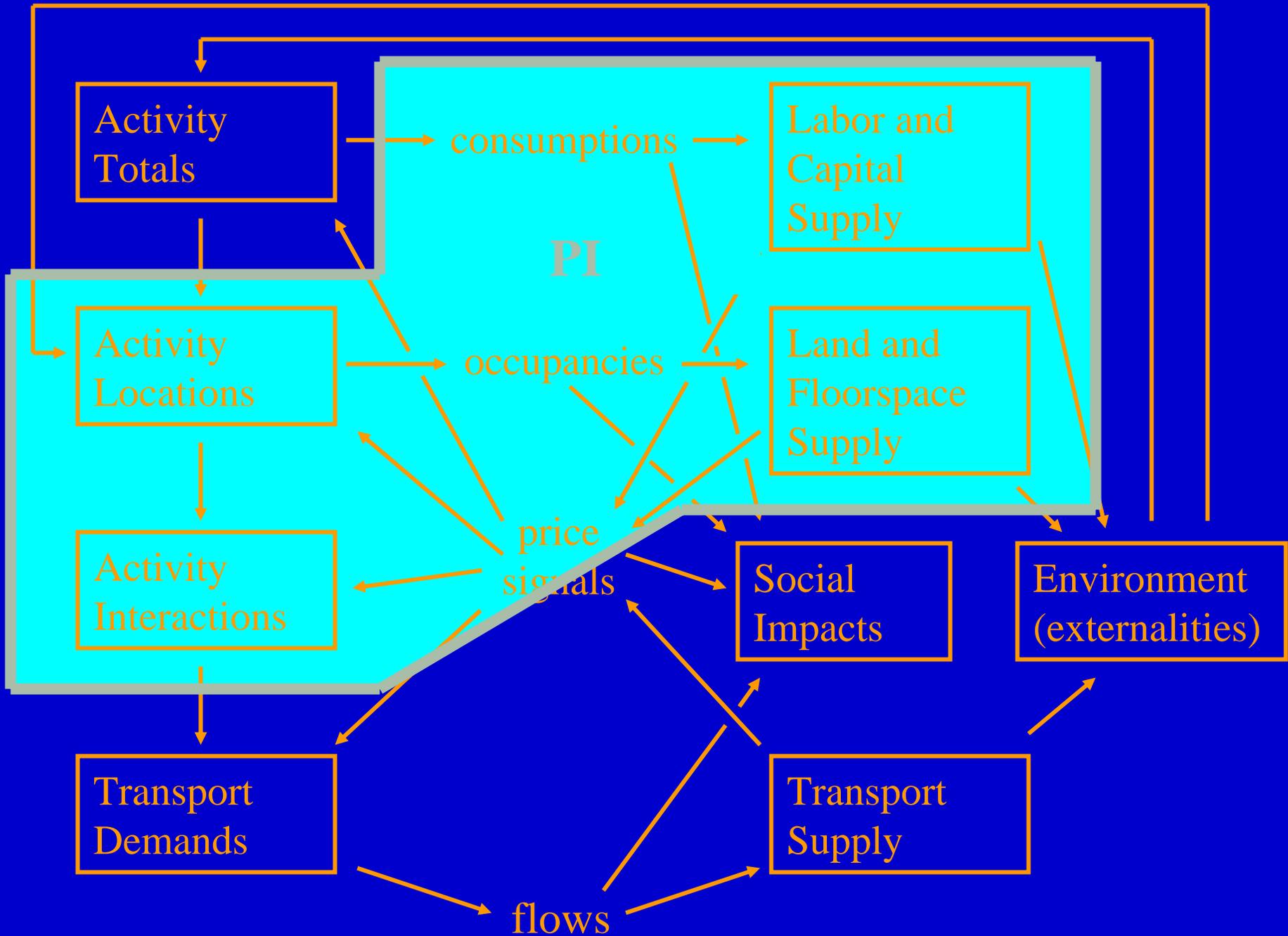
Treatment of Space

works at zone level
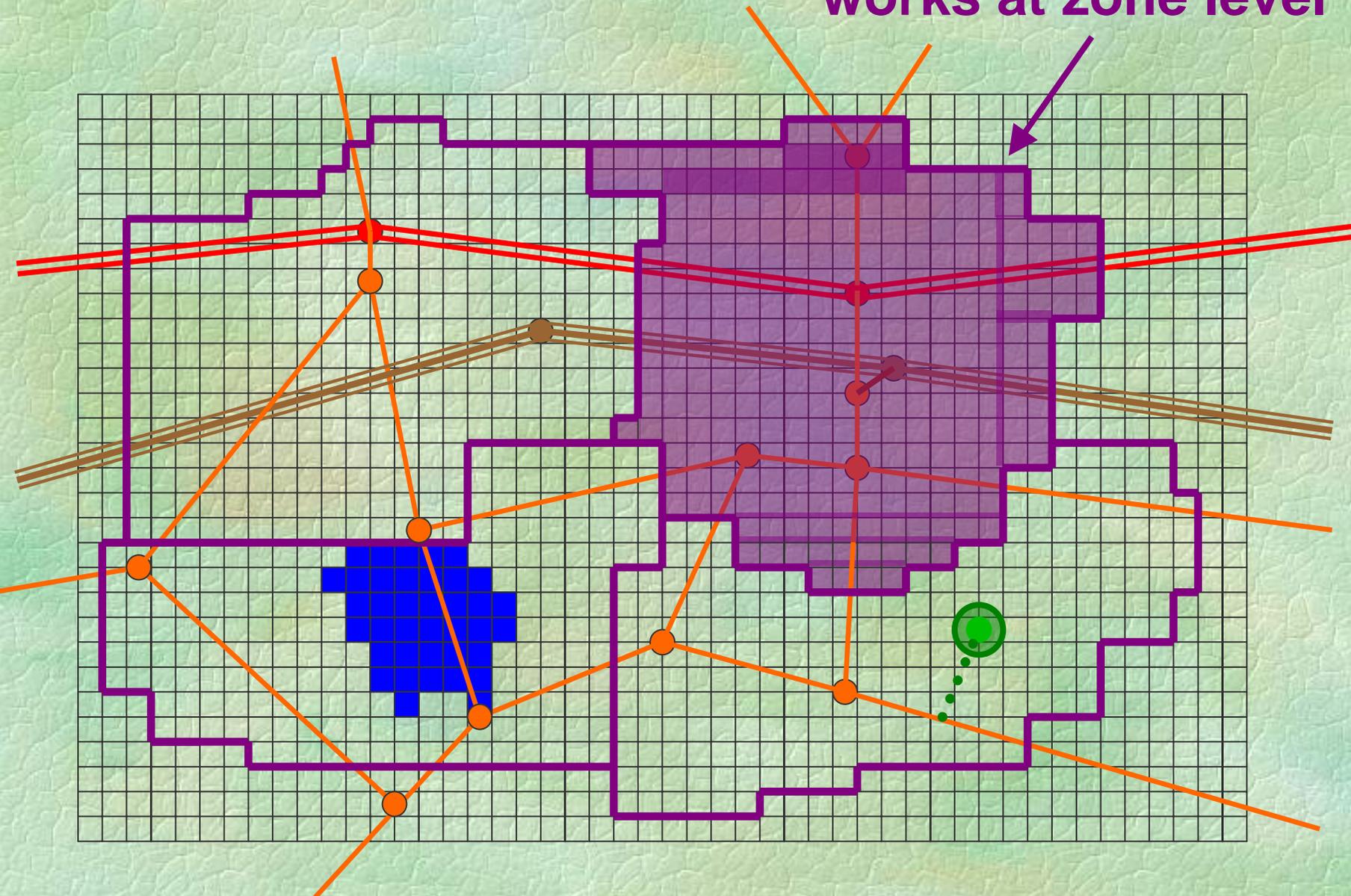
Zone System

748 zones; 609 in Oregon + 140 outside Oregon

Production - Exchange - Consumption

total consumption

buying allocation process

exchange zone

exchange zone

exchange zone

commodity flows

selling allocation process

total production

total production
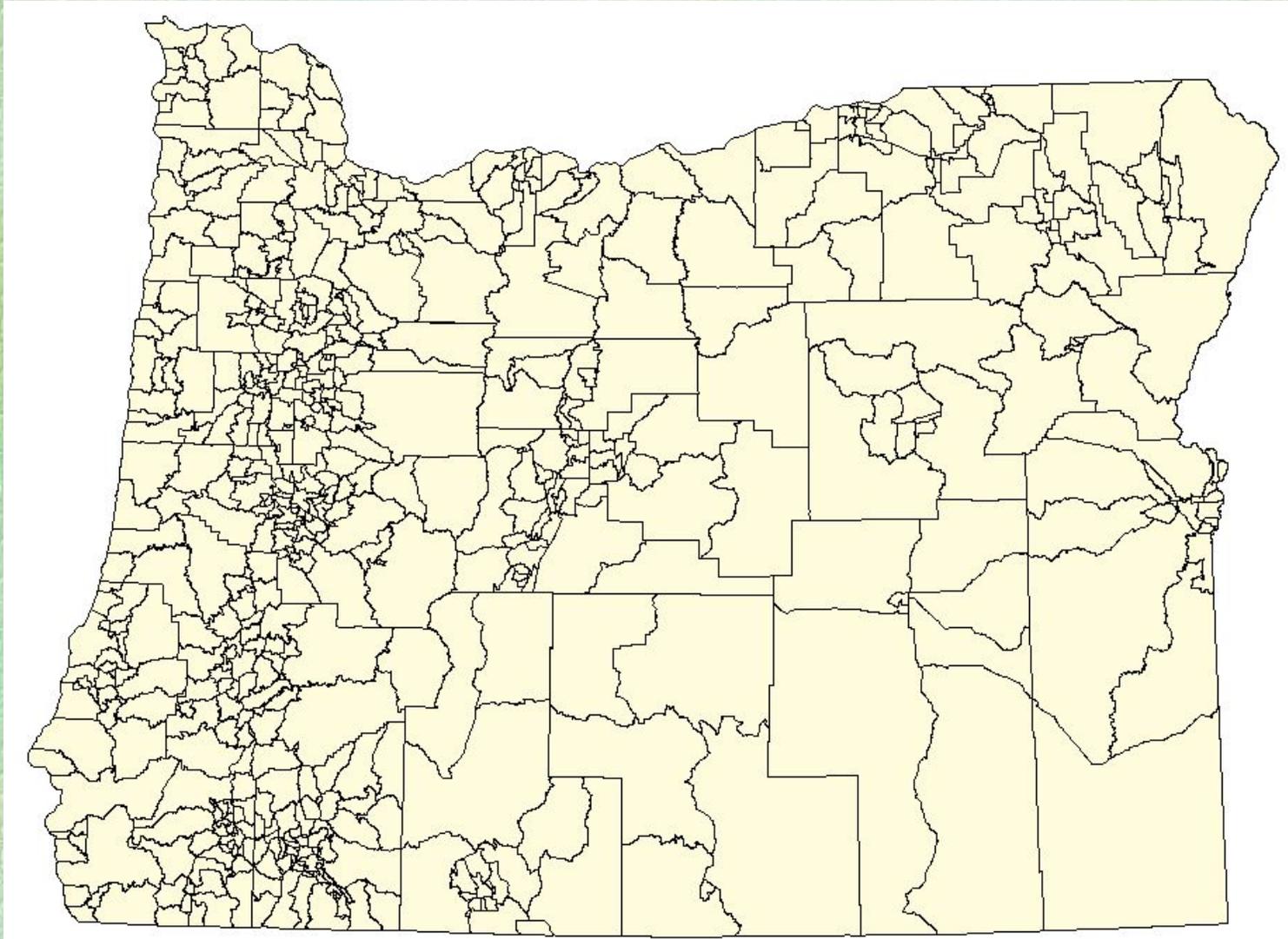
total production
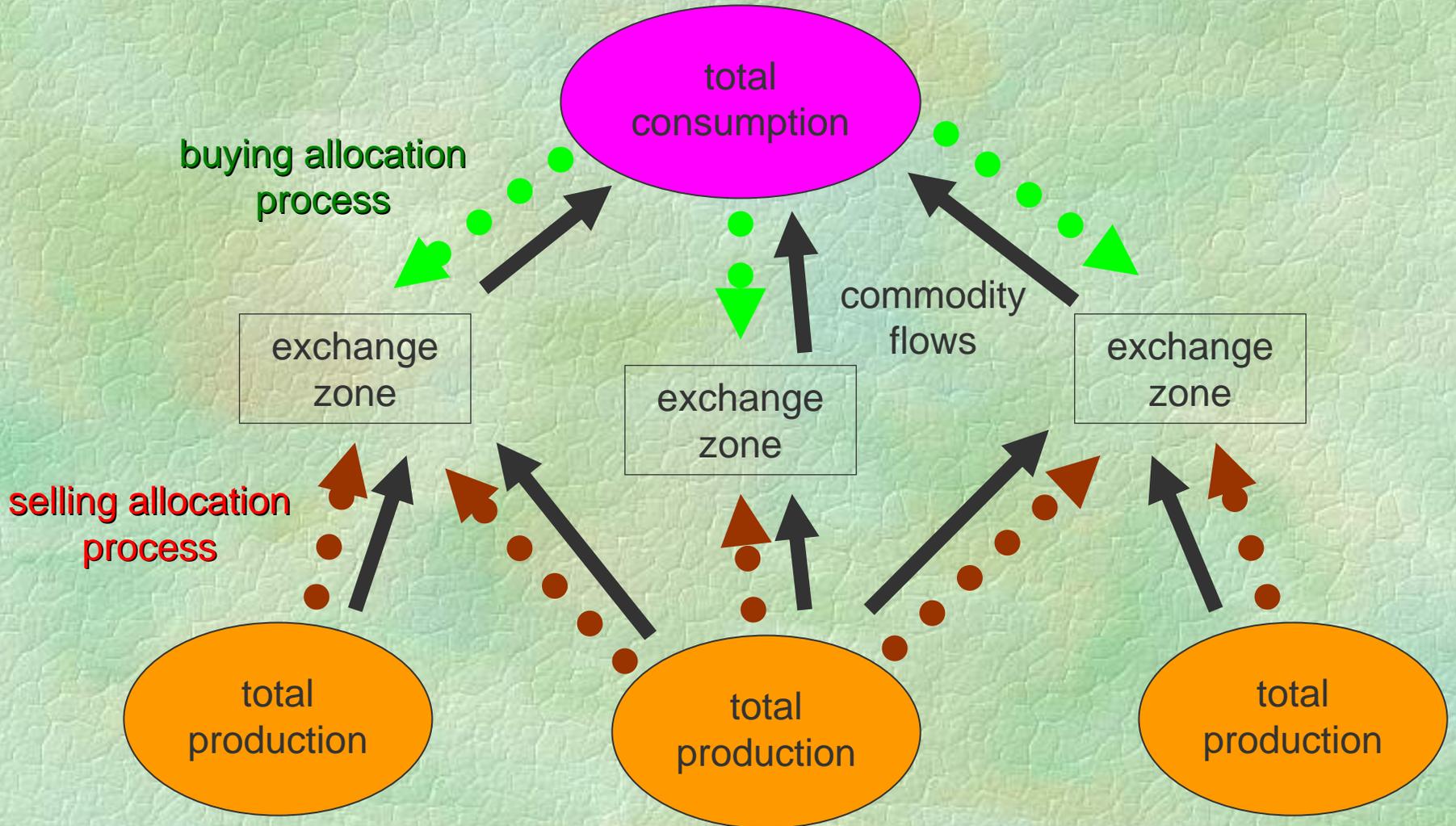
An 'Integrated' Modeling System

allocation of activity interactions (buying and selling) among destination zones
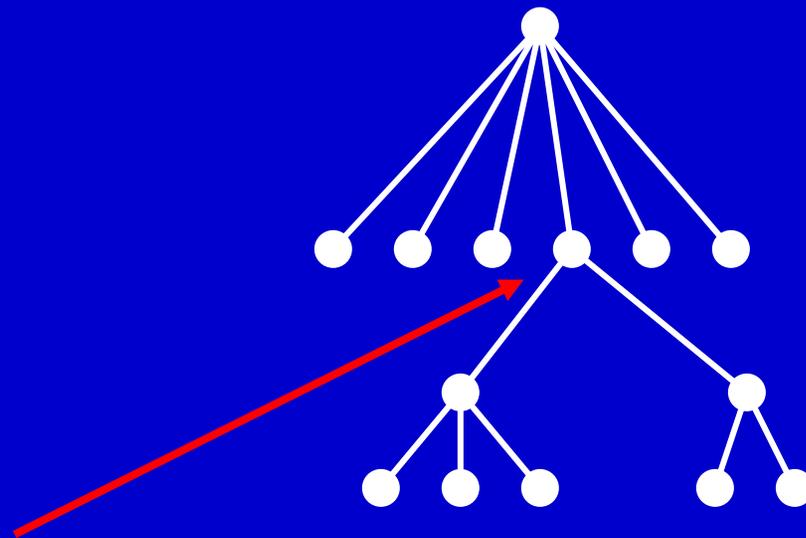
destination choice dεD

mode choice mεM

mode choice logsums used to allocate activity interactions among destination zones

Also A 'Connected' Modeling System

'accessibility values' (similar to
destination choice logsums) used
to allocate activity totals among
location zones
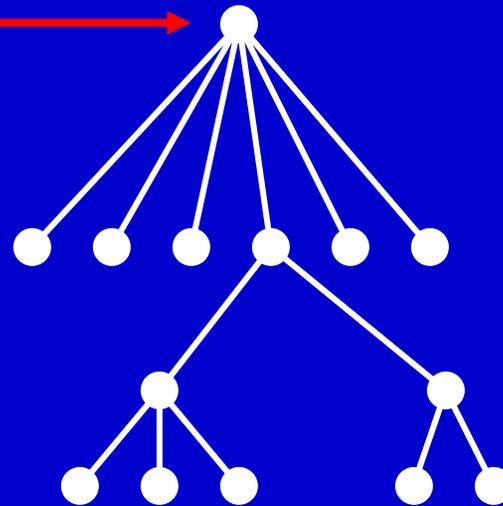
destination choice dεD

mode choice mεM

allocation of activity totals
among location zones

Also A 'Connected' Modeling System

'accessibility values' (similar to destination choice logsums) used to allocate activity totals among location zones
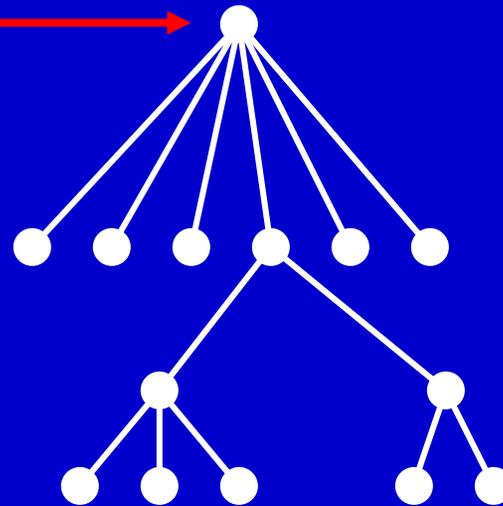
destination choice dϵD

mode choice mϵM

allocation of activity totals among location zones

provides consistent evaluation measures via logsums

Make-Use Relationships

- Detailed design chart posted here

- Development Tech Memo posted
  on ODoT website:

  http://www.odot.state.or.us/tddtpau/papers/PITechMemo.pdf

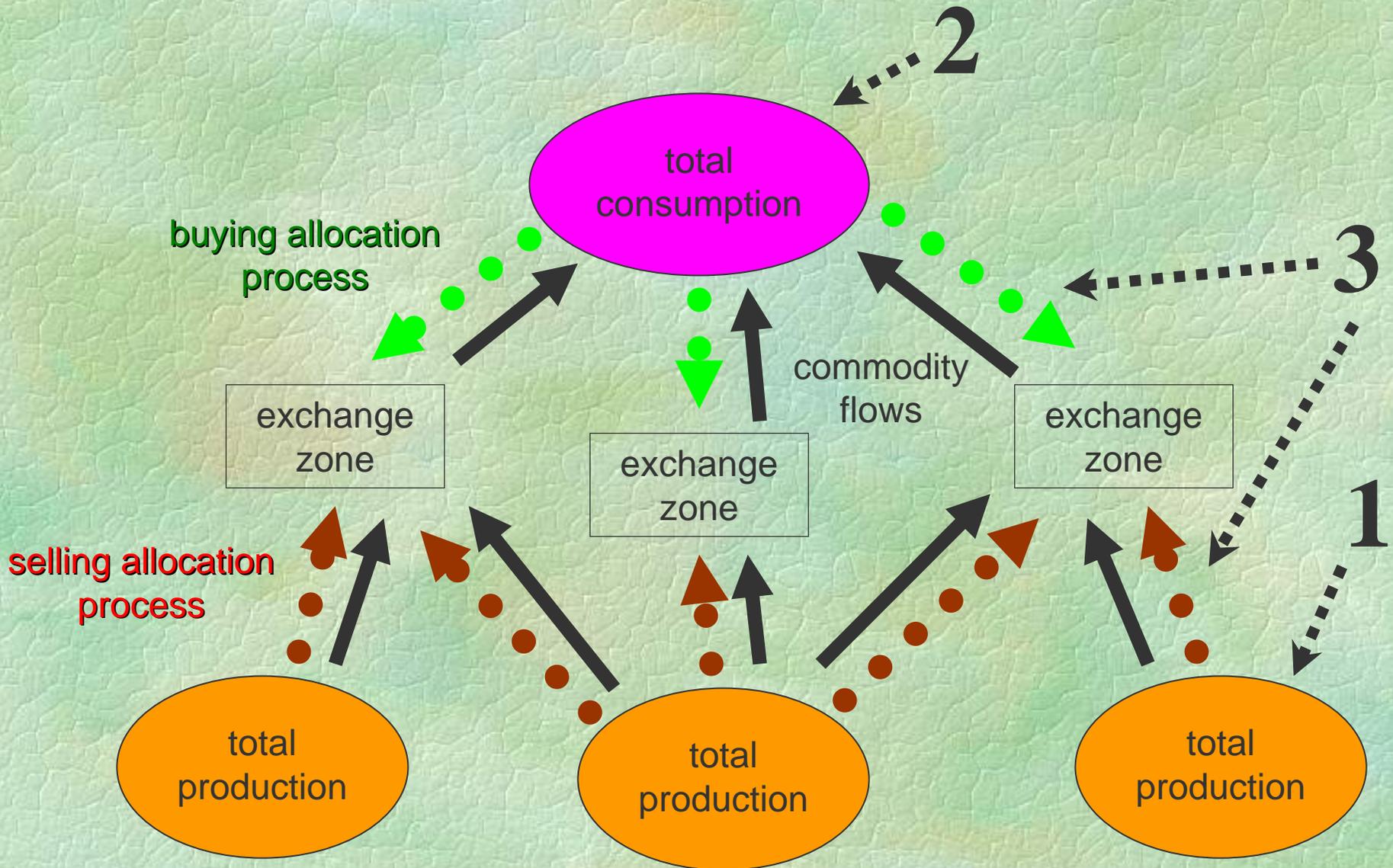|	commodities								
	goods	internal management services	services	education services	retail services	domestic services	labor	non-residential space	residential space
producing activities (making)									
industry	goods production by industry	internal management services production by	services production by industry	education services production by industry	retail services production by industry				
government	goods production by government		services production by government	education services production by government					
households						domestic services production by households	labor production by households		
export locations									
edge exit points	r						r		
airports and waterports points	r								
all production points			r	r	r				
exchange locations									
consumption points		x				x	x	n	n
production points	x		x	x				n	n
all zones									
selected zones									
import locations									
edge entry points	i		i				i		
airports and waterports points	i		i						
all production points									
consuming activities (using)									
industries	goods consumption by industry	internal management services consumption by industry	services consumption by industry	education services consumption by industry			labor consumption by industry	space consumption by industry	
government	goods consumption by government		services consumption by government	education services consumption by			labor consumption by government	space consumption by government	
households	goods consumption by households - direct		services consumption by households	education services consumption by households	goods consumption by households - via retail	domestic services consumption by households			space consumption by households

