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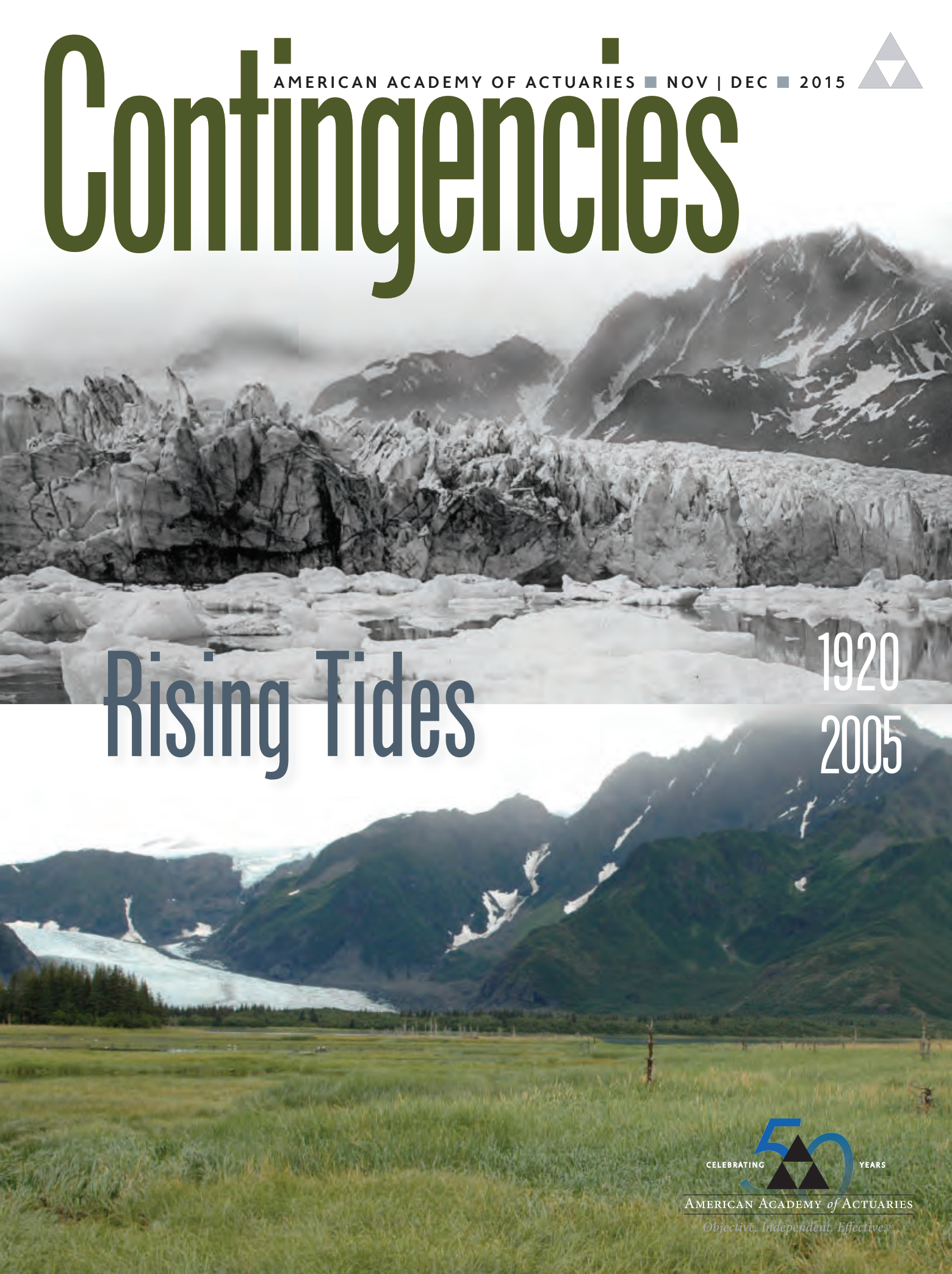
Contingencies



Rising Tides

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The United States faces a serious economic disruption from higher sea levels unless action is taken soon.

