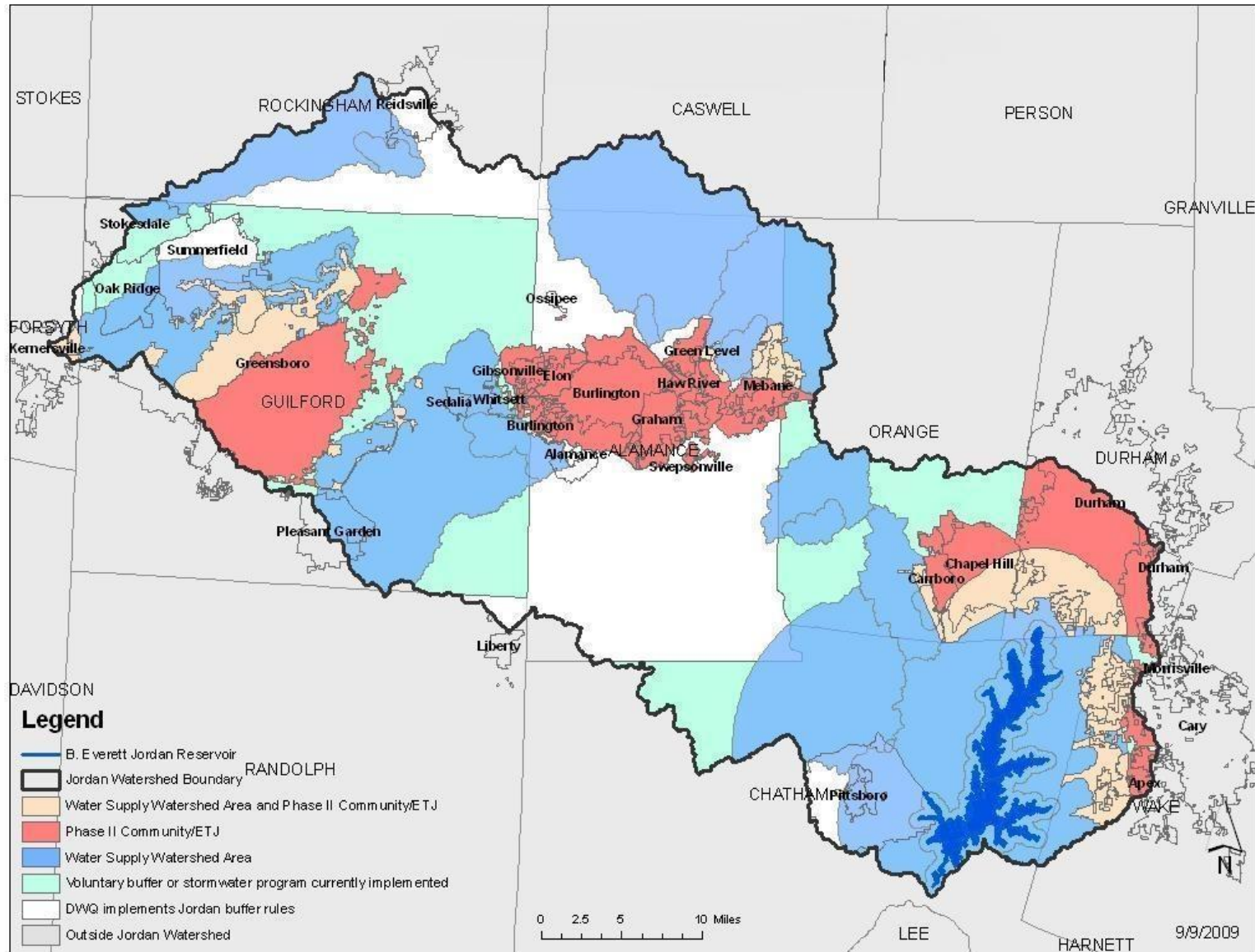


Nitrogen Loading in the Upper New Hope Arm of the Jordan Lake Watershed

Capstone Final Report Spring 2012
UNC Institute for the Environment

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Jordan Lake Rules

- Nutrient management strategy
- Items addressed
 - Wastewater discharges
 - Stormwater runoff from new and existing development
 - Agriculture
 - Fertilizer Application
- Effective August 11th, 2009

Nitrogen Mass Balance

INPUTS

Natural inputs of fixed Nitrogen

- **Deposition**
 - Wet and Dry
- Over ground water inflows
- Wildlife waste
- Ecosystem Fixation

Anthropogenic Nitrogen inputs

- **Food Import**
 - Septic Output
 - Wastewater Discharge
- Fertilizer Import
 - **Lawn fertilizer application**
 - Agricultural runoff and waste

