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Keynote Address by Dr. Howard Frumkin

Ambassador Benedick, wonderful staff at the NCSE, friends, and colleagues, good morning. It is a real honor and pleasure to be here and it is a delight that NCSE is grappling with the issue of health as part of its environmental science agenda. Thank you very much. And so, I congratulate the organization for this choice of topic and I'm told that this is the biggest turnout that has ever occurred at an NCSE conference.

So, this is a wonderful reflection of the importance of this topic and how much we all appreciate that. My title is, "An Intimate Connection between Environment and Health." This is a picture of an intimate connection. You may wonder why I picked swans. Well, if you go to Google images and you put in "intimate," you will be amazed at how few images are actually appropriate for showing in a public setting, but this is one of the nicest ones that I could show you. There is indeed an intimate connection between environment and health. I'm going to make the case for that connection using kind of a historical approach. I want to make the case first that the quest for healthy, wholesome environments, for good places in which to live, work, and play, is as old as we are as a species. It is elemental. We care about having good environments. I then went to trace the history forward a bit until the last few decades, when for one reason or another, environment and health have diverged somewhat. And then, I want to look forward to the future, identify some of the challenges that face us in the environmental sciences and make the case that health is absolutely central to meeting those challenges and that we need to reunite the two fields to reestablish intimacy, as the counselors would say. As we move forward, we will do better. We will have better success if we do it that way.

Well, I want to identify three phases in our history, what I'll call the sanitarian phase, the Carsonian phase -- this is a word that I made up, so do not worry if you have not heard it -- and emerging challenges for the coming century. Sanitarian challenges are those that are probably better addressed by

civil engineers than by health professionals and they reflect challenges that are as old as humanity. Five-thousand-year-old ruins show evidence of dealing with water supply and with sanitation, such as these from the Indus Valley. Indoor environments have been a problem for as long as humans have sought habitation.

You can see in this ancient photograph of an early home that there were problems with illumination, problems with water management, and if you look to the right, probably problems with vector control as well. The Anasazi ruins in the Southwest remind us not only of the importance of living in harmony with the environment to achieve sustainability, health, and well-being, but, as Jared Diamond has shown us, the dangers of overshooting the carrying capacity of an environment for long-term health and sustainability of the society. These ancient photographs of restaurants remind us that Jewish and Muslim dietary practices originating several thousand years ago reflected early recognition of the importance of food safety. These are practices that survived to the present.

And still, in every public health department in this country, we have professionals, often called sanitarians or environmental health professionals, who are dealing with water, with sewage, with food safety. These remain very important issues. Mold has an interesting history. This is a conversation recorded in Noah's Ark: "When the water subsides, the problem is going to be mold." I cannot resist showing you this segment from the Book of Leviticus. It is often translated as leprosy, but follow the text with me and see what you think: "He who owns the house shall come and tell the priest, 'There seems to me to be some case of disease in my house.' Then the priest shall command that they empty the house and afterward the priest shall go in to see the house. He shall examine the disease and if the disease is in the walls of the house with greenish or reddish spots and if it appears to be deeper than the surface, then the priest shall shut up the house seven days and come back on the seventh day, having let the clock run for the entire week." This is the first recorded episode of environmental consulting that we know of. There have been instructions here for remediating the mold in the house and interestingly, "Taking the

debris to an unclean place outside the city.” This may be the first hazardous waste site in recorded history.

So, these are functions that are as old as we are. Fast forward to the industrial revolution - we begin manufacturing chemicals; we begin using energy in intense concentrated forms previously unknown to humanity. We encounter a whole new set of environmental challenges and health challenges encapsulated nowhere better than in *Silent Spring* by Rachel Carson. Hence, my neologism, the Carsonian Era that followed for the last few decades. This was an era where toxic chemicals became imprinted on the public imagination as threats to health and widely used in ways that were not always optimal for human health. This was a time when air pollution, which had been known since the dawn of time but became much more concentrated with the industrial revolution, became a major recognized public health problem.

The picture of Pittsburgh -- and sorry to Bernie Goldstein, but that is what it looked like. Pittsburgh early in the 20th century looked as you see on the left. Approaching travelers would describe seeing the city from 50 to 100 miles away on a clear day marked by the plume of smoke that rose from Pittsburgh. Donora, Pennsylvania is shown on the right, midday during the famous Donora air pollution episode.

