"Restoring Science to Its Rightful Place:
Its Role In America's Future"
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As Delivered

Provost McLendon and Dr. Lane, thank you for the warm welcome

It's a privilege to be a part of the Civic Scientist Lecture Series. I've long admired Dr. Neal Lane and his focus on scientists' larger responsibilities to engage citizens in active dialogue, to listen, to learn and to share knowledge. I'm delighted to be able to finally join you to honor Dr. Lane and his vision, and to share ideas on our collective responsibilities.

I share his passion and commitment for both science and engagement with society. I believe that scientists have a responsibility to share their knowledge broadly and to serve society. Serving society means being responsive to societal needs, not just telling the public what we think they need to know.

In my time with you today, I wish to share some thoughts about current challenges and opportunities for scientists to engage with and serve society. I'll do so by focusing on 5 things:

- Role of Science in Democracy
- The Social Contract between science and society
- A recent example of science informing response in a crisis: DWH
- A current example of informing public understanding of weather and climate changes underway.
- Then conclude with some of the steps I believe are necessary to strengthen science and its contribution to society.

ROLE OF SCIENCE

Science plays a number of roles in society. The five 5 most commonly cited are:

1. To improve health and conquer disease
2. To protect national and homeland security
3. To improve lives - communications, weather warnings
4. Be engine of economic growth
5. Source of national prestige - first to the moon; # Nobel prizes

Two other less cited, but no less important roles

6. Satisfy curiosity ("Curiosity," the Mars Rover that just launched on its 8-and-a-half month journey to search for life on another planet.)
7. Inform understanding and decisions

The purpose of science is to inform policy, not dictate it.
Decisions – by individuals and institutions
Decisions based on many considerations; science should be at the table.
Decisions will be better if informed.
'Inform' = how does the world work? Changing? Likely consequences of different options? Solutions?

BUT: Science won't be at the table if scientific information is not

i. **Understandable**
ii. **Credible** (scientific adequacy of tech evidence and Arguments)
iii. **Salient** (relevance of the assessment to the needs of decision-makers)
iv. **Legitimate** (perception that the production of information and technology has been respectful of stakeholders' divergent values and beliefs, unbiased in its conduct, and fairing its treatment of opposing views and interests)
v. And **useable**

ROLE OF SCIENTISTS: SOCIAL CONTRACT

I believe scientist have an obligation to do more than discover new knowledge. They should also (1) share their knowledge broadly, not just w other scientists and (2) serve society by working at least in part on problems that are relevant to social challenges. Let me touch on each of these briefly.

(1) Until recently, the culture of academia has emphasized communication with other scientists – through peer review pubs; meetings and teaching, with very little attention paid to public communication.

Leads to public not knowing about and therefore not using scientific information.

Changing the culture: training programs, opportunities, a new community of practice is evolving: e.g.,
Leopold Leadership Program, COMPASS,

- Communication is 2-way: learn to listen
- Known to related unknown
- Layer information
- The three thys

- Become bilingual
- Stories, analogies, metaphors, demos, even jewelry
- Learn by doing: practice, get feedback

(2) The basic vs applied paradigm no longer describes the full suite of categories.
A third choice: championed by Lew Branscomb: Jeffersonian Science = cutting-edge but relevant science: combines elements of both curiosity-driven and applied science.

Today in a plethora of arenas, the real world is the cutting edge: societal challenges offer opportunities to both serve society and push boundaries of knowledge:

- chemistry of the stratosphere,
- complex dynamics inside hurricanes or tornadoes,
- biodiversity needed to provide ecosystem resilience and continued provision of ecosystem services in a changing environment

Most of the science we do at NOAA is Jeffersonian Science – cutting edge but immediately relevant to our service and stewardship mission: climate, weather, oceans, coasts.
This kind of science is not sufficiently appreciated and seriously underfunded.
In the FY 12 budget, NSF's budget was increased while NOAA's research budget was cut.
Despite the complex reasons behind the numbers, the reality is that cutting-edge science in many mission agencies like NOAA is neither sufficiently recognized nor supported.

I'm going to give you two examples to show the essential role of Jeffersonian science in society.

SCIENCE IN A CRISIS: DWH & GULF RESTORATION

Science guided the response to the Deepwater Horizon oil spill, but the public was often confused.

