

Planning for North Carolina's Future: Ask the Climate Question

Workshop on Climate Change Adaptation
McKimmon Center at North Carolina State University
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PROCEEDINGS



Ask The Climate Question

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Acronyms and Abbreviations

APA	American Planning Association
CAFÉ	Corporate Average Fuel Economy
CCAP	Center for Clean Air Policy
CDC	U.S. Centers for Disease Control and Prevention
CEQ	White House Council on Environmental Quality
CO₂	Carbon dioxide
EPA	U.S. Environmental Protection Agency
EU	European Union
FHWA	Federal Highway Administration
GHG	Greenhouse Gas
ILT	North Carolina Interagency Leadership Team
IPCC	Intergovernmental Panel on Climate Change
NCDENR	North Carolina Department of Environment and Natural Resources
NCDCR	North Carolina Department of Cultural Resources
NCDOI	North Carolina Department of Insurance
NCDOT	North Carolina Department of Transportation
NOAA	National Oceanic and Atmospheric Administration
RENCI	Renaissance Computing Institute
UNC	University of North Carolina
USACE	U.S. Army Corps of Engineers
UAE	United Arab Emirates
USDOT	U.S. Department of Transportation

INTRODUCTION

The North Carolina Interagency Leadership Team (ILT) was established in 2004 when five state agencies and five federal agencies committed to using a collaborative and interdisciplinary approach to developing a transportation system that involves all stakeholders and preserves the historic and natural resources, community values, and economic vitality of the state. The ILT has been working on climate change for several years, researching the science and projected impacts for North Carolina, and discussing how to plan for those impacts.

The *Planning for North Carolina's Future: Ask the Climate Question Workshop on Climate Change Adaptation*, which was held on March 2–3, 2010 in Raleigh, North Carolina, was the result of those efforts and was intended to be the foundation for a planning effort for the state's climate change adaptation future. The workshop examined how North Carolina can reduce its risk while enhancing its resilience to the changes that are already occurring in the climate and which are projected to increase in the future.

Approximately 440 staff from federal, state, and local government agencies, as well as from universities, non-governmental organizations attended the workshop. Attendees represented the various planning sectors that will need to develop climate adaptation strategies: natural resources, transportation, land use, economic development, emergency management, infrastructure, health, cultural resources, insurance, and tourism. This report provides a summary of the presentations made and discussions held.

OPENING SESSION

Welcome and Introduction

Moderator – Linda Rimer, U.S. Environmental Protection Agency (EPA) Region 4 Liaison to North Carolina
Bill Friday, President Emeritus, University of North Carolina

Speakers: Secretary Dee Freeman, NC Department of Environment and Natural Resources (NCDENR)
Secretary Eugene Conti, NC Department of Transportation (NCDOT)
Secretary Linda Carlisle, NC Department of Cultural Resources (NCDCCR)
Deputy Secretary Dale Carroll, NC Department of Commerce
Commissioner Wayne Goodwin, NC Department of Insurance (NCDOI)

Why is Climate Change an Important Issue for North Carolina?

Leaders of several North Carolina state government departments provided their agencies' perspectives on why climate change is an important issue for the state.

- *NCDENR:* Secretary Dee Freeman noted that climate change is one of the most important topics that the state will deal with in the coming years. The DENR has included climate change as one of the eight primary goals included in its strategic approach to the future. The DENR is committed to being a leader, not only in talking about the issue, but in doing something to address climate change. When dealing with this sometimes controversial topic, it was noted that it is up to state government to bring clarity, to discuss all the possibilities, and to end up with results in the form of good public policy.
- *NCDOT:* Secretary Eugene Conti stated that the NCDOT is committed to environmental stewardship, protecting the state's natural beauty, and helping to build safe and sustainable communities. The NCDOT has a number of initiatives underway to address climate change including running its off-road construction equipment on biodiesel, the recent construction of a green rest area, which has photovoltaic panels and a geothermal heat pump, and the ongoing planning for the southeast high-speed rail corridor. In addition to these initiatives, the NCDOT is integrating climate adaptation into

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its activities. The department has started to consider how changes in climate will impact the planning, design, building and maintenance of the transportation network to ensure that it can withstand the forces of nature.

- *NC Department of Commerce*: Deputy Secretary Dale Carroll reported that the Department of Commerce continues to ask the critical question on why climate change is an important issue for the state. The department is implementing a number of tactical, solution-oriented activities to address climate change. Examples for various departments include:
 - Division of Community of Assistance uses community development block grant funds to replace older water systems in non-entitlement governments¹ to address critical water supply and works with groups seeking to strategically plan for responses to climate change at the grassroots level through the 21st Century Communities program www.nccommerce.com/en/CommunityServices/CommunityPlanningAssistance/21stCenturyCommunities/.
 - Division of Science and Technology continues to strengthen green business development by increasing funding from \$2 to \$8 million to support entrepreneurs in finding and implementing new energy solutions.
 - The State Energy Office and Weatherization Program performs significant weatherization of homes to reduce the carbon footprint of residences across the state.
- *NCDCR*: Secretary Linda Carlisle explained that NCDCR is responsible for protecting the state's cultural resources and heritage. The NCDCR's purview includes over 300 buildings, 3,000 acres of land, and millions of documents, artifacts, and art work that are historically important to the state. A key issue for the department is to assess the potential impact of sea level rise on the cultural resources in the Coastal Plain region. Understanding the science of climate change and sea level rise will affect the department's ability to assess and react to such impacts in a responsible manner. Currently, the department is developing disaster preparedness plans and is proud to be a part of building a statewide climate change adaptation plan.
- *NCDOI*: Commissioner Wayne Goodwin stated that insurance availability, affordability, and safety are impacted by climate change, which is why the Department of Insurance is focused on climate change. Climate change will have an impact across many lines of insurance, including property, health, and life insurance. The key issue for the NCDOI is to ensure the availability of insurance and to work with the insurance industry to develop solutions to maintain solvency so that the state's consumers are protected.

Comments, Questions, and Answers:

Question: What is the next step after the workshop to "Ask the climate question?"

Answer: Many of the state's departments are taking a comprehensive look at how climate change affects their operations and activities. As an outcome of this conference, participants should take what they have learned back to their communities and start similar initiatives in their work. Ask the question: "How in the course of my business can I integrate what we are learning about mitigating and adapting to climate change into policy and best management?"

¹ Non-entitlement communities are all units of general local government that do not meet the definition and qualifications for an entitlement community. This includes all cities, counties, towns, townships, etc. that do not qualify to receive CDBG entitlement funds; and any incorporated units of general local government located in urban counties who have opted not to participate in the urban county's entitlement CDBG program. www.hud.gov/offices/cpd/communitydevelopment/programs/nonentitlement.cfm

GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES

Speaker: Tom Peterson, Intergovernmental Panel on Climate Change (IPCC) and the National Oceanic and Atmospheric Administration's National Climatic Data Center

Summary: Dr. Peterson's goal was to summarize the findings from the report, "Global Climate Change Impacts in the United States," www.globalchange.gov/publications/reports/scientific-assessments/us-impacts. The report, which addresses global and national impacts, covers nine geographic regions of the U.S. and is divided into seven sectors:

- Water resources
- Energy
- Transportation
- Agriculture
- Ecosystems
- Human health
- Society

The report's 10 key findings include:

- 1. "Global warming is unequivocal and primarily human induced"** based on data for the 800,000 year record of carbon dioxide concentration in the atmosphere. Climate models have looked at natural forces versus natural and human forces. Observed warming only appears with the addition of human forces.
- 2. "Climate changes are underway in the U.S. and are projected to grow."** High and low emissions scenarios explore the impact on carbon dioxide (CO₂) emissions as well as temperature and sea-level rise. Other impacts include heavy downpours, earlier snowmelt, longer growing seasons, thawing permafrost, changes in river flows, and others. Recent data (since 1961) reveal changes in weather patterns (e.g., fewer below-freezing days in the southeast U.S. and more days with temperatures over 90 degrees).
- 3. "Widespread climate-related impacts are occurring now and are expected to increase."** Growing patterns are changing and ecosystems are migrating. For example, a mid-range emissions scenario shows the Maple-Beech-Birch forest in the Northeast U.S. being replaced by Oak-Hickory ecosystems.
- 4. "Climate change will stress water resources."** There is likely to be less snow and more rain, drier dry areas and wetter wet areas, and a decline of mountain snow packs. Droughts have been increasing over the last 50 years and will continue to occur. Changes in runoff patterns can have implications for agriculture, human health, ecosystem management, and energy.
- 5. "Crop and livestock production will be increasingly challenged."** There will be an impact for commercial agriculture, landscaping, and backyard gardening. Some plants will grow larger but they may not be as nutritious (particularly pastures). Warming winter temperatures will allow many insect pests and crop diseases to expand and thrive.
- 6. "Coastal areas are at increasing risk from sea level rise and storm surge."** The impact will be felt when there is a storm surge. The IPCC projected sea level rise in feet from ~.5 feet (lower emissions scenario) to ~2.0 feet (highest emission scenario). Coastal barrier islands have suffered dramatically from hurricanes and will continue to be vulnerable. Many factors influence hurricane growth and development (e.g., wind shear) but it is clear that hurricane power is related to sea surface temperature. One remaining question is whether or not there will be more "land falling" hurricanes in the U.S.

7. "Threats to human health will increase." Possible impacts include heat stress, water-borne diseases, reduced air quality, extreme weather events, diseases caused by insects and rodents, and increased allergenic pollen counts.

