North Carolina Corn Basis Fundamentals—Final Report

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Graduate Ph.D Students: Robert Thompson

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Technical Support: Extension Information Technology

Application Development Specialist: Rob Ladd

Project Funded by: Corn Growers Association of North Carolina

Project Reference #: 582871/082871

Original Timeline: 4/15/19 -1/31/2021

Revised End Date: 1/31/2022 (1-year no-cost extension granted)

Funded Amount: $64,100

Research Objectives

1. To develop a workable database of historical corn prices and basis at different North Carolina markets for:
   a) Enabling market participants (buyers and sellers) to make more informed selling and purchasing decisions including evaluating cash bids, basis contracts, storage decisions, hedging, and other risk management strategies;
   b) Undertaking an econometric analysis of the factors that potentially impact corn basis in North Carolina for several prominent locations such as seasonal factors, demand and supply shifters, and to isolate and establish an estimate of the transportation component.

2. To establish a database of inflows and outflows of feedstuffs combining publicly available data from the Census Bureau and U.S. Department of Transportation with private data sources from Bloomberg, IHS Markit, and DAT for:
   a) Profiling feedstuff imports by transportation mode;
   b) Examining the timing of these flows and the impact they may have on North Carolina basis;

Update Database Objective (1a)— Important Details Regarding the Data

- A new database for corn price was established
  - Replaced the USDA RAGR110 report
- Utilized USDA reports from USDA RA_GR110 reports in .txt format and compiled them into a new database using SAS. Importantly it now includes cash (spot) and forward price bids (new crop).
- In August of 2020 the RA_GR115 report was discontinued in favor of the AMS 3156 report – which contains the same information in PDF format which is also accessible through an API provided by the USDA AMS.
- The new corn database consists of 89,730 data points
  - 36 unique locations
  - Delivery Point (Country Elevator, Mill and Processor)
  - 42 unique Location # Delivery Points
  - Bids (Immediate [spot], Delivery [new crop])
- Daily futures price data for nearby and new crop contracts were sourced from Barchart and also the CBOT and merged into the database
- Daily observations for futures prices and bids (spot and new crop) were used to calculate basis (immediate and new crop) and then were aggregated to month averages over the period 2001(3)-2020(4) to create a workable database of monthly prices and basis to engage in econometrics

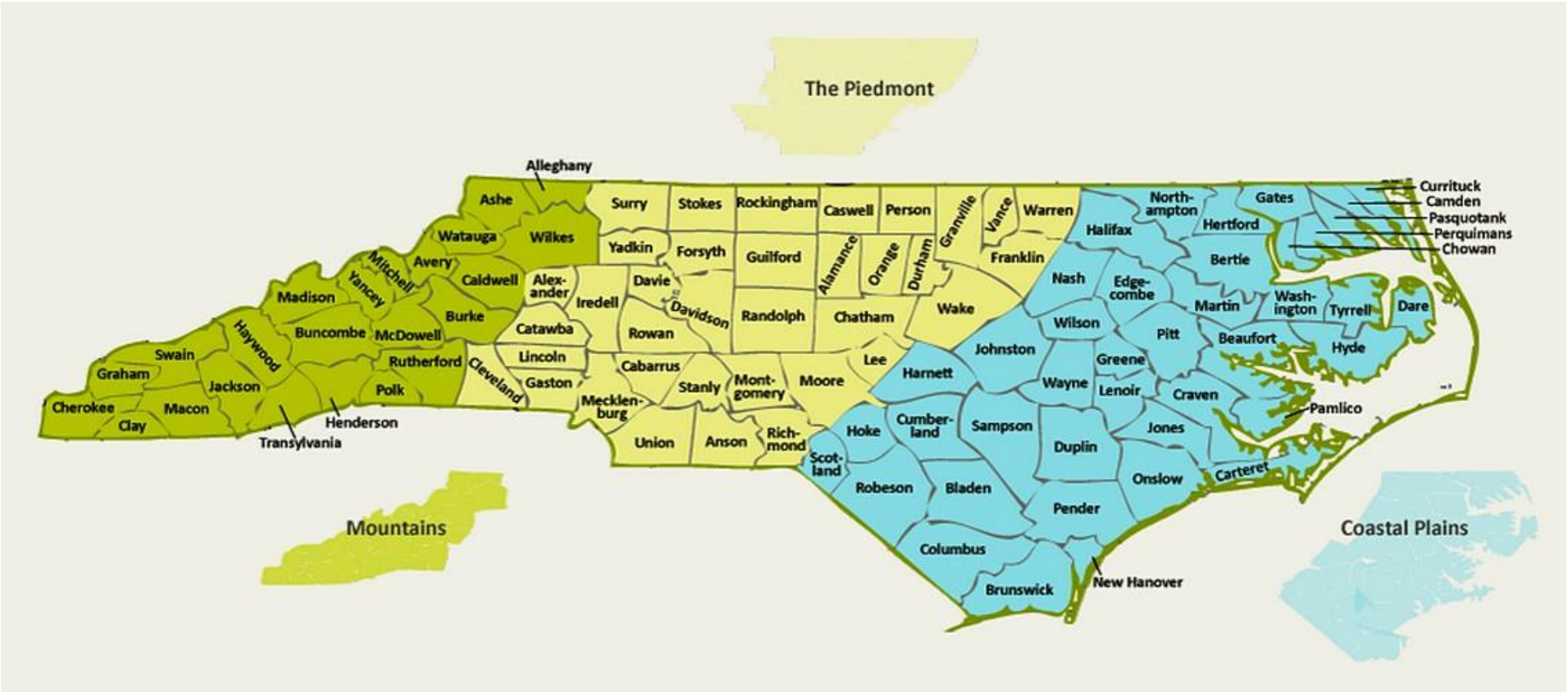
Different Locations in Database

Location	Country Elevators	Mills and Processors	Total
Barber	1	1	2
Bladenboro	1	1	2
Creswell	1	1	2
Pantego	1	1	2
Rose Hill	1	1	2
Warsaw	1	1	2
Candor	0	1	1
Cofield	0	1	1
Laurinburg	0	1	1
Monroe	0	1	1
Nashville	0	1	1
Roaring River	0	1	1
Selma	0	1	1
Statesville	0	1	1
Autryville	1	0	1
Calypso	1	0	1
Chadbourn	1	0	1
Clarkton	1	0	1
Clement	1	0	1
Cleveland	1	0	1
Clinton	1	0	1
Dunn	1	0	1
Elizabeth City	1	0	1
Greenville	1	0	1
La Grange	1	0	1
Lagrange	1	0	1
Lumberton	1	0	1
Mount Olive	1	0	1
Mount Ulla	1	0	1
New London	1	0	1
Newton	1	0	1
Norwood	1	0	1
Register	1	0	1
Shelby	1	0	1
Whiteville	1	0	1
Wilson	1	0	1
Totals	**28**	**14**	**42**

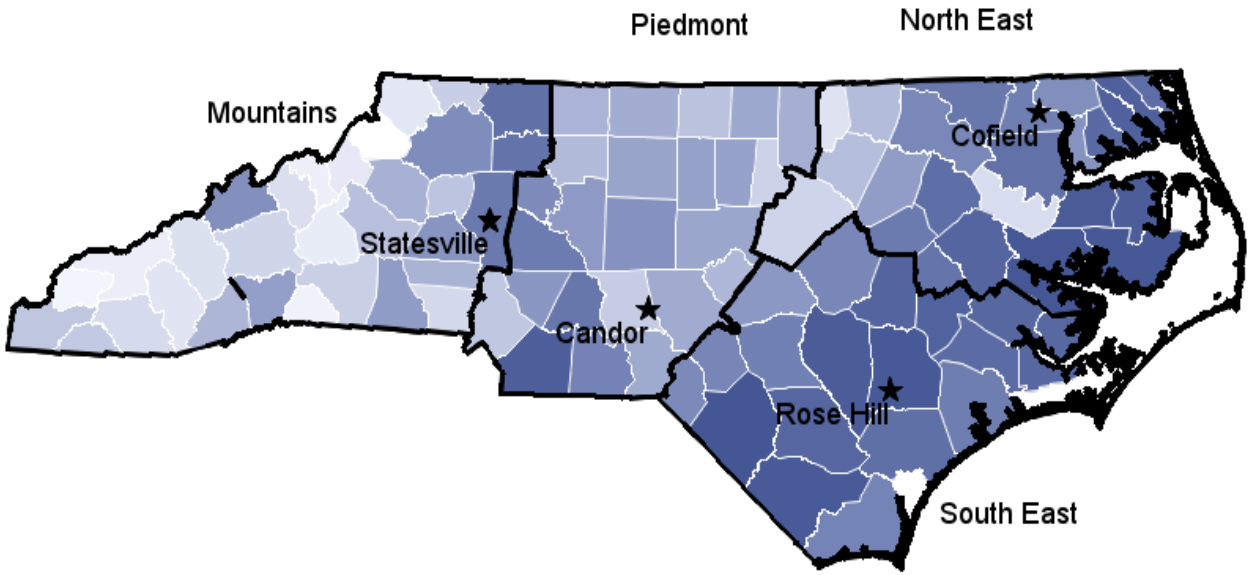
New locations added after the tool launched

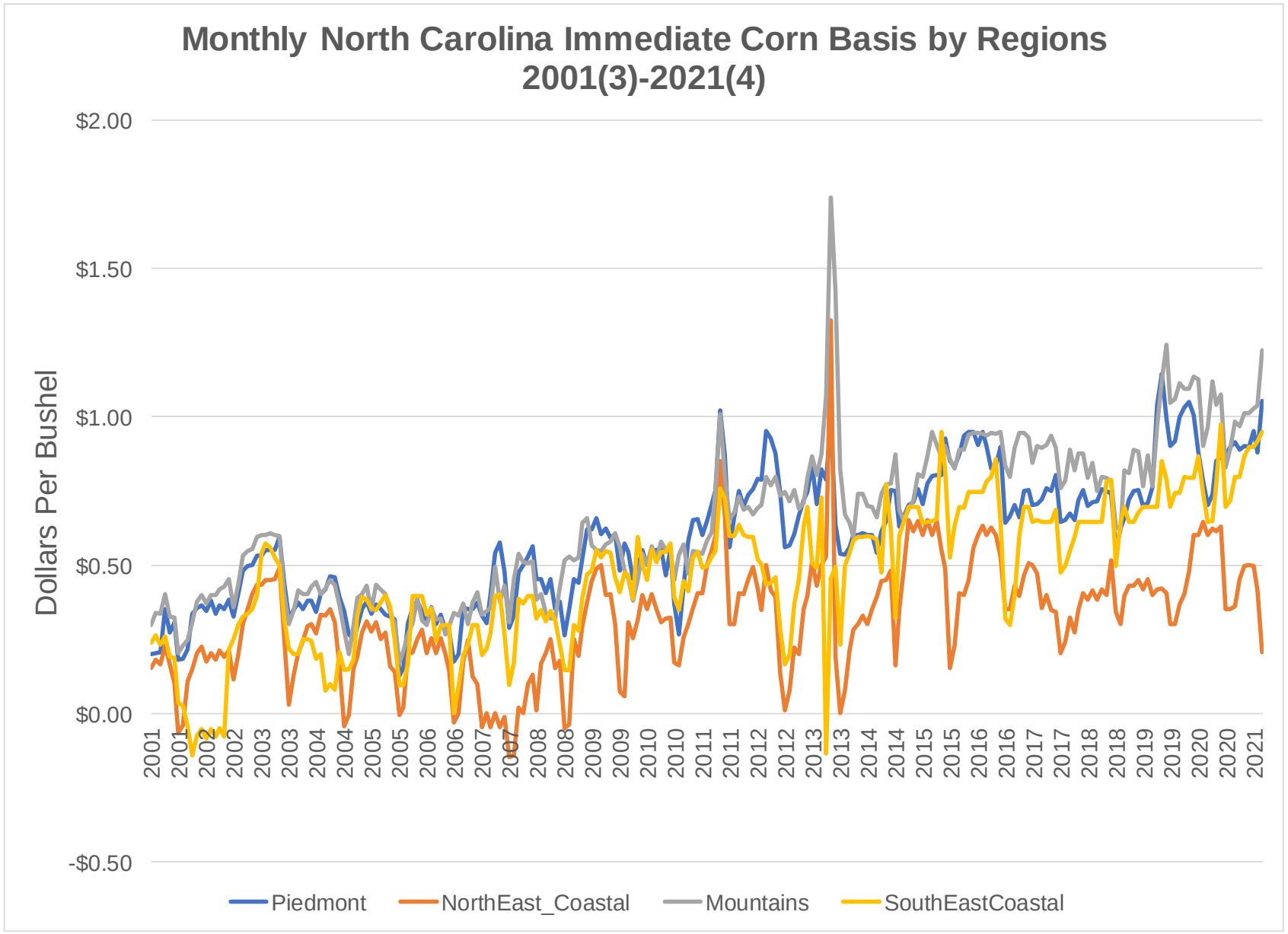
- 5 new data series in the Piedmont region added January 2021
  - Shelby: corn and soybean bids
  - Newton: corn, wheat, and soybean bids
- Only possible with the efforts and coordination between extension and NCDA; credit is due to
  - Jenny Carleo (NC Extension, South Central District)
  - Karrie Gonzalez (NCDA, Market News)

Production Regions



Corn Production by Regions and Markets




Monthly North Carolina Immediate Corn Basis by Regions
2001(3)-2021(4)
$2.00
$1.50
$1.00
$0.50
$0.00
-$0.50
Dollars Per Bushel
2001
2001
2002
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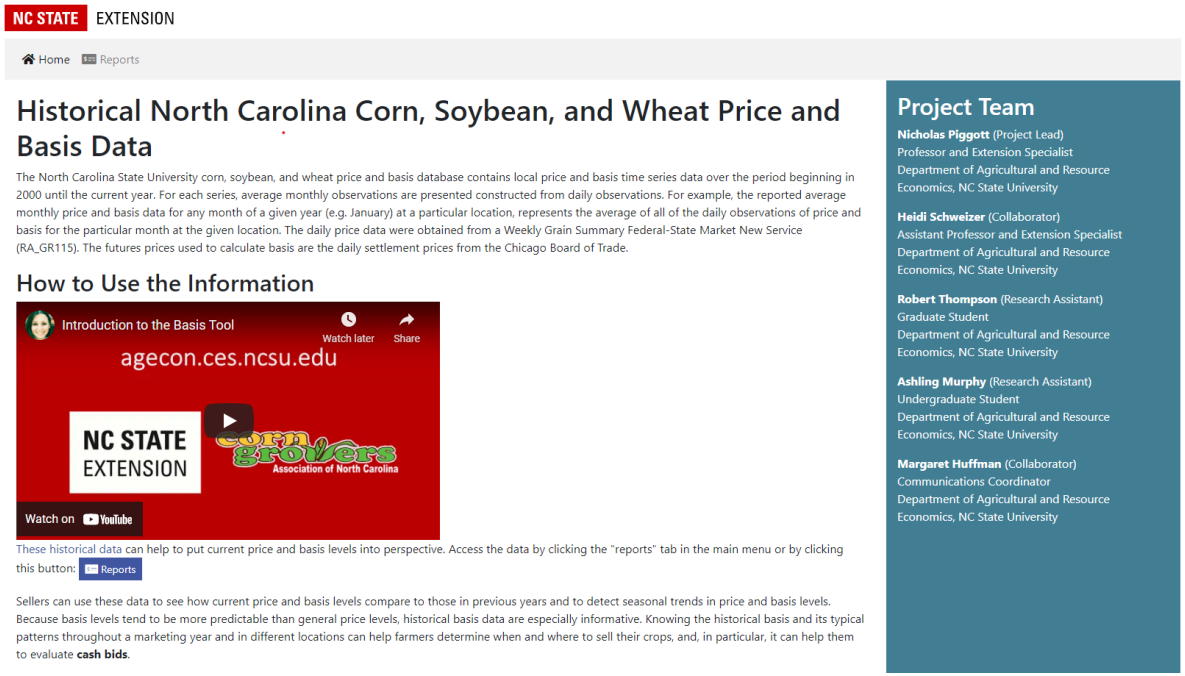
2017
2017
2018
2018
2019
2019
2020
2020
2021
Piedmont
NorthEast_Coastal
Mountains
SouthEastCoastal

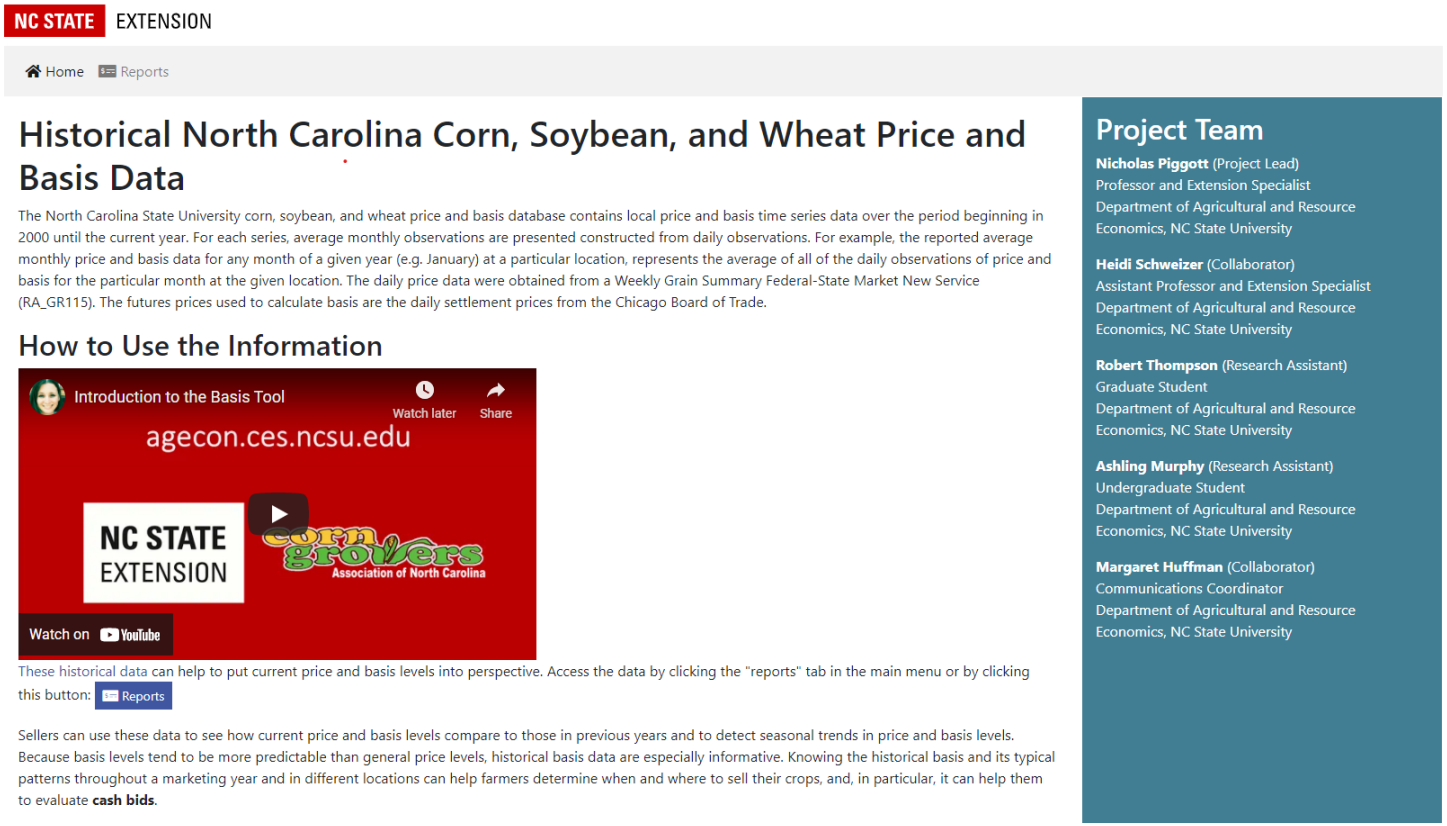
Online Price/Basis Tool

- From the database, a publicly accessible tool was created
  - https://agecon.ces.ncsu.edu/
- Extension Information Technology provided expert coding and functionality to make the tool operational online
- Displays monthly average price and basis for all locations for immediate delivery and delivery at harvest



Online Price/Basis Tool

- An introductory video is embedded in the home-page that explains basic use of the tool



NC STATE EXTENSION

Home Reports

Historical North Carolina Corn, Soybean, and Wheat Price and Basis Data

The North Carolina State University corn, soybean, and wheat price and basis database contains local price and basis time series data over the period beginning in 2000 until the current year. For each series, average monthly observations are presented constructed from daily observations. For example, the reported average monthly price and basis data for any month of a given year (e.g. January) at a particular location, represents the average of all of the daily observations of price and basis for the particular month at the given location. The daily price data were obtained from a Weekly Grain Summary Federal-State Market New Service (RA_GR115). The futures prices used to calculate basis are the daily settlement prices from the Chicago Board of Trade.

How to Use the Information

These historical data can help to put current price and basis levels into perspective. Access the data by clicking the "reports" tab in the main menu or by clicking this button: Reports

Sellers can use these data to see how current price and basis levels compare to those in previous years and to detect seasonal trends in price and basis levels. Because basis levels tend to be more predictable than general price levels, historical basis data are especially informative. Knowing the historical basis and its typical patterns throughout a marketing year and in different locations can help farmers determine when and where to sell their crops, and, in particular, it can help them to evaluate **cash bids**.

Project Team

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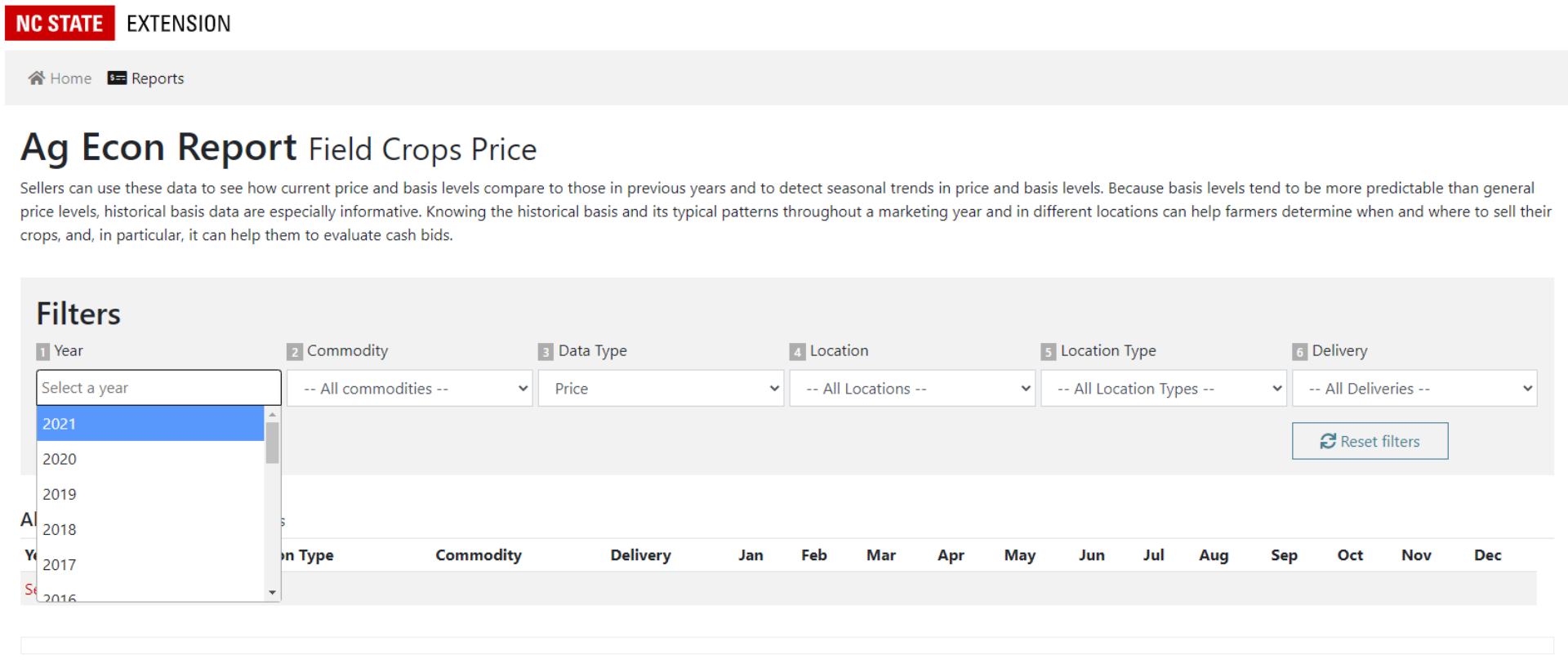
Margaret Huffman (Collaborator)
Communications Coordinator
Department of Agricultural and Resource Economics, NC State University

Online Price/Basis Tool

- Drop-down menus allow the selection of a particular year, commodity, price or basis, location, location type, and delivery period.



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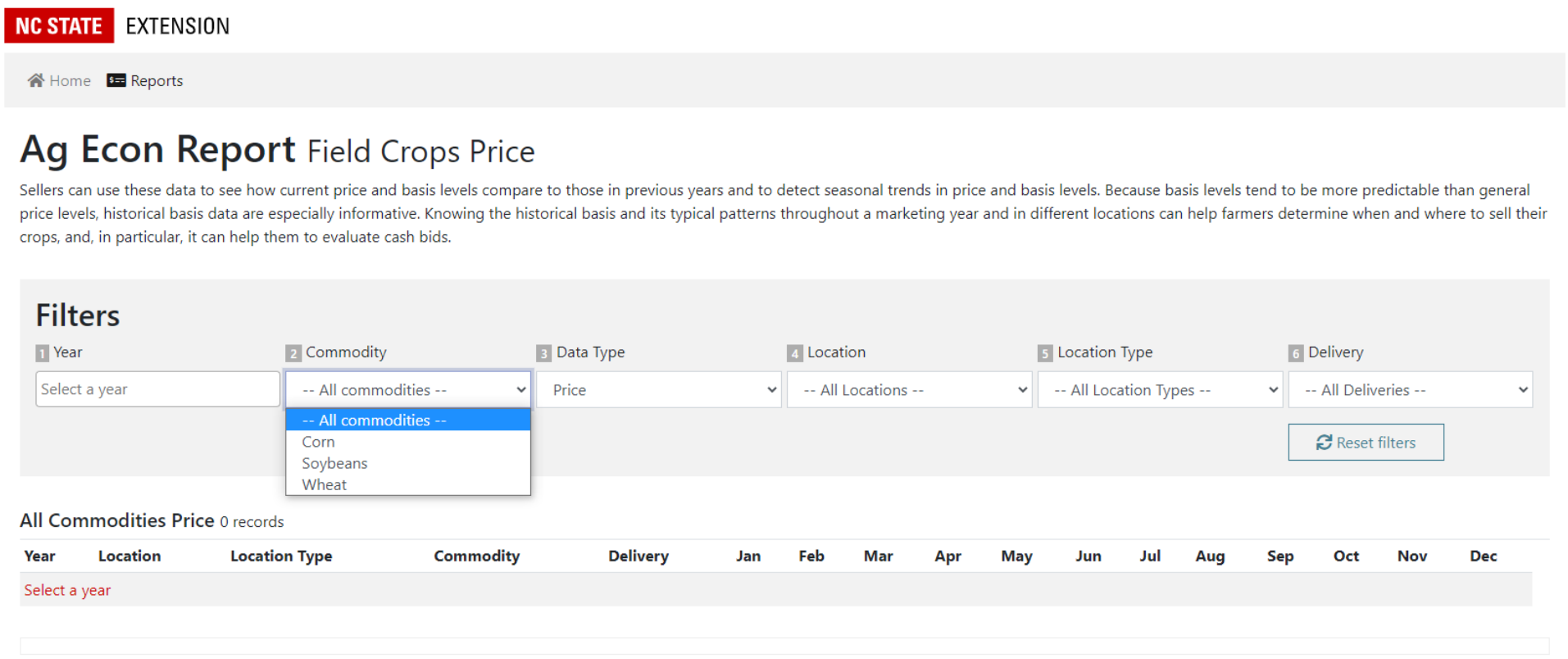

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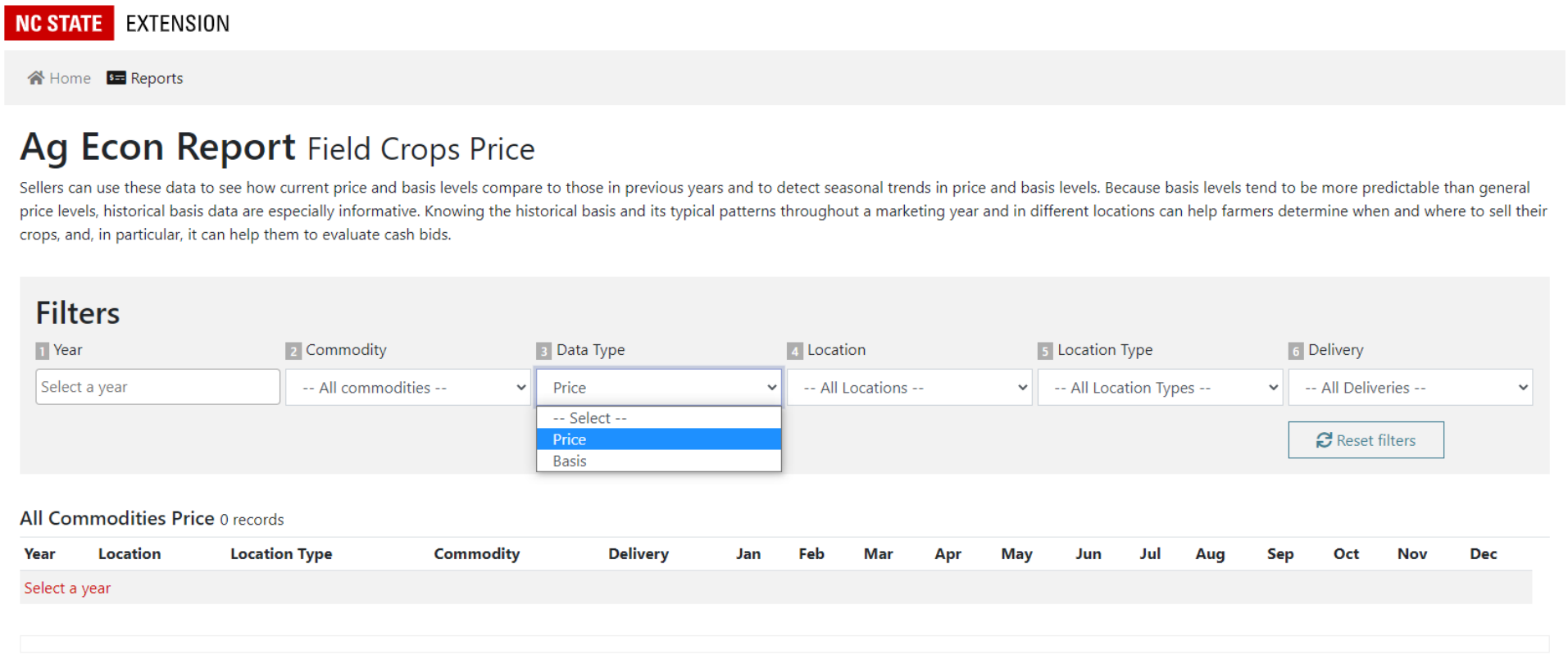

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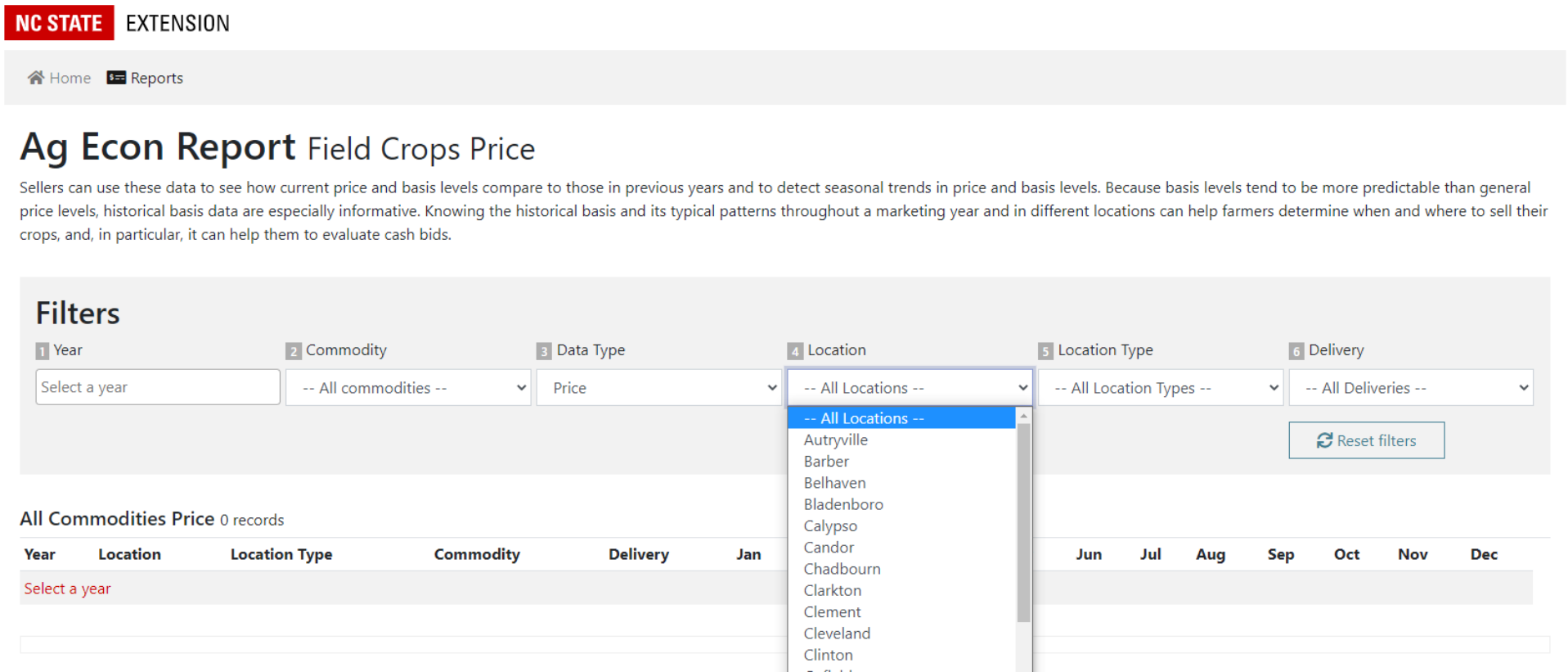