On April 20, 2010, the nation was catapulted into the largest marine oil spill in our history. Within hours of the initial explosion, we had to know where the oil was going and what might be in harm's way.

In those same early hours, NOAA began pumping out the scientific information needed for a smart, tactical response.

Why NOAA? Because NOAA is, by law, the nation's lead science agency for oil spills in marine and coastal environments. Every year, NOAA responds to as many as 150 oil spills.

NOAA's role in the Deepwater Horizon oil spill was and is five-fold: to conduct and share science, keep seafood safe, protect wildlife and habitat, assess damage, and restore the natural resources injured as a result of the spill. I'll describe each very briefly.

1. Conducting and sharing science

Scientific information told responders where to deploy boom and where to skim and burn.

- Hours after the initial explosion, the newly constituted Unified Command in Robert, Louisiana, had at its fingertips a trajectory forecast showing where the oil would be headed should it appear. This trajectory forecast was produced by NOAA.
- Less than 20 hours later, the first spot weather forecast was issued by NOAA's National Weather Service Forecast Office in Slidell, Louisiana at the request of the Unified Command. These special forecasts consider time, topography, and weather, providing more detailed, timely, and specific information than regular zone forecasts.
- Scientists in NOAA's war room in Seattle ran oceanographic and atmospheric models day after day, using the latest satellite, plane, and ship observations to initialize models and predict patterns of movement.
- Day after day, National Weather Service meteorologists produced spot weather forecasts, over 4000 in total
- These scientific tools gave us the vital information needed to mount a smart, tactical response.

2. Keep seafood safe

Scientific information told us which fisheries might have to be closed and when they could be re-opened.

- NOAA closed fisheries as the first line of defense to prevent contaminated seafood from entering the marketplace.
- Scientific information – the location of oil and forecasts showing us where the oil likely was going – guided NOAA's decisions on where we would close fisheries and where areas could stay open safely.
- Like closures, fishery re-openings depended on good science. A science-based protocol for re-opening a closed area was agreed upon by NOAA, the Food and Drug Administration, and the Gulf states.

3. Protect wildlife & habitat

To protect wildlife and habitat, we conducted overflights almost daily to monitor marine mammals, turtles, specific fisheries, wetlands and marshes.

- NOAA research ships initiated ongoing investigations of the impact of the oil on marine mammals and fisheries.
- NOAA experts are part of the Federal team documenting impacts as well as rescuing and rehabilitating sea turtles. Five of seven species of sea turtles live in the Gulf. All are threatened or endangered.
- NOAA led a focused effort to take boats out to oiled areas to find and rescue turtles, and rehabilitate them if needed. Our second major turtle effort focused on eggs and hatchlings.
- Scientific knowledge of turtle physiology, ecology, and behavior guided all of the efforts, helping us to know where to look for animals affected by the spill, and assess vulnerabilities of and impacts on these species.

4. Assess damage
To assess damage, the Natural Resource Damage Assessment, or NRDA, process began almost immediately. NOAA is one of three Federal trustees for the NRDA process, helping to identify and quantify short- and long-term impacts to the Gulf of Mexico's ecosystems.

In each instance of the DWH response, NOAA was poised for the Deepwater Horizon response because of the USG's long-term investment in research and science.

5. Restoration
For restoration, we along with the Gulf Coast Ecosystem Restoration Task Force, ask the hard questions of how this spill impacts this and future generations of species within the ecosystem, and how those changes in turn affect the ecosystem services provided to the people of the Gulf. Science will be a keystone in informing this work.

The Gulf Coast Ecosystem Restoration Task Force was created by President Obama through an Executive Order on October 5, 2010, and is the result of a recommendation made in Secretary Ray Mabus' report on long term recovery following the Deepwater Horizon Oil Spill. The Task Force was charged with development of a restoration strategy that proposes a Gulf Coast ecosystem restoration agenda. The draft plan was released for public comment earlier this year and the final plan released yesterday here in Houston at the Gulf Coast Summit organized by the Harte Research Institute.

CONCLUSION: Science was used effectively to inform decisions during the spill. Nonetheless, that same information did not always get communicated accurately or in timely fashion to the public.

