Carbon Offset Payments and Spatial Biomass Supply in Arkansas: Implications of Pine and Switchgrass

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Introduction

- With climate change legislation and biofuels markets likely, producers and policy makers need information about likely spatially sensitive land use change
- An existing Arkansas crop model is modified to add
  - Loblolly pine as a dedicated carbon sequestering crop
  - Modeling efforts now include not only hypothetical biomass markets but also a carbon offset market

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Introduction

- Pine and switchgrass are added to a base model as land use alternatives to traditional agriculture to determine changes in:
  - Net carbon foot print (C.E. emissions – sequestration)
  - Biomass potential
  - Net state returns
  - Acreage reallocation
- 13 cropping scenarios were run
  - Base
  - Base + Biomass ($35,$45,$55)
  - Base + Biomass + Carbon Offset ($15,$30)

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Objectives

- i) Quantify the net carbon footprint by traditional and alternative crops
- ii) Estimate the effects of policy changes on cropping patterns, net carbon footprint and net returns
- iii) Provide an estimate of biomass supply under varying hypothetical biomass prices and carbon offset payment scenarios

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Modeling

- A life cycle assessment (LCA) method is used:
  - Estimates emissions of the most common production practices for the six largest crops in Arkansas (corn, wheat, cotton, rice, soybeans and sorghum), hay, CRP, pasture and the less traditional crops of switchgrass, forage sorghum and pine
  - Carbon equivalents (CE) embedded within inputs (herbicides, pesticides, fuel, plastics, and fertilizers) used in crop production + N_2O from N fertilizer + CH_4 from paddy rice, but no livestock emissions
- Carbon sequestered
  - Below ground (harvest index, shoot:root, soil type and tillage)
  - Above ground sequestration in timber products
  - Harvested biomass is not given carbon credit

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Modeling (cont)

- Objective function: maximize net state returns

$$\text{Maximize NR} = \sum_{i=1}^{75}\sum_{j=1}^{20}\left(p_j \cdot y_{ij} - c_{ijn}\right)\cdot x_{ijn} + \left(BCF_{ij} - S_{ijts}\cdot x_{ijn}\right)\cdot p_c$$

- Where:
  - P_j July 2007 futures prices as of Dec. of previous year
  - Y_{ij} '04 – '07 average county crop yields
  - C_{ij} county and crop specific 2007 total specified costs
  - X_{ijn} acres in county *i* and crop *j* by production method *n*
  - BCF_{ij} is the base carbon foot print without policy changes for each county and crop combination
  - S_{ijts} is the net carbon foot print per crop linked to yield via harvest index, shoot to root ratio, above and below ground biomass including carbon content and adjusted for tillage *t* and soil type *s*
  - P_c carbon offset payments for carbon sequestration beyond BCF_{ij}
- Subject to:
  - $xmin_{ij} \leq x_{ij} \leq xmax_{ij}$
  - $irrmin_j \leq irr_{ij} \leq irrmax_j$
  - $iacresmin_i \leq x_{ij} \leq iacresmax_i$
  - $acresmin_i \leq x_{ij} \leq acresmax_i$
  - $xmin/max_{ij}$ historical min. and max. crop acres since 2000
  - $acresmin/max_i$ historical min. and max. county harvested and pasture acres

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Results

- Overall
- Crop Return Changes
- Acreage
- Net Carbon
- Biomass

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Results Summary

Scenario	Net Carbon (0'000 tons)	Emissions (0'000's Tons)	Acres (Millions)	State Profit (Millions)
Base	(42)	305	7.99	969
$35 Biomass	(35)	306	8.07	980
$45 Biomass	(36)	309	8.12	1,003
$55 Biomass	(23)	310	8.12	1,101
$35 Biomass w pine	(91)	303	8.08	984
$45 Biomass w pine	(84)	306	8.12	1,005
$55 Biomass w pine	(67)	308	8.12	1,102
$35 Biomass w pine w $15 Carbon	(105)	302	8.08	992
$45 Biomass w pine w $15 Carbon	(106)	304	8.12	1,014
$55 Biomass w pine w $15 Carbon	(67)	308	8.12	1,106
$35 Biomass w pine w $30 Carbon	(114)	300	8.08	1,003
$45 Biomass w pine w $30 Carbon	(116)	302	8.12	1,024
$55 Biomass w pine w $30 Carbon	(67)	308	8.12	1,110