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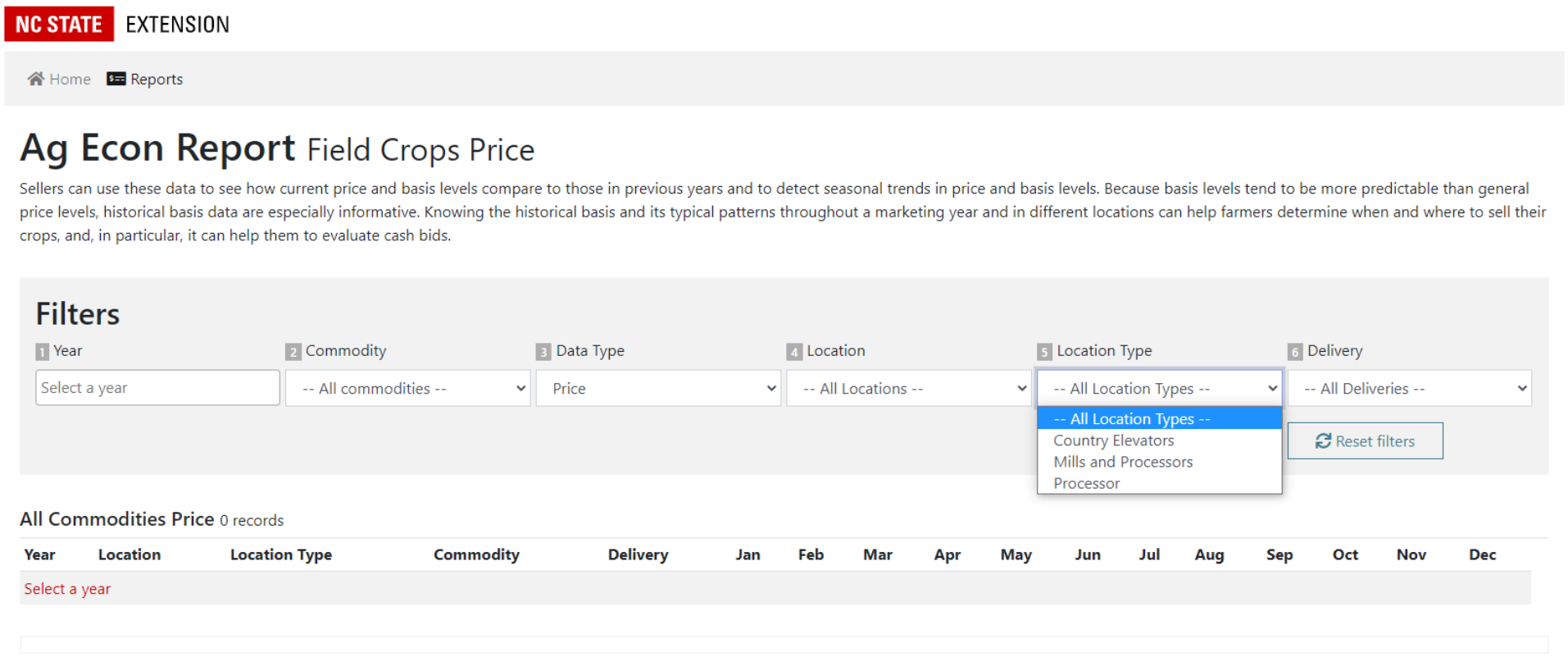

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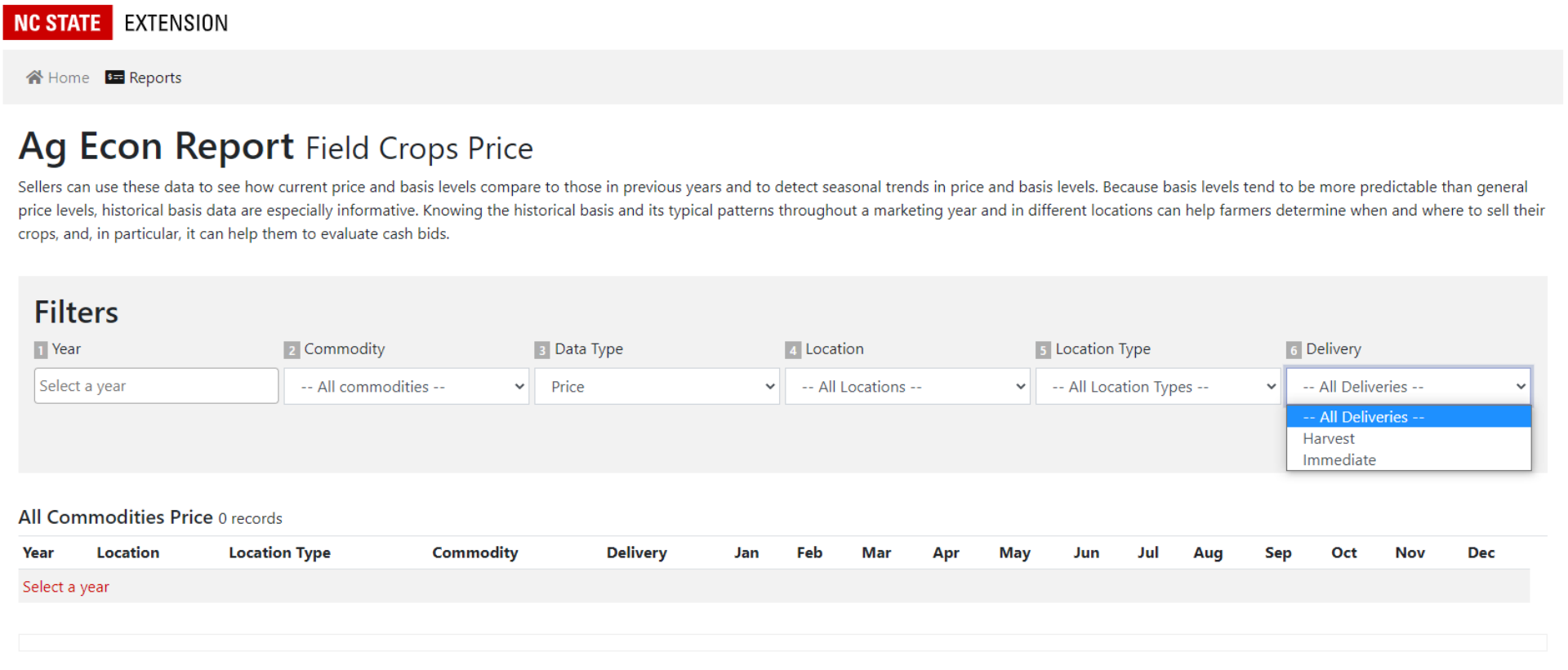


Online Price/Basis Tool

- When a selection is made, the data satisfying the filtered selection appears in spreadsheet form by month

Filters

1 Year: × 2020 | 2 Commodity: -- All commodities -- | 3 Data Type: Price | 4 Location: -- All Locations -- | 5 Location Type: -- All Location Types -- | 6 Delivery: -- All Deliveries --

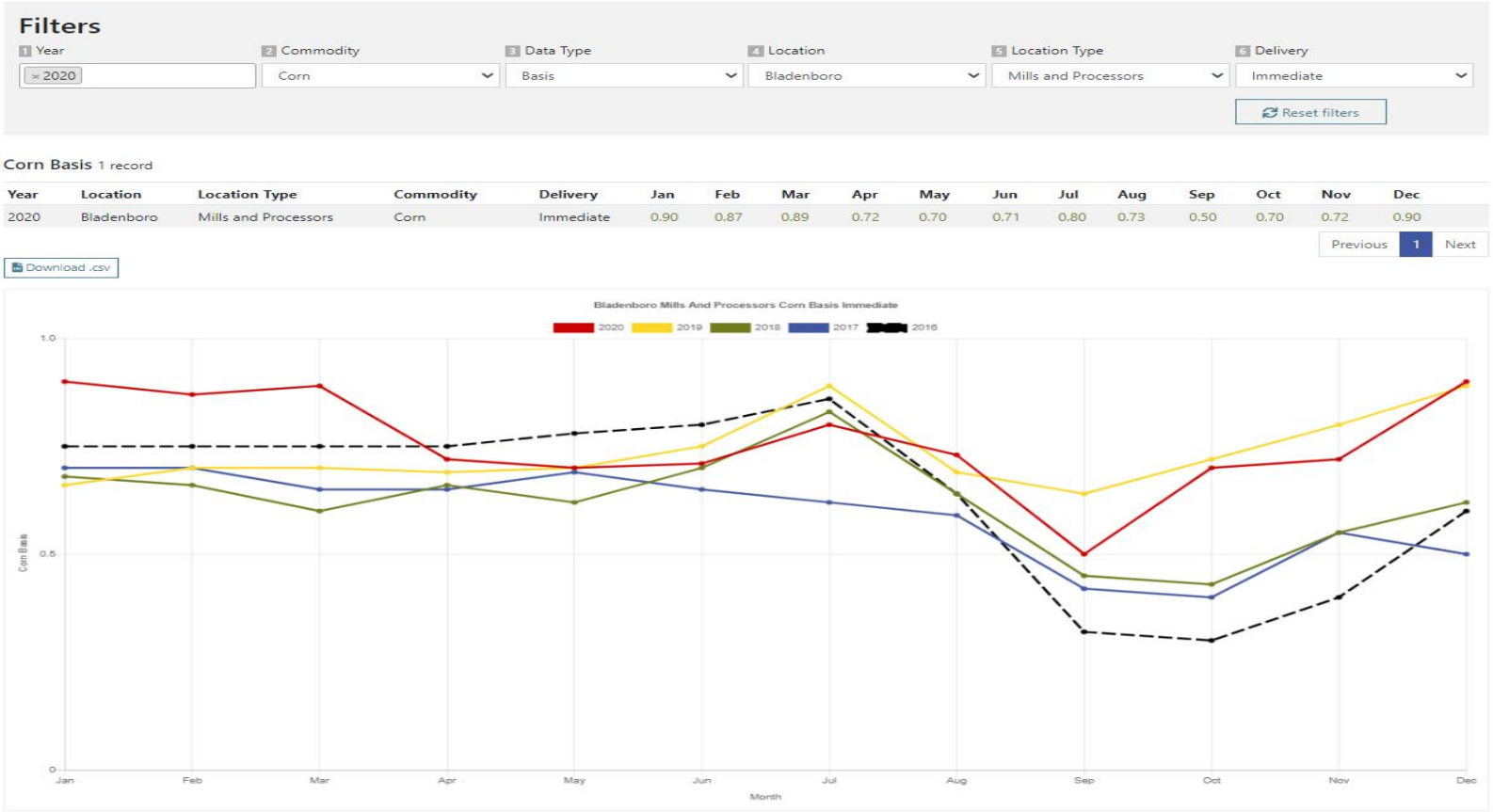
Reset filters

All Commodities Price 132 records

Year	Location	Location Type	Commodity	Delivery	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2020	Autryville	Country Elevators	Corn	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	⦸	3.74	⦸	⦸	⦸	⦸
2020	Autryville	Country Elevators	Soybeans	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	⦸	8.59	9.53	10.10	⦸	⦸
2020	Autryville	Country Elevators	Corn	Immediate	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	4.06	4.28	4.36	4.63
2020	Autryville	Country Elevators	Soybeans	Immediate	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	11.10	11.50
2020	Autryville	Country Elevators	Wheat	Immediate	⦸	⦸	⦸	⦸	⦸	⦸	⦸	3.64	4.00	4.33	4.41	4.77
2020	Bladenboro	Country Elevators	Corn	Harvest	4.39	4.28	4.00	3.66	3.59	3.65	3.64	3.65	⦸	⦸	⦸	4.75
2020	Bladenboro	Country Elevators	Soybeans	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	8.57	8.66	9.62	10.40	⦸	⦸
2020	Bladenboro	Country Elevators	Wheat	Harvest	4.67	4.46	4.15	3.66	3.49	3.53	⦸	⦸	⦸	4.63	4.69	4.87
2020	Bladenboro	Country Elevators	Corn	Immediate	4.50	4.39	4.23	3.89	3.64	3.64	3.86	3.88	4.06	4.24	4.32	4.65
2020	Bladenboro	Country Elevators	Soybeans	Immediate	9.01	8.94	8.83	8.73	8.58	⦸	9.06	9.13	9.70	10.40	10.90	12.10
2020	Bladenboro	Country Elevators	Wheat	Immediate	⦸	⦸	⦸	⦸	⦸	3.59	3.76	3.70	4.00	4.44	4.52	4.85
2020	Bladenboro	Mills and Processors	Corn	Harvest	4.64	4.53	4.22	3.87	3.79	3.85	3.89	3.88	⦸	⦸	⦸	5.00
2020	Bladenboro	Mills and Processors	Wheat	Harvest	4.87	4.75	4.45	3.95	3.79	3.83	⦸	⦸	⦸	4.98	5.04	5.22
2020	Bladenboro	Mills and Processors	Corn	Immediate	4.75	4.64	4.48	3.93	3.89	3.99	4.11	3.98	4.16	4.69	4.80	5.25
2020	Bladenboro	Mills and Processors	Wheat	Immediate	⦸	⦸	⦸	⦸	⦸	3.99	4.16	4.10	4.40	4.84	4.92	5.20
2020	Calypso	Country Elevators	Corn	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	⦸	3.70	⦸	⦸	⦸	4.80

Online Price/Basis Tool

- When a selection has been made for all filters, such that one year of data is displayed for a particular commodity, data type, location, location type, and delivery, a plot of the data is displayed by month that includes the current selection and 4 previous years data.



Online Price/Basis Tool

- If any selection has been made, the data may be downloaded in .csv format. This allows additional analysis to be performed in an excel spreadsheet.

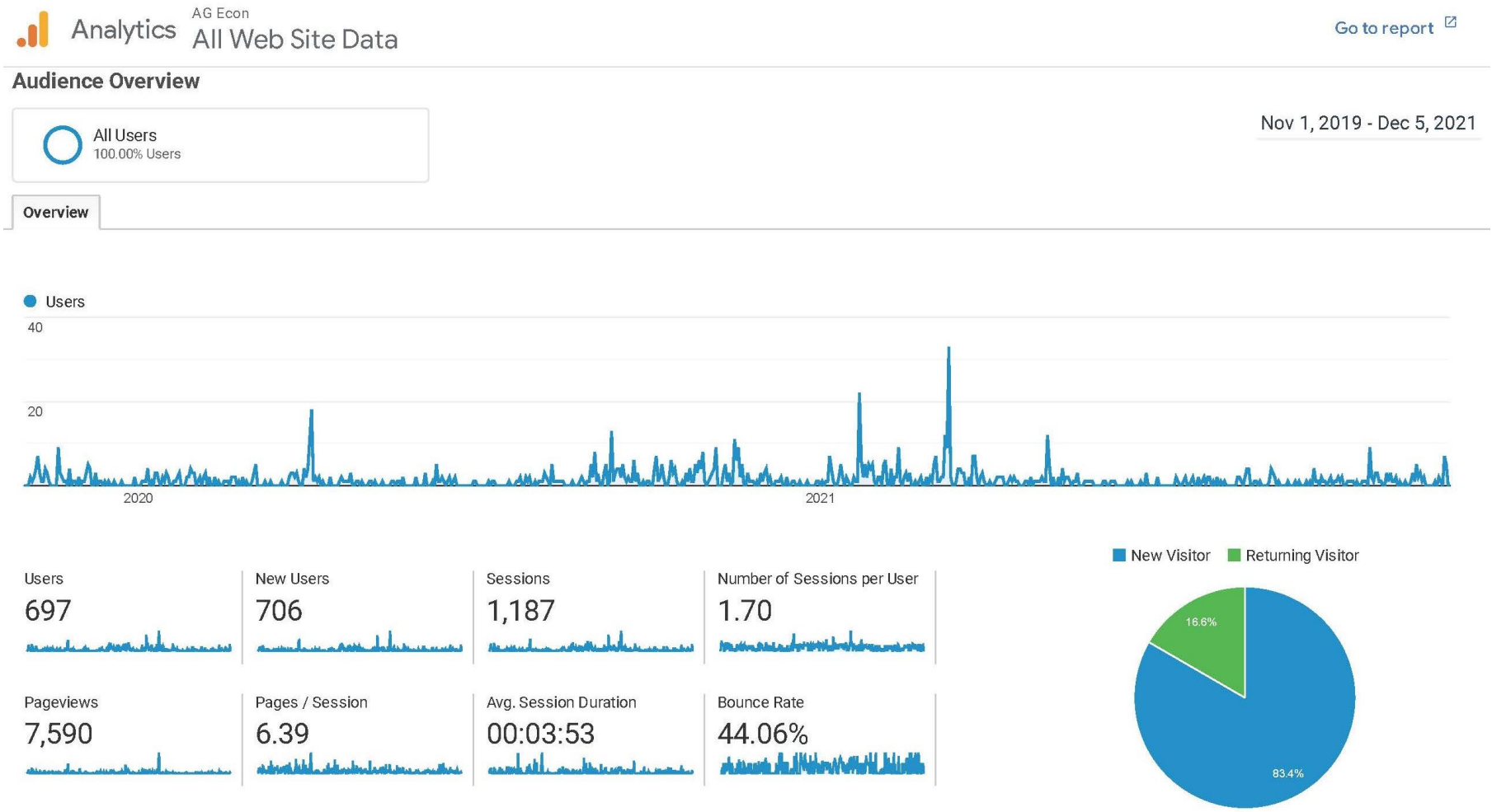
2020	Roaring River	Mills and Processors	Corn	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	5.06
2020	Roaring River	Mills and Processors	Corn	Immediate	4.95	4.91	4.72	4.11	4.16	4.40	4.35	4.33	4.49	4.88	5.05	5.32
2020	Rose Hill	Country Elevators	Corn	Immediate	⦸	⦸	⦸	⦸	⦸	⦸	⦸	3.79	4.10	4.31	⦸	⦸
2020	Rose Hill	Mills and Processors	Corn	Harvest	4.64	4.53	4.23	3.87	3.79	3.85	3.89	4.02	⦸	⦸	⦸	5.03
2020	Rose Hill	Mills and Processors	Wheat	Harvest	4.87	4.75	4.44	3.95	3.79	3.83	⦸	⦸	⦸	4.94	4.99	5.22
2020	Rose Hill	Mills and Processors	Corn	Immediate	4.65	4.57	4.45	3.95	3.84	3.92	4.08	4.23	4.36	4.70	4.87	5.15
2020	Rose Hill	Mills and Processors	Wheat	Immediate	⦸	⦸	4.73	⦸	⦸	3.89	4.11	4.05	4.35	4.79	4.87	5.20
2020	Selma	Mills and Processors	Soybeans	Immediate	9.16	8.85	8.76	⦸	⦸	⦸	⦸	⦸	⦸	10.70	11.10	12.20
2020	Statesville	Mills and Processors	Corn	Immediate	4.35	4.27	4.08	3.70	3.69	3.78	3.81	3.75	4.15	4.49	4.57	4.84
2020	Warsaw	Country Elevators	Corn	Immediate	4.65	4.57	4.38	4.02	3.89	3.99	4.11	4.00	4.25	4.65	4.87	5.14
2020	Warsaw	Mills and Processors	Corn	Harvest	4.64	4.53	4.22	3.87	3.79	3.85	3.89	3.88	⦸	⦸	⦸	5.03
2020	Warsaw	Mills and Processors	Wheat	Harvest	4.87	4.74	4.47	4.00	3.84	3.87	⦸	⦸	⦸	4.98	5.04	5.22
2020	Warsaw	Mills and Processors	Corn	Immediate	4.65	4.57	4.45	3.94	3.84	3.92	4.08	4.08	4.16	4.69	4.87	5.15
2020	Warsaw	Mills and Processors	Wheat	Immediate	⦸	⦸	⦸	⦸	⦸	3.91	4.31	4.22	4.35	4.79	4.87	5.20
2020	Whiteville	Country Elevators	Corn	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	⦸	3.82	⦸	⦸	⦸	4.78
2020	Whiteville	Country Elevators	Soybeans	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	⦸	8.70	9.62	10.40	⦸	⦸
2020	Whiteville	Country Elevators	Wheat	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	⦸	4.63	4.76	4.87
2020	Whiteville	Country Elevators	Corn	Immediate	⦸	⦸	⦸	⦸	⦸	⦸	⦸	3.97	4.06	4.44	4.52	4.72
2020	Whiteville	Country Elevators	Soybeans	Immediate	⦸	⦸	⦸	⦸	⦸	⦸	⦸	9.21	9.54	10.40	10.80	12.10
2020	Whiteville	Country Elevators	Wheat	Immediate	⦸	⦸	⦸	⦸	⦸	⦸	⦸	3.74	4.00	4.44	4.52	4.82
2020	Wilson	Country Elevators	Soybeans	Harvest	⦸	⦸	⦸	⦸	⦸	⦸	8.57	8.66	9.56	10.10	⦸	⦸
2020	Wilson	Country Elevators	Wheat	Harvest	4.67	4.46	4.15	3.66	3.49	3.53	⦸	⦸	⦸	4.63	4.69	4.87
2020	Wilson	Country Elevators	Soybeans	Immediate	9.01	8.96	8.92	8.68	8.55	⦸	9.06	9.13	9.66	10.20	10.60	11.30
2020	Wilson	Country Elevators	Wheat	Immediate	⦸	⦸	⦸	⦸	⦸	3.59	3.83	3.70	4.00	4.44	4.52	4.82

Previous 1 Next

Online Price/Basis Tool—Usage Metrics

- 697 users over the period Nov 1, 2019 and Dec 5, 2021
- 1,187 sessions that visited an average of 6.4 pages for a total of 7,590 page views
- sessions average almost 4 minutes
- Users locations
  - 21 percent or 167 of the users are in Raleigh, NC
  - 7 percent or 51 users locations are not set
  - other notable NC locations where users were located is Charlotte (33), Greenville (17), Cary (10), Durham (10), Clayton (9), Belhaven (7), Wake Forest (7), Apex (6), Winston-Salem (6)
  - other notable non-NC locations are Chicago (16), New York (8), Washington (6), and West-Lafayette (5)

Online Price/Basis Tool—Usage Metrics

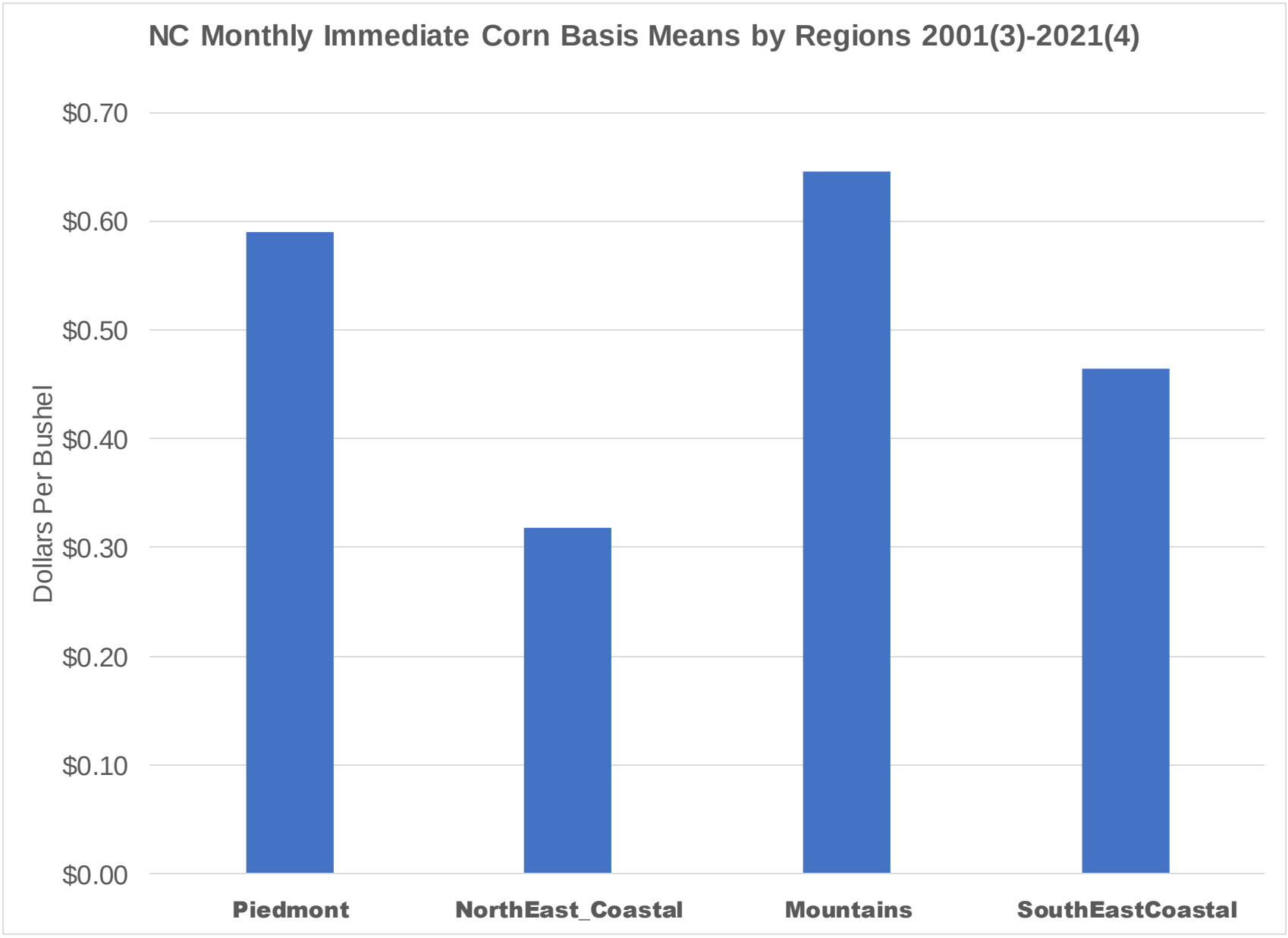


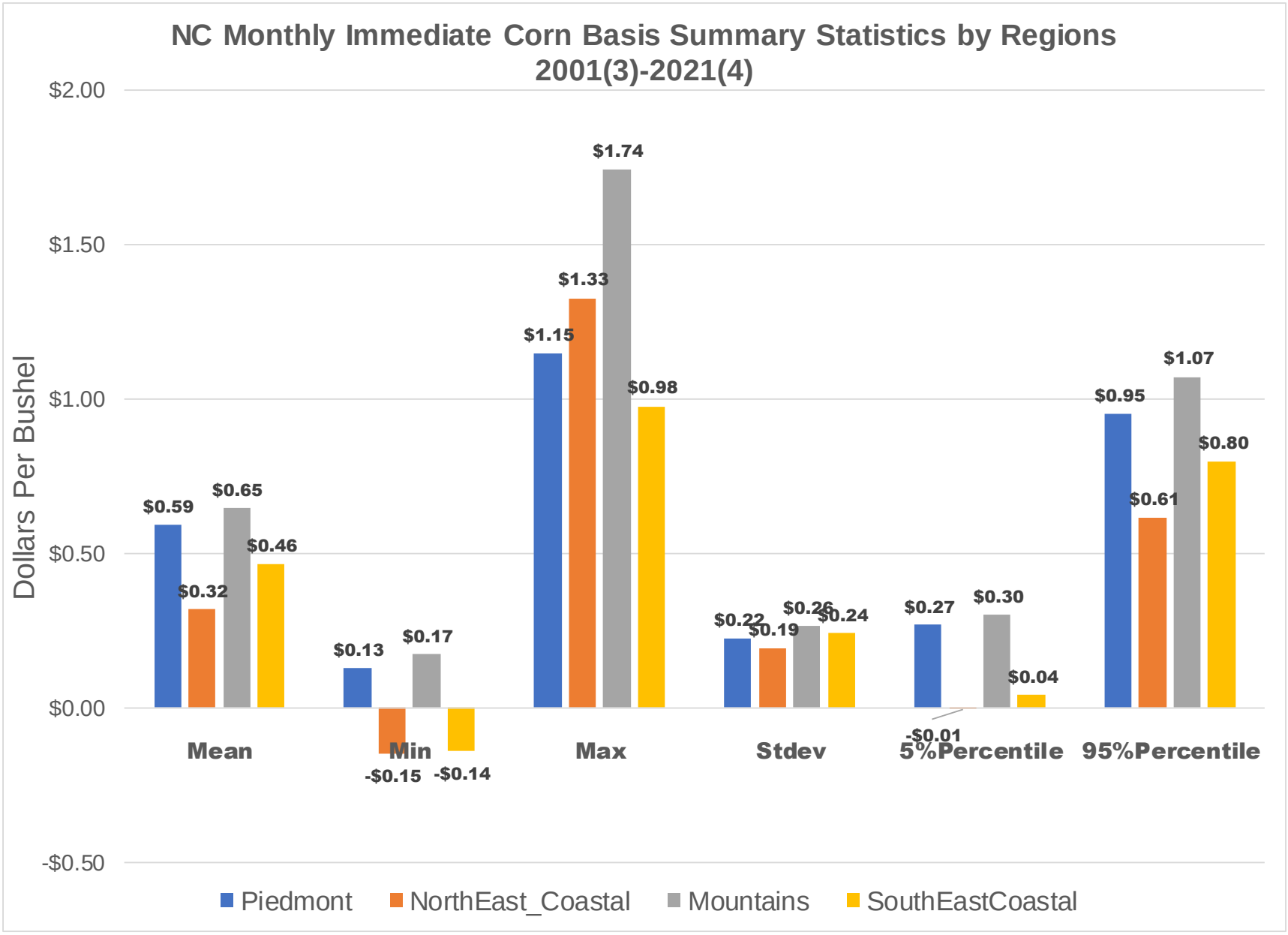
Online Price/Basis Tool—Usage Metrics

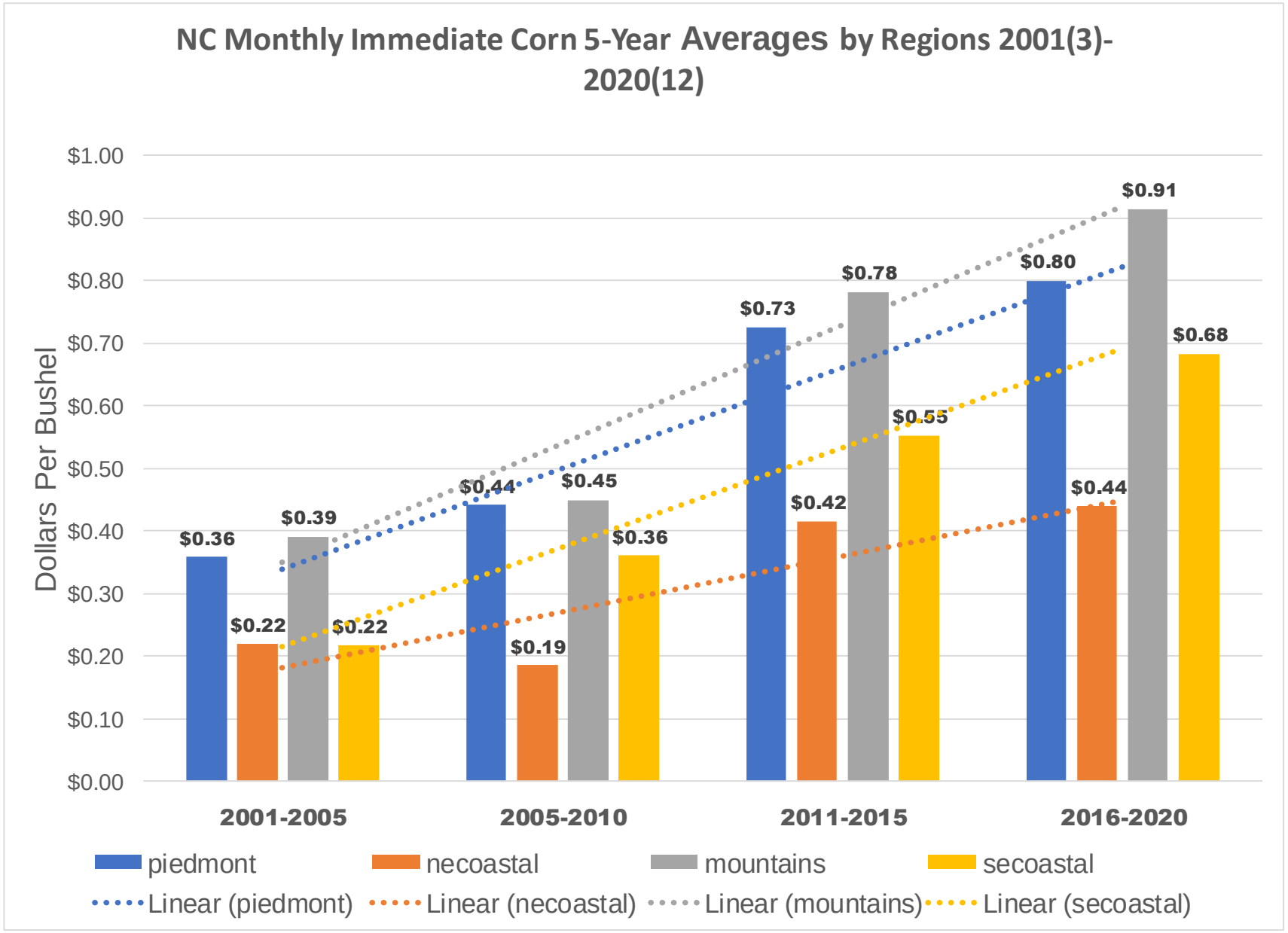
City	Users	New Users	Sessions	Bounce Rate	Pages / Session	Avg. Session Duration
	697 % of Total: 100.00% (697)	706 % of Total: 100.00% (706)	1,187 % of Total: 100.00% (1,187)	44.06% Avg for View: 44.06% (0.00%)	6.39 Avg for View: 6.39 (0.00%)	00:03:53 Avg for View: 00:03:53 (0.00%)
1. Raleigh	**167** (21.44%)	165 (23.37%)	401 (33.78%)	37.16%	7.50	00:05:23
2. (not set)	**51** (6.55%)	41 (5.81%)	58 (4.89%)	56.90%	5.69	00:03:26
3. Charlotte	**33** (4.24%)	31 (4.39%)	45 (3.79%)	53.33%	3.78	00:01:59
4. Greenville	**17** (2.18%)	15 (2.12%)	17 (1.43%)	41.18%	3.94	00:00:51
5. Chicago	**16** (2.05%)	16 (2.27%)	16 (1.35%)	100.00%	1.00	00:00:00
6. Cary	**10** (1.28%)	8 (1.13%)	16 (1.35%)	43.75%	3.75	00:01:09
7. Durham	**10** (1.28%)	9 (1.27%)	11 (0.93%)	36.36%	7.36	00:05:07
8. Clayton	**9** (1.16%)	8 (1.13%)	22 (1.85%)	27.27%	8.82	00:03:54
9. Athens	**8** (1.03%)	8 (1.13%)	8 (0.67%)	37.50%	2.12	00:00:29
10. New York	**8** (1.03%)	7 (0.99%)	10 (0.84%)	60.00%	2.90	00:01:01
11. Blacksburg	**8** (1.03%)	7 (0.99%)	18 (1.52%)	44.44%	3.17	00:01:18
12. Belhaven	**7** (0.90%)	7 (0.99%)	15 (1.26%)	53.33%	6.67	00:02:02
13. Fayetteville	**7** (0.90%)	5 (0.71%)	12 (1.01%)	33.33%	4.25	00:02:45
14. Wake Forest	**7** (0.90%)	7 (0.99%)	7 (0.59%)	28.57%	7.43	00:03:53
15. Boardman	**7** (0.90%)	7 (0.99%)	7 (0.59%)	100.00%	1.00	00:00:00
16. Madison	**7** (0.90%)	6 (0.85%)	8 (0.67%)	62.50%	4.25	00:02:29
17. Washington	**6** (0.77%)	5 (0.71%)	6 (0.51%)	50.00%	3.17	00:02:31
18. Apex	**6** (0.77%)	6 (0.85%)	7 (0.59%)	28.57%	4.29	00:01:44
19. Winston-Salem	**6** (0.77%)	4 (0.57%)	8 (0.67%)	62.50%	7.88	00:03:14
20. West Lafayette	**5** (0.64%)	5 (0.71%)	6 (0.51%)	16.67%	6.00	00:01:30