This is the London smog episode of 1952, another picture also taken at midday. This picture, in addition to demonstrating the intensity of these air pollution episodes also demonstrates a truth to which we will return later, and that is that in the midst of enormous environmental challenges one can find hope. In this case, if you look to the upper left, you will see that even in London, the land of fish and chips, you could find ethnic food. Water pollution became a major problem in recent years with industrial dumping. That has largely been addressed, fortunately, but non-point source pollution remains a major challenge for us. And solid and hazardous waste, of course, from slow exposures like Love Canal, from rapid releases like Bhopal, remind us and remind the public and policymakers that chemical exposures are very much an environmental health problem.

We responded to this growing awareness now in the Carsonian era by passing an enormous portfolio of important environmental legislation. We developed the science base in toxicology, epidemiology, and related sciences; we developed risk assessment; we developed an entire field of environmental professionals who went to their own schools, read their own journals, went to their own meetings, and eventually occupied their own agencies, which became distinct from health agencies.

So, environment and health academically, intellectually, organizationally to some extent went their separate ways leading to what we might call the great divorce, the great split. We have sundered what used to be an intrinsically close relationship between the two. But I want to make the case that as we go forward, as we identify and confront the major environmental challenges of coming years, everything tells us that we ought to reestablish that intimacy, recognize the centrality of health in environmental thinking and vice versa, and achieve better success by doing that. I'm going to make that case by using three examples. These are various parts of environmental science and environmental practice: conservation biology, climatology and earth science, and urban planning. In each case, by showing you examples of scientific data and by talking about the practice of these fields, the application of these fields to improving well-being, I want to make the case that these are health sciences, that conservation biology is public health, and so on.

Well, let's begin with conservation biology. I'm going to focus on one particular aspect of conservation biology, which is trees. Trees, either in the natural state as you see here, or in more manicured and human-managed settings as you see here, are nice things. Trees are pleasant. We like trees. But not only that, we have evidence that trees are good for health. Let me show you two snippets of evidence that are especially impressive. This is a landmark 1984 study by Roger Ulrich. The floor plan on the left shows you the post-surgical wing of a hospital in Pennsylvania. It turns out that when you have your surgery and when you go to your room afterwards to recuperate, some of the rooms face out onto green trees; that is the view out the window. Other rooms face out onto a brick wall. Which room you end up in is essentially a random selection based on whether it happens to be an empty bed that day.

Roger Ulrich took a look at the records of all patients who had their gall bladders out over a 10-year period restricting the look to the summer season when deciduous trees were in bloom, and he observed the outcomes of the patients in the two kinds of rooms. Those in rooms with tree views had shorter hospitalizations. They had closer to eight days than nine days; this is in the pre-HMO era. I mean, this is before we had drive-thru cholecystectomies. Less use of analgesic medications and fewer negative nurses' notes. No difference between the two groups of patients could be detected other than the view of trees out the room. So, it appears that there is an association between viewing trees and more expeditious and smoother recovery from surgery.

A brilliant series of studies by Bill Sullivan and colleagues at the University of Illinois took place at the Robert Taylor Homes in Chicago. This is a series of 28 high-rise homes -- public housing. And what is fascinating about these homes, in the opportunity that Bill and his colleagues recognized for a natural experiment, is this. Some of the buildings, when you walk out the door have trees outside; other buildings, when you walk out the door face on barren courtyards that look like this. Which kind of building you end in is essentially a random assignment, depending on when you come to the top of the list at the Housing Authority Office.

And so people in the two kinds of settings can be compared. The Illinois group did interview studies with a group of 145 residents, probing into social dynamics in aggressive behavior and comparing people in the tree buildings with people in the barren buildings. I'm not going to go through all the results. It is a very rich data set. I'm fortunate to have Bill with us at this meeting and so I encourage those of you who are interested to talk with him during the next couple of days.

The green bars in each case are the individuals, the respondents who live in buildings with trees outside; the pale yellow bars are the respondents who live in the more barren buildings. Do you know people on your floor? Do you know your next door neighbor? Do you feel a sense of unity and cohesion with the people with whom you share a building? Do you have many visitors daily? Do you socialize within your building? Do you know people in your building? When you encounter others, do you

acknowledge each other? Do you help each other? In every single case, better indicators of social dynamics if there are trees outside the building than if there are not. They also asked about aggressive and violent behavior against one's partner. And again, the green signifies people living in the buildings with trees outside. Do you engage in spiteful behavior? Have you threatened to hit your partner? Have you thrown or smashed items? Have you thrown something at your partner? Have you hit your partner with something? Have you hit your partner with your fist? Have you beaten your partner up? Have you used a gun or a knife? In every case, substantially lower levels of aggression and violence among those who live in buildings near trees.