ECOSYSTEM CYCLING & ACCUMULATION

- Biological sequestration
- Deposition in soil (vadose zone and groundwater) and ponds
- Nitrogen processing and cycling
- Sequestration in lakes/reservoirs

OUTPUTS

Deliberate export

- Farm Export
- Biosolids
- Denitrification

Natural export

- Denitrification
 - Ecosystem
- Stream Loads
- Volatilization
- Assimilation by riparian vegetation or aquatic organisms

Methods

- Household lawn fertilizer surveys
- Water sampling
- Literature reviews
- Spatial analysis
- Modeling of compiled data

Household Lawn Fertilizer Survey

- Chose neighborhood sites
- Created survey instrument
 - IRB review
 - Analysis components
 - Numerical
 - Social
- Analyzed results



Lawn Area: GIS & Remote Sensing

- 2010 aerial images obtained from the Orange County GIS Division
- Lawn area calculated using the 'measure' tool; polygons drawn around grassy areas on each property
- Calculated 3 times, by 3 separate people

Lawn Surveys - Main Results

Site ID	Number of Households	Percent That Fertilize	Percent Employing a Company	Percent Self-Fertilization	Average Nitrogen Added/year (lb)
1	8	100	50	50	155.69
2	17	53	66.7	33.3	69.19
3	5	100	100	0	236.82
4	15	60	44.4	55.6	80.99
Total	45	69	61.3	38.7	542.69

Lawn Surveys - Additional Results

- Strongest association between N input (lbs/year) and home value (dollars)
 - R-squared: 0.125
 - p-value: 0.0185
- Top reasons given for maintaining lawn
 - aesthetics (60%)
 - health of lawn (29%)
 - keeping up appearances (29%)

Lawn Surveys - Additional Results

- Limitations

- small sample size
- recall bias
- selection bias – overestimation

- Recommendations

- send notices ahead of time
- use all variables to explore seasonality and lawn watering practices

Consumption Data – Food/Person

	Average (Per Person)	Standard Deviation (Per Person)
Food Total (Dollars)	3168.04	1263.85
Food at Home (Dollars)	1826.27	714.71
Bakery (Dollars)	243.20	94.79
Dairy (Dollars)	202.70	78.44
Produce (Dollars)	318.63	131.59
Meat, Poultry, Fish (dollars)	422.58	163.74

Average daily calorie intake grew by 523 calories

Commodity group	Per capita consumption			
	1970	2003	Increase in pounds, 1970- 2003	Increase in daily calories, 1970- 2003
	<i>Pounds</i>		<i>Percent</i>	<i>Number</i>
Fats and oils	53	86	63	216
Grains	136	194	43	188
Sugar and sweeteners	119	142	19	76
Meat, eggs, and nuts	226	242	7	24
Vegetables	337	418	24	16
Fruits	242	275	12	14
Dairy	564	594	5	-11
Total	1,675	1,950	16	523

The ERS per capita data represent the amount of food and calories available for consumption after adjusting for spoilage, plate waste, and other losses in the home or marketing system.

Consumption Data- Food/Consumer Unit

	Average (Consumer Unit)	Standard Deviation (Consumer Unit)
Food Total (Dollars)	7920.10	3159.63
Food at Home (Dollars)	4565.68	1786.78
Bakery (Dollars)	608.00	236.98
Dairy (Dollars)	506.75	196.10
Produce (Dollars)	796.58	328.98
Meat, Poultry, Fish (Dollars)	1056.45	409.35



Consumption Data - Lawn Data

Amount Spent on Lawn Upkeep and Fertilization per Year, by survey site

Site ID	Number of Households	Mean amount of money spent/year	Standard Deviation
1	8	\$441.67	\$192.39
2	17	\$535.71	\$664.25
3	5	\$390.00	\$440.95
4	15	\$2050.00	\$1492.48
Average		\$639.72	\$873.95