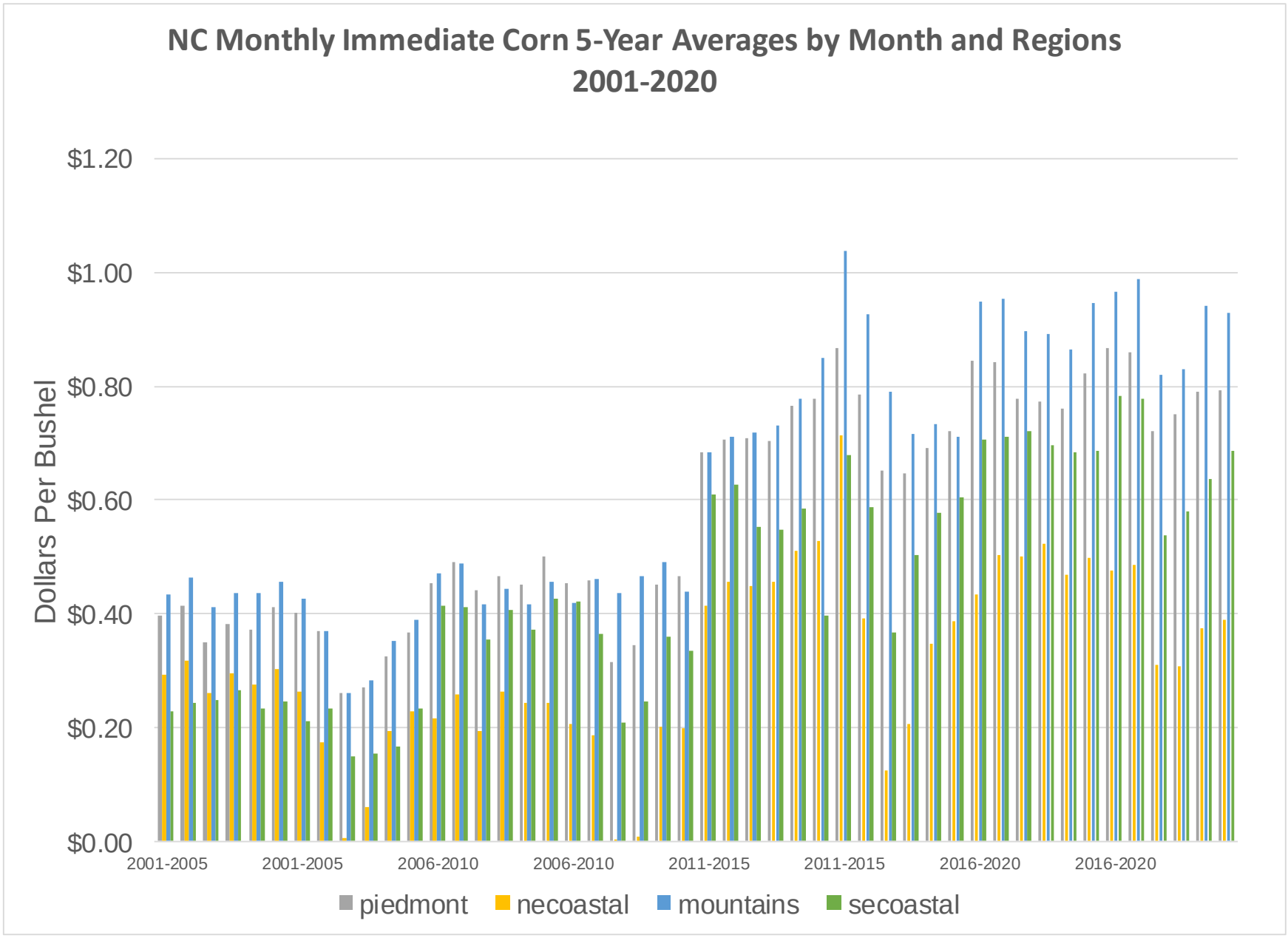
Econometric Analysis Objective (1b)—Key Questions of Interest

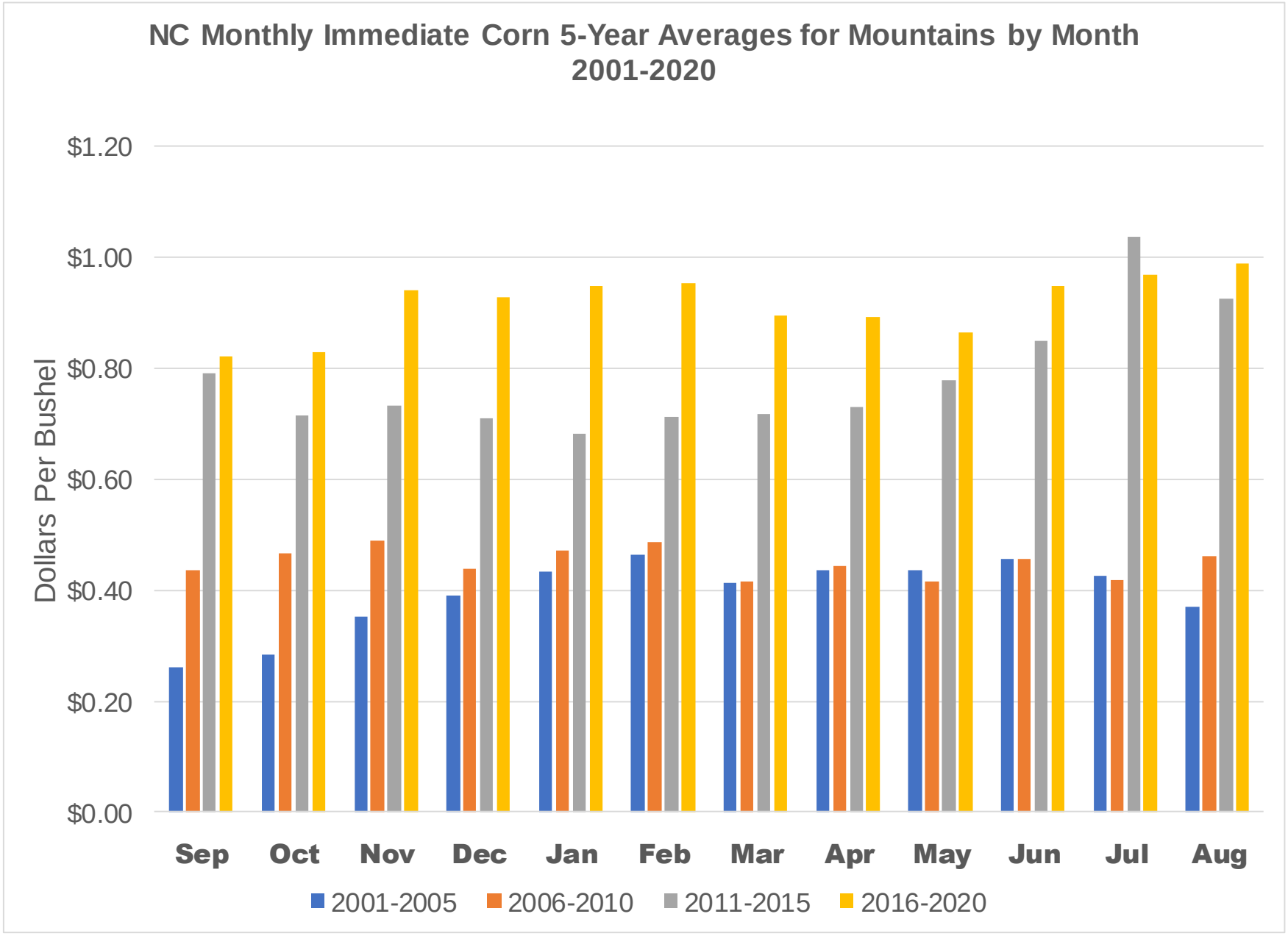
- Identify factors that potentially impact corn basis for several prominent locations in each region
  - Quantify and measure differences by location
    - Calculate critical summary statistics (e.g., mean, std dev, min, max)
  - Investigate seasonal factors at specific locations and across locations
    - Test whether seasonal factors (monthly dummies) are statistically significantly different from zero and whether they are statistically different for different periods (different months)
- Identify the critical origins of rail shipments to inform an analysis of basis to isolate and establish an estimate of the typical transportation costs

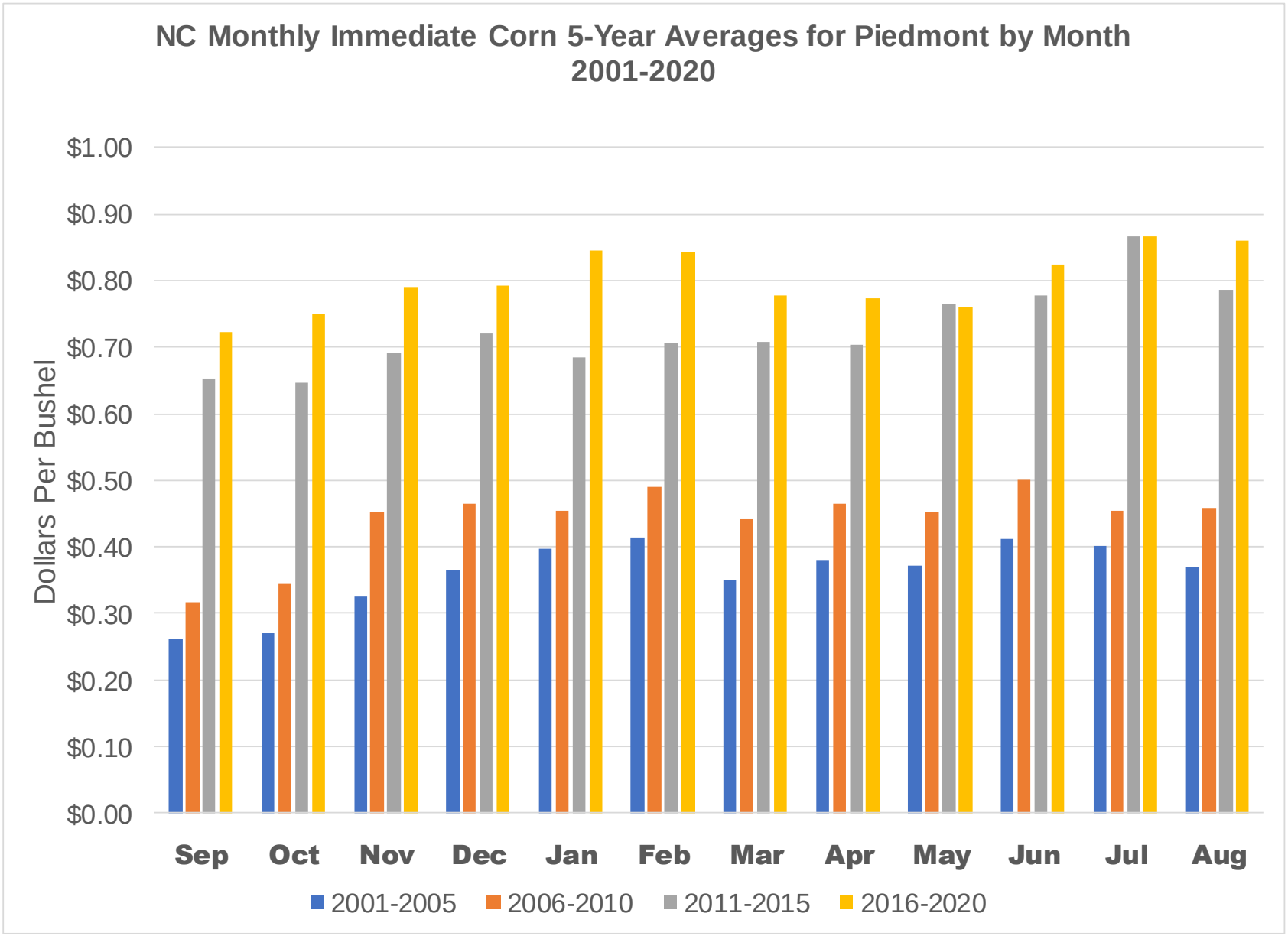

NC Monthly Immediate Corn Basis Means by Regions 2001(3)-2021(4)
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
Dollars Per Bushel
Piedmont
NorthEast_Coastal
Mountains
SouthEastCoastal

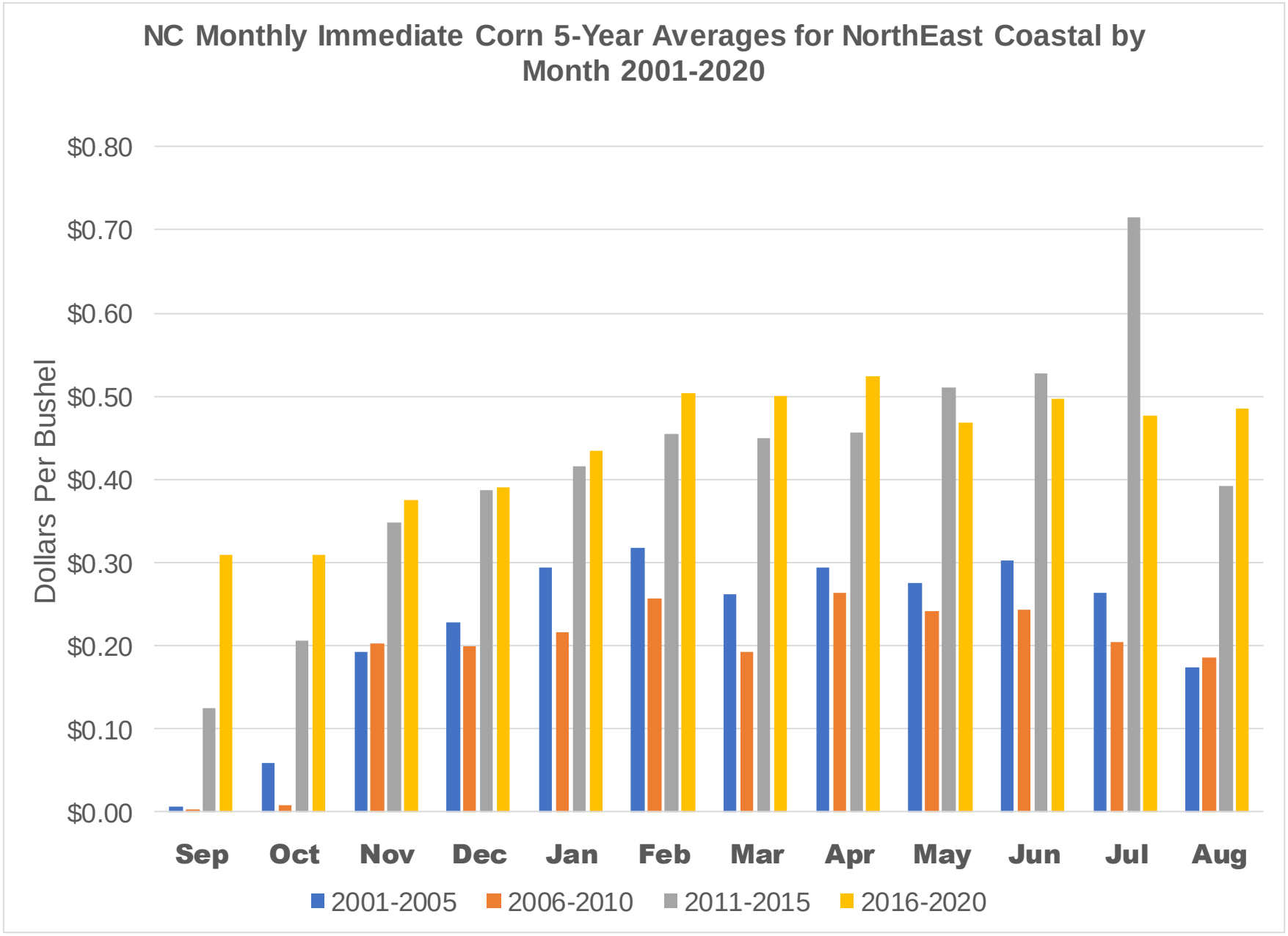

NC Monthly Immediate Corn Basis Summary Statistics by Regions
2001(3)-2021(4)
Dollars Per Bushel
$2.00
$1.50
$1.00
$0.50
$0.00
-$0.50
$0.59
$0.32
$0.65
$0.46
$0.13
-$0.15
$0.17
-$0.14
$1.15
$1.33
$1.74
$0.98
$0.22
$0.19
$0.26
$0.24
$0.27
-$0.01
$0.30
$0.04
$0.95
$0.61
$1.07
$0.80
Mean
Min
Max
Stdev
5%Percentile
95%Percentile
Piedmont
NorthEast_Coastal
Mountains
SouthEastCoastal

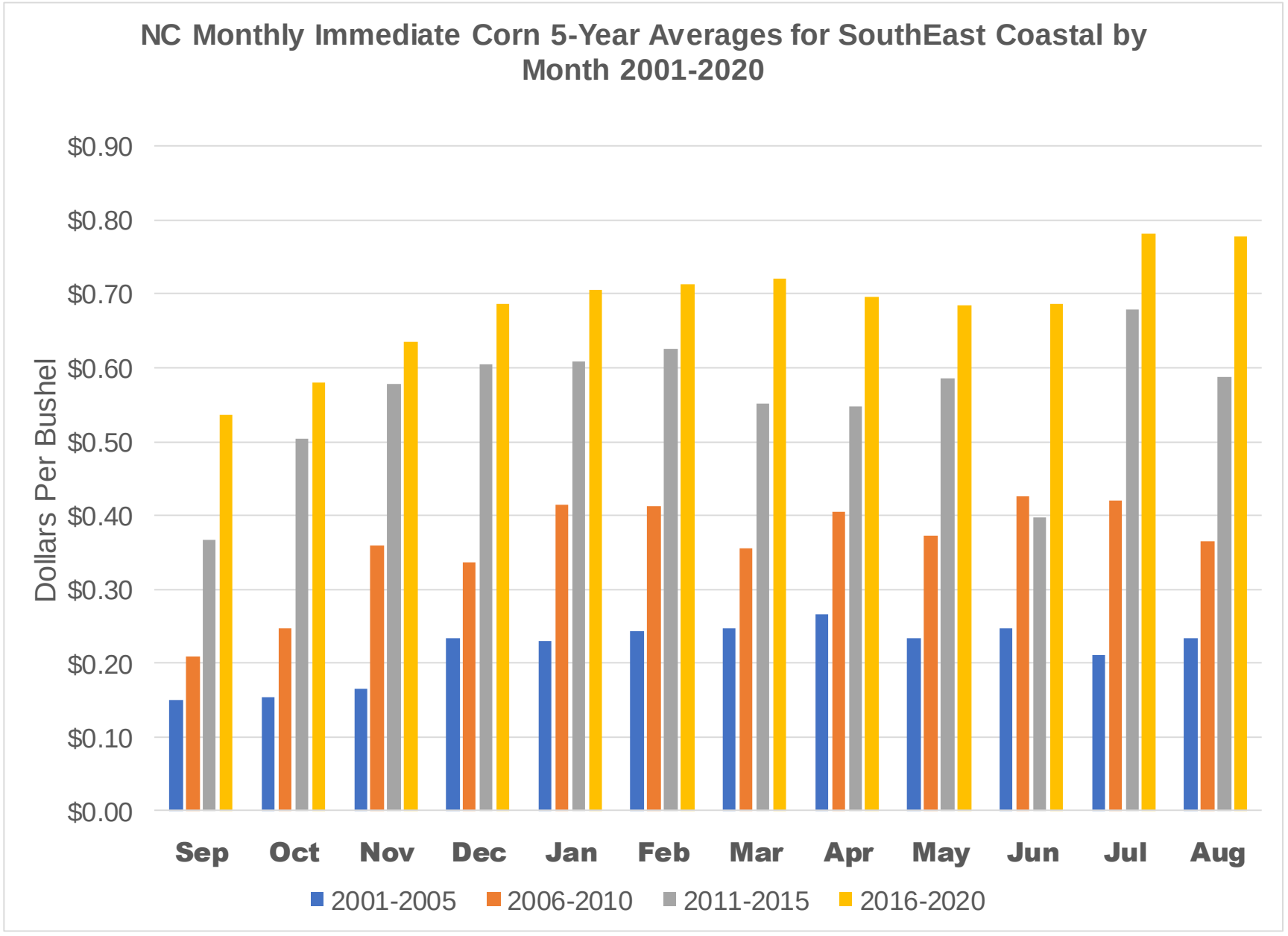

NC Monthly Immediate Corn 5-Year Averages by Regions 2001(3)-2020(12)
Dollars Per Bushel
$1.00
$0.90
$0.80
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
$0.36
$0.22
$0.39
$0.22
$0.44
$0.19
$0.45
$0.36
$0.73
$0.42
$0.78
$0.55
$0.80
$0.44
$0.91
$0.68
2001-2005
2005-2010
2011-2015
2016-2020
piedmont
necoastal
mountains
secoastal
Linear (piedmont)
Linear (necoastal)
Linear (mountains)
Linear (secoastal)

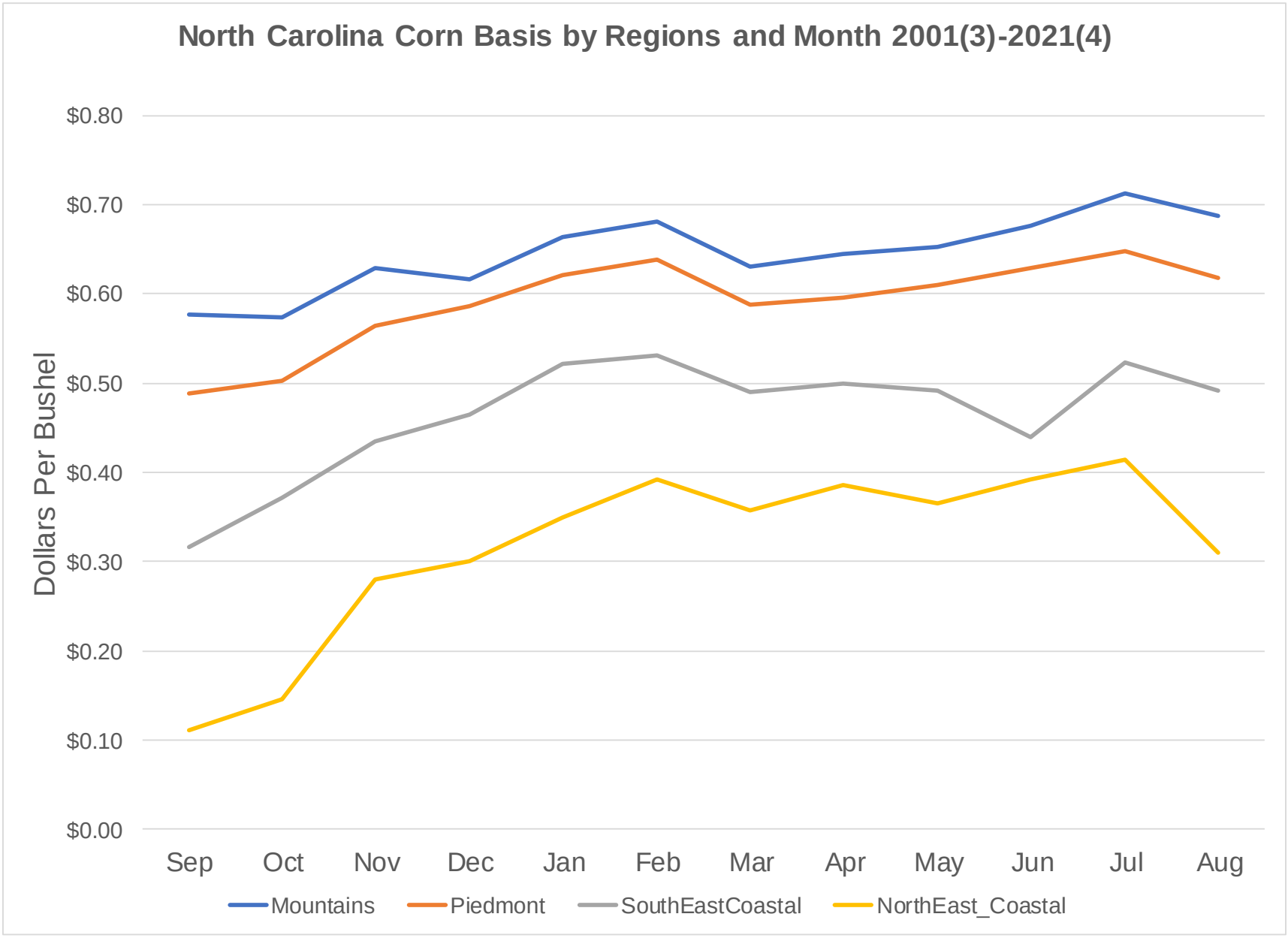

NC Monthly Immediate Corn 5-Year Averages by Month and Regions
2001-2020
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
Dollars Per Bushel
2001-2005
2001-2005
2006-2010
2006-2010
2011-2015
2011-2015
2016-2020
2016-2020
piedmont
necoastal
mountains
secoastal

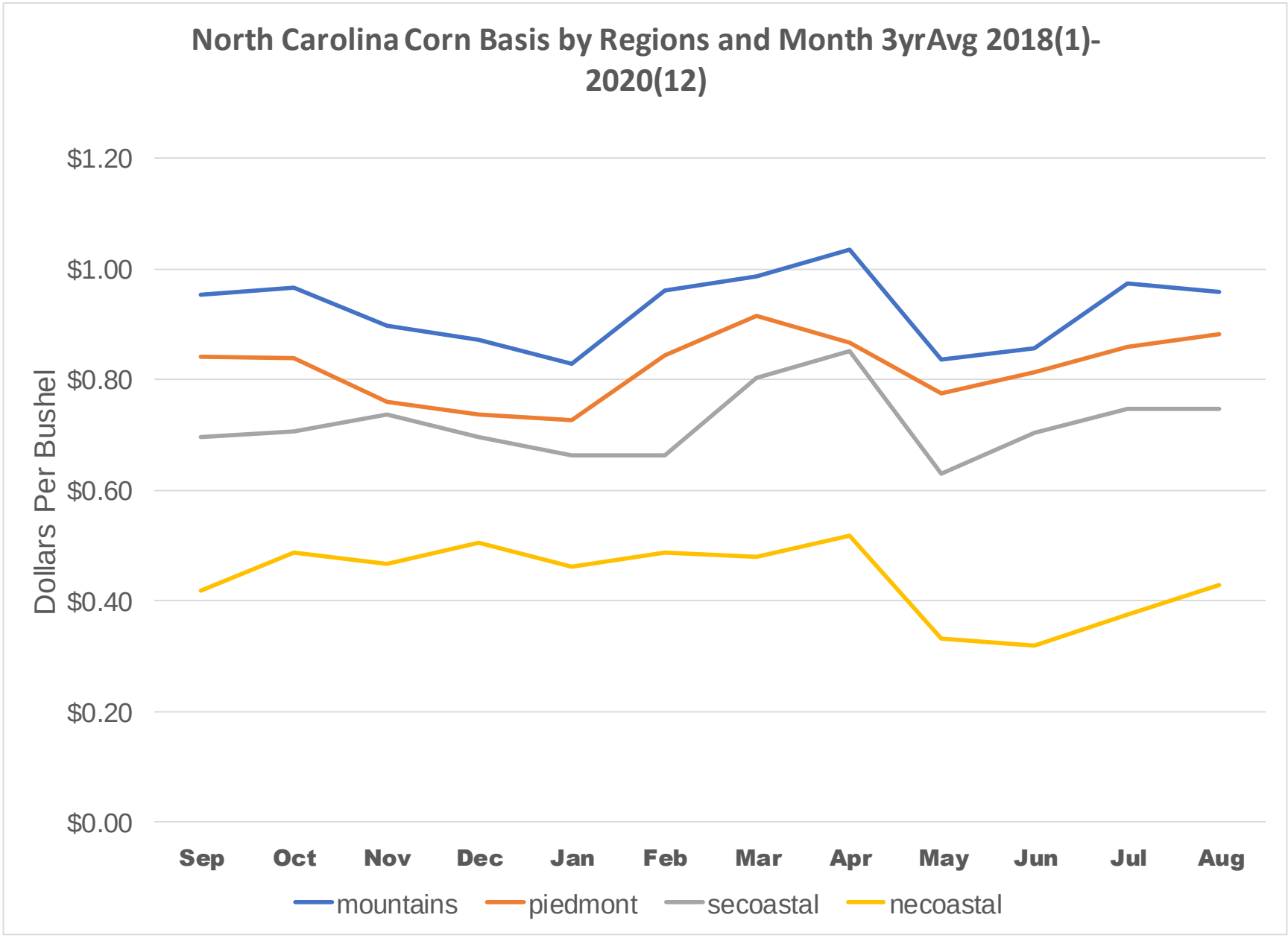

NC Monthly Immediate Corn 5-Year Averages for Mountains by Month
2001-2020
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
Dollars Per Bushel
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2001-2005
2006-2010
2011-2015
2016-2020

