




# Tree Canopy Change in Georgia: Impacts on Ecosystem Services



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Title Slide



## Land Use Change in Georgia: Impacts on Ecosystem Services



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We need to look at land use change as a whole not just trees, or agriculture, or urbanization

# Conservation

- The act or process of conserving
  - Preservation or restoration from loss, damage or neglect.
  - **The protection, preservation, management or *restoration* of wildlife and of natural resources, such as forest soil or water.**
  - The maintenance of a physical quantity such as energy or mass during a physical or chemical change.
    - American Heritage Dictionary of the English language 4<sup>th</sup> edition
- 
- **Conservation = Environmental Protection**

When we use the term conservation, it often has different meaning to different people. These are definitions from the American Heritage Dictionary. In the broadest sense conservation is the protection of the environment.

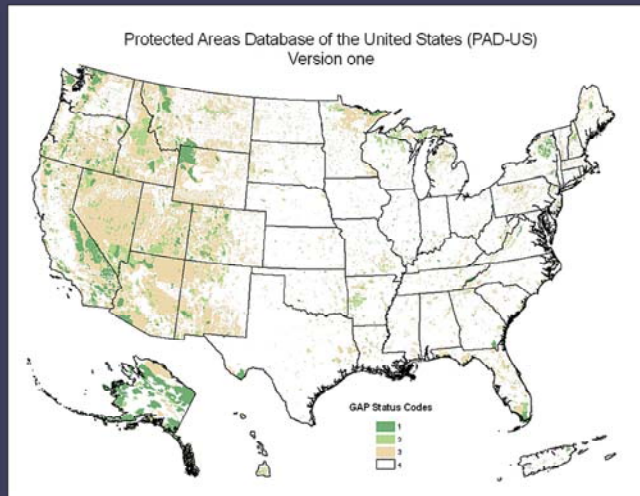
## Conservation is not a new Concept

- Conservation is a state of harmony between men and nature Aldo Leopold
- Conservation means the wise use of the earth and its resources for the lasting good of men Gifford Pinchot
- The conservation of natural resources *is* the fundamental problem. Unless we solve that problem it will avail us little to solve all others Theodore Roosevelt - 1906



These are quotes from many of the early US Conservationists. It is important to note that they realize that there must be a balance and that the natural environment can work for the benefit of people.

## Environmental Protection: Do our current tools meet the needs for the future?



Land Acquisition –  
•How much is enough?  
•Area = environmental quality?

We have models that we have been using for the past 100 years that conservation and environmental protection can be accomplished through land acquisition strategies. There are states with much higher amounts of land under government protection than Georgia, however, they do not provide a higher quality of environment they what we have in Georgia. Private land owners can and do provide us with much of our environmental benefits in Georgia and we need to recognize that they are critical partners in protecting our resources.

## Environmental Protection: Do our current tools meet the needs for the future?



Regulation – What we do with or on the land

- Regulation sets basements not ceilings
- Most environmental degradation is due to population and choices
- Blunt tool and heavy handed

Over the past 40 years we have seen the benefits of federal laws such as the Clean Water Act and the Clean Air Act in improving much of the environmental quality. Rivers are no longer burning and the air for the most part is clearer. These laws work well by providing end of pipe solutions. We must realize that many of the pressures now put on our environment are brought about by population and the choices we make. Where we live and how we live impact our environmental quality and therefore, we need to think about using different approaches to maintaining and improving our environmental quality

## Environmental Protection: do our current tools meet the needs of the future?

- Incentives, markets, and education
- New players, new tools, different scales
- Devolved responsibility from fed, to state, to local governments
- Ultimately the individual becomes responsible
- Must make economic sense for land owner, government, and community



. We can no longer turn to solely to regulation to maintain and protect the environment. We need better education and incentive for environmental protection. More and more the responsibility has devolved from Federal to State, to local and individual land use and life style decision. We need to make sure that our community leaders take into account the economic benefits for all when making decisions not limiting the benefits to just the individual land owner.

# Ecosystem Services

- Benefits people obtain from ecosystems
  - Provisioning services
    - Food, water, fuel, and fiber
  - Regulating and supporting services
    - Climate, water, disease regulation, and pollination
    - Soil formation, nutrient cycling, and decomposition
  - Cultural services
    - Educational, aesthetic, cultural heritage, recreation and tourism

# Green Infrastructure

- “the substructure or underlying foundation, especially the basic installations and facilities on which the continuation and growth of a community depend”
  - gray infrastructure - roads, sewers, utility lines, hospitals, schools, prisons, etc
  - Green infrastructure – waterways, wetlands, woodlands, wildlife habitats, natural areas, greenways, working farms, ranches and forests, wilderness, etc.
  - Green infrastructure = green space

# Positive Impacts of Green Space

- Environmental Impacts
  - Decrease stormwater runoff & improved water quality
  - Protection of wildlife habitat and wildlife
  - Keeping working landscapes (forest & farm)
  - Improved air quality
  - Reduces contributes to climate change
- Economic Impacts
- Social Impacts



The next three slides are a composite from many sources, touching on the many negative impacts of our current growth patterns. Environmental impacts are perhaps the easiest to intuitively grasp.

# Positive Impacts of Green Space

- Environmental Impacts
- Economic Impacts
  - Increase property values & tax base in cities
  - Lower taxes for community services in suburbs
  - Lower construction and maintenance cost
  - Lower health care costs
- Social Impacts



Economic impacts are slightly harder to grasp, and are only now being quantified.

\*\*\*Loss of Economy of Scale.

# Positive Impacts of Green Space

- Environmental Impacts
- Economic Impacts
- Social Impacts
  - Increase in economic opportunity
  - Improved feeling of sense of place and community
  - More access to open space
  - Increased social interaction (“public life”)
  - Less traffic and shorter commutes
  - Inner-city redevelopment



Social impacts are perhaps the most devastating....depending on whom you talk to, of course.

\*\*\*Lack of “choice” in housing markets. Little low income housing/rentals/etc

## Economic Benefits of Trees

- Trees saves local governments money on servicing development
- Trees raises property values (and taxes) for surrounding properties
- Trees attracts businesses, thereby creating jobs
- Trees attracts educated, skilled workers, indirectly attracting businesses

## Green Space Attracts Business

- Small business owners ranked proximity to open space, parks, and recreational areas as the number one factor in choosing a business location (national survey)
- Attractive green spaces near business locations attract shoppers, making businesses more profitable and attracting more businesses

## How Green Space Saves Money

- Different land uses require different amounts of service expenditures per dollar of revenue paid to local government
- Using results compiled by AFT, the national averages are:
  - Residential: **\$1.15**
  - Commercial/Industrial: **\$0.29**
  - Farmland/Forestland/Open Space: **\$0.37**

## How Trees Make Money

- Trees has been shown to increase property values by about 10% on average based on studies around the country
  - This effect holds for about 1/4 mile around green space
- Parks, greenbelts, etc., near homes can generate enough additional property taxes to be self-financing in some cases
- In Atlanta large trees on a property raises the value of a house by \$1,000 - \$2,000

## The Indirect Jobs Effect Quality of Life

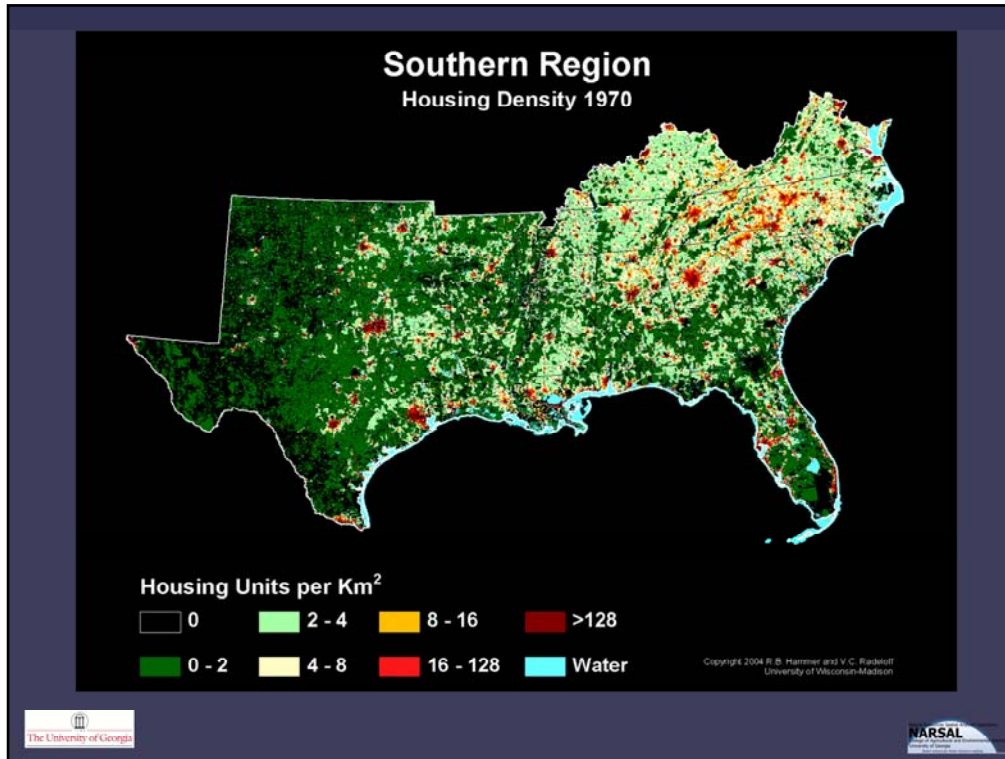
- Sociologists are finding that today more and more high skill workers are choosing where to live first, then finding jobs
- Because businesses want high skill workers, they follow these workers to places with good quality of life
- If you attract good workers, good jobs follow