I believe the reasons for challenges in the public understanding were multiple: cacophony of voices, lack of background information to understand issues, and interests that competed with getting credible information in front of the public. We are and will continue to figure out how to do better on this complex front.

1. **USING SCIENCE TO INFORM PUBLIC UNDERSTANDING OF CHANGES IN WEATHER AND CLIMATE**

I'm going to now turn to another example. This example shows how science underpins the services that NOAA delivers and how that same science can fuel American business. I'm talking about America's long-standing weather services and our emerging climate services.

Extremes

This has been a year of unusual weather-related events: Texas is a victim of the seriousness of these extremes with extended drought and wildfires.

2011 is already in the record books as a year of historic extreme events.

2011 set a new record for the number of events totaling at least $1Billion in damages. NOAA tallied 10 >$1 billion dollar disasters this year, and the Texas drought and wildfires is among them.
All totaled, the U.S. has sustained 10 billion-dollar weather/climate disasters so far in 2011, breaking the record of 9 set in 2008. This number of billion dollar disasters is expected to change within days as we assess the data on disaster events.

More than 1,000 people died from these disasters (1,016). Deaths this year are almost double the yearly average (~600).

Each of these events is a huge loss for victims who experience them; collectively, they are an unprecedented challenge for the Nation – for the safety of citizens, the bottom line for businesses, and the societal stresses they engender.

Timely, accurate, and reliable weather warnings and forecasts are essential to both our collective well-being and the Nation's recovery and economic prosperity.

I've emphasized how unusual this year has been, but a single year can just be an anomaly or an outlier of sorts. The question is: What are the larger patterns? And what might we expect in the future?

What does scientific information and knowlege suggest?

Globally, according to Munich Re, one of the world's largest reisurers, the frequency of extreme events has risen steadily over the past 20 years. The number of meteorological and hydrological events each tripled in that time.

The Intergovernmental Panel on Climate Change - IPCC - issued its Special Report on Managing the Risks of Extreme Events and Disasters in November. This report says:

- "It is virtually certain (99-100% probability) that increases in the frequency of warm daily temperature extremes and decreases in cold extremes will occur throughout the 21st century on a global scale.
- "It is very likely—90 per cent to 100 per cent probability—that heat waves will increase in length, frequency, and/or intensity overmost land areas.
- "It is likely (66-100% probability) that the average maximum wind speed of tropical cyclones (also known as typhoons or hurricanes) will increase throughout the coming century, although possibly not in every ocean basin.
- "It is very likely (90-100% probability) that average sea level rise will contribute to upward trends in extreme sea levels in extreme coastal high water levels."

A separate study, a white paper from the White House Office of Science and Technology Policy, tells us that it's very likely that large-scale changes in climate have influenced – and will continue to influence – many different types of extreme events, such as heavy rainfall, heat waves, and flooding. Large-scale climate change is also likely to affect small-scale phenomena like severe thunderstorms and tornadoes, but the nature and the degree of that influence are very uncertain, particularly for tornadoes.

These patterns only underscore the importance of enhancing our ability to predict and manage these events.

NOAA's role for weather and climate

NOAA's unique responsibilities underpin everyone's ability to prepare for and manage extreme events. Our science and services are vital to national and homeland security, food security, economy, health, commerce, community preparedness. We provide the information that people, communities, and businesses use to make decisions every day.

NOAA is America's trusted broker for weather and climate data, information, and warnings. We are the National Weather Service. All U.S. weather information – whether you see in on the Weather Channel, MSNBC or your smart phone - originates with NOAA via the National Weather Service.

We provide forecasts for short-fuse events, such as tornadoes, heavy rains, heat waves, like the extremes we experienced in every state this summer, or solar storms, which are becoming more frequent with impacts on GPS, air travel, search and rescue. We track the progress of extreme events, such as the maturation of a tropical depression into full-blown hurricane. We generate long-term forecasts weeks to months in advance, such as droughts in Texas, Oklahoma, New Mexico, Georgia, etc., and winter flooding events, as we did for North Dakota, the Ohio River Valley this spring

Climate forecasts as decision support tools

While weather forecasts look to hours to about 10 days into the future, long-range forecasts – what we call climate forecasts look ahead beyond 2 weeks. Climate forecasts are decision support tools that help people, communities, and business plan.