Consumption Lawn Care Expenditures

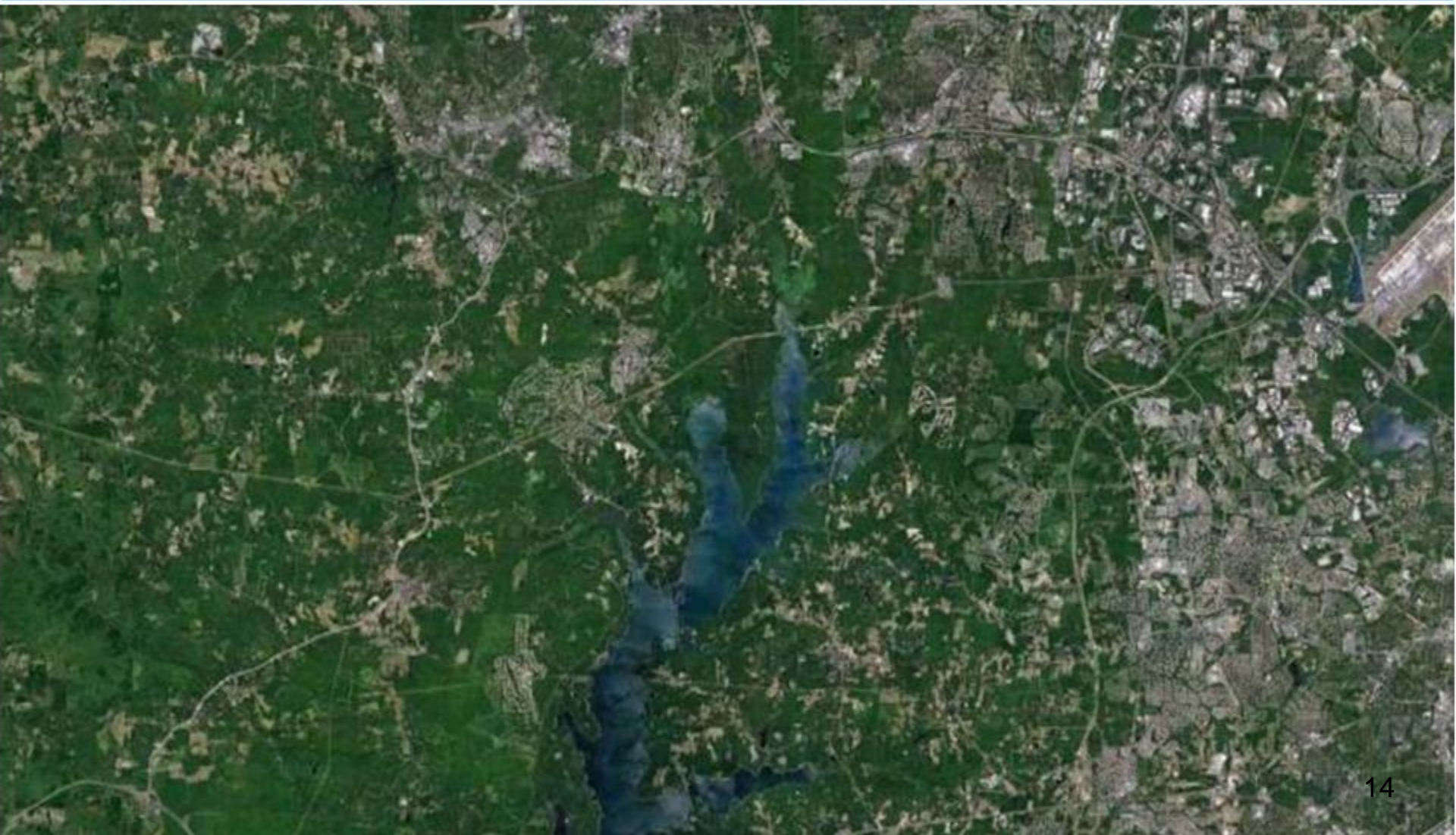
Person	Household
\$173.08	\$519.24
\$87.37	\$262.11

Stream Water Sampling

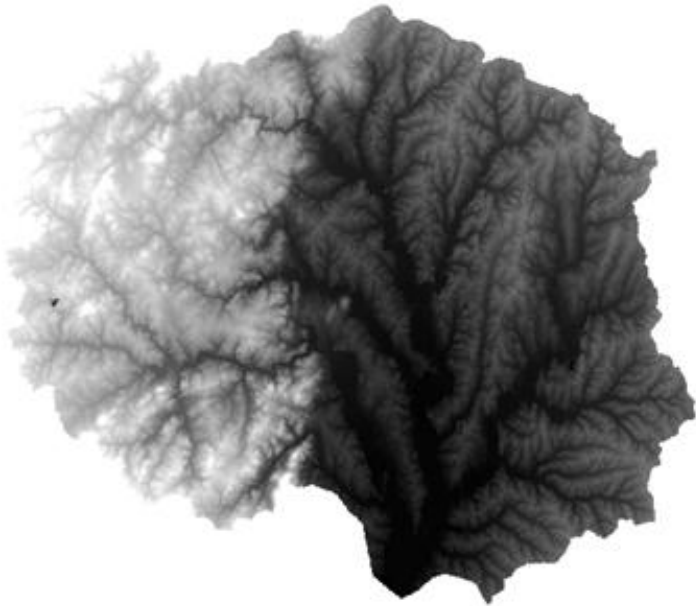
- Restricted sites to first- and second-order streams
- 60 mL samples collected at 6 sites for 5 consecutive weeks
- Samples sent to UGA environmental lab for nitrate analysis
- Limitations
 - Temporal
 - Only spring average
 - Only once per week
 - Consistency in measurement