## Bottom Line

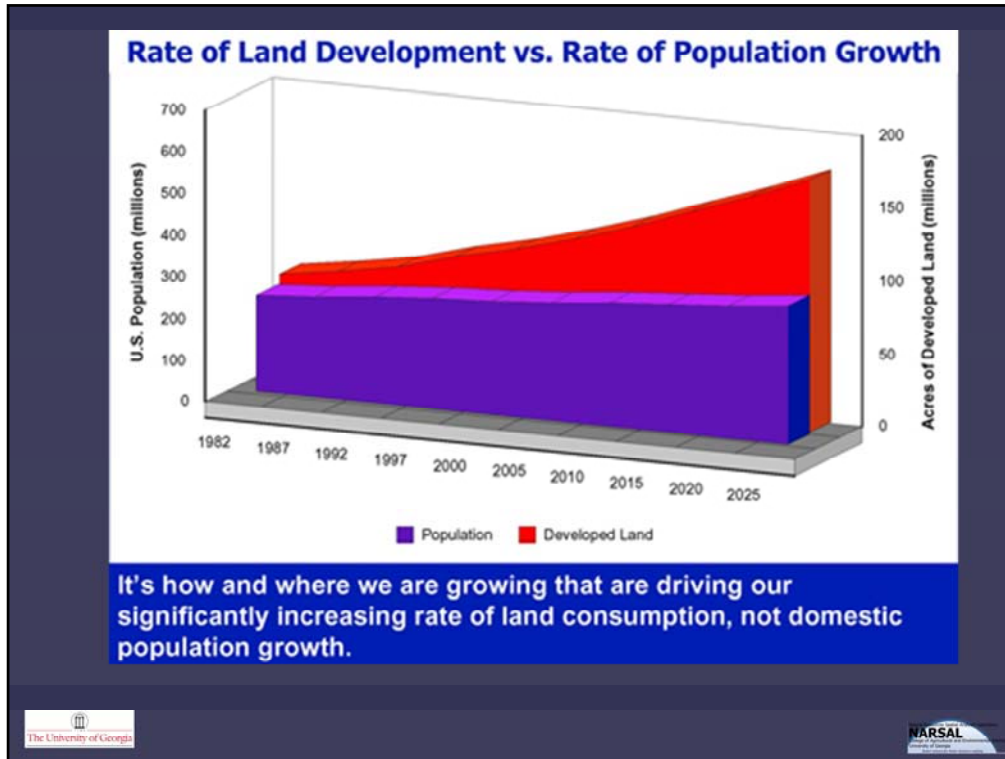
- Value added to the sales price of a median priced house for just the tree - \$973
- Value of services provided to by that one tree to an urban or suburban community is in excess of \$2,500



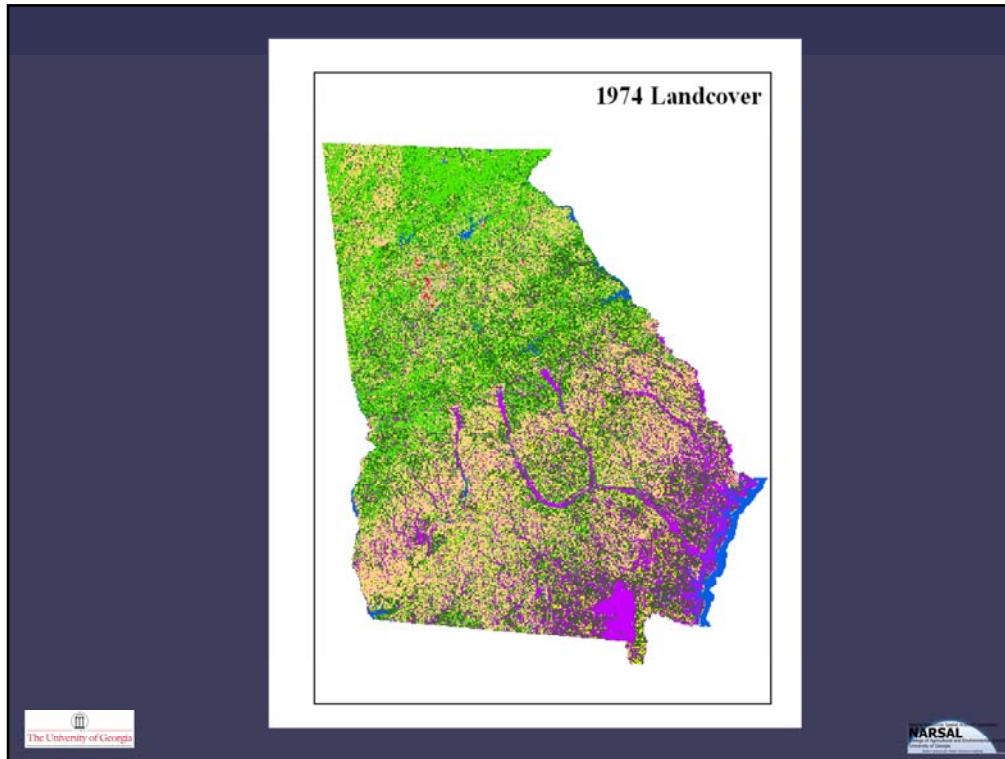
Natural Resources has always been and will likely continue to be the economic driver of Georgia's economy. Sometimes even when we are using the best available technology and science we can do harm to our environment. Like when we dumped anywhere from ½ a foot to 4 feet of topsoil into our river and streams growing cotton at the turn of the last century. But we find the natural environment has the capacity (with a little help from man and over time) to heal itself.



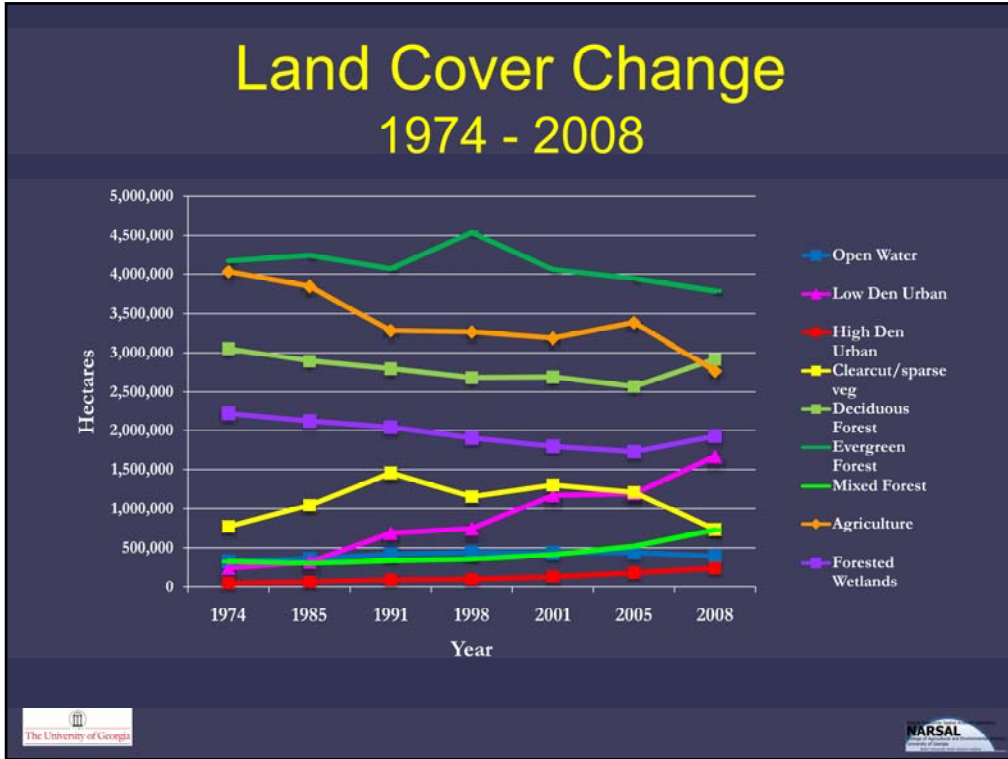
The southeastern US is one of the fastest growing regions in the US and will continue this trend over time.



Our development footprint has doubled over the course of 30 years, where each new person consumes twice as much land as someone moving here 30 years ago did. This is a trend across the county. There are even communities where populations shrunk but the development footprint increased.

