The Emergent Biomass Industry and Potential Land-Use Competition*

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Specter of Bio-Economy Sector

- Recent projections of energy production and consumption trends in the U.S. show substantial national dependencies upon foreign oil which have continued to put pressure on domestic energy security
- Alternative energy programs--such as biomass energy crop systems--are currently under development
  - Considerable research and development on them is projected through at least the year 2012 (Department of Energy 2005)
- Economic studies of massive biomass crop production (e.g., De La Torre Ugarte et al. 2003) estimate net increases in crop prices on the order of 3-14%
  - Net farm increases up to $6 billion per year
- President Bush identified such alternative fuel programs in his 2006 & 2007 SOU Addresses
  - One of his strategic initiatives for the remainder of his term
- All told, bio-energy systems, and **biomass crop production** in particular, will be important elements of U.S. national security, economic vitality, and public policy in the foreseeable future

Social Policy & Bio-Economy Sector

- With the prospects of such a massive bio-energy sector of the economy on the horizon, we know very little about the potential magnitude, location, and social policy issues arising from it
- The "pathway approach" sponsored under the auspices of the DOE largely ignores the social systems that must adapt to make bio-energy a significant and wholly sustainable sector of the economy
- For instance, transportation costs are crucial economic factors in determining the "break-even" cost for growing biomass alternative fuels
  - This market force alone will likely create concentrated zones of biomass crop production
  - Perhaps not unlike CAFO-style hog operations
- Where in the U.S. will these zones emerge and what will their proximity be to population centers?
- The locations of these optimal agronomic biomass crop zones will tell social scientists much about the social policy issues most likely to arise from the emergence of the associated industrial, workforce, and agricultural changes necessary to support the new bio-economy

Approach

- The identification of high-likelihood spatial clusters of counties, or agronomic crop “zones” for biomass production
- The estimation of economically optimized crop production zones where crop yield potential is weighed against land-value and production costs in the locality
- The proximity of these biomass zones to metropolitan areas so as to assess patterns of potential land-use conflict in the future
- Existing yield forecasts provide evidence that biomass may become a serious contender for land currently allocated towards traditional crops. Thus, land-use conflict associated with the bio-economy is likely to be situated both **within** agriculture and **between** agricultural and other land-uses, especially at the urban fringe and other areas of high development potential
- The competition for land-use in the bio-economy appears at the core of the major social policy issues that the biomass sector will face

Research Methods: Data Sources

- Data were obtained from several sources, all pertaining to the county-level for the 48 contiguous states
- The main sources of biomass crop data came from Oak Ridge National Lab [Graham et al. (1997)]
- The estimates for biomass crops--switchgrass (SG) and short-rotation, woody crops (SWRC)--produced by Robin Graham and her associates pertained to 1992. We obtained those data from Dr. Graham and produced similar estimates for 1997 and 2002 using the same procedures but updating the key variables (e.g., CRP acres, harvest acres, etc.) from the successive Censuses of Agriculture
- Information on region, metropolitan proximity, county landmass, and total cropland in acres were respectively taken from the Census Bureau, the USDA Economic Research Service, and the Census of Agriculture for 1997 and 2002

Figure 2. Total Acres of Potential Biomass from Switchgrass (SWG) and Short-Rotation Woody Crops (SRWC) by Metro Status and Region

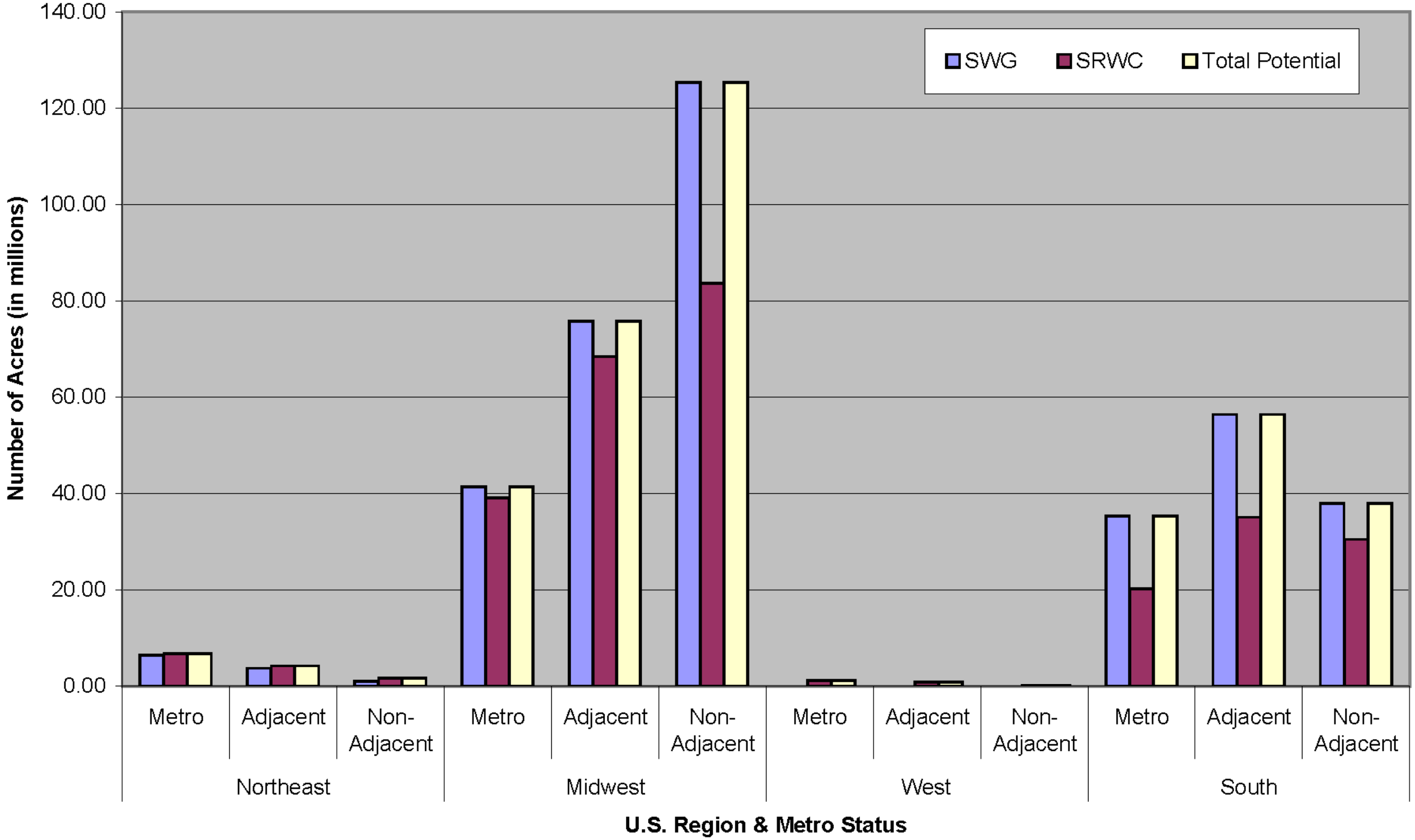


Figure 4. Total Potential Biomass Acres from Switchgrass & Short-Rotation Woody Crops (ORNL 2002)

