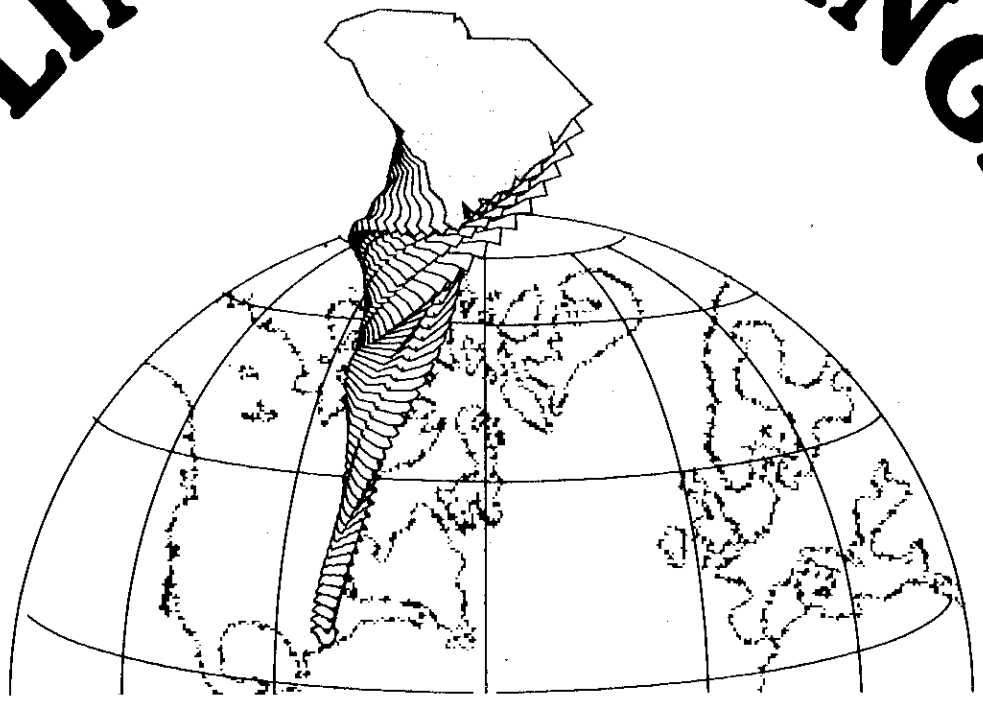
CLIMATE CHANGE



Planning Ahead for South Carolina

PROCEEDINGS
OF THE
SOUTH CAROLINA SEA GRANT CONSORTIUM'S
EIGHTH ANNUAL WINTER CONFERENCE

Columbia, S.C.
January 16, 1990

FOREWORD

Imagine more intense hurricanes than Hugo hitting South Carolina, ripping through communities with fiercer winds and higher waves. Scientists tell us that this may be possible within the next century because the Earth could grow warmer. A warmer Atlantic Ocean means that hurricanes will be spawned farther north, near the U.S. coast.

Imagine shortages of drinking water in South Carolina. A rising sea level could enable saltwater to move farther inland, affecting rivers and aquifers. A changing climate could also reduce rainfall, which could diminish our water supply even further.

These are just a few of the potential implications of climate change. Scientists believe that increased levels of atmospheric gases –caused in part by man's burning of fossil fuels—are warming the Earth. The impacts of such warming in South Carolina would be significant—and would demand a response.

The South Carolina Sea Grant Consortium devoted its eighth annual winter conference to presenting the facts about climate change and its implications for the state. National scientists explained how global warming could affect us all, and state scientists and policymakers analyzed management options. Through this forum, the Consortium hopes to expand public understanding of global warming, helping South Carolina respond to the changes that may be ahead.

ACKNOWLEDGEMENTS

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CONFERENCE MODERATOR:
Ms. Margaret Davidson, *Executive Director, South Carolina Sea Grant Consortium*

UNDERSTANDING CLIMATE CHANGE

Dr. John Firor
National Center for Atmospheric Research

You all remember that almost two years ago it became very hot here in South Carolina and elsewhere in the United States. Also very dry. One result of those unusual conditions was that almost every newspaper, magazine, TV and radio station in the country discussed the hot weather and its possible connection with the "greenhouse effect."

A second result of that hot, dry spell was that my colleagues and I, who have been studying this topic in considerable obscurity for decades, suddenly were in great demand as speakers.

In giving talks to a wide variety of audiences, from utility executives, water managers, economists, air conditioning engineers, to Senate and House committees, congressional study groups, resource lawyers, and others, I have become aware of one fact. Despite the wide newspaper and TV coverage, people still have major misconceptions about climate change. Today I don't wish just to repeat what has been well covered in the press, but instead will emphasize those items that are understood by the scientific community but which are still unclear to many people.

Each of you is familiar with the broad outline of this problem. Scientists have understood for a long time that life on Earth depends on certain gases which appear in the air in very small concentrations. These gases absorb heat, or infrared radiation, that would otherwise escape from the atmosphere. They thereby warm the surface of the Earth and keep it livable. It is a fairly easy calculation to ask what would happen if we could magically remove all the heat-trapping gases from the Earth without changing anything else. The answer is the Earth would be about 60 degrees Fahrenheit colder than now.

The problem arises because the amounts of these heat-trapping gases in the air are increasing rapidly. So the obvious question is: if the historical amounts of heat-trapping gases in the air warm the Earth by such a large amount, will doubling those amounts of gases heat the Earth even more? The answer is, certainly yes, unless there is some magic that would level off the temperature of the Earth at today's temperature. My colleagues and I, and people all over the world, have searched very hard for 20 years for that magic, but so far we have failed to find it, so we believe that the Earth is going to heat more as we double the amounts of gases in the atmosphere.

Let's look at the curve of measurements of carbon dioxide over the past thousands of years. Carbon dioxide is found trapped in small ice bubbles in the Greenland Ice Cap. Every year the snow falling on Greenland brings down some air with the snowflakes. The next year the snow comes down again and after a few years that air is trapped and preserved there for our analysis. You can drill a hole in Greenland to bring up the ice, and you can count the layers just like you can count tree rings. Thus, we can find out how much carbon dioxide there was in the air each year. Carbon dioxide stayed fairly constant for 10,000 years, but note that the curve starts to come up here as the Industrial Revolution and the population explosion got under way, which meshes with measurements made in Hawaii at a Mauna Loa observing site, noted for the clean air found there. Therefore, we know that human beings are well on their way to changing the amount of greenhouse gases in the atmosphere.

Carbon dioxide is the most important greenhouse gas, but there are others. Methane – natural gas – is another such gas, which also started increasing about the time of the Industrial Revolution. We now know from the ice measurements that methane was fairly constant for 10,000 years, but in the recent era it's already doubled.

Let's go to another set of gases. These are the freons, the chlorofluorocarbons (CFCs), which are completely synthetic, which did not exist 10,000 years ago. Invented in the 1930s, they came into great commercial use right after World War II. They are with us in exceedingly minute quantities, parts per trillion by volume, yet they are powerful absorbers of heat and they play a role in warming up the Earth in the future.

So there is no doubt that the greenhouse effect is true, that it works, that it's big, and there is no doubt that we are changing the rules of the game by changing the concentration of these gases in the atmosphere. The only questions are: how fast will the climate heat? where will the heating show up first? Those are very difficult questions to answer. We try to answer these questions by putting all of the understanding that we have about the atmosphere into the world's largest computer, by making a model simulation of the atmosphere, and by doing the experiment — that is, in a simulated atmosphere we double the amount of greenhouse gases to see how much the planet heats.