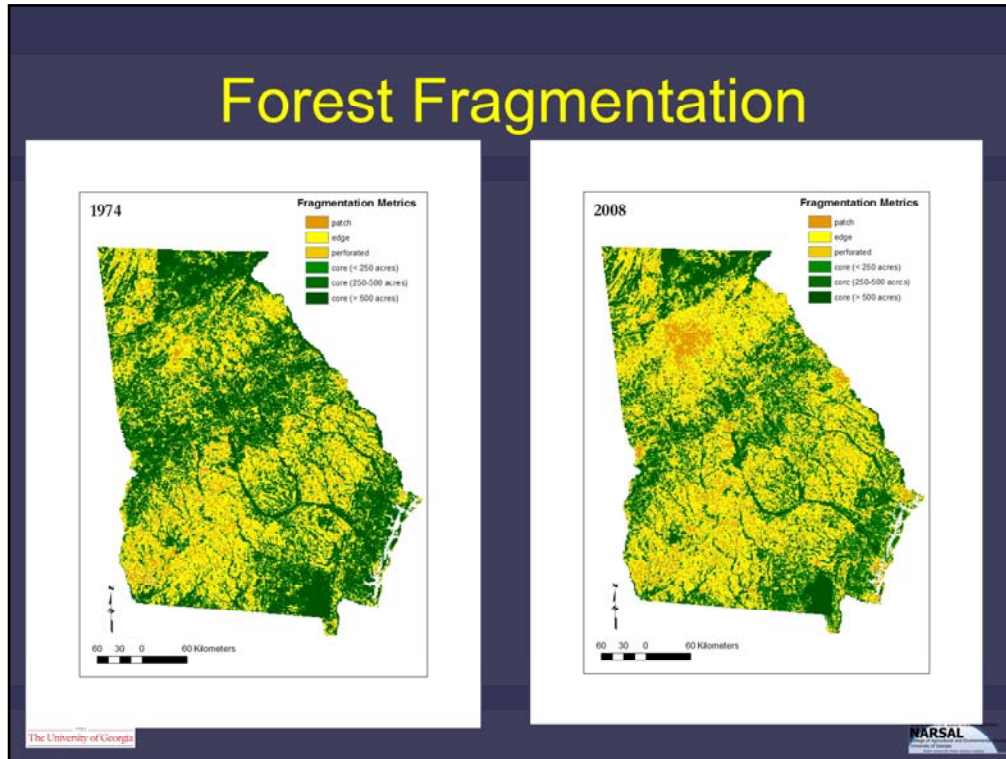


The Georgia Land Cover Change (GLUT) project has been tracking the changes to the landscape for the past 35 years.



These are some of the trends that we are seeing.

# Forest Fragmentation

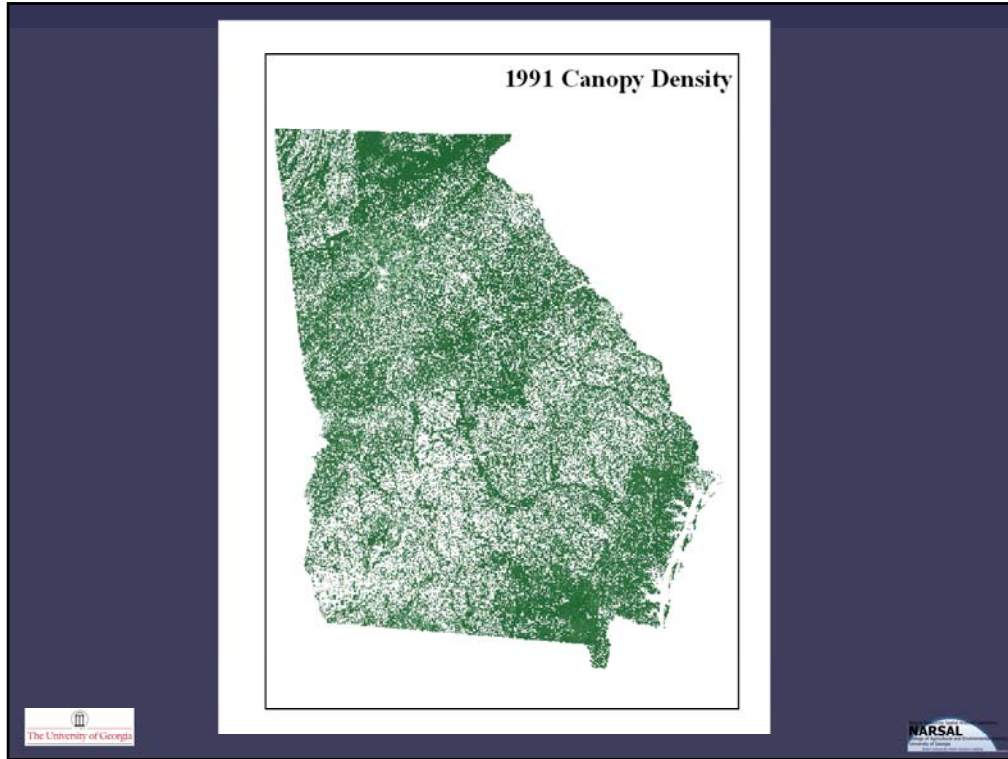


Because of the changes in our development footprints, we are fragmenting our forests across the state. We have seen a significant loss of large forest patches over the past 35 years. This change impacts water quality and quality as well and our wildlife.

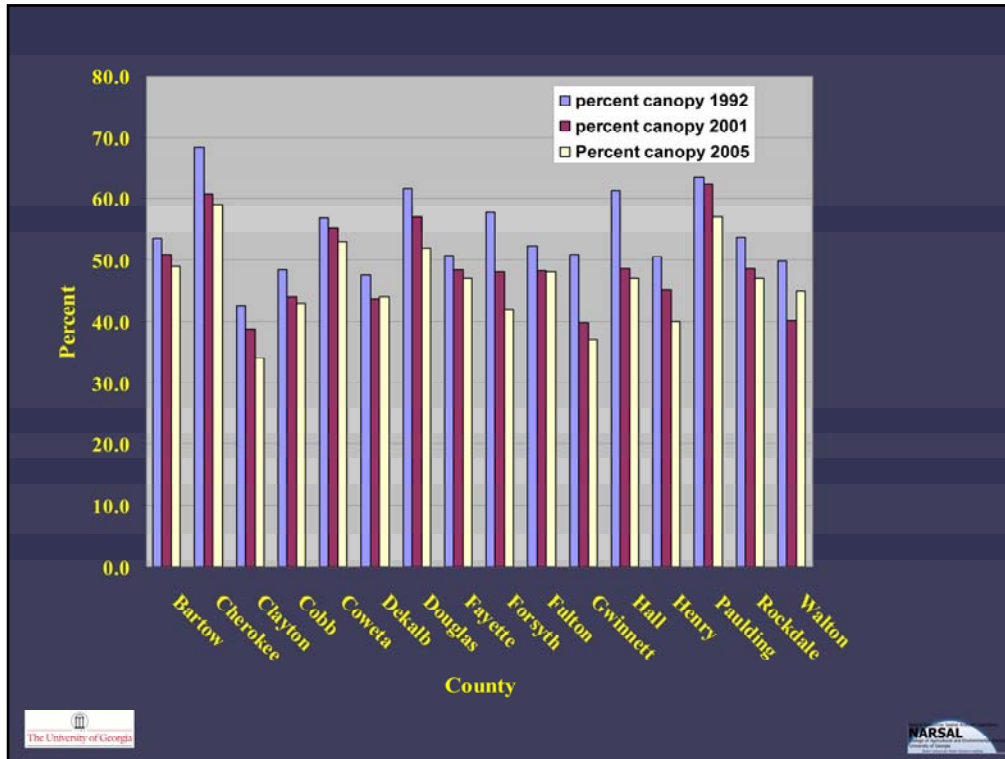
# Tree Canopy Change



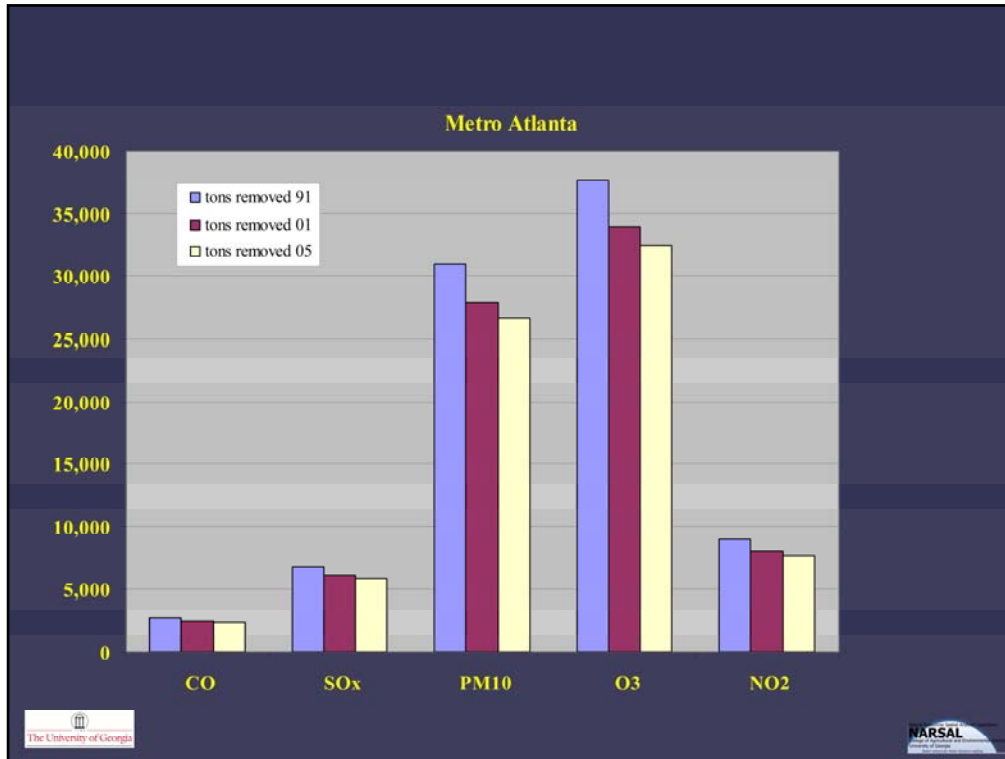
Another problem caused by deforestation



We have also be tracking tree canopy density of over time. The good news is that we can't see our urban areas if we look at tree canopy alone. We grow trees very well in Georgia.