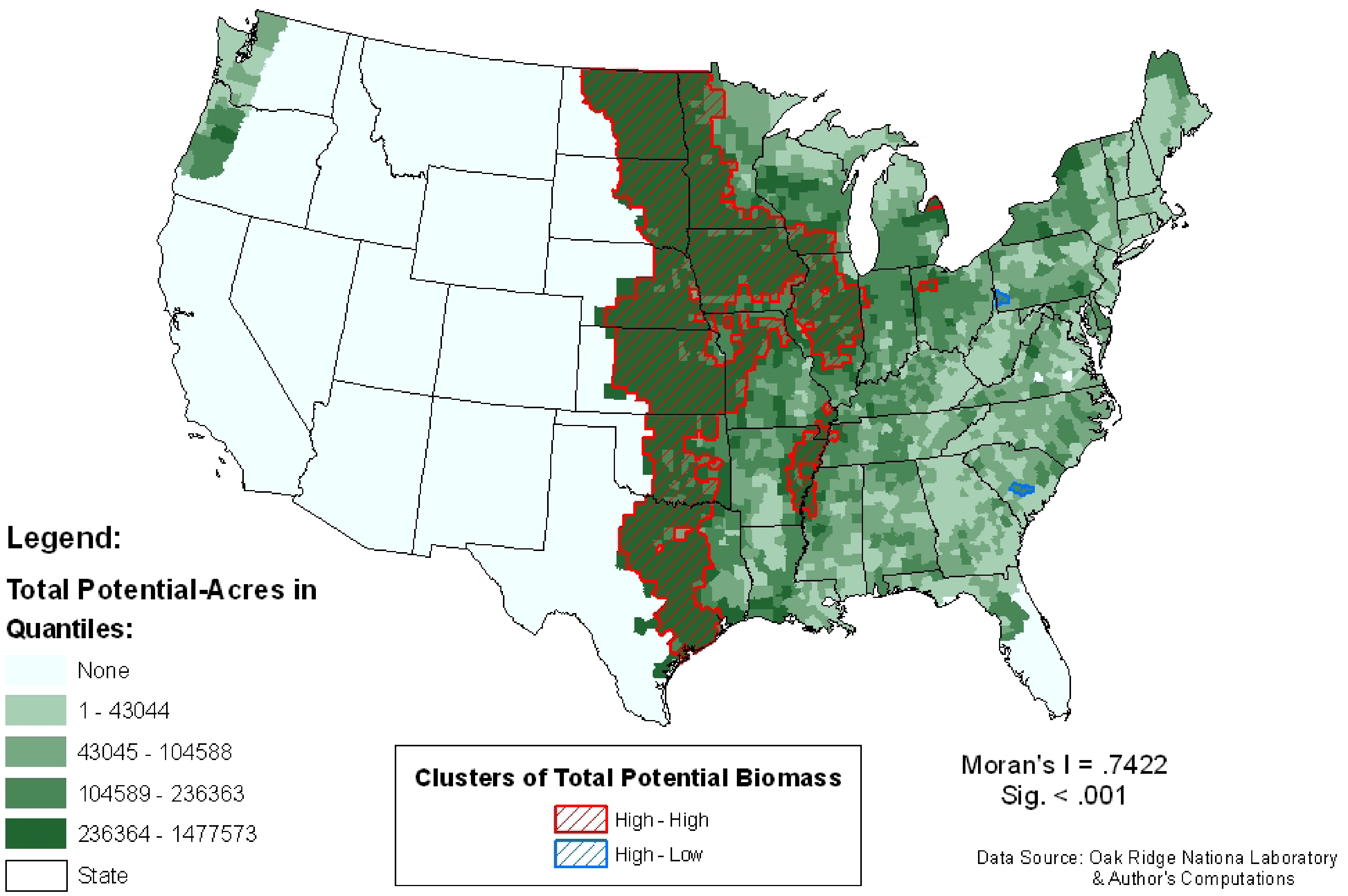
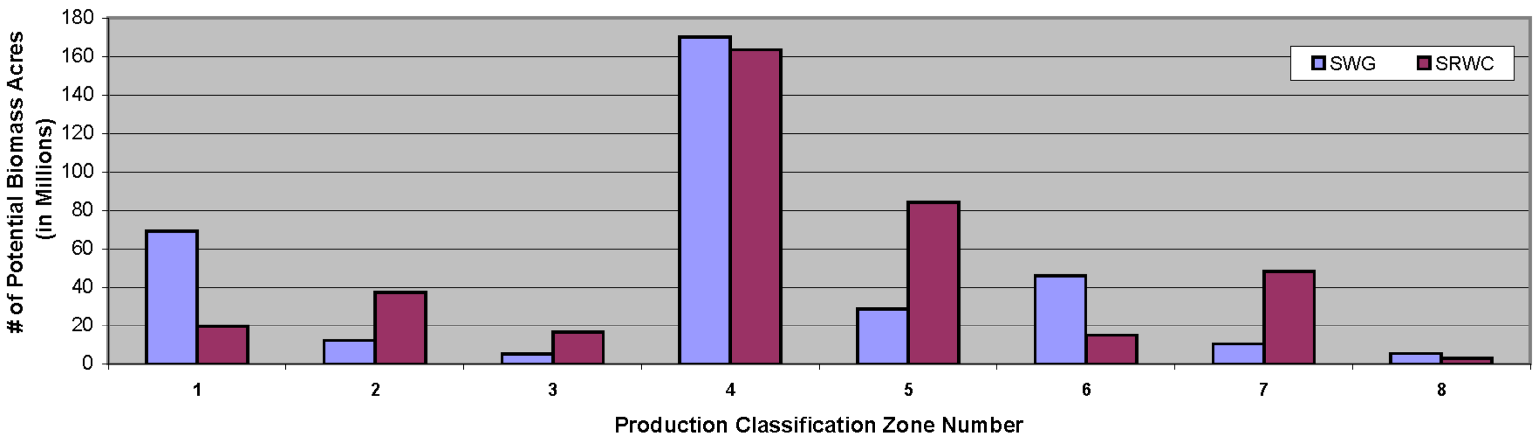


Figure 7. Optimization Breakdown and Descriptives of Production Classification Zones*

	Optimization Variables			Number of Counties in Classification Zone by U.S. Region							
Variable	Rent	Yield	Production Costs	SWG Optimal Zone				SRWC Optimal Zone			
Median SWG	$50.73/acre	$35.84/dry ton	$1216.44/acre/year								
Median SRWC	$50.73/acre	$65.62/dry ton	$1443.40/acre/year	Northeast	Midwest	West	South	Northeast	Midwest	West	South
Classification Zone #											
1 (Most Optimal)	**Low**	**High**	**Low**	16	147	0	117	0	21	0	87
2	Low	High	High	0	66	0	9	13	94	0	297
3	High	High	Low	59	96	0	136	10	4	0	155
4	**High**	**High**	**High**	0	634	0	258	13	664	35	144
5	Low	Low	Low	104	97	218	279	44	166	218	396
6	Low	Low	High	19	11	0	454	82	40	0	79
7	High	Low	Low	18	4	196	83	10	40	161	231
8 (Least Optimal)	**High**	**Low**	**High**	1	0	0	53	45	26	0	0

Number of Acres of Total Potential Biomass from Switchgrass (SWG) and Short-Rotation Woody Crops (SRWC) by Production Classification Zone



* Low and high cutpoints based in relation to the U.S. median of the specific variable.

Figure 8. Switchgrass Production Zones Based on Rent, Yield Price, & Production Costs*