We don't understand everything about the climate, but we do know the atmosphere here interacts with the ocean, interacts with sea ice, and with mountains; in addition, we have to take clouds into account. If the Earth warms up, there may be more clouds or fewer clouds, or higher clouds, or lower clouds, as the climate changes. We have to take these possible changes in clouds into consideration. Ocean temperatures and ocean circulations will also change. It's a very complicated problem, and computer model simulations only handle this problem very crudely. Therefore, we must work hard to try to answer the question: how trustworthy are these models? Can we build up enough confidence in these models so that we can use them to help us in our planning? In a few laboratories around the world for the last couple of decades, we've been trying to do just that.

Building a numerical simulation of the climate is a major task. It takes a large group of scientists, the world's largest computer, millions of dollars of effort in computer time, and the data sets from all over the world for the last hundred years to test it with. It's not an easy job, and that's why there are only a handful of organizations in the whole world that are capable of doing this sort of calculation. How do we test the model? The first test that we could do is sit back and wait for 50 years and see how warm the climate gets and check it against the model. But this is not a good idea.

I get called upon with great regularity to come testify in front of congressional committees. They want the answer yesterday to the problems of climate change, not 50 years from now. How hot is it going to get, where is it going to show up, how fast is it going to heat? We have to develop other techniques of gaining confidence or losing confidence in these models, and we try to check them against other features of the climate to see how well they do.

The first test of the computer models is obvious. If I put all this information in the computer, make the computer do the calculation, does it give me the correct climate for today? If it fails that test, we're not even at the starting line. The model, in fact, does very, very well; it passes that test. It not only gives the correct average temperature of the Earth; it gives correct numbers for various regions of the Earth; it gives the winds flowing in the right direction and the clouds in approximately the right place. In other words, the model passes that test with at least a B+, and maybe an A-.

But that's just a static test. Can the model predict any sort of climate change that we know about? Well, nature gave us a test by giving us two other planets with very different amounts of carbon dioxide. Venus is mostly cloud covered, but we know now from satellite measurements and other ways that it has hundreds of times as much carbon dioxide as the Earth does. Because Venus is completely cloud covered and most of the heat and the light are reflected back, much less sunlight gets to the surface of Venus than gets to the surface of Earth, even though Venus is closer to the Sun. Yet Venus is fiercely hot on the surface; you can melt metals by just simply putting them on the surface of Venus. So the models give the right answer for Venus, which has an extreme greenhouse effect.

Mars, on the other hand, has very little carbon dioxide in the atmosphere, so it should be colder. The models also give the right answer there. If you put carbon dioxide on the surface of Mars, it freezes, making dry ice. So we know the greenhouse effect is true, we know it works, we know it works over a very wide range of temperatures and concentrations. But knowing about the atmosphere of these two planets does not mean we can predict a true climate change.

So we needed to study the largest climate change we know anything about — the change from summer to winter on Earth. We have very good measurements of this change and we know exactly what causes it — the motion of the Sun and the sky. We can put that information into

the model and see if it gives us the right answer, the difference in temperature between January and July. It's only recently that models have been able to reproduce this change because you had to have a very large computer. But now the model is doing that test exceedingly well. The model gets at least an A-, and maybe an A, on that test, so that we are now fairly confident that these models are good, that we have not left out any feature that would change the results by large amounts. You will read in the newspaper speculations that as the climate gets warmer it will make more clouds, and that will reflect more sunlight and that will keep the Earth from getting warmer. If that were true, we couldn't reproduce the difference between summer and winter because the clouds are very different in summer and winter. The humidity is very different. So we know we are getting roughly the right answer by this test.

There are other tests; I could go on. To summarize, we have high confidence in these models. **Experts think that it is highly probable that if the Earth continues to emit greenhouse gases to the atmosphere, the Earth will heat at a greater rate than has ever been seen by human civilization.** And that's our starting point for discussion of climate change.

The number that gets attached to that conclusion, 0.3 degree Celsius warming per decade, sounds like a very small number. You and I can't tell the difference between 0.3 degree Celsius change in temperature. If this room were warmed up by twice that amount, we wouldn't know it. So why should that bother us? Why should 0.3 degree Celsius per decade produce any reaction whatsoever? For an answer, we have to look back at climate changes that have happened earlier.

Over the last thousand years, the climate warmed and cooled by about one-half degree Celsius. During a very warm period, the Norse explorers sailed across the North Atlantic. The conditions were warm enough so the Norse established colonies around the coast of Greenland. We think of Greenland as completely frozen over, but there were Norse colonies in this period, grazing cattle alongside the rivers in Greenland. Those colonies died out some hundreds of years later when it cooled off, when the grass and the cattle disappeared, so the explorers disappeared. This period is called the Little Ice Age; it was when rivers froze in Europe.

But earlier, there were wine grapes grown in England. Of course, wine grapes can't grow there anymore so this is a big climate change. The change's total amplitude is less than a degree, and the rate of change – cooling or warming – is a few hundredths of a degree per decade. So the change I am discussing, 0.3 degree per decade that is predicted for a modern-day possible global warming, is five to 10 times faster than any change of the last thousand years. We know that the change in climate that became the Little Ice Age affected agriculture in Europe. Many studies in England and Scotland show that during this period farmers tended to move their fields down hillsides to the lowlands because it is slightly warmer down low than up high. These farmers probably did not know they were responding to a climate change. They probably just observed that the low field did better, and they enlarged the low one and abandoned the high one.

We know also that in the Netherlands the canal system became less effective in this period because it was frozen more months out of the year, and this caused changes in the marketing system. In other words, this climate change touched us in many ways, in agricultural ways and commercial ways, even though its total amplitude was less than a degree and its rate of change was a few hundredths of a degree per decade.

We can look back even further. A monster climate change occurred during the period of 16,000 to 12,000 years ago; there was as much as nine degrees change. This is when the last Ice Age retreated. This change was large enough to rearrange completely the face of North America. All the large mammals died off, such as camels and mastodons. Forests had to migrate to keep up with the climate they were comfortable with. Spruce trees, which were the common tree in what is now Ohio, are now found far north in Quebec, because they followed the temperature north. Forests of oak trees at one time were here in South Carolina. We learned this from pollen graves which are left in bogs and other places that can be dated. Those forests migrated to Ohio and Indiana and places like that. You still have oak trees in South Carolina. They occur over a wide range, but the center of the oak population is now much farther north. That migration took place surprisingly rapidly, a couple of hundred yards a year. I can't quite visualize how a forest can move a couple of hundred yards a year unless it had some very

hard-working squirrels out burying seeds ahead of the forest. But in any case, it can happen. It happens because the distribution of trees is not uniform. There are always a few trees out ahead; and those prosper and the ones behind tend to die off.

Can trees migrate five or 10 times that fast? The answer, my forestry friends tell me, is not likely. If by the time a seed grows and the tree matures enough to drop a seed, the climate will be too harsh for that seed to take root; therefore, you won't get serial reproduction out of any one tree. A swift climate change may mean that the unmanaged forests of the country will suffer great damage because they won't be able to migrate. In addition, what does a forest do when it comes to Interstate 70? It's going to have physical barriers as well as climatic barriers to migrations north away from the hotter climate, so that 0.3 degree Celsius per decade is, in fact, a very rapid climate change, one that inevitably will touch the unmanaged biosphere very strongly and indirectly affect everything that we do.