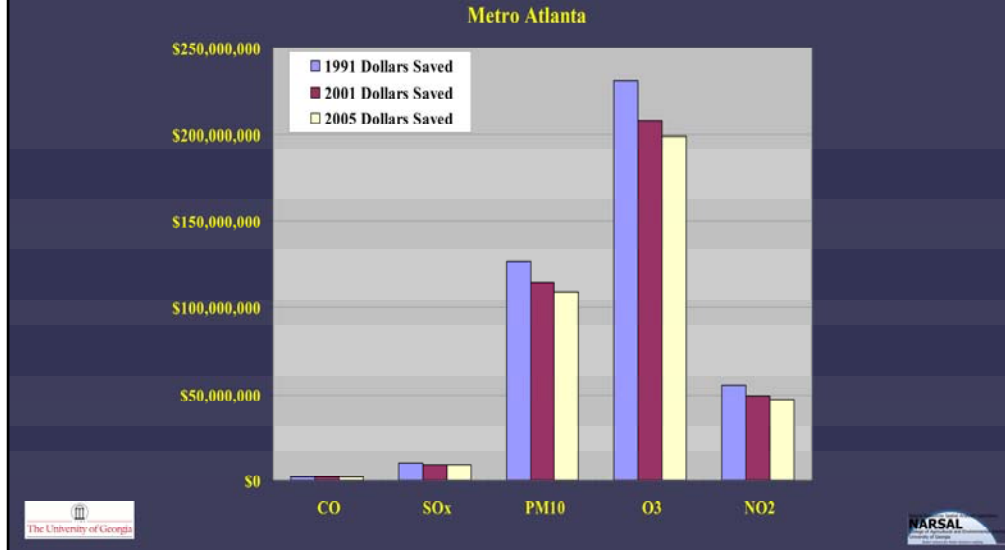


This graph shows tree canopy change over a 15 year period in the Atlanta Metropolitan Region. We see that some counties are losing canopy while others are increasing canopy and a few are holding the line.



We can use the USFS UFORE model to estimate the changes in removal of a number of air quality pollutants due to changes in tree canopy density within the region. Tree canopy plays a significant role in regulating pollutants.

# Results from Ben Map Models (EPA)



We can also begin to estimate the cost to communities when we lose tree canopy. Many of these costs are due to human health impacts such as increase in hospital visits due to asthma and heart attacks from ozone and exposure to increases in small particles that trees remove.

## Trees are Important to Human Health

- 1000 Trees remove 100 tons of CO<sub>2</sub>/year
- 1000 trees removes 5 tons of pollutants/year
  - 4000 lbs of ozone
  - 3000 lbs of particulates
  - In Metro Atlanta, an Acre of trees provides \$240 of air quality benefits



# Trees reduce power plant emissions

- In summer they can save 30% of Air Conditioning Costs
- In winter they can save up to 25% of heating costs



## Thermal Images of Downtown Atlanta

10 am



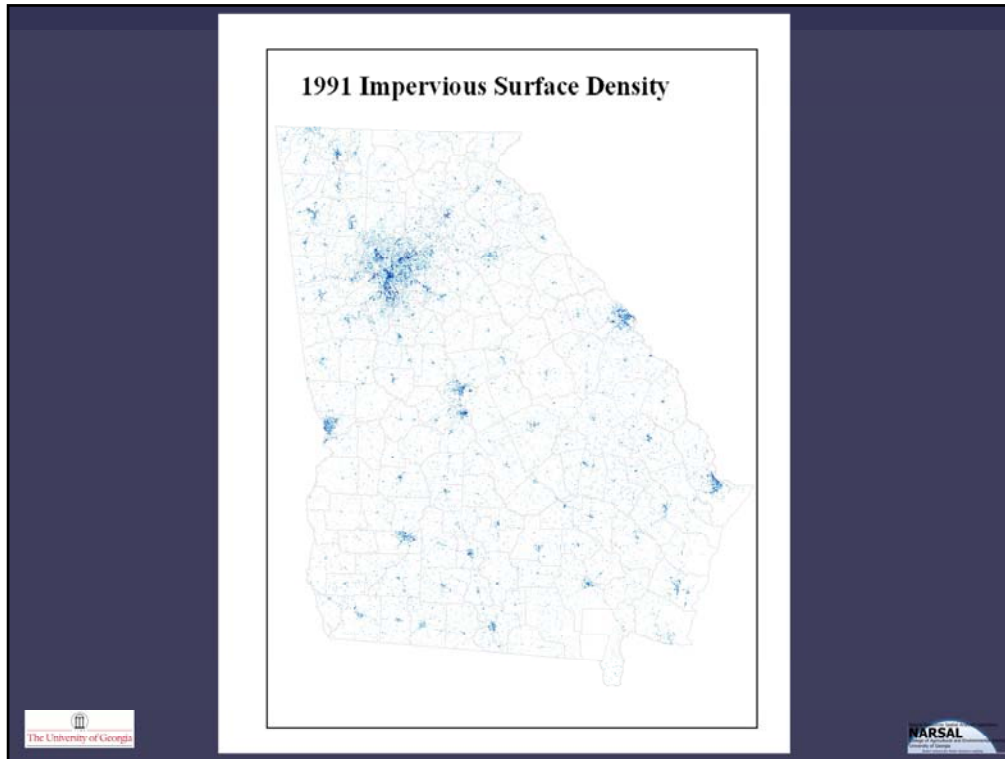
2 am



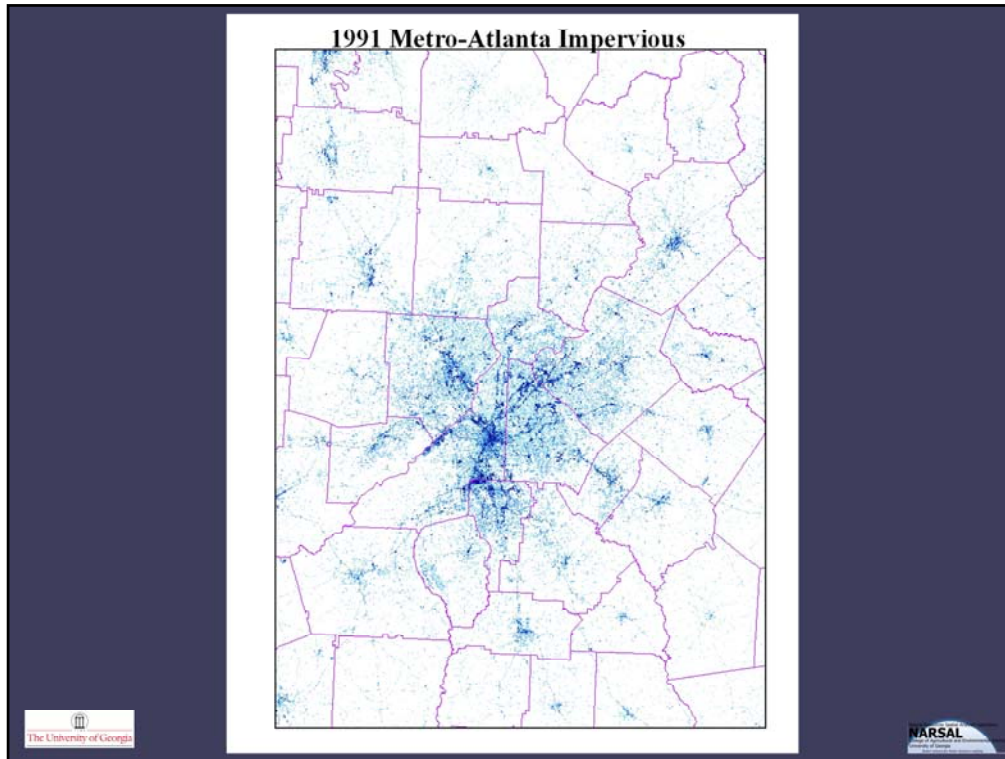
Dark colors are cooler areas and light colors are hotter areas.  
The downtown area is radiating a lot of heat at night the treed areas are cooler.



These thermal images show how trees and the built environment modify surface temperatures. The built environment causes urban heat island effects.



Impervious surfaces are the buildings, parking lots, roads, driveways, sidewalks, etc. Those objects that represent our development patterns.



We see an increase in low densities of impervious surfaces through out the Atlanta area. This represents the increases in low density residential areas across that area and the state.