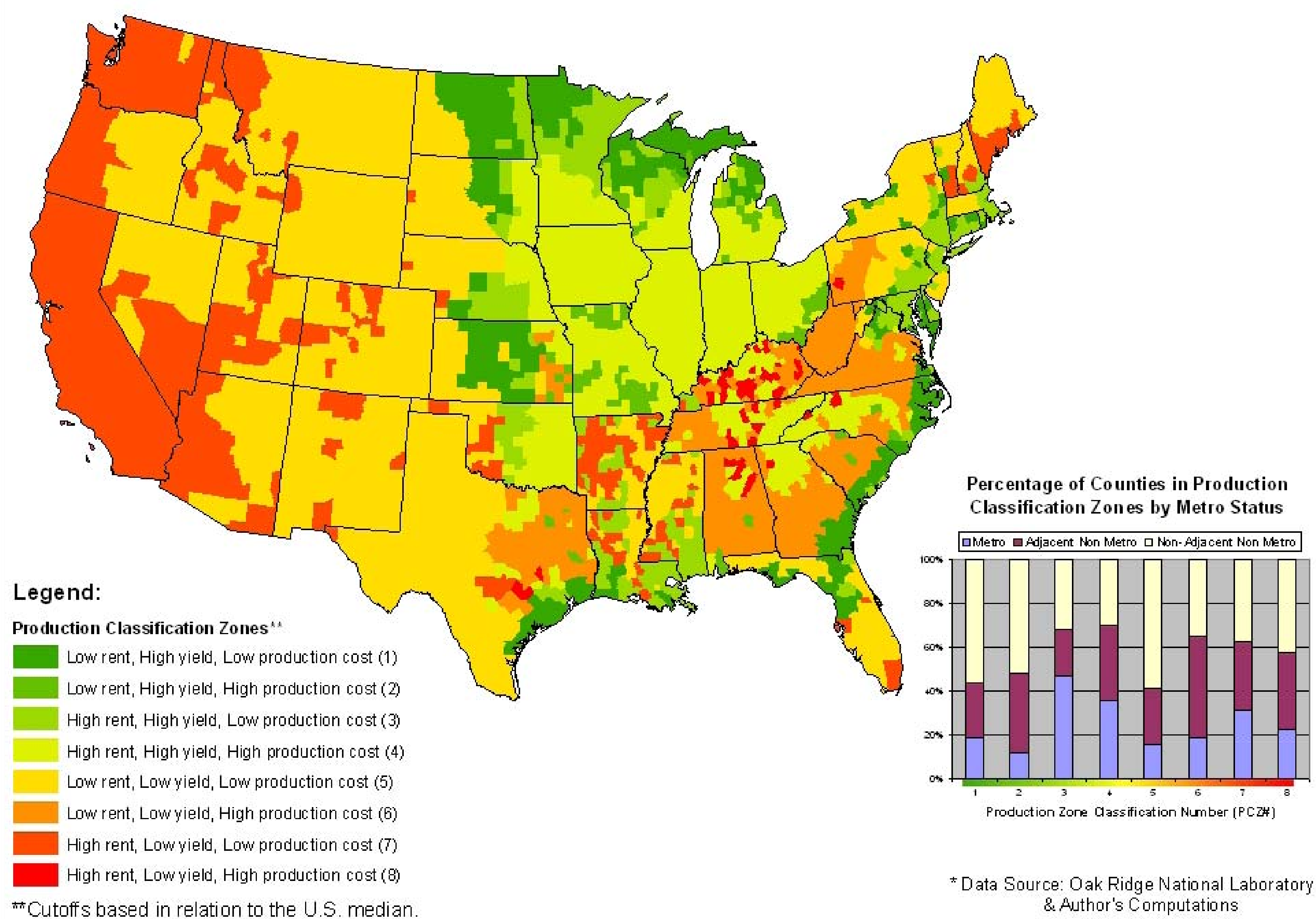
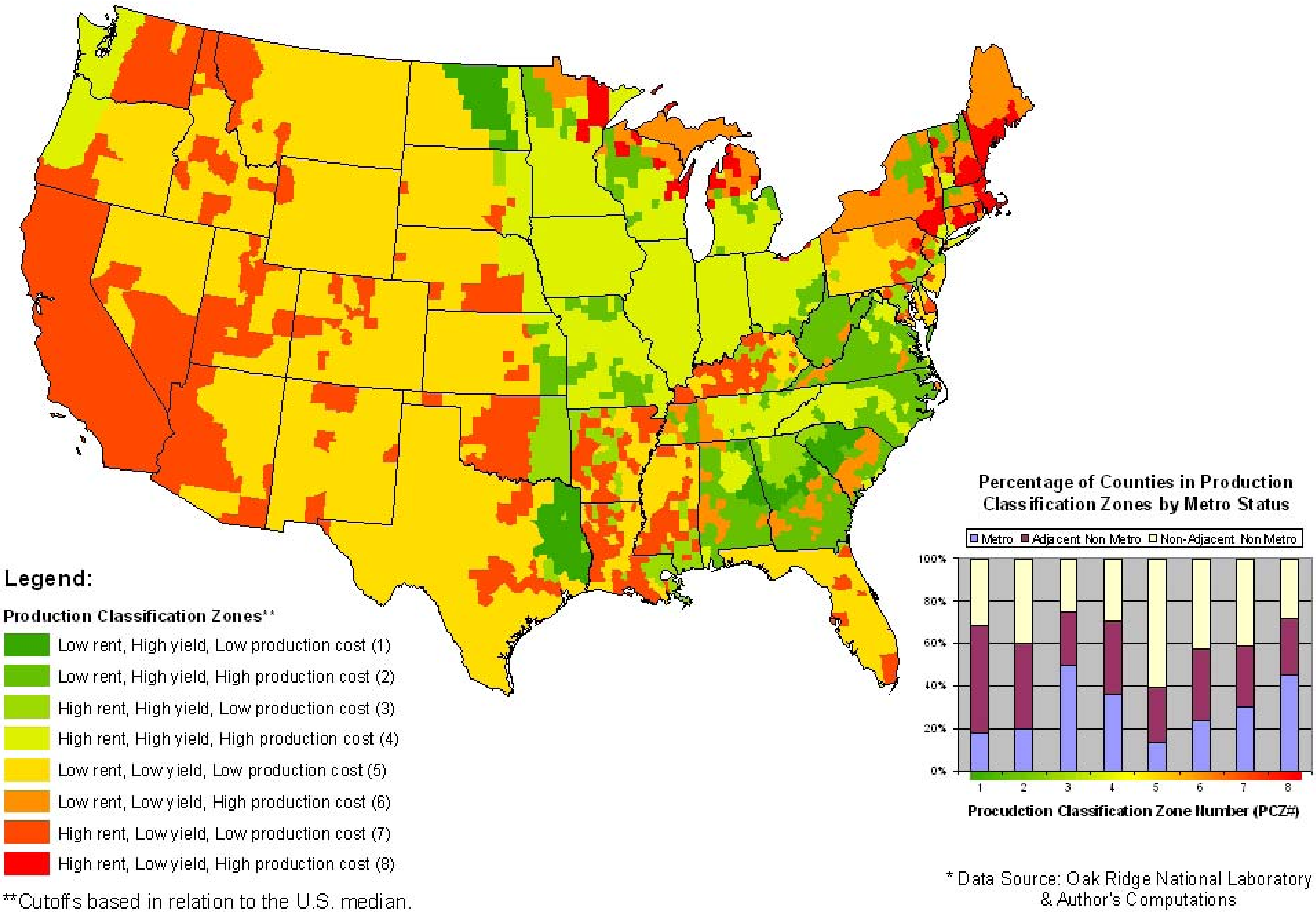
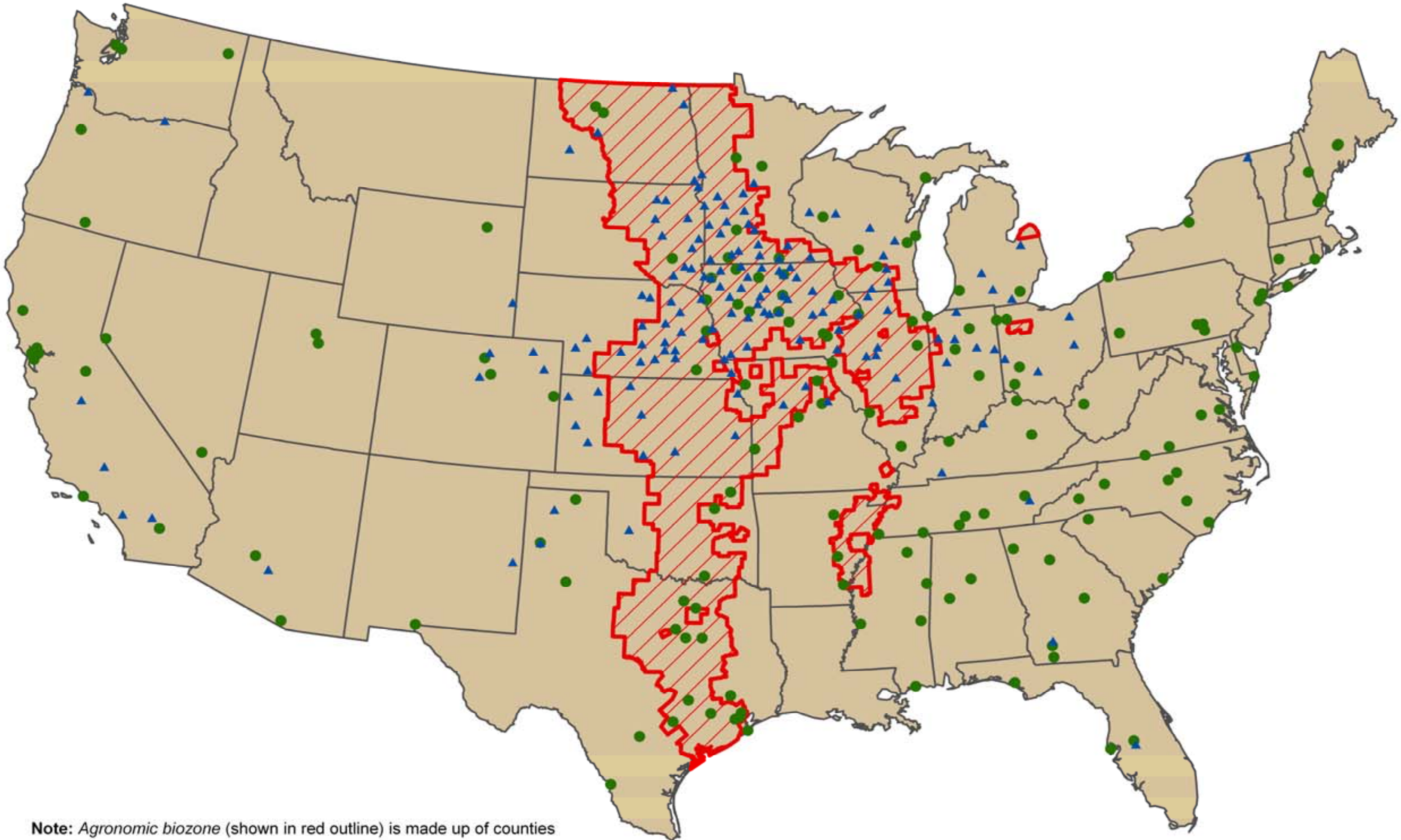


Figure 9. Short-Rotation Woody Crop Optimal Production Zones Based on Rent, Yield Price, & Production Costs*



* Data Source: Oak Ridge National Laboratory & Author's Computations

Spatial Demography of Potential Biomass Production and Current Processing Plant Facilities



Note: *Agronomic biozone* (shown in red outline) is made up of counties with high potential biomass acreage surrounded by counties with high potential biomass acreage. Data are circa 2002. Moran's I coefficient is 0.742, p <0.001.

Data sources: Oak Ridge National Laboratory (ORNL), Authors' Calculations

Legend:

- Current ethanol plant
- Current biodiesel plant
- Agronomic biozone
- State boundary

Competitive Land-Use Threats

Urban Development Threats:

- Have interstate highways
- Pct. of land/place area growth is above the median, 1990-2000
- Pct of land that is urban built is above median, circa 2000
- Population density is above the median, 2000

Population Threats:

- Est. population change is above the median, 2000-2006
- Est. population change is above the median, 2000-2010
- Pct. change in housing stock is above the median, 2000-2005
- Pct. of single family housing building permits is above the median, 2000-2005

Farm Resistance to Adoption Threats:

- Pct. of family independent farms is above the median, 2002
- Pct. of farm operations whose primary operator's income is derived from farm is above the median, 2002
- Pct. of farms with net gains, 2002

Farm Exit Threats:

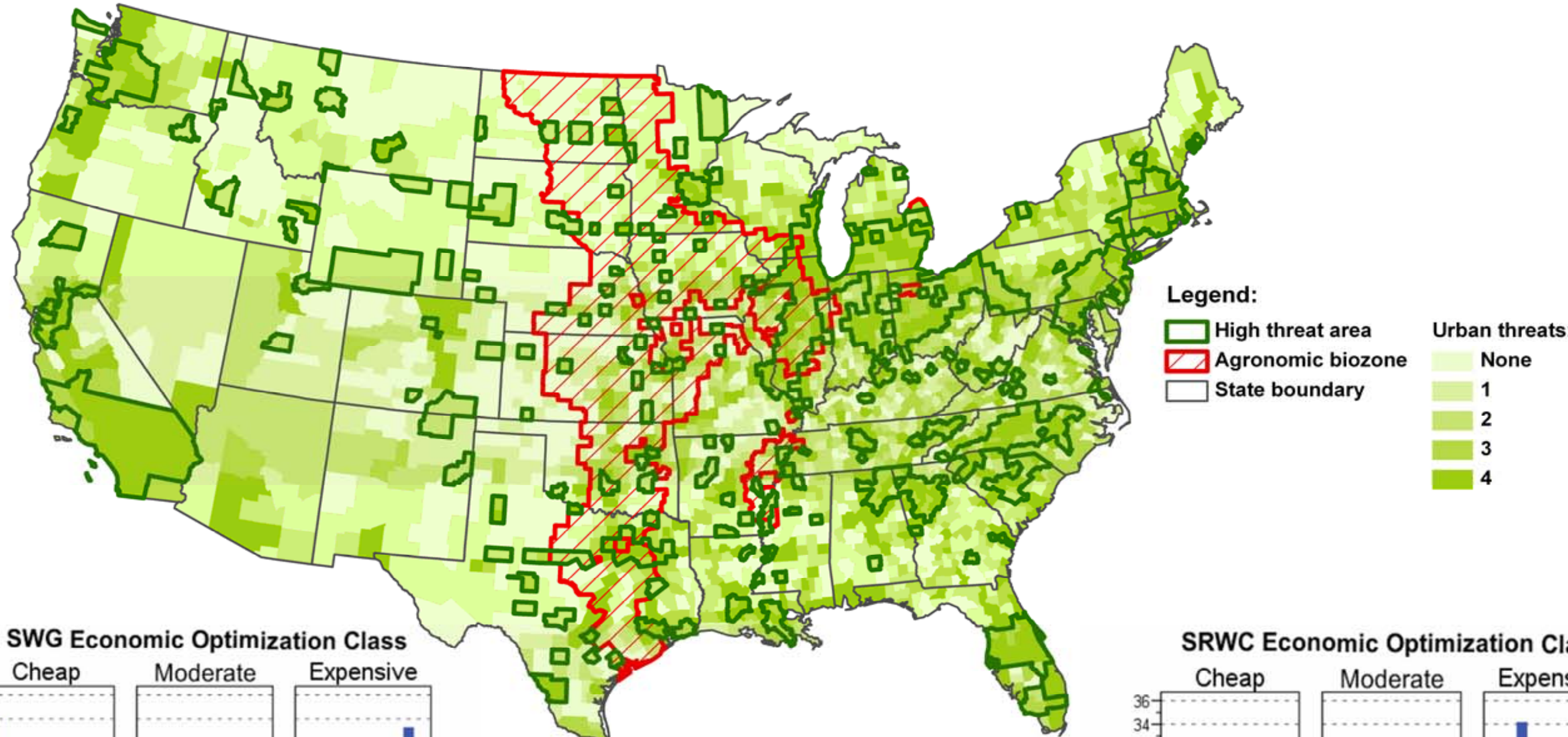
- Percent of farmers aged 65 or more is above the median, 2002
- Agricultural acres declined, 1997-2002

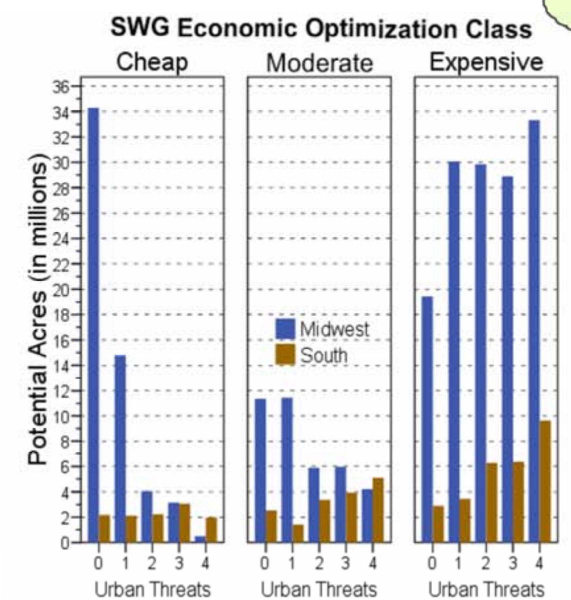
Total Competitive Land-Use Threats:

Sum of 0,1 dummy variables:

- Farm Exit Threats
- Farm Resistance to Adoption Threats
- Population Threats
- Urban Development Threats

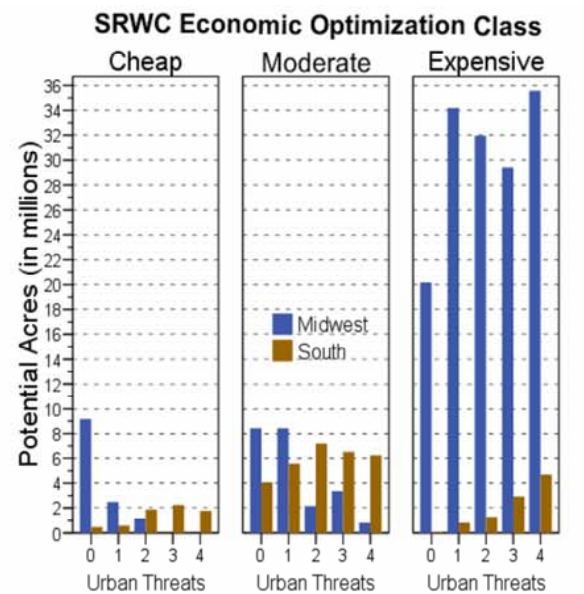
Urban Development Threats for Potential Acres of Switchgrass (SWG) and Short-Rotation Woody Crops (SRWC) Production, & High Yield Economic Optimization



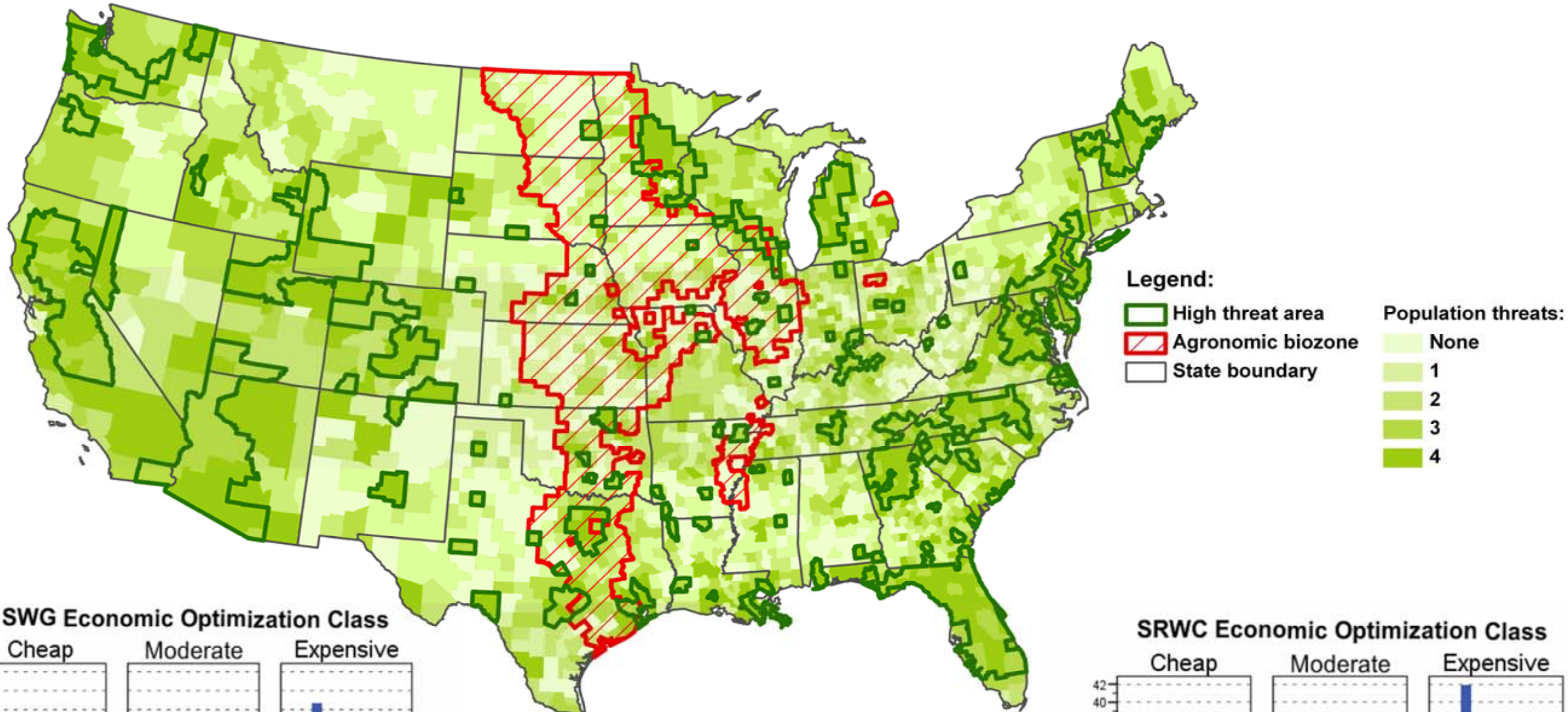


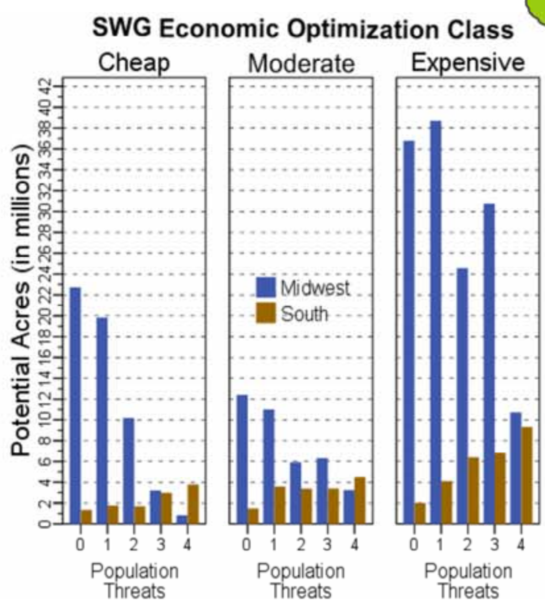
Note: *Agronomic biozone* (shown in red outline) is made up of counties with high potential biomass acreage surrounded by counties with high potential biomass acreage. Data are circa 2002. *High threat area* (shown in green outline) is a county with high threats surrounded by counties with high threats. *Urban threats* (shown in green) is made up of four variables: whether the county contains an interstate highway, percent of area growth, percent urban area between 1990-2000, and population density (2000) for the county are higher than the median (see text). Moran's I coefficient for Urban threats is 0.4344, p <0.001.