Can we do anything about this? Many groups that are called together by congressional committees or academic committees or international groups, ask, "What is the best strategy for the people of the Earth in the face of this damaging effect?" There are people who say, "Well, the models are not yet 100% perfect. You don't want to do anything until you are sure." I am reminded of a few months ago where some courageous people in Charleston, South Carolina took a weather forecast and said, "Let's evacuate." They were not 100% sure. That hurricane could have turned; hurricanes do turn north, turn south, weaken, turn back, go back the other way. But these people took the most probable forecast, acted on it and saved many lives. It's the best we can do in this world — take the most probable event and formulate our plans around it. **The most probable event for the Earth is a rapid warming of the climate,** with many other things happening in association with it: changes in patterns of precipitation, changes in flows of the river, changes in the health of the unmanaged biosphere, etc. That's why these committees that assemble to study climate change always say that we need to do something.

It's true that people are adaptable. They can adapt to all sorts of things, but let's give ourselves a fighting chance to adapt in an economically rational way, one that gives us time to adapt calmly. To adapt wisely, we must slow this change down by reducing the emissions to the atmosphere.

But we must also acknowledge that the fossil fuel consumption problem is in the highly industrialized countries such as the United States. We are the bad actors, the ones who are putting these gases into the atmosphere. If you look at these other gases – methanes and fluorocarbons – the same story holds true by and large. Therefore, the scientific leaders in the world need also to be the active leaders in the world to say, "Let's not emit so much stuff to the atmosphere; let's give ourselves time to adapt in a reasonable way."

The technology exists to adapt to global warming. It would be technologically quite easy for the U.S. to cut its emissions by 20% or 30% or 40%. We have better everything on the shelf: better automobiles, better light bulbs, better motors, better generators, better everything. If we were to introduce those changes we could cut the emissions, and make ourselves more efficient, and probably make a little money on the side because efficiency pays for itself.

So the problem is well defined. The probable events are laid out clearly. And the solution is obvious. It will be interesting to see how we work it out. Thank you.

Question from audience:
How do storms such as Hugo affect our local weather patterns?

John Firor:
This climate change will not affect the average temperature much, but it will affect extreme events. For instance, if a storm comes ashore and the sea level is higher, it comes farther inland. If each storm that hits the coast of the U.S. in the next century comes at a higher sea level than it did in the last century, it's going to create a lot more damage. Even if you have the same pattern of storms, the average hurricane will probably be stronger because you have more hot water providing the energy. In that case you have a double whammy: the strongest storms coming in at higher sea levels.

IMPLICATIONS OF CLIMATE CHANGE

Dr. Stephen Leatherman
University of Maryland

My own area of research as a scientist is coastal studies. The issue that brings my research area together with global warming is, of course, sea level rise. When I first started studying beaches along the Outer Banks of North Carolina during the 1960s, we recognized erosion was ongoing, but we didn't really understand why it was happening until Steacy Hicks at the National Ocean Survey in Rockville, Maryland used the tide gauge records from around the United States coastline to investigate long-term changes. He noted that the water level records, originally collected for navigation, showed the mean sea level as far back as the 1880s. Hicks showed that sea levels have risen about one foot in the last century along the U.S. East Coast. During the last Ice Age about 15,000 - 18,000 years ago, tremendous amounts of water were locked up in great ice sheets and sea level was 300-400 feet below its present stand.

Sea level can be thought of as the dipstick of climate change. As the temperature of the Earth increases, land-based ice is melted and thermal expansion of the ocean water occurs. **Rising sea levels will have many repercussions, particularly here in South Carolina, which depends upon its beach resorts for a sizeable share of tourism dollars.** Many scientists are anticipating sea level to rise about three feet in the next century.

There are many physical effects of sea level rise. One effect is simply inundation. It doesn't take much change in the sea level to flood extensive areas of land along low-lying coastal areas. Another effect is erosion - the removal of sand along the outer beaches, which is already a significant problem along most U.S. sandy coastlines. South Carolina is not immune to this problem, but fortunately the state has some of the lowest erosion rates for the Atlantic coastline. Salt water intrusion into aquifers and surface waters is another effect of sea level rise. It has been shown that if sea level were to rise about a meter then the city of Philadelphia, which gets its drinking water from the Delaware River, would be sucking up unusable brackish water. Several major cities depend upon these surface waters for their drinking supply, but groundwater is becoming less usable as well because of over-pumping.

Today, I want to concentrate on increased flooding and storm damage because it has such an important impact. Our U.S. East and Gulf Coasts are very much prone to hurricanes and smaller tropical storms; if smaller storms passing by our shores get stronger with global warming, they will also have a much bigger impact. Some areas are affected by more storms than other areas. Cape Hatteras, sitting farther out than South Carolina, is more prone to hurricane landfall. The Gulf of Mexico has been hit with more hurricanes in recent decades, with Hurricane Hugo representing the first major Atlantic hurricane landfall since Hurricane Donna in 1960.

As you may know, a 100-year storm is one that has a one percent probability of occurring in any year. A 100-year storm can flood 10 to 20 miles inland along a very flat coastline. We did a case study for U.S.E.P.A. a number of years ago at Galveston, Texas, an urbanized area built on a barrier island. What does just the rise of a few feet in sea level mean to a city on a barrier beach like Galveston? The U.S. Army Corps of Engineers maps do not show Galveston flooded in the 100-year storm scenario. The urban part of the city is protected from flooding at the present time because of the Galveston sea wall built in the early 1900s. The island of Galveston has a very flat terrain, and the city's elevation is generally less than 10 feet above sea level. The sea wall has an elevation of 17 feet above sea level, thus providing a margin of protection under present sea levels. The sea wall has protected this city from destruction several times, much like the bulkheads around Charleston. The problem in Galveston is that it used to be a beachfront community. There was about a 300-foot beach in front of the seawall, but by 1940 the beach was entirely lost as erosion continued. Since then the sand level has been dropping in front of the seawall, and rocks have been placed farther seaward for protection during storms.

During a 100-year storm, the flood elevations at Galveston would be 4.2 meters (13 feet) above normal. That is even lower than Hurricane Hugo's maximum surge. The seawall can survive this surge, but flooding to Galveston Island can occur from the back side. It doesn't take much change in water level to allow these storms to overtop the low-lying levee of the back side of the island and flood the city. Studies by the Corps of Engineers show that for every extra foot of water during a storm, the damage to buildings increases by about 10%. Therefore, just another foot or two of storm surge makes a tremendous difference in terms of damage that would be experienced in the city.

Because of a possible global warming, the 100-year storms might be converted to 75- or even 50-year events in terms of their impact. Hurricanes are rated according to their storm surge or height. A 50-year storm generates a 10.4-foot storm surge in the Galveston area. If sea level rises three feet because of global warming, we are converting a 50-year storm into a 100-year event in terms of flood levels. Most of us realize that it is the flood levels that cause so much damage, allowing the water to move so much farther onshore. Flooding also accounts for most deaths during hurricanes. Folly Island was completely underwater during Hurricane Hugo. The surge was so high that it swept over the outer barrier islands. When the hurricane of 1900 swept over Galveston, this beautiful Victorian city was reduced to rubble. Over 6,000 people lost their lives during this hurricane, which still stands as the worst natural disaster for humans in all of North America. At that time, Galveston was the leading city in Texas, and it has only been in the last couple of decades that it has come back into its own.