When overall scales were calculated for the aggressive and violent behavior as you will see here, there are substantial and statistically significant differences in favor of living in the buildings with trees. Well, two different kinds of evidence that being around trees is good for people. Is there a theoretical basis for this? Well, there may be a basis in evolutionary theory as we follow the history of human evolution over time. We remember that most of the time during which we have evolved has been time spent living in natural settings. This is, of course, the biophilian hypothesis put forward Harvard biologist E.O. Wilson. Biophilia is defined as "the innately emotional affiliation of human beings to other living organisms." It may be that we have a deep-seated connection to nature and that conservation biology, by preserving for us opportunities to have contact with nature, improves our health and well-being. Not to mention all of the other benefits that trees may offer - cooling effects in cities, improved air quality, source water protection, medications that come from trees, shade from sunlight, the beauty of trees, and the spiritual inspiration that many people take from trees.

Here is a good example of the nexus of conservation biology, one of the core environmental sciences in human health and well-being. Conservation biology is health science. Second example: climatology and earth science. And you all know that I'll be talking about climate change now. Climate change is the phenomenon of the week, if not the decade, if not the century. President Bush acknowledged the seriousness of climate change in the State of the Union message. The new IPCC report

will be coming out tomorrow, but leaks this week have indicated some of its findings. You will hear a lot about climate change from some of the world's experts who happen to be here - Jonathan Patz, Rita Colwell, and others.

Solar energy reaches the earth; much of it reflects, but part of it cannot reflect because it is retained by the greenhouse gas layer, much as what happens in your car on a warm day, much as what happens in a greenhouse. That greenhouse layer has been thickening over the last century-and-a-half due to carbon dioxide accumulation from burning fossil fuels and from other sources, and in association with that thickening of the greenhouse gas layer and the increasing carbon dioxide levels has come increases in temperatures.

We have seen changing global conditions. Katrina just over a year ago reminded us of the association of severe weather events with climate change. If you look at the graph on the right - this is work from my neighbors and friends at Georgia Tech - the red line at the bottom indicates categories 4 and 5 storms on the Saffir-Simpson Scale. Over the last 30 years, the proportion of hurricanes that are severe has risen substantially, which corresponds to the predictions of most of the major climate change models. What I call the balding of the world, the shrinkage of the Arctic ice cap, has now become well documented. The New York Times ran this picture a year ago showing the edge of the summer ice retreating over time.

You could not go through the North Pole historically. Those who like old English folk music know the story of Lord Franklin who disappeared trying to find the Northwest Passage. Amundsen finally crossed the North Pole in 1905. It took more than two years. By 2005, there were only 40 miles of scattered ice in Victoria Strait and we are now at the point - wonder of wonders - that you can go to the web and look up "North Pole expedition." You can book to summer voyage through the North Pole. This is unprecedented in human history and maybe good for well-heeled tourists; it is not very good for polar bears. The polar bear population on the Hudson Bay is declining -- one-year survival is declining. There

are documented reports now of polar bears drowning, swimming across long distances, unable to reach solid ice in time to get out and rest, and reports of polar bear cannibalism.

Glacier loss. This is Glacier Bay National Park in 1941 with a glacier 2,000 feet thick; here is the same scene in 2004. This is the Boulder Glacier in Glacier National Park, the soon-to-be-misnamed National Park. This is 1932; here is the same scene in 1988. This is the Matterhorn. You can see that snow cover is disappearing over time. This is Pasterze Glacier in Austria; the same scene in 1875 and 2004. This is the Portage Glacier in Alaska in 1914 and 2004. This is my impression of Al Gore. How am I doing? This is the ice melt in Greenland, 1992 and 2002; rapid loss of ice in Greenland.

This is the only planetary and earth science journal that I can actually understand, and this is The Sun, and it predicts the oceans are rising 150 feet. I think this is an exaggeration. We do have documented sea level rise in the range of centimeters over the last decade alone, with predictions of greater sea level rise over the coming century. More frequent floods have been well-documented - this is since 1950 - with catastrophic results because large numbers of people live in coastal areas and are subject to the effects of floods.

In short, we live in a changing world - rising temperatures, more severe weather events, and so on, and so forth. Why do we care about that as a health issue? Because up until now and certainly moving forward, thanks to the climate change commitment we have already undertaken, you can see the extrapolation here for the next few years. There is uncertainty, but we know that temperature will continue to rise. We are expecting rises in ocean levels. We are expecting more severe weather events. And those commitments have implications for health.