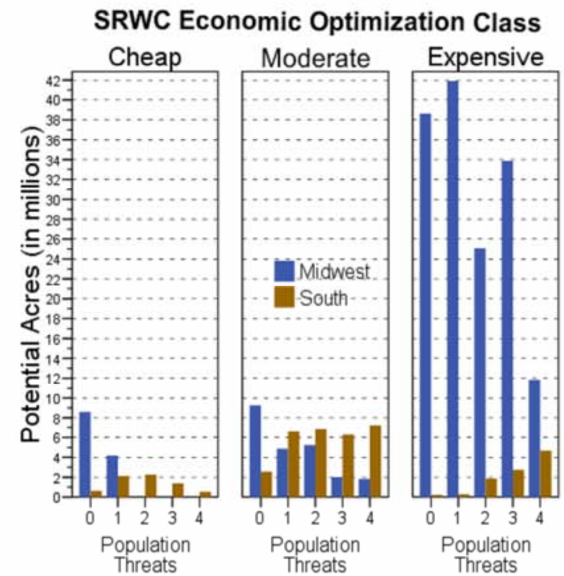
Data sources: Environmental Systems Research, Inc. (ESRI), Oak Ridge National Laboratory (ORNL), U.S. Geological Survey, Authors' Calculations



Population Threats for Potential Acres of Switchgrass (SWG) and Short-Rotation Woody Crops (SRWC) Production, & High Yield Economic Optimization



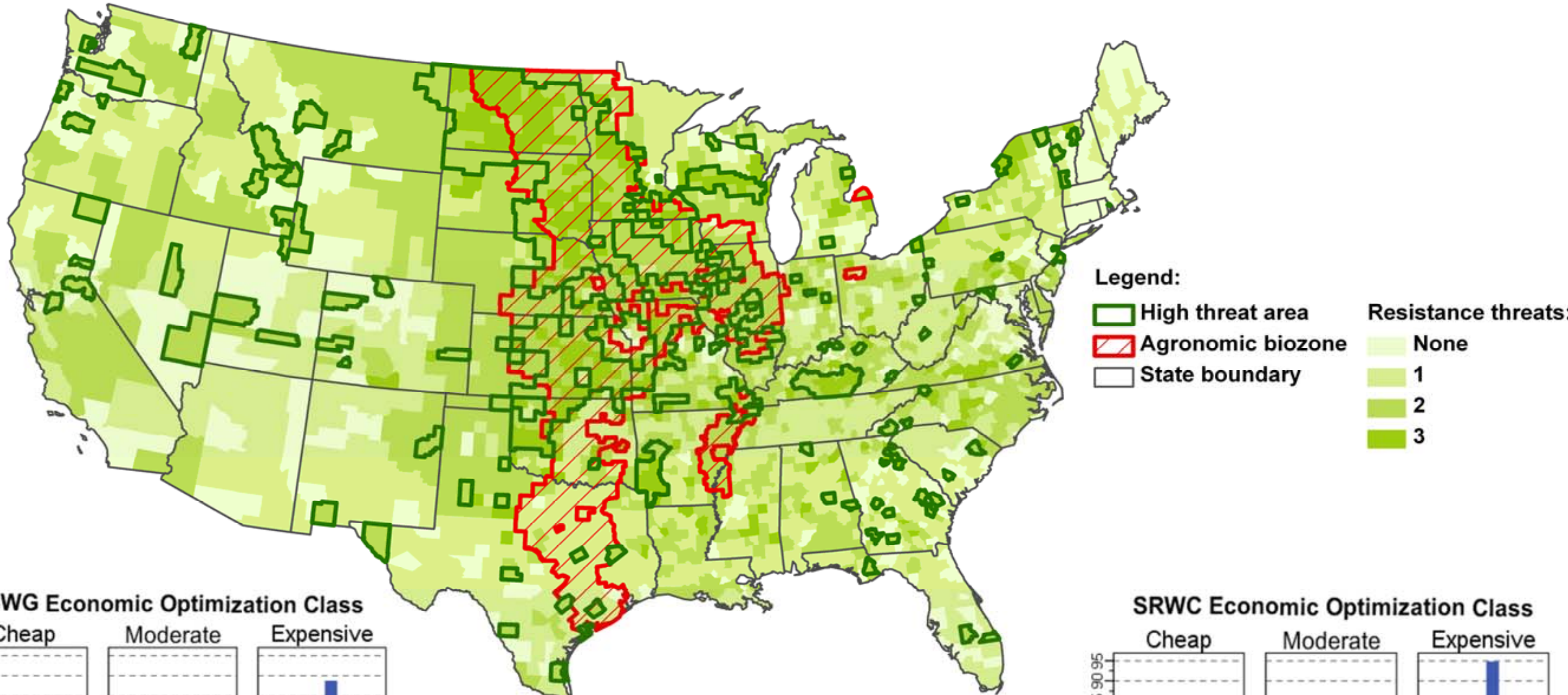


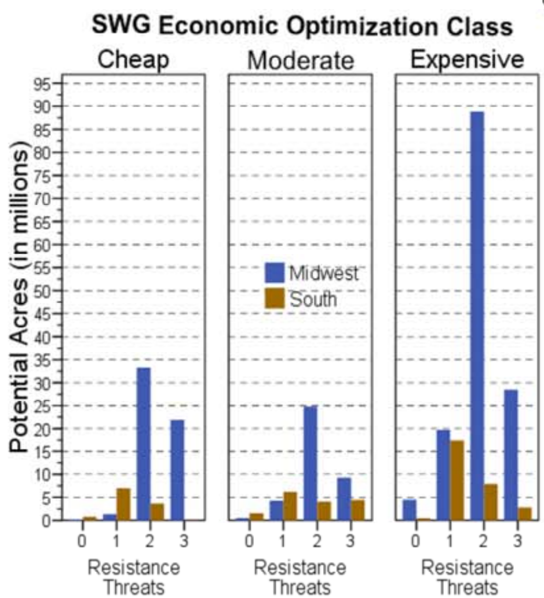


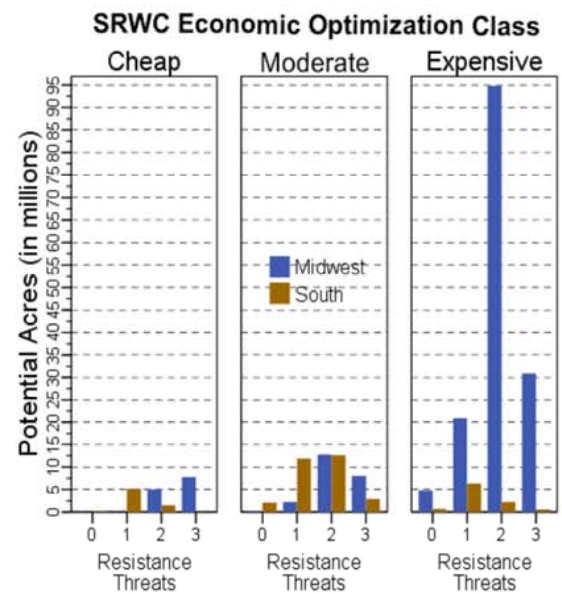
Note: *Agronomic biozone* (shown in red outline) is made up of counties with high potential biomass acreage surrounded by counties with high potential biomass acreage. Data are circa 2002. *High threat area* (shown in green outline) is a county with high threats surrounded by counties with high threats. *Population threats* (shown in green) is made up of four variables: whether the percent of building permits for single family homes, percent change in housing stock (2000-2005), and population change between 2000-2006 and 2005-2010 for the county are higher than the median (see text). Moran's I coefficient for Population threats is 0.4580, p <0.001.