Production - Exchange - Consumption

Transport Utility Functions

for a commodity being transported between zones:

$$TU_k = \gamma_{time,k} \cdot Time_k + \gamma_{dist,k} \cdot Dist_k$$

Transport Utility Coefficients		
commodity		
categories	γ_{time}	γ_{dist}
labor	11.11 $/hr	0.135 $/mile
goods and services	11.11 $/hr	0.135 $/mile

Buying Allocation (LEVEL 3)

for each commodity consumed;
logit with buying utility

Terms in buying utility function:

- exchange price
- transport disutility
- exchange size

Buying Allocation Functions

for a commodity consumed at an activity location zone:

$B_k = BU_k / \Sigma_{k\varepsilon K} BU_k$

with:

$BU_k = \exp(\lambda_{a,c,b} \cdot (\beta_{size} \cdot Size_k + \beta_{price} \cdot Price_k + \beta_{transport} \cdot TU_k + Cons_k))$

-ve β_{price}
+ve $\beta_{transport}$

note: $CU_{buying} = (1/ \lambda_{a,c,b}) \cdot \ln (\Sigma_{k\varepsilon K} BU_k)$

Selling Allocation (LEVEL 3)

for each commodity produced;
logit with selling utility

Terms in selling utility function:

- exchange price
- transport disutility
- exchange size

Selling Allocation Functions

for a commodity produced at an activity location zone:

$$S_k = SU_k / \Sigma_{k\epsilon K} \, SU_k$$

with:

$$SU_k = \exp(\lambda_{a,c,s} \cdot (\delta_{size} \cdot Size_k + \delta_{price} \cdot Price_k + \delta_{transport} \cdot TU_k + Cons_k))$$

+ve δ_{price}
+ve $\delta_{transport}$

note: $CU_{selling} = (1/ \lambda_{a,c,s}) \cdot \ln (\Sigma_{k\epsilon K} \, SU_k)$

Buying Allocation Coefficients

commodity categories		λ	βsize	βprice	βtransport
labor		2	1	-0.15	0.25
goods and services		1	0.1	-0.15	0.25
floorspace		1	1	1	0

Selling Allocation Coefficients

commodity categories		λ	δsize	δprice	δtransport
labor		1	1	0.15	0.25
goods and services		2	0.1	0.15	0.25

Technology Selection (LEVEL 2)

for each commodity consumed;
response to changes in composite buying utilities

Forms:

- constant
- negative exponential
- logit allocation among several (potential)
- Stone-Geary consumption function (potential)

Technical Coefficient Functions

for a commodity at an activity location zone:

$M = M_{min} + \alpha_{make,c} \cdot \exp(\lambda_{m,c} \cdot (CU_{selling} - CU_0))$

and

$U = U_{min} + \alpha_{use,c} \cdot \exp(\lambda_{u,c} \cdot (CU_{buying} - CU_0))$

+ve $\alpha_{make,c}$, so M increases with higher $CU_{selling}$
+ve $\alpha_{use,c}$, so U increases with higher CU_{buying}

Make Technical Coefficients

commodity categories	M_{min}	α	λ	CU_0
labor	0.9 of average salary	0.2 of average salary	1	1
goods and services	IMPLAN values	0		

Use Technical Coefficients

commodity categories	U_{min}	α	λ	CU_0
labor	IMPLAN values	0		
goods and services	IMPLAN values	0		
floorspace	0.9 of average values	0.2 of IMPLAN total / total area	3	1

Production Allocation (LEVEL 1)

for each production activity;
logit with location utility

Terms in location utility function:

- size; relative amount of space
- inertia; relative allocation in previous year
- selling utility; sum of selling allocation composite utilities
  weighted by technology coefficients
- buying utility; sum of composite buying allocation utilities
  weighted by technology coefficients
- relevant travel utilities (potential)
- zonal attributes; space-based taxes, amenities (potential)
- zone specific constant

Production Activity Allocation Functions

for a total (model-wide) quantity of production activity:

$$A_z = LU_{z,a} / \Sigma_{z\epsilon Z} \, LU_{z,a}$$

with:

$$LU_{z,a} = \exp(\lambda_a \cdot (\alpha_{size} \cdot Size_a + \alpha_{inertia} \cdot PrevPropA_z + Constant_z$$

$$+ \, \alpha_{selling} \cdot \Sigma_{c\epsilon C} \, (\, CU_{selling,z,c} \cdot M_c \cdot SImpact_c \,)$$

$$+ \, \alpha_{buying} \cdot \Sigma_{c\epsilon C} \, (\, CU_{buying,z,c} \cdot U_c \cdot BImpact_c \,)$$

Production Activity Allocation Coefficients

activity categories		λ	αsize	αinertia	αselling	SImpact	αbuying	BImpact
industries		0.35	0	0.50				
government		1	0	1				
households		1	1	0				
commodity categories								
labor						0	1	1
goods and services					1	1	1	1
floorspace							1	1

Exchange Points

market where supply meets demand; designated zones

Components of supply:

• sum of selling allocations; elastic with respect to price
• imports (if available); single function elastic with respect to price

Components of demand:

• sum of buying allocations; elastic with respect to price
• exports (if available); single function elastic with respect to price

model solves for equilibrium: adjusts exchange prices at exchange points until all markets clear
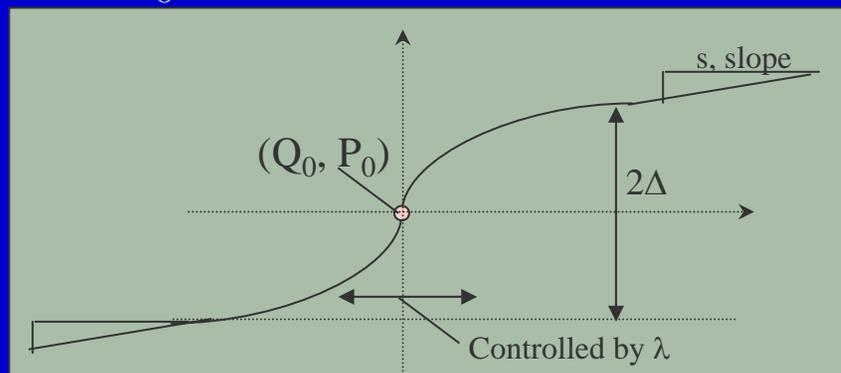
Imports and Exports Functions

for a commodity at an exchange point:

$$Q_j = Q_0 + \Delta \cdot ([a-1]/[a+1]) + s \cdot (Price - P_0)$$

with:

$$a = \exp(\lambda_j \cdot (Price - P_0))$$

+ve Δ and s for imports, so Q increases with higher Price
-ve Δ and s for exports, so Q decreases with higher Price

Imports Coefficients

commodity categories	Q_0	Δ	λ	s	P_0
labor	0	0	0.2	0.001	1
goods and services	.1 of IMPLAN values	.02 of IMPLAN values	0.2	0.001	1
floorspace	specified amount	0		0.001	1

Exports Coefficients

commodity categories	Q_0	Δ	λ	s	P_0
labor	0	0		-0.001	1
goods and services	.1 of IMPLAN values	-.02 of IMPLAN values	0.2	-0.001	1
floorspace	0	0		-0.001	1

Maps of Inputs

- Households by zone
  - currently same occupations ('make rates') across income categories, to be varied later