Fortunately, the degree of damage with South Carolina's Hurricane Hugo was not as extensive as that in Galveston. Also, the people heeded the storm warnings, and headed for higher ground inland. The Galveston houses were built on sand at grade; they were not elevated or reinforced for the type of wind, wave and surge conditions that occurred. FEMA and the coastal communities have taken action to change our building standards, which has helped enormously. However, as we saw from our post-storm inspection, more needs to be done to tighten up the Standard Southern Building Code. Also we need to elevate buildings; and we need to move them back.

The Dutch have been very skillful at building dikes and tidal gates that can be opened for water traffic but closed during storms. This type of hurricane gate protects Providence, Rhode Island but it is not a general solution for our barrier island coastlines such as in South Carolina.

Now I would like to discuss beach erosion. The general effect of sea level rise on coastal lowlands is to induce landward retreat — beaches erode and marshes are lost. Most sandy shorelines worldwide have experienced retreat, but accelerated sea level rise due to global warming would greatly increase erosion rates.

There is no doubt that our beaches are moving. Sand supply is very important to beach stability, but the underlying reason for recession is a rising sea level. Sea level rise has amounted to about one foot on the average along the East Coast of the United States in the last century. In the Charleston area, it has actually been about 14-15 inches in the last century due to greater land subsidence. Our studies tell us that about one-half foot is due to the overall subsidence of the coastal zone, which is not global related; in Charleston's case it is about seven to eight inches. The other one-half foot of rise probably is due to the global rise in sea level. We have over 100 tide gauges around the United States coastlines, along with almost 1,000 gauges worldwide, and they are showing roughly the same trend. There are some discrepancies, such as Alaska, where sea level is dropping because the land is being uplifted so rapidly by earthquakes and other tectonic forces.

Ocean City, Maryland lies on a barrier island. Most of the new buildings on the beach are high-rise condominiums and hotels. Most of the construction occurred in the 1970's — relatively recent development along an eroding coastline. These buildings cannot be moved out of harm's way. During the construction, the then Mayor Kelly of Ocean City, a very strong politician in the state of Maryland, said there was no beach erosion. He made this statement at a public forum at the Ocean City Convention Center in front of about 500 people. He said that he had grown up on the beach at Ocean City and lived there for 65 years, and not one iota of change had occurred. Mayor Kelly was able to control the city and ran it with an iron fist. The people believed him.

Our data show that there has been ongoing beach erosion for over 100 years at about two feet per year. Ocean City now has a much more enlightened mayor named Fish Powell. He has addressed the erosion problem with a beach nourishment project.

We are faced with several alternatives when dealing with the beach erosion problem. The seawall has done a remarkable job of protecting Galveston, but we have lost the beach. Another approach is to move out of harm's way. As you know, coastal real estate is some of the most valuable property in the country. Along the coastlines of South Carolina, North Carolina and Texas, some houses have been moved relatively inexpensively and there is considerable land available on some barrier islands. In these cases it is usually best to move back, but it is not a general solution.

The last approach is to bring back the beach as we have done in Miami and Bal Harbor and other areas in Florida. Many coastal communities are coming to rely upon beach nourishment, but it is expensive. The Miami Beach project restored 10 miles of beach 300-feet wide at a cost of $65 million or $6.5 million per mile of shore. That project, finished in 1980, has performed remarkably well. In 10 years, they have only lost about 10% to 15% of the sand, but that is without the damage brought by a major coastal storm. The sand may not last that long in other areas, as experienced at Huntington Island, South Carolina. Beach nourishment is not a uniform solution. It must be tailored for each site, taking into consideration the cost and the long-term benefits.

People build houses along the edge of the shore and then are surprised that the beaches can shift 100 to 200 feet. Beaches are dynamic, and are often risky places to make major investments. Moving back and letting the beaches return to nature is 20/20 hindsight.

There is the question of where sand can be obtained to nourish the beach. In the past, sand has come from various locations, including the dredging of bays and harbors and estuaries. The back-barrier areas are generally not good sources of sand; a problem in the Cape Hatteras project occurred where they dredged out behind the Outer Banks and sucked up mostly silt and clay. Silt and clay on a beach are not stable and will wash offshore. In other areas, sand is being trucked from inland sites, such as at Virginia Beach. However, coastal communities are now turning to offshore sand deposits on the inner shelf. Along the South Carolina coast, there are large sand bars in the inlets that can be tapped for sand. You have to be very careful about mining these inlet-related sands because you might cause a drawdown of sand to the adjacent beaches.

The U.S. Army Corps of Engineers has inventoried and found suitable supplies of sand off the South Carolina coast several miles offshore. Fortunately, it appears that South Carolina has quite a bit of sand available for the near future. Other areas aren't so lucky. Parts of Florida are going to run out of sand in the next 20 or 30 years. The state of Florida has already sent a delegation to the Bahamas to talk about buying white carbonate sand from the Bahamian government, but the cost will be high to ship this material to the Florida shore.

Global warming and accelerated rates of sea level rise will only exacerbate the present problem by greatly increasing erosion rates. We are making investment decisions today that go beyond the traditional "payback period"; where we locate our buildings and facilities is critical with respect to erosion. We need to plan for future sea level rise and erosion now. The problems and impacts are not remote; indeed, **we are now only beginning to address the challenge of making wise use of our coasts.**

CLIMATE CHANGE: PLANNING AHEAD FOR SOUTH CAROLINA

Mayor Joseph P. Riley Jr.
City of Charleston

There is much ado currently about global climate change. After a decade of debate, many climatologists agree that we are, or will be soon, experiencing global warming, brought upon us by increases in the "greenhouse gases." Yet, as is always the case with the scientists, there is a small but increasingly vocal minority that disputes the models and the "signals" of warming and says that the end result of these increased gases is more clouds and a cooler, wetter world.

I would not presume to sort out these scientific disputes; that is best left to scientists. What I do know is that both schools of thought are actually talking about the same thing, although not the same effect. Natural processes are changing at heretofore unimagined rates due to the by-products of our human industrial age. And within those rapidly changing natural processes lie the greatest challenges that our always slow-to-change political institutions must face.

The world that we have shaped will not be a constant world in the future. We have built our social and government systems on the basis of expectations that may not any longer be fulfilled.

I presume that I was asked, in part, to be here today because of my recent and extensive experience with possible climate change and climate variability. This fall, our coast had the hurricane of the century. We celebrated the start of winter with an unprecedented "white Christmas," and we have just started off our New Year with a record-breaking rainfall. I now better appreciate the types of problems that the natural range of climate variability can bring. And I have been aware for some time of the potential problems posed by the prospects of global warming and rising sea levels.

Yet, as a public official faced with hard decisions about revenues and expenditures in the future, I can empathize with the sentiment that underlies the recent *Forbes* magazine article on global warming. The article expressed much concern about the long-term economic (and potentially disastrous) consequences of government acting too soon on too little scientific certainty.

But I bring two lessons to my talk today. Based on my experience, there is rarely the sort of scientific certainty that we often wish for as public officials. And while government should not act precipitously, we should carefully calculate the risks and begin identifying the range of suitable actions, for government can as easily waste money through non-action as well as by hasty action. And as I now have new insights into the costs associated with responding to the extremes of climate variability, I know that we can do a better job of being prepared for these events.

Now, down on the coast, we have been listening for some time to the scientific discussions about the potential for increasing sea levels. It does seem to be a real occurrence. And over the framework of geological time, the relative sea level has been and is rising in our area. The twist that global warming provides is potentially to accelerate the rate of that rise, to accelerate the range of impacts.