Data sources: Census Bureau, Oak Ridge National Laboratory (ORNL), Authors' Calculations

Farm Resistance to Adoption Threats for Potential Acres of Switchgrass (SWG) and Short-Rotation Woody Crops (SRWC) Production, & High Yield Economic Optimization



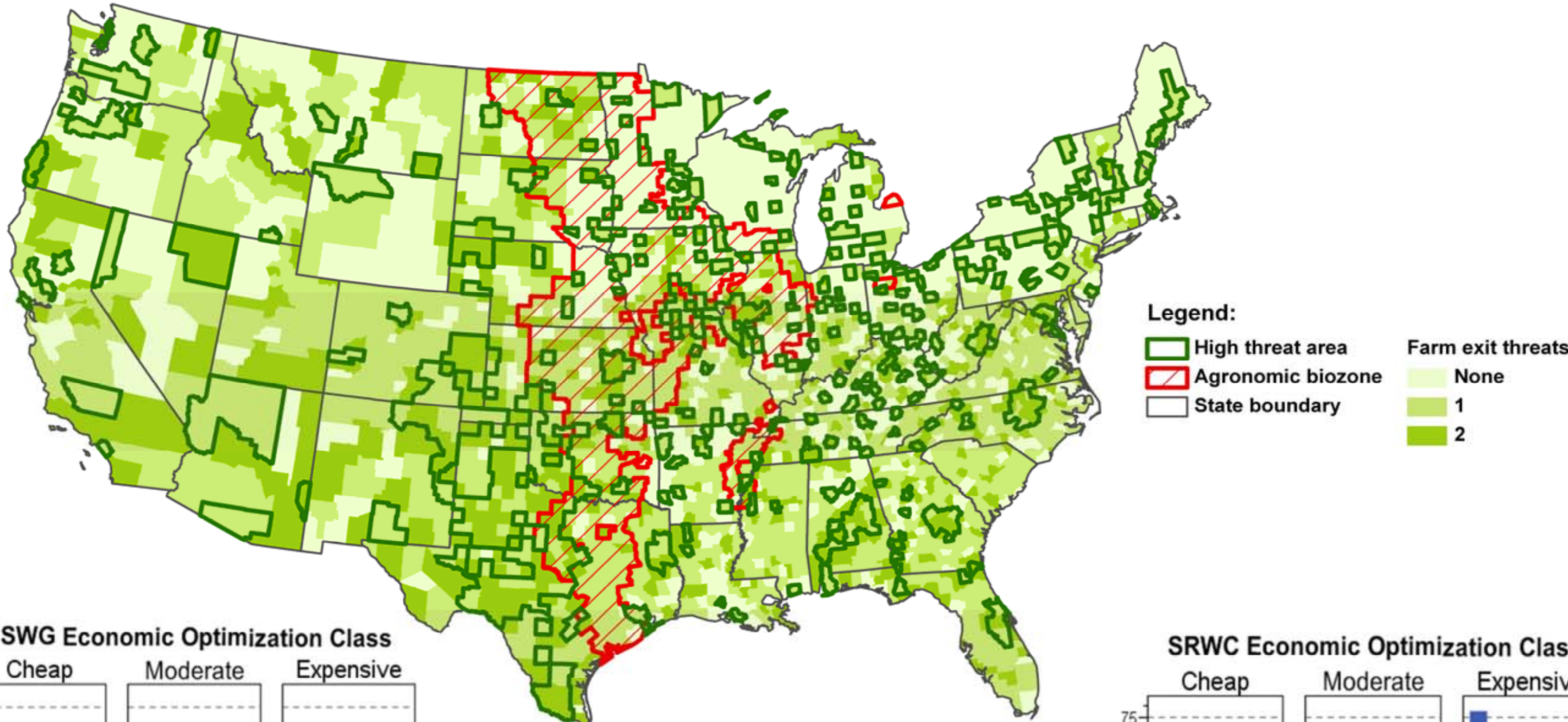


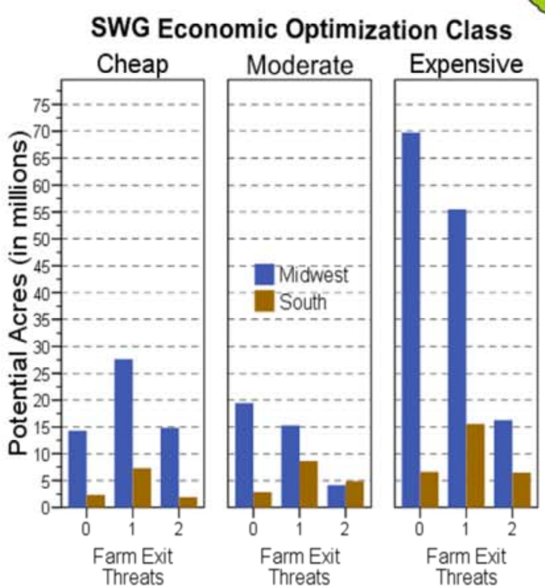


Note: *Agronomic biozone* (shown in red outline) is made up of counties with high potential biomass acreage surrounded by counties with high potential biomass acreage. Data are circa 2002. *High threat area* (shown in green outline) is a county with high threats surrounded by counties with high threats. *Resistance threats* (shown in green is made up of three variables: whether the percent of family farms, primary operator's income is derived from farm, and farms' with net gain for the county are above the median (see text). Moran's I coefficient for Resistance threats is 0.4244, p <0.001.

Data sources: Census of Agriculture, Census Bureau, Oak Ridge National Laboratory (ORNL), Authors' Calculations

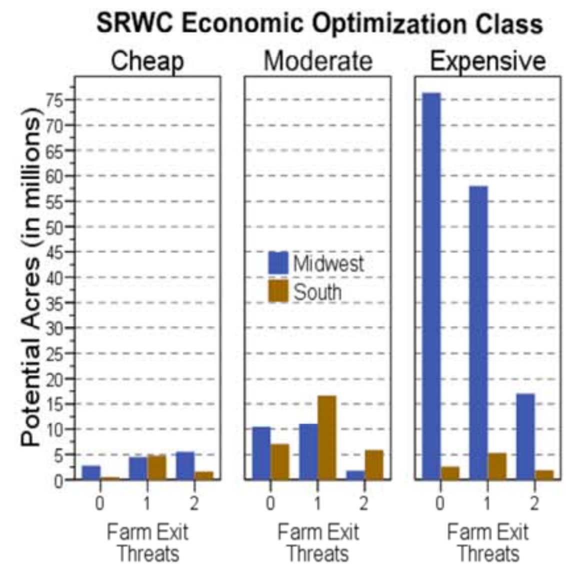
Farm Exit Threats for Potential Acres of Switchgrass (SWG) and Short-Rotation Woody Crops (SRWC) Production, & High Yield Economic Optimization