- Can farmers in Northeastern Minnesota grow higher value crops such as soybeans on their farms? The U.S. Department of Agriculture uses NOAA's climate information to develop regional, national, and global crop outlooks that provide the agricultural industry with information about conditions that may impact crop production.
- How far from the Mississippi River or the Gulf Coast should houses be built? Will there be enough water to support the anticipated growth in Atlanta's suburbs 20 years from now?
- Long-term flood forecasts helped us warn Minot, ND as early as November to start

preparing for intense floods the following spring.

- Long-range drought forecasts in Texas warned state fire managers as early as last December helped preposition firefighting assets and resources so that first responders could act quickly when fire season arrived.
- NOAA data are being used by the NYC Panel on Climate Change to plan and prepare for sea level rise and flooding caused by coastal storms. For example, the New York City Department of Environmental Protection is raising pumps at the Rockaway Wastewater Treatment plant from 25 feet below the existing sea level to 14 feet above the existing sea level.
- In Boulder, CO, the city is using NOAA data and climate models to manage their water future based on projections by climate change models and streamflow.
- The home building industry uses NOAA air-freezing data to develop new insulation standards for protecting building foundations from frost.
- Pacific NW oyster hatcheries are using ocean acidification data in real-time to protect oyster larvae from seasonal corrosive waters, protecting production and jobs. Ocean acidification is the formation of corrosive water as a result of absorption of roughly 30% of the CO2 in the atmosphere.

These long-range forecasts along with NOAA data and science are being used by communities and businesses to make smart plans for their future. This is what climate services means to the economy, food security, water management, businesses, and communities all across the country.

Science underpins weather and climate forecasts

Weather forecasts are predictions made from data that NOAA collects: data from observations made by satellites in space, planes and balloons in the air, radar on the ground, ships and buoys on the water, and gliders under the sea. Among these platforms, satellites loom large- >90% of the data that go into our numerical weather prediction models come from NOAA's weather satellites.

Satellites and other platforms provide data about current global conditions. We feed those data into weather models, which crunch data to generate weather forecasts. That number crunching is no small feat – it uses some of the country's most powerful supercomputers available! NOAA produces data and forecasts and distributes it widely. At that point, the private sector weather industry (think the Weather Channel or AccuWeather, etc) tailors the information and sells it to specific users.

So your tax dollars provide both a public good- weather forecasts and warnings, and they provide opportunities for businesses. The private weather industry is now a multi-billion dollar industry.

Through investments in research, NOAA has vastly improved its ability to predict these extreme events; the bad news is that with climate change underway, we'll likely see continued increases

in severe storms and drought and heat waves.

We know that investments in research pay off. Research has made amazing improvements in weather forecasts in a relatively short period of time. Since 1990, NOAA's hurricane track error – a hurricane's track is its projected path - has decreased 60 percent since 1990. Today's 5-day hurricane track forecast is as good as the 3-day track forecast of a decade ago. Over the past 20 years, tornado warnings have gone from a 5-minute advance warning to a current average of 15 minutes. Today, long-term seasonal forecasts for river flooding and drought are made.

In parallel to working to reduce greenhouse gas emissions and providing outlooks so communities and businesses can plan, NOAA is partnering with emergency managers to achieve a weather ready nation, where communities are prepared and citizens have options and information before disaster strikes.

2. PROTECTING SCIENCE AND DEMOCRACY: SCIENTIFIC INTEGRITY

I've given you two extended examples of the role of science in producing science and services of great value to the nation. Now, I'm going to turn to what we're doing to protect the integrity of NOAA science. It would be a major disservice to the American public if scientific information is distorted, suppressed, or altered.

On March 9, 2009 – 3 months after the President took office – he issued a memorandum that directed federal agencies to ensure that their science was used appropriately. That memo directed OSTP Director John Holdren to ensure that scientific integrity be addressed by policies developed by each USG agency.

I am proud to say the NOAA will be releasing its Scientific Integrity Policy this week.

Why is a SIP a keystone in NOAA's ability to produce science that the American people rely on? Scientific integrity is an obligation to America, an obligation to the scientific community, and an obligation to the common good. SI is a core value of science.

Scientific integrity is at the core of conducting ethical science.