8. "Climate change will interact with many social and environmental stresses." Social trends can increase vulnerability to climate change impacts (e.g., population migration to vulnerable areas like the southeast and southwest, aging populations, agricultural and economic changes, and others).

9. "Some tipping points will be reached, leading to unpredictable changes." Not all impacts can be statistically modeled or projected.

10. "Future climate change and its impacts depend on choices made today." Options include adaptation, mitigation, or doing nothing.

In addition to these key findings, the report also puts forward examples of adaptation in practice. The report also suggests that responses to climate change will evolve over time, and adaptation will become an iterative process. The IPCC's full report is available at www.GlobalChange.gov/USImpacts.

IMPORTANT CLIMATE RELATED ISSUES FOR COMMUNITIES

Speaker: Scott Shuford, Onslow County, North Carolina Planning and Development Director

Summary: The presentation summarized findings from the American Planning Association's (APA) recently published research report, *Planning for a New Energy and Climate Future*. The report was the culmination of a three-year research and education project on the integration of climate change and energy issues into planning practice. The report presents fundamental information about energy and climate change and offers strategies for communities to address energy and climate across a variety of issues. The website for the research effort (www.planning.org/research/energy/), contains climate and energy resources and over 200 case studies.

Mr. Shuford noted that since the climate is expressed locally as weather, climate change is inevitable, and adaptive action will be necessary. Local planners must engage stakeholders with climate change issues to be able to address adaptation. Planners have several strategic points of intervention, or ways that they engage their community (such as visioning, plan making, and outreach), that can be channeled towards adaptation. Focus areas for planners include:

- **Development patterns.** Planners can consider both benefits and challenges that will result from in-migration and out-migration related to weather-events that make communities uninhabitable. They can also better identify risk and plan to concentrate development in areas less risk prone.
- **Infrastructure.** Planners can design new infrastructure investments to withstand climate impacts, and consider both infrastructure benefits and costs associated with climatic changes.
- **Economic development.** Planners should anticipate adjustments to agriculture and forestry industries, as well as major impacts to the insurance industry when historical patterns of risk development become less useful.
- **Sites and buildings.** Planners should encourage accommodations at the site level, such as stormwater management techniques, and building designs, such as raised buildings in flood-prone areas, that are adaptive to climate impacts.

- **Natural resources.** Planners should be aware of the consequences of new water management patterns, caused by droughts and flooding. They must also understand the ecosystem and cultural losses that may result from sea-level rise, such as loss of key recreation areas.

Additionally, interagency collaboration is key to planning for adaptation, and communities will need to use “interdisciplinarity,” or collaboration across sectors and across disciplines, to meet climate challenges. Planners should recognize that decision-makers face competing interests and frame adaptation choices accordingly to meet these political constraints. One suggestion is to develop and use scenario-based approaches and solutions that would bring benefit to the community regardless of the severity of climate impact.

Comments, Questions, and Answers

- **Question:** How much are planners taking climate change adaptation into consideration already?
Answer: The APA is emphasizing the message more and more; there will be over 40 sessions related to climate change at the APA conference in April 2010 (compared with two sessions in 2007). Interest is growing quickly.
- **Question:** Can the cost of climate change adaptation versus mitigation be compared?
Answer: From the local level, mitigation is relatively inexpensive because it involves things we are doing anyway (i.e., compact land use patterns). Adaptation is a question of marginal decisions; the main cost of adaptation is usually fairly small compared to overall project cost. Planning ahead saves money in the long-run.
- **Question:** How is Onslow County integrating its County Hazard Mitigation Plan with a Climate Adaptation Plan?
Answer: Onslow County is a coastal county that takes emergency issues very seriously. Climate impacts are already being studied. Public safety is a good starting point from which to engage the community, because the community can recognize its vulnerabilities. An incremental approach is being taken in Onslow County. There is an opportunity to develop and implement adaptation strategies, and save money in the long run, especially if planning begins early.

WHAT LEADING STATES ARE DOING TO ADDRESS IMPACTS OF CLIMATE CHANGE

Speaker: Zoe Johnson, Office for Sustainable Future, Maryland Department of Natural Resources

Summary: This plenary session featured the state of Maryland's recommendations for addressing the state's vulnerability to climate change. The Maryland Department of Natural Resources has established an Office for a Sustainable Future. Ms. Johnson oversees that office and is currently implementing the state's Climate Change Adaptation Policy and Practice.

Climate resilience in Maryland includes both mitigation and adaptation. Mitigation means reducing greenhouse gas (GHG) emissions to slow or stop global climate change. Adaptation is the adjustment in natural or human systems in response to climactic stimuli or their effects. Current climate-related action features the development of key pieces of legislation and successes such as the Healthy Air Act, the Clean Cars Act, Regional Greenhouse Gas Initiative, Sustainable Forestry Act.

The adaptation planning process has three components:

- Scientific assessment (sector by sector impacts)

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- Comprehensive mitigation strategy (containing 42 policy recommendations)
- Comprehensive strategy for reducing the state's vulnerability to climate change.

Sectors that include scientific assessment include:

- Water resources
- Bay/aquatic ecosystems
- Human health
- Agriculture
- Forest/terrestrial ecosystems
- Growth and infrastructure
- Sea level rise and coastal storms

Phase 1 implementation of the Climate Change Adaptation Policy focused on sea level rise and coastal storms adaptation. There are six new adaptation working groups that have been working for more than a year to develop specific strategies. The working groups, which are generally small (between 5 and 20 people), used an integrated application network to ensure an interactive story-boarding process to facilitate development of the report.

Maryland's adaptation planning process includes 8 steps:

1. Review state of the science
2. Assess climate vulnerability
3. Identify critical information gaps
4. Consider and prioritize key issues of concern
5. Explore potential adaptation strategies
6. Evaluate adaptation infrastructure (institutional framework)
7. Identify opportunities and mechanisms to effect change
8. Recommend action strategies (short, medium, and long term)

This iterative process has featured multiple studies that have evolved over time and actions that have been implemented or revised and redeployed. Maryland first published a sea level rise response strategy in the year 2000, then revised that document and released it in 2004. The sea level rise section used data from the IPCC and other sources. It also factored in Chesapeake Bay subsidence and then created lower and higher emission scenarios to arrive at recommendations for sea level rise (2.7-3.4 feet over 100 years). The current document has evolved from these predecessors. In addition, an adaptation strategy is not "one size fits all" – what works in Maryland may not work in North Carolina. Additionally, the adaptation strategy is multi-faceted and addresses land use planning, transportation planning, shoreline management, building codes and infrastructure and design standards, natural resources management, and emergency/disaster preparedness and response.

Other serious climate threats in Maryland include:

- Increased storm surge. During Hurricane Isabelle, portions of the state sustained 6-8 foot storm surges.
- Erosion and land loss. For example, in 1847 James Island measured 976 acres but by 1994 was only 92 acres. This represents a loss of 884 acres. The state is working with the Army Corps of Engineers (USACE) to try to restore and rebuild some of the bay islands.

The state's adaptation toolbox includes data, resources, policy analysis. Examples of activities undertaken include light detection and ranging (LIDAR) high-resolution topographic mapping, the state's study of the economic cost of sea level rise, the USACE Chesapeake Bay Shore Erosion Study, and sea level rise visualizations. The state's land use and development staff also previously established "priority funding areas" to direct future growth and development. Some of those priority funding areas are vulnerable to sea level rise. In response, multiple state offices are working together as the state development plan is created to think about whether to restrict growth in areas that are vulnerable to sea level rise.

Maryland's approach for integration of climate adaptation includes:

- Promoting programs and policies to *avoid* impacts.
- Shifting to sustainable economies and investments.
- Enhancing preparedness and planning efforts to protect human health, safety, and welfare.
- Protecting and restoring Maryland's natural shoreline and its resources.

Some strategies cannot be implemented in as few as five years, but instead are longer term strategies. For example, a "protect, retreat, and abandonment policy" for vulnerable coastal infrastructure might take 10 to 20 years to implement. Also, state and local governments must have the right tools to plan and adapt. The state must commit resources and time to assure progress. Local governments likely need technical planning guidance to help direct adaptation activities. Additionally, Maryland passed a Living Shoreline Protection Act and the Chesapeake and Coastal Bays Critical Area Amendments in 2008. Staffs are now merging aquatic and terrestrial priorities by overlaying data about sea level rise and vulnerabilities and data about land conservation and protection. Analysis of the data is anticipated to help lead the state to develop strategies for relocation of coastal communities.

PLANNING IN A CHANGING CLIMATE: PROJECTED IMPACTS AND ADAPTIVE RESPONSES

Moderator: Nina Szlosbery-Landis, Conservation Council of North Carolina and NC Transportation Board

Speakers: Nancy Beller-Simms, Program Manager, Sectoral Applications Research Program, National Oceanic and Atmospheric Administration (NOAA) Climate Program Office

Susan Asam, ICF International

David McNeils, UNC Chapel Hill, Center for Sustainable Energy, Environment and Economic Development

Sam Pearsall, Southeast Land, Water and Wildlife Program Manager, Environmental Defense Fund

Dr. Howard Frumkin, M.D., Special Assistant to the Director of Climate Change and Health, U.S. Centers for Disease Control (CDC)

Chrus Emrich, University of South Carolina, Institute of Hazard Research

The *Planning in a Changing Climate: Projected Impacts and Adaptive Responses* session featured experts discussing projected climate change impacts in six key sectors, each speaker giving special emphasis on the need for comprehensive integrated planning. Topic areas included water, transportation and infrastructure, energy, ecosystems, human health, and society.