- Imports and exports points

- Floorspace by type by zone
  - currently based on employment
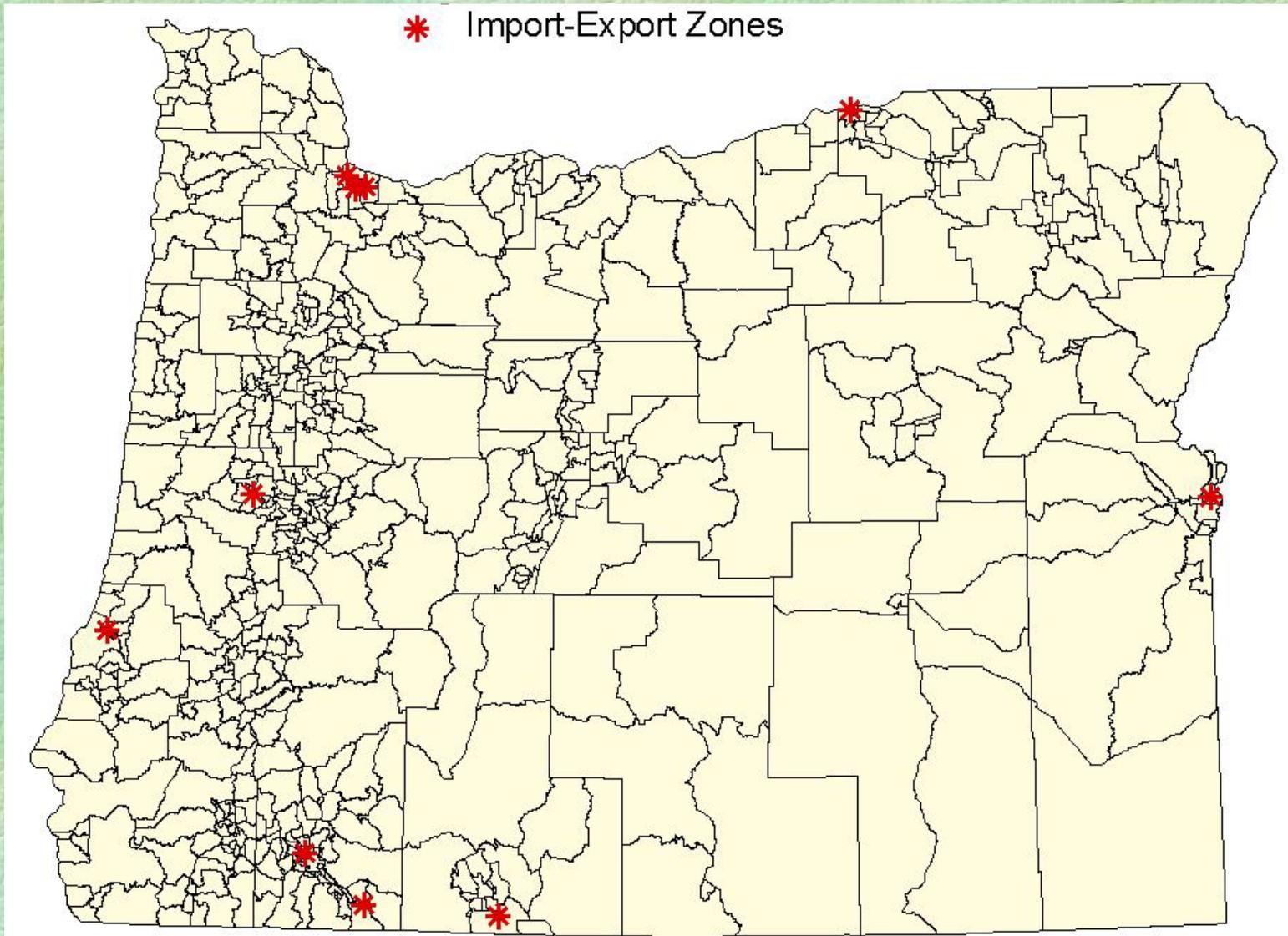 - will be based on observed and employment, age and density
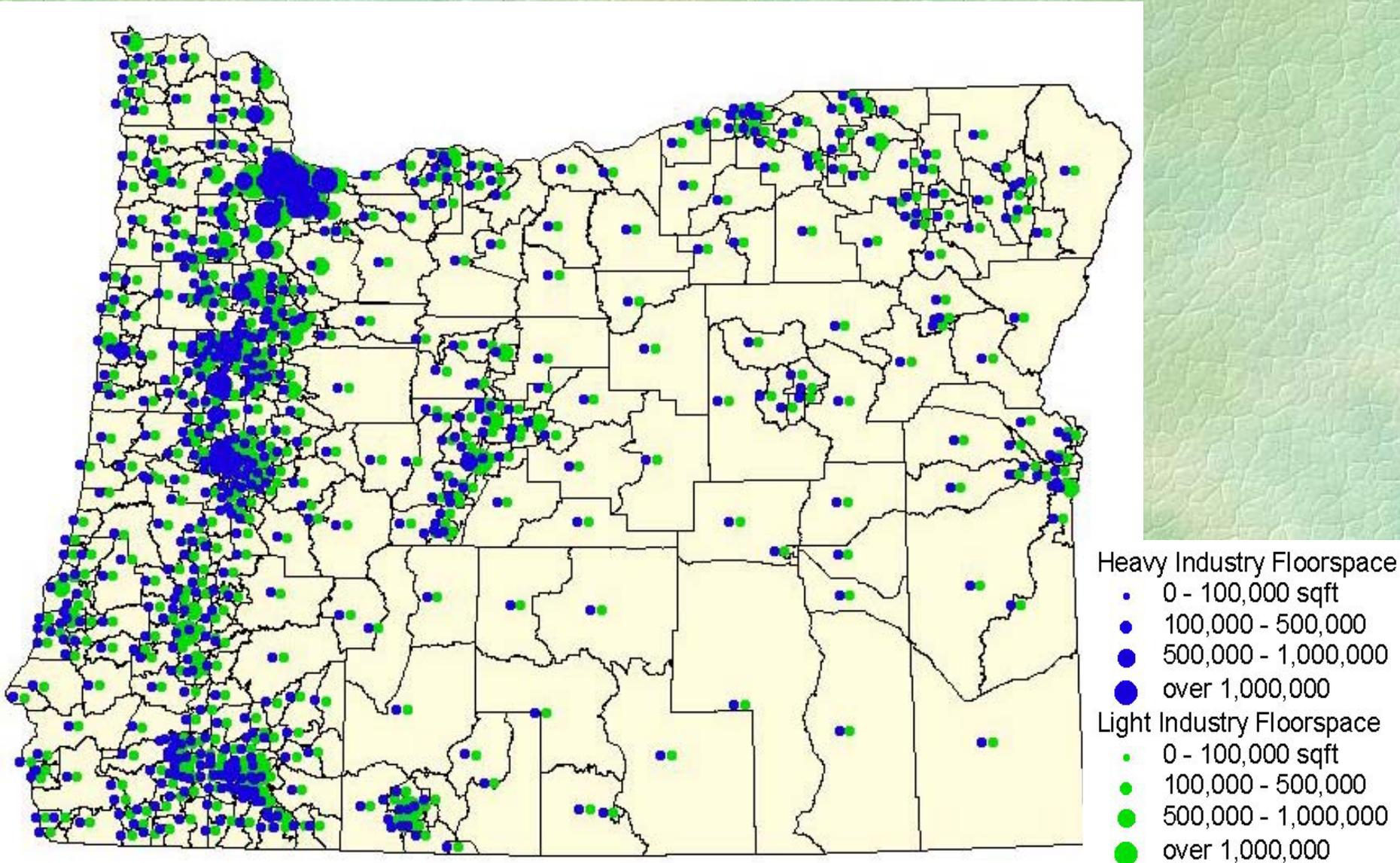
Population Distribution

1 Dot = 100

Portland Enlargement
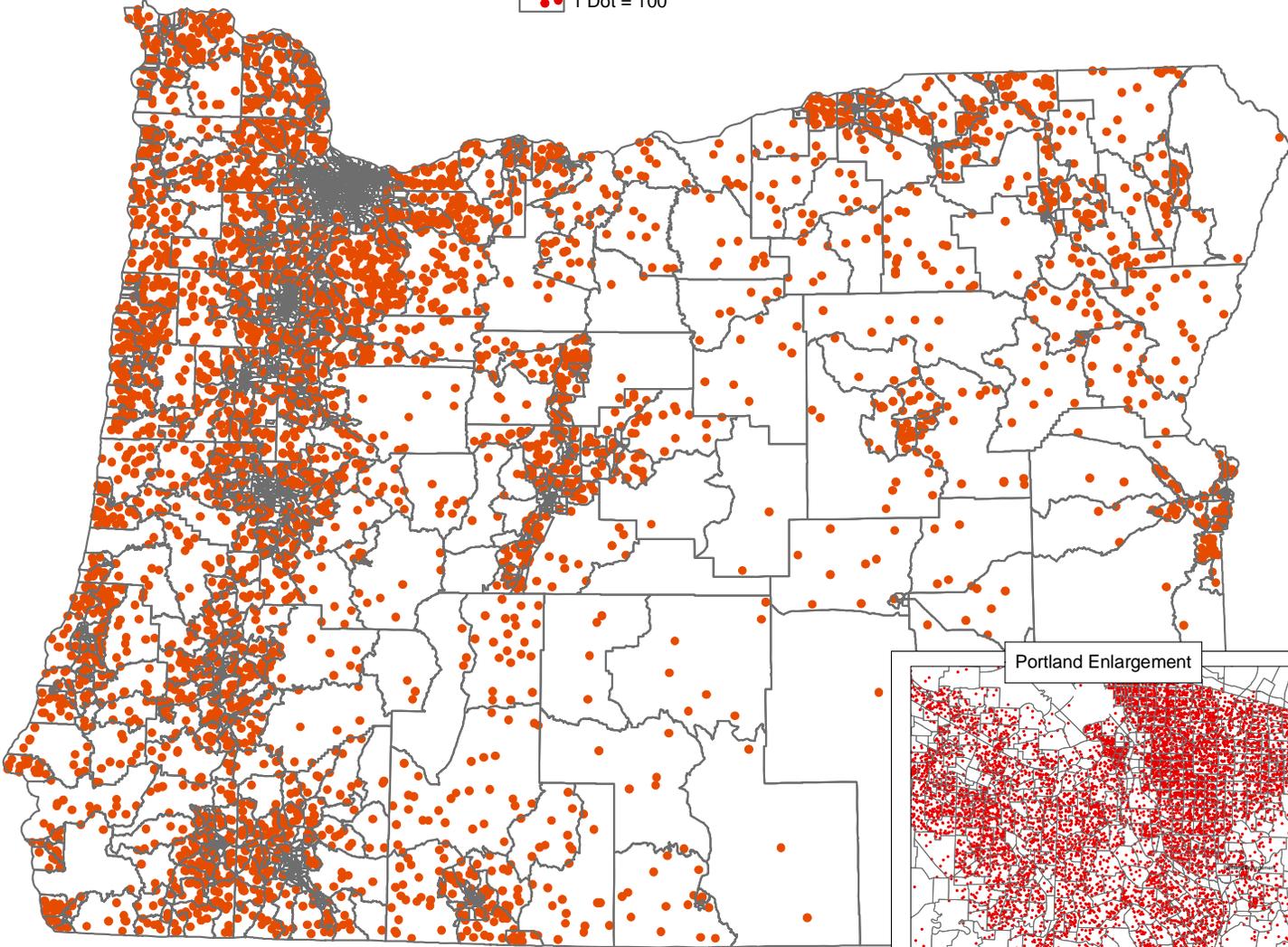
Import-Export Points
(2 airport, 2 water port, 6 road; also each exchange zone)

Light and Heavy Industry Floorspace
(estimated)

Heavy Industry Floorspace
- 0 - 100,000 sqft
- 100,000 - 500,000
- 500,000 - 1,000,000
- over 1,000,000

Light Industry Floorspace
- 0 - 100,000 sqft
- 100,000 - 500,000
- 500,000 - 1,000,000
- over 1,000,000

Retail and Office Floorspace
(estimated)

Retail Floorspace
- 0 - 100,000 sqft
- 100,000 - 500,000
- 500,000 - 1,000,000
- over 1,000,000