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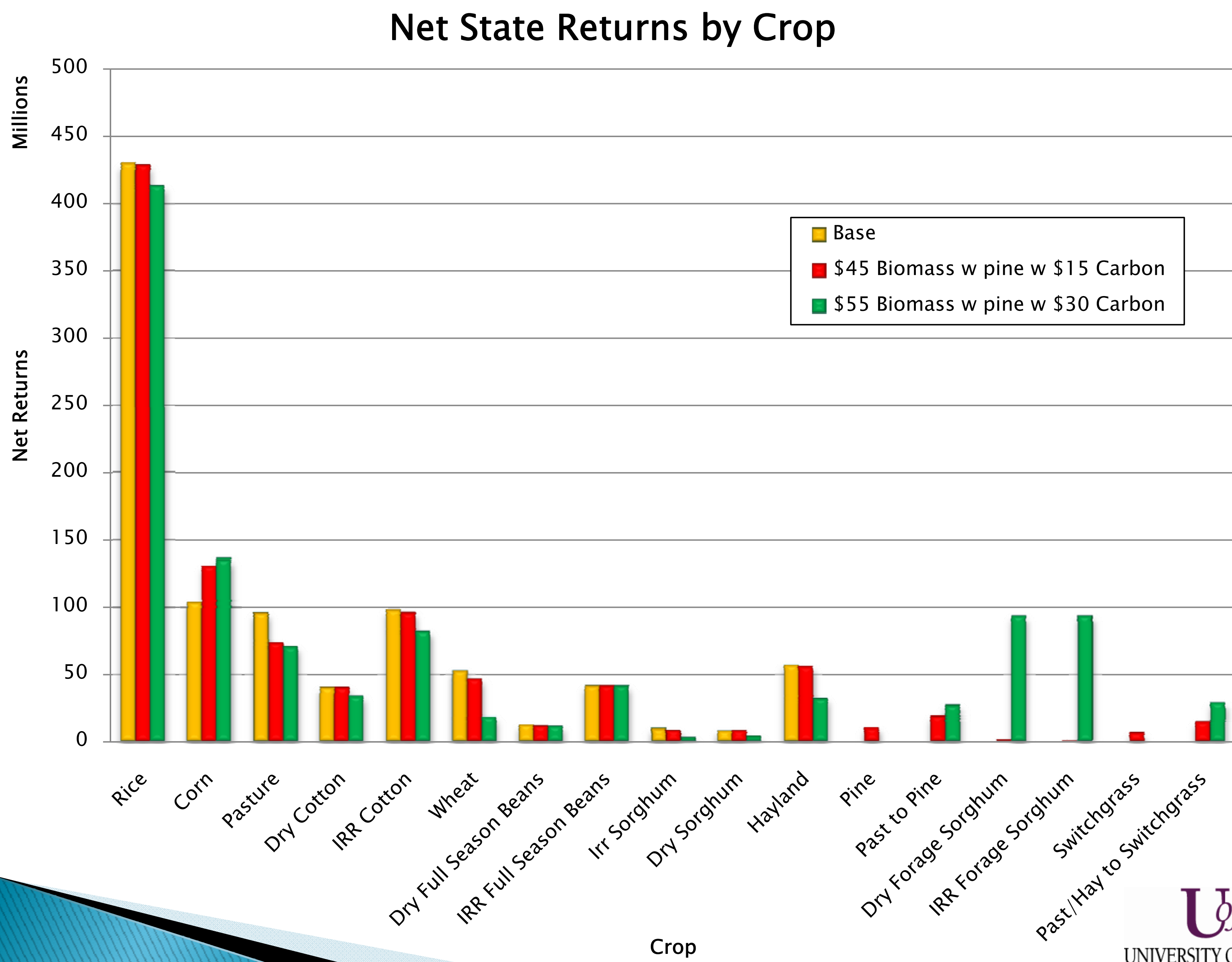

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Traditional and Biomass/Carbon Crops Net Returns and Acres

	Net Returns (Millions)		Acres (Millions)	
Scenario	Traditional Crops	Biomass / Carbon	Traditional Crops	Biomass / Carbon
Base	969	-	12.29	-
$35 Biomass	980	0	12.27	0.1
$45 Biomass	980	23	11.76	0.66
$55 Biomass	885	216	10.37	2.05
$35 Biomass w pine	970	14	11.84	0.55
$45 Biomass w pine	970	35	11.37	1.05
$55 Biomass w pine	875	227	9.99	2.43
$35 Biomass w pine w $15 Carbon	962	30	11.74	0.64
$45 Biomass w pine w $15 Carbon	961	53	11.25	1.17
$55 Biomass w pine w $15 Carbon	870	236	9.99	2.43
$35 Biomass w pine w $30 Carbon	956	47	11.69	0.69
$45 Biomass w pine w $30 Carbon	953	71	11.19	1.23
$55 Biomass w pine w $30 Carbon	865	245	9.99	2.43