WATER

Speaker: Nancy Beller-Simms, Program Manager, Sectoral Applications Research Program, NOAA Climate Program Office

Ms. Beller-Simms discussed the potential impacts of climate change on water resources and the strategies that planners can adopt in order to adapt. Regardless of the prevailing beliefs about climate change, adaptation efforts offer the opportunity for a "win-win" situation. They provide the public and decision-makers a greater ability to plan for changes in the environment. Furthermore, adaptation planning and strategies do not require precise information. Managers must make decisions with imperfect information since how climate change is going to impact specific regions is not completely known. Climate studies have often relied upon historical information to plan for the future, but in the case of climate change, the past does not necessarily accurately portray the future, especially in terms of the severity of increases in storm intensity, flooding, and drought.

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In any case, the impact of climate change on water resources is expected to be great. Floods, droughts, and other primary impacts will be important to address, along with secondary and tertiary impacts as well:

- **Water Quality:** Increases in flooding and storm intensity will likely inundate drinking water with sediment and threaten to introduce contaminants from vulnerable facilities like wastewater treatment plants. Increased flooding will likely overwhelm drainage infrastructure.
- **Water Quantity:** Higher temperatures will likely increase demand for water, and changes in precipitation levels will likely alter the supply of drinking water.
- **Changes to Coastal Ecosystems:** Sea level rise will likely threaten coastal habitats and facilities located in vulnerable locations. New York City, for example, has already begun to plan for wastewater treatment plants at higher elevations in order to adapt to future conditions. Sea level rise will likely also cause estuarine waters to become more saline, threatening biological systems and drinking water supplies.

In order to account for these changes, planners will need to pay careful attention to permits for drinking water, wetlands, discharge, and stormwater and will need to adjust their priorities and planning for tropical storms, storm surges, flooding, and high water. Some water-focused programs within NOAA's Climate Program Office that could help include:

- **Sectoral Application Research Program:** Provides grants to researchers to look into how to use climate information to develop tools for planners. www.climate.noaa.gov/cpo_pa/sarp/
- **Regional Integrated Sciences and Assessments:** Supports research that addresses complex climate sensitive issues of concern to decision-makers and policy planners at a regional level. www.climate.noaa.gov/cpo_pa/risa/
- **Transition of Research Applications to Climate Science:** Transitions experimentally mature climate information tools, methods, and processes, including computer related applications (e.g., web interfaces, visualization tools), from research mode into settings where they may be applied in an operational and sustained manner. www.climate.noaa.gov/cpo_pa/nctp/
- **National Integrated Drought Information System:** Provides drought information through its website www.drought.gov.

TRANSPORTATION AND INFRASTRUCTURE

Speaker: Susan Asam, ICF International

Ms. Asam presented on four related topics: (1) an overview of the impacts of climate change on transportation infrastructure, (2) barriers within the transportation sector to adaptation, (3) a framework to streamline the adaptation process, and (4) example efforts that are currently underway. Climate change will likely result in both positive and negative impacts to transportation, including warmer winters with less snow accumulation in some areas but more intense winter storms in others. Changes will likely be highly localized, though heat waves and extreme precipitation and flooding could be widespread. These changes could damage roads and infrastructure, increase accident rates, and overwhelm drainage capacity. Ms. Asam emphasized that with the high levels of investment currently feeding into transportation, 21st century infrastructure should not be designed for a 20th century climate.

Significant barriers exist for the transportation community to begin adapting to climate change. Transportation decision-making often involves participants with a diverse array of capacities and information needs. This interdisciplinary atmosphere can present opportunities for collaboration among decision-makers in different realms but certainly creates obstacles to adaptation that must be overcome. The perception and reality of the uncertainty surrounding climate change is another significant barrier hindering adaptation since

existing information is not concrete. As a result, estimating the cost-effectiveness of adaptation strategies or, conversely, the cost of inaction, is difficult. Furthermore, existing engineering standards are potentially irrelevant under climate change scenarios and many climate risks have low probabilities of occurring but high consequences.

A simple framework for streamlining adaptation involves:

1. Risk Screening: Prioritize where to focus efforts to adapt climate change in the near term, questioning how sensitive assets and systems are to climate change, what is at stake if the wrong decision is made, and the potential time horizon for climate change effects and impacts. The output of risk screening will group risks into three categories:
 - Group 1: Climate change is not a key stressor
 - Group 2: Climate change could become important but adaptation options remain open
 - Group 3: Risks need to be assessed and managed now
2. Risk Assessment: Assess the impacts of the stressors in Group 3 to inform management decisions. FHWA has taken a leadership role in developing Climate Change Risk Assessment tools like climate effect scenarios and damage functions. These Risk Assessment tools will inform transportation agencies about how to take action to reduce impacts or exploit beneficial opportunities.
3. Risk Management: Simple risk management tools include lists of adaptation options, cost estimate models, effectiveness models (co-benefits, cost of inaction), and methods to characterize and estimate uncertainty.

FHWA's climate change activities include regional estimates of climate effects, the development of a framework for conducting vulnerability assessments and pilot projects, peer exchanges, technical assistance on adaptation issues, and long-term adaptation research initiatives.

ENERGY

Speaker: David McNeils, UNC Chapel Hill, Center for Sustainable Energy, Environment and Economic Development

Summary: Mr. McNeils discussed some of the challenges that climate change adaptation poses to the energy sector. There is an intimate interrelationship between water and energy: energy allows for water distribution, while water contributes to power generation, either directly through hydroelectric methods, or indirectly as a coolant for nuclear and coal power generation. The electric power sector will need to find ways to address the following key technology challenges in order to significantly reduce CO₂ emissions over the next decade:

- Current grid capacity and reliability can only accommodate 10-20 percent intermittent renewable (solar and wind) energy but will need to accommodate 20-30 percent intermittent renewable energy.
- Expansion of nuclear energy and continued safe and economic operation of existing nuclear energy facilities will support significant reductions in CO₂ emissions.
- A viable strategy for capturing and sequestering at least 90 percent of CO₂ emissions from coal-based generation by 2020 will be required in order to reduce the impact of coal-based generation.
- Smart grids and communications will be needed to enable end-use efficiency and demand response.

Climate change may ease energy demand in places like northern Europe, where an increase in temperature will lower the demand for heating energy. In other areas like the Southeastern U.S., energy production will be impacted significantly as demand for cooling energy rises. Furthermore, decreased water supplies will constrain power production while warmer water temperatures will decrease the utility of water as a coolant to power plants and cause losses in power plant operations efficiency as the resistance to power transmission

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and generation increases. Sea level rise, extreme weather events, and changing precipitation and snowmelt patterns will also affect and disrupt power generation and transmission.

Three suggested adaptation strategies to the energy issues climate change will likely bring are:

1. Societal behavior modifications: Changing habits, lifestyles, and technology-based behavior could reduce household energy usage by up to 30 percent over the next 5 to 8 years.
2. Adaptive policies and regulations: Could include renewable portfolio standards, increased Corporate Average Fuel Economy (CAFE) standards, \$4.00/gallon gasoline price fix (with subsidies for those who cannot afford it), subsidies, tax incentives, loan guarantees.
3. Technological fixes: Could include industrial ecology, smart technology, collocation of complementary facilities (so that one facility's waste is another's fuel), technology transfer and outreach (investing in other countries), and clean electricity generation using wind, ocean currents, and unobtrusive hydroelectric methods.

Questions, Answers, and Comments

Question: Looking at the report from Tom Carl and Tom Peterson, it's clear that some areas of the Southeastern U.S. will experience impacts of climate change sooner than North Carolina will. Can North Carolina partner with other neighboring states to learn from their efforts as they are more urgently forced to deal with these issues? Are there any thoughts on who will be the leaders in these specific sectors (water, transportation, energy)?

Answer: There are different leaders for a variety of these areas and in the Southeast. Drought is an issue for many states. The resource www.drought.gov examines drought by region rather than by state.

Maryland is a great example of a state that is taking many adaptation steps and can share lessons learned. New York City is also beginning to think about these issues, and while they are going to face different issues than the Southeast, there will be an opportunity to share lessons learned, even if the specifics vary from place to place. Also, the *Synthesis and Assessment product 4.7 "Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study"* (www.climate-science.gov/Library/sap/sap4-7/final-report/) took a preliminary look at Gulf Coast transportation infrastructure, particularly in the Mobile, Alabama area. Even though the issues might be slightly different than those that North Carolina will need to address, there will be lessons learned that can transfer to other regions.

California is very proactive in terms of the environment and energy. The European Union (EU) might also be a place to look for examples. The EU is currently ahead of the United States in terms of time and, in certain cases, technology regarding adaptation.

Question: Coal is inexpensive to burn from a monetary standpoint but very expensive in terms of its impact on public health. What will it take to phase out the burning of coal for electric power in North Carolina?

Answer: Unfortunately, coal and nuclear power will likely be around for the next 50 years. Many of the public health concerns surrounding coal will be minimized or eliminated with the use of carbon sequestration practices, but coal-fired power plants still produce more radiation at the fence-line than a nuclear power plant. Carbon sequestration, as well as implementation of a carbon tax or cap and trade system, will drive up the price of coal, but for now, coal-fired power plants remain consistently inexpensive to build, operate, and maintain.

Question: Does "win-win" equal "co-benefits?" Can specific examples be cited?