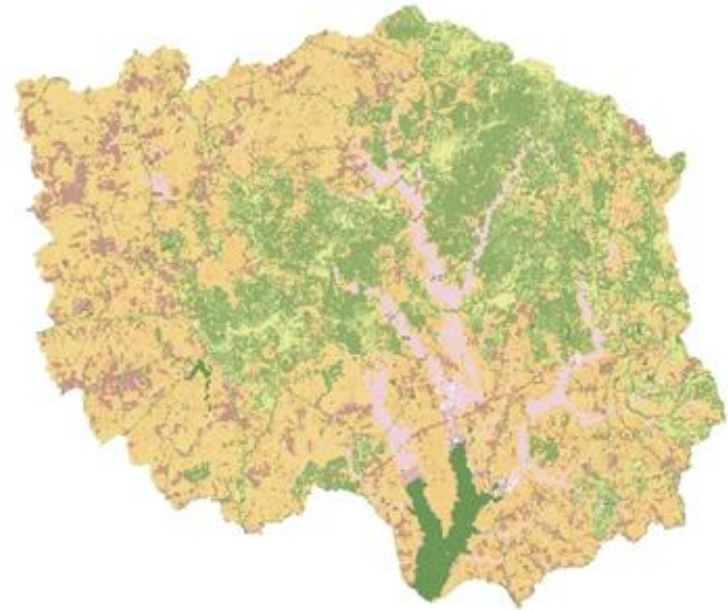
Spatial Analysis



Datasets Used



NED



NLCD

NED: DEM was used to determine stream channels and watersheds