Rising Tides

Rade Musulin

AMERICA IS FACING WELL-DOCUMENTED ISSUES with Social Security and Medicare stemming from a combination of an aging population and expensive new medical technology, among other factors. While both of these programs can currently pay benefits from positive balances, long-term projections made annually by the trustees of the Social Security and Medicare trust funds show that they face threats of reserve depletion. Such projections have prompted Congress and the Obama administration to propose corrective actions to avoid adverse consequences for the nation.

The process used to examine long-term financial viability of these critical social programs is an example of a successful mechanism to identify and warn of serious problems. This examination allows public policymakers to take gradual, moderate corrective action that will result in far less economic disruption than abrupt emergency action would when a crisis is imminent.

Indeed, significant changes have been made based on projections of costs decades in the future involving many assumptions and complicated models. For example, the 1983 amendments to the Social Security Act that were signed into law by Ronald Reagan increased the Social Security tax rate in stages from 10.7 percent in 1981 to 12.4 percent beginning in 1990. This tax

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increase was passed in reaction to projections showing Social Security would run out of money far in the future. This is an example of a difficult political act designed to head off problems long after the people who passed it have left office.

Even greater political courage may be required to address another long-term problem that has the potential to cause severe economic disruption: managing the consequence of melting ice on sea levels across the world. As with Social Security and Medicare, forecasting the problem requires complex modeling and many assumptions. It also involves difficult intergenerational trade-offs.

During the remainder of this century, hundreds of millions of people and trillions of dollars of property will be threatened by rising tides fed by melting surface ice currently trapped in glaciers and high-latitude ice sheets. The good news is that the effects of melting ice will materialize gradually. The bad news is that unless we begin the process of planning for adaptation soon, there is a high likelihood of serious economic disruption in the future.

The key problem is that we are building (and rebuilding after catastrophes) houses, commercial buildings, and other infrastructure in coastal areas with design lifetimes of a century or more without sufficient consideration of the future cost of protecting those assets from rising sea levels. This is a significant issue for the United States given its wealth and concentration of exposure in coastal areas like New Orleans, New York, or south Florida. The government is likely to incur hundreds of billions of dollars of costs from sources such as the National Flood Insurance Program (insurance payouts), the Federal Emergency Management Agency (disaster relief), or the Army Corps of Engineers (levees or other defenses) that are not currently considered in long-term budget projections. Even the Department of Defense has concluded that numerous military installations are at risk and will require investment in protection.

Rising Sea Levels

There has been a great deal of controversy about climate change. Some question whether the climate is changing at all. Others are convinced we face imminent doom unless radical steps are taken. With regard to potential property damage, even if one accepts that the climate is changing, the effects may not be clear. For example, consider North Atlantic hurricanes. Activity could be increased by higher sea surface temperatures (ocean heat fuels tropical cyclones), while it could be decreased by more dry air from desertification of Africa (dry air suppresses thunderstorm activity).

Even ignoring *any* change in climate, human activity is affecting the likelihood of catastrophes from flooding. For example, parts of many coastal cities have been built on reclaimed land, marsh, or river deltas. The enormous weight of buildings can cause such land to sink, increasing flood risk. Perhaps the best example of this phenomenon is Bangkok, where a recent study forecast a total "sea-level rise" by 2050 of 32.3 cm, of which 20 cm is from land subsidence. Flood losses in 2050 could be 4.25 times today's losses, with 70 percent of the increase attributable to land subsidence alone.

Of all the things that may or may not be occurring in the global climate, the prospect of rising sea levels is the one that is very hard to dispute. Both ground and satellite observations clearly show a significant decline in ice contained in glaciers and high-latitude ice caps in recent decades. Observed temperatures have increased significantly in the Arctic and Antarctic. Even if high-latitude temperatures stabilize at current levels, significant amounts of ice will melt in coming decades. Tremendous amounts of stored water are being released, and there is only one place that water can go: into the oceans and onto beaches. As Steve Nerem, head of NASA's Sea Level Change Team, recently said, "Given what we know about how the ocean expands as it warms and how ice sheets and glaciers are adding water to the seas, it's pretty certain we are locked into at least 3 feet of sea-level rise, and probably more."