Answer: It depends on the specific situation. Usually when the environment is the topic, there is an opportunity to improve operations and at the same time reduce your environmental impact. An example exists in New York City. There, the city is planning new wastewater treatment plants at higher elevations. In doing this, New York City is planning for both climate change impacts as well as severe storm impacts.

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The *Synthesis and Assessment product 4.4 "Preliminary review of adaptation options for climate-sensitive ecosystems and resources"* (www.climate-science.gov/Library/sap/sap4-4/final-report/) found that one of the best adaptation options was better resource management. Employing known existing best management practices in this area can, in many cases, result in the added benefit of enhancing resilience to climate change.

On an individual level, choosing to use public transportation instead of driving for some trips can result in the co-benefits of reducing emissions and the cost of travel. Reducing one's personal vehicle miles traveled (VMT) by 10,000 miles per year could save \$5,000 at a cost of \$0.50 per mile.

Question: Can an example of a low-probability, high-consequence climate change scenario be provided?

Answer: An event like Hurricane Katrina, which destroyed an area's entire transportation infrastructure, is a good example.

Question: Does localized energy generation improve transmission efficiency?

Answer: Localized energy production does make sense but base load is needed, which implies that more resources are also needed. At some point, there may be a transition to localized energy generation because the transmission losses over short distances are so small. On the other hand, a great deal of energy is lost when attempts to transmit power over a few hundred miles are made. At that point, voltage has to be increased to 765,000 volts to make it work. With wind and solar, there will likely be a transition to more distributed energy sources. They will take a part of the intermittent power sources, but coal and nuclear power will still be necessary.

Question: Instead of the impact of climate change on transportation infrastructure, please speak to the potential conflict between transportation infrastructure and climate change and adaptation policy. How can transportation infrastructure work against local climate change adaptation strategies?

Answer: That's related to land use and urban planning. There are certainly many improvements that can be made in terms of urban planning and not creating communities that are residential pockets connected by large highways. This is a large and challenging issue, particularly in communities that are already very developed. Communities that are currently growing will have to take a leadership role in showing other communities what can be done.

Question: What are Europeans doing related to climate change adaptation, and what can be learned from them?

Answer: Europe is very advanced in wind power technology and has been very good with nuclear energy as well. About 80 percent of France's power is nuclear, and although Germany initially backed away from nuclear power, it is now rethinking that strategy in light of the natural gas situation that is taking place in Belarus and Ukraine. There is a worldwide renaissance in nuclear energy and with American efforts in Georgia, the U.S. might be poised to benefit from it. The United Arab Emirates (UAE) recently purchased four reactors from South Korea, which will be the first South Korean reactors to come online and the first reactors in the UAE. Thailand is also thinking about nuclear power. There are currently 35 nuclear reactors under construction worldwide.

The Bundesrat in Germany initiated a policy in 2002 that capped the energy per square foot on new building construction, resulting in a cost for any energy uses above that cap. As a result of that one policy decision, the renewable energy industry saw huge growth.

A major difference between the U.S. and the EU is that the EU has a different mindset and therefore, approaches climate change adaptation differently than Americans. Europe has already seen that its resources are limited and its approaches and world view reflect that. Australia has had a similar experience to Europe. The Netherlands is exploring an interesting concept to address sea level rise. Instead of addressing sea level rise through dikes and adapting structures, the Netherlands is investigating the concept of floating cities that could rise with sea levels.

Question: Are there any unintended consequences of carbon sequestration?

Answer: A lot of energy will be required to capture carbon. A way to transport the carbon and develop the geology to retain it will also need to be devised. There are some pilot plants currently operating with carbon sequestration, and there is one company that has already taken the concept to the next level of demonstration. As of last summer, the Electric Power Research Institute was confident that it would be able to capture all carbon by 2020. The biggest unintended consequence would be if the carbon is re-released somehow. Capture and sequestration has been taking place for a long time in the oil industry. In order to enhance the ability to extract oil, the industry has pressurized oil wells with CO₂ in order to drive the oil out.

ECOSYSTEMS

Speaker: Sam Pearsall, Southeast Land, Water and Wildlife Program Manager, Environmental Defense Fund

Summary: The probability that the planet will warm by 3.5 to 5 degrees F is nearly a given. At that point, 20–30 percent of known species will be living far outside of their current temperature ranges. This session focused on understanding the wide-ranging ecological implications of a temperature rise of a few degrees in North Carolina and how the state's ecosystems might adapt to such a scenario.

While ecosystems are typically thought of as natural places, most also have significant interaction with humans. In fact, human interactions have affected all ecosystems on earth in some way. Similarly, human activity has already changed the climate, and, according to the National Academy of Science² (Solomon *et al.* 2009), will likely continue to do so for at least a century. Some have projected that even if carbon emissions and forest destruction were completely stopped today, the influence of previous emissions and deforestation on temperature and sea-level rise will continue until at least the year 3,000.

The complexity of an ecosystem is a good measure of its ability to adapt to changing conditions. Ecosystem complexity can be measured by three variables: composition, structure, and function. The redundancy of pathways and interactions related to these variables is what makes ecosystems strong and allows them to persist. Without redundant pathways, ecosystems are more susceptible to catastrophe. In other words, the simplification of ecosystems compromises their adaptive capacities.

To help improve the state's adaptive capacity, North Carolina's Coastal Hazards Committee of the Coastal Resources Commission advised the state that it should begin planning for at least one-meter sea level rise. The Albemarle Sound is one of the country's places most susceptible to sea level rise. Should the one-meter sea level rise occur, many plants and animals will be forced to move (helping to avoid ecosystem simplification)—an occurrence that can be a difficult one to achieve; imagine an oak tree trying to extend its geographic range by dropping acorns. Taking this concept further, ecosystems cannot move—only the things of which they are made do, and thus planners should be thinking about how their decisions affect species' movement and local resilience in response to change.

Movement into and out of an ecosystem presents unique issues. While not all species that move in to an area are invasive species, invasives do pose threats as the climate changes and species migrate. There is a need to develop predictive models that help determine which species expected to move in are likely to be invasive. On the other hand, in lowland areas like those in North Carolina's coastal plains, barriers can prevent organisms from moving inland and upland, which they might need to do to survive higher sea levels. There is a need to make sure that there are adequate networks of protected areas inland and upland for moving species to occupy.

Species movement in mountainous areas like those in western North Carolina is also challenging. For example, soils vary with elevation, as does the amount of area of available habitat (many species occupy

² Solomon, Susan, *et al.* 2009. Irreversible climate change due to carbon dioxide emissions. National Academy of Sciences. www.pnas.org/content/early/2009/01/28/0812721106.full.pdf+html

narrowly defined habitats). Planners should treat future species range maps, especially those for mountainous areas, with caution. While the climate may shift, soils and topography do not.

Some recommended near- to mid-term actions include:

- Develop and implement market incentives to protect ecosystem services.
- Consider having more prescribed burns, especially in coastal areas where soils might be inundated with salt and thus might burn hotter if a natural fire were to occur.
- Consider following the Netherlands' example. There, measures to protect against sea level rise have been occurring for over 500 years. After Hurricane Katrina, the Dutch government spent \$100 billion more in strengthening and expanding existing adaptation strategies. Even so, representatives from the Netherlands have acknowledged to U.S. government representatives that the Dutch will begin planning for scenarios where communities are forced to relocate.

HUMAN HEALTH

Speaker: Dr. Howard Frumkin, M.D., Special Assistant to the Director of Climate Change and Health, U.S. CDC

Summary: Climate change related health threats include direct effects of heat, injuries from severe weather, diseases caused by air pollution, increases in allergens, vector- and water-borne diseases, changes in food and water supply, mental health problems, and the potential creation of environmental refugees. These problems are all familiar to the public health world; climate change serves as an amplifier. The unprecedented scale, scope, and time frame of these health problems will likely require new applications of existing public health tools, as well as new tools all together.

As with other climate change adaptation strategies, state and local agencies will lead actions to protect public health. The CDC already works with local partners (including the National Association of County and City Health Officials and the Association of State and Territorial Health Officials) for climate adaptation preparedness, and climate change planners are urged to partner with local public health officials, who already have many of the key skills needed to address climate change adaptation. One potential problem, however, is that reduced funding for local public health departments can diminish the capacity of these professionals to help as climate adaptation needs become more severe.

The 10 essential functions of public health are very closely related to the steps and tools needed for climate change action:

1. *Forecasting.* This is the one function that is not as familiar to public health officials, as they do not generally forecast and model decades in advance. A key need is to pay attention to vulnerable populations, accepting uncertainty when forecasting at the local level.
2. *Surveillance.* Data on tracking diseases should be analyzed in relationship with data on climate and ecosystem conditions to find early warning trends.
3. *Outbreak investigation.* Acknowledge that surprises will happen. Be prepared to find those surprises and alert the public to minimize adverse impact.
4. *Research.* There is limited knowledge and understanding on several areas of climate and health, including the specific impacts of climate change and associated costs. The CDC is funding research in this area, but there is a need for research funding especially at the macro level.
5. *Preparedness planning.* Create a model to predict *where* vulnerable populations will be, verify the accuracy of the model, and target preparedness plans to those populations. Plans should also be practiced and modified, as appropriate, to ensure they can be implemented as the need arises.