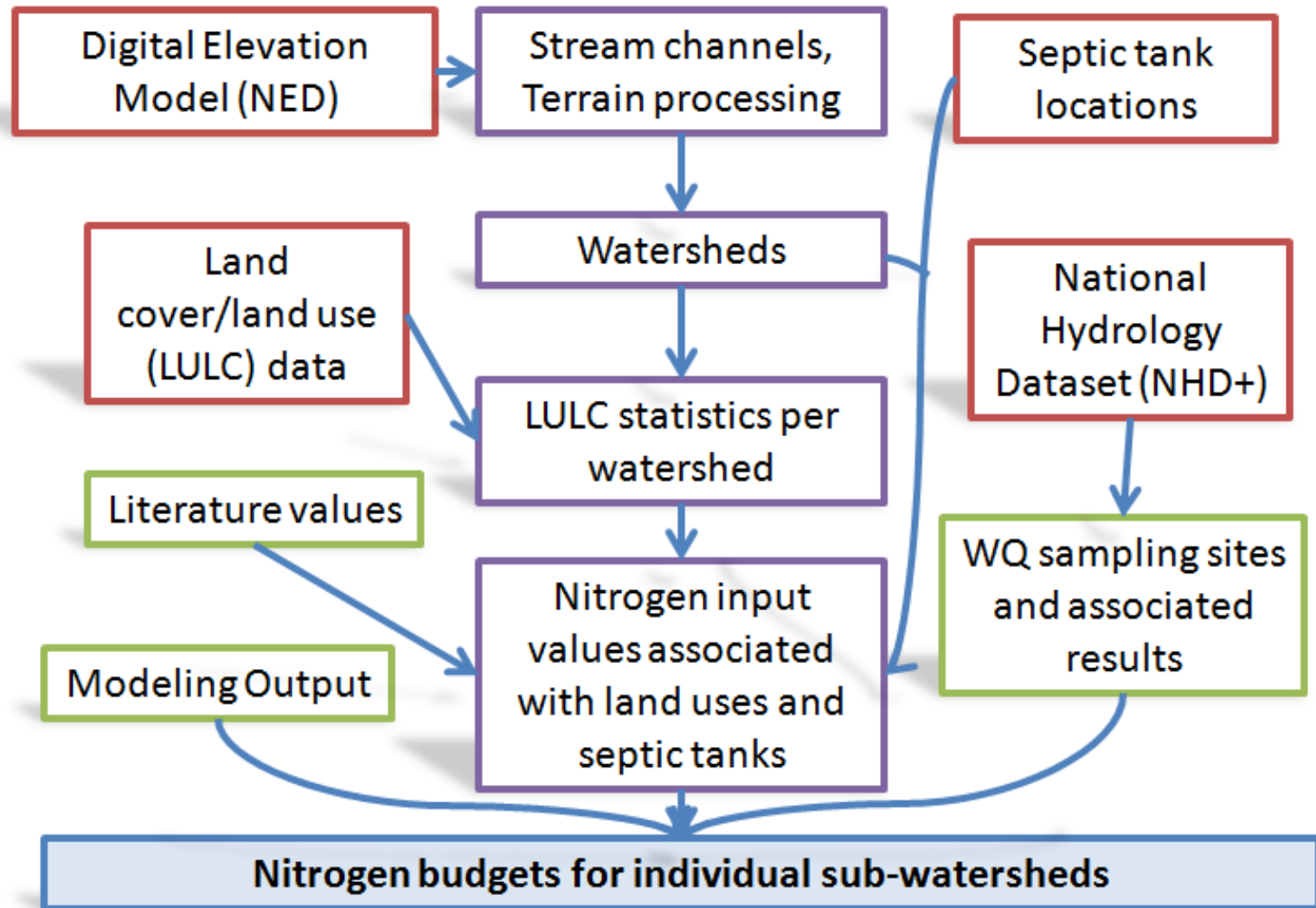
NLCD: Land cover/land use

NHD+ : Basic stream locations and choosing of sample sites

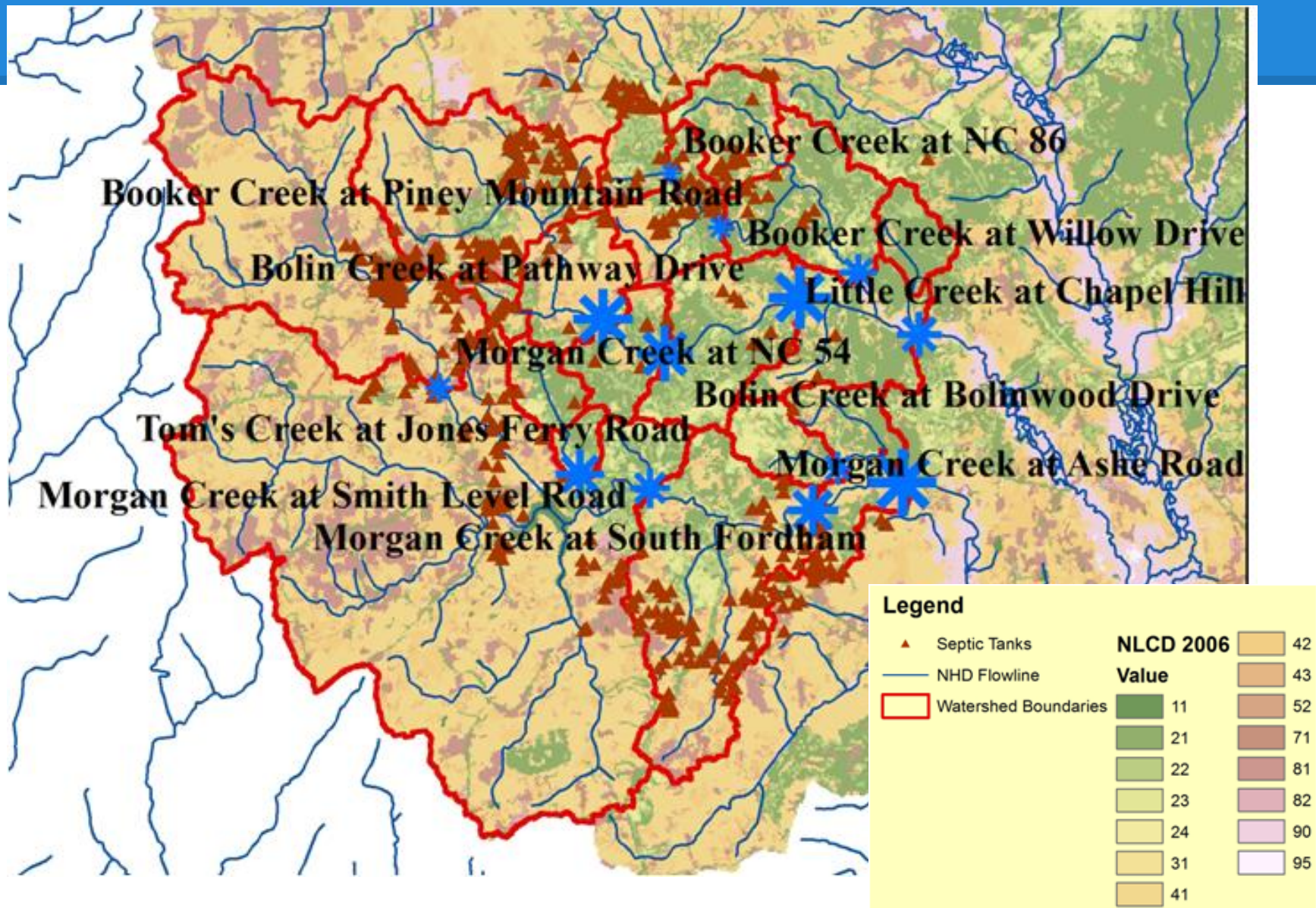