## Top 10 Impervious Surface as Percent of County

1991	2001	2005	2008
Clayton (14)	Clayton (20)	Clayton (25)	Clayton (28)
DeKalb (13)	DeKalb (18)	DeKalb (22)	DeKalb (25)
Fulton (10)	Cobb (16)	Cobb (20)	Cobb (24)
Cobb (10)	Fulton (15)	Gwinnett (19)	Gwinnett (24)
Gwinnett (7)	Gwinnett (15)	Fulton (18)	Fulton (22)
Muscogee (7)	Muscogee (9)	Muscogee (12)	Muscogee (14)
Richmond (6)	Richmond (9)	Richmond (10)	Richmond (12)
Bibb (6)	Clarke (8)	Clarke (10)	Clarke (11)
Clarke (5)	Bibb (6)	Rockdale (9)	Rockdale (11)
Rockdale (4)	Rockdale (4)	Bibb (8)	Bibb (10)



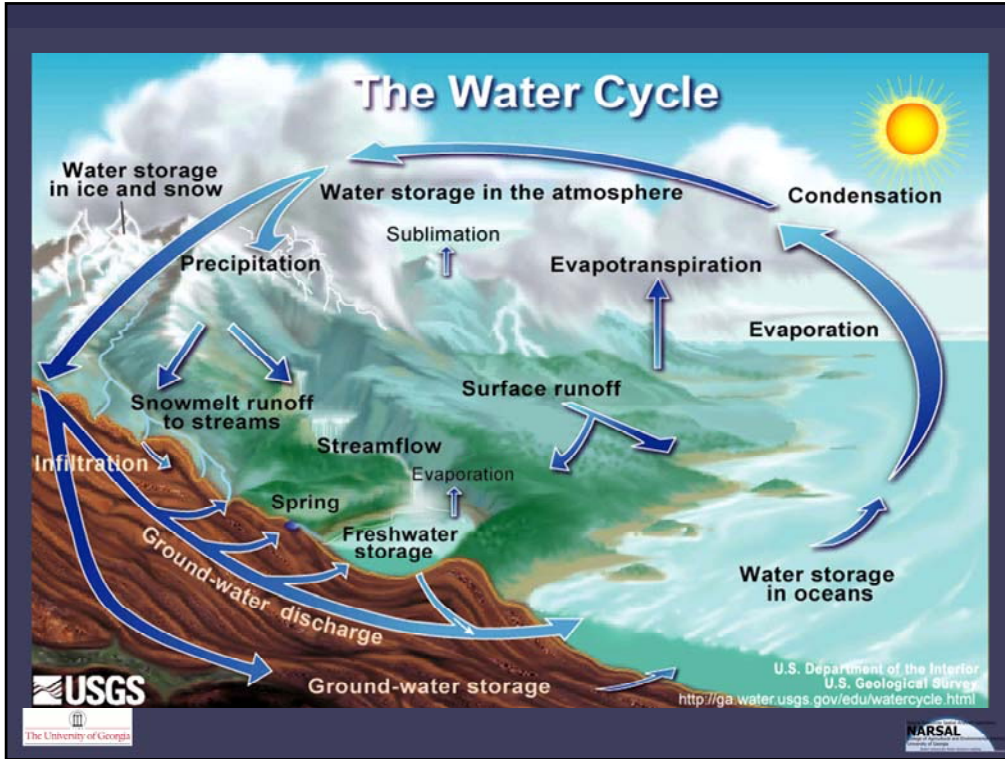
The number in parentheses are percentages of the county that are covered with impervious surfaces. Note that this is not limited to the Metro Atlanta Area, it is happening over the entire state.

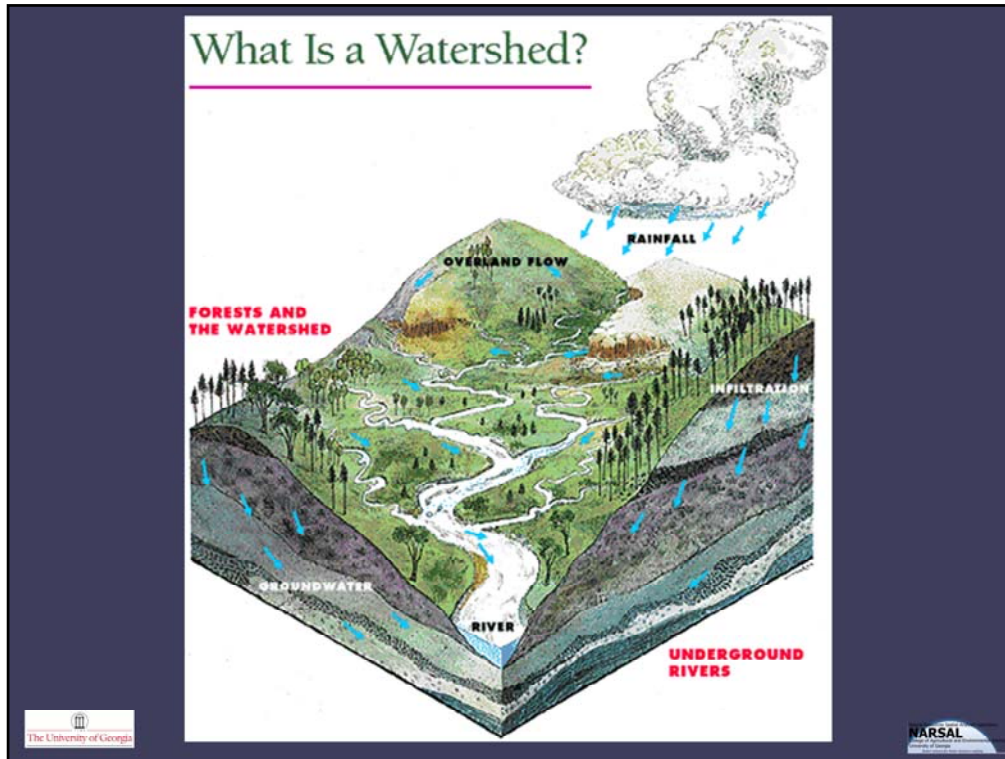
## Impervious Change: Top 10 Counties in Acres Per Day

- 1991 – 2001
  - Gwinnett (6)
  - Fulton (5)
  - Cobb (4)
  - DeKalb (2)
  - Forsyth (1)
  - Clayton (1)
  - Henry (1)
  - Chatham (1)
  - Cherokee (1)
  - Richmond (1)
- 2001 – 2005
  - Gwinnett (9)
  - Fulton (8)
  - Cobb (6)
  - DeKalb (5)
  - Henry (4)
  - Clayton (3)
  - Chatham (3)
  - Paulding (3)
  - Cherokee (3)
  - Muscogee (2)

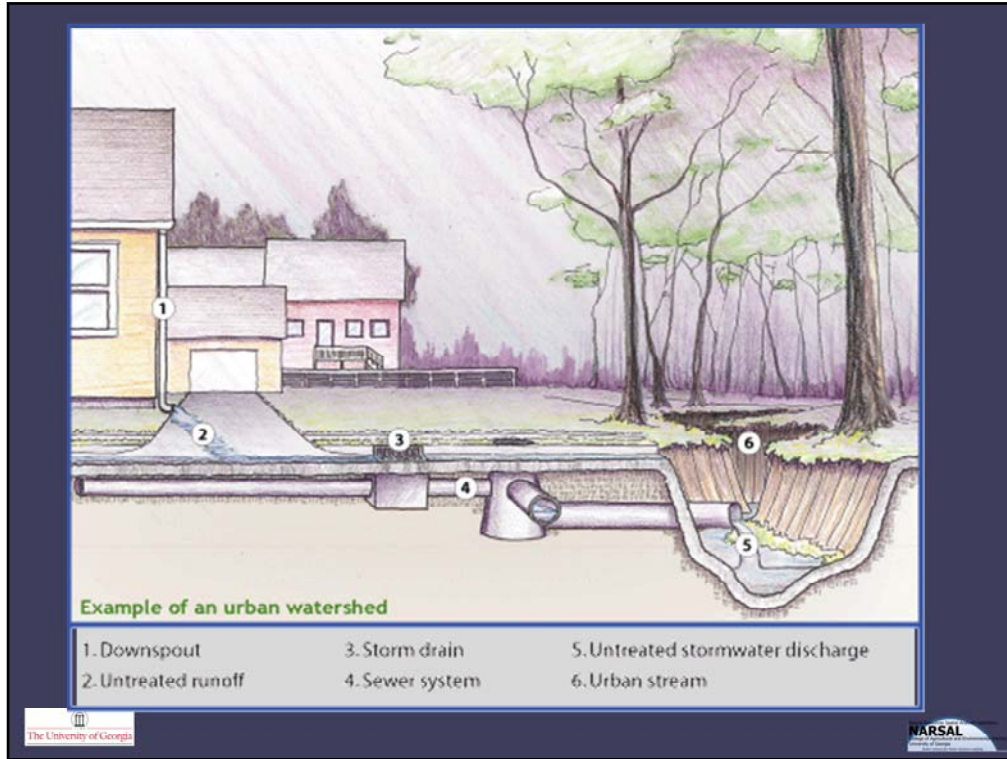


The number in parentheses are estimated average acres per day that was added to each county during the two time periods. An acre is the equivalent of the area of a football field.