6. *Decision support.* A health impact assessment is a tool that provides a systematic way to analyze health impacts and fit them into decision-making process.
7. *Health Sector Mitigation.* Contributing to the greening of the health care sector could be a way to show leadership in addressing climate change.
8. *Training and capacity building.* There is a need for a multi-disciplinary workforce that is fluent in many pieces of the climate and health puzzles in order to ensure that public health preparedness is successful.
9. *Climate communication.* Public health officials are accustomed to communicating difficult news that people often do not want to hear, especially to diverse audiences. Potentially effective communication strategies include recognizing populations with disbelief about climate change, providing actionable recommendations along with bad news, and emphasizing the co-benefits of recommended actions.

SOCIETY

Speaker: Chris Emrich, University of South Carolina, Institute of Hazard Research

Summary: Dr. Emrich's presentation featured three key points regarding social vulnerability and climate change hazards in the southeast United States:

- Climate change is a major public health threat;
- Adaptation to climate change can protect public health; and
- Public health adaptation measures are well-defined.

According to the presentation, the field of geography is less about states and capitals and more about humans' interactions with the environment. The research discussed focuses on the identification of social vulnerabilities and biophysical vulnerabilities. The science aims to identify and analyze the circumstances that place people and localities at risk, the drivers of the ability to respond to and recover from environmental threats, and the geographic patterns between and among places.

The social vulnerability index is multidimensional so it is important to decouple results and understand the effect of several criteria on vulnerability (wealth and poverty, gender, race, etc.). As part of the research, a social vulnerability map of the Southeast US has been developed. The map provides county-by-county assessments of vulnerable populations.

After developing the map, the researchers looked at four climate change hazards (30 years of drought data, flood insurance information, 30 years of hurricane information, and sea-level rise estimations) in order to overlay the biophysical vulnerability to climate change on the social vulnerability scale. This allowed the researchers to understand the "intersectionality" of the circumstances and situations that present climate hazards. This information can make it easier to mitigate and adapt to events.

The results of the work reveal areas of interest in West Texas, the Mississippi Delta region, and many coastal communities. In North Carolina there are three areas with high hazard potential *and* high social vulnerability. Bertie, Chowan, and Perquimans Counties are key areas of interest. Other areas have high hazard potential but only moderate social vulnerability (e.g., Gaston, Hyde, and Rutherford counties). Additionally, it would be possible to scale down the data from the county level to the Census tract and block group levels. This would allow county planners to more precisely pinpoint vulnerable populations.

The project offers the researchers the ability to provide guidance to jurisdictions planning for climate changes adaptation and can help government officials advocate for those whom climate related hazards will threaten. The research also provides governments with a spatially-referenced decisions support tool.

See: Social Vulnerability Index at sovius.org

See: Hazards and Vulnerability Research Institute at webra.cas.sc.edu/hvri

IMPORTANCE OF COMMUNICATION, EDUCATION, AND ENGAGEMENT IN DEVELOPING PLANS

Speaker: Dr. Heidi Cullen, Senior Research Scientist, Climate Central, "Seeing Climate, Seeing Change: Communicating Climate Science in a Changing Media Landscape"

Summary: Focusing on communicating the message that the underlying goal of adaptation is to keep people out of harm's way as climate change impacts increase should help people broaden how they think about climate change. It is important to recognize that it is difficult to ask the public to think on a long-term time frame and make expensive infrastructure investments; therefore patience and persistence are also essential.

Public concern about climate change is based on three "pillars:" (1) their belief that climate change is caused by human activities, (2) their trust in scientists, and (3) their belief that scientists are in agreement about climate change. While the public generally holds scientists in high esteem, recent media attention has focused on removing integrity from scientists relative to climate change, working against public trust. People generally fall within a range of concern from alarmed about climate change to dismissive, and the range of concern has shifted towards being more doubtful and dismissive in the past two years based on media portrayal of uncertainties and climate hoaxes.

Much of public perception about climate change is related to media coverage. Global warming is a trend but media coverage is a cycle. If coverage dies down or shifts to a negative portrayal, then people will disengage or doubt more. A recent decline in climate change coverage is related to the current economic recession; people are concerned with the present instead of long-term problems. Additionally, major media layoffs have led to even greater decreases in science coverage. A positive is that new social platforms might be able to engage new audiences.

Several techniques for communicating climate change more effectively to the public include:

- Integrate climate into areas like weather, energy, national security, and business. This is where climate has its impacts; climate trends alone are expressed as statistics and are not immediately relevant to people.
- Apply climate locally; show trends of what are normal weather events at a local level. Use new tools that can simulate or help people visualize impacts to their environments.
- Communicate science and not politics. People engage with science but politics may alienate them. Use visualizations and relevant, mainstream applications of the science. Present basic scientific concepts that are held in agreement by the scientific community.
- Give weather events context. Routinely show weather events that are out of the ordinary.
- Recognize that climate literacy will vary by demographic group; look for ways to increase the general climate literacy of all groups.
- Show long-term data and trends, but clarify that prediction of trends is different than predicting specific weather several decades into the future.

DEVELOPING CLIMATE CHANGE ADAPTATION STRATEGIES

Speaker: Robert R. Verchick, Deputy Associate Administrator for Policy, Office of Policy, Economics, and Innovation, EPA

Summary: Mr. Verchick discussed the effects of climate change, actions that the federal government is taking to address climate change, and the use of multiple scenario planning as an adaptation strategy.

Climate change adaptation is particularly important in the U.S., because many cities, such as Miami, New York, and New Orleans, are internationally ranked as the coastal cities with the most assets at risk to the effects of climate change. In order to address climate change, the federal government needs to integrate decision-making vertically among federal, state, and local governments, as well as horizontally among agencies. Adaptation to climate change involves mitigating risk, which has three main components:

1. Reducing exposure: to storm surges, heat waves, etc.
2. Reducing vulnerability: includes social vulnerability, as areas most at risk from the effects of climate change have disproportionately high populations of certain minority groups.
3. Increasing resilience: includes the introduction of lines of defense, both natural and artificial, against hazards

The federal government is taking several actions to address climate change adaptation. In October 2009, the President signed an Executive Order on sustainability. Its primary focus was to reduce the green house gas footprint of federal agencies while Section 16, in particular, requires all federal agencies to participate in the interagency Climate Change Task Force and encourages them to develop policies and practices that reinforce the U.S.' climate change adaptation strategy. Led by the Council of Environmental Quality (CEQ), the Office of Science and Technology Policy, and the NOAA, the Climate Change Adaptation Task Force consists of about 20 federal agencies and has three primary responsibilities:

- Integrating resilience and adaptive capacities within federal agencies
- Equipping communities with information for local adaptation policies
- In December 2010, the Task Force will release recommendations for a national adaptation strategy

Many workgroups exist within the Climate Change Adaptation Task Force to address topics such as Agency Planning, Science, Water Resources, International Resilience, and Insurance. These workgroups meet weekly to discuss and recommend how federal agencies can integrate adaptation into their regular activities.

The EPA's Office of Policy, Economics, and Innovation is currently creating an Adaptation Team, which will consist of about 20 experts from various fields that will examine how to address climate change throughout the EPA. The team will support interagency initiatives, consider climate in the regulatory process, support local pilot projects, and build local capacity. An on-the-ground example of these initiatives is a pilot project in Waverly, Iowa, in which the EPA will help the city recover from flooding that occurred in 2008 and integrate hazard mitigation into its planning practice.

Other important proposed federal initiatives include:

- Draft guidance recently released by CEQ on climate change and the National Environmental Policy Act, which represents the first time that the federal government has strongly recommended that agencies look at climate adaptation in all federal projects.

www.eenews.net/public/25/14417/features/documents/2010/02/18/document_pm_03.pdf

- Principles and Guidelines on Water Resource Projects – For the first time, this guidance recommends that the construction of dams, levees, and navigation waterways should consider environmental protection and economic development equally. It also requires any agency in charge of a project to consider a change in climate over the lifecycle of the plan.
www.whitehouse.gov/administration/eop/ceq/initiatives/PandG

Discussing situations that are going to occur decades in the future is difficult. What will happen cannot be predicted, but what might happen can be considered. Choices based on those considerations can be made. Decisions should not be based on the possibility of a single, low-probability, high-consequence event. “Multiple Scenario Planning,” a concept the military developed, addresses some of the shortcomings of previous planning strategies by considering multiple potential scenarios in the decision-making process with the understanding that some or all of the scenarios are unlikely to occur. Multiple Scenario Planning:

- Is a cognitive tool and a communications tool
- Avoids the urge to predict
- Is holistic
- Considers factors that are both exogenous and endogenous
- Places factors in memorable situations, allowing scientists to converse with non-scientists

An example of scenario planning is currently underway in the restoration of New Orleans. Congress is requiring the USACE to restore New Orleans to “Category 5” standards without the use of predictive models. USACE is utilizing multiple scenario planning, feeding the values that residents have assigned to different assets into scenarios comprised of various combinations of economic growth, population dispersion, and other factors. Multiple scenario planning allows real people to be involved in a decision-making process that is still science-based.

Questions, Answers, and Comments

Question: The report from the Adaptation Work Group is due in December 2010. How can moving forward quickly be ensured once that report is completed?

Answer: There might be a series of Executive Orders requiring agencies to act on some of the recommendations. A softer approach would be to have all of the agencies involved in making those recommendations address some of those issues. That is what the EPA is hoping for. Absent leadership on climate change adaptation in agencies, Executive Orders or something comparable will probably be necessary.

Question: Should the climate change discussion be part of the sustainable communities initiative and, if so, how?