The direct effects of heat, the effects of severe weather, the effects of air pollution, infectious diseases, changes on the water and food supply, effects on mental health, the large scale of displacement of people who will become environmental refugees, the potential civil conflict that may result from that - all of these are potential health impacts from climate change, meaning that planetary and earth science is very much health science. This is a picture of the timeline of the European heat wave in 2003, which

claimed about 30,000 lives. We know very well that heat waves kill people and that heat waves will become more common in coming decades. Heat waves offer us an opportunity to engage in system thinking, something to which I'll return also and on which we will have a panel later this morning led by Bernie Goldstein.

Other things happened in Europe during the heat wave than simply warmer temperatures. People turned up their air conditioning. The high demand for electricity led to power outages including, in some cases, melting cables. River temperatures rose, making it difficult to cool power-generating plants. It became impossible for the French to purchase electricity from elsewhere because others needed their electricity as well. So, there were shortages that could not be addressed by the usual methods. There were severe agricultural losses. There was livestock mortality, huge economic losses.

And so, thinking through the heat wave issues became a complicated challenge. In addition, we know that as more and more of humans live in cities as we become an urbanized species, the urban heat island phenomenon will intensify. And that, together with rising temperatures, will cause more intense heat waves within the cities. The predictions from the EPA over a decade ago were for substantial increases in mortality in American cities due to heat waves in association with climate change. This will remain a public health challenge. Severe weather events came to the forefront last year with Katrina and Rita. We know that more and more humid air dumps its moisture more precipitously, no pun intended. Injuries and deaths, water contamination, food contamination, carbon monoxide poisoning -- an interesting spin-off.

When you have a disaster, people lose their electricity. They begin to use generators and predictably and regularly some people misuse the generators, and we see carbon monoxide deaths. This is something that we followed for some years at the CDC - fires, explosions, and electrocutions. The mental health impact of disasters may be one of the most lasting and important effects. After Katrina, this has certainly has been a terrible issue. Disparities across populations in most of these effects, reminding us that bad things do not affect to all of us equally and that includes most of the outcomes of climate change

and health. As sea levels rise, coastal populations are at risk of being displaced; coastal land will erode and some of it will be lost; freshwater may be contaminated, and saltwater may intrude on freshwater tables.

We have had very good projections made of which coastal areas will become uninhabitable. This is a picture of Florida after a projected one-meter rise in sea level. The red area has become uninhabitable. Here is from a Harvard Magazine article on climate change last year, projecting a 3.5-meter sea level rise. You can see that a large part of Florida and the Louisiana coast are lost. For those of you from New York, you can see that now large parts of Manhattan are lost.

Infectious diseases are expected to become more common under climate change scenarios. As tropical climates expand their range, tropical diseases will expand their range. The WHO projections of which diseases are liable to become more common and with what probabilities are shown here. Malaria, as you can see, is the one rated highly likely to expand in its range and to affect more people. This is a highly prevalent disease already. Others will also expand and you will hear more about that from Dr. Patz and Colwell and others later in this meeting, and certainly at next year's meeting.

We have good data supporting these trends. Here is just one example: the relationship between temperature and the incubation of the malaria parasite inside the mosquito. This is an odd graph. I have always had a fun time showing this because the independent variable is on the Y-axis instead of the X-axis. So, this is a brainteaser to get you going in the morning. What you can see is as the temperatures get warmer, the incubation period gets shorter. That means that the mosquitoes are more actively transmitting malaria under warmer temperature scenarios. Air pollution will become more common under climate change scenarios. The formation of ozone, a secondary pollutant that forms an air from the reaction of nitrogen oxides in hydrocarbons, is accelerated when the temperature gets warmer as you see here. That is why in warm smoggy cities like my own, like Atlanta, the ozone season is the warm months. Well, as the warm months occupy more of the year, we expect ozone levels to rise and to remain more persistent over time.

That is not the only air pollutant we have to worry about. Particulate matter from power plants may be an increasing issue as we demand more and more energy from power plants to run our air conditioners during warm days. In addition, some of the plants that generate mold, that generate pollen, thrive under conditions of warmer temperature and higher CO₂ levels. Mold and fungi like warm, wet environments and so we can expect those aero-allergens to torment people who currently suffer from allergies.

Production of food is important to maintain health and there is a complex set of relationships governing the effects of climate change on food production. In some cases, they are positive; some food crops thrive under conditions of climate change. In many cases, they appear to be negative by our best projections. Even where we think things may not be too bad, it is very hard to predict the effects of plant diseases and animal diseases on livestock and in food production. Unfortunately, the projections are that some of the food stuffs that are most fundamental to diets in poor parts of the world where nutritional supply is already marginal are the ones whose productivity will decline the most under climate change. And so, again, we see equity issues or disparities. The shortages of food are liable to hit hardest those who already are marginal in their diets and in their health.