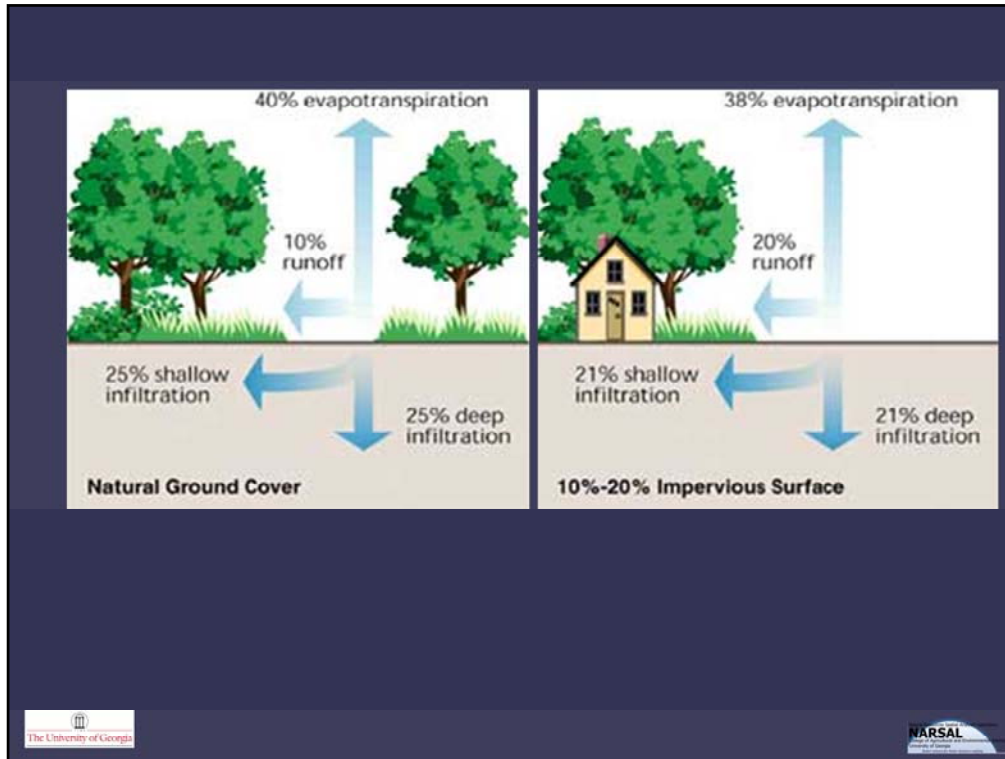




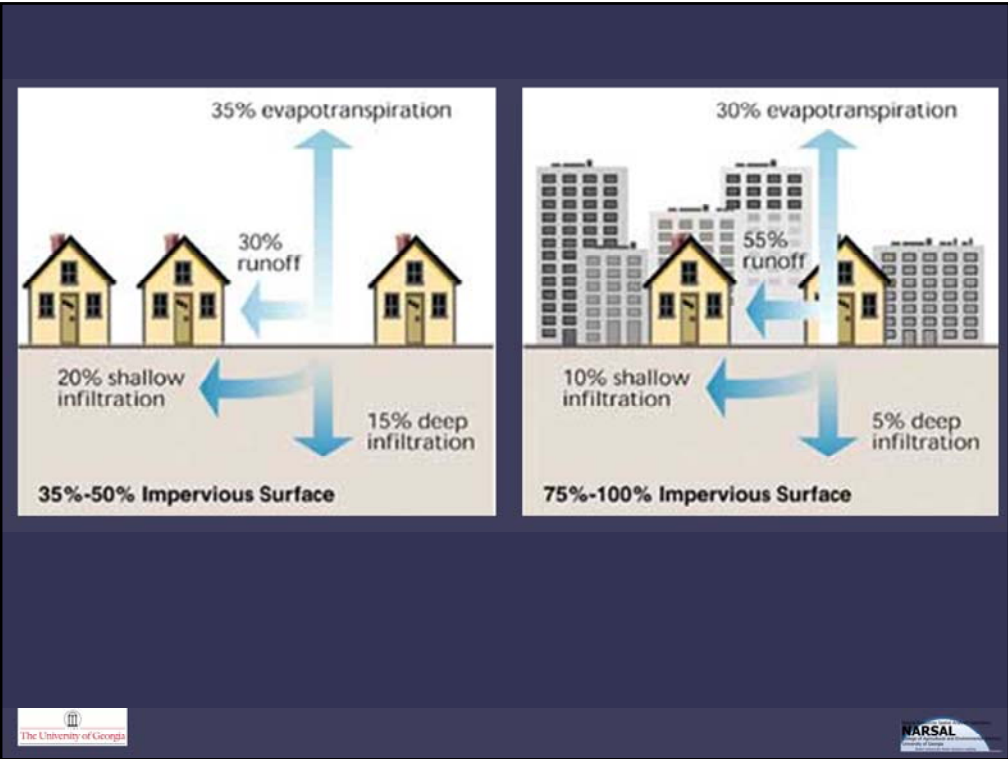
A watershed is the area of land that feeds an individual river. The ground water from infiltration keeps feeding our streams and rivers when it is not raining. These are extremely efficient and cost effect. If we reduce the ability of the watershed to provide ground water to our rivers and streams we will have to use expensive engineered solutions to provide drinking water to our communities.



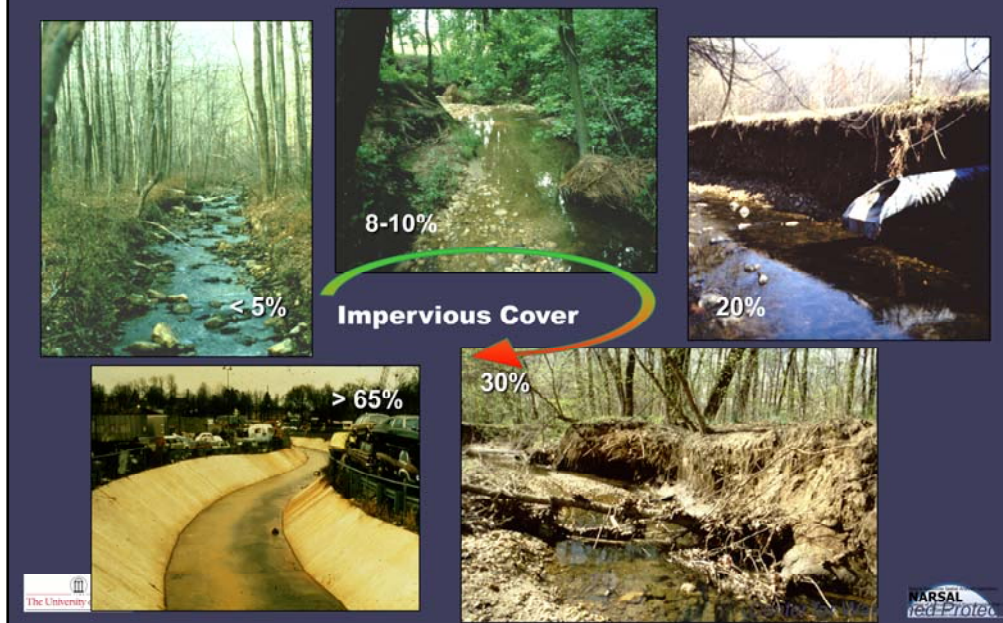
In urban areas we must engineer our watersheds to provide the same functions that nature provides us.



As we develop and increase our impervious surfaces we change how water moves through the watershed.



## Stream Quality Is Related to Impervious Cover



This slide illustrates how stream quality, as measured by bank stability, water quality and available habitat, deteriorates when impervious cover increases in a watershed.

Watersheds with less than 5% impervious cover, have stable stream banks, good water quality and provide a variety of habitat.

The second picture shows a stream that has about 10% impervious cover in its watershed. While relatively stable, the stream shows some signs of erosion.

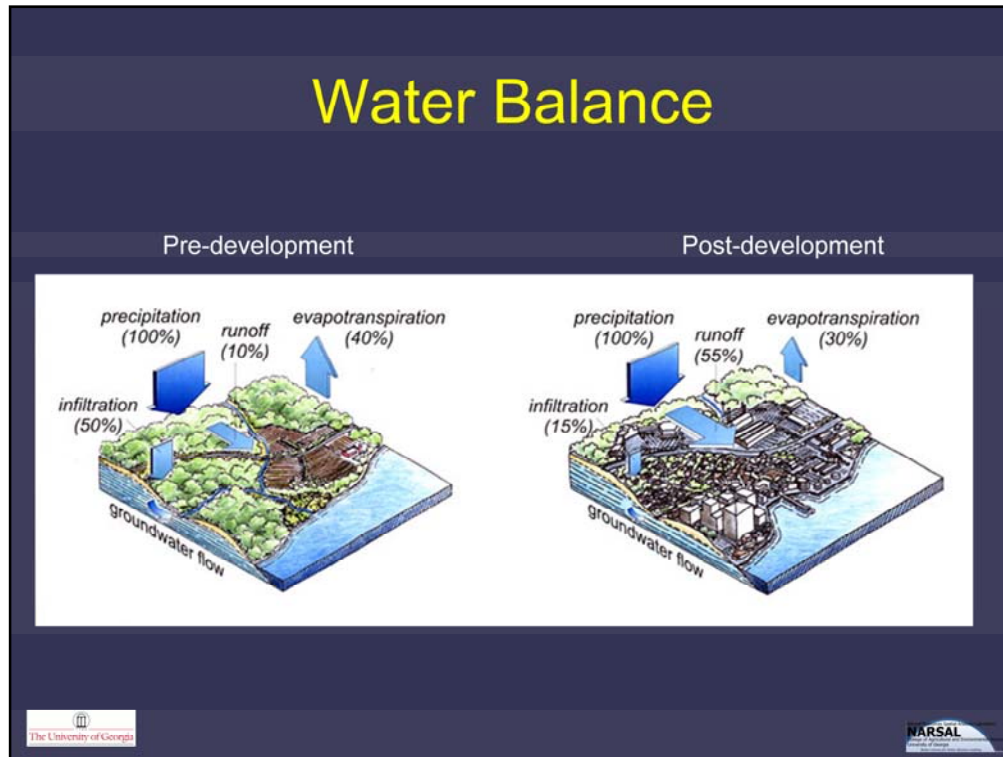
The third stream has about 20% impervious cover in its watershed. Stream erosion has become serious. Note that the amount of erosion has been so great that the drain pipe that once rested on the stream bottom and within the stream bank is now 2 feet above the water and protrudes nearly 6 feet from the stream bank

The fourth picture shows a stream with about 30% impervious cover. The stream channel has "blown out" and is about five times larger than it was before development. The water quality is poor and there is very little suitable habitat for aquatic life.