And as we are already concerned with flooding during normal — let alone extreme — storm events, discussion about things like sea level rise gets our attention early. Even a modest increase in the rate of sea level rise will have profound impacts on low-lying coastal areas — like Charleston. These areas are presently subject to short-term dynamic processes that significantly affect natural systems. The range of possible impacts of global warming and sea level rise include increased risk of hurricanes, more frequent and severe flooding, saltwater intrusion of surface and groundwater supplies, marsh destruction, and habitat alteration.

In the face of potentially pervasive sea level rise impacts, **local government must recognize the inability of our state and federal colleagues to address climate change issues.** This is especially true in South Carolina where we have little centralized planning. And

we will be faced with financial constraints at all levels of government into the next millennium.

We have the tools and occasionally the will to respond to these kinds of anticipated impacts, if we so choose. We have begun to consider these potential impacts where it seems prudent to do so. For instance, the city of Charleston has been looking at upgrading its stormwater drainage system. In fact, it is in the replacing of worn infrastructure that we have the easiest opportunity to do some long-range planning, by designing systems that meet the potential increased requirements imposed by sea level rise. We can also use more foresight in looking at the expansion of infrastructure into areas like Johns Island.

Now, when a proposed response might require the relocation of physical capital in exposed or vulnerable areas, another set of problems generally associated with land-use planning presents itself. We have begun the process of reassessing and revising our Master Plan, and I have asked that a range of environmental issues, including the potential of sea level rise, be taken into consideration during that process.

Some infrastructure will wear out and we can be smarter in its replacement. Some can be moved. But we will need much better physical and fiscal impact information before we can think about significantly redesigning our urbanized areas. And especially long-lived infrastructure like roads, water treatment facilities, and ports will require the special efforts of the scientific, the economic, and the political communities to address.

We will need to combine regulatory and incentive-based approaches to address these difficult issues. Government can and must take a leading role, but the private sector and individual households will have to act responsibly. We can begin by identifying the most sensitive areas and assessing our options. We then must work together to increase awareness of the importance of this issue. As we all know, elected officials are most inclined to lead when a number of folks are following close behind them.

We are a pluralistic society, and whatever response we take will be manifest in many ways, in many places, by people in diverse positions of power and responsibility. Hurricane Hugo has heightened our awareness of the natural forces. For instance, we will soon be taking a closer look at our building codes – looking to factor in hurricanes and earthquakes; the effort has been discussed for some time, but it was Hugo that may have galvanized the political will to address the problem of building design in hazardous areas. Because of Hugo, and because of other events, the timing seems right to proceed crafting a reasonable policy direction for dealing with issues such as sea level rise along the coast of South Carolina. And in the process, we will become better prepared to deal with accelerated climate change, should it happen.

CONSIDERATIONS FOR SOUTH CAROLINA

Panel Discussion

James Hite:
We're going to talk about the things that should be done in the future to ameliorate some of the effects of climate change in South Carolina. Freddy Vang, what do we need to do now?

Alfred Vang:
Within the federal and state establishments there are a lot of diverse efforts in regard to climate change. But there has been no definition of policy options, and no attempt to come up with a plan. The research efforts also are not developed coherently, according to a plan. We're funding a little piece here and a little piece there. We need to develop a plan for the future.

James Hite:
Tim Kana, how do we go about planning for the problems associated with climate change, such as sea level rise?

Timothy Kana:
In some societies you can go for a 100% solution to a problem like sea level rise. Consider the Dutch, for instance, building sea walls to protect their land. However, to achieve a 100% solution it costs an inordinate amount of money. Here in the United States we have tended to design solutions on the coast that entail some degree of risk, so you don't get 100% protection in all cases. We're willing to sacrifice some protection in order to gain a lower cost and to send some of the risk over to other people. In the developed cities on the coast, we can't afford to have a high degree of risk with so much infrastructure at stake. But in the outlying areas, the barrier islands and so forth, we probably can't afford full protection, so we've got to reintroduce some risk. In the last 20 years, our whole society has been reducing the degree of risk for coastal development and we're at a point now, particularly since Hugo, where we have to reintroduce some risk back into coastal development. In other words, development can't be fully subsidized by flood insurance or passed on to taxpayers. There has to be some inherent risk reinserted into the whole process of development.

James Hite:
There are many things we could do now to improve our ability to adapt to a changing climate. For instance, Charleston is redesigning its storm water system partly in response to sea level rise. What other kinds of things can we do? Perhaps we should change how the Budget and Control Board writes specifications on buildings that the state is going to build. For instance, I work in an office at Clemson right now where I can't open the window. Half of the time of the year in this climate I wouldn't need any air conditioning or I wouldn't need any heat. But the building is a closed system and requires tremendous energy to heat and cool.

Are there some other things we can do to improve the situation? Geoff, how do you think we can solve the problems we have?

Geoff Scott:
This is going to be a transitional problem because it's not just our problem today. The larger scope and magnitude of the problem are going to belong to our children and our children's children. So one way that we can effect change is to begin with education early on with children. For instance, recently we passed a seat belt law to make people put on their seat belts. This began with child-restraint laws. I don't know about your children, but when my children jump in the car, they immediately put their seat belt on. Why? Because it's been instilled in them early on that that's the way to deal with things. Maybe there's a lesson in regard to climate change. If children learn early on, for instance, that we have to recycle things to save energy, the process of education will work. One way to effect change is to begin with our young people and make them part of the solution. We cannot divorce them from this process as it's going to be their problem.

Richard White:
We also need to change other important practices such as those of agriculture. Recently, I read an article from the Rocky Mountain Institute. The director there, Amory

Lovins, who has worked in the area of global warming and weather for some 20 years, said, "Roughly one-quarter of global warming is caused by unsustainable farming and forestry practices." Unsustainable agriculture has costly inputs – fuel and fertilizer, for instance – so that in the long-term, it's an unsustainable practice. But perhaps Lovins is also referring to worldwide agricultural problems where farmers slash and burn and then after two or three years they have to move on. That's unsustainable. Even in the developing countries where food production is so low, there is an emphasis to develop sustainable practices. If one-quarter of the global warming is caused by unsustainable agriculture, then we need to pay more attention to this problem. On the federal level, there will be a new farm bill introduced with emphasis on sustainable agriculture. What is driving this sustainable agriculture movement is environmental concern: groundwater pollution, for instance. Now there will probably be more emphasis on global warming. So that is an area where there needs to be some additional work.

James Hite:
I agree with you. But we also have to develop better incentives. For instance, people fuss about the rise in gasoline prices in the last three or four weeks. But if you figure out how many hours the average worker has to work in the United States to buy gasoline for his car, and if you look at what gasoline costs today in those terms versus what it cost in 1940, gasoline is a whole lot cheaper today than it was in 1940.

It makes no sense to conserve on gasoline if gasoline prices are going down in real terms. You won't put engineering talent to work trying to find ways to reduce your use of gasoline if the cost of gasoline is going down. Instead you put your engineering talent to work trying to reduce the cost of those things that are going up. Therefore, we have a set of incentives now that add to the global warming problem rather than detract from it.

Geoff Scott:
We can also translate the momentum of personal health issues into a greater environmental concern. Most Americans are concerned about their diet, the types of food that they eat, whether or not they get the proper amount of physical activity. They are concerned on a personal basis about their health. Yet, they often ignore environmental health issues. Therefore, we have to address how to get preventive strategies into environmental issues as much as possible. Early childhood education is obviously the place to start.