Office Floorspace
- 0 - 100,000 sqft
- 100,000 - 500,000
- 500,000 - 1,000,000
- over 1,000,000
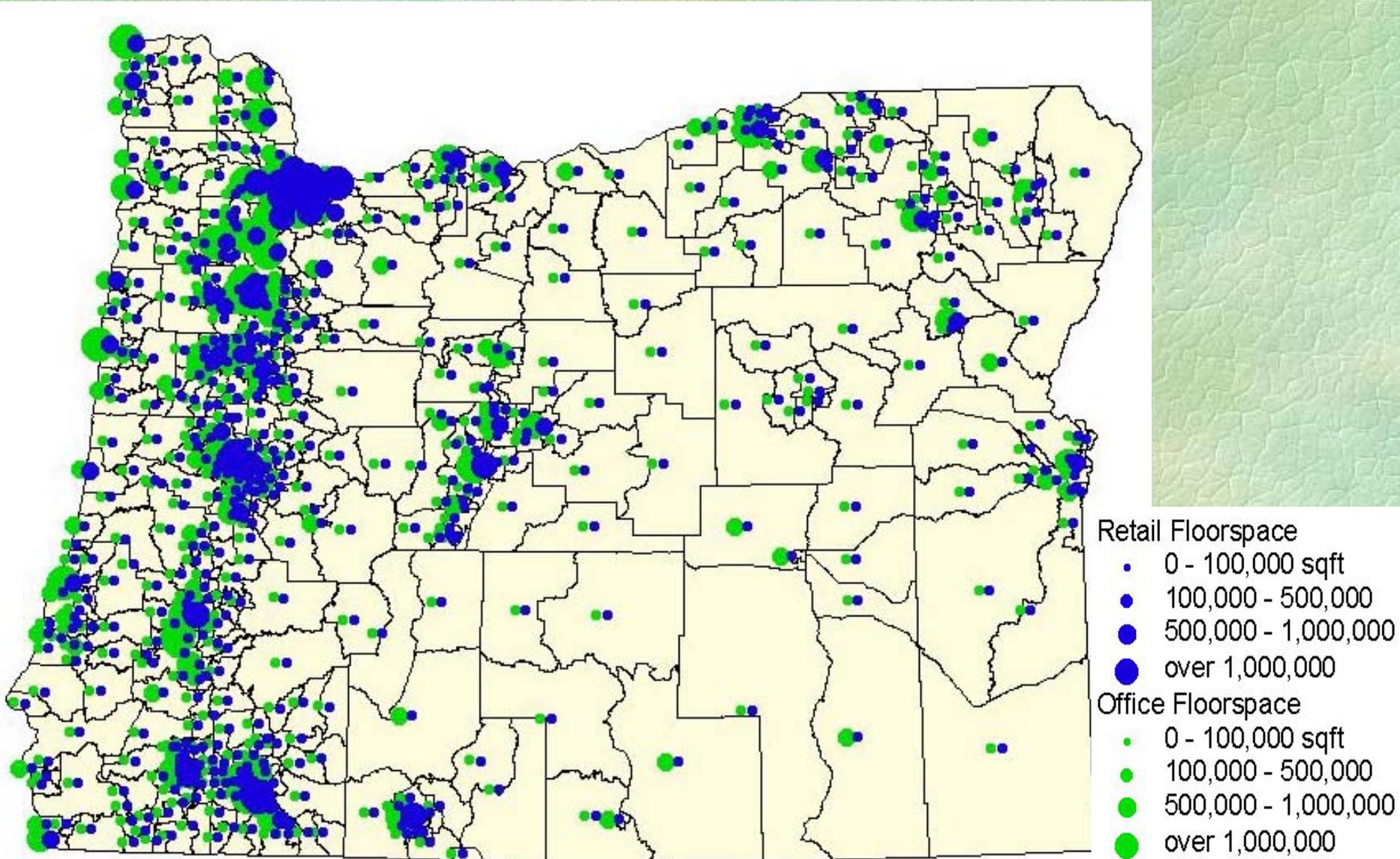
Employment by Production Activity Category

Activity

1 Dot = 20

- AGGREGATE-MINING OFFICE
- AGGREGATE - MINING
- FOOD PROCESSING - OFFICE
- FOOD PROCESSING HEAVY INDUST.
- FOOD PROCESSING LIGHT INDUST.
- LUMBER, WOOD OFFICE
- LUMBER, WOOD LIGHT INDUST.
- LUMBER, WOOD LOGGING
- OTHER DUR OFFICE
- OTHER DUR HEAVY INDUST.
- OTHER DUR LIGHT INDUST.
- OTHER NONDUR OFFICE
- OTHER NONDUR HEAVY INDUST.
- OTHER NONDUR LIGHT INDUST.
- PULP & PAPER OFFICE
- PULP & PAPER HEAVY INDUST.
- ELECTRIC & INSTR. OFFICE
- ELECTRIC & INSTR. LIGHT INDUST.
- WHOLESALE OFFICE
- WHOLESALE WAREHOUSE
- RETAIL OFFICE
- RETAIL
- ACCOMMODATIONS - HOTEL
- CONSTRUCTION
- HEALTH CARE OFFICE
- HEALTH CARE HOSPITAL
- HEALTH CARE INSTITUTION
- TRANSPORTATION OFFICE
- TRANSPORTATION DEPOT
- COMM UT OFFICE
- COMM UT LIGHT INDUST.
- FIRE & PROF OFFICE
- OTHER SERVICE RETAIL
- K-12 SCHOOL OFFICE
- K-12 GRADE SCHOOL
- ENRLHIGHED
- ENRLGOVOFF
- ENRLGOVSPT

Total Employment

- 0 - 816
- 817 - 2,722
- 2,723 - 7,109
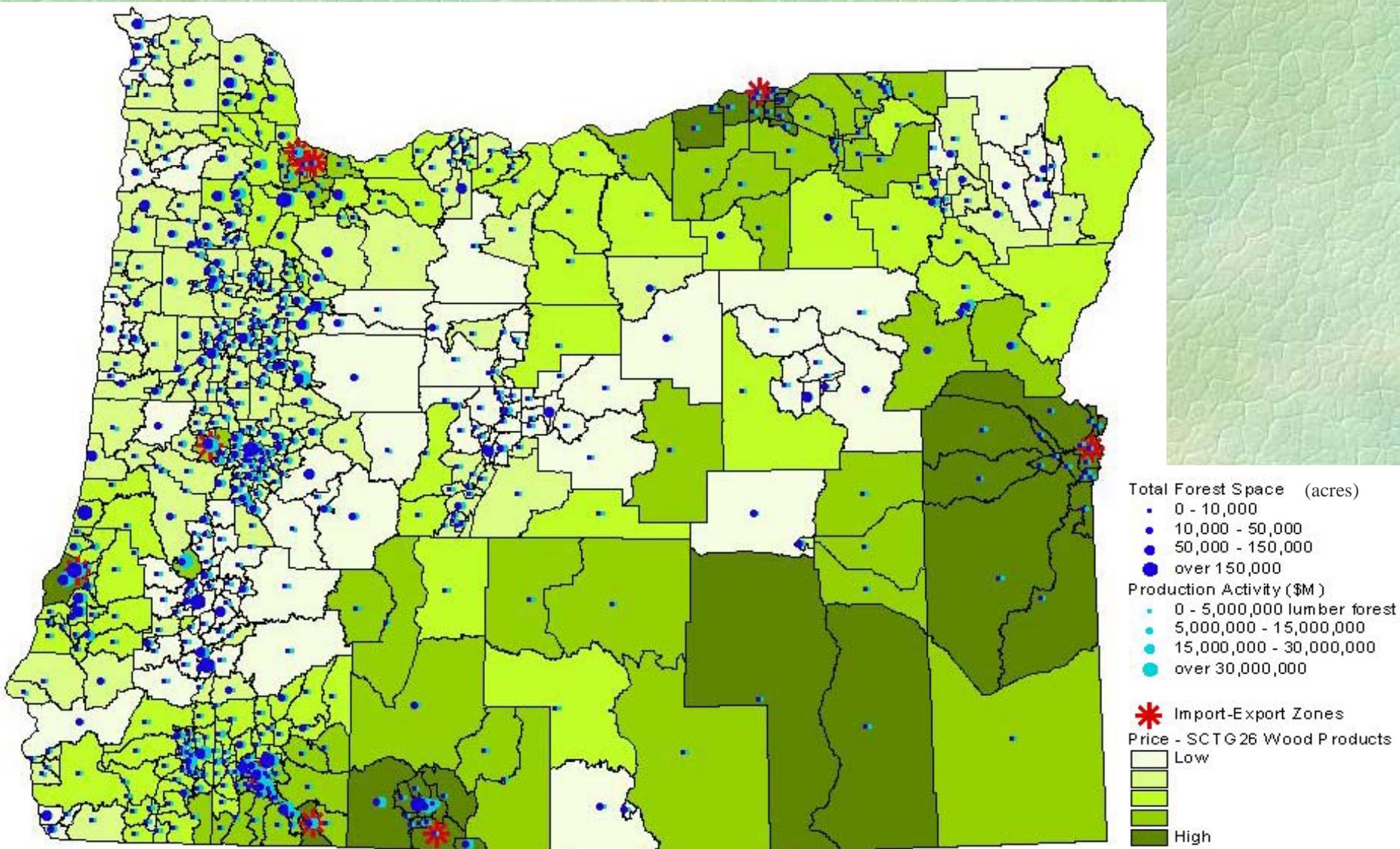- 7,110 - 17,290
- 17,291 - 34,877
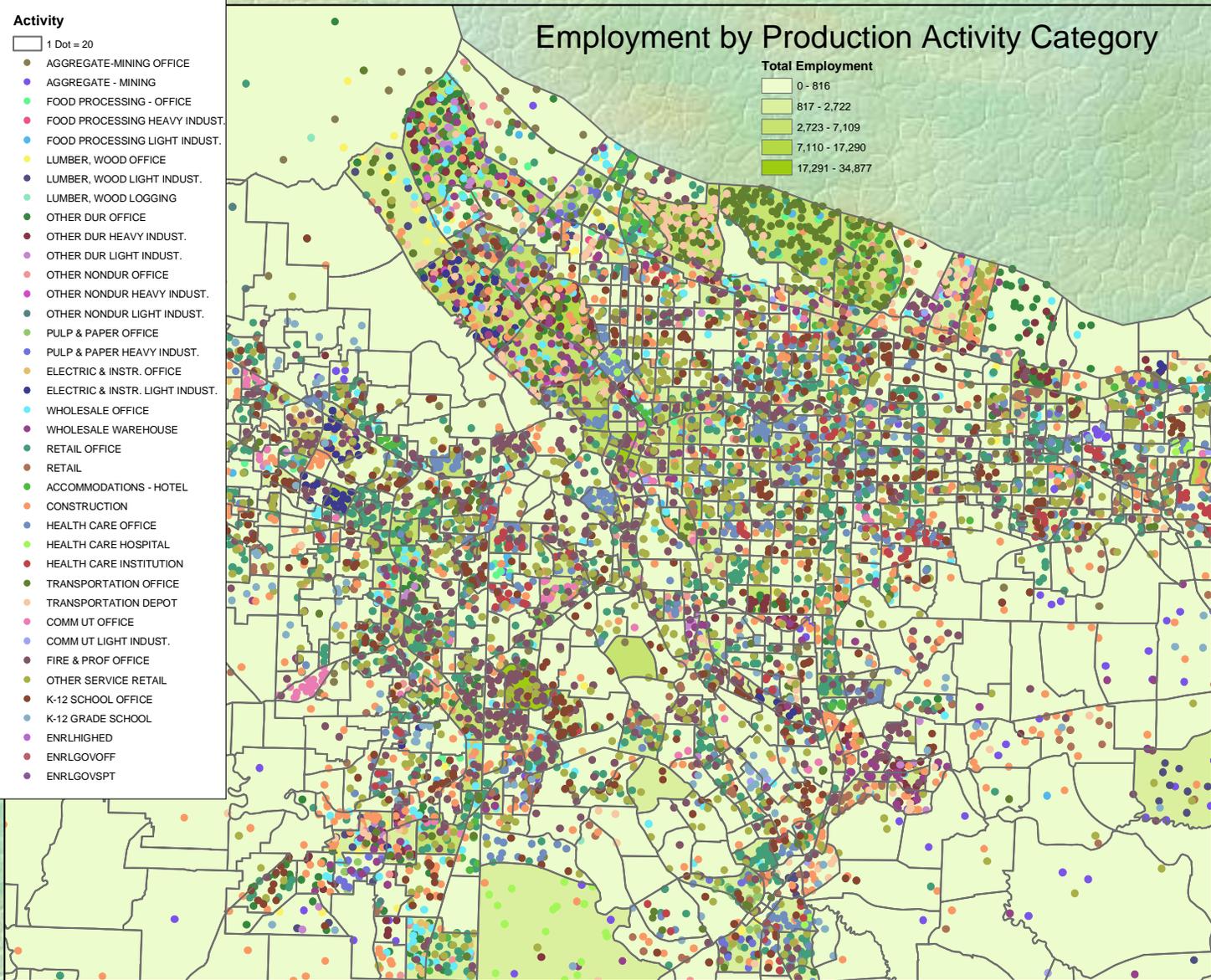
Some Preliminary Outputs