Septic Site locations

Previous and current water sampling locations

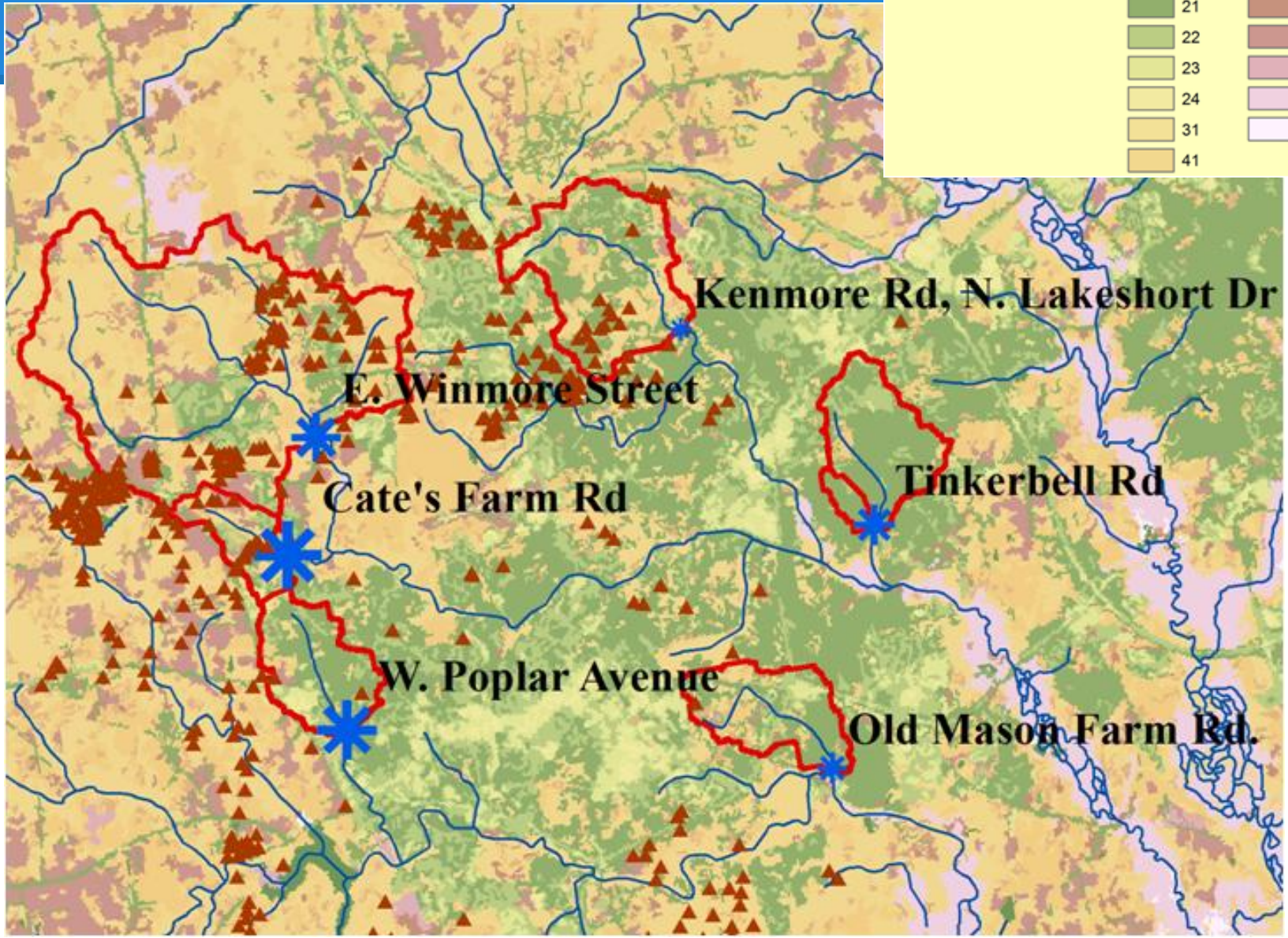
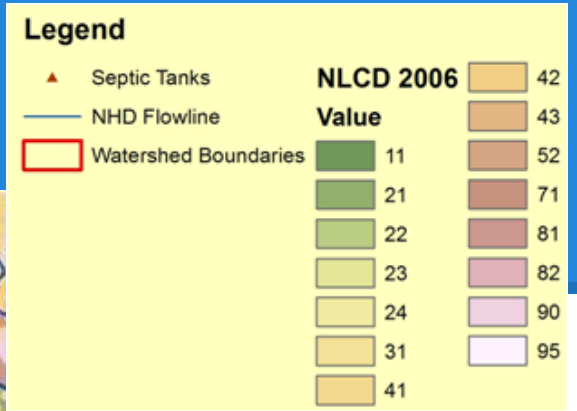
Data Processing