James Hite:
There are two topics I want to get on the table. The first is, what happens to the South Carolina economy if we get increased ultraviolet radiation? If staying out in the sun becomes a very dangerous thing? If you lay out on the beach at Myrtle Beach for an hour, and you get skin cancers? We've got a substantial industry in this state that is oriented toward worshipping the sun.
Another problem is one of difficult trade-offs caused by a potential change in climate. For instance, we've got enough water in this state to supply all our needs well into the future, providing we get normal rainfall on the historic basis. But if we get into a drought situation because of climate change or because rainfall becomes a lot more variable—that is, if we have a lot more dry years and a lot more wet years—then we'll have problems. In a number of cases we're now using 40% to 60% of the flow of the stream. If you get only 50% rainfall prolonged for any time period, then you won't have enough water. Now the obvious answer to that problem is to build storage. But if we build more reservoirs, we will create environmental problems. And that's a difficult trade-off. Geoff, tell us more about the skin cancer problems.

Geoff Scott:
The number of skin cancer and cataracts may increase with the increased amounts of ultraviolet light that may occur due to the erosion of the ozone layer by CFCs. There has been an 83% increase in skin cancer here in the United States in just the last five or six years, and that's a very alarming statistic. Researchers project 30,000 additional deaths by the year 2075 from skin cancer and also up to two to three million additional cases of cataracts, many occurring at a much earlier age. This is a problem that each individual has a personal stake in. It's hard for somebody living in the mountains of South Carolina to get upset about somebody's house washing into the sea down along the coast, but everybody who works outside, whether he be a fisherman along the coast or a farmer in the upstate, is going to be exposed to that sunlight, exposed to ultraviolet rays. So whether he's a weather-

man or a farmer, he has a stake in this problem. One way that we can mobilize activity is in these areas where people have a personal stake.

Timothy Kana:
I'd like to reiterate Geoff's point about developing consensus, and I want to use a recent example, The Beachfront Management Act, which was passed in 1988, was a first effort to control development through the use of setbacks along the front beach. It took many years to reach a consensus within the legislature or among coastal property owners to do something so apparently radical, although in many people's minds the act is not radical enough. However, at least we are making a step in the right direction. Once you can develop a consensus about the importance of beachfront management, then you have some hope of implementing solutions.

John Dean:
Another problem on the coast with a rising sea level is the loss of wetlands. We know, for instance, that marshes have to develop over time, and that certain organisms are dependent upon salt marshes. Unless the salt marshes can migrate inland as sea level rises, which they are trying to do, then you will not have the necessary structure to support coastal resources, such as fish, shrimp, crabs, etc. But what we are now seeing along the coast is an armoring of the creek banks as sea level rises. **The next time that you see a golf tournament televised, notice the number of golf holes that are sited right next to the marsh that have bulkheads placed around them. In other words, support structures that you build to support tourism can ultimately be destructive to the resources that you are using to attract tourism in the first place.**

James Hite:
We must also consider the building code situation in South Carolina. The state should have a blue ribbon commission to say we're going to rewrite South Carolina's codes on the presumption that we're going to have climate change. We're not quite sure how much or what kind of climate change, so we're going to be flexible. Second, we're going to issue instructions to the highway department to build nothing below about six feet above sea level because we're assuming we'll get sea level rise and we're not putting any more roads in places where they're going to get flooded out. There are other relatively inexpensive things that could be done now.

Even if we are wrong about climate change, there won't be anything lost from doing these things.

Geoff Scott:
We also must examine the role of environmental education in our public schools. We need a unified effort there. A few years ago we passed an Education Improvement Act to improve the standards in our public schools, but now we should add a significant environmental component. During this legislative session, there will be a debate about recycling, and recycling is inherently related to the greenhouse problem. The energy saved from recycling will help diminish greenhouse warming. We must help change societal attitudes. One way we can do that is through our schools.

Gaylord Witherspoon:
On a positive note, it's good that all kinds of people are getting involved. For example, in some of the big urban projects, shopping centers, and housing developments, you've got teams of people, bankers, realtors, developers, architects, engineers, all working together, although it's important for someone to be in a leadership role who understands how all of this activity will have an impact on the environment. We're recognizing today that team solutions are absolutely essential. This kind of a panel is important because we can team up to face some of these problems and do some of this research together. This team approach will be one of the positive ways to go in the future.

Question from audience:
How does a community or a jurisdiction best plan for the future?

Timothy Kana:
Now the important word in coastal zone management is multiple usage—that is, developing a plan that identifies multiple uses of a region, sustaining a certain level of those uses, and recognizing you can't have it all one way. You can't develop everything and expect to have good aquaculture or fisheries. The idea of multiple uses means trying to isolate sensitive areas as well as having your industrial areas and tourist areas all within one large area.

It's a total plan. It requires management to achieve the best common denominator for everybody.

James Hite:
In considering managing the coast, we also have to look at how much of a tax subsidy we are providing to people on federal flood insurance on the beach. It is enormous. It may be on the order of $1,500 to $2,000 a year that each taxpayer is providing to those people who live on the beach.

The problem is that the American people are so generous that they see all these millionaires whose houses are blown away, and they say let's help those poor people. Now there's a lot of people on the coast who needed help, but there are an awful lot of people who should have had enough sense not to have built down there in the first place.

PLANNING AHEAD FOR THE COAST:

Climate Change and Coastal Planning

Mr. Thomas Bigford
National Marine Fisheries Service

My topic today is climate change and coastal planning. Specifically, I'm going to talk about sea level change and the need for local action. There will be a definite New England flavor to my talk.

To begin with, sea level rise around the U.S. is not uniform. There are a lot of different numbers attributed to the amount of sea level rise we can expect each year. The numbers differ depending on where you are, where there is subsidence, where the shoreline is rocky, where it's sandy, a lot of different factors.

Now I want to spend a few minutes talking about affected sectors. One of the most striking problems is that many sectors that are affected by sea level rise have not been involved in trying to find a solution. From my perspective, the fishing industry is a missing partner. The fishing industry, for instance, will probably be hurt by sea level rise because fish habitat will be affected, but fishermen have not become involved in long-term issues like sea level rise, primarily because they are concerned about their short-term existence. They are spending considerable energy on other issues, neglecting the long-term issues that might have very important implications on their long-term existence.

I'm going to take a tour around the coast, examining some of the implications of sea level rise on certain sectors. In many places you've got houses perched right on the shoreline, and you've got a public landing that is already eroded and crumbling. Consider a typical multiple use area with recreational boats, bulkheads, and a parking lot. You've also got the commercial fishing fleet, which is very important. In addition, you have to be concerned with the habitat that the fish depend on, or clams, crabs, or whatever. About three-quarters of the commercial and recreational fisheries harvested in the United States are dependent on the estuaries at some stage of their life. These fisheries at some stage go into the areas that might be most susceptible to encroaching waters. If those areas cannot migrate inland at about the same pace of sea water inundation, then we'll lose some of the habitat and perhaps some of the productivity.

Continuing around the coast, let's look at the sectors of the economy that can be affected by sea level rise. For instance, a lot of the transportation sector is coastal and water dependent; also there's a major shore-side support industry for dry docks. Other major users of the coast are the factories, warehouses, and processing plants. Waterfront businesses also include the restaurants, parking lots,

and marine-support facilities that many people associate with the immediate shoreline.