Mental health. Here is a New Yorker cartoon character explaining to her friends, “This past summer, I got deeply depressed about our planet. As if I did not have enough problems of my own.” Confronting these issues is tough. There is a risk of anxiety, of depression, of despair. I recall when I was growing up being sent down with some regularity to the basement of the school along with all my classmates, told to sit on the floor, put our head between our knees, and wait for the bomb to go off and wait for the all-clear signal to be given. These were nuclear bomb drills. This was not a cheerful message to be given as a child about the future of the world.

Similar messages are now becoming more and more pervasive as children hear about climate change. Those messages have the risk of immobilizing us and we will return to that a little bit later as well. If some of these scenarios blossom fully, we can expect displacement of population and scarcity of

resources. And we know all too well and all too tragically that people fight in situations like that. War is terrible for public health. War is terrible for the social fabric, and this may be one of the bigger concerns that we have over coming decades. So, climate change has a number of health implications. Climatology and earth science are health science. Addressing climate change is addressing human health and well-being. There is an intimate connection between the two.

And the third example I want to develop, the third and final, is urban planning, not generally considered one of the environmental sciences but very much the applied practice of environmental thinking and systems thinking. The cities and towns we have been developing over recent decades look like this picture of Denver. They sprawl over vast geographic distances. We have converted traditional land uses at the edge of our cities and towns from forest and farm land to residential housing as you see here. We have abandoned large sections of our central cities despite the presence of perfectly good infrastructure there in order to develop that in the green fields. We are using land at unprecedented low densities. People live in places like this instead of several families per acre, several acres per family. It can be said with confidence that these people will never walk or bike anywhere because no place is close enough for them to reach by foot or by bicycle. That requires that we commit ungodly acts of civil engineering, such as the one you see here, and commit ourselves to an automobile-dependent transportation system.

The land use and the transportation decisions are as intimately connected as health and environment are on a larger scale. Despite the construction of all those miles of roads in all of our cities and towns, we have not been able to avoid this phenomenon occurring twice everyday. It is quaintly called the rush hour, as if it only lasts an hour, but it lasts well over an hour in most places.

Here is a graphic depiction. Is anybody from Baltimore? Some of you are so you will recognize the geography. For those who are not, just to orient you, this is the year 2025 after the Baltimore Beltway has been newly widened to 1472 lanes. You can see that up on the left. Up to the Northeast is the New York Beltway, formerly known as the State of New Jersey. And down to the bottom left to the southwest

is where we are; that is the Washington Beltway separated from the Baltimore Beltway by I-95, signifying 95 yards between the two beltways. If you look at about four o'clock, you will see the human impact of this pattern: "Mommy, when are we going to be home?" Mommy says, "We spent 60 hours a week in our car, honey. This is our home." Quite a change in human habitation and travel patterns. Coming down to the neighborhood scale, here is the so-called loop-and-lollipop neighborhood configuration featuring low connectivity, difficult to get from point to point and featuring low land use mix.

You will see large tracts of land that look like this with nothing but residential properties; not a store, not a school, not a library, not a church - a radical departure from traditional principles of town and city building. Here it is graphically. A grid-like arrangement down below, a typical town or city from years past, and a more conventional contemporary arrangement up above. Up above, you will see different land uses separated having been developed on separate parcels of land. The single family house is separated from the schools, separated from the apartments and so on. To get from one of those single-family houses to the school, a child has to go down through the network in his subdivision along the feeder road and back into the school, a trip that is certainly too dangerous for mom or dad to allow the child to do it alone and that therefore requires not only a car ride, but intervention by mom and dad, the last thing a kid wants to depend on. Down below, you see a more traditional grid-like arrangement almost certainly with sidewalks, allowing easier transit from point A to point B. Destinations are closer to homes; more independence for children.

Here is another feature of modern development. Let's do this as a multiple choice test. Do you think this is a) a medium security prison, b) one of the last remaining industrial facilities in the country, c) a UFO that just landed, or d) a school? These are schools. This is actually how we build schools. It is a pattern that the *Governing* magazine called the "edge-ucation," the compulsion to build schools in the middle of nowhere on 40-acre parcels way out far from where anybody lives. So we see schools that look like this one in Minnesota. This one in Arkansas, surrounded by a huge lagoon of parking. My favorite

one, this is in Hubbard Lake, Michigan. Its motto is “Outstanding in its field.” This school is seven miles from the nearest town. No child for the entire life of this school will ever walk or bike to school.