Sample Watersheds



Sample Watersheds



Modeling: Soil and Water Assessment Tool (SWAT)

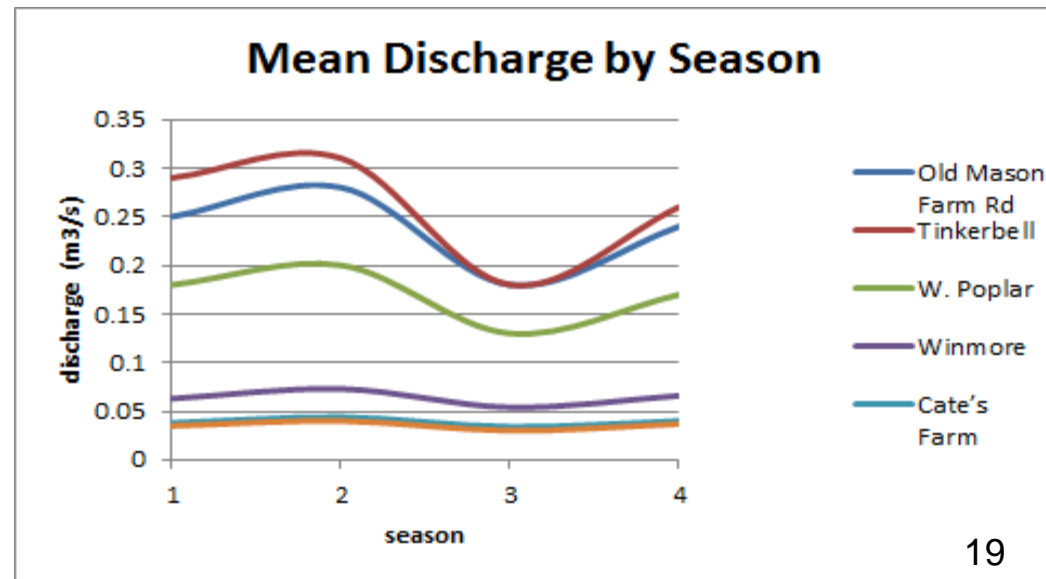
- **Inputs**

- NED
- LULC
- Soils
- Weather data
- Sampling locations

- **Outputs**

- Monthly discharge 1996-2008

Sampling Site	Winter Discharge (m3/s)	Spring Discharge (m3/s)	Summer Discharge (m3/s)	Fall Discharge (m3/s)
Cate's Farm	0.038 <i>0.038</i>	0.044 <i>0.042</i>	0.034 <i>0.033</i>	0.040 <i>0.037</i>
Morgan Creek at South Fordham	0.89 <i>0.94</i>	1.03 <i>0.99</i>	0.75 <i>0.71</i>	0.93 <i>0.85</i>



Components of the Final Budget

Inputs and assumptions (Actual values)

- Fertilization: lawn, agriculture
- Wastewater
- Atmospheric deposition
- Septic failures