- returns increase with added market opportunities
- total harvested acres increase marginally and do switch to energy and carbon crops

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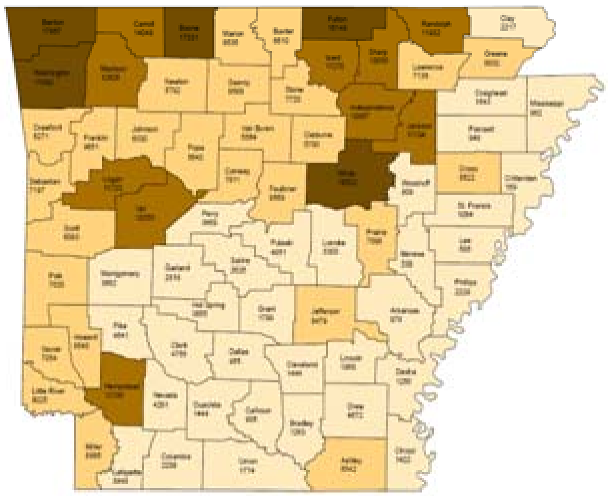
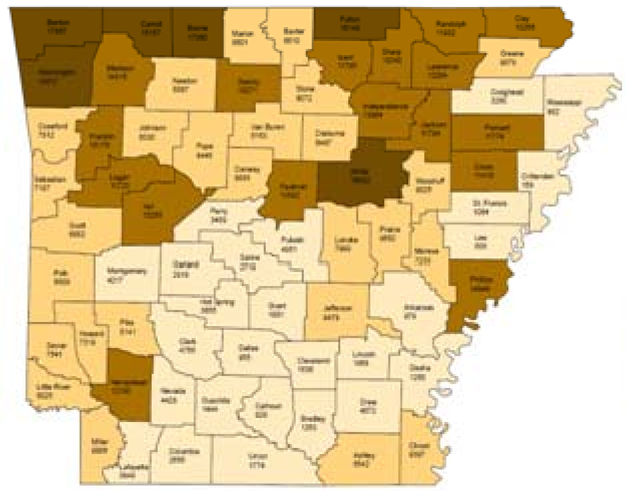
Pine Acres by County