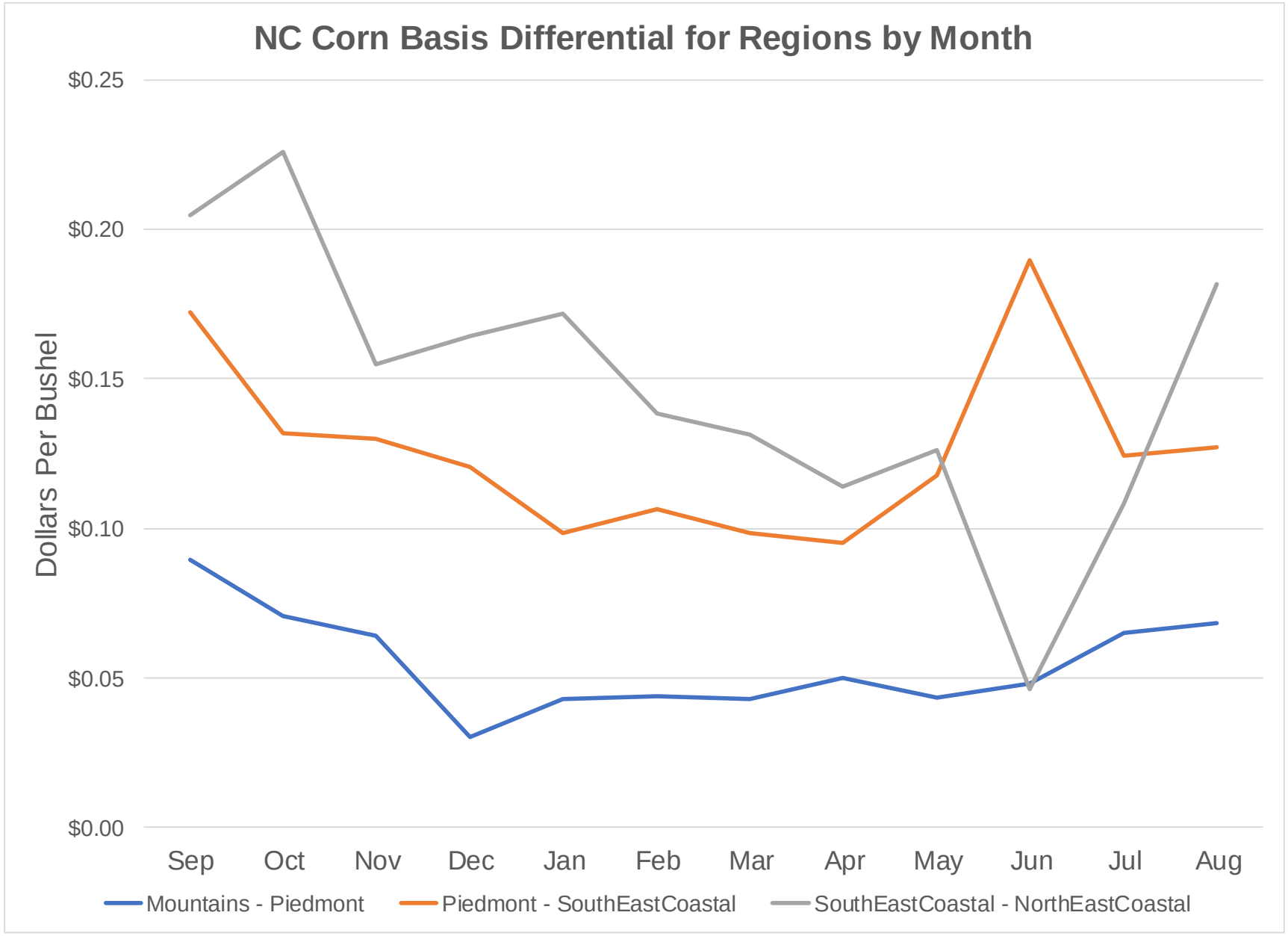

NC Monthly Immediate Corn 5-Year Averages for Piedmont by Month
2001-2020
Dollars Per Bushel
$1.00
$0.90
$0.80
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2001-2005
2006-2010
2011-2015
2016-2020

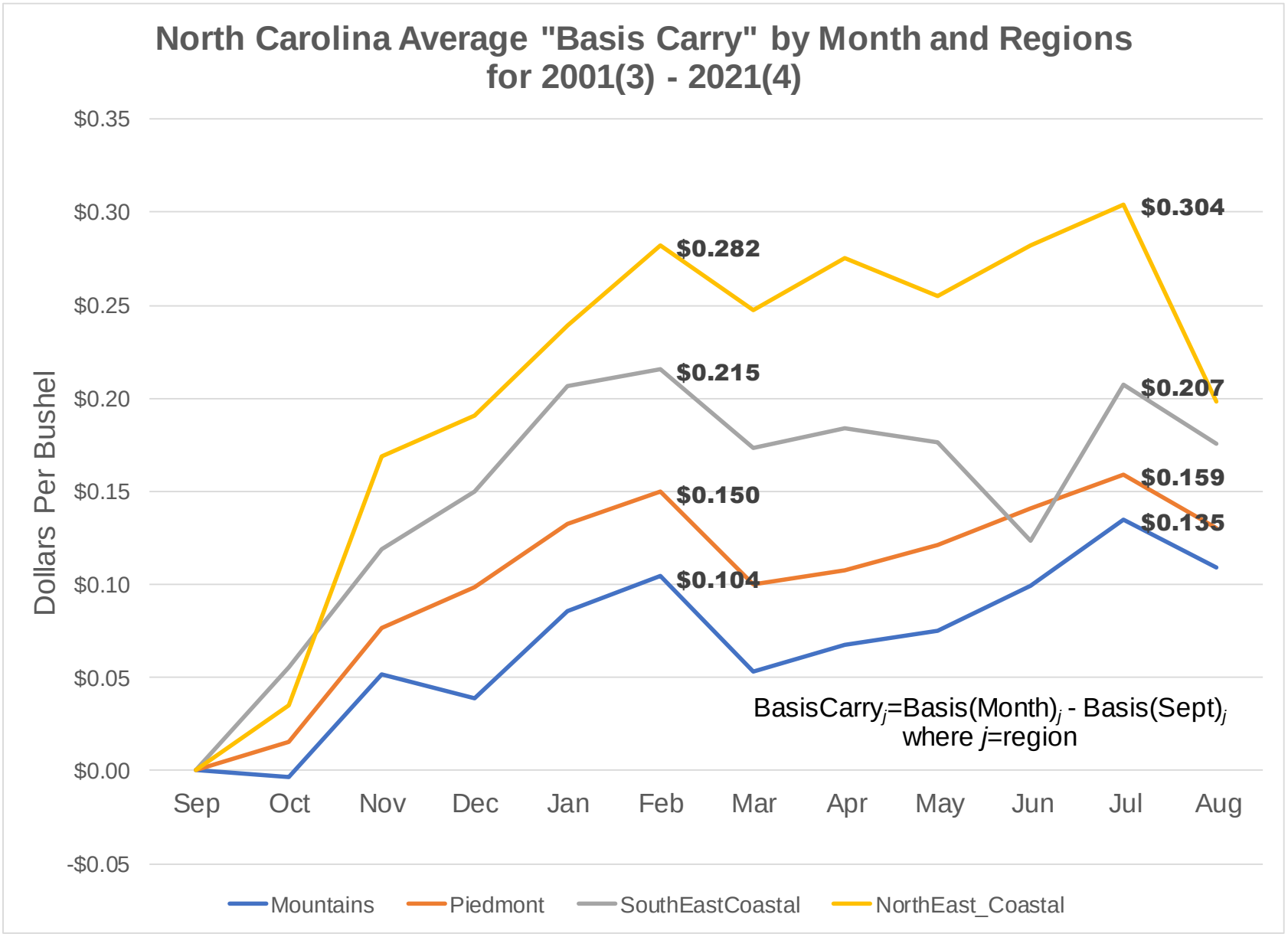

NC Monthly Immediate Corn 5-Year Averages for NorthEast Coastal by Month 2001-2020
$0.80
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
Dollars Per Bushel
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2001-2005
2006-2010
2011-2015
2016-2020

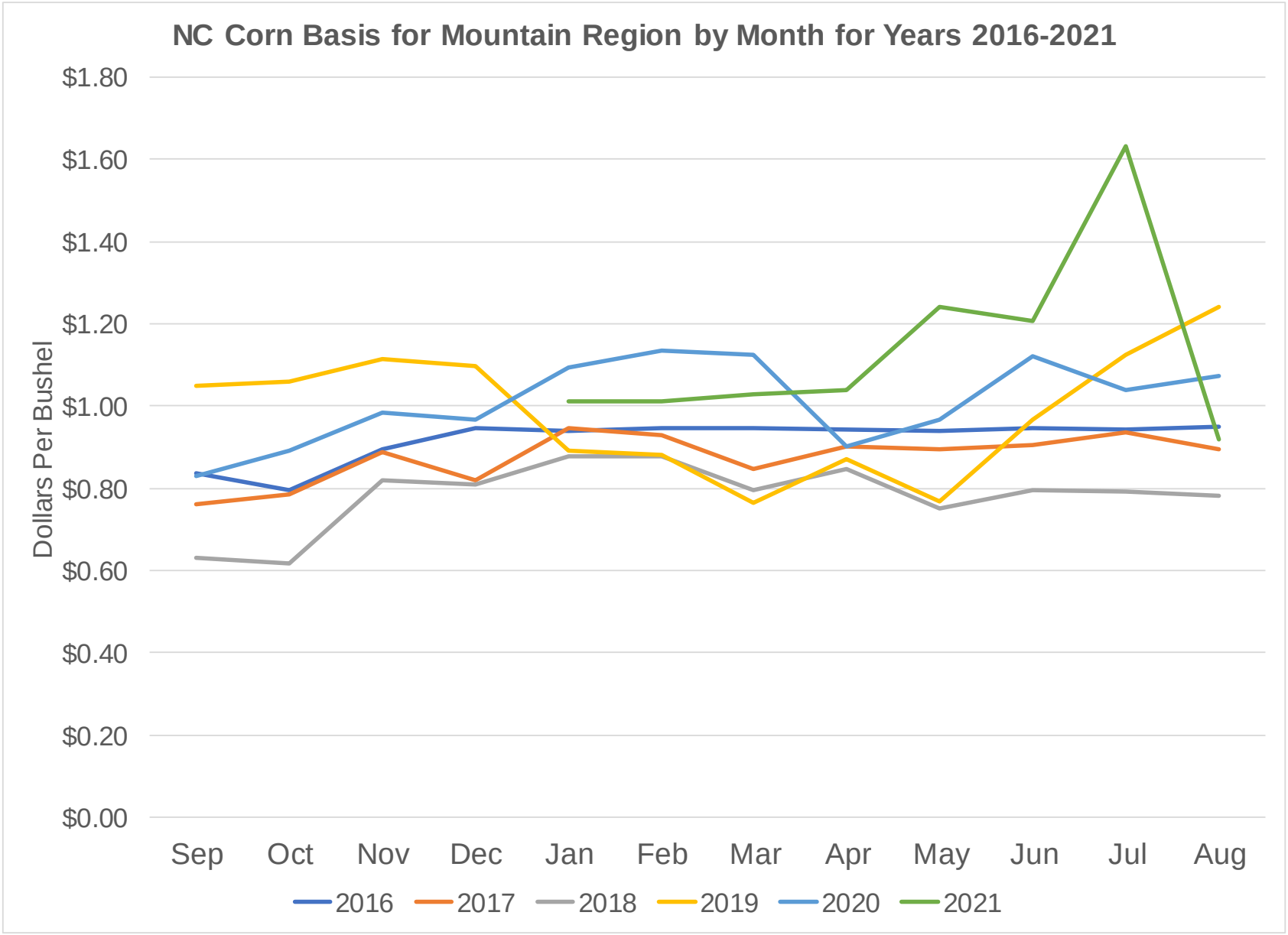

NC Monthly Immediate Corn 5-Year Averages for SouthEast Coastal by Month 2001-2020
Dollars Per Bushel
$0.90
$0.80
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2001-2005
2006-2010
2011-2015
2016-2020

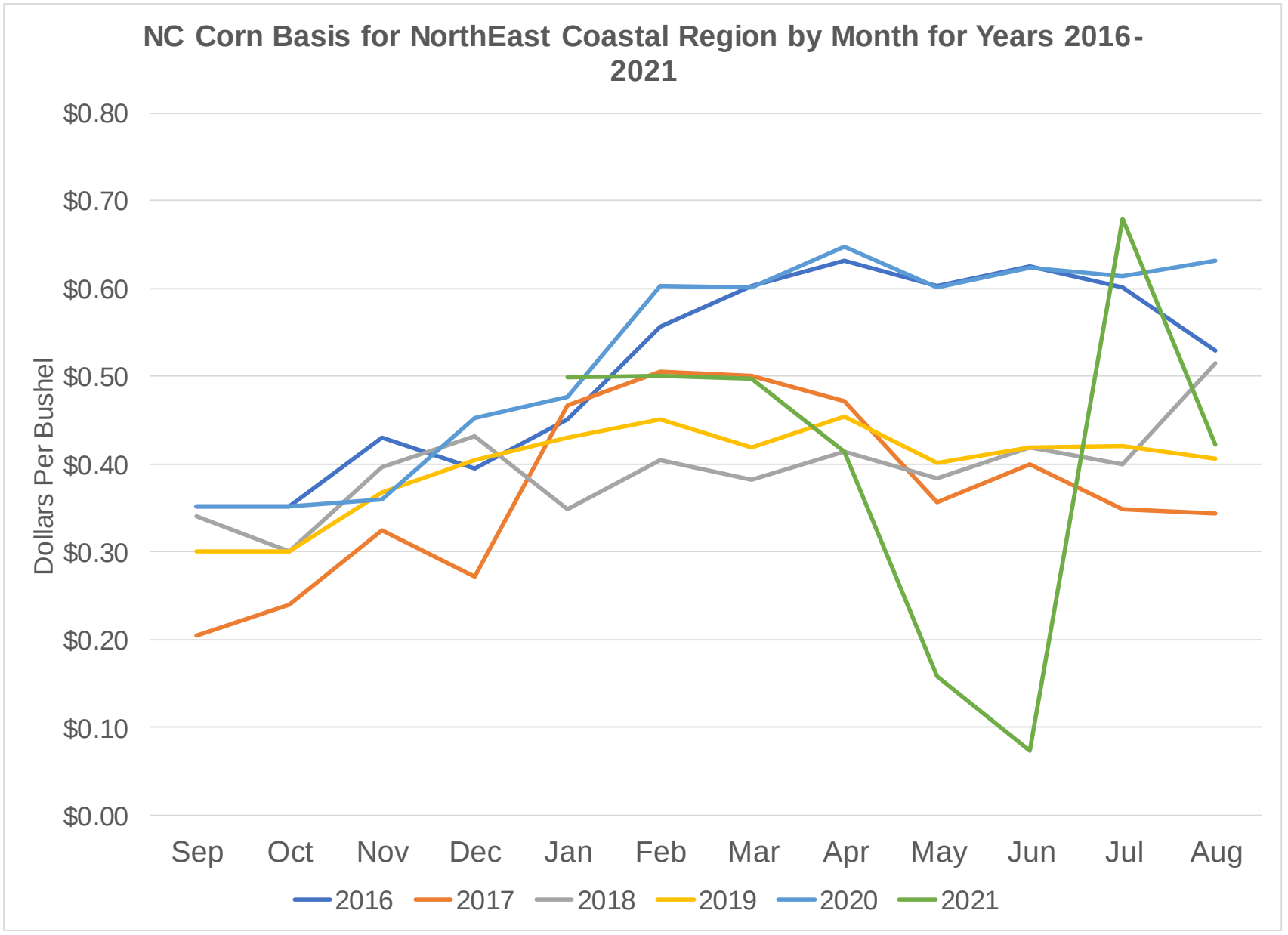

North Carolina Corn Basis by Regions and Month 2001(3)-2021(4)
Dollars Per Bushel
$0.80
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Mountains
Piedmont
SouthEastCoastal
NorthEast_Coastal

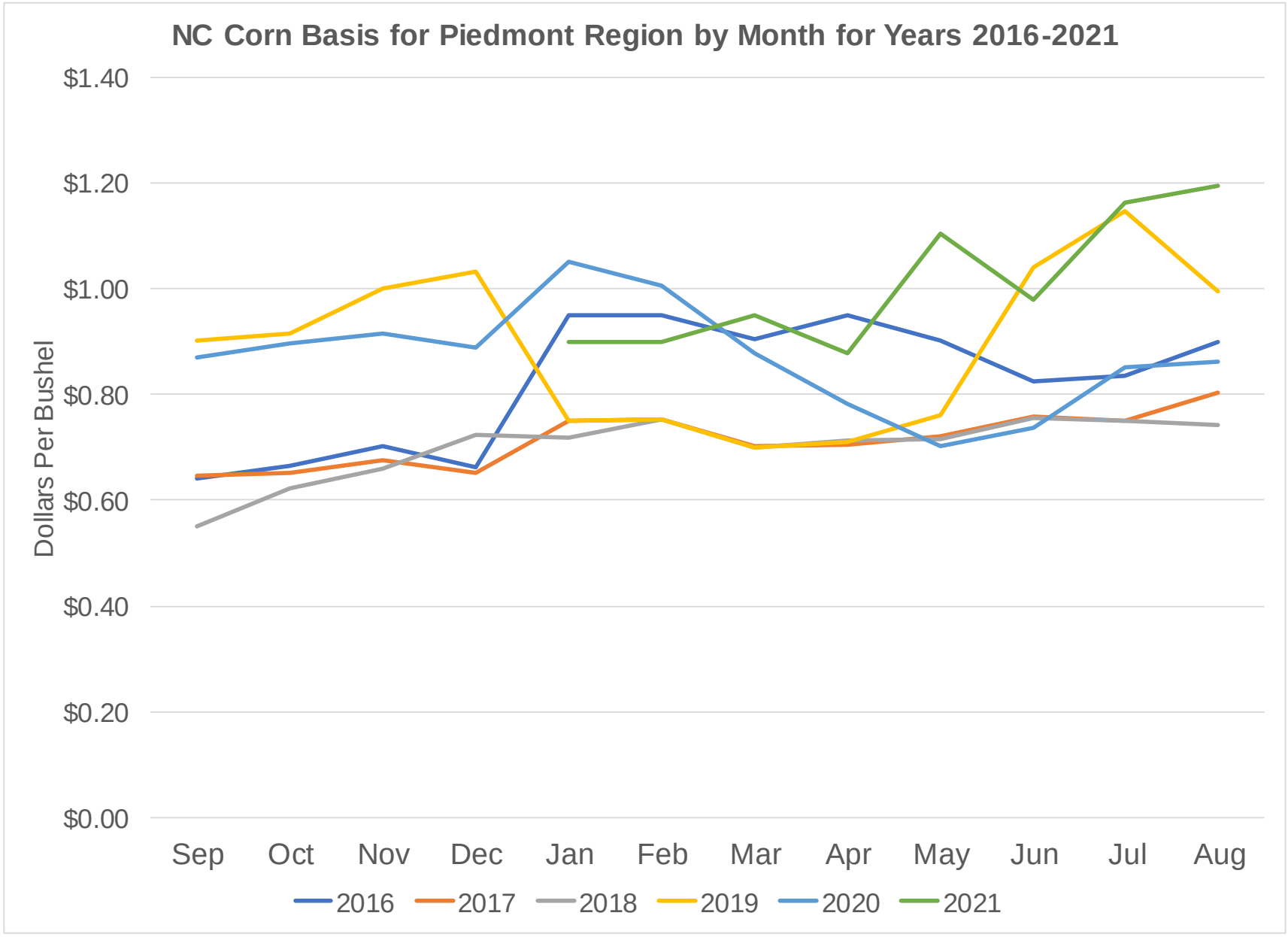

North Carolina Corn Basis by Regions and Month 3yrAvg 2018(1)-2020(12)
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
Dollars Per Bushel
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
mountains
piedmont
secoastal
necoastal

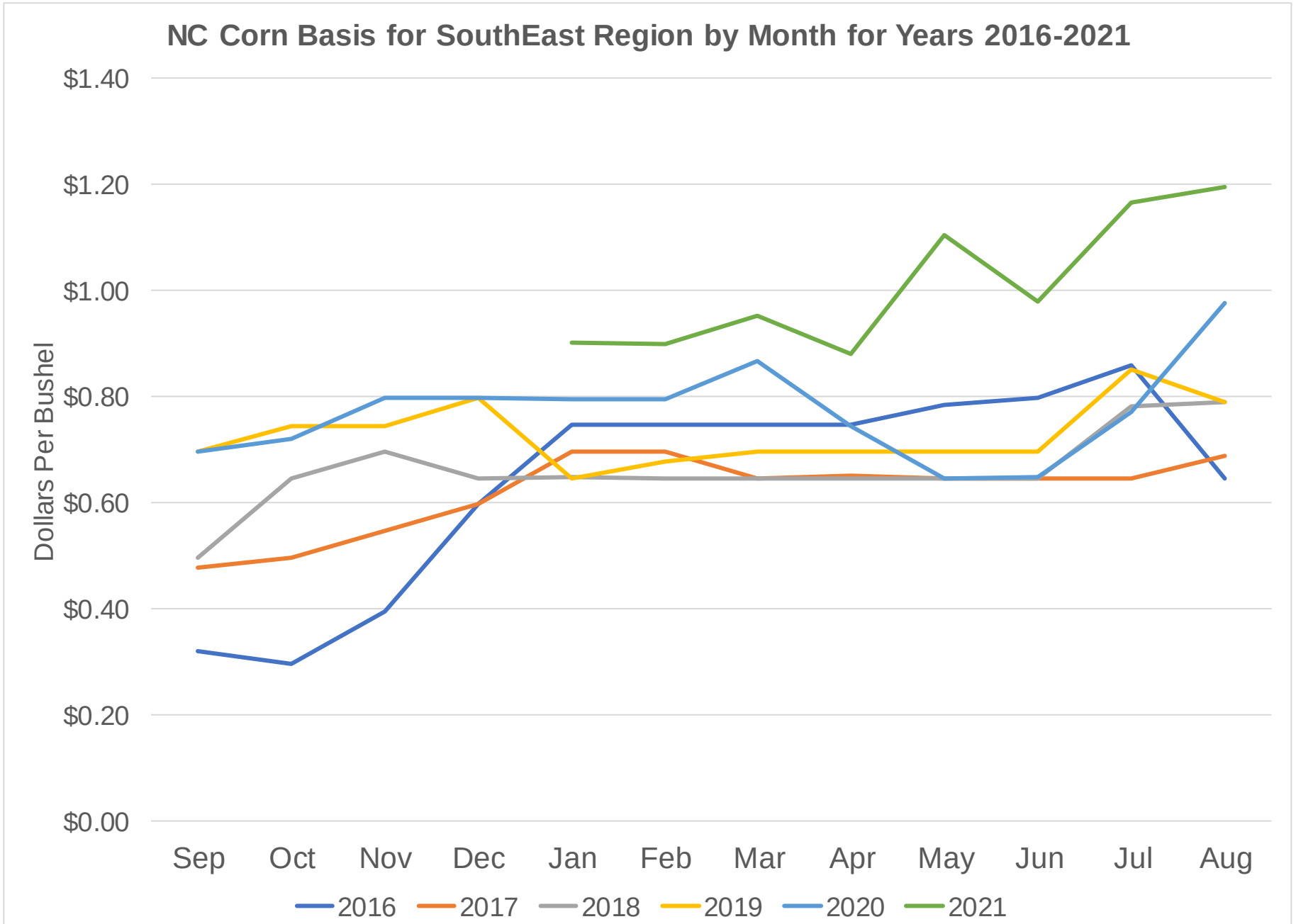

NC Corn Basis Differential for Regions by Month
$0.25
$0.20
$0.15
$0.10
$0.05
$0.00
Dollars Per Bushel
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Mountains - Piedmont
Piedmont - SouthEastCoastal
SouthEastCoastal - NorthEastCoastal


North Carolina Average "Basis Carry" by Month and Regions
for 2001(3) - 2021(4)
Dollars Per Bushel
$0.35
$0.30
$0.25
$0.20
$0.15
$0.10
$0.05
$0.00
-$0.05
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
$0.304
$0.282
$0.215
$0.207
$0.159
$0.150
$0.135
$0.104
BasisCarry$_j$=Basis(Month)$_j$ - Basis(Sept)$_j$
where j=region
Mountains
Piedmont
SouthEastCoastal
NorthEast_Coastal


NC Corn Basis for Mountain Region by Month for Years 2016-2021
$1.80
$1.60
$1.40
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
Dollars Per Bushel
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2016
2017
2018
2019
2020
2021


NC Corn Basis for NorthEast Coastal Region by Month for Years 2016-2021
Dollars Per Bushel
$0.80
$0.70
$0.60
$0.50
$0.40
$0.30
$0.20
$0.10
$0.00
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2016
2017
2018
2019
2020
2021


NC Corn Basis for Piedmont Region by Month for Years 2016-2021
Dollars Per Bushel
$1.40
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2016
2017
2018
2019
2020
2021


NC Corn Basis for SouthEast Region by Month for Years 2016-2021
$1.40
$1.20
$1.00
$0.80
$0.60
$0.40
$0.20
$0.00
Dollars Per Bushel
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
2016
2017
2018
2019
2020
2021

Basic Econometric Model

$$Basis_t^r = \alpha + \sum_{j=1}^{11} \beta_j Month_j + \tau T$$

where

- $Basis_t^{Region}$ = average monthly basis for r^{th} region 2001(3)-2021(8)
- $Month_j$ = monthly dummy variable for the j^{th} month
- τT = linear time trend
- *r*={ Mountains, Piedmont, SEcoastal, NEcoastal}
- *j*={ Oct, Nov, Dec, Jan, Feb, Mar, Apr, May, Jun, Jul, Aug}
- α and β_j are parameters to estimate

Single Equation Regressions

Single Equation Regressions								
	Mountains		Piedmont		SEcoastal		NEcoastal	
R-Square	0.7456		0.7547		0.7547		0.4916	
Variable	**Estimate**	**Pr > |t|**	**Estimate**	**Pr > |t|**	**Estimate**	**Pr > |t|**	**Estimate**	**Pr > |t|**
Intercept	0.18792	<.0001	0.15988	<.0001	-0.02307	0.0992	-0.05848	0.0992
m_oct	-0.00661	0.8819	0.01254	0.7349	0.05289	0.4572	0.03346	0.4572
m_nov	0.04515	0.3103	0.07147	0.0546	0.11329	0.0003	0.16591	0.0003
m_dec	0.02948	0.5074	0.09022	0.0155	0.14128	<.0001	0.18623	<.0001
m_jan	0.07302	0.1014	0.12173	0.0012	0.19505	<.0001	0.2338	<.0001
m_feb	0.0882	0.0482	0.13627	0.0003	0.20138	<.0001	0.27496	<.0001
m_mar	0.05345	0.2243	0.0999	0.0068	0.17363	<.0001	0.24724	<.0001
m_apr	0.06456	0.1425	0.10458	0.0046	0.18129	<.0001	0.27363	<.0001
m_may	0.06946	0.1147	0.11862	0.0013	0.17051	<.0001	0.25013	<.0001
m_jun	0.11499	0.0093	0.14922	<.0001	0.14022	<.0001	0.26265	<.0001
m_jul	0.16602	0.0002	0.1731	<.0001	0.21674	<.0001	0.3111	<.0001
m_aug	0.10426	0.0183	0.14455	0.0001	0.17946	<.0001	0.19697	<.0001
t	0.00322	<.0001	0.00271	<.0001	0.0028	<.0001	0.0014	<.0001
Test	F-test	Pr > F	F-test	Pr > F	F-test	Pr > F	F-test	Pr > F
All Monthly = 0	2.46	0.0064	4.1	<.0001	5.03	<.0001	9.31	<.0001
All Monthly Equal	2.2	0.0186	2.84	0.0024	2.65	0.0044	5.74	<.0001

Shaded estimates and test statistics are significant at the 5% level

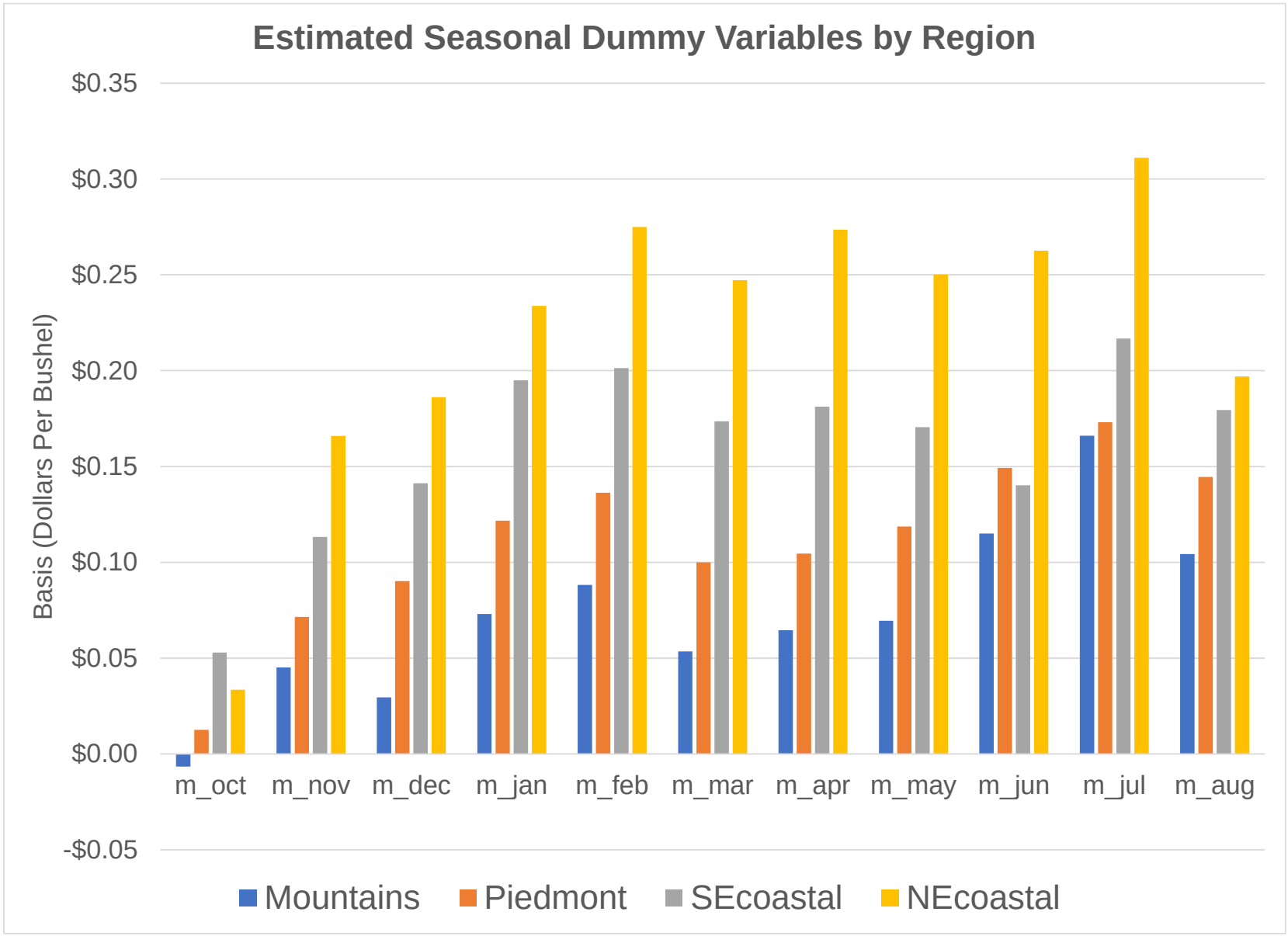
Seeming Unrelated Regression Test Results