Water quality data as output

- Stream loads

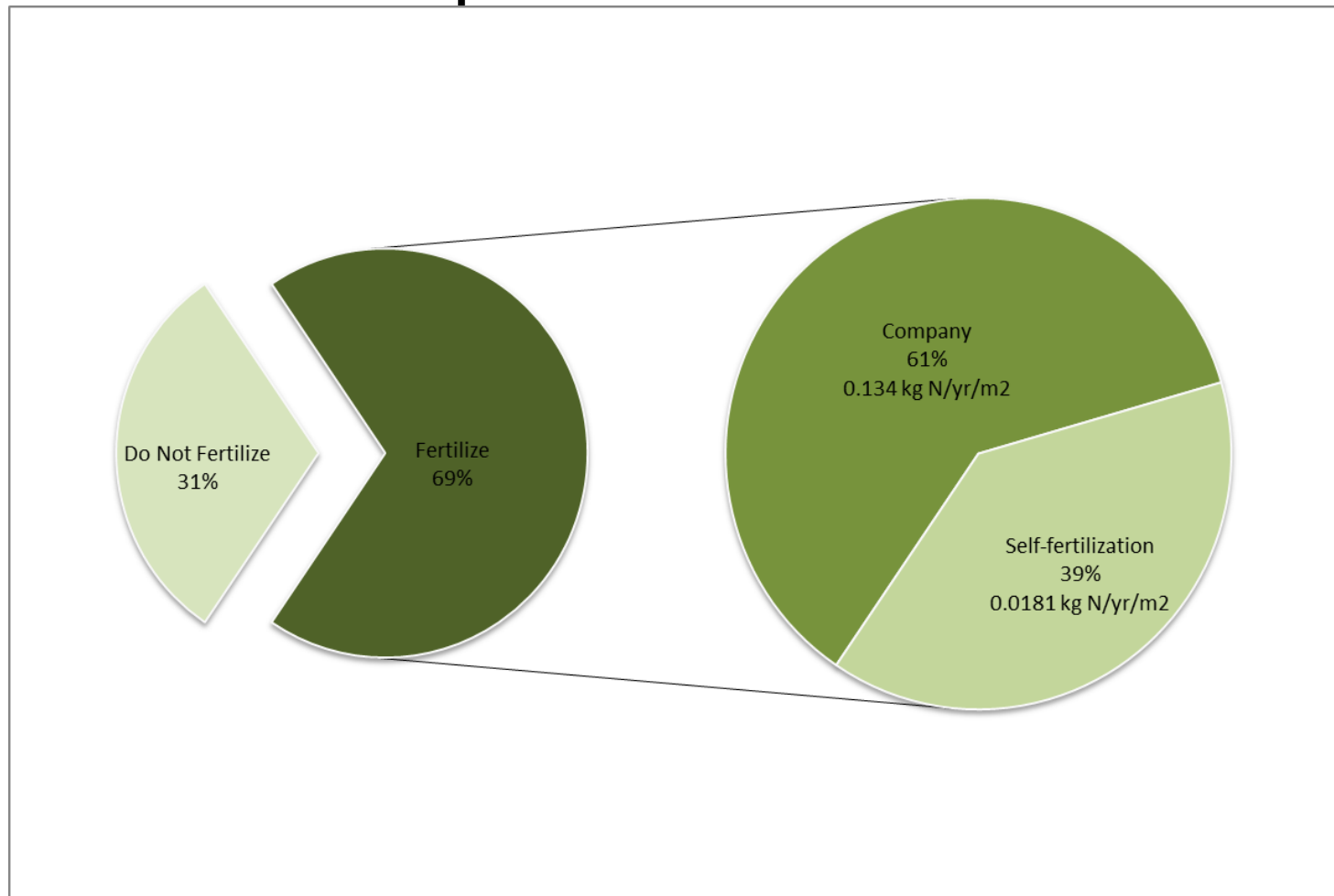
Modeling: Final Budget

Scale-up of the lawn surveys

Site ID	Watershed	Av. Lawn area (m2)	App. # of houses	Kg N/yr/ household	Total Developed Area (m2)	Total Lawn area (m2)	% Lawn area
1	Cates Farm	559	400	70.8	369679	223600	60.5
2	Kenmore Rd	474	1000	31.5	1827737	474000	25.9
3	Winmore	884	500	107.6	1529632	442000	28.9
4	Tinkerbelle	568	925	36.8	1993023	525400	26.4

Model- Lawn Survey Assumptions

35.4% of developed area assumed as lawns



Final Budget Data

Annual averaged output-to-input ratio at each sub-watershed

Site	% Output to Input
Morgan Creek at Ashe Road	4.57
Meeting of Waters Creek at Laurel Hill R	0.21
Morgan Creek at South Fordham	915.16
Bolin Creek at Bolinwood Drive	13.48
Bolin Creek at East Franklin Street	12.08
Little Creek at Chapel Hill	2.35
Morgan Creek at NC 54	3.51
Booker Creek at Piney Mountain Road	1.79
Morgan Creek at Smith Level Road	0.67

Site	% Output to Input
Tom's Creek at Jones Ferry Road	7.96
Bolin Creek at Pathway Drive	12.66
Booker Creek at NC 86	136.01
Booker Creek at Willow Drive	1.27
Cate's Farm	26.51
Winmore	2.31
W. Poplar	4.88
Kenmore Rd.	1.54
Tinkerbelle	3.02
Old Mason Farm Rd	2.34

CONCLUSION

More time needed

Sample and survey in areas outside of the watershed

Use agriculture production data instead of consumption data

Acknowledgements

Special thanks to Dr. Shay, Dr. Band, Jon Duncan, and Charles Scaife: We appreciate all the help and advice you gave us throughout the semester. Without of your help, this project would not have been possible.

Questions?