The streetscape. Streets that are made to move traffic, but are pedestrian-hostile. Streets like this are pretty good for moving traffic when they work well. They are also good because they allow us to play a fun game called “Find the victim.” If you look carefully here, there is the intrepid pedestrian trying to cross the street. So that the suburban dream of access to green space, peace and quiet that drove many people to the suburbs ended up in many cases feeling more like this.

Coming on to the sidewalk level, I have undertaken a personal study; this was before I worked for the CDC. This is not government work at all. This is private work; and I have discovered in carefully studying sidewalks around the country that there is an insidious clandestine national “Never Walk” campaign designed to get Americans never to walk. I have identified 11 strategies that are used with regularity. The first is not to build sidewalks since we see roadways that look like this. But you can see from the folk path along the side of the road that some people insist on walking anyway, so we need 10 more strategies. The second strategy is to build repellant sidewalks, sidewalks that look like this: With no buffer between the pedestrians and the traffic, with nothing interesting to look at as you take a walk, with nothing to shade you from the sun. Why should anybody ever want to talk on a sidewalk like this? Allow sidewalks to disintegrate. Put public funds into other things, anything other than pedestrian infrastructure. Build treacherous sidewalks. Sidewalks like this that slope directly into the traffic, so that if you are walking your child in a stroller and you lose hold of the stroller then the stroller goes into the traffic and a potential contributor to the pedestrian gene pool is removed. Obstruct sidewalks. Sending a clear signal to pedestrians of how we value walking. This scene is just about a half-mile from the CDC. A storm came through; a tree fell down. The County Way Highway Department, God bless them, came right out with their chainsaws. Now, they could have sawed off the tree on the inboard side of the sidewalk, but no, they are part of the National “Never Walk” Campaign.

Use creative design. I, of course, given my background, use medical metaphors. This one is *sidewalkus interruptus*. This is dislocation. Now, crosswalks are designed to get people from one sidewalk to another across the street, but if you strategically place crosswalks that go nowhere, nobody will ever walk on the crosswalk. Combining multiple strategies is very good for leveraging resources at a time scarcity here. For example, we have *sidewalkus interruptus* and obstruction. Anybody will get the message with this. Never place an interesting or useful destination anywhere near where people live. If you build low land use mix neighborhoods, then nobody will ever walk or bike.

We will use motor vehicles. This has environmental consequences as well as health consequences. Anybody who lives here who wants a quart of milk or a loaf of bread gets in the car. Being explicit is always a good idea. This is an entrance to a gated community, the fastest growing residential configuration in America. And if you look closely, you are not allowed to get there on foot. No pedestrians. You have to get there by car. Finally, make everything car-accessible so that no one ever has to get out of the car. We live in a drive-through world. We have drive-through pharmacies, drive-through dry cleaners. As I show you these pictures, notice please, that “drive-through” is always spelled T-H-R-U on the theory that busy drivers have much better things to do than deal with O-U-G-H and other complications like that. Drive-through liquor stores; drive-through bakeries; drive-through grocery stores; drive-through automobile service establishments; drive-through food which can be washed down by drive-through coffee; drive-through banking. This is one of the best-developed examples of the National “Never Walk” Campaign. If you look carefully at the console on this ATM, you will see that the buttons are braille, so that even blind drivers can -- never have to get out of their car. We have drive-through mailboxes, drive-through utility bills. This -- we love nature; we have drive-through trees. You can get married without having to get out of your car as this happy couple is doing in Las Vegas. But this is a bit pricey, for those who cannot afford the tunnel of love, they can have drive-up wedding windows. This is a variant of the drive-through wedding. If it does not work out, the marriage does not last, here in

this courthouse in Alabama, you can drive up to make your child support payments. And speaking of lifecycle events, we have drive-through funerals. This is the break for the wake approach to funerals.

Now, speaking of systems thinking, if anyone can explain this to me after the talk, I would appreciate it. And if you think this one is tough to explain, I'm not going to comment on this one. Well, the consequences of this strategy are that we have engineered a society in which walking and bicycling are difficult. In sparse metropolitan areas, mass transit is not financially viable and that means we are automobile dependent. That complex of decisions has multiple consequences for human health and well-being. Air pollution is increased by a reliance on cars. Climate change contributions are worsened. Between a quarter and a third of our greenhouse gas emissions come from the transportation sector, relatively and absolutely more than is the case in denser, better designed urban areas. Traffic-related injuries increase because of the amount of time that we spend in cars. Physical activity is decreased because we have engineered out much of our routine physical activity from our days. Water quantity and quality are threatened by these patterns of metropolitan development. The urban heat island is intensified by the expansion of cities without adequate attention to retaining trees and to cooling cities through other techniques.