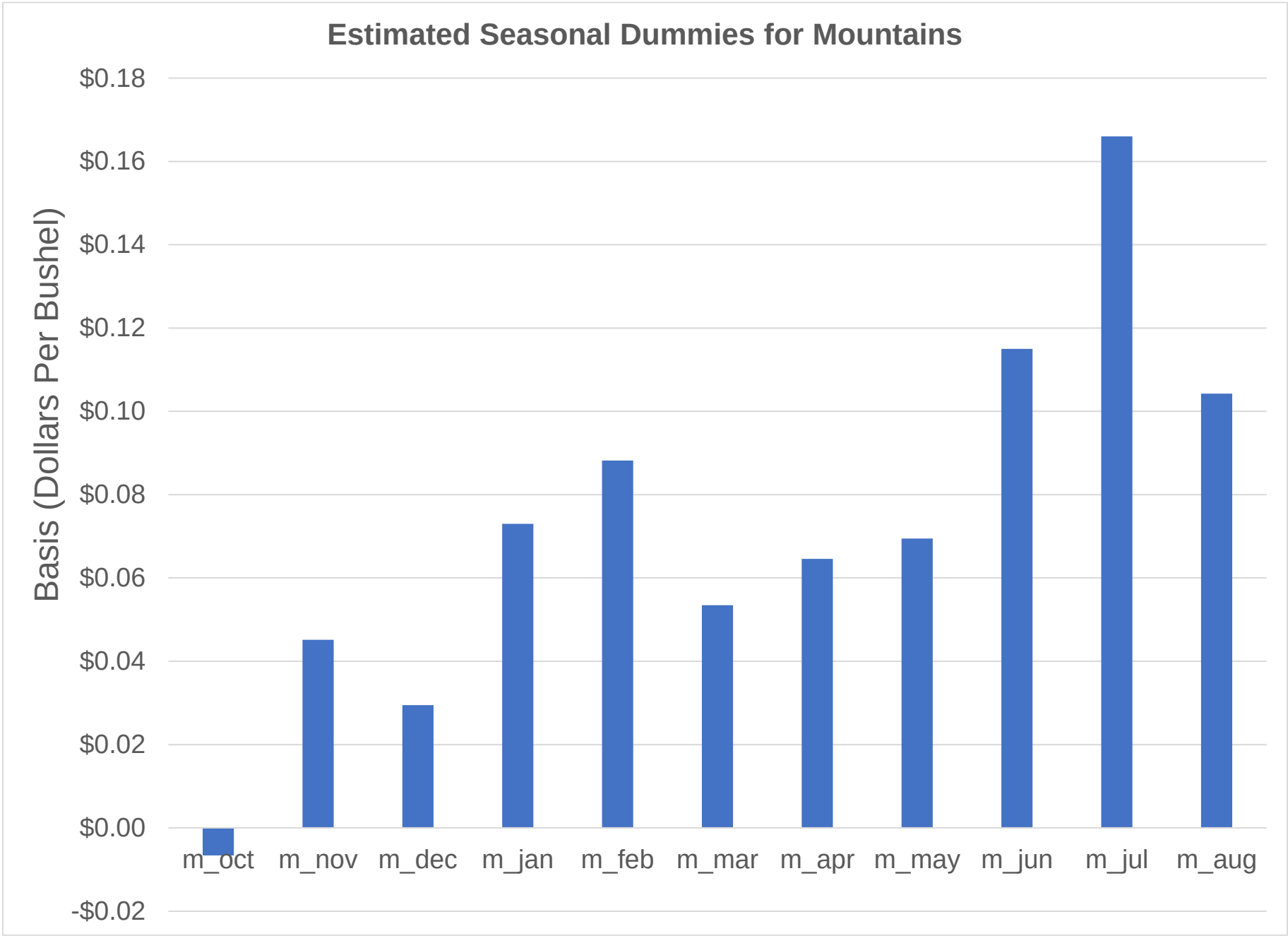
Seemingly Unrelated Regression		
Test	F-test	Pr > F
M_OCT Across Region Equal	0.44	0.7262
M_NOV Across Region Equal	2.38	0.0679
M_DEC Across Region Equal	3.89	0.0089
M_JAN Across Region Equal	4.21	0.0057
M_FEB Across Region Equal	5.6	0.0008
M_MAR Across Region Equal	6.25	0.0003
M_APR Across Region Equal	7.44	0.0001
M_MAY Across Region Equal	5.34	0.0012
M_JUN Across Region Equal	4.28	0.0052
M_JUL Across Region Equal	4.08	0.0069
M_AUG Across Region Equal	1.43	0.2338

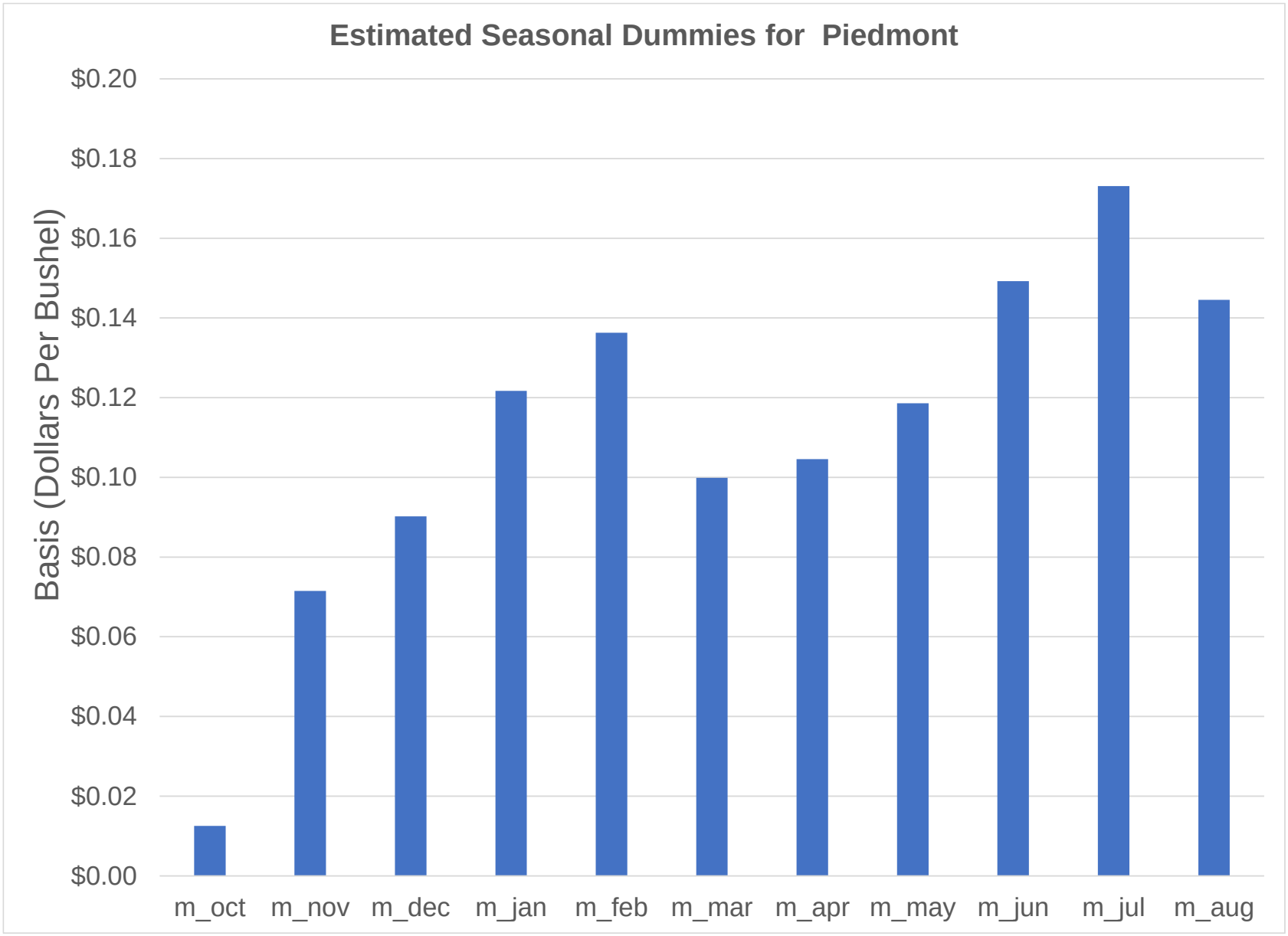
Shaded estimates and test statistics are significant at the 5% level

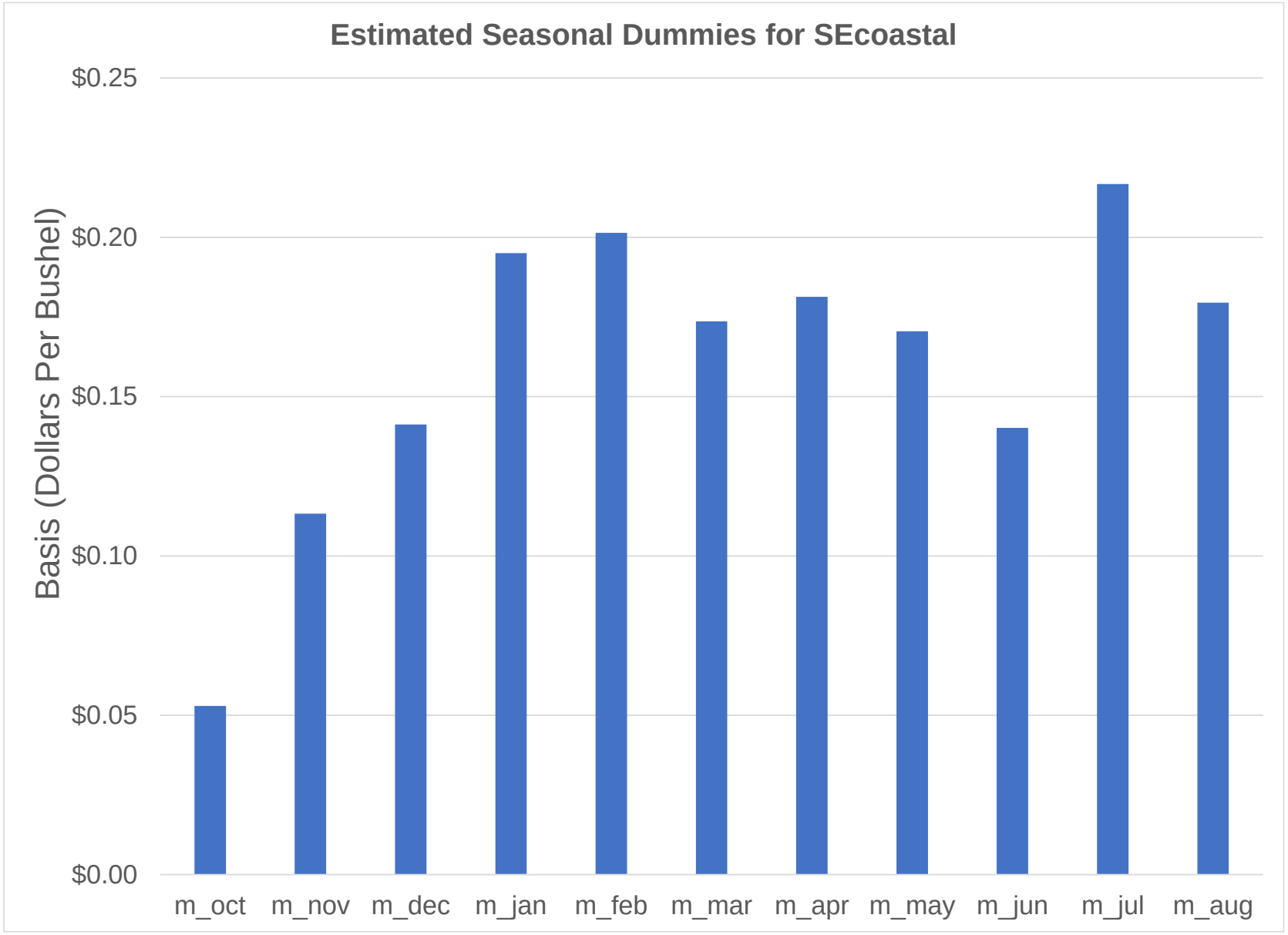
Single Equation and System Estimate Tests Reveal

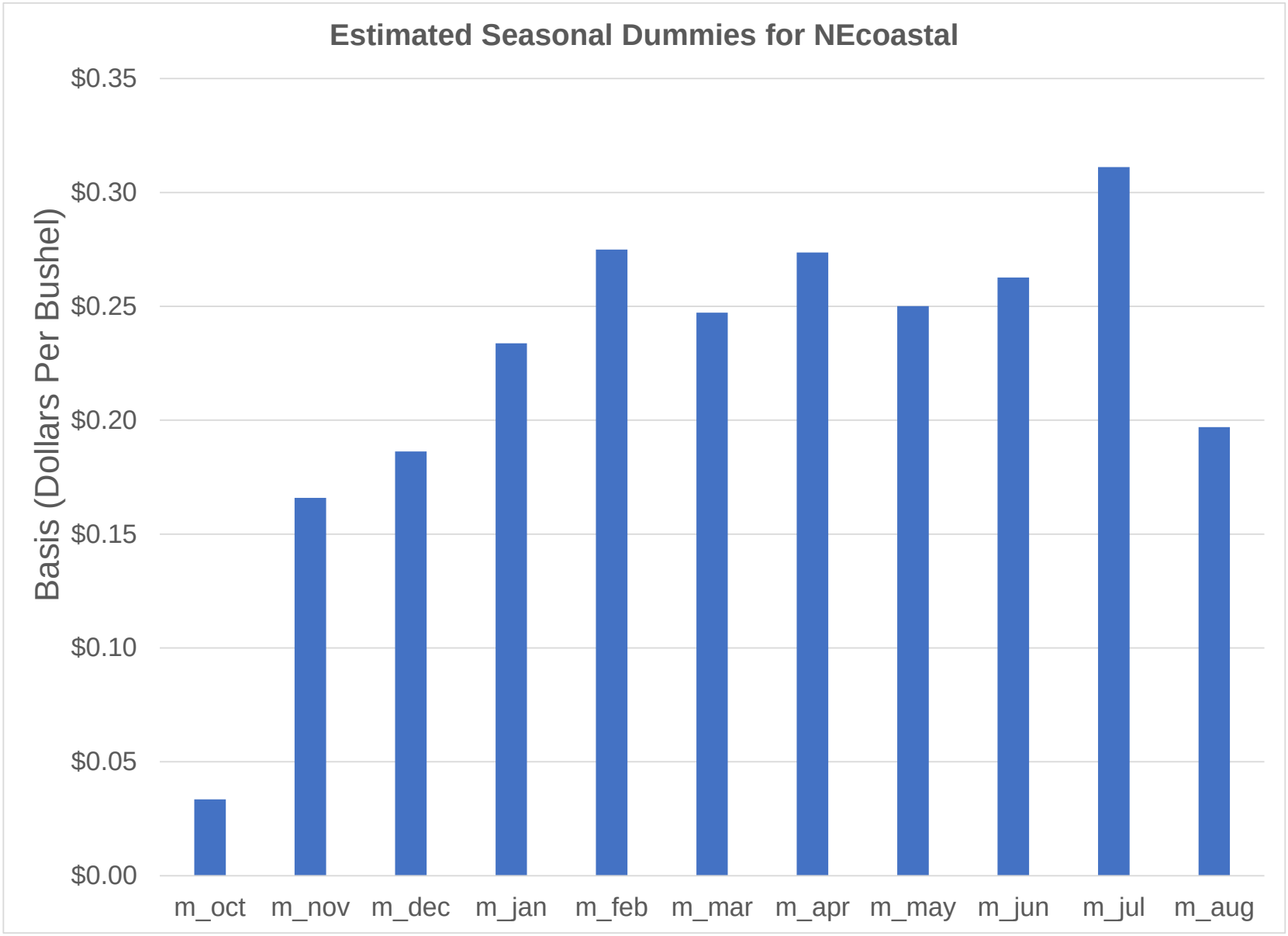
- For each region we can reject:
  - All of the Dummy Variables for Months are jointly equal to zero.
  - All of the Dummy variables are equal to each other
  - These test results indicate that there are important differences in basis by month and region in NC
- Across regions we can reject that season components (as measured by monthly dummies) are equal with a few exceptions of around harvest time (August, October, November)
  - Estimates reveal basis strengthens after harvest in November up until February then it levels off or declines
  - Important implications for the return to storage can be gained from these seasonal estimates
  - The average “basis carry” from September to February by region is estimated to be:
    - NorthEast Coastal= $0.28 per bushel
    - SouthEast Coastal= $0.22 per bushel
    - Piedmont = $0.15 per bushel
    - Mountains= $0.10 per bushel


Estimated Seasonal Dummy Variables by Region
Basis (Dollars Per Bushel)
$0.35
$0.30
$0.25
$0.20
$0.15
$0.10
$0.05
$0.00
-$0.05
m_oct
m_nov
m_dec
m_jan
m_feb
m_mar
m_apr
m_may
m_jun
m_jul
m_aug
Mountains
Piedmont
SEcoastal
NEcoastal


Estimated Seasonal Dummies for Mountains
Basis (Dollars Per Bushel)
$0.18
$0.16
$0.14
$0.12
$0.10
$0.08
$0.06
$0.04
$0.02
$0.00
-$0.02
m_oct
m_nov
m_dec
m_jan
m_feb
m_mar
m_apr
m_may
m_jun
m_jul
m_aug


Estimated Seasonal Dummies for Piedmont
Basis (Dollars Per Bushel)
$0.20
$0.18
$0.16
$0.14
$0.12
$0.10
$0.08
$0.06
$0.04
$0.02
$0.00
m_oct
m_nov
m_dec
m_jan
m_feb
m_mar
m_apr
m_may
m_jun
m_jul
m_aug


Estimated Seasonal Dummies for SEcoastal
Basis (Dollars Per Bushel)
$0.25
$0.20
$0.15
$0.10
$0.05
$0.00
m_oct
m_nov
m_dec
m_jan
m_feb
m_mar
m_apr
m_may
m_jun
m_jul
m_aug


Estimated Seasonal Dummies for NEcoastal
Basis (Dollars Per Bushel)
$0.35
$0.30
$0.25
$0.20
$0.15
$0.10
$0.05
$0.00
m_oct
m_nov
m_dec
m_jan
m_feb
m_mar
m_apr
m_may
m_jun
m_jul
m_aug

Objective 2: Establish a Database about Flows of Feedstuffs to NC

2A. Profiles of feedstuff movements in and within NC

2B. Better understanding of the timing of flows

Conclusions

- There is a consistent story about NC feedstuff flows across datasets and modes of transportation. NC grain transportation flows are dominated by livestock production
- NC bulk transportation and feed markets are co-evolving over time in important ways with higher corns basis and commodity flows that are differing by regions
- Multiple mechanisms used to adjust to national and international market conditions – but there are some concentrated supply chain risks within rail and ocean modes

Sources Combined to Describe Feedstuff Movements In & Within NC

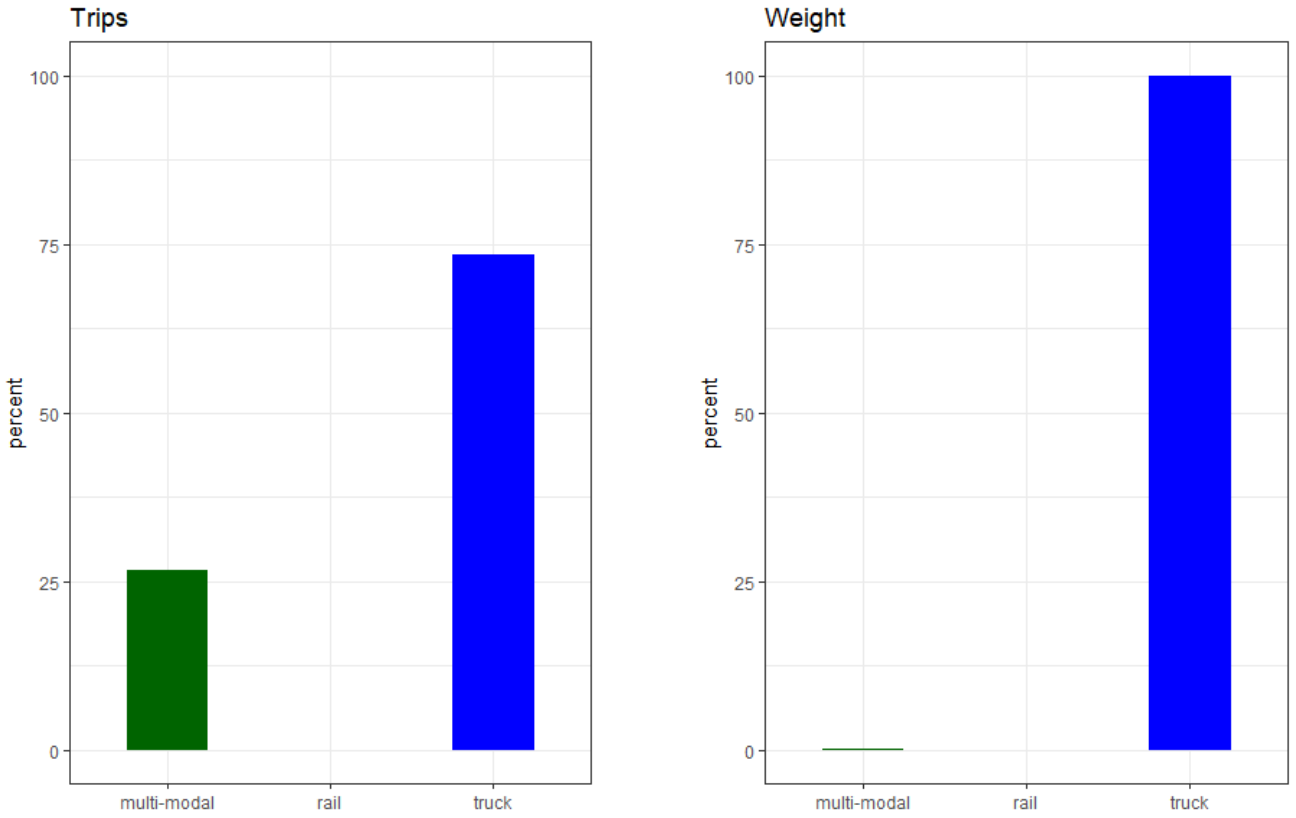
Data	Source	Frequency
Ocean shipment bills of lading	IHS Markit PIERS	Shipment-level [2005 - 2021]
Carload Confidential Waybill Sample	Surface Transportation Board	Shipment-level [1990 – 2018]
Commodity Flow Survey	US Census Bureau	Annual volumes [2012 microdata, 2017]
Freight Analysis Framework 4 & 5	USDOT Federal Highway Administration	Annual volumes [2017 most recent]
Ag Census	USDA NASS	Annual [census years 2002, 2007, 2012, 2017]
Map Layers	ERSI	NA [time invariant features only]

Transportation Profile by Mode: Truck

Corn moves within NC by truck; from counties with surplus feedstuffs to deficit counties with large livestock populations, and these spatial relationships change over time.

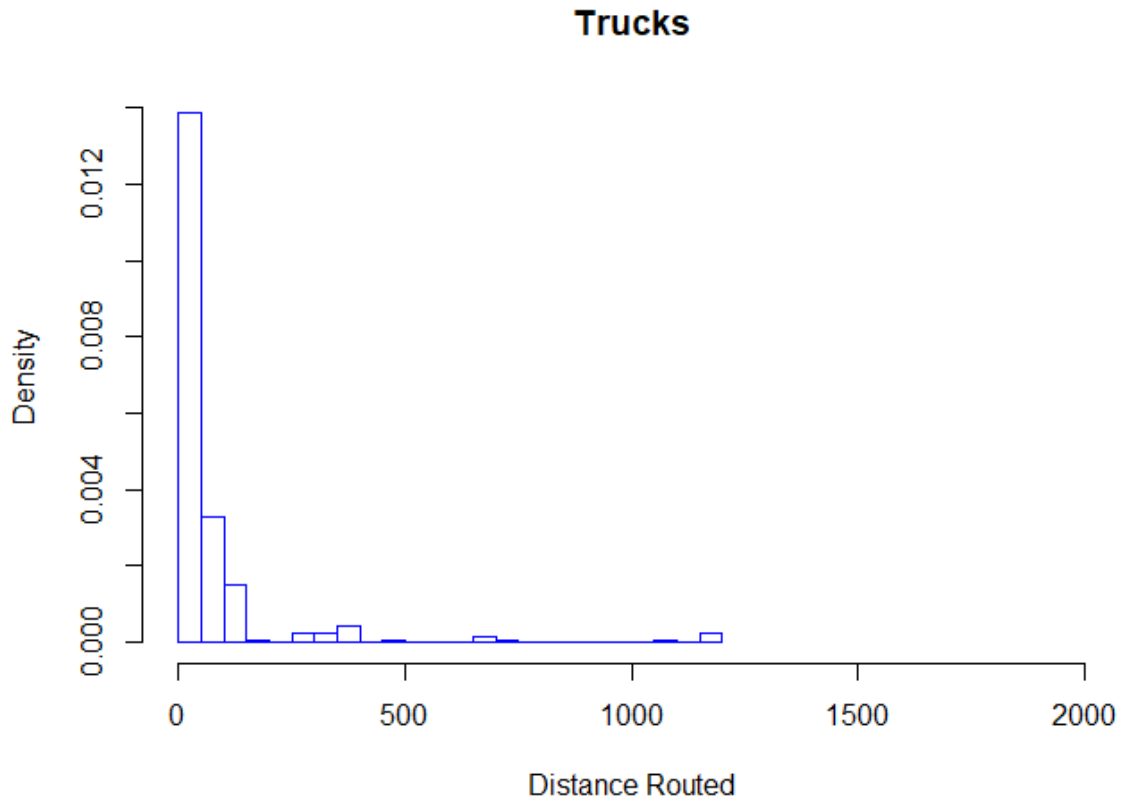
- Many Northeastern counties actually have an annual surplus of feedstuffs.
- County-to-county or region-to-region flow data/extrapolation does not exist, information is not collected with enough granularity.
  - However we can use origin/destination feedstuff demand and supply data to provide insight about the derived demand for transportation.
- Nearly all trips within NC involve trucks:
  - Can be solely truck or truck & rail
  - A typical truck movement is less than 100 miles

Grain and Oilseed Movements Within NC by Mode



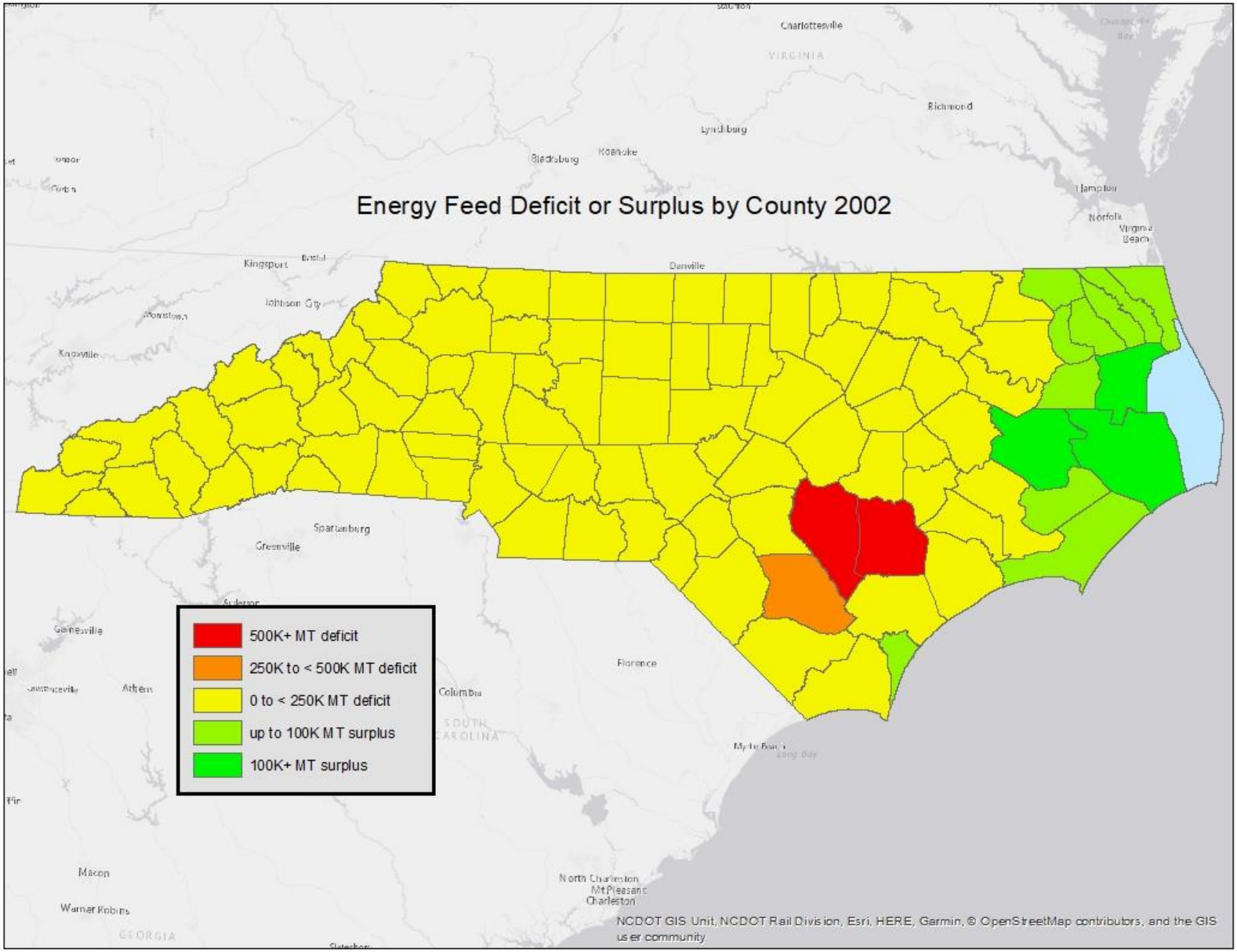
Source: 2012 Commodity Flow Survey Microdata