In many areas along the coast, a town's streets, parking lots, restaurants, and marina are all perched at the seashore, with higher ground upland and no place to migrate.

Also affected is a major support network, including bridges and other transportation corridors — for instance, streets right along the shoreline, some of which are already eroding and have to be shored up. There is also the usual utility network — gas and power plants. Power plants represent a special problem in areas where sea level is rising on a grand scale, such as southern New Jersey where there are some nuclear power plants. Sewage systems are also often right on the coast. Another concern is for secondary and tertiary treatment; communities have often designed them so that marshes are the recipient of their outfall. But in many cases as the water rises, the sewage treatment plants will be at water level.

Schools will be affected by sea level rise. This is a picture of a town in Massachusetts that put the high school three feet below high water. There's a dike or a sea wall right here, and the high school is on the other side and the football field is under water when they play. The name of the high school is the Gloucester Fighting Fishermen, and it fits perfectly.

Major recreational facilities will also be affected. This will apply to the Grand Strand as much as anywhere else around the country. Sea level rise will affect beaches, parks, and public landings, many of which the high tide laps right up against. Access will also be a problem. The hardened access such as that for the handicapped will be damaged, but also visfas will be affected. We have to get the public involved in public lands concerns. **We have to get the individual homeowners involved because they are going to be deeply affected by sea level rise.** Interest in this issue will swell among homeowners, and it will end up with public education and awareness programs starting.

We also need to raise awareness of this issue among the financiers, the developers, and banks that are behind development of the coast. In Massachusetts we have rules that protect you when you buy a home against insect infestation, lead paint, etc. There is a movement now to include in that list specific information about where the property is in relation to the flood plain today, in 30 years, and in 100 years in order to increase public awareness of what can happen to property. **In 30 years, will a homeowner be able to sell his home, or is flooding so imminent that he won't be able to sell his property?** So there needs to be public education on this issue. The realty industry is behind that in Massachusetts, and the state coastal zone management program is giving them all the help it can.

I'll finish up my talk with suggested planning and responses to sea level rise, basically in three different categories.

First, education. We don't need scare tactics. The reality of the situation, as it's been told many times today, is rather simple. If we take the most conservative projections, or the possible implications of sea level change, the public will be moved to act. I certainly hope that people will act and I think they'll be moved to act even more if we share with them some of the information documents that are coming out around the country.

In Massachusetts the state commissioned Graham Giese and David Aubrey, two geologists from Woods Hole Oceanographic Institute, to do a planning document, which is excellent. It's the only one I have seen for a state looking at every coastal community along the shore and calculating the percent of upland that it expects to lose to encroaching sea level under three different scenarios, and the scenarios were very conservative. The numbers in these scenarios were less than half of those in the scenario that Stephen Leatherman was talking about. So, in fact, they were ultra-conservative scenarios. The geologists didn't want to scare people, but they wanted to wake them up, and the percentages were high enough to wake them up. The geologists proceeded town by town and calculated the number of acres that would be lost, the percent of the town area that these losses represented, and they did it for each of three scenarios.

Now about planning. In Massachusetts there is a Cape Cod town called Barnstable that has had two conferences to talk specifically about what it can do about sea level

rise. The town has major erosion problems, so town leaders looked at evacuation routes and public disclosure signs to inform people about where they stand at a particular time with respect to flooding and sea level rise, and also where the shore used to be. But town leaders have also embarked on major education efforts. They are explaining the basic choices of retreating or entrenching and the different ways you can treat the shoreline. They are emphasizing the time dimension, comparing, for instance, the implications of sea level change to earthquake planning. Some people compare sea level rise to war or hurricanes, or tornadoes, or something that's more immediate that you can't plan for. But earthquakes are something people predict are very likely over the next couple of decades or centuries, and I think sea level rise fits in that same category. You have to change your zoning ordinances, your construction ordinances, you have to change the way you think, the way you build and where you build. Sea level rise fits neatly into that category.

Finally, a few very specific recommendations. I think the checklists that are in the Sea Grant Consortium newsletter are very useful. I'd like to see another list that addresses the local communities. We also have to do something regionally or statewide. The local citizens also have a role. Certainly in places like Hilton Head and Kiawah there might be a very strong local role. We also have to work with the politicians, but we should seek to have standing committees; that's been done for harbor planning and coastal zone management. We should get civic groups involved, like those that help to beautify a town. Sea level rise has little to do with politics, but has everything to do with long-term problems that are going to persist.

Each sea level rise committee should look at the local geology and the local sectors to figure out which sectors and which areas of the town, which businesses might be most susceptible to relative sea level change, and it should focus on these. Committees should also review options for retreat, considering the secondary issues; for instance, what are the implications for utility lines and other very necessary components of a successful economic structure in the town, both the way it is now and the way it's going to be?

We also have to spend considerable time reassessing the decision-making processes that we now use to site more facilities along the coast. It's enough of a problem addressing the facilities that are already there. We certainly don't need to make the problem even grander by continuing to site more and more facilities, constructing new buildings in an area where we know we're going to have more problems.

I think the state has to take the lead in developing very strong regulations that remove the ambiguity about sea level rise for the local government and for the citizens. Thank you.

PLANNING AHEAD FOR THE COAST:
How Decision Makers Can Respond to the Possibility of Climate Change

Dr. Gary Yohe
Wesleyan University

NOTE:

Gary Yohe's presentation was highly technical; therefore, the Consortium will make his paper available on request.

PLANNING AHEAD FOR THE COAST:

Pre-Storm Mitigation and Post-Storm Reconstruction – A Plan for Nags Head

Dr. Bruce Bortz
Town of Nags Head

I'm from the town of Nags Head, North Carolina. I'm a land use planner. The town of Nags Head, for the last 12 to 15 years, has been working on various storm mitigation issues — pre-storm mitigation and post-storm mitigation, actions the town can take ahead of time to reduce the risks to both lives and property.

We've gone through quite a few changes in Nags Head, including changes to the subdivision regulations, to zoning, to town ordinances — all directed toward reducing the intensity of development along the oceanfront.

One of our major philosophies in Nags Head is retreat. That is, make it easy to retreat, to get off the oceanfront. And we've also adopted a lot of disincentives that discourage certain types of development on the oceanfront.

Nags Head is along the outer banks of North Carolina, part of a barrier island that stretches from the Virginia border down to the Wilmington area. Nags Head itself is a fairly narrow part of the island. We range anywhere from 1,600 feet wide to about three miles wide, and we have two roads that parallel the coastline. Most of our development is, of course, along the oceanfront. That's the demand area where folks like to build. A lot of our development is single family development. We like single family development, and a lot of our land use regulations and policies are directed at single family development.

Nags Head prides itself as a family beach, an area where people can get away from the big city, a place where the kids can play safely, and we've tried to preserve this image of what we call the family beach atmosphere. Nags Head has had a family beach atmosphere for 100 years. We've never had the pressure to develop intensely. However, we have had to deal with erosion. At home I don't talk about sea level rise, because that might confuse the folks and they might not understand what sea level rise means, but they certainly know what erosion on a barrier island means. It's a problem we've had to deal with for years.

In the early 1970s, one evening we had a strong northeaster come in that took away about 30 feet of beach, and did a lot of damage. Northeasters, especially in the springtime, coupled with the lunar tides, create a lot of damage. And, of course, so do hurricanes. We haven't had a major hurricane for 20 to 30 years. We've had a severe northeaster, the Ash Wednesday storm in 1962, but a hurricane we haven't had, though we realize that one is coming. It's not "if," it's "when," and our elected officials have realized that hurricanes and tornadoes are going to occur. So we set out years ago to answer the basic question, "What types of pre-storm mitigation measures can the town put in place to lessen the impact of property loss, save more lives, and so forth?"