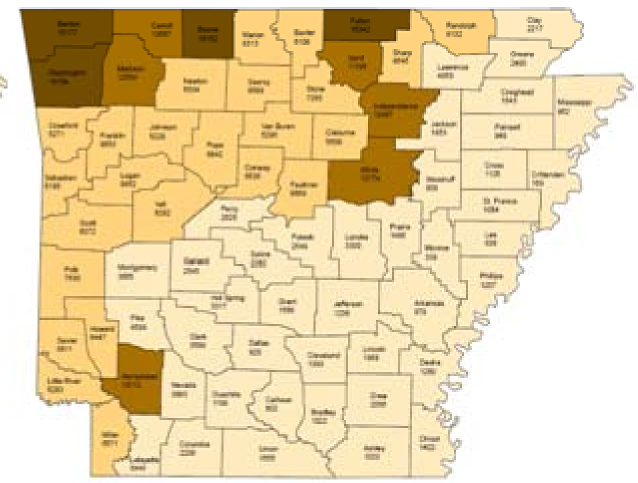
$35 Biomass w Pine



$45 Biomass w Pine w $15 Carbon



$55 Biomass w Pine w $30 Carbon



Legend

- 0 to 4,999 Acres
- 5,000 to 9,999
- 10,000 to 14,999
- 15,000 to 20,000

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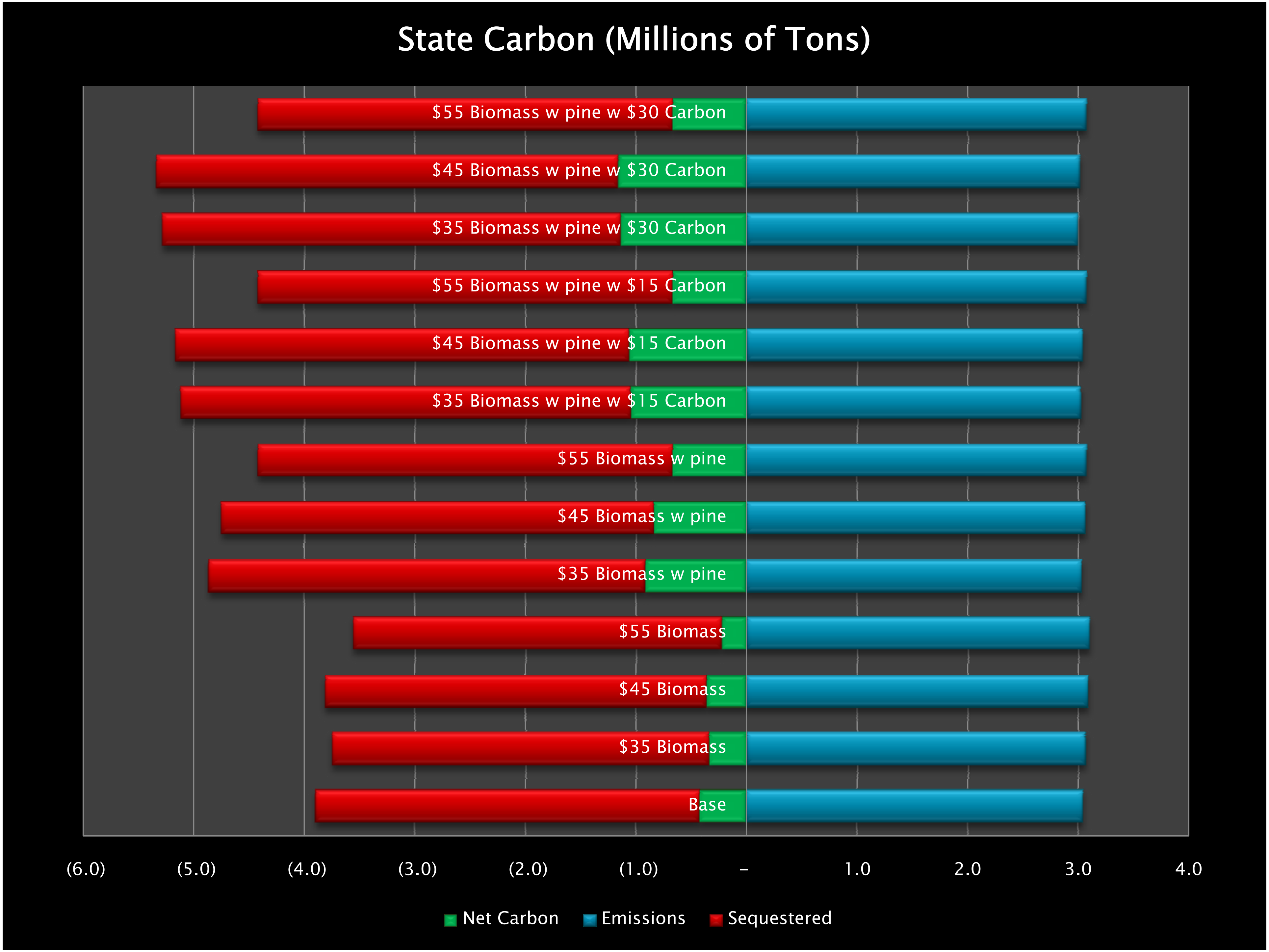
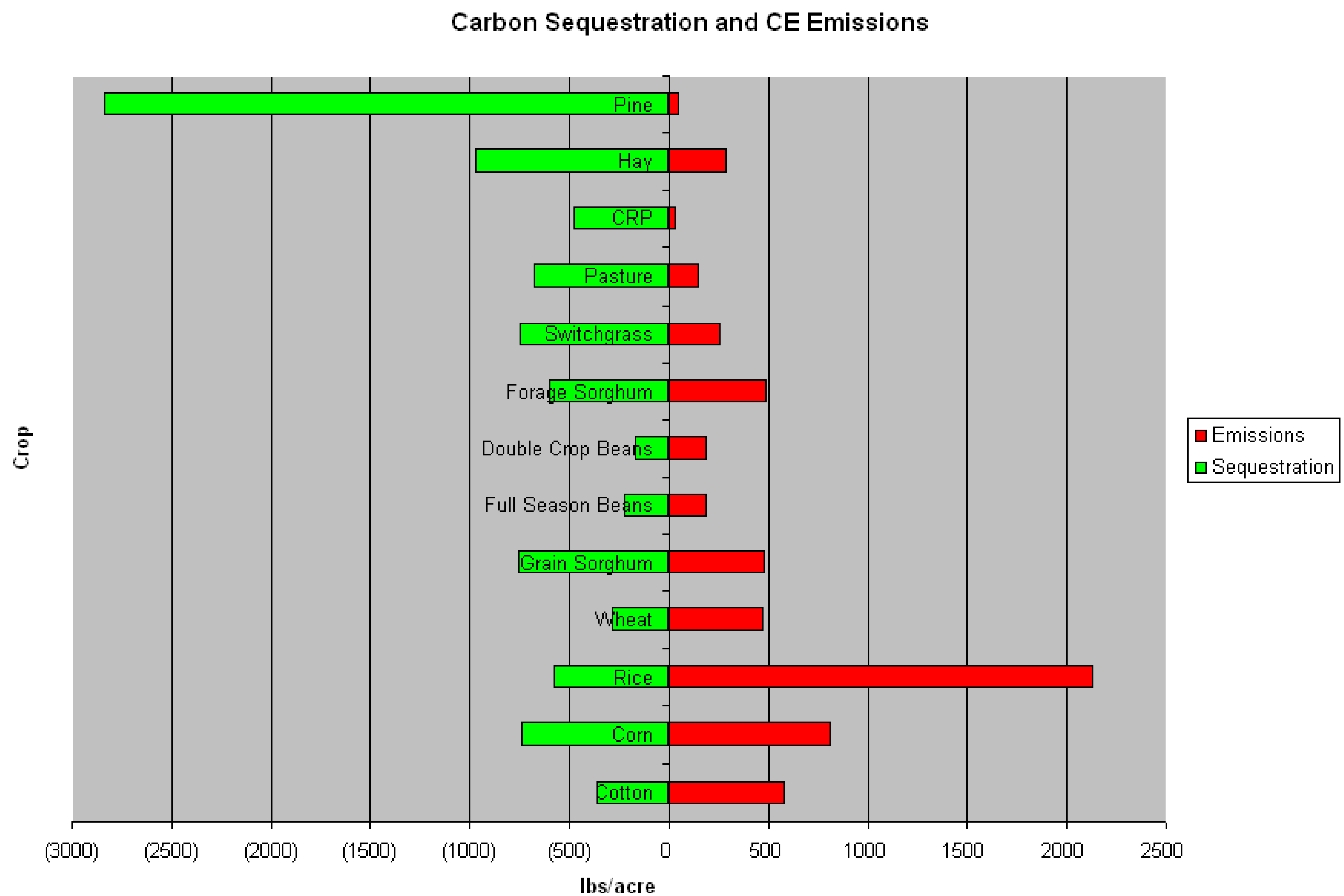