Grain and Oilseed Shipment Distance

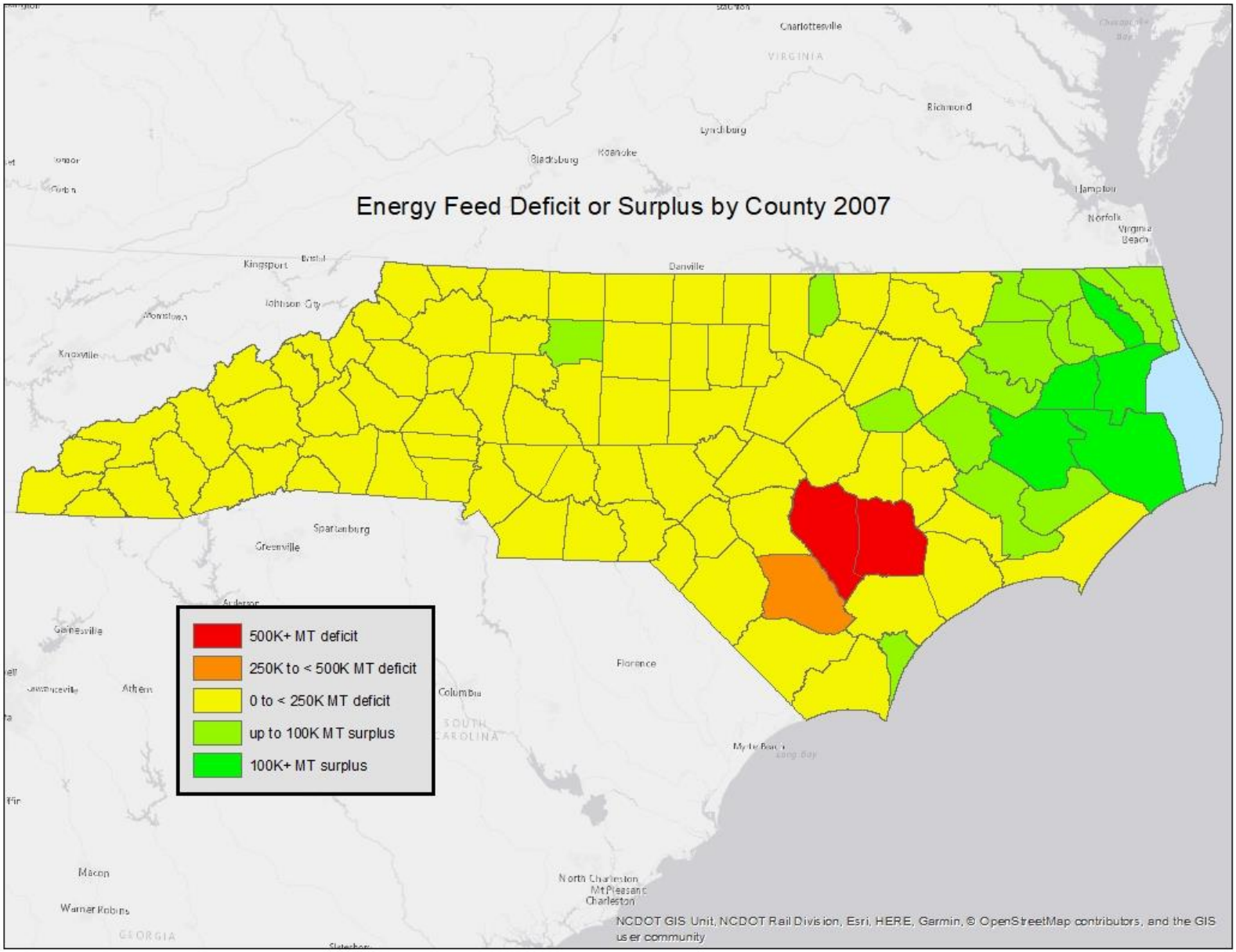


Average distance routed = 74 mi

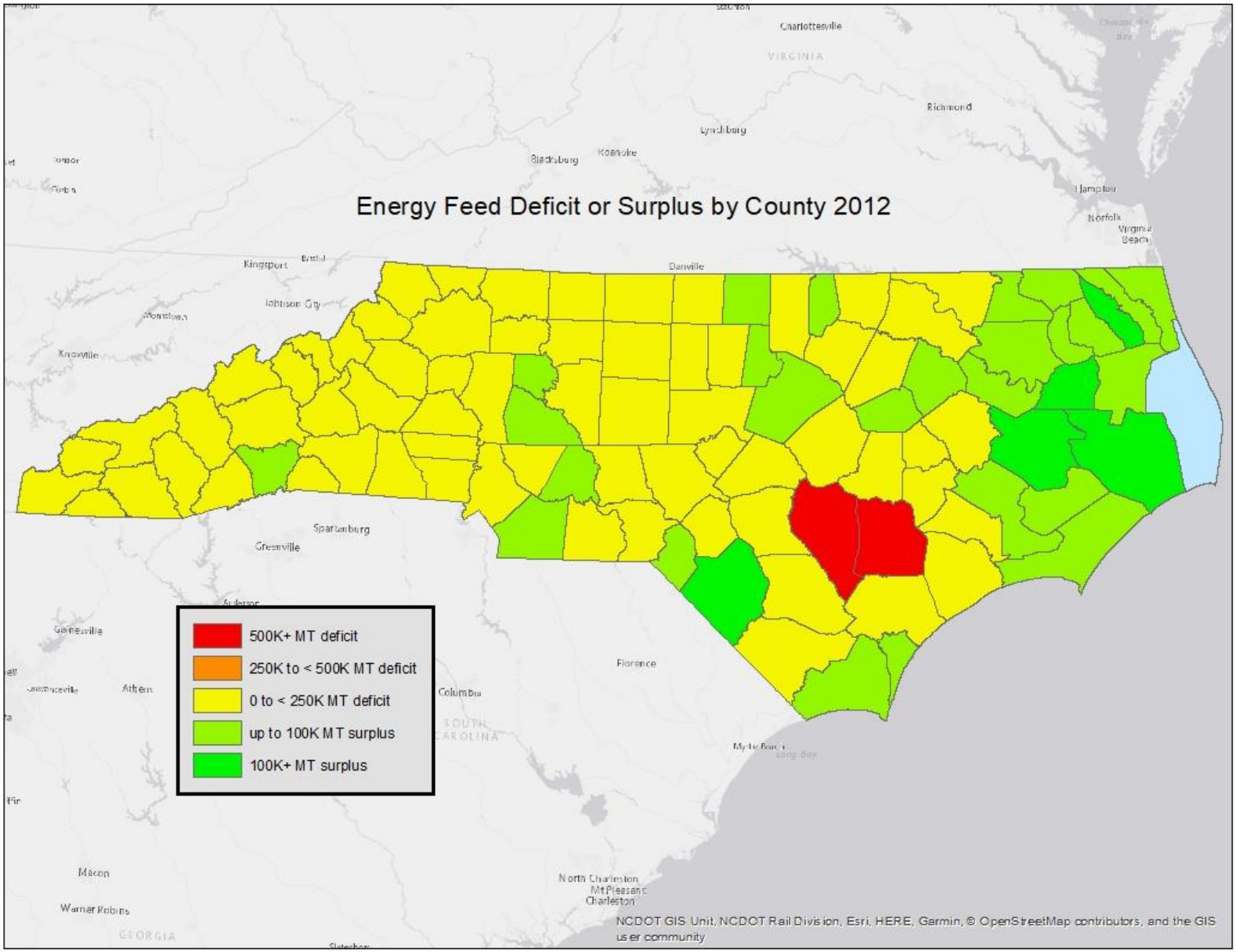
Source: 2012 Commodity Flow Survey Microdata



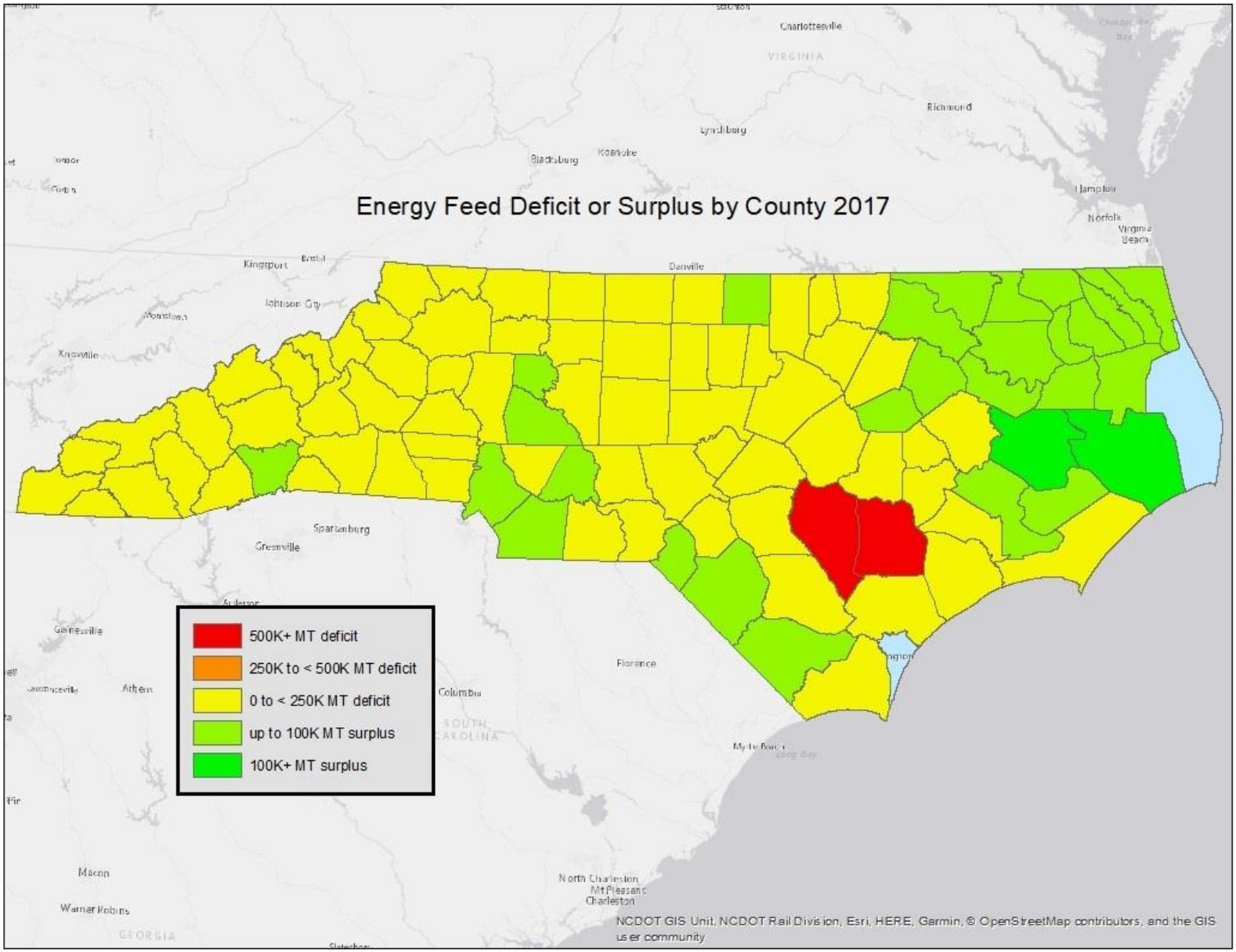
Data Sources: ERSI, USDA NASS



Data Sources: ERSI, USDA NASS



Data Sources: ERSI, USDA NASS



Data Sources: ERSI, USDA NASS

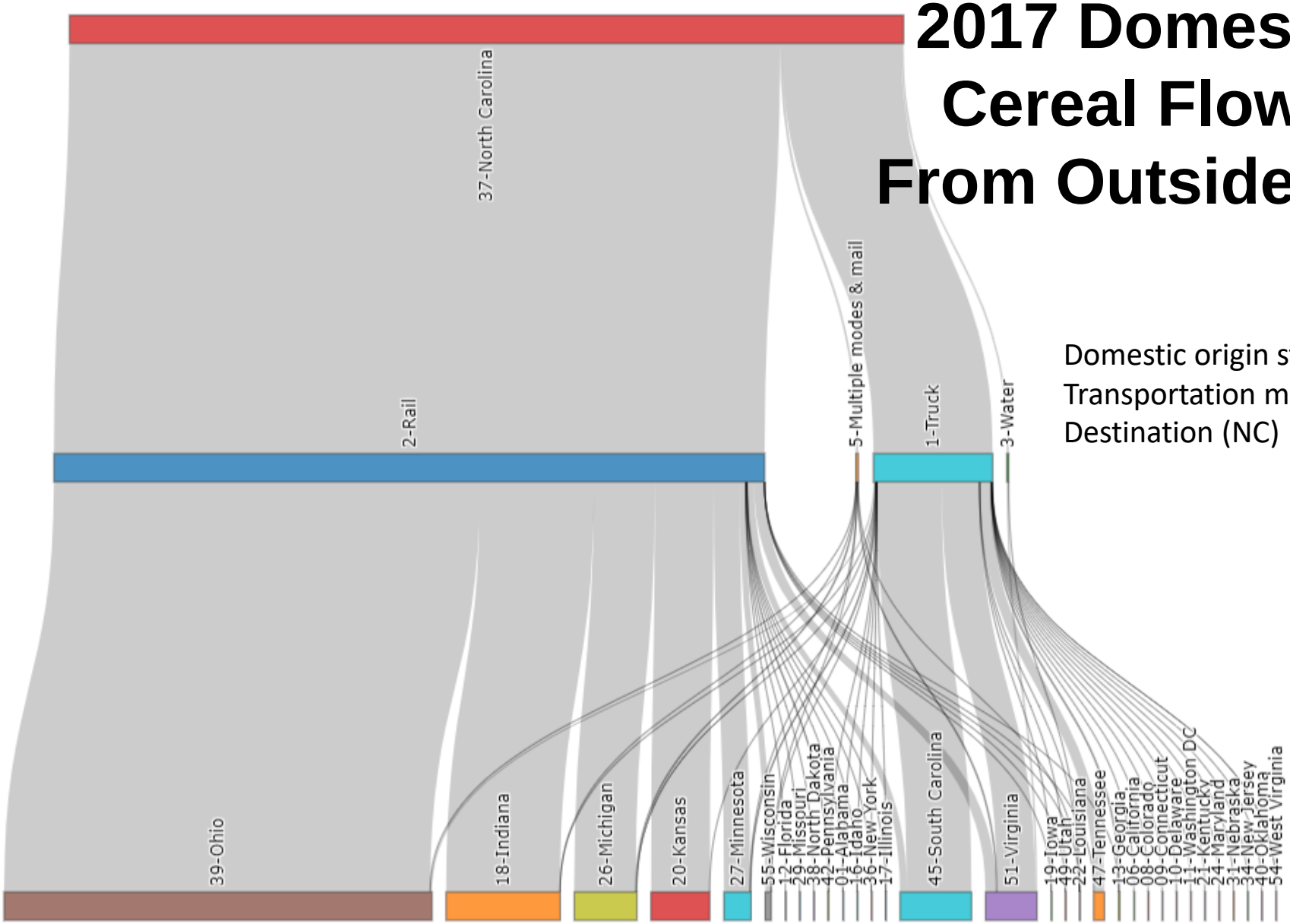
Transportation Profile by Mode: Rail

Most corn sourced domestically outside of NC is imported via rail and NC's feed deficit is largely met with feedstuffs from MI,OH, and IN.

- Imports from adjacent states (SC and VA) are trucked
- Only two Class 1 rail carriers service NC: CSX and Norfolk Southern
  - Most NC regions only have access to a single service provider
  - CSX historically has provided more unit train services (80-120 carloads)
- Most import volume occurs January to June

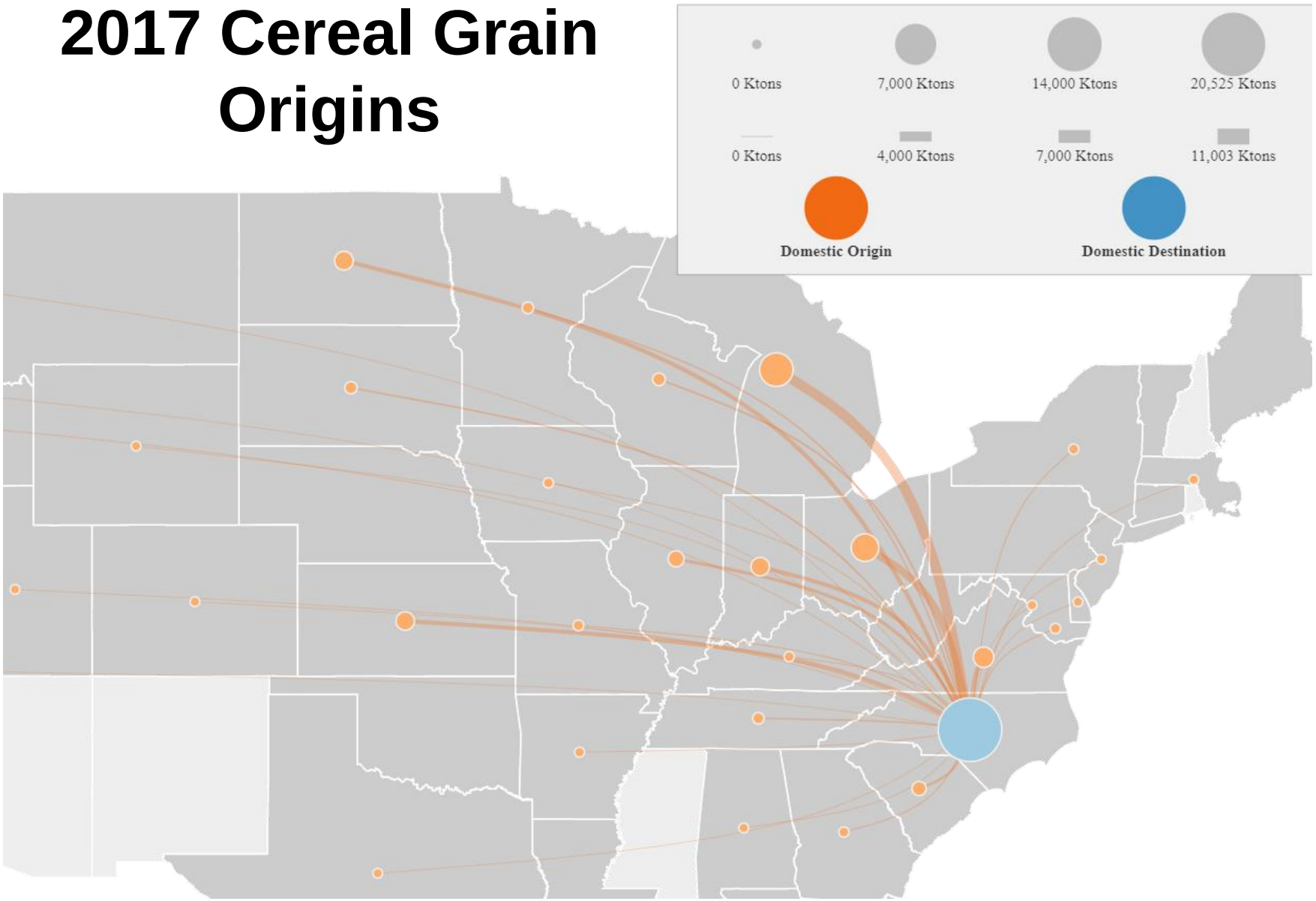
Source: US DOT Freight Analysis Framework 5

2017 Domestic Cereal Flows From Outside NC



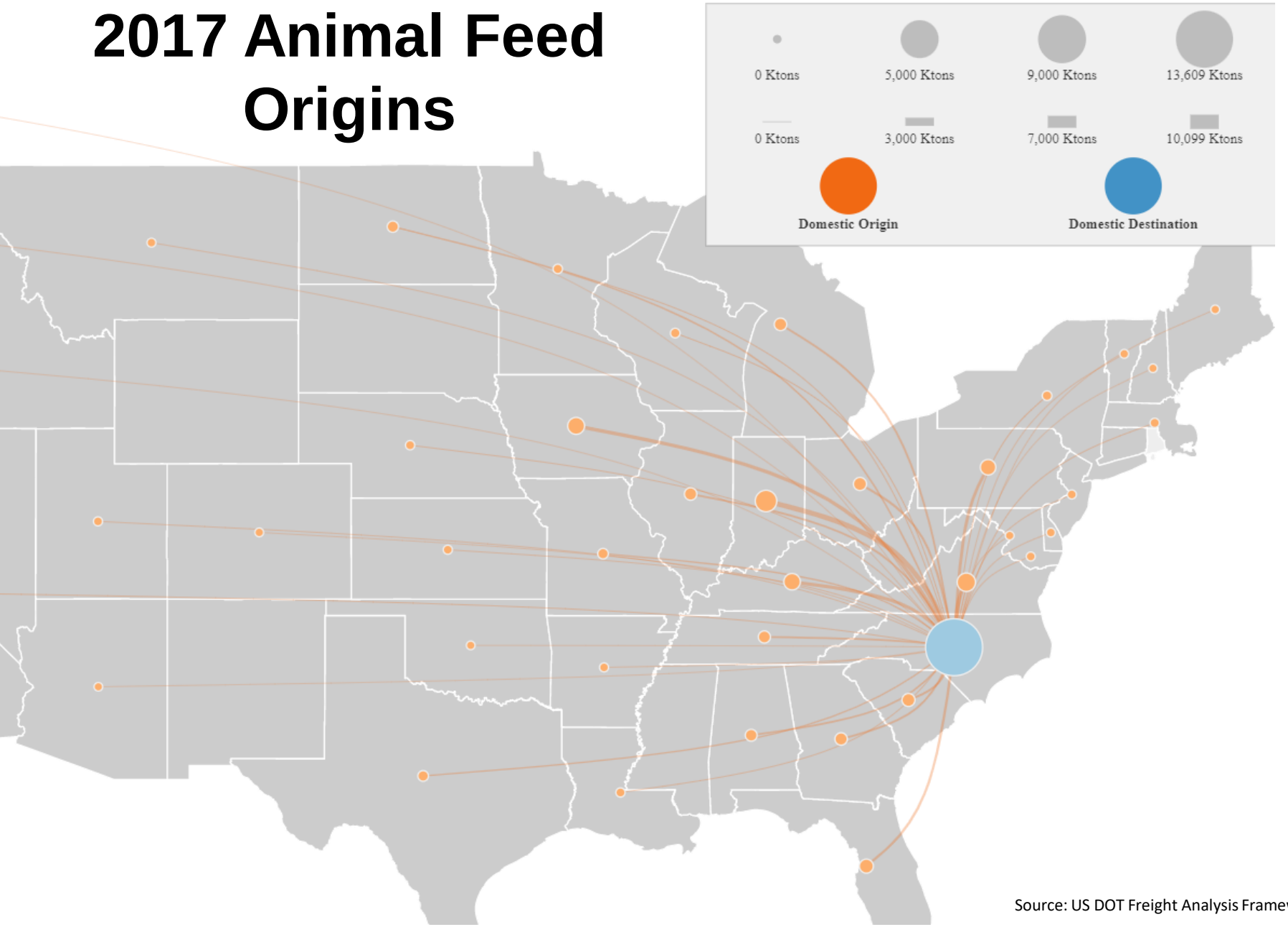
Domestic origin state →
Transportation mode →
Destination (NC)

2017 Cereal Grain Origins



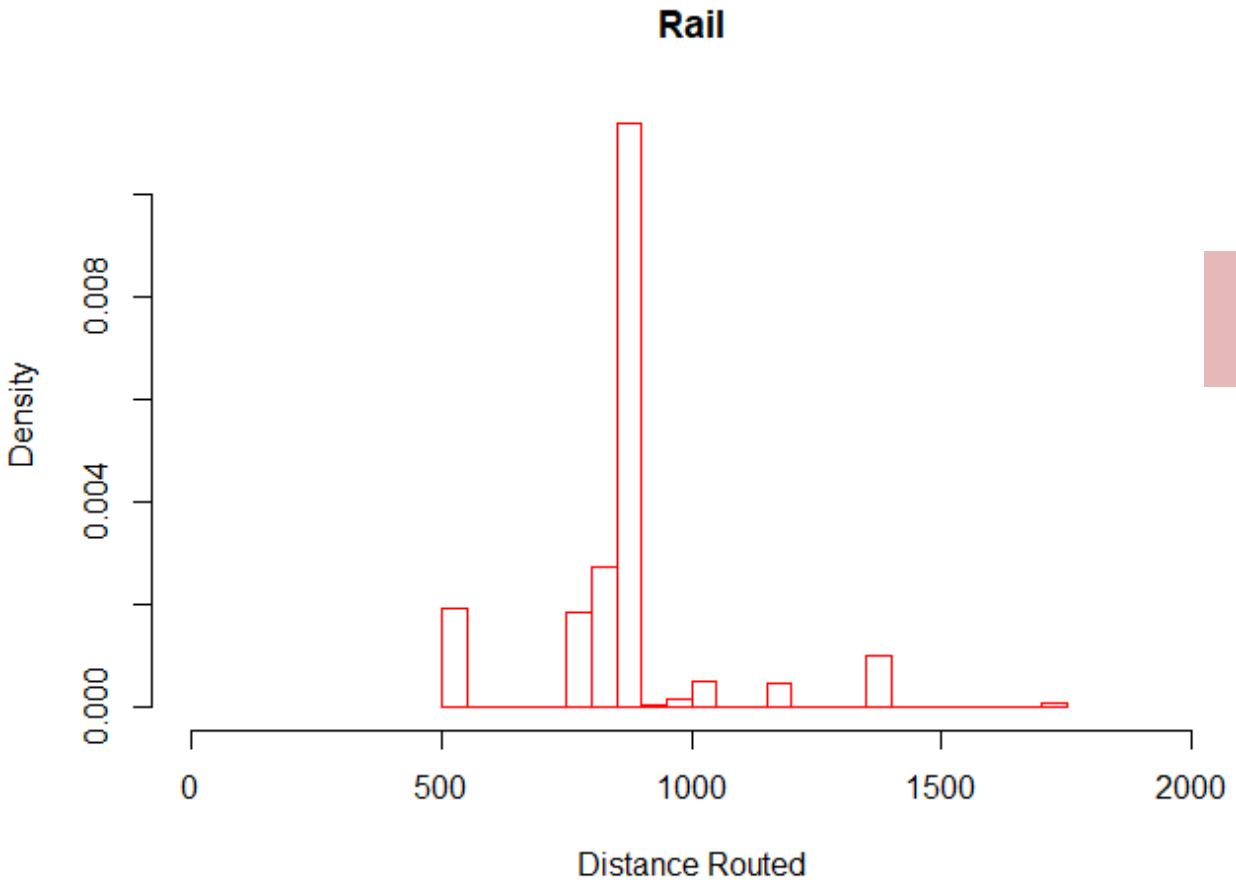
Source: US DOT Freight Analysis Framework 5

2017 Animal Feed Origins



Source: US DOT Freight Analysis Framework 5

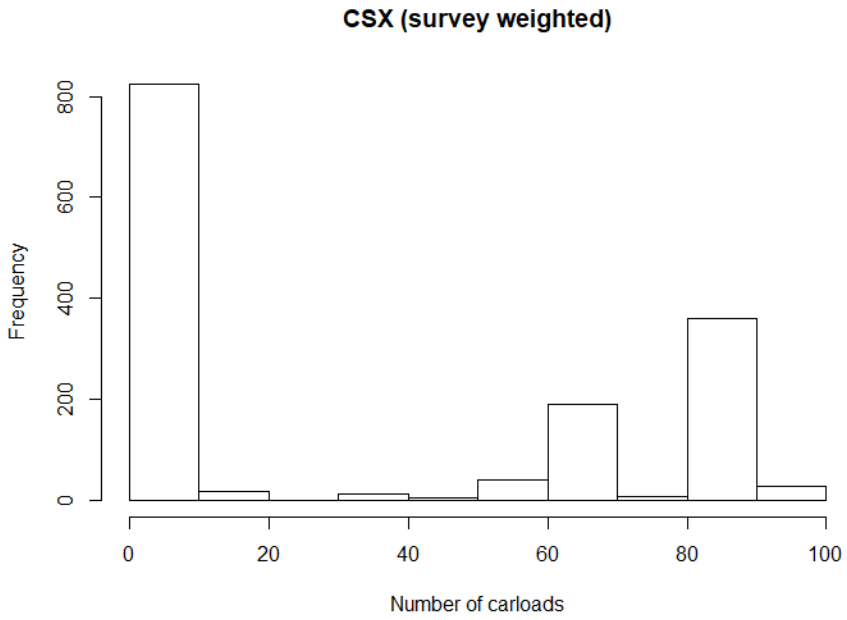
Grain and Oilseed Shipment Distance

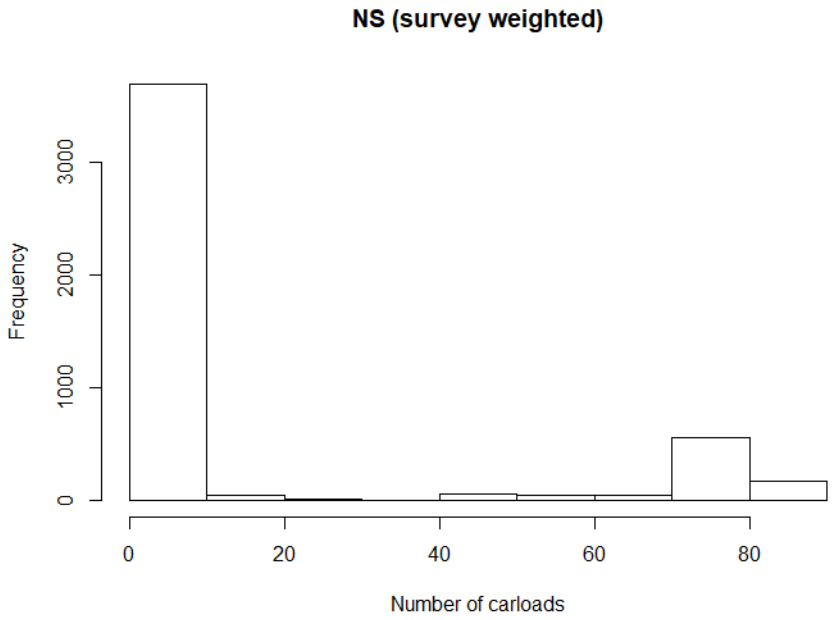


Average distance routed = 874 mi

Source: 2012 Commodity Flow Survey Microdata

Corn Shipments to NC: Number of Carloads 2000-2018





Source: Waybill Sample

Shipment Characteristics Affecting Rail Costs

Decreases in cost per ton-mi
- More carloads
- More miles

Increases in cost per ton-mi
- Fourth quarter is the most expensive time to import corn
- Using railroad-owned cars increases costs
- Purchasing from an origin that requires switching to NS or CSX increases costs

1 ton-mile = 1 ton of freight moved 1 mile

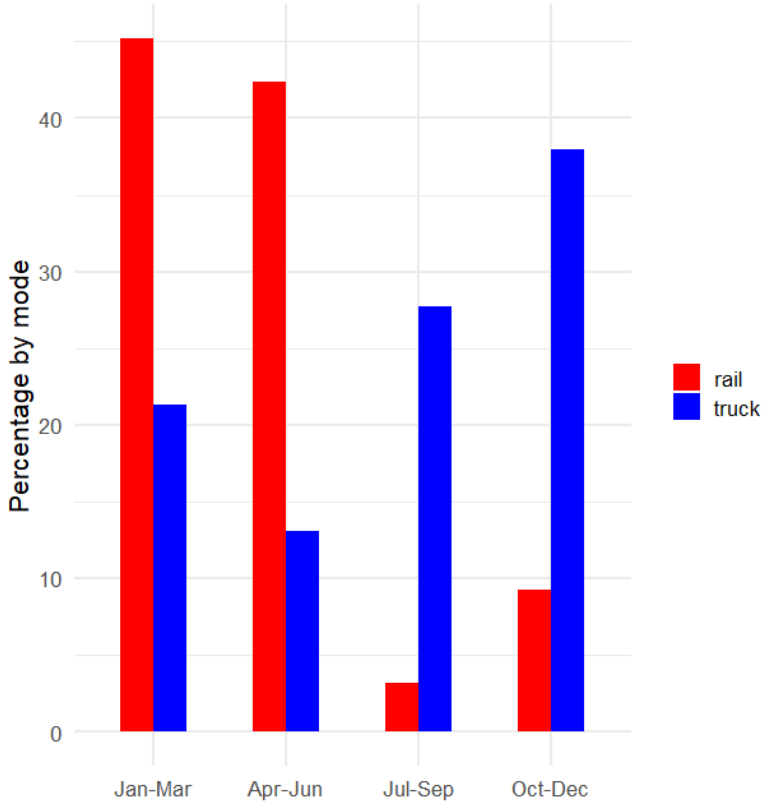
100 ton-miles = **100 tons of freight** moved 1 mile

100 ton-miles = 1 ton of freight **moved 100 miles**

Source: analysis of Waybill Sample data

Rail vs. Truck Movement Timing for Shipments Terminating in NC

Rail and Truck are both seasonal and counter-cyclical to each other



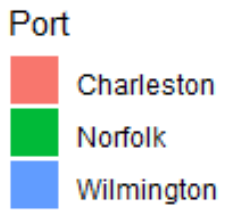
Source: 2012 Commodity Flow Survey Microdata

Transportation Profile by Mode: Boat

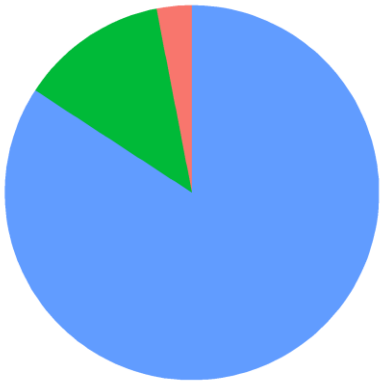
International imports via ships are a substitute for domestic imports of feedstuffs from the Midwest. Since 2005,

- ocean imports for any single commodity are infrequent and on an annual basis have contributed very little towards meeting total NC feed needs
  - there were no energy feed imports in 2006 and 2007
  - the highest quantity of energy feed imports was 12M bu in 2019, less than 5% of total NC energy feed needs
- the majority of “local” international corn imports have arrived via Wilmington
- the majority of “local” international soybean imports have arrived via Norfolk
- the majority of regional international organic grains and oilseeds imports have arrived via Norfolk
- Brazil is a primary origin for Wilmington grain and oilseed imports
- not enough data to determine if ocean imports are likely to happen during a certain time of year