The last picture shows a stream that has 65% impervious cover in its watershed. Stream erosion has become such a problem that the stream was channelized with concrete. The concrete provides no habitat to support aquatic life.

It is important to note that these impacts generally apply to headwater streams, which are composed of first- and second-order streams. Since these small headwater streams comprise about 75% of all the river and stream mileage in the contiguous U.S., their proper management and protection is essential to the protection of our larger lakes, rivers, and estuaries.

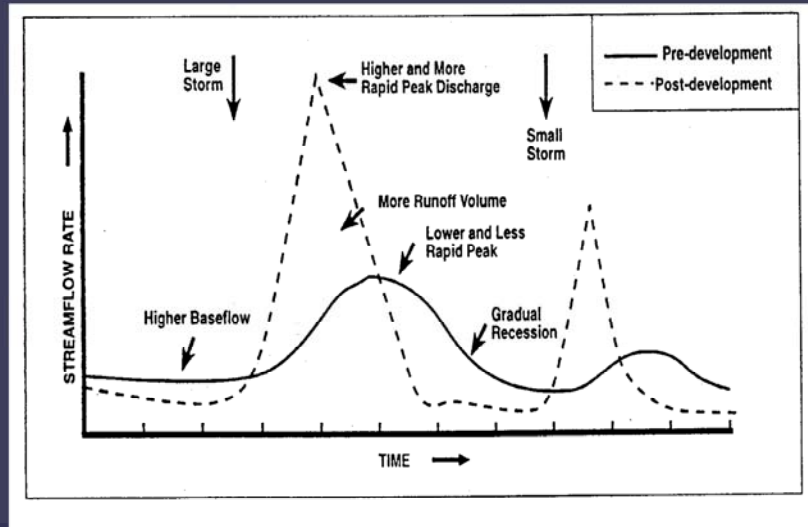
# Water Balance



One of the major impacts of urbanization on streams is its effects on stream hydrology. Stream hydrology is defined as the study of the movement or flow of water and understanding water balance is essential to understanding the impact of development on urban streams.

This diagram shows how development and its corresponding increase in impervious cover disrupts the natural water balance. In the post-development setting, the amount of water running off the site is dramatically increased.

## Urban Hydrograph



With increases in development our streams and rivers begin to get more flashy small rain events can begin to create floods. Also, the amount of available water decreases after rain events due to a reduction in infiltration.

This slide illustrates the effect of urbanization on hydrograph peak discharge. In predeveloped conditions, flow gradually increases to a relatively flat peak and gradually descends to a low flow condition. In the urbanized condition, flow rapidly increases to a peak and just as sharply descends, often to a low flow condition less than the pre-development condition.



# Urban Growth Modeling

- SLEUTH - Slope, Land-use, Exclusion, Urban-extent, Transportation, Hillshade
- Brute-force simulations
- Types of growth – spontaneous growth, new spreading centers, edge growth, and road-influenced growth
- Growth coefficients – dispersion, breed, spread, slope, and road



gravity



We can explore how future growth will impact water quality and quantity.

It stands for slope, land-use, exclusion, urban-extent, transportation, and hillshade. This model was chosen because it is ready to use out-of-the box, and has modifiable source code. The model itself has the ability to incorporate different levels of habitat and landscape protection allowing you to set many different priorities for protection or development.

SLEUTH is a cellular automata type model that follows a set of urban development rules and gives a binary designation to any given cell, either urban or non-urban.

The model is implemented in two phases – a calibration phase, where historical land use patterns are simulated, and the prediction phase, where the historical trends and patterns are projected into the future.

The calibration requires at least four historical urban extents from different time periods, a historical transportation layer, slope, and an exclusion layer determining undevelopable areas or areas resistant to development

In this initial phase, a brute force simulation is run and compared to the historical data to determine the growth processes that occurred in the past, in order to predict future trends.

The model simulates four types of urban growth – spontaneous growth, new spreading centers, edge growth, and road-influenced growth.

Each of these is sequentially and iteratively applied to the data for each growth cycle and is regulated by five growth coefficients.

These are dispersion, breed, spread, slope, and road gravity. Each coefficient is calibrated by spatially comparing the simulated land cover change through the historical time period to the actual historical data.

## Scenarios

1. Current Trends
2. Future Land Use Alternative
3. Service Delivery - Cluster Alternative

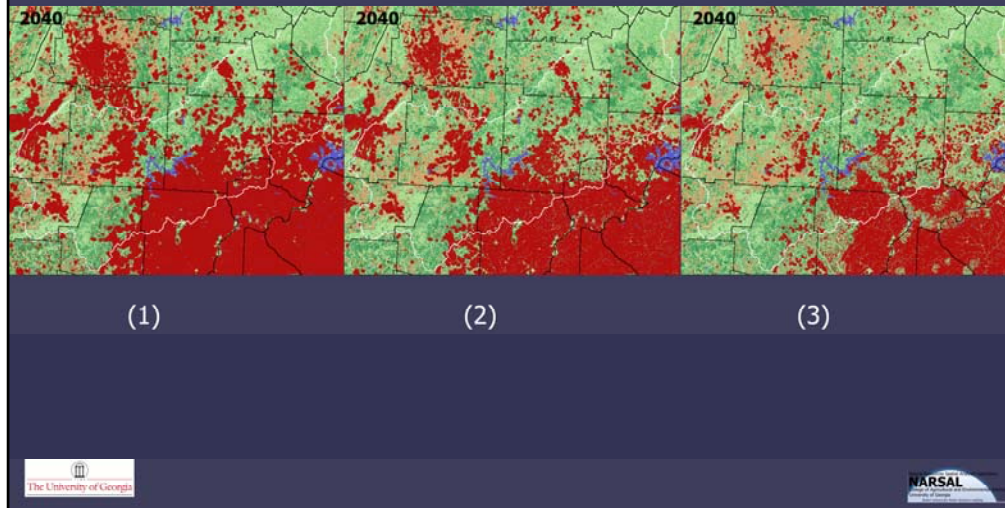


The next step is to develop the future scenarios. Three future scenarios were developed, with varying degrees of land protection to analyze the effects of different types of urban growth on stream water quality and hydrologic response. They are driven by the coefficient values determined by the calibration phase.

The primary means by which the scenarios are developed is with the exclusion layer. The scenarios are a current trends scenario, a land use zoning scenario, and conservation driven scenario. Each scenario presents increasing restrictions as to where newly created impervious surface development can occur.

Each uses a weighted roads layer, slope, and a unique exclusion layer for each

## Scenario Results



This study has shown that there can be a significant environmental impacts depending on how future urbanization occurs. This can demonstrate what can happen environmentally if a county or jurisdiction deviates from their future land use plans. The sleuth model could help develop future land use plans either regionally or at the county level enabling planners to create what-if scenarios.

So what are Some Next steps?

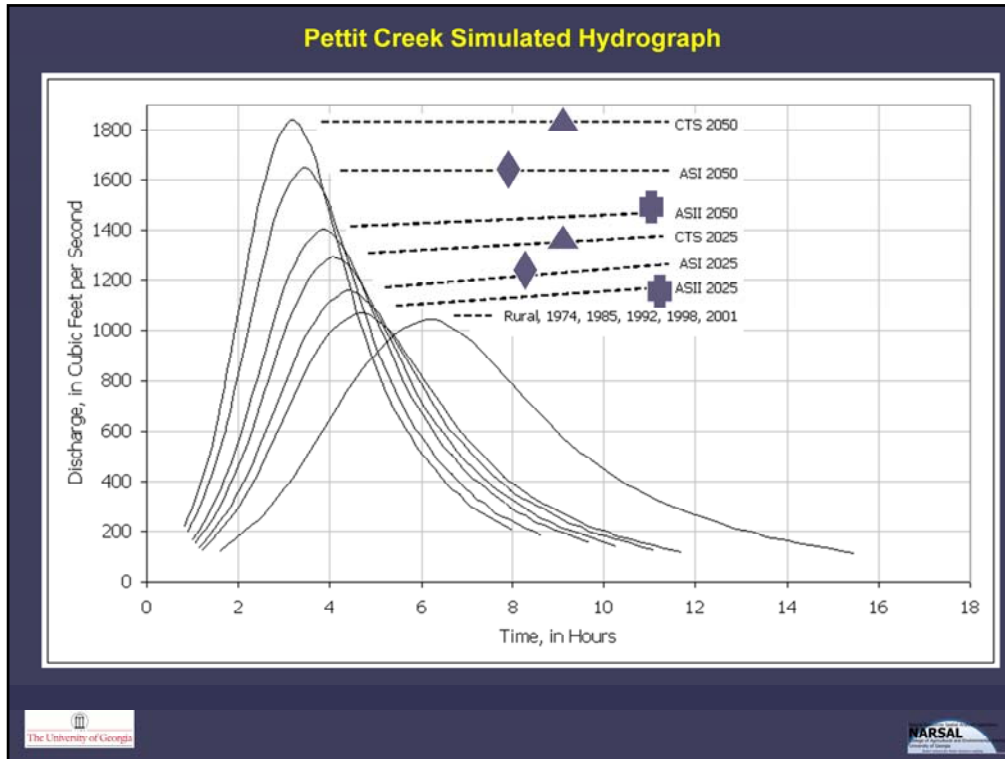
to look at the effects of different growth and economic policies as well as different ecological influences and outputs, such as percentages of tree canopy.