The mental health impact ranges from road rage, an interesting kind of indicator phenomenon, to the social disconnectedness that occurs from sparse low-interaction cities without common places and a decrease in social capital, which is itself an important determinant of health. Let me give you one snippet of evidence because, after all, we are here with the NCSE. We are all about promoting good environmental science, and I want to make the point, yet again, that health science is environmental science.

SMARTRAQ is an acronym for a study of transportation and land use patterns and their effects on health in Atlanta. It was a cross-sectional study of almost 11,000 adults in Atlanta. The independent variables were connectivity, measured by intersection density using GIS techniques; land use mix, which came from county real estate data and residential density. The dependent variables were travel behavior,

which people maintained with diaries and was verified with accelerometers; and weight. The associations that were sought between those independent variables and those dependent variables were controlled for age, education, and income. This was a cross-sectional study and one of the best state-of-the-art cross-sectional studies looking at whether urban form, at whether the built environment impacts travel behavior and weight.

Some of the results. Land use mix is on the X-axis here and the probability of obesity is on the Y-axis. As land use mix increases, the probability of obesity decrease. Apparently, people who live in mixed-use areas such as DC, more readily walked to their destinations or used transit than people who live in sparse suburban or rural areas, and the probability of obesity controlling for other factors decreases. Minutes spent in a car per day on the X-axis, probability of obesity on the Y-axis; the more time you spend in the car, the higher the probability of being obese. Not a big effect. Other things affect the probability of obesity as well, and a more powerful predictor has been time spent in a car; but a substantial effect. Walking distance per day on the X-axis, probability of obesity on the Y-axis; the more you walk, holding other factors equal, the lower the probability of being obese.

So, not only is urban planning, as an example of an environmental field, very much a health field; but the research that we need to do to understand these associations is at the interface of urban planning and environmental research and health research. Urban planning is health science. Well, where do we go with all of this? I want to just make a few concluding remarks and step down. First, I have described a number of daunting problems and it might be depressing to hear them all recounted like that. The good news is that solutions are at hand. When it comes to nature deficit, the absence of contact with nature, principles of biophilic design, either at the scale of buildings and/or at the scale of parks, communities, and metropolitan areas are becoming better and better established. Parks and green space help to address that problem. Smart growth, the complex of urban planning principles that includes higher density, mixed use, and so on, prominently features giving people access to green spaces, undertaking land conservation. When it comes to climate change, we need to reduce greenhouse gas emissions; we need energy

efficiency; we need to reduce travel demand; we need more parks and green space to help mitigate some of the effects of climate change.

Smart growth offers a number of those advantages. When it comes to community design, I described a number of community design practices that may not be optimal for health and well-being, but we know some of the answers - higher density, mixed land use, transportation alternatives, the principles known as smart growth. In fact, what is lovely about this is that for relatively disparate, disconnected-appearing environmental challenges to health and well-being, some of the very same solutions serve all of them. There is a lot of synergy here that we can celebrate and exploit. We need to envision healthy wholesome environments. This is a vision that has been part of our species since the early days of our history. As Sir Francis Bacon said, "They are ill discoverers that think there is no land, when they can see nothing but sea." We look around [audio glitch] re-designed places. We see non-sustainable practices. We see threats to health and well-being. But we can envision something better; we should envision something better. Some of these problems are extremely daunting to consider, climate change probably foremost among them.

But we have had experience in recent years with thinking about the unthinkable. This began arguably with Hiroshima and Nagasaki. We never expected the attacks of 9/11 to occur. But through tragedies like that, we have come to understand that we can address those problems. We can undertake preventive efforts and we can protect people's health, safety, and well-being. We need to remember that things do not have to be the way things are. You can look at a terrible-looking place like this, barren and unattractive; you can envision how to make it better. You might put in a transit line. You might broaden the sidewalks and you might introduce mixed use with residential above the retail. If you had a bicycle lane and a trolley, this becomes a sustainable neighborhood with a smaller environmental footprint, room for more people, and the ability for those people to travel on foot or on bicycle or in transit instead of driving, which is, in turn, better for their health and well-being.

Let me offer a perspective from the medical world where I trained. When I worked as a clinician taking care of individual patients, I would sit in the clinic. In the office, I would face the individual patient and I would be completely focused on diagnosing and treating the patient, doing the very best for that individual. As I migrated into public health, I began to think of the entire community as my patient and I thought about solutions and approaches that would benefit an entire community. Many of us in public health are now taking the third step, the step that I commend to all of you.