Combined with land subsidence caused by building on soft soil, many global cities face losses due to flooding, investment in very expensive flood control systems, or both.

For our purposes in this article, it is unimportant whether melting ice is caused by burning fossil fuels, long-term fluctuations in natural climate processes, sunspot activity, or space aliens beaming ray guns at the planet. The evidence that ice is melting is overwhelming, and unlike other perils like tropical cyclones, there is little question what will occur in the medium term, or that large costs will be eventually be incurred.

Seas are rising, and trillions of dollars of property are at risk. The only question is whether societies begin adaptation soon, when adjustments can be spread in modest increments over many years, or wait until calamity strikes, when economies will be seriously disrupted by abrupt changes in activity.

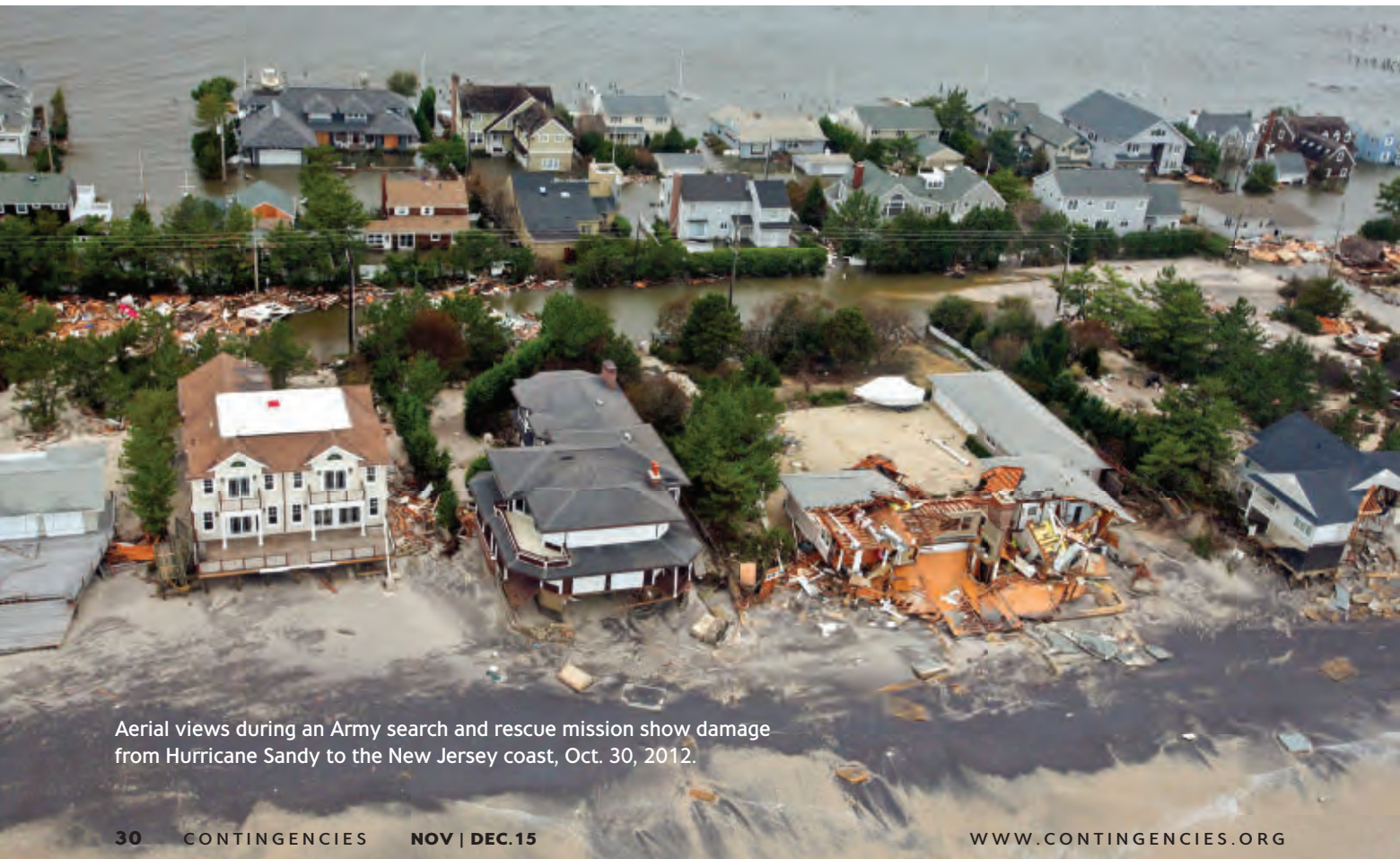
(A comprehensive discussion of the evidence that ice is melting is beyond the scope of this article. Interested readers are referred to NASA's Earth Observatory website.[1])