- Prices in exchange zones
  - various commodities
  - land and floorspace

- Import and export quantities

- Activity by zone
  - various types (but without all zonal location utility constants)

- Note that population totals match - are inputs

Forest Products
(Activity, Forest land, SCT26 wood product price)

Total Forest Space (acres)
- 0 - 10,000
- 10,000 - 50,000
- 50,000 - 150,000
- over 150,000

Production Activity ($M)
- 0 - 5,000,000 lumber forest
- 5,000,000 - 15,000,000
- 15,000,000 - 30,000,000
- over 30,000,000

Import-Export Zones

Price - SCTG26 Wood Products
- Low
- High

Lumber Light Industry
(Activity, Light Ind Floorspace, SCT26 wood product price)

Total Light Ind Floorspace (sqft)
- 0 - 100,000 sqft
- 100,000 - 500,000
- 500,000 - 1,000,000
- over 1,000,000

Production Activity ($M)
- 0 - 10,000,000 lumber-lt ind
- 10,000,000 - 50,000,000
- 50,000,000 - 150,000,000
- over 150,000,000

Price - SCTG26 Wood Products
- Low
- High
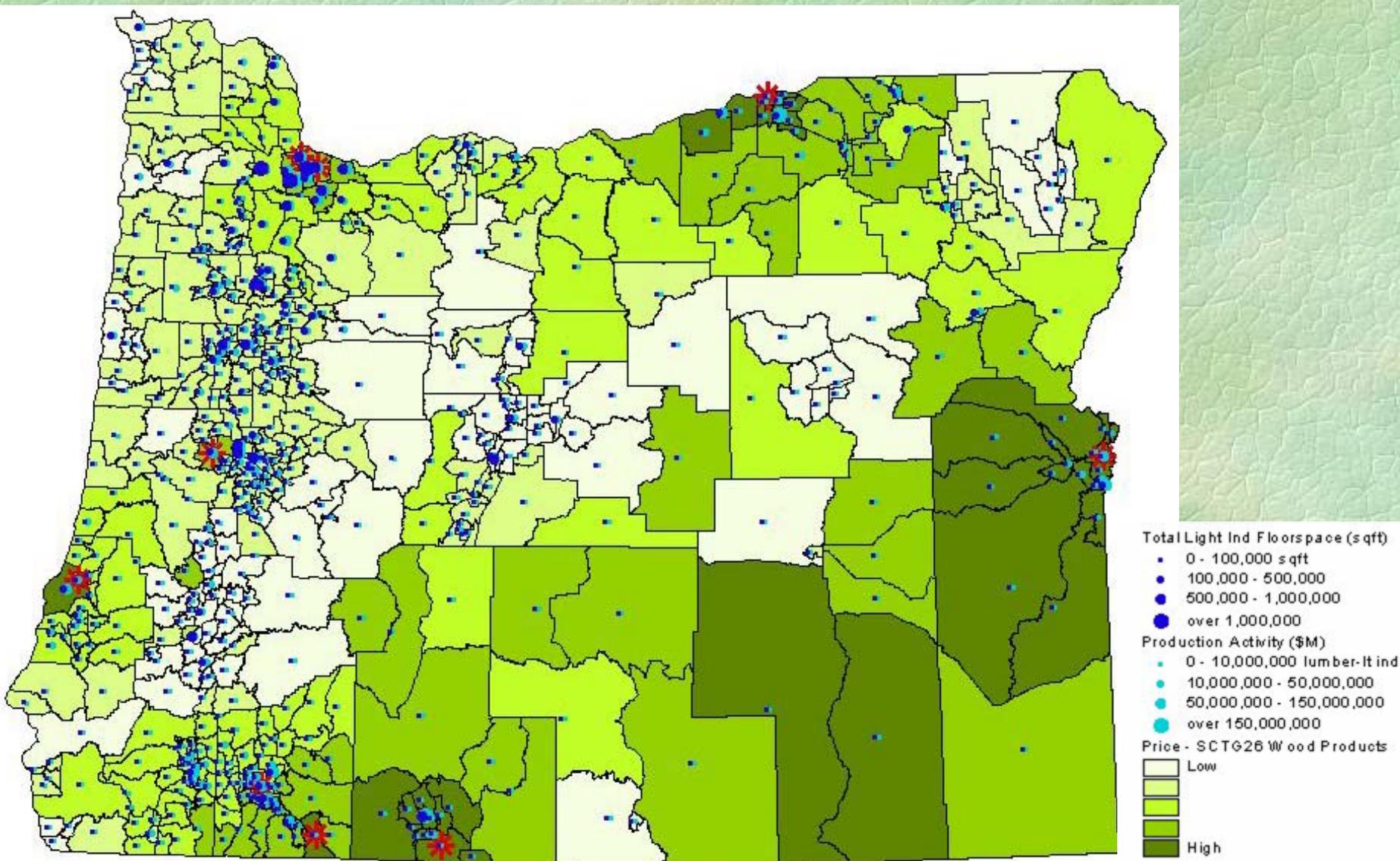
Lumber Light Industry
(Activity, Skilled Wages)

Production Activity ($M)
- 0 - 10,000,000 lumber-lt ind
- 10,000,000 - 50,000,000
- 50,000,000 - 150,000,000
- over 150,000,000

Wage - Skilled Labor
- Low
- High
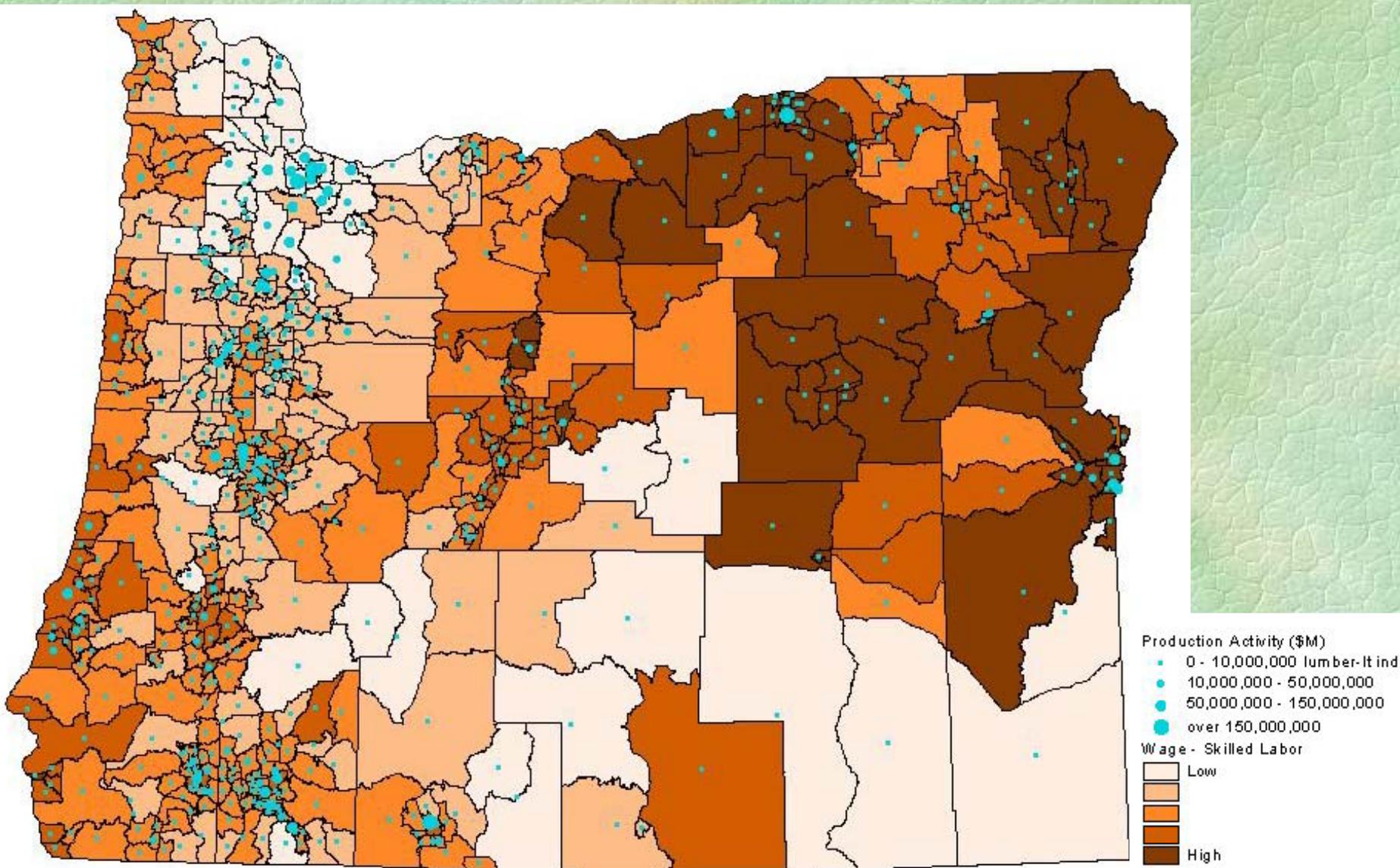
Retail Industry
(Activity, Retail Floorspace, Retail Floorspace Price)