# Scenario Comparison

- **Current Trends Scenario**
  - 2001: 13% urban, 4.3% impervious
  - 2025: 33% urban, 6.7 % impervious
- **Future Land Use Scenario**
  - 2001: 13% urban, 4.3% impervious
  - 2025: 31% urban, 6.4% impervious
- **Service Delivery Cluster Scenario**
  - 2001: 13% urban, 4.3% impervious
  - 2025: 26% urban, 5.8% impervious

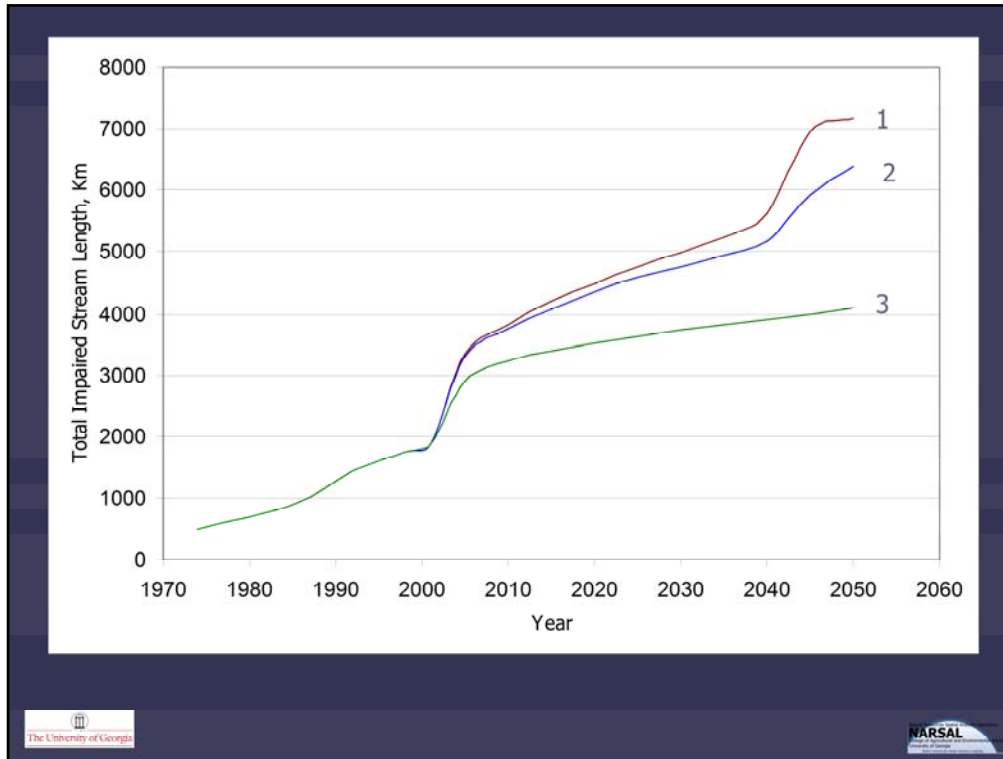


Here is a quick comparison of percent urban areas between the scenarios. Each subsequent scenario reduces the amount of urban land from the previous.



This is the simulated hydrograph for Pettit creek in Bartow county. The triangle represents results for the same growth pattern scenario, the diamond is the scenario that used the future land use for the comprehensive plans, and the pluses show a scenario that limits growth based upon providing water service delivery and compact development. In each case the stream is becoming more flashy and losing flows over time.

It has remained a rural watershed and you can clearly see how the future scenarios would affect the storm discharge and cut the lagtime almost in half.



This shows the increase in impaired waterways under each of the growth scenarios. Once we've determined the threshold for stream impairment, the actual length of stream impairment was estimated.

In 2002, the Georgia EPD designated approximately 1,275 km (406 km in the watershed proper) of stream in the Etowah study area as impaired.

1974, 491 km, 33 km proper

1985, 885 km, 73 km

1992, 1447 km, 207 km

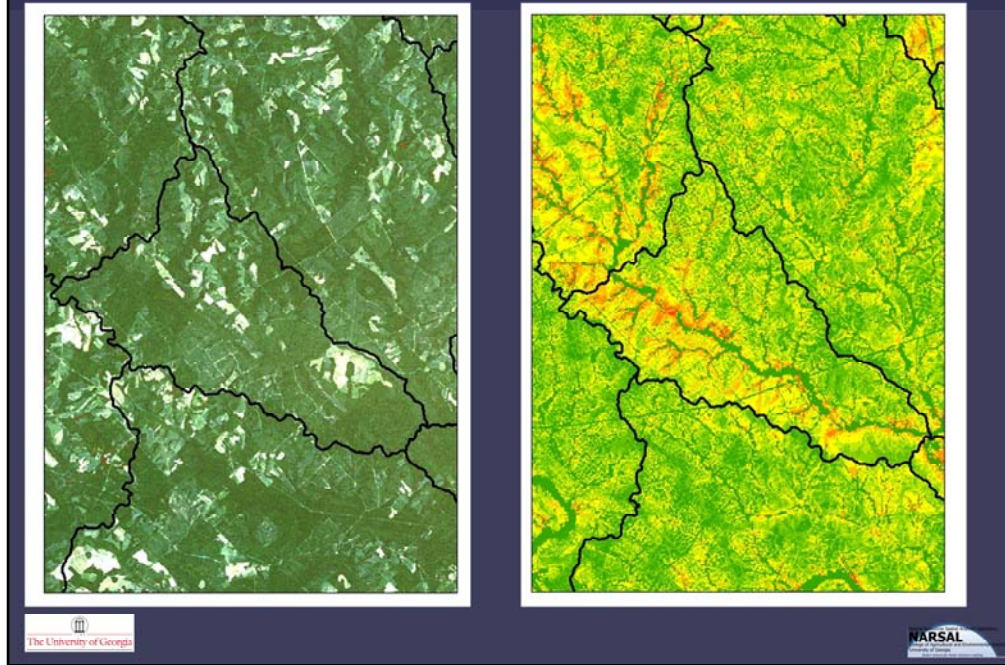
1998, 1746 km, 282 km

2001, 1886 km, 323 km

This is a 284 percent increase of impaired stream length from 1974 to 2001 while the total urban area grew from 559 km<sup>2</sup> to 1,486 km<sup>2</sup> or 166 percent, a 1.5 to 1 relationship.

Compare future scenarios

## Is all land the same?

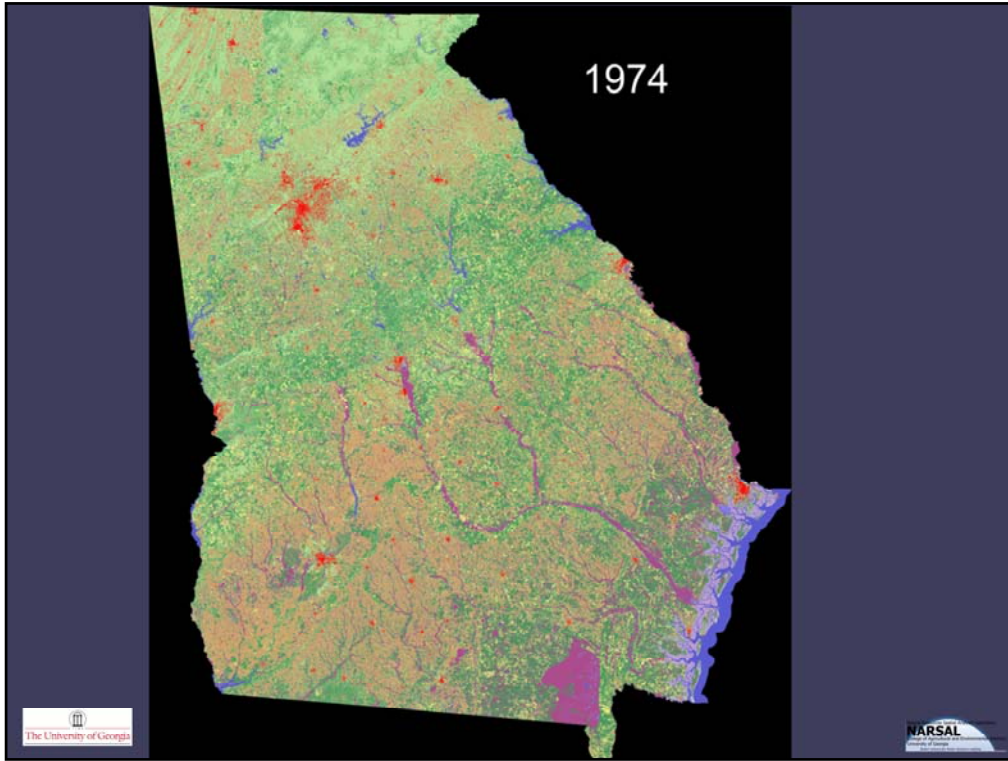


These areas are the same. The image on the left shows the vegetation from an aerial photograph. The image on the right shows that depending upon where a forest land is in relation to the stream and wetlands and what type of land use activity occurs on that piece of land, we can impact our water bodies very differently. The red and orange areas provide better protection of water quality and quantity. The lighter green and yellow areas are best area for human dominated land activities.

## Georgia encompasses 37 million acres of land



We estimate that the population of the state will double in the next 30 – 40 years. Since we are not going to add more land to the State, it is important to think about how we develop our land in the future to maintain our natural resources.





It is imperative that we start now!

# Questions?