Rethinking Building Codes

This article offers a specific application of concepts outlined in a previous one this author published in *Contingencies* in 2014 titled "Demographics, Development, and Disasters—Implications for the Insurance Industry's Role in Planning for the Future." That article outlined reasons that current building code development and insurance pricing practices are insufficient to ensure that an optimum level of investment in loss mitigation is made. Specifically:

- The cost of risk transfer for a property is likely to change during its design lifetime.
- In the case of coastal property, the cost is likely to increase over time due to higher concentration of risk and changes in hazard from rising sea levels.
- The two key mechanisms that should work to encourage investments in loss mitigation on such properties—insurance pricing and building codes—are not well suited to addressing the issue because:
  - Insurance pricing is focused on the short-term exposure to loss due to the predominance of one-year policies, meaning it ignores:
    - –future changes in hazard, which can increase expected losses (e.g., rising sea levels); and
    - –future risk concentration, which will drive higher "risk load" to reflect the cost of capital (e.g., growing wealth and population).
  - Building codes generally:
    - –are focused on life safety;
    - –consider single buildings rather than the community;
    - –ignore macroeconomic costs and community resilience; and
    - –reflect current conditions, not those that may affect the building during its design lifetime.

The way building codes are currently developed compounds the problem with a change in hazard due to rising sea levels, because the assumed resistance to loss may not work as intended.



Aerial views during an Army search and rescue mission show damage from Hurricane Sandy to the New Jersey coast, Oct. 30, 2012.

Buildings may be built to expected 100-year return period flood (e.g., by requiring a certain elevation), but if changing conditions mean the 100-year flood is now a 25-year flood, not only will losses exceed expectations due to more frequent inundation, but also the effect of mitigation will be less than planned when more severe events than were designed for occur.

Building code standards need to evolve to consider:

- economic cost (in addition to life safety);
- community resilience (in addition to single-building engineering); and
- a range of future conditions viewed stochastically, including both hazard and risk concentration.

If building standards were revised in this way, structures would be required to withstand hazards that can be expected to arise over their lifetimes. If things we build are designed for a century of use, then our planning horizon must consider conditions during the next century. While this consideration is likely to increase current construction costs, it also will reduce future coastal protection costs and preserve long-term property values.

Potential Loss Costs

Many studies have developed measures of future vulnerability to coastal flooding. One is summarized in *Nature Climate Change* (September 2013), titled "Future flood losses in major coastal cities." It was supported by the Organization for Economic Co-operation and Development and the World Bank. It developed a method to quantify future flood losses in major coastal cities.

The study concluded that flood exposure is increasing in coastal cities due to a combination of "growing population and assets, the changing climate, and subsidence." Present and future flood losses for 136 of the world's largest coastal cities were estimated under a range of socioeconomic, climate, and adaptation scenarios. Important findings include:

- Global flood losses are projected to increase almost tenfold by 2050 due to socioeconomic changes alone.
- Including climate change and subsidence to 2050, significant investment will be required in adaptation to avoid "unacceptable losses of US$1 trillion per year."
- Even if adaptation investments maintain constant flood probability, sea-level rise and subsidence will increase global flood losses substantially by 2050.
- To maintain present flood risk, adaptation will need to reduce flood risk below present values due to increased severity of extreme events.
- Flood defenses can make a big difference, as is demonstrated by comparing the world's best protected cities (Amsterdam) with cities with relatively poor defenses (e.g., Ho Chi Minh City).
- Currently, due to their high wealth, three American cities (Miami, New York, and New Orleans) explain 31 percent of global aggregate losses, indicating the United States is "particularly vulnerable."