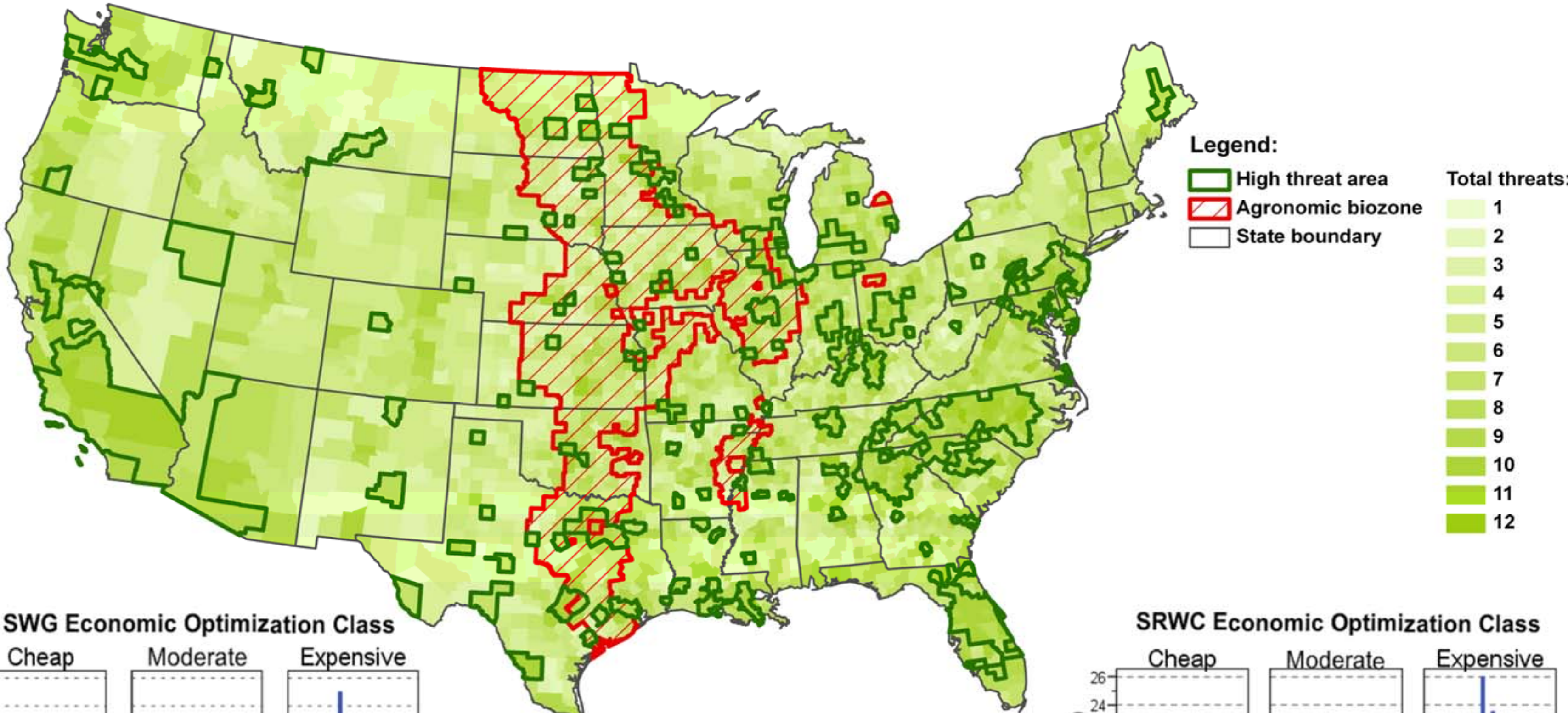


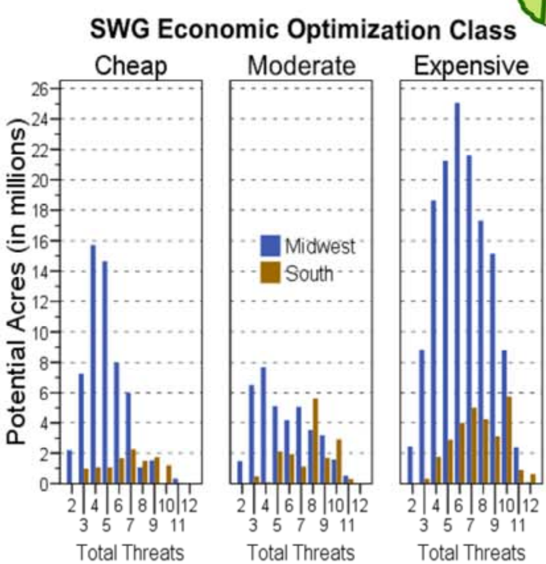
Note: *Agronomic biozone* (shown in red outline) is made up of counties with high potential biomass acreage surrounded by counties with high potential biomass acreage. Data are circa 2002. *High threat area* (shown in green outline) is a county with high threats surrounded by counties with high threats. *Farm exit threats* (shown in green) is made up of two variables: whether the county experienced a decrease in farm acres, and the percent of farmers over age 65 is above the median (see text). Moran's I coefficient for Farm exit threats is 0.2693, $p < 0.001$.

Data Sources: Census of Agriculture, Oak Ridge National Laboratory (ORNL), Authors' Calculations



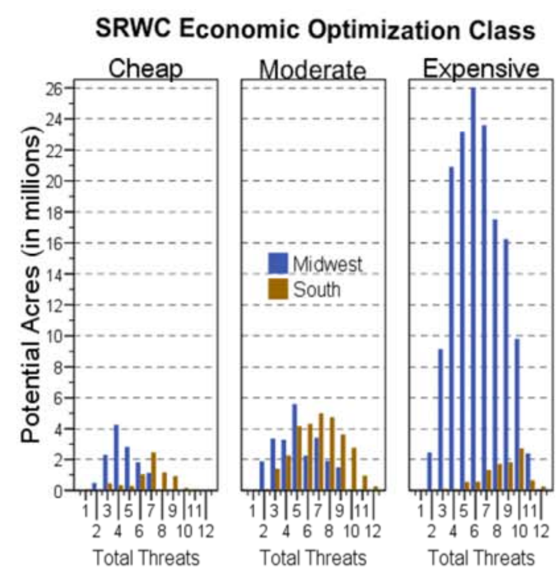
Total Competitive Land-Use Threats for Potential Acres of Switchgrass (SWG) and Short-Rotation Woody Crops (SRWC) Production, & High Yield Economic Optimization



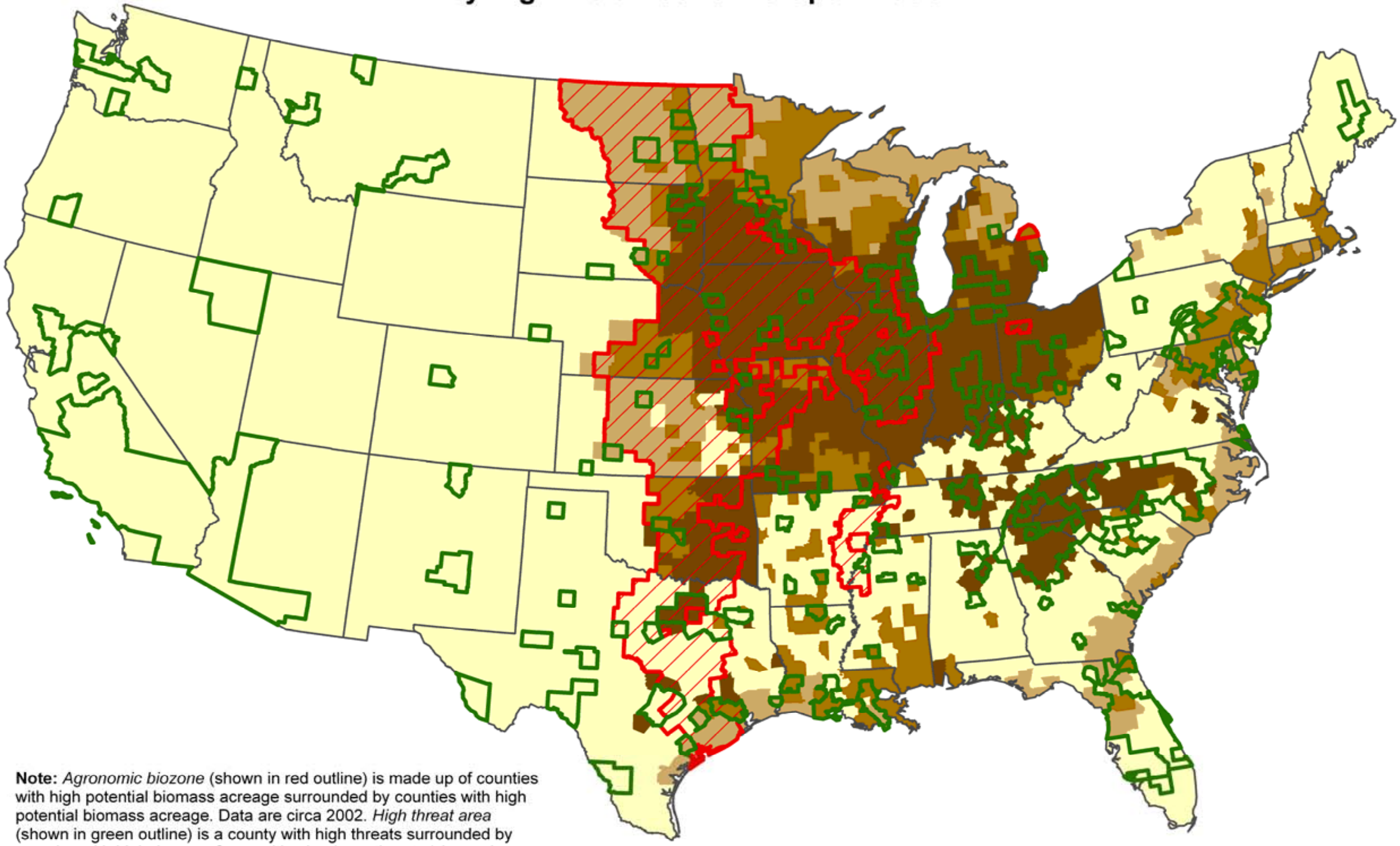


Note: *Agronomic biozone* (shown in red outline) is made up of counties with high potential biomass acreage surrounded by counties with high potential biomass acreage. Data are circa 2002. *High threat area* (shown in green outline) is a county with high threats surrounded by counties with high threats. *Competitive land-use threats* (shown in green) are made up of four threat types: farm exit, farm resistance, population, and urban threats (see text). Moran's I coefficient for Urban threats is 0.3928, $p < 0.001$.

Data sources: Census of Agriculture, Census Bureau, Environmental Systems Research, Inc. (ESRI), Oak Ridge National Laboratory (ORNL), U.S. Geological Survey, Authors' Calculations



Total Competitive Land-Use Threats for Potential Acres of Switchgrass by High Yield Economic Optimization