Total Retail Floorspace (sqft)
- 0 - 100,000
- 100,000 - 500,000
- 500,000 - 1,000,000
- over 1,000,000

Production Activity ($M)
- 0 - 100,000,000 retail
- 100,000,000 - 300,000,000
- 300,000,000 - 750,000,000
- over 750,000,000

Price - Retail Floorspace
- Low
- High
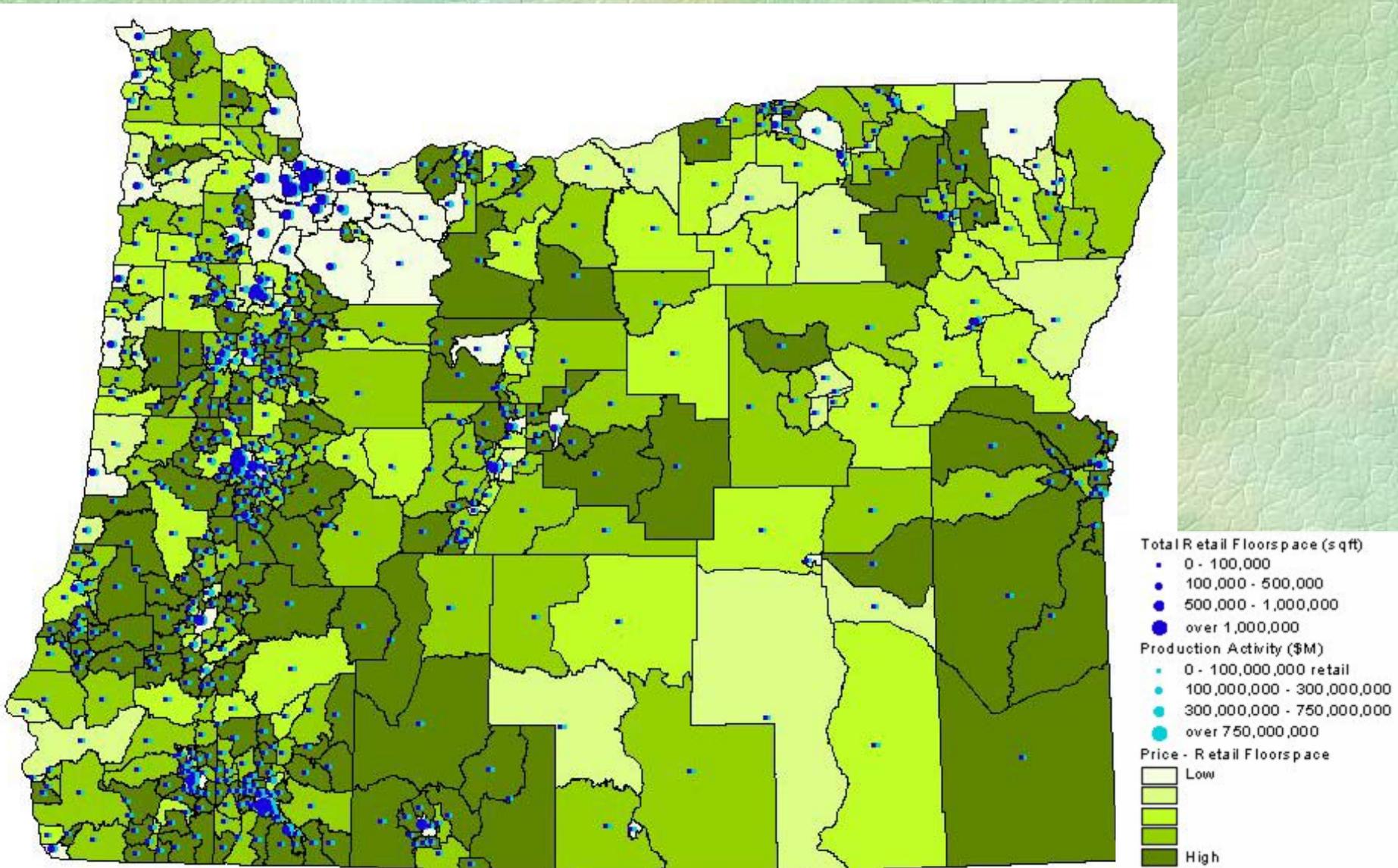
Retail Industry
(Activity, Retail Floorspace, Retail Margin Price)

Total Retail Floorspace (sqft)
- 0 - 100,000
- 100,000 - 500,000
- 500,000 - 1,000,000
- over 1,000,000

Production Activity ($M)
- 0 - 100,000,000 retail
- 100,000,000 - 300,000,000
- 300,000,000 - 750,000,000
- over 750,000,000

Price - Retail Goods
- Low
- High
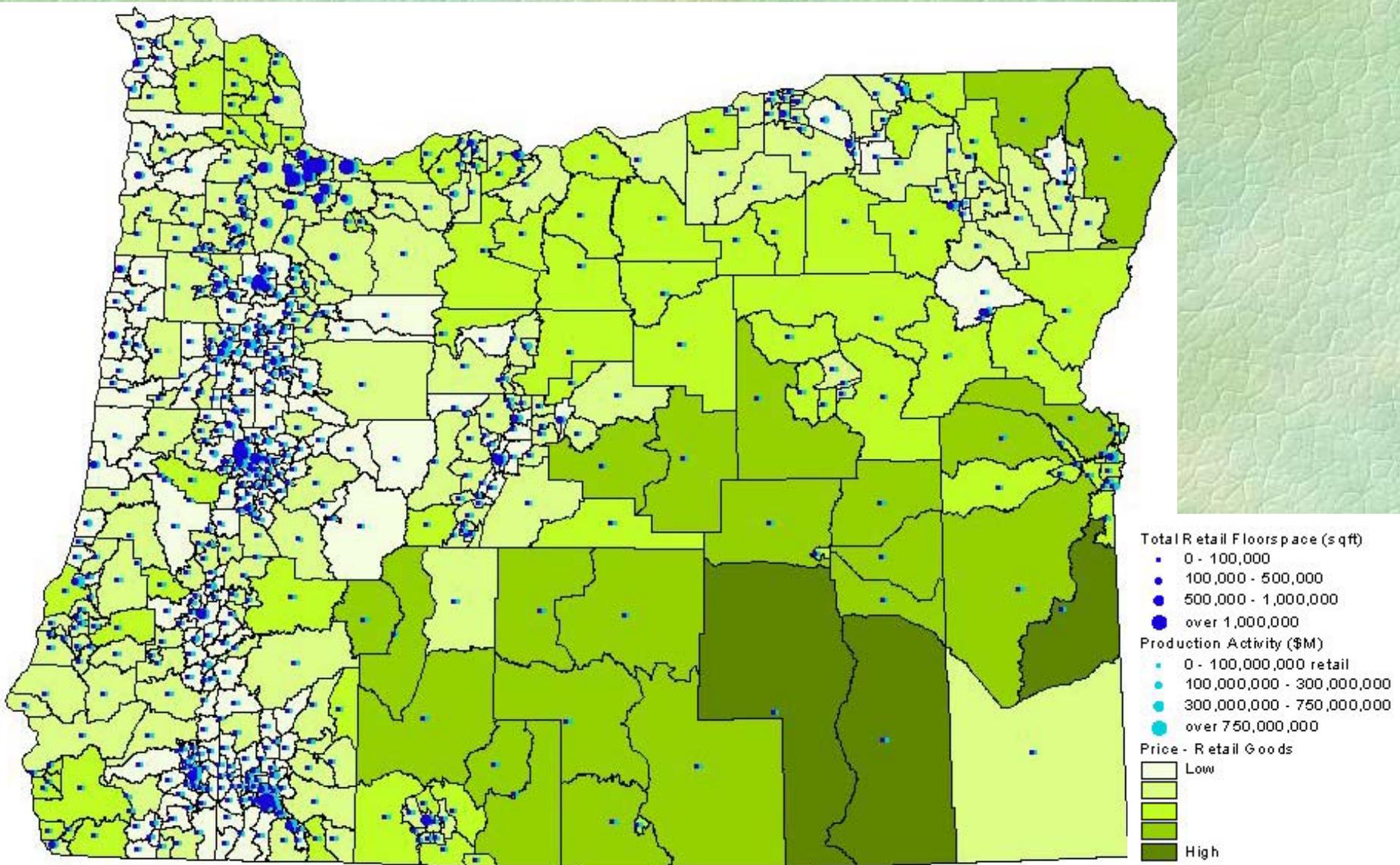
Management
(Activity, Office Floorspace, Floorspace Price)

Total Office Floorspace (sqft)
- 0 - 500,000
- 500,000 - 2,500,000
- 2,500,000 - 7,500,000
- over 7,500,000

Production Activity ($M)
- 0 - 100,000,000 Mgmnt
- 100,000,000 - 300,000,000
- 300,000,000 - 750,000,000
- over 750,000,000

Price- Office Floorspace
- Low
- High

Management
(Activity, Office Floorspace, Wages)

Production Activity ($M)
- · 0 - 100,000,000 Mgmnt
- · 100,000,000 - 300,000,000
- ● 300,000,000 - 750,000,000
- ● over 750,000,000