State Carbon (Millions of Tons)
$55 Biomass w pine w $30 Carbon
$45 Biomass w pine w $30 Carbon
$35 Biomass w pine w $30 Carbon
$55 Biomass w pine w $15 Carbon
$45 Biomass w pine w $15 Carbon
$35 Biomass w pine w $15 Carbon
$55 Biomass w pine
$45 Biomass w pine
$35 Biomass w pine
$55 Biomass
$45 Biomass
$35 Biomass
Base
(6.0)
(5.0)
(4.0)
(3.0)
(2.0)
(1.0)
–
1.0
2.0
3.0
4.0
Net Carbon
Emissions
Sequestered


Carbon Sequestration and CE Emissions
Pine
Hay
CRP
Pasture
Switchgrass
Forage Sorghum
Double Crop Beans
Full Season Beans
Grain Sorghum
Wheat
Rice
Corn
Cotton
Crop
(3000)
(2500)
(2000)
(1500)
(1000)
(500)
0
500
1000
1500
2000
2500
lbs/acre
Emissions
Sequestration

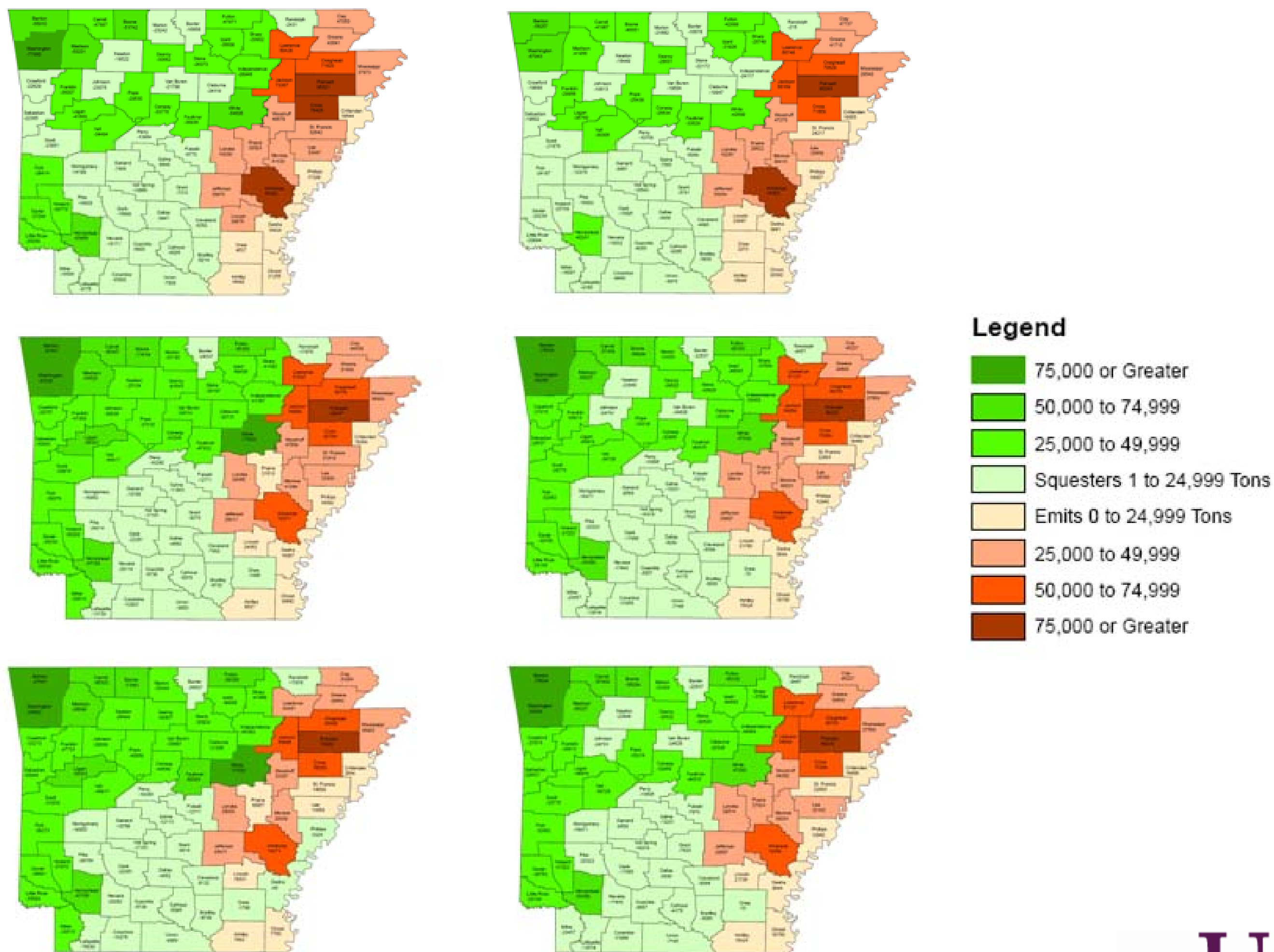
Net Carbon Footprint by County

$35 Biomass | $55 Biomass

Base

Base+Pine

Base+Pine +$30 Carbon



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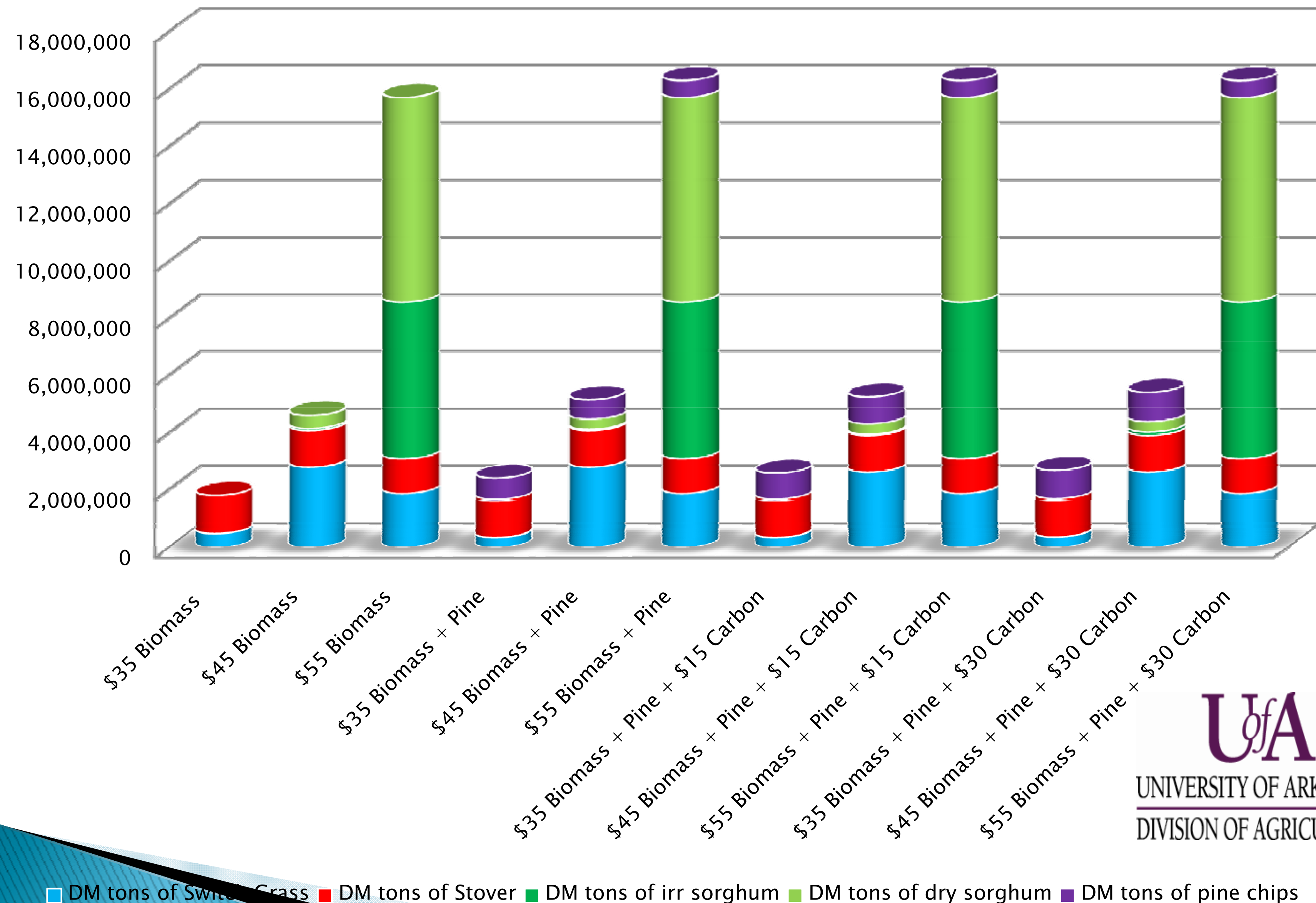
Total DM Tons Biomass Produced



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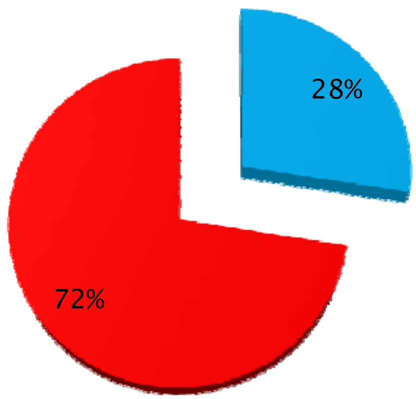
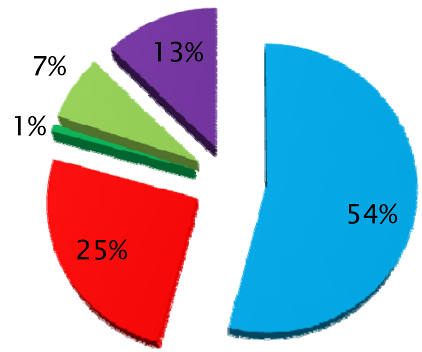
Dry Matter Tons