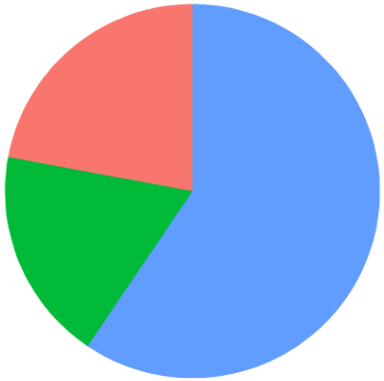
Ocean Imports 2005-2021



Corn



Wheat

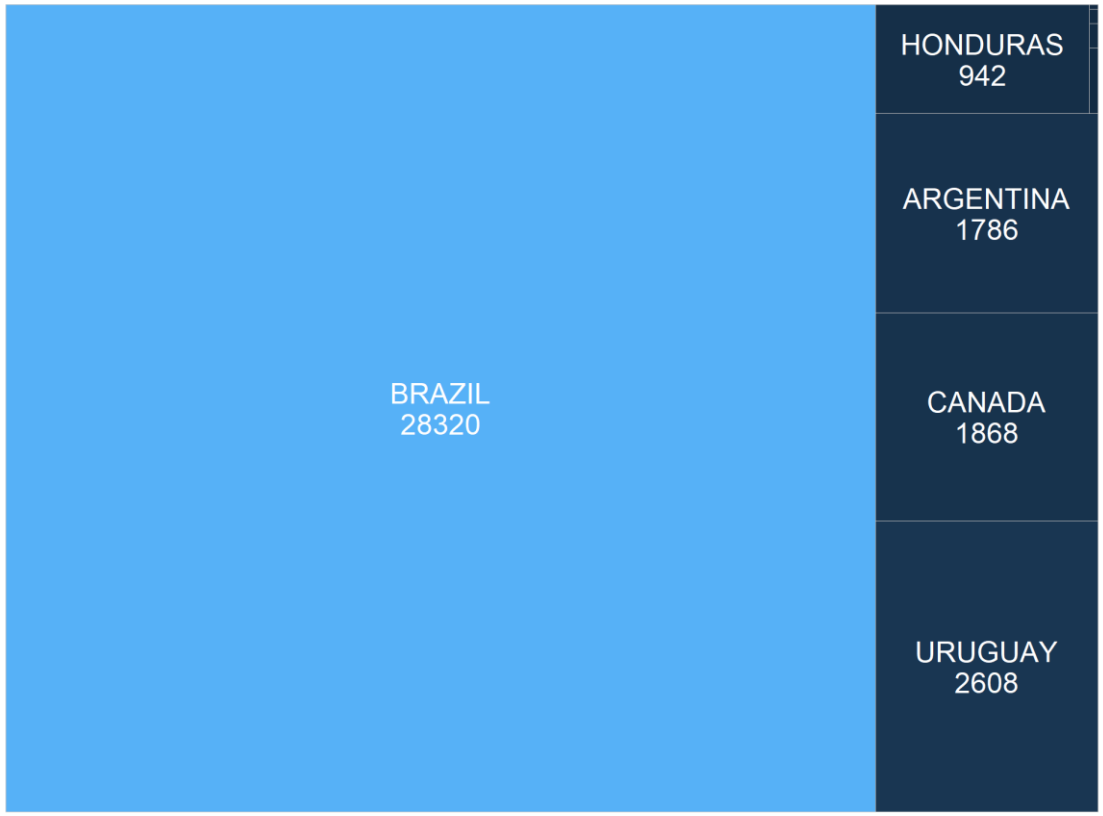


Soybean

Data Source: PIERS

Imported Corn at the Port of Wilmington, 2005 to 2021

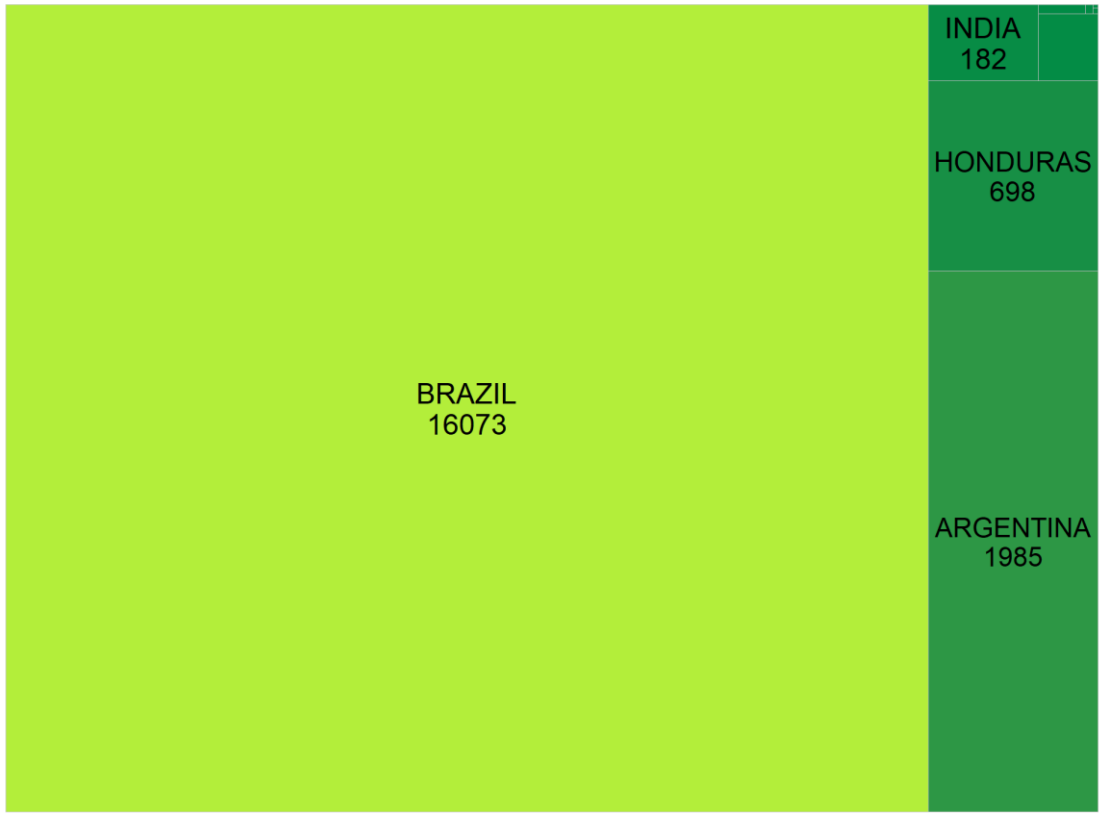
By country of origin (total 35560 thousand bushels)



Data source: PIERS

Imported Soybeans at the Port of Wilmington, 2005 to 2021

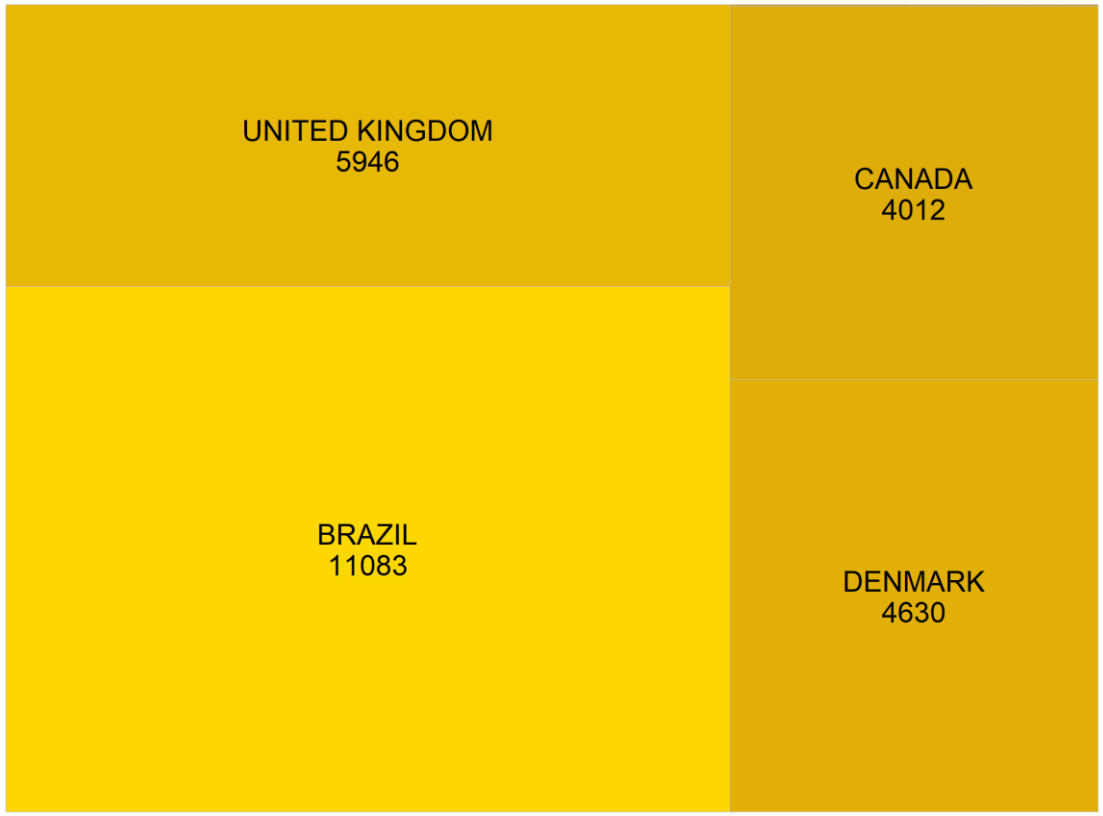
By country of origin (total 19034 thousand bushels)



Data source: PIERS

Imported Wheat at the Port of Wilmington, 2005 to 2021

By country of origin (total 25687 thousand bushels)

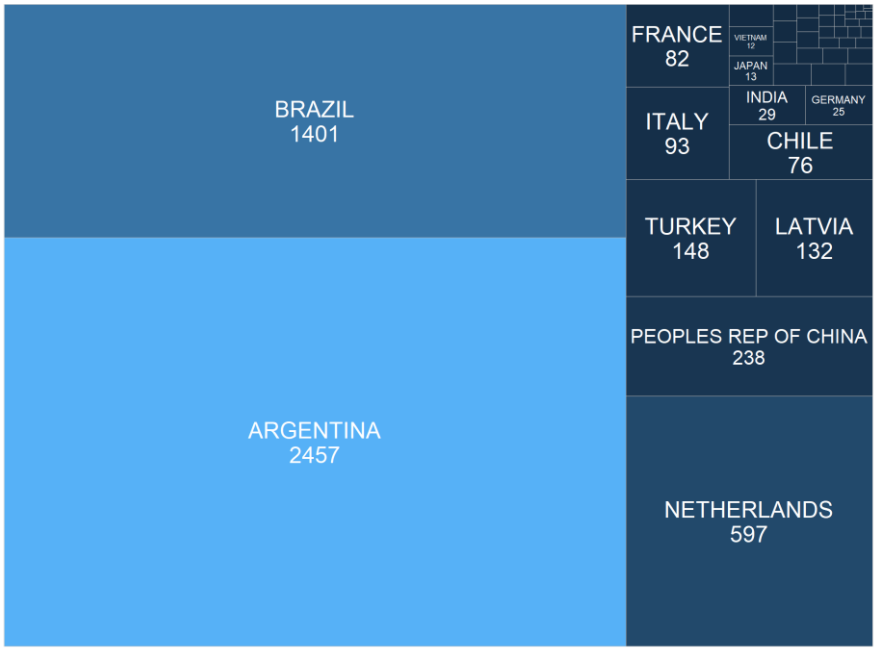


Data source: PIERS

Norfolk

Imported Corn at the Port of Norfolk, 2005 to 2021

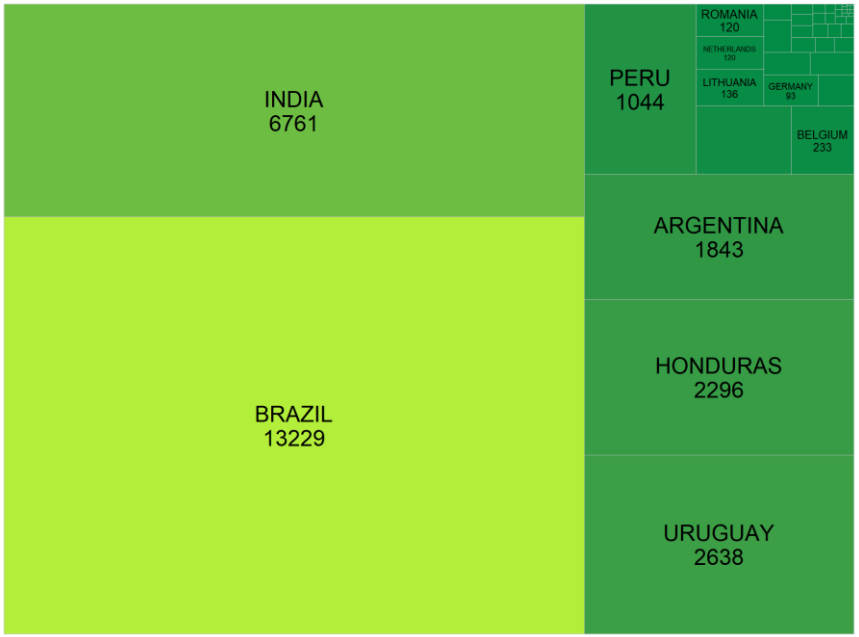
By country of origin (total 5390 thousand bushels)



Data source: PIERS

Imported Soybeans at the Port of Norfolk, 2005 to 2021

By country of origin (total 29280 thousand bushels)

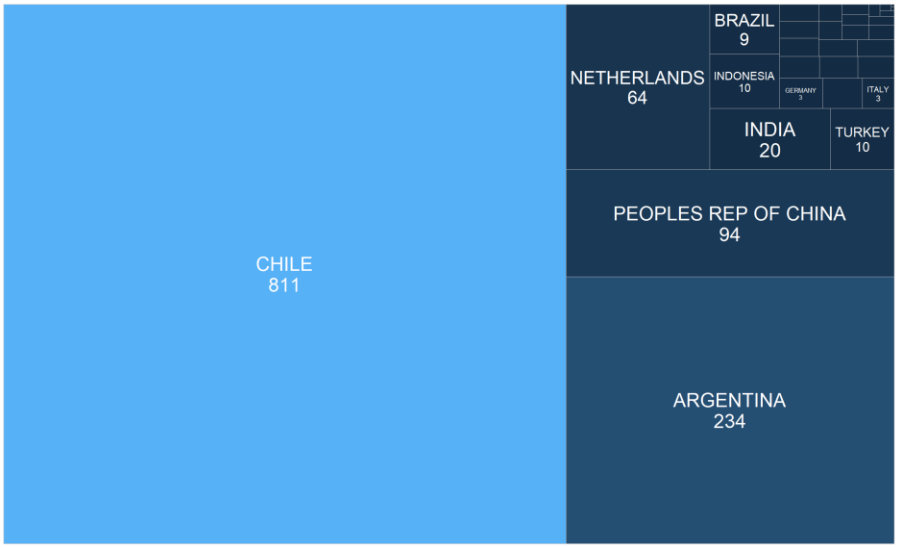


Data source: PIERS

Charleston

Imported Corn at the Port of Charleston, 2005 to 2021

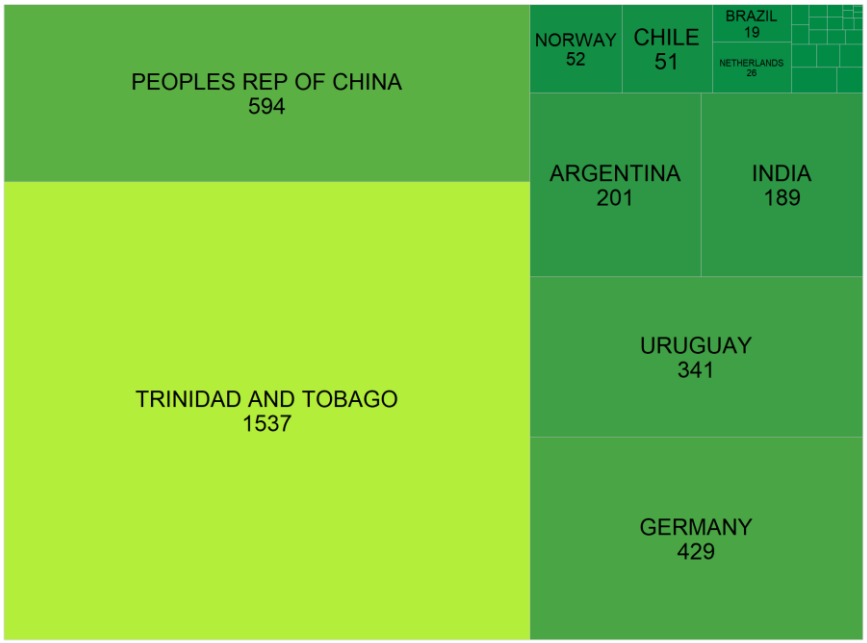
By country of origin (total 1284 thousand bushels)



Data source: PIERS

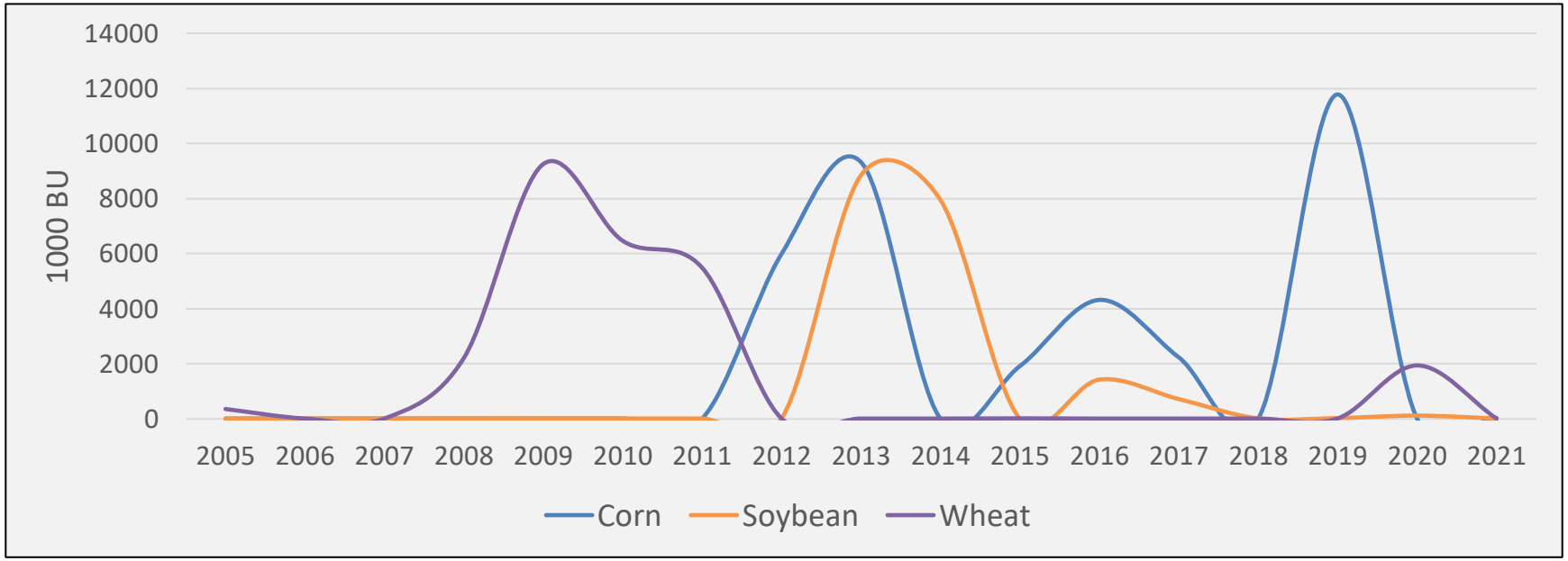
Imported Soybeans at the Port of Charleston, 2005 to 2021

By country of origin (total 3478 thousand bushels)



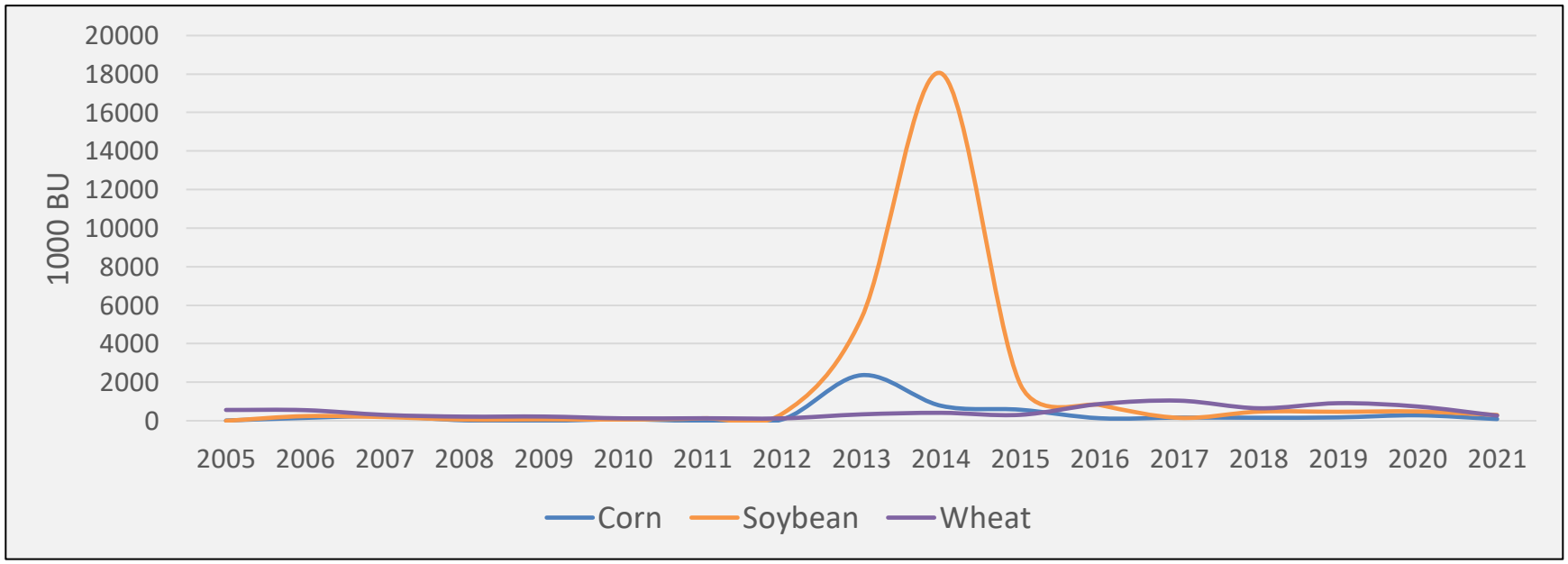
Data source: PIERS

Imports to Port of Wilmington by Commodity



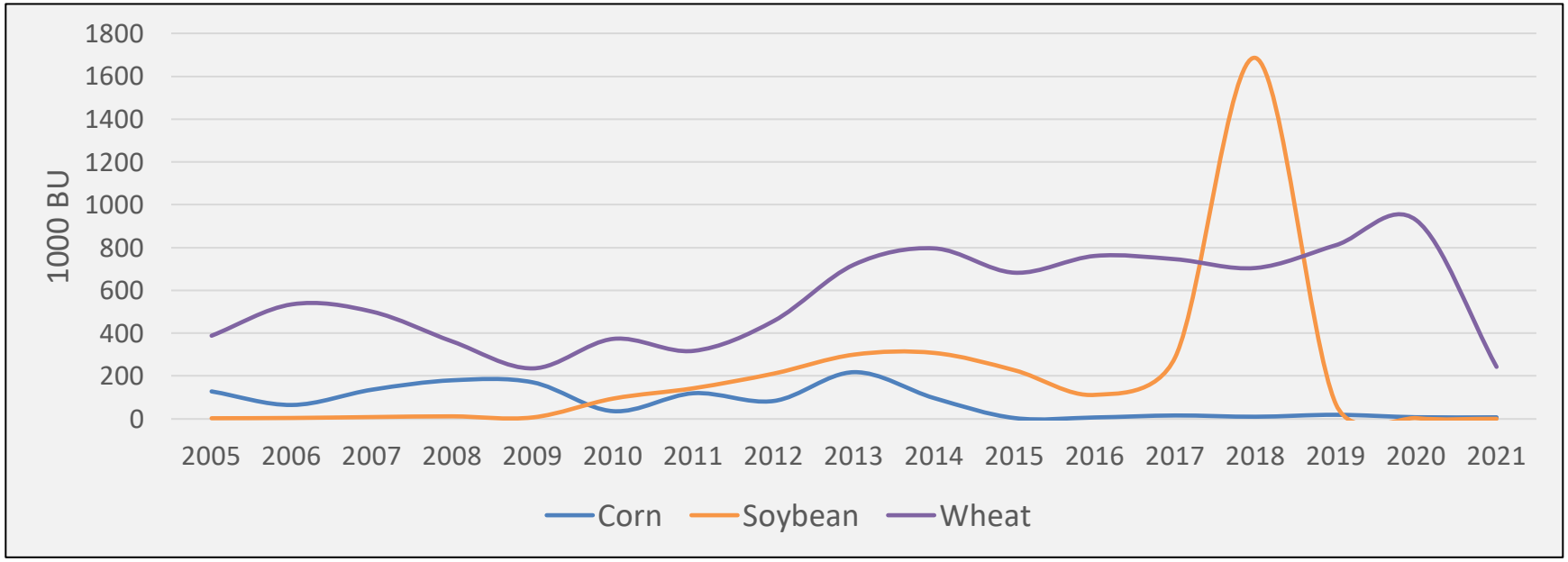
Data Source: PIERS

Imports to Port of Norfolk by Commodity



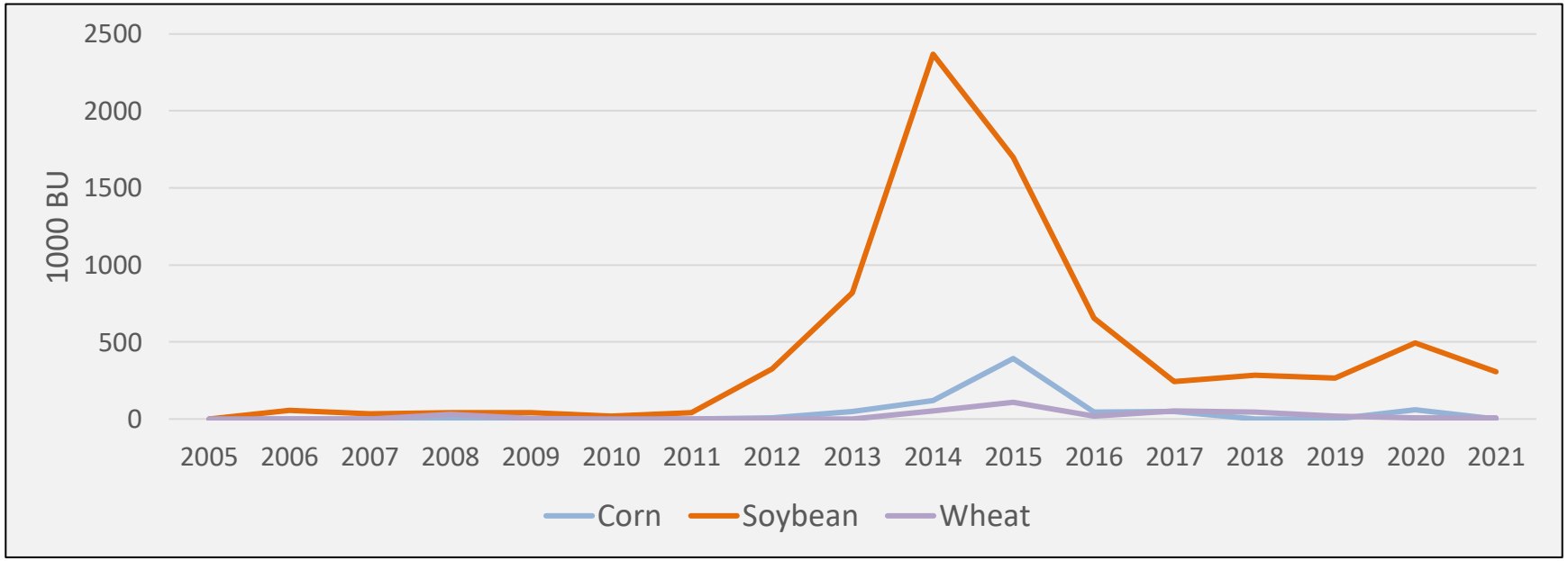
Data Source: PIERS

Imports to Port of Charleston by Commodity



Data Source: PIERS

Total Organic Imports to Norfolk, Wilmington, and Charleston by Commodity



Data Source: PIERS

Organic Imports by Port and Commodity for Years 2005 - 2021

	Port of Wilmington		Port of Norfolk		Port of Charleston	
	Organic Load (1000 BU)	Percent of Total	Organic Load (1000 BU)	Percent of Total	Organic Load (1000 BU)	Percent of Total
Corn	0.00	0.00%	883.01	16.38%	2.30	0.18%
Soybean	188.30	0.99%	7369.15	25.17%	182.00	5.23%
Wheat	0.00	0.00%	340.24	4.27%	7.67	0.08%

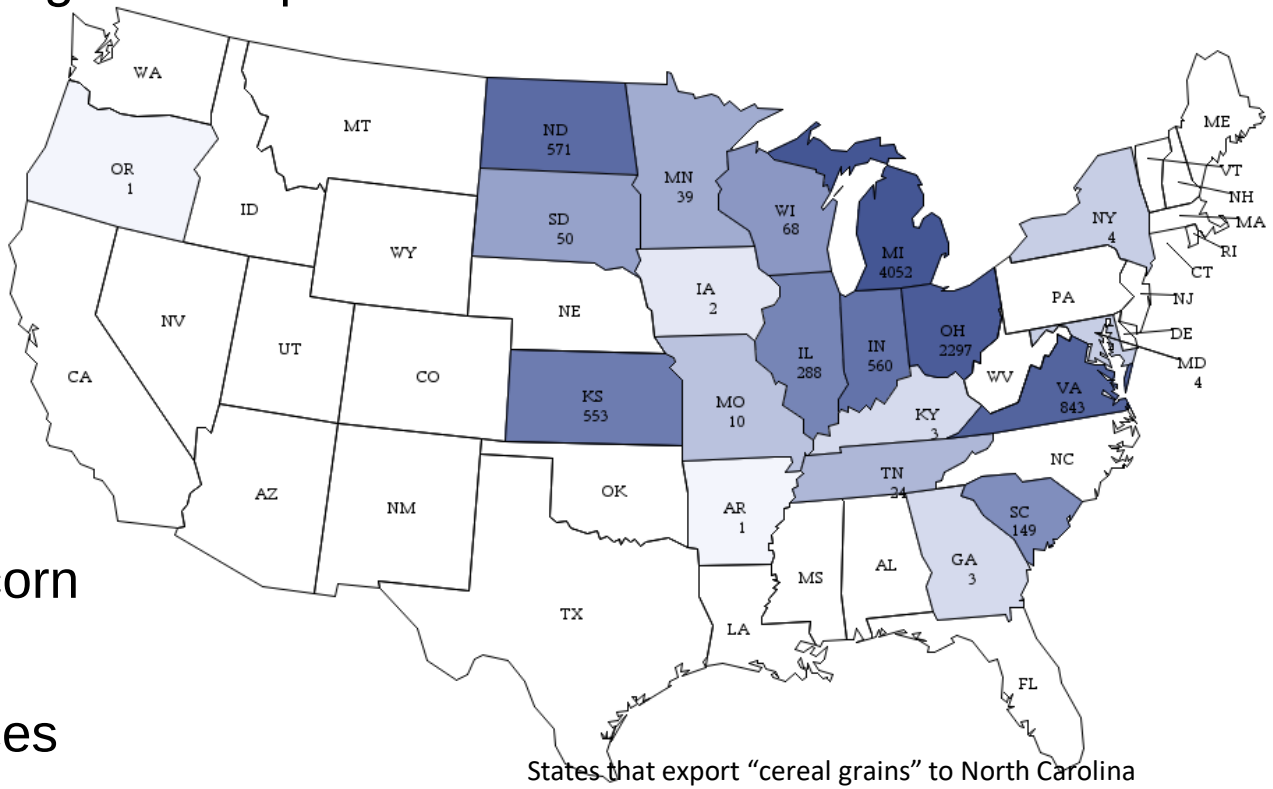
Data Source: PIERS

Robert Thompson's Dissertation Research

- Second chapter of my dissertation is about North Carolina corn markets and basis forecasting
- The dissertation itself can be found by request or from the NC State library
  - I will include the "punchlines" in the slides that follow
  - robert.stan.thompson@gmail.com
- Often Agricultural Economics research is "high level" research that has implications for large markets in general
  - Often not relevant for individual farm level decision making
- This dissertation is a good example of research relevant for individual farm level decision making
  - Shows one example of research that utilizes the new database
  - There are many potential extensions of this research and other research topics that would use the database.