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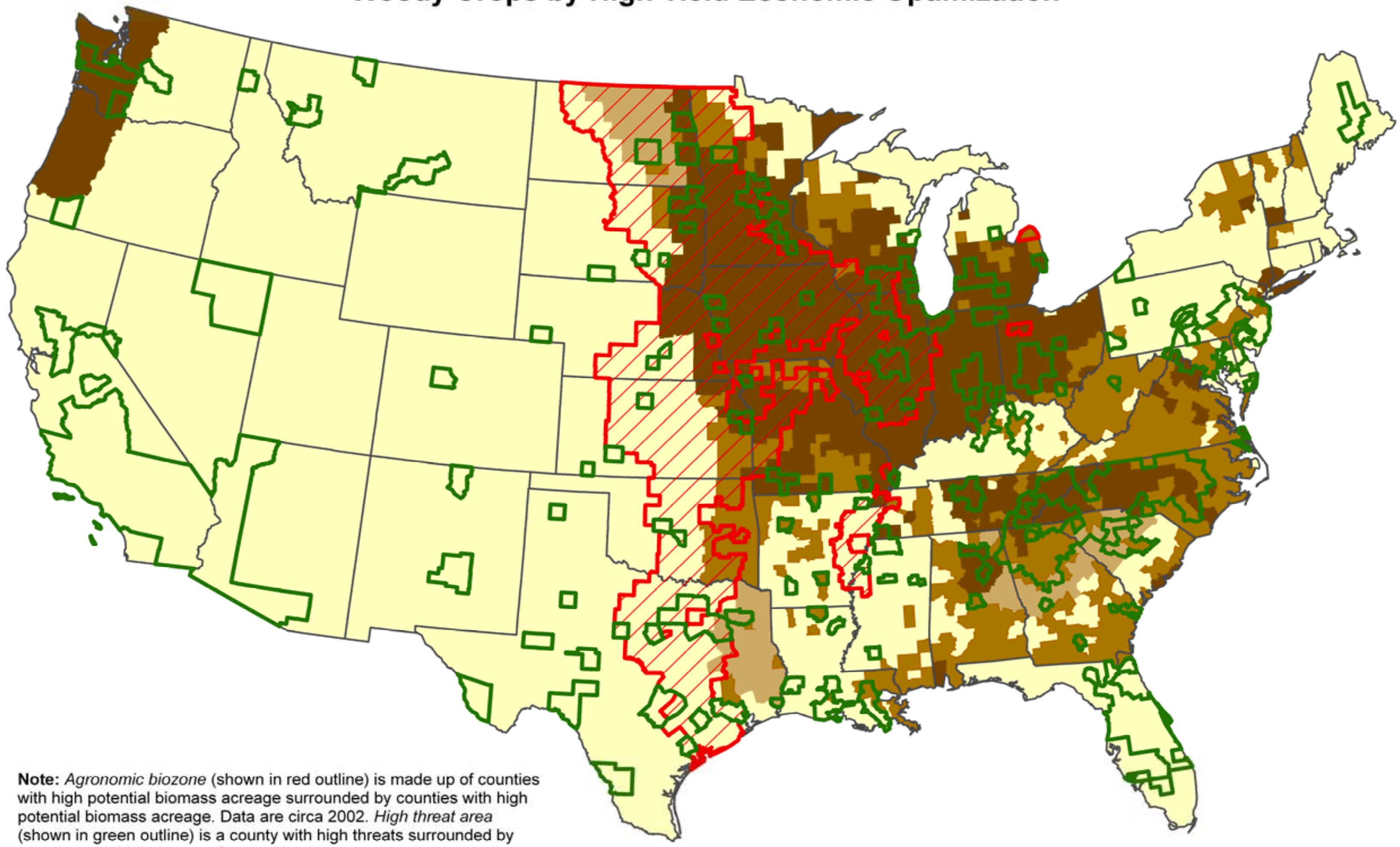
Data sources: Census of Agriculture, Census Bureau, Environmental Systems Research, Inc. (ESRI), Oak Ridge National Laboratory (ORNL), U.S. Geological Survey, Authors' Calculations

Total Competitive Land-Use Threats for Potential Acres of Short-Rotation Woody Crops by High Yield Economic Optimization



Note: *Agronomic biozone* (shown in red outline) is made up of counties with high potential biomass acreage surrounded by counties with high potential biomass acreage. Data are circa 2002. *High threat area* (shown in green outline) is a county with high threats surrounded by counties with high threats. *Competitive land-use threats* (shown in green) is made up of four threat types: farm exit, farm resistance, population, and urban threats (see text). *High yield economic optimization* has four categories: not high yield, cheap, moderate, and expensive cost for high yield production. Moran's I coefficient for Total threats is 0.3928, p <0.001.

Data sources: Census of Agriculture, Census Bureau, Environmental Systems Research, Inc. (ESRI), Oak Ridge National Laboratory (ORNL), U.S. Geological Survey, Authors' Calculations

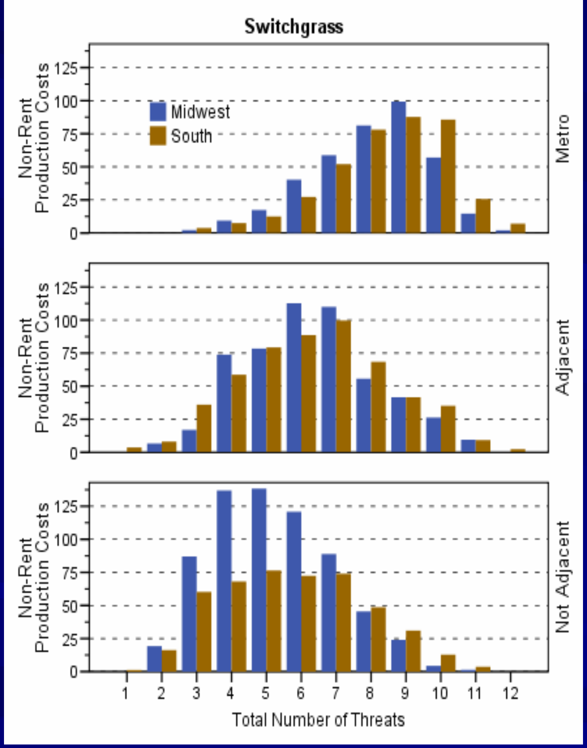
Legend:

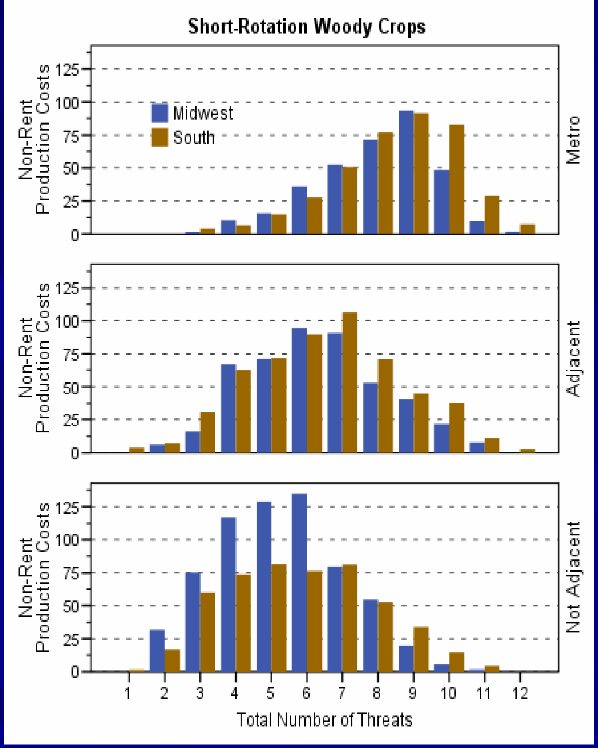
- **High threat area**
- **Agronomic biozone**
- **State boundary**

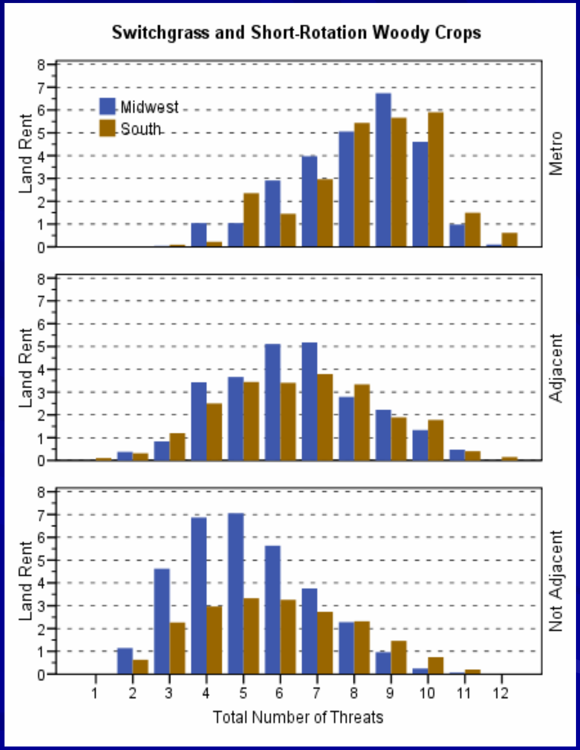
High yield economic optimization:

- Not high yield
- Cheap
- Moderate
- Expensive

Total Competitive Land-Use Threats for Switchgrass and Short-Rotation Woody Crops, Metro status, Land Rent Costs (per acre), and Non-Rent Production costs Per Year (in thousands): Midwest and South, circa 2002







Main Findings

- Midwest has many more millions of acres than the South, but at greater production cost and with more potential land-use threats
- The South has fewer acres available, but has less threats facing it, and is projected to be cheaper production. Non-adjacent areas in South are substantially cheaper, have less threats
- Areas non-adjacent to metro centers have many acres potentially available with relatively few threats in both the South and Midwest
- Non-rent production and rent costs are notably higher in Midwest than South
- Heavy land-use competition exists in Texas and the Chicago and Minneapolis metropolitan areas
- The South may have powerful influences on the bio-economy if they adopt secondary crops (i.e. SWG or SRWC) that are not in competition with Midwest crops (i.e. corn ethanol)

Discussion

- Two key spatial factors will provide significant social conflict over competitive land-use:
  - Significant portions of biomass crop zones are near coastal areas of Gulf Coast and South Atlantic seaboard
  - Especially in the South, significant portion of biomass crop zones are in counties adjacent to urban centers
- The competition for land-use in the bio-economy appears at the core of the major social policy issues that the biomass sector will face
- The dominance of the Midwest in the optimal biomass crop zones identified in this study begs questions of Frey's "command-and-control" centers of the bio-economy:
  - Will the Midwest become the "back yard" for Chicago as Cronon described in his historiography, Nature's Metropolis?
  - Can Des Moines, IA or Minneapolis-St. Paul, MN become the "Houston" of the new bio-economy as the latter has been in the fossil-fuel economy?
  - Or, can Kansas or North Dakota, largely free of competitive land-uses, emerge as a hub for the biomass industry?

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