Our patients are not only individuals, not only communities, but future generations, those who will come after us. And so, if we think of our work as a legacy approach, if we commit ourselves to being good ancestors that greatly informs the work that we do at the intersection of environment and health, what sometimes is called the triple bottom line, I call the three-legged stool because of my early training in gastroenterology. We need to think about both environmental benefits and economic benefits and health and well-being benefits for every decision we undertake. We would never undertake a major infrastructure investment without having an economist on board because we need to think about the economic implications of that investment.

By the same token, we need to incorporate health analysis into our thinking and planning and doing. The tool known as health impact assessment is a convenient tool to use for doing this. It is akin to environmental impact assessment, but it is non-regulatory. It is simply a decision-making tool. Andy Dannenberg is here today. He has been a champion of health impact assessment and for those who will hear him later, you will learn a lot about this technique. It is a way of embedding and incorporating health thinking into all of the other decision-making that we do, not to the exclusion of other things.

We need to think about each of these three domains with every major decision we undertake. We need good science. This is at the core of NCSE's mission, and it ought to be at the core of all of our dedication. We need to identify the health impacts of environmental phenomena. We need to understand better how various exposures affect health, clarifying etiologic mechanisms. We need to remember health disparities. We need to remember that we are not all equally susceptible to environmental problems.

Children, the elderly, poor people, people of color, people with disabilities, many, many subpopulations - almost of all of us belong to at least one of those subpopulations and we need to think in terms of the disparate effects so we can address the special vulnerabilities of subpopulations.

We need to devise and test solutions scientifically so that we know, based on evidence, what works. And we need to undertake cost-benefit research because we need to know which solutions will be most effective and cost-beneficial. Our training efforts need to take into account the links between health and environment. As I had the opportunity to say to the Council of Environmental Deans and Directors earlier this year, thanks to NSCE, there should never be an environmental studies curriculum that does not include strong training in environmental health. And by the same token, there should never be a health science curriculum that does not include strong training in environmental issues. We need to train a generation of leaders who can talk across the divide, think across the divide, and act.

We need systems thinking. This is a simplified picture of reality here. I have talked about some of the ways in which systems thinking can help us make better environmental decisions in the examples I developed. Climate change has a lot to do with peak petroleum, another major global phenomenon we will encounter on coming decades. Population growth has a lot to do with both of those. The obesity epidemic, defined as one of our major health challenges in this country has a lot to do with all of those as well.

So, if we think systematically about the interactions among those issues, we will make better decisions and achieve better success. We will enjoy synergies. Synergies are wonderful things. Sometimes called “collateral damage” in military parlance, there are collateral benefits in the context that we are discussing today. Here is an example. This is a mom walking her kids to school; 1956, the last known time this was sighted in the United States. One of the benefits of this is physical activity. Another benefit is a decrease in air pollution concentrations because they are walking rather than driving. Another benefit is that they are not contributing to climate change. Another benefit is that social capital is improved when they encounter and greet their neighbors on the sidewalk rather than shake their fist and

hurl imprecations at other drivers through the windshield. Another benefit is that physical activity is a very effective antidepressant. Another benefit is that their injury risk is lower because they are not in a car. Another benefit is that physical activity helps prevent osteoporosis. Another benefit is that they get to see the trees as they walk down the streets of their neighborhood. And incidentally, the more people walk and bike, the less money we have to put into building huge road systems and the more money we have available for priorities such as law enforcement, healthcare, education and others. So, a simple strategy such as walking to school in the morning offers many synergistic benefits, benefits that are predictable in that flow from systems thinking about these problems.

We need to collaborate. The many, many different professions that are represented in this room – and some that did not come to this meeting because they do not consider environmental health to be their field. All need to work together to achieve safe, healthy, wholesome environments that are both sustainable and good for people. We need to pursue justice. We need to remember that within our own country enormous disparities bedevil us, and that on a global scale, the North-South divide is large and growing. But as we improve our environment and as we attend to the health and well-being of people, we always, always need to remember the least fortunate among us and to strive to achieve just, fair, and equitable solutions.

And finally, be joyful, have fun. We have great work to do. The science is fascinating. The policy work is compelling. The people who do this work, the people sitting to the right and the left of you are wonderful people. Be joyful and have fun. We need to take heart because solutions are at hand. We need to envision healthy wholesome environments. We need to be brave and visionary in the phase of what seem like daunting challenges. We need to be good ancestors. We need always to consider health, environment, and economics in all of the decisions that we make. We need to support good science, thinking broadly and systematically as we do so. We need to collaborate across disciplinary divides, pursue justice, and have fun. Thank you very much for your attention. Have a wonderful conference and thanks again to the NSCE.