Robert Thompson's Dissertation Research

- According to 2017 Commodity Flow Survey
- Volume of "cereal grains" imported from other states into North Carolina

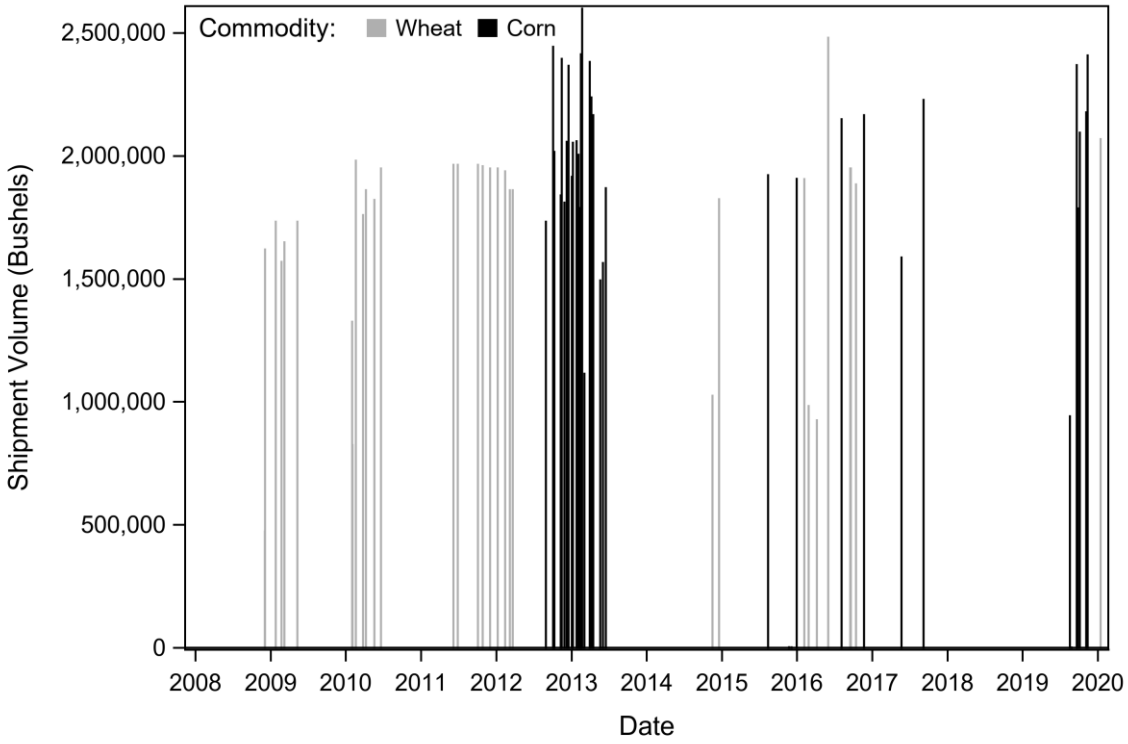


Shows what state corn prices will be relevant for NC prices

States that export "cereal grains" to North Carolina
Note: States that exported more cereal grains to NC have darker shading. Units are Thousands of Tons. States reporting less than one thousand tons are excluded
Source: 2017 Commodity Flow Survey

Robert Thompson's Dissertation Research

- The outside option for sourcing corn – South America



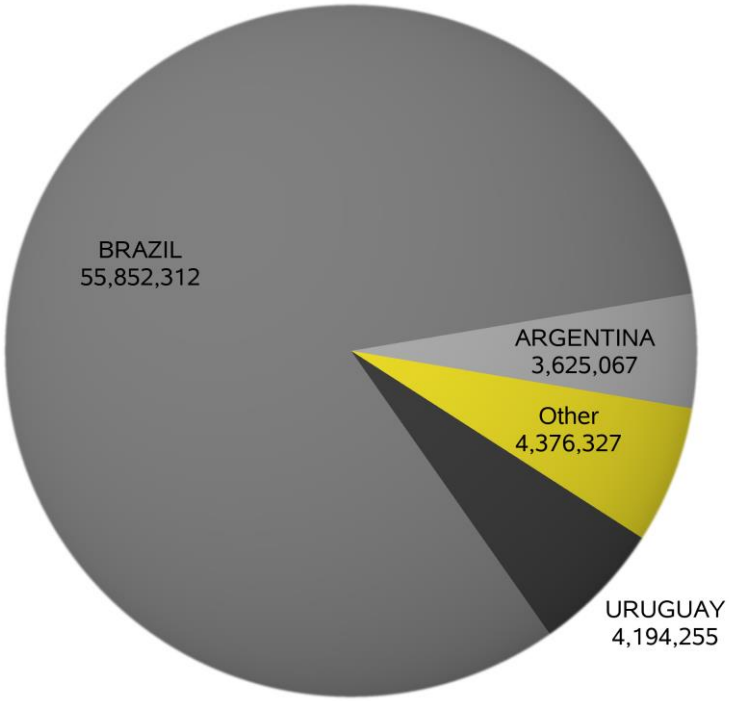
Shipments of Corn and Wheat into the Port of Wilmington
Source: PIERS database

This shows that these shipments are infrequent and relatively small in the grand scheme of NC corn demand

Robert Thompson's Dissertation Research

- The outside option for sourcing corn – South America

Most of the internationally sourced corn comes from Brazil



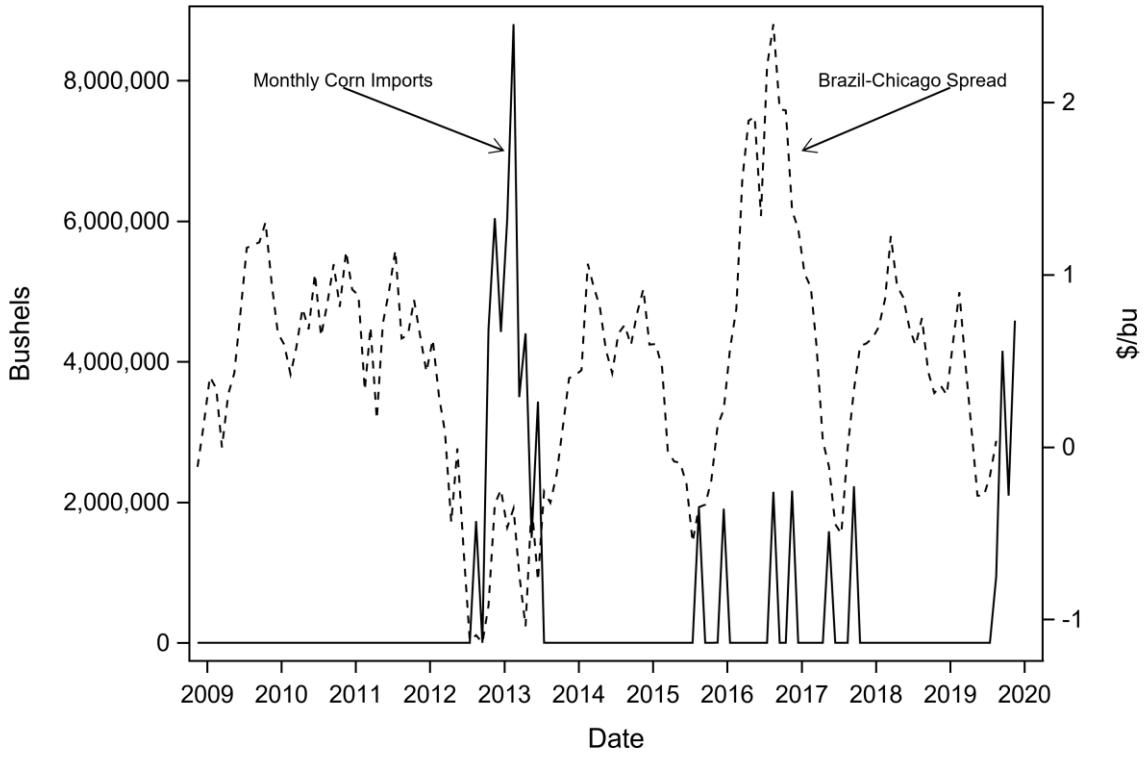
Source of Internationally sourced corn
Source: PIERS database

Robert Thompson's Dissertation Research

- The outside option for sourcing corn – South America

This shows the bottom line - corn is only purchased from Brazil when it is cheap relative to US corn

This is when it is likely corn will be sourced from South America, *and* perhaps more importantly for NC farmers, when South American prices are likely to influence NC prices



Relationship between Brazil - Chicago Spread and Shipments of Corn into the Port of Wilmington
Brazil-Chicago Spread = Nearby Brazil Corn Futures - Nearby Chicago Corn Futures

Robert Thompson's Dissertation Research

- I consider 3 different forecasting methods
  - Simple Moving average
    - Forecast of basis in a certain month is an average of basis in the past few years
  - Forward prices as a forecast
    - Forecast of harvest basis is the current forward price for delivery at harvest
  - New methods
    - Somewhat complicated methods using spatial "arbitrage" relationships that should hold given NC market structure
    - Details can be found in the dissertation, but put simply these methods generate an estimate of transportation costs from the Corn belt in the US (the first sourcing option) and Brazil (the second sourcing option). Then, uses forward prices as a forecast of Corn belt corn prices and Brazil corn futures as a forecast of Brazil corn price. The NC price is then given by the minimum of the price of corn plus transportation from the Corn-belt and Brazil.

Robert Thompson's Dissertation Research

- Simple Moving Average
  - How many previous years should be included?
  - This table shows the average of the absolute value of forecast errors found for the past 20 years using this forecasting method for 3 NC locations
  - Smaller values mean better forecast
  - A 3 year average seems to be the best option overall

Table 2.1 Mean Absolute Errors for Moving Average Forecasts

		Years Included in Moving Average								
		1			3			5		
Location	Month	N	MAE	Std Dev	N	MAE	Std Dev	N	MAE	Std Dev
Rose Hill	1	19	0.093	0.097	17	**0.088**	0.067	15	0.095	0.059
	2	19	0.098	0.093	17	**0.086**	0.055	15	0.095	0.061
	3	20	0.132	0.152	18	**0.088**	0.065	16	0.106	0.065
	4	20	0.132	0.154	18	**0.086**	0.074	16	0.098	0.078
	5	20	0.172	0.170	18	0.105	0.089	16	**0.101**	0.102
	6	19	0.207	0.203	17	**0.166**	0.180	15	0.172	0.164
	7	15	0.206	0.157	11	0.163	0.109	8	**0.127**	0.113
	8	17	0.119	0.105	13	**0.079**	0.101	9	0.112	0.090
	9	19	**0.130**	0.109	17	0.148	0.109	15	0.165	0.105
	10	19	0.155	0.124	17	**0.151**	0.105	15	0.156	0.102
	11	19	0.132	0.101	17	**0.123**	0.075	15	0.139	0.070
	12	19	0.112	0.105	17	0.100	0.061	15	**0.092**	0.081
Candor	1	19	0.106	0.084	17	**0.102**	0.088	15	0.110	0.093
	2	19	**0.103**	0.078	17	0.104	0.077	15	0.112	0.083
	3	20	0.117	0.078	18	**0.113**	0.079	16	0.124	0.088
	4	20	0.112	0.069	18	**0.108**	0.068	16	0.113	0.087
	5	20	0.141	0.103	18	**0.130**	0.112	16	0.143	0.121
	6	19	0.133	0.091	17	**0.117**	0.088	15	0.127	0.102
	7	19	0.191	0.140	17	**0.154**	0.148	15	0.166	0.161
	8	19	0.121	0.080	17	**0.113**	0.093	15	0.122	0.110
	9	19	**0.112**	0.099	17	0.136	0.079	15	0.137	0.096
	10	19	0.134	0.112	17	**0.130**	0.093	15	0.130	0.110
	11	19	0.128	0.096	17	0.112	0.094	15	**0.110**	0.105
	12	19	0.113	0.087	17	**0.108**	0.095	15	0.117	0.092
Cofield	1	19	**0.093**	0.080	17	0.094	0.065	15	0.098	0.076
	2	19	**0.105**	0.085	17	0.108	0.075	15	0.116	0.075
	3	20	**0.129**	0.115	18	0.133	0.103	16	0.152	0.092
	4	20	0.136	0.095	18	0.133	0.098	16	**0.131**	0.093
	5	20	0.149	0.122	18	**0.149**	0.101	16	0.160	0.100
	6	18	0.146	0.119	14	0.148	0.090	10	**0.143**	0.104
	7	19	0.260	0.266	17	**0.228**	0.201	15	0.244	0.238
	8	19	**0.143**	0.133	17	0.154	0.095	15	0.145	0.108
	9	19	0.106	0.072	17	**0.105**	0.079	15	0.112	0.084
	10	19	0.107	0.077	17	0.101	0.068	15	**0.097**	0.089
	11	19	0.098	0.080	17	**0.083**	0.062	15	0.088	0.068
	12	19	0.123	0.099	17	0.105	0.089	15	**0.092**	0.105

Note: The lowest Mean Absolute Error is surrounded by a box.

Robert Thompson's Dissertation Research

- Simple Moving Average
  - Same information but plotted by month with range of uncertainty
  - Summer months have the poorest performance – but they also have the largest basis variability in general

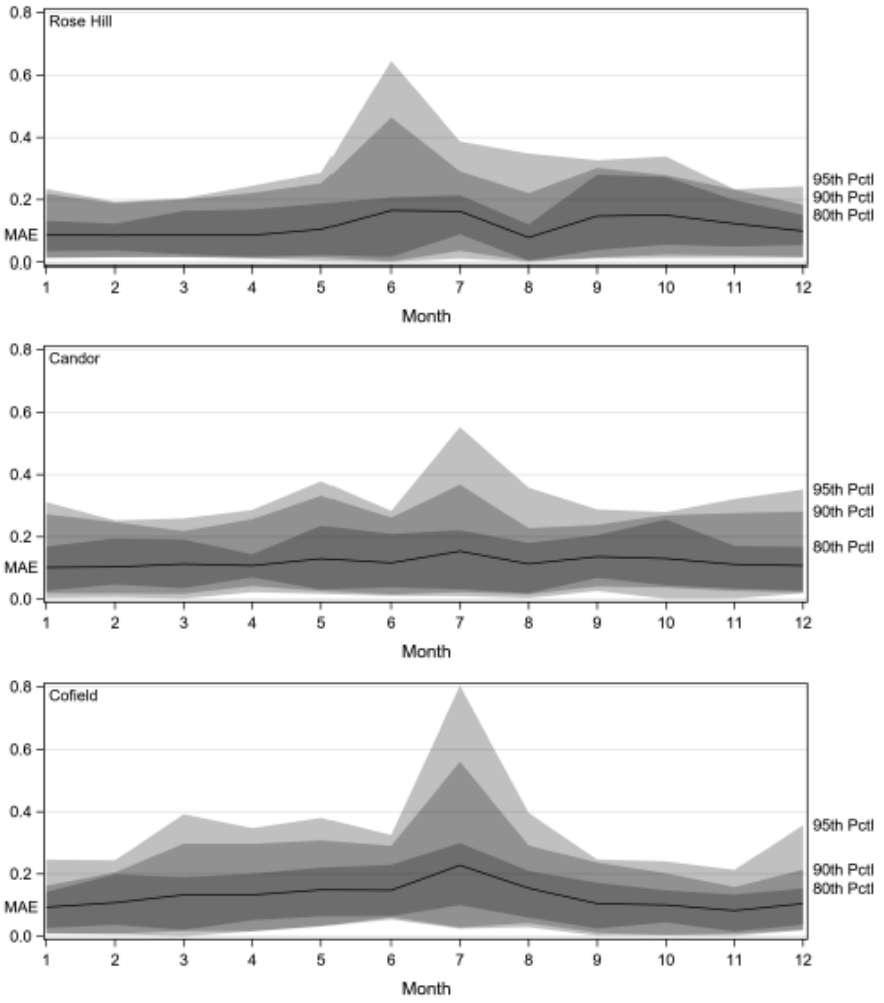


Figure 2.7 Mean Absolute Errors of 3 Year Moving Average Forecasts by Month

Robert Thompson's Dissertation Research

- Regression Based Methods
  - Variables
    - Monthly dummy variables, NC production, Michigan Basis, lagged NC basis
  - Parameter estimate for NC Production is negative and significant for this regression
    - This implies that as NC Production increases, NC basis decreases
    - i.e. bumper crops are associated with high basis and crop failures with low basis
  - Parameter Estimate for Michigan basis is positive and significant
    - This implies that as Michigan (or eastern cornbelt in general) increases, so does NC basis
    - This is because this is the primary outside option for NC imports of corn
  - Figure here shows average forecast error by "horizon", i.e. how many months in the future the forecast was made

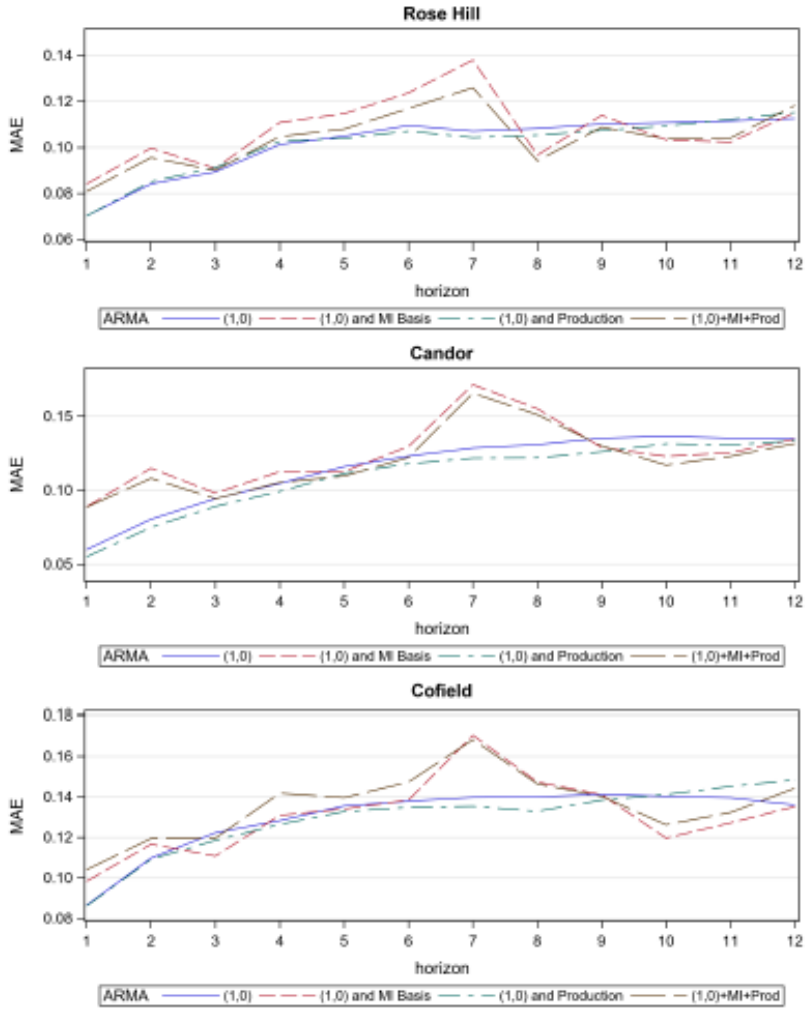


Figure 2.14 MAE of Forecasts produced with Regression Equation 2.19 by horizon

Robert Thompson's Dissertation Research

- Regression Based Methods
  - This shows that the forecasts made with only monthly dummy variables and lagged NC basis perform relatively well – there is not much gained (in terms of forecast accuracy) by including other variables in the regression
  - This simple specification may be preferred for practical purposes since it only requires NC basis data
  - The specification with NC production require yearly production data which can be obtained from USDA NASS quick stats very easily (https://quickstats.nass.usda.gov)
  - The specification with Michigan basis included may be preferred at longer forecast horizons, but basis data is more difficult to obtain
    - Forward price data is also required to make the forecasts with Michigan basis data

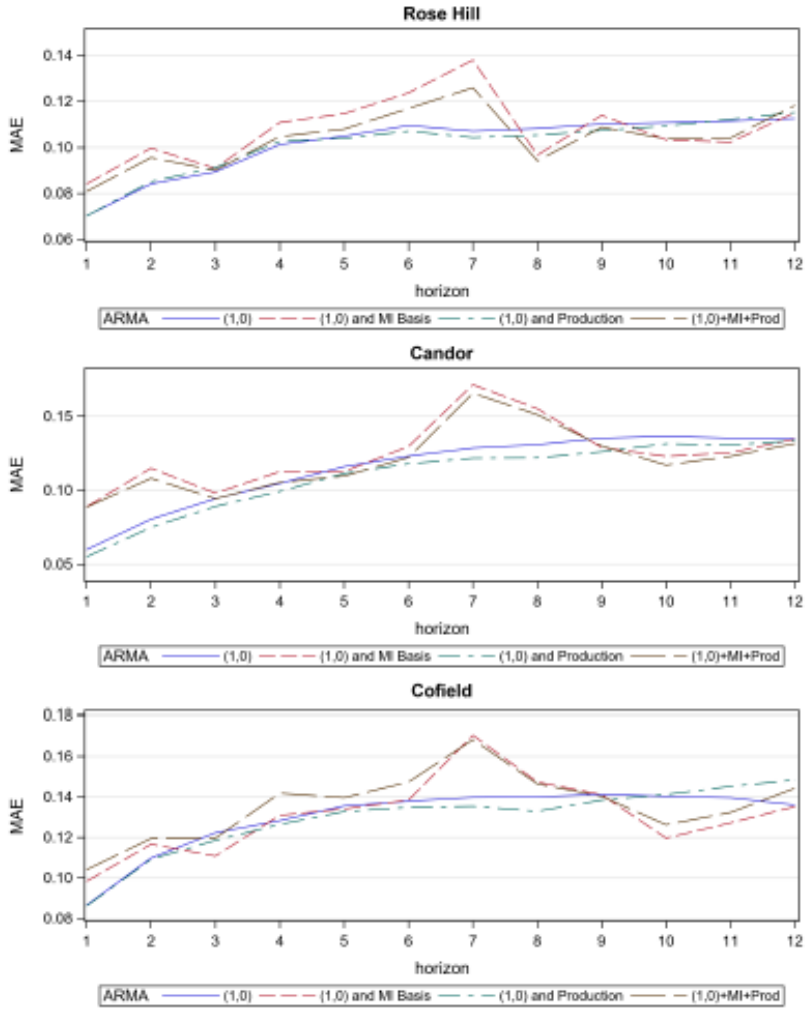


Figure 2.14 MAE of Forecasts produced with Regression Equation 2.19 by horizon

Robert Thompson's Dissertation Research

- Forward prices as a forecast
  - IMPORTANT: Only have data on forward prices for delivery at harvest – so these results are only relevant for forecasts of harvest basis
  - Uncertain whether results would hold for other delivery months, research at other markets show there can be large differences in performance for different delivery months
  - In general this method outperforms the 3 year average forecasts and errors are lower for forecasts made closer to harvest

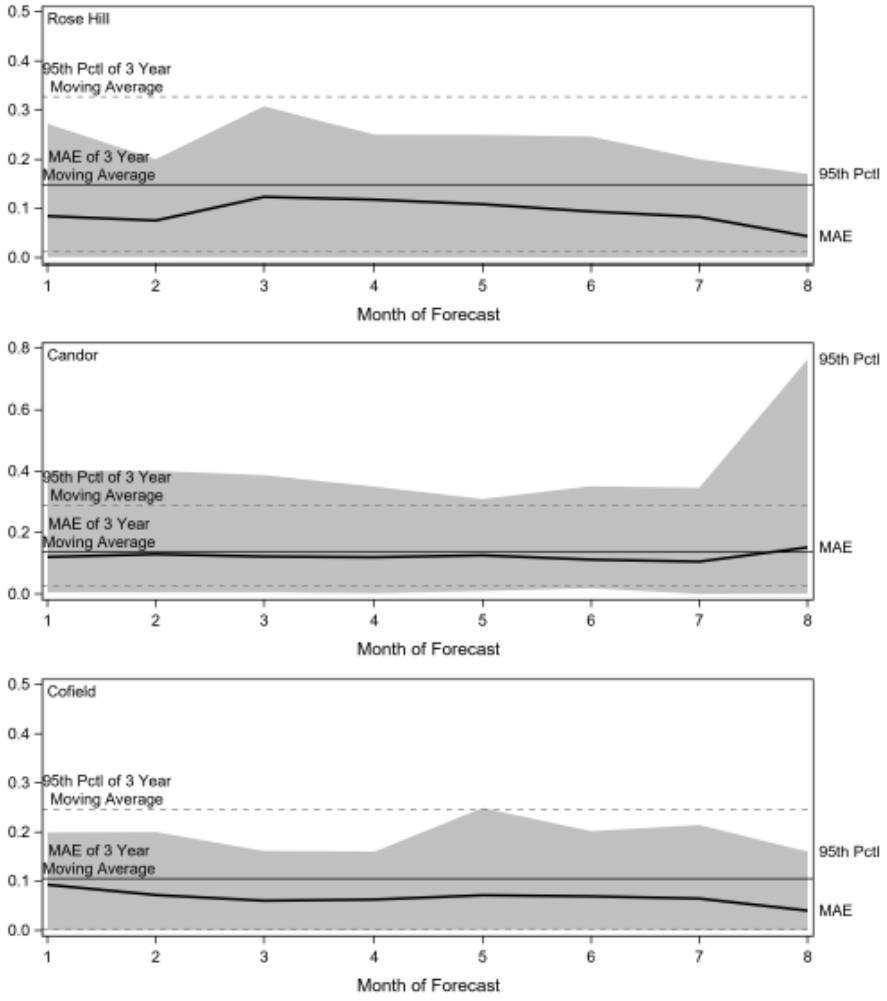


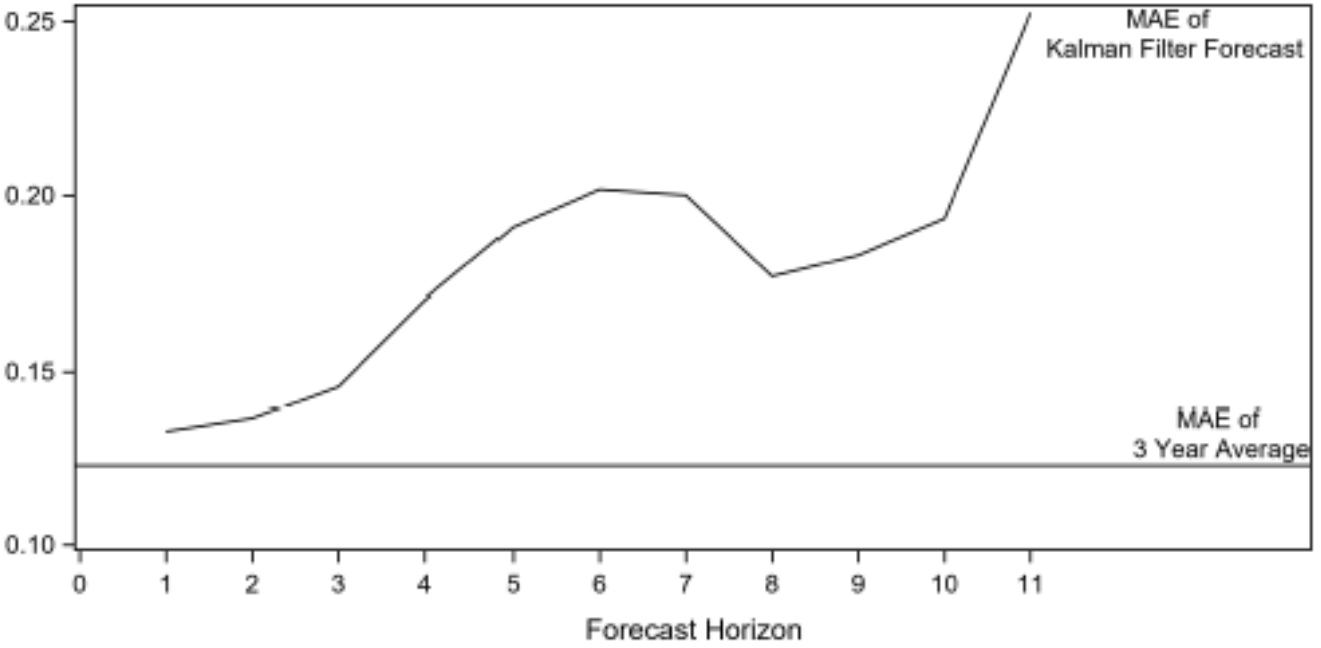
Figure 2.8 Mean Errors and Percentiles of Forward Prices as a Forecast in Comparison to the 3 Year Average Forecast Method

Robert Thompson's Dissertation Research

- Forward prices as a forecast
  - Lots of research for this method on other markets show there is a "risk premium" in forward prices.
  - In other markets this risk premium is implicitly paid by farmers to buyers in the form of harvest forward contract prices that are lower on average than spot prices at harvest
    - The idea is that farmers are willing to accept lower prices on average in order to eliminate price risk
  - Other research focuses on grain surplus regions, NC is different in that it is grain deficit
  - This risk premium is non-existent in NC markets! This means:
    1) Forward prices are an unbiased forecast of prices at harvest
    2) Forward contracting is an attractive option – relative to the case of a risk premium being present
  - This was done for Rose Hill, Candor, and Cofield, but preliminary work shows no risk premium was found for any of the other markets included in the database

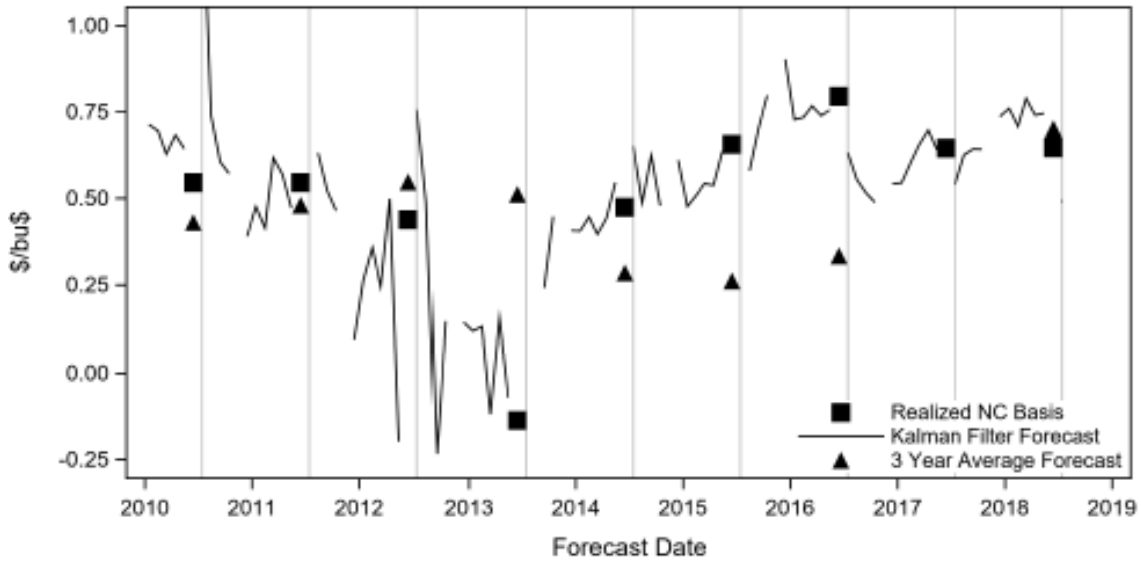
Robert Thompson's Dissertation Research

- New Method – The "Kalman Filter Method"
  - Performs poorly relative to the simpler 3 year average method
  - However,
    - It is an unbiased forecasting method
    - Performs better during certain time periods – namely when corn is being sourced from South America



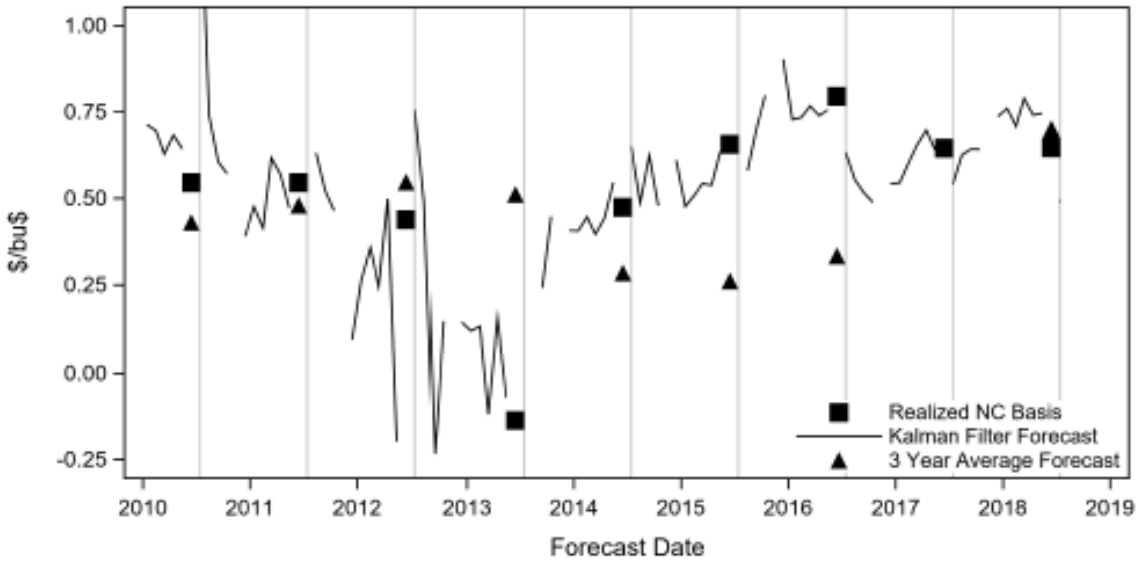
Robert Thompson's Dissertation Research

- New Method – The "Kalman Filter Method"
  - This method has promise – just needs some kinks to be worked out
  - For example, below shows June basis forecasts and realized basis by the 3 year average method and the Kalman filter method
  - Kalman filter method is "noisier" but predicts well during 2013 when corn was imported from Brazil in large quantities



Robert Thompson's Dissertation Research

- New Method – The "Kalman Filter Method"
  - This research should be continued, I identify several potential improvements in the dissertation
  - The main advantage for this method could be an "early warning system" for predicting large drops in basis if South American corn prices ever become very low relative to US prices



Robert Thompson's Dissertation Research

- Main points
  - 3 year average works pretty well
  - If forward prices for harvest are available, they work a little better
  - New methods show promise, but the simpler methods are better in general
    - If some improvements can be made it would be good to integrate these methods into an online tool that would display forecasts
  - Dissertation should be publicly available at the link below

https://repository.lib.ncsu.edu/handle/1840.20/39332

  - Please let me know if any questions or if you would like more details about the forecasting methods/how to improve them

THE END