Answer: Yes, but determining how this will happen is more difficult. The adaptation team in EPA’s Office of Policy, Economics, and Innovation has three people from the smart growth office. EPA is also working with USDOT and U.S. Department of Housing and Urban Development on sustainable development, and climate adaptation is a topic to be incorporated in this work.

Funding is likely the most effective method for making this happen. The concept of adaptation might be an easier sell to the public than mitigation. One can ask, “Do you really want to spend half a billion dollars on something that won’t work ten years from now?” Most people don’t need 100 percent predictability on something like that. People intuitively understand adaptation.

RISK ASSESSMENT AND PLANNING: BRIDGING THE HAZARDS MANAGEMENT- CLIMATE CHANGE ADAPTATION DIVIDE

Speaker: Gavin Smith, Center for the Study of Natural Hazards and Disasters at the University of North Carolina's Hazards Center and Department of Homeland Security's Center of Excellence: Natural Disasters, Coastal Infrastructure and Emergency Management

Summary: The distinction between a natural hazard and a disaster is an important one. Natural hazards are events that occur naturally (e.g., floods, earthquakes) and do not affect human development. Disasters, on the other hand, are a human construct. They occur when natural hazards interact with the natural environment. Without a build environment to damage, a disaster would simply be a natural hazard. Two relevant documents that summarize what is known about hazards are:

- Disasters by Design (Mileti 1999). This book provides an alternative and sustainable way to view, study, and manage hazards in the United States that would result in disaster-resilient communities, higher environmental quality, inter- and intragenerational equity, economic sustainability, and improved quality of life. www.nap.edu/catalog.php?record_id=5782
- Facing Hazards and Disasters: Understanding Human Dimensions (National Research Council 2006). The document describes the current state of the practice in hazards and disaster research, describing what is known and what needs to be known before a disaster. It also articulates a future research agenda in the field. www.nap.edu/catalog.php?record_id=11671

Emergency management is a term that should probably be recast to "hazards management." Consisting of four phases, preparedness, response, hazard mitigation, and recover, it describes how hazards are effectively recognized and their impacts are reduced or mitigated. The third phase, hazard mitigation, is synonymous with "adaptation" in the climate change realm.

A major challenge is that there is often a divide between the emergency management community and the land use planning community. For example, the Disaster Mitigation Act of 2000, which was developed for the emergency management community, is relatively unknown legislation to many in the climate change community, though it has many implications for both. The Act requires state and local governments to develop hazard mitigation plans and allows them access to a pre-disaster hazard mitigation grant program. It was aimed at trying to get communities to think about where and how they construct their respective built environments. Community risk reduction measures that are supposed to be adopted include both forward-looking policies (e.g., changing flood ordinances to require higher elevation of flood-prone structures) and projects (e.g., addressing the existing actions that put us at risk in the first place, such as, the relocation of flood prone properties). Currently, however, the Act is not widely used as a key tool to encourage development away from areas known to be vulnerable.

Vulnerable areas can be identified by identifying and analyzing potential hazards and assessing the capabilities of state and local agencies to affect change. Vulnerability assessments then lead to hazard mitigation strategies, which lead into plan adoption and implementation. Often, plans are only updated after a disaster. It is recommended that they be updated before disasters. Some common hazard mitigation strategies are:

- Land use planning
- Risk assessment
- Hazard notification
- Public investments (e.g, Are communities looking at their capital investment plans and still building critical infrastructure in areas known to be vulnerable to climate change?)
- Hardening surfaces (such as levees or seawalls)

- Relocation/retreat
- Land acquisition
- Education and outreach
- Elevation of structures
- Revision of building codes

After a disaster, the number of stakeholders that are involved in recovery activities can create a complex array of relationships. Additionally, massive amounts of funding often come into the affected community. For example, after Hurricanes Fran and Floyd, North Carolina received \$600 million in hazard mitigation funding. This inflow of money creates a critical decision point. The community could actively pursue hazard mitigation or risk reduction techniques (labor intensive but potentially very effective) or choose to rebuild to the pre-disaster condition (potentially less effective but requiring less work). A challenge in making the decision will be determining future vulnerabilities or communicating risk in the post-disaster environment. What are appropriate design standards? How far, if at all, should structures be moved? One option for addressing these and other questions could be to hold large-scale community charettes to illustrate what elevated infrastructure would look like (in a coastal environment) or what types of development more rigorous building codes would encourage.

Other fundamental issues that need to be considered include:

- *Social components of disaster.* For example, shortly after Hurricane Katrina, property values rose sharply in Mississippi, displacing some poorer communities. Temporary-, transition-, and resettlement housing needs create unique challenges. Disasters should not lead to the forced resettlement of disenfranchised populations.
- *Geography of disaster.* Mass migration can be a concern post-disaster. As a result, some areas might not be able to provide adequate levels of some public services (e.g., police, sewer facilities, clean water). A question to think about is whether high-risk communities can be sustainable and resilient.
- *Insurance.* There will likely be questions as to whether insurance will be coupled with climate change considerations in the future.

Recommendations are to:

- Work to ensure that state and local hazard mitigation plans and climate change adaptation plans are better integrated
 - Work to improve pre-event planning for post-disaster recovery
 - Consider the nexus between climate change and hazard mitigation in terms of coalition building. Communities and organizations need more effective ways to work together to achieve complementary objectives.
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ASK THE CLIMATE CHANGE QUESTION: ADAPTING TO CLIMATE CHANGE IMPACTS IN URBAN REGIONS

Planning for North Carolina's Future: Ask the Climate Question, March 2–3, 2010
Proceedings

Speaker: Josh Foster, Center for Clean Air Policy (CCAP)

Summary: There is a growing demand for people to understand the concept of climate adaptation. The CCAP, an organization that helps governments develop and implement climate policy, developed the Urban Leaders Adaptation Initiative to serve as a resource for local governments as they face important infrastructure and land-use decisions that affect local adaptation efforts. The initiative is expected to help empower regional local communities to develop and implement climate resilient strategies, since it is their decisions that directly affect GHG emissions and community resilience to climate change. It is at these scales that weather and climate risks are likely best managed.

With its charter partner, Washington State King County, and core funding from the Rockefeller Foundation, CCAP's vision is to examine projected climate impacts in 2050 and "back cast" to identify what steps are necessary to reduce GHG emissions and build community resiliency. The other self-selected Urban Leaders partners include representatives from: Chicago; City of Los Angeles, Miami-Dade County (Florida); City of Milwaukee; Nassau County (New York); New York City; Phoenix; San Francisco; and Toronto. Over the course of the next two to three years, CCAP and these partners aim to:

- Operationalize key steps of the adaptation process with the end goal of implementing one or more specific policies and/or programs that incorporate resiliency strategies;
- Formulate recommendations that help advance the development of national adaptation policy and/or programs that support local resiliency efforts; and
- Disseminate findings on partners' actions and successes to inform and motivate other local communities in the U.S. and worldwide.

The concept of adaptation sometimes has gloomy connotations of barely surviving cataclysmic events. CCAP believes adaptation should be viewed as a solution-oriented opportunity. For example, adaptation projects can help improve or provide ecosystem services (e.g., through green roof or urban forestry activities). Adaptation should also be considered an important component of preparedness, planning, and response across all time scales. On a daily to weekly scale, emergency responders must deal with extreme weather events. On a seasonal or yearly scale, public works personnel deal with weather variability. On a yearly to decade to century scale, planners and others must concern themselves with long-term climate change; in one example, it is estimated that over the next 20 years, capital improvement costs for water projects in the U.S. will be \$480 billion without or \$1 trillion with climate change.

To help urban areas address some of these issues, CCAP released "*Ask the Climate Question: Adapting to Climate Change Impacts in Urban Regions*," a 2009 report that highlights best practices for how cities and counties throughout the country should be thinking about the actions and strategies that can reduce their communities' vulnerability to the dangers of a changing climate. The report should help decision-makers avoid the unmanageable (mitigation) and manage the unavoidable (adaptation). Some findings include:

- *New York City.* New York City has launched a Climate Change Adaptation Task Force—the first effort of its kind—that includes representatives from local, state, and federal governments, as well as the private sector. The task force is developing adaptation strategies beyond the protection of water supply, sewer, and wastewater treatment systems to include all essential city infrastructure.
- *King County, Washington.* King County plans to spend up to \$335 million to manage sea level rise. There, local officials have invested in infrastructure that will improve levees and help the county meet its future water supply needs despite a decreasing snowpack. The county also wrote an adaptation guidebook designed to help local, regional, and state governments prepare for climate change by recommending a detailed, easy-to-understand process for climate change preparedness based on familiar resources and tools. The guidebook can be downloaded at ces.washington.edu/cig/fpt/guidebook.shtml#downloading.
- *City of Los Angeles.* The City of Los Angeles has incorporated a climate and sustainability-focused checklist for its city's project procurement process.

Finally, there is a need to bring together sectors that have roles in climate change adaptation but that might not have been extensively involved yet in adaptation activities. For example, universities could provide technical capacity to locals on adaptation via a “climate extension” program.