This and other studies show that the United States faces the potential for significant costs from coastal flooding in coming decades through direct losses, required investments in adaptation, or both. This is not a cause for panic, but rather a prospect that calls for careful planning and long-range thinking, similar to what is used to examine trends with social programs.

Government Exposure to Loss

There are many ways the federal government could incur costs from coastal flooding. Two obvious examples are through the National Flood Insurance Program (NFIP; which exposes the government to loss when covered losses exceed premiums) and the Army Corps of Engineers (Corps; which is charged with maintaining levees and other defenses). We have seen recent instances of how these agencies can be affected by coastal flooding in hurricanes Katrina and Sandy.

If things we build are designed for a century of use, then our planning horizon must consider conditions during the next century.

The NFIP

Katrina was the largest loss in the history of the NFIP, resulting in direct losses unadjusted for inflation of over $16 billion on about 168,000 claims. Sandy was the second largest loss, totaling almost $8 billion from 130,000 claims. Katrina exhausted the program's reserves and led to large borrowing from Treasury to pay claims.

Congress reacted to the NFIP's experience in Katrina with a series of reforms, the most significant of which was the Biggert-Waters Flood Insurance Reform Act of 2012. Biggert-Waters directed the NFIP to charge "actuarial" premiums reflecting flood risk and eliminated "grandfathering" of certain rates.

As is sometimes the case when legislative bodies mandate "actuarial" rates, the ensuing premium increases triggered a firestorm of opposition. In January 2014 Congress passed the Homeowner Flood Insurance Affordability Act. It reversed many of the changes introduced with Biggert-Waters, including reinstating grandfathering and effectively delaying increases in flood insurance premiums to obtain risk-based premiums.

By the time the 2014 act was passed, the NFIP was $24 billion in debt. Biggert-Waters and the reaction to it illustrate the tremendous difficulty government programs have in achieving long-term financial solidity and undoing ingrained subsidies. This experience demonstrates why careful planning and gradual change is critical in enacting effective public policy.

What will become of the NFIP as sea levels rise? The Biggert-Waters experience shows how difficult it is to adjust prices.

U.S. AIR FORCE PHOTO BY MASTER SGT. MARK C. OLSEN

Local governments, builders, and realtors routinely mount fierce opposition to changes in flood maps that indicate higher hazard (and hence higher flood premiums, stronger mitigation requirements, and/or limits on construction). Some members of Congress—particularly those from inland districts and fiscal conservatives—decry huge program deficits. It will be impossible to maintain current premiums, coverage, and eligibility without severe limits on building, strong mitigation requirements, or exposure to enormous program losses. Something has to give.

The Corps

The Corps was sharply criticized following Katrina for the failure of levees and other defenses in New Orleans. It was subject to numerous lawsuits and avoided paying billions of dollars in damages only because the Federal Tort Claims Act sheltered it from liability. In 2013 Federal Judge Stanwell Duval wrote:

> I feel obligated to note that the bureaucratic behemoth that is the Army Corps of Engineers is virtually unaccountable to the citizens it protects despite the Federal Tort Claims Act. The public will very possibly be more jeopardized by a lack of accountability than a rare judgment granting relief. The untold billions of dollars of damage incurred by the greater New Orleans area as a result of the levee failures during Katrina speak eloquently to that point.

The Corps itself acknowledged catastrophic failure when it issued a 6,000-page report titled "Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System" in 2006. The report described "a disjointed system of levees, inconsistent in quality, materials and design, that left gaps exploited by the storm." It went on to note that engineers failed to consider poor soil quality underneath New Orleans and did not allow for land subsidence.

Over several years