Well, we've adopted a lot of pre-storm mitigation measures. We have four phases of response. First, we have a pre-planning stage, then we have a storm event, then we have recovery, then we have mitigation, and we start planning again. The town of Nags Head has done a lot of this pre-storm planning. We've adopted a lot of zoning changes in the last 10 or 15 years that will mitigate the loss of lives and property. We've also prohibited all commercial activity on the oceanfront. We have no commercial activity whatsoever on the ocean beaches. We have a strong, active program to acquire property along the oceanfront and develop public beach access sites. We have laws on the books now where we can close the ocean beaches if we think a storm's coming, to get the people off the oceanfront. We recently amended our zoning ordinance to require large lot sizes on the oceanfront. When the town was originally planned in the 1930s and 1940s, we had 5,000 square foot lots, entirely too small for oceanfront development. So we've amended that now. We have 20,000 square foot or half-acre lots, again, aimed at limiting the intensity of development along the oceanfront.

The town has recently adopted some strong measures for hotel and condominium development. We require large setbacks. Multifamily dwellings are limited to 35 feet in

height. This is a disincentive, so we've had very few multifamily developments. Hotels are limited to 50 feet in height. If they go 50 feet, they have to set back 120 feet on each side of the structure. That's been a disincentive, too. We also require a lot of open space for hotels and motels and multifamily condominium units. Again, a disincentive. Developers don't want to put away 60% of their lot in perpetual open space, but the town wants that openness to keep a family beach atmosphere. So these are some pre-storm mitigation measures which the town has adopted in the last 10 to 15 years. We have, in addition to what I've just gone over, reduced our potential for hotel development by 73%. About 10 years ago you could build 60 hotel units an acre in Nags Head. You can't do that anymore. We've reduced that by 75%. Multifamily we reduced by 60%. So no longer are we going to have very high intensity development on the oceanfront.

That takes us through some of the pre-storm mitigation measures we've taken to reduce the intensity before a storm. We have either not allowed certain types of development on the oceanfront, or we have diminished the intensity with greater setbacks, greater front yards, and greater open spaces.

We've also done post-storm mitigation measures — that is, measures that the town can take and implement before a storm and after a storm. We've addressed these post-storm issues before a damaging storm event. We have adopted laws and regulations which will set, among other things, an automatic building moratorium. As soon as a hurricane hits Nags Head, we have a building moratorium. This building moratorium will extend for 30 days. It's automatic. However, the elected board can change it, extending or shortening it. The building moratorium extends to building permits being issued. There won't be any building permits issued until the town's building inspectors can recover from the storm and assess damage. Part of the reason for a moratorium and some breathing room is, of course, that the federal government requires all municipalities and counties to assess damage. So we have to have breathing room to get out in the field and assess damage, and this all goes back to the declaration of an emergency by either the governor or the president. So we have to buy time for assessment. And one part of our post-storm mitigation program is that we have preference to those houses that have received minor damage.

We have three categories of damage. We have minor, major and destroyed. For those houses that are destroyed, we're saying we don't have time to try to get you a new house. We have to put our efforts into helping those individuals that have light damage or moderate damage. If you're destroyed, we don't have the resources or time — that is, we, the Planning Department, the building inspectors, the planners — to get you back on your feet.

Part of Nags Head's post-storm hurricane reconstruction program is the development of a damage assessment task force, which is mandated by the Federal Emergency Management Agency (FEMA) folks. We have to assess damage. One of the first things we do after a storm is assess damage. And to help our local building inspectors assess damage, we have a program which we call the Building Inspector Assistance Program where we have set up contracts with other municipalities in North Carolina to bring in building inspectors to help ours. It's an arrangement that's made ahead of time. We have arrangements, I think, with five or six municipalities in North Carolina where basically all we do is make a phone call and they will send building inspectors.

We do have coastal standards, setback standards. The town of Nags Head exceeds those standards mandated by the state. We have some requirements which are more restrictive than state standards.

The town has adopted several policies on roads. We have, of course, quite a few roads in town. We have public roads and we have private roads. We have town-owned roads and we have state-owned roads and one nagging question that has always come up, because we have several roads that are going to get washed away in a hurricane, is who is going to put the roads back? Well, the town has several policies now. One is that if it's a private road, the town is not going to put it back. Those private individuals who put that private road in will have to find a way to get to their property. If it's a town road, the town will only put that road back after the town has considered all alternatives. In other words, is there another place, a better place to put that road than right beside the ocean? One other pre-storm issue: we have a lot of old sub-

divisions that are next to the Atlantic Ocean, with cul-de-sac lots and very shallow lots. Recently the town has amended our subdivision ordinance. Now we only allow what we call "ocean to road lots" — ocean being, of course, the Atlantic Ocean, and road being one of two major roads in the town of Nags Head. This action would result in lots being 60 feet wide, 400 feet long. The purpose of this action would be to allow the relocation back of structures that are threatened. In these old subdivisions we don't have that opportunity. Homeowners run out of room. The house is either destroyed, or if homeowners can find another lot in Nags Head, they move it.

We have a land banking program in effect now. In this program, the town puts away money every year for purchasing land. This money can be used for a number of purposes. It can be used for recreation. It can be used to purchase land that the town infrastructure may need for sewer lines or water lines or roads. It can be for beach access. But we have an established program to buy oceanfront property.

One aspect of our post-storm plan is that we have a reconstruction task force; this task force has already been set up. Town law says that upon the declaration of a storm event, this reconstruction task force will be assembled to look at the storm damage. It will recommend to the elected board changes in zoning that should be made as a result of the storm. It will recommend to the elected board what types of assistance the town should go after and who should go after it. This reconstruction task force will negotiate for the acquisition of property and participate in federal mitigation measures. The task force is a group of 13 individuals, most of them town employees, but also including three or four town citizens. It takes one phone call to get them together if we have our phone lines, and the task force will assist the town in getting back on its feet.

Again, all this effort is directed at helping people get back on their feet. For those folks that have destroyed houses, we have to worry about getting the debris cleaned up, but we also have to worry about getting those people who have minor damage back on their feet. That's a good place to end my presentation. Does anybody have any questions?

Question from audience:
When the town has determined that a house has major damage, will you let the homeowner rebuild?

Bruce Bortz:
Yes, we will. In our zoning, we basically say that if 50% or more of your house is destroyed, you can't build it back, but major damage is from 10 to 50%. If it's destroyed, you would be able to rebuild if you could get the necessary permits for septic tanks and if there's enough land left there. A lot of our problem now is that the structure is still fine, the structure is standing, but the town of Nags Head does not have a municipal sewer system, so it has to be on-site septic, and homeowners simply just run out of room to put on-site septic, so the houses are subsequently condemned and they're either torn down or they wait for the ocean to take them. Any other questions?

Question from audience:
What happens to that real estate?

Bruce Bortz:
Let's hope the homeowner has FEMA flood insurance, and FEMA will reimburse the homeowner, and the town will get the back taxes. Folks let their taxes lapse two or three years while they're trying to settle with the insurance companies. There have been some cases where the individuals will give the town the property for beach access or for oceanfront. Depending on how much land is left, usually the lot has no value at all to it, so homeowners try to give it away for a tax advantage.