Wage - Managerial/Professionals
- Low
- High
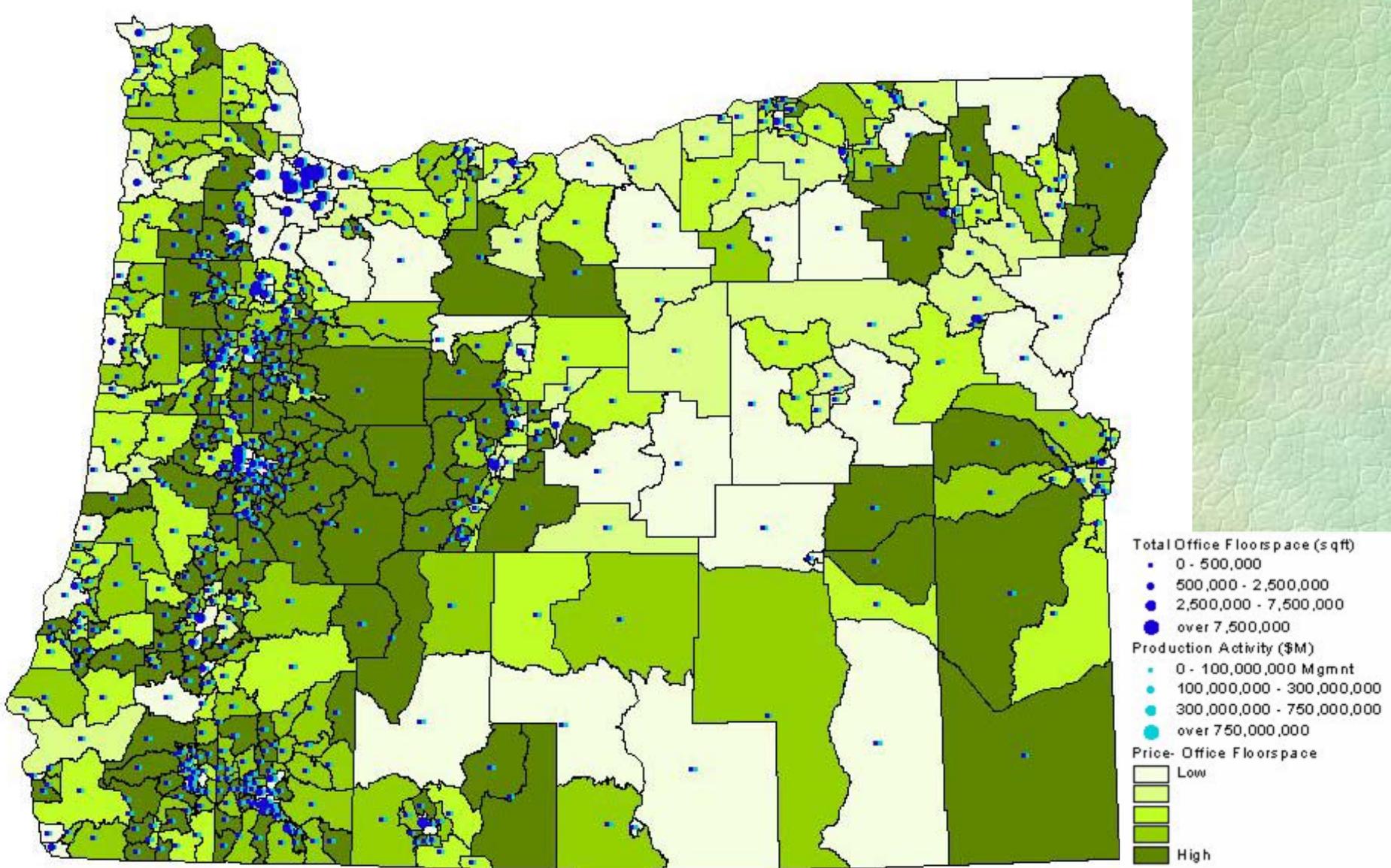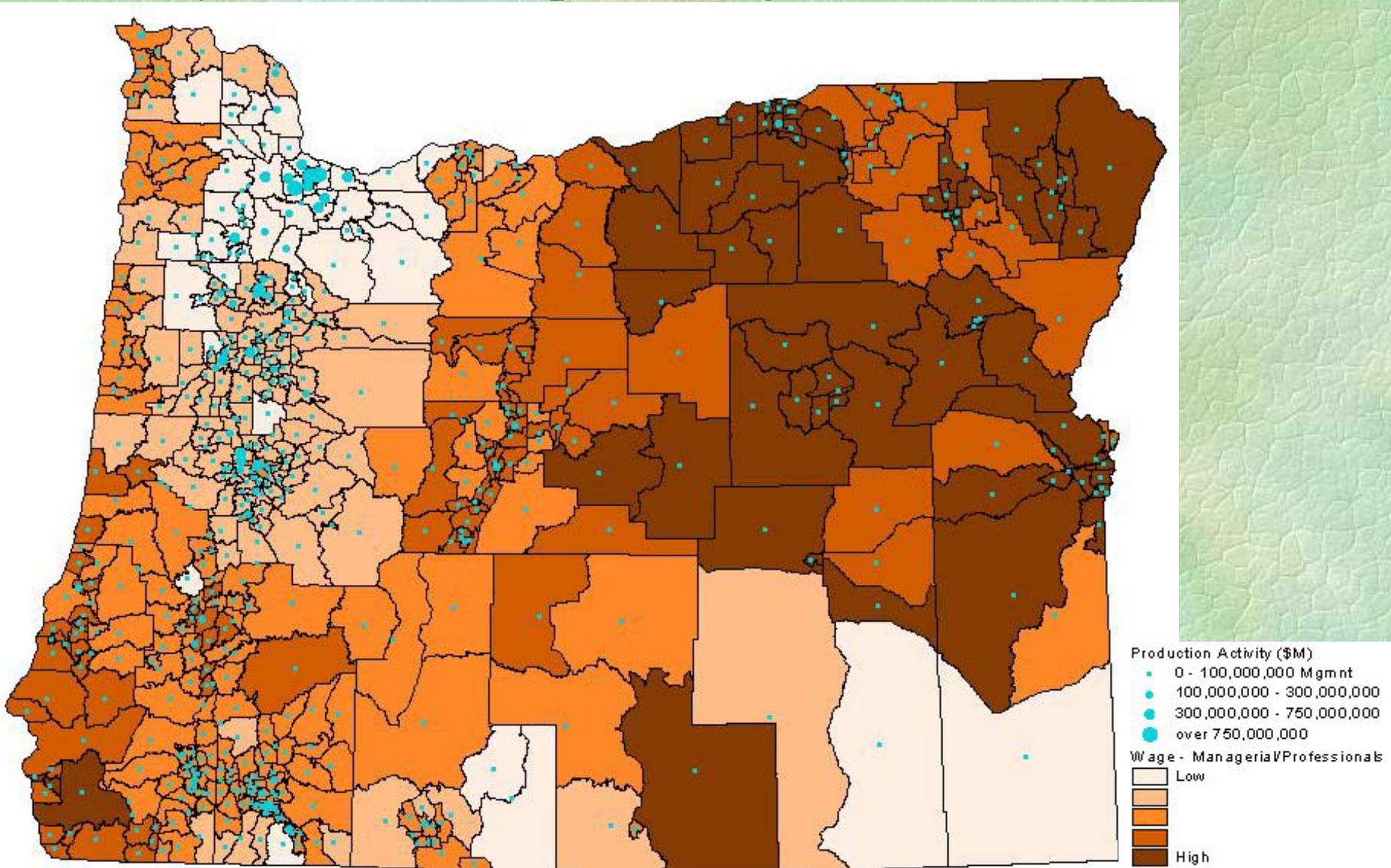
Gradeschool Education Industry
(Activity, School Space, Teacher Wage)

Total K12 School Floorspace (sqft)
- · 0 - 30,000
- • 30,000 - 100,000
- ● 100,000 - 350,000
- ● over 350,000

Production Activity ($M)
- · 0 - 3,000,000 K12 schools
- • 3,000,000 - 10,000,000
- ● 10,000,000 - 25,000,000
- ● over 25,000,000

Wage - K12 Teachers
- Low
- High
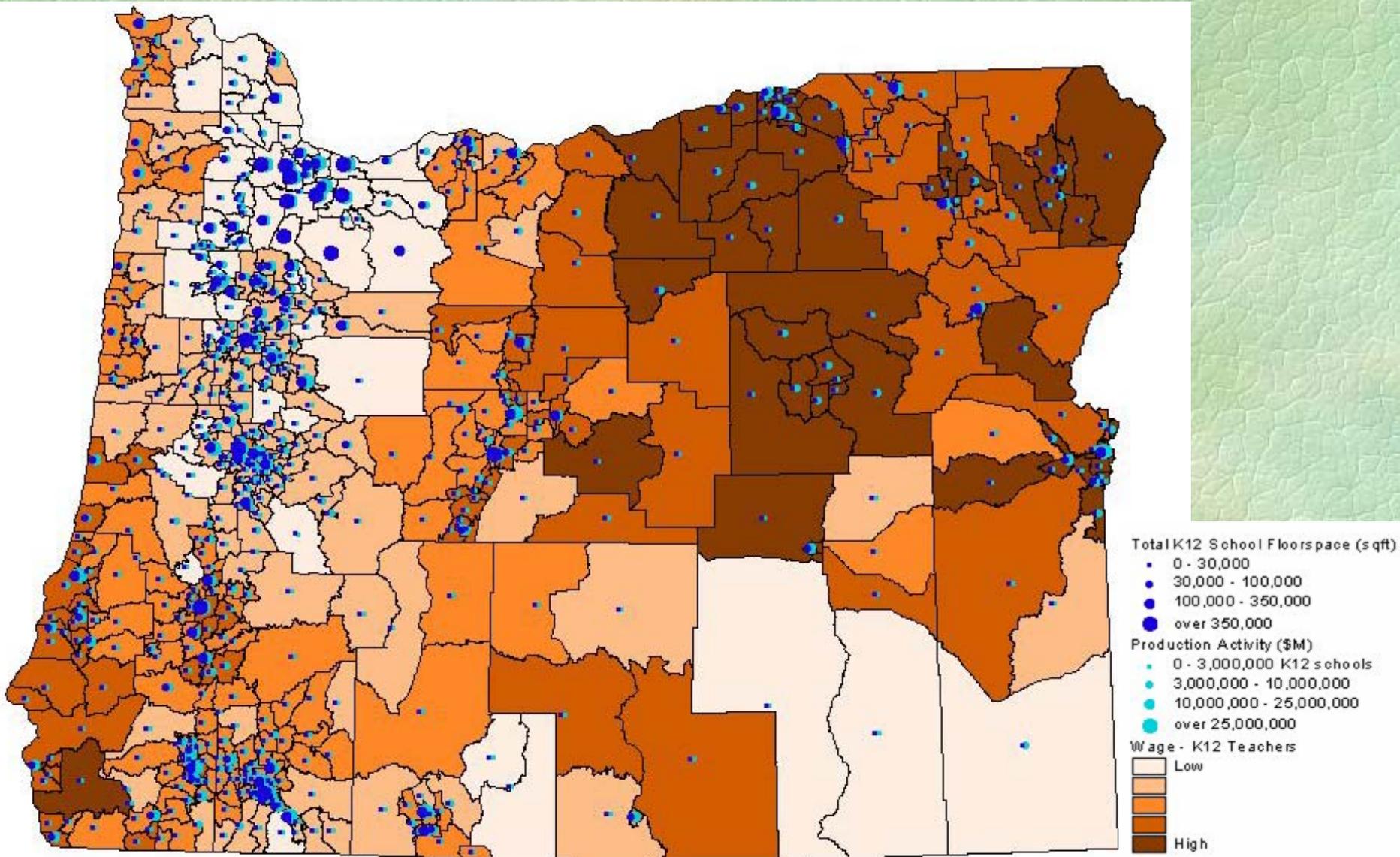
Calibration Strategy

- Establish space consumption functions
  - to match observed variations in space prices vs use rates

- Adjust zonal constants in location utility
  - to match observed employment by zone

- Adjust dispersion parameters at all levels and price coefficients for buying and selling
  - to match range of observed labor and commodity prices

- Adjust dispersion parameters at all levels and transport coefficients for buying and selling
  - to match range of observed transport distance distributions

Conclusions

- Still work-in-progress
  - running and being calibrated
  - feasibility demonstrated
  - novel, flexible, generalized framework available incorporating previous 'integrated' and 'connected' types
  - provides fully consistent consumer surplus and producer surplus
  - basis for stand-alone aggregate model when combined with treatment of land development

- Calibration challenging
  - data needs
  - complexity and interconnectivity

PECAS:

Production, Exchange & Consumption Allocation System