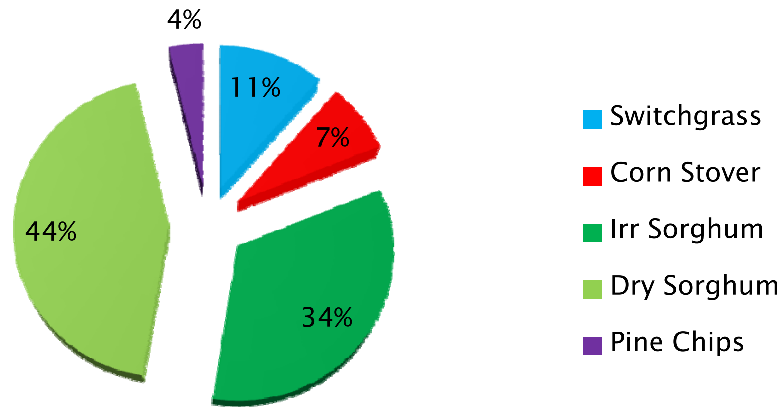
$35 Biomass



$45 Biomass + Pine



$55 Biomass + Pine + $30 Carbon



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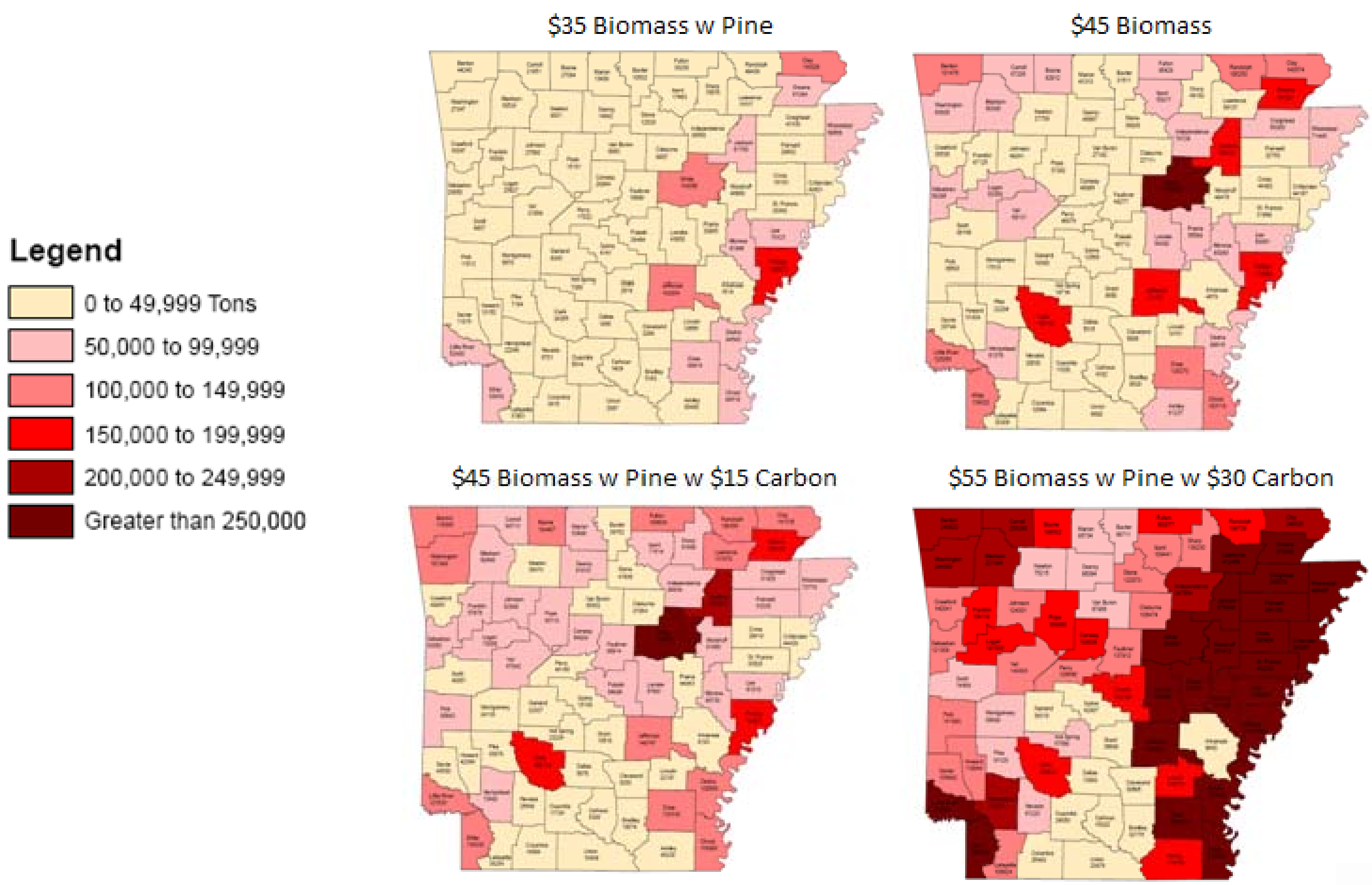
Dry Matter Tons Produced by County



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Conclusions

- Profitability increases as biomass price and carbon offset price increase
- $35 and $45 biomass price primarily reduces wheat and pasture acres
- Carbon sequestration decreases with a biomass price of $55/ton
- Biomass production at a price of $35 and $45 is achieved through corn stover, pine, and switchgrass
- Biomass production moves to forage sorghum at $55/ton
- Traditional crops do trade out for energy and tree crops

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