CCAP's “Ask the Climate Change” report is available at:

www.ccap.org/docs/resources/674/Urban_Climate_Adaptation-FINAL_CCAP%206-9-09.pdf

UNDERSTANDING REGIONAL VARIATIONS IN POTENTIAL IMPACT OF CLIMATE CHANGE: MOUNTAINS, PIEDMONT, AND COASTAL PLAIN

Speakers: Jim Fox, Renaissance Computing Institute at UNC Asheville
Vicki Bott, Renaissance Computing Institute at UNC Charlotte
Dr. Tom Allen, Renaissance Computing Institute at East Carolina University Engagement Center

Summary: This session featured three speakers discussing the unique climate change stresses that North Carolina's Mountains, Piedmont, and Coastal Plain regions face, respectively. Each of the speakers is a partner with the Renaissance Computing Institute (RENCI). RENCi is a virtual collaborative venture of Duke University, North Carolina State University, the UNC Chapel Hill and the state of North Carolina. The organization brings together multidisciplinary experts and advanced technological capabilities to address pressing research issues and to find solutions to complex problems that affect the quality of life in the state.

Communities rely on a certain set of services that are paid for through taxes. The variety of potential stressors on those services can usually be planned for based on past trends. However, services that are interrupted are often more difficult to manage, especially when the differences between and relative values of vulnerable human and ecosystem services/populations are considered. According to the speakers, it is not likely that society will make decisions based solely on climate change. Instead, communities must be able to integrate climate change information with other value drivers (e.g., energy, water resources, and development pressure). In addition, solving the adaptation puzzle will require an understanding of region-specific climate change impacts; adaptation strategies aligned with those impacts; and cross-disciplinary collaboration.

Mountains

Climate change is expected to create precipitation challenges, in particular, for western North Carolina. The driest and wettest parts of the state in terms of average annual precipitation are in the mountains and roughly 45 miles apart. Some cities in the region have had both historically bad droughts and floods over the last 6 years. With climate change, droughts will likely occur more frequently, and when it rains, the precipitation events will likely be more extreme; the frequency of extreme rain events could also increase. To compound the dilemma, the North Carolina Mountains lack deep, continuous aquifers and therefore have a limited groundwater supply. These issues, which stress the importance of local solutions, can create emergency management concerns.

Buncombe County, North Carolina developed an online, multi-hazard risk tool to help the county better analyze natural hazard risks and their potential costs. The Buncombe County Multi-hazard Risk Tool, which is linked with city of Asheville's and the county's parcel GIS databases, allows users to view information about the risks of natural hazards, including floods, landslides, fires, dam breaks and winter storms, in specific areas. A user who wants to know the flood risks in a given town, for example, can determine how many

acres or parcels are in the 100-year floodplain. Users can also view a map that displays multiple layers of geographic information about an area of inquiry, including roads and other critical infrastructure, current and projected land use, and sensitive or vulnerable populations.

Although the site is password protected and not yet intended for public use, communication, education, and outreach on the issues the tool relates to are still necessary. Communities should have the capacity to integrate land use and planning processes with ecosystem services considerations to create sustainable regions, especially since natural systems are likely less resilient to rapid climate change than human systems might be.

Piedmont

Most of the climate change challenges the Piedmont region is expected to face are related to temperature and precipitation patterns. In terms of temperature, climate change will likely exacerbate the heat island effect experienced in the region's urban areas. This could lead to increases in heat-related illnesses, heat stress, or heat stroke. Increased temperatures might also cause increased ground-level ozone formation and the number of unhealthy air quality days, leading to higher prevalence of respiratory illness. Higher temperatures could also cause rainfall patterns to shift downwind. Some potential adaptation strategies include revised tree ordinances, incentives for roof gardens, and the creation of parks and open space.

In the region's more agricultural areas, rising temperatures could induce crop and habitat migration, potentially contributing to conservation and development conflict. Increased drought or flood occurrence could have significant implications for the sustainability of agriculture in the region. A potential adaptation strategy would be to consider farmer assistance programs. Such programs would aim to train farmers in how to transition between kinds of crops or operational practices.

In terms of precipitation patterns, decreased storm frequency is expected. The Piedmont has several headwater reservoirs (5 of 8 water basins), so the region does not have the benefit of being downstream to rivers filled with rainfall. This could lead to the creation of arid areas like those in the western United States. When storms do occur, they are expected to be of increased intensity, and thus flood and wind damage could be greater. The most vulnerable populations to stronger storms are low income, elderly/youth, or other populations that rely on others for transportation. Potential adaptation strategies include rain water harvesting, gray water usage, improvements in irrigation efficiency, and building code enhancements. Adaptation in the transportation sector is also likely an important focus area given the amount of transportation infrastructure in the Piedmont.

Coastal Plain

North Carolina has one of the most distinctive shorelines in continental United States. It has 325 miles of barrier beaches; 20 inlets; 5,000 miles of estuarine shoreline; and a population of 865,000. The region can be characterized by tourism, agriculture, forestry, fisheries, ports, fisheries, extensive public lands, diverse ecosystems and cultural heritage, and considerable infrastructure. Proactive management strategies that increase the adaptive capacity of the Coastal Plain's ecosystems are needed to cope with the effects of accelerating sea level rise; sea level projections specific to North Carolina are available in Kemp et al. 2009: geology.gsapubs.org/content/37/11/1035.full.pdf+html.

Some potential climate change impacts and associated adaptation strategies follow:

- Potential Impact: Sea level rise, which is expected to bring with it higher energy currents, including stronger waves and storm surges, is outpacing vegetation's retreat upland. It could also cause the barrier islands to break, inducing tides into the sounds, which previously did not experience tidal action. Sea level rise will also likely reduce beaches and render them less accessible for tourists. Future conflicts among commercial and recreational fishers could occur.

Potential Adaptation Strategy: Restore brackish marsh vegetation along shoreline to maintain natural buffers.

- Potential Impact: Coastal storms could increase in frequency and intensity. Precipitation and drought extremes are expected to be more severe. Some cities, such as Wilmington, NC, could be rendered inaccessible. Land, shoreline, and riparian buffer loss could occur. In the past, this latter impact has led to bulk-heading and the construction of other similar structures. These structures can inhibit landward habitat migration, endangering aquatic living resources.
Potential Adaptation Strategy: Implement living shorelines.
- Potential Impact: Loss of habitat, including that used by oysters.
Potential Adaptation Strategy: Restore oyster reefs along high-energy shorelines.
- Potential Impact: Salt intrusion into extensive ditch networks leading to salt poisoning of interior wetland vegetation. The rapid amplification of peat soil decomposition by sulfate-reducing bacteria could lead to subsidence and increased inundation locally, and the release of previously sequestered carbon and methane globally.
Potential Adaptation Strategy: Installation of water control structure equipped with flashboard risers and tide gates at strategic locations. Preservation of carbon reservoir in peat lands to forestall additional climate change.
- Other Potential Impacts: Increases in timber damage; increases in drought; prevalence of pathogens (e.g., from new mosquito species); incidence of wildfire; groundwater salinization; and demographic shifts.

Additional Resources:

Bin, Okmyung *et al.* 2007. Impacts of Global Warming on North Carolina's Coastal Economy.
econ.appstate.edu/climate/

Titus, JG and J. Wang. 2008. Maps of Lands Close to Sea Level along the Middle Atlantic Coast of the United States: An Elevation Data Set to use While Waiting for LIDAR.
epa.gov/climatechange/effects/coastal/section1_1_may2008.pdf

Storms to Life: www.ecu.edu/renci/stormstolife. Storms to Life is a project aimed at improving public awareness of the risks of living in hurricane-prone areas of North Carolina.

TOOLS AND RESOURCES FOR PLANNERS

Speaker: Reid Ewing, Department of City and Metropolitan Planning, University of Utah "Growing Cooler: The Evidence on Urban Development and Climate Change"

FHWA North Carolina Division Administrator John Sullivan (also co-chair of Interagency Leadership Team) spoke briefly on the importance of climate change preparation to allow agencies to better face crises when they arise. The interagency leadership team's next step is to help North Carolina leaders make informed decisions about climate change.

Summary: The current political climate is both conducive to and inhibitive of climate change action, but regardless climate change will likely be the defining issue for planners in the 21st century. *Growing Cooler*, published by the Urban Land Institute in 2007, establishes the potential of urban development patterns to reduce U.S. CO₂ emissions through providing an array of data and studies. A key lesson is that the infrastructure (cars, roads, buildings) that will determine how the public lives in the future has not been built

or invented yet, and thus choices can be made that will help make necessary infrastructure less emissions-intensive.

Some key findings featured in *Growing Cooler* include:

- Both VMT and the U.S. urban footprint have grown three times faster than population growth in recent decades. The sprawling land use patterns are directly responsible for the disproportionate U.S. share of global CO₂ emissions.
- Two-thirds of the development on the ground in 2050 will be built between now and then, meaning there is considerable opportunity to change development patterns.
- Market for compact development is solid and growing due to Baby Boomers and Millennial desires (55 percent of Americans surveyed preferred a compact community to a low-density one). Since most current development is low-density, all new growth should be compact to meet demand.
- While new CAFE standards and the Energy Bill of 2007 make progress towards a national goal to reduce emissions to 10 percent below 1990 levels by 2050, VMT growth threatens to undo that progress.
- Total VMT reduction that would be possible due to compact development would be about 20-40 percent (based on four analyses that look at VMT from the regional and the individual level). Applying this on a national level, there is the potential to reduce metropolitan VMT by 12-18 percent by 2050. To reach the final CO₂ emissions target and reduce VMT by 38 percent by 2030, the U.S. needs the following four actions:
 - Compact development
 - Transit
 - Less highway expansion
 - Higher gas prices

Several noteworthy actions at the state and federal levels can offer lessons for North Carolina:

- The Kerry-Boxer Senate bill expands the role for planners (e.g., planning grants for metropolitan planning organizations (MPOs))
- California has been a national leader by adopting mandates that recognize that technology is insufficient to reduce emissions. Transportation actions include vehicle standards, low-carbon fuel standards, and transportation and land use strategies.
 - California increased the percentage of its CO₂ reduction that could be derived from smart growth according to the authors of *Growing Cooler*.
 - SB 375 requires all MPOs to prepare a Sustainable Community Strategy to streamline approval of transit-friendly projects and transportation projects that reduce CO₂.
- Portland, OR has succeeded in decreasing its CO₂ emissions due to a series of plans and actions that include transportation strategies, even as emissions in the rest of the U.S. have been increasing steadily. The community has recognized the need to change transportation behaviors even more drastically by cutting daily VMT per person by 2050.