By being open and honest about our science, we build understanding and trust. Freely and honestly sharing science means we invite open discussion of the process, the evidence, the interpretations and the applications to policy and practice. And it means the knowledge is revised through time.

Free and open inquiry is the backbone of science. Free and open inquiry is the backbone of democracy. When we stand up for scientific integrity, we stand up for democracy.

This is what I think of as the "rightful place" of scientific integrity. This is why I am so firmly

committed to seeing a meaningful and well-executed scientific integrity policy in this Administration and in NOAA.

Moreover, science is not, and should not be made to be, partisan. Policies that are informed by science will be better and most helpful to society.

Recap: thus far OUTLINE

1. **Homage to Neal Lane and the concept of 'civic scientist': THANK YOU!**
2. **Role of science: TO INFORM**
3. **Role of scientists: Social Contract: COMMUNICATE, BE RELEVANT**
4. **Using science to inform action in a crisis: DWH & Gulf restoration; CONDITION THE CLIMATE; BACKGROUND IS KEY**
5. **Using science to inform understanding of changes: weather and climate; MUCH WORK TO BE DONE!**
6. **Protecting science and democracy: scientific integrity policy: MAKE SURE WE HAVE GOOD CHECKS AND BALANCES**

And my final point concerns

3. **ENSURING A VIBRANT SCIENTIFIC ENTERPRISE FOR AMERICA'S FUTURE: strong science is essential to democracy. We must do everything possible to strengthen and protect the scientific enterprise, and to ensure that science is not misused, distorted or altered in making policy. Moreover, citizens need to feel confident in science, support it, and use it. That means engaging them in science, having science be responsive to societal interests. It also means have citizens who can use the scientific information provided to make smart choices.**

Science gives us many powerful tools and services. Science provides us with the means to respond to oil spills. Science gives us the knowledge, information, tools, and services to conserve and manage our oceans and coasts. Science saves lives and property – for which there is rapidly growing need as extreme events become routine.

But science is being undermined on multiple fronts, and that is a threat to democracy. In some cases it is not valued, in others it is dismissed or misused.

In a time of downward pressure on federal budgets, it will be increasingly important for citizens and policy makers alike to understand how important basic, Jeffersonian and applied science is to their lives and to ensure a good balance among them.

With fewer dollars, there is the temptation to reduce research functions. NOAA's mission has three core areas – Science, Stewardship and Service -- each important in its own right, but together constituting an integrated, vibrant whole that is much more than the sum of the parts. This integrated triad is essential to the very design of NOAA as an agency. Underfund any one of these areas, and the others will reflect the loss. Underfund two, and the entire

agency begins to lose not only mission cohesion, but also the very ability to make progress to effectively address the needs of Americans.

Today, what NOAA provides comes at a cost of a nickel a day to each American. The question for Congress is: Isn't it worth much more – not much less? And how will we ensure science's rightful place in America's future?

END

BACKUP

a. **Communication is 2-way**

Listen to what society says it wants, but, per Steve Jobs, "'A lot of times, people don't know what they want until you show it to them."

b. **Examine what we do and how we talk about it: what do we promise?**
   vi. **Deterministic vs stochastic**
   vii. **Reductionistic vs holistic**
   viii. **Communication of uncertainty**

c. **Challenges in changing perceptions**
   ix. **It's not about information, but about experiences that underpin beliefs**
   x. **Must replace old bad experience with a new positive experience, not just assertions**

The FY 2012 Conference Agreement includes a total of $4.9 million in discretionary funds for NOAA and does not establish NOAA's proposed Climate Service. This is 6.39% above NOAA's FY11 funding and 9.78% below the FY12 President's Request.
In the coming budget year, I appreciate that difficult, careful and prudent choices must be made in allocating funding among competing activities in this fiscally challenging time. In my view, the decision of what activities to fund should distinguish those functions which are inherently governmental and which provide unique and essential services for the American people versus those that might be supported outside the federal government or that are less essential. These are tough choices, and determining the appropriate mix is difficult.
As we look forward to FY 2013, I anticipate that the Nation's economic condition will continue to be fragile. NOAA will work to balance our capabilities to ensure integrated science-service-stewardship roles in each mission area. I would like to continue our work together to find new and creative ways to highlight the work that NOAA does to support our mission critical science.