The Southeast is the most vulnerable region in the U.S. as it is susceptible to sea level rise, storm intensity, heat waves, and other secondary impacts. Adaptation strategies tend to be lacking in Southeastern states, although Florida has proven to be a leader in adaptation for the region. Eight states (including Florida) have State Adaptation Plans complete or in progress and six states (including NC) have Adaptation Plans recommended in Climate Action Plans.

WHAT HAVE WE DISCOVERED IN THE BREAKOUT DISCUSSIONS?

Speakers: Jim Fox, Renaissance Computing Institute at UNC Asheville
Eric Wahlberg, Albemarle-Pamlico National Estuary Program; and Physical and Environmental Planning
Department of Hampton Roads Planning District
Judy Francis, NCDENR
Gerard Voos, UNC Asheville
Vicki Bott, UNC Charlotte
Tom Allen, East Carolina University

Summary: This session highlighted results from breakout sessions held for each of North Carolina's three regions. There were several breakout groups for each region. During the breakout discussions, groups were asked to reflect on and then consolidate their answers to six questions. Where there was overlap among answers from a given region's breakout groups, responses were bolded during the plenary report-out. Only bolded answers are detailed here. In cases where no topics were bolded, only the first three responses are included here. For a complete list of breakout group responses, see the workshop's archived presentations at www.climatechange.nc.gov/pages/ClimateChange/CC_Workshop_Archive.html.

1. What effect will altered ecosystems have on the livability and economy of my region?

Mountains

- An altered ecosystem will negatively change tourism/livability due to citizen perceptions of the desirability of current mountain settings.
- Changes in the agricultural economy (timber and forest) will have winners (e.g., viticulture) and losers (e.g., trout habitat) from climate change, especially from intensified drought.

Piedmont

- Water availability and quality will be negatively affected. There will be impacts on tourism, industry and energy; competition for scarce water; and a need to deal with both drought and precipitation extremes.
- Economic viability and livability will be reduced due to higher costs, taxes, and environmental degradation.
- The cost of living will increase as a result of impacts on air, water, transportation, agriculture and increased population; this will lead to lower quality of life.
- Ecosystem losses will result in a change in recreation and occupational opportunities.

Coastal Plain

- Tourism will be lost.
- The traditional economy will be destabilized.
- Cultural resources will be lost, and there will be impacts to quality of life, including a need to retreat and relocate. There may be a loss of sense of identity and impacts to public health.

2. What is needed to accommodate anticipated migration patterns in my region?

Mountains

- The region needs to include multi-modal and connected transportation capabilities (e.g., consideration of more walking and bicycling facilities, extended runways, and connectivity to rail systems).
- Comprehensive land use planning is needed that incorporates manmade and natural resource preservation through adaptive reuse, smart growth and compact building design.

Piedmont

- The Piedmont will need to provide integrated land use and transportation and infrastructure (roads and sewers) planning to allow for smart growth.
- There is a need to provide a pro-active statewide policy that sets a clear direction.
- There is also a need for statewide leadership supported by political will and voter support that will convince leaders to change through public education.

Coastal Plain

- Comprehensive, regional sustainable planning for future infrastructure.
- Land suitability planning for both human environments and ecosystems
- Economic development and identifying best places for people to move.

3. How will my community prepare for new/increased hazards resulting from climate change?

Mountains

- Targeted education on vulnerability related to hazards, especially for underserved groups, is needed.
- Hazards planning requires a stronger collaboration between climate information providers, emergency and natural resource managers, and the planning communities.

Piedmont

- Reevaluate emergency management plans to incorporate evacuations; communications; early warning and identification of public health needs of vulnerable populations.
- Undertake leadership development, community education and community outreach activities (e.g., conservation, disaster preparedness, health effects, include vulnerable populations).

Coastal Plain (no topics were bolded)

- Conduct adaptive planning to reduce risk exposure.
- Conduct contingency planning for immediate and long-term disaster impacts.
- Prepare for future increased hazards by improving construction standards and land use regulations (buffers, setbacks, evacuation routes).

4. What adjustments to infrastructure investment and design must be made (e.g., bridge height, storm water management, fire protection, etc.)?

Mountains

- There need to be multiple funding sources/adjustments/incentives for activities.
- Strong design standards are needed to minimize vulnerabilities.

Piedmont

- Green planning and investment that will remove barriers, change ordinances, and could include acquiring private land are needed.

- Infrastructure enhancement and planning, consistent with smart growth, risk minimization, and improved codes is needed.
- Encourage sustainable design principles in the built environment by creating incentives.

Coastal Plain (no topics were bolded)

- Use anticipatory design, better placement, and budgeting for climate impacts.
- Manage ecosystem flows to protect infrastructure.
- Develop design changes and a system for abandoning vs. maintaining infrastructure that better consider hazards.

5. What tools/support do I need to persuade my decision-makers to take action to reduce vulnerability and risk resilience (e.g., Visioning, visualizations, risk assessment scenarios, data at the community scale, etc.)?

Mountains (no topics were bolded)

- Science agencies need to communicate findings through public outreach efforts and strengthened through NGO and partner collaboration.
- Build support for comprehensive plans at local, state, regional, and federal levels.
- New data and decision support tools are needed.

Piedmont

- Supportive financial information is needed (e.g., answers to questions of how much funding; where will funding come from; what are the costs of not acting; what are the benefits?).

Coastal Plain (not topics were bolded)

- Regulatory design and planning mandates from state and federal governments is needed.
- Science-based educational tools for decision-makers are needed.
- Provide information that can be used to model consequences, including inaction, needs to be updated and accessible.

6. What will I be doing differently in my work to enhance adaptation activities now that I have attended this workshop?

Mountains (no topics were bolded)

- Live by example.
- Collaborate with others.
- Integrate climate change with what I already do, and integrate other disciplines in planning

Piedmont

- I will ask the climate question.
- Explore new partnerships.
- We will use what we learned to teach and reach others, such as filling in colleagues and sharing materials and references.

Coastal Plain

- Effectively create awareness for all stakeholders by packaging information differently.
- Advocate for enforceable regulatory guidelines.

- Use new information, and lead by example.
-

CLOSING MESSAGE: APPLYING WHAT WE HAVE LEARNED

Speaker: Secretary Dee Freeman, NCDENR

Summary: To conclude the workshop, NCDENR's Secretary Dee Freeman provided observations he made at the workshop, discussed some of the most salient take-home messages heard, and challenged workshop participants to continue the momentum generated at the event.

Some observations from the workshop follow:

- From the numerous compliments heard, it appeared that most participants thought the workshop was worthwhile. The time-keeper was especially helpful, and many commented that the punctuality of the speakers was appreciated.
- With such a long term proposition as climate change, state and local governments have to establish innovative ways to engage the public and to speak in plain language—help them develop ownership over the adaptation strategies being proposed. A goal of the Secretary's is to help North Carolina gain traction in this area and become a leader in adaptation.
- The presence of leadership from an array of North Carolina government offices should not be viewed as perfunctory. The state's leaders are aware of the issues and are leading their agencies to ask the climate question.
- During difficult times, strategic thinking must prevail. NCDENR has focused on strategic thinking, and one of its eight major goal areas is climate change.

Prominent concepts or comments that were heard over the two days of presentations include:

- There will be a climate change adaptation strategy report published in September, which could lead to Executive Orders. A question for participants is "how ready are you?" should direction be given?
- Environmental planning could become as important as economic planning, which might be considered a somewhat nascent thought.
- There is a need for giving greater attention to multi-scenario planning as well as national disaster planning. Communities should be getting together to answer the question, "What are we going to do if....?"
- The Southeast U.S. could be considered the most vulnerable region to climate change. The Governors' South Atlantic Alliance, which includes North Carolina, South Carolina, Georgia, and Florida, is already working at the gubernatorial level to address climate change related issues. In particular, the Alliance is helping communities to become more sustainable and walkable; to reduce their carbon footprints, reduce VMT; and to increase transit and transit-oriented development options. www.southatlanticalliance.org/

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- Much of the infrastructure the U.S. will need by 2050 has not been built yet. This thought brings with it a great opportunity for communities, regions, and states to build things in environmentally sound ways. It also offers the chance to integrate the concept of climate change into new policies or best management practices. Legislative action or Executive Orders should not always signal the beginning of action.

The final challenge for workshop participants to consider taking on is to determine where to go now. They should return to their organizations and figure out how to maintain the energy and focus that was demonstrated at the workshop. North Carolina's ILT could be an entity around which others could rally or get direction. The state's universities are also assets that could be relied upon to help workshop participants do their jobs in the best and most effective manner possible. In the end, there is a need for agencies, communities, and people in general to stay connected with each other and engaged in climate change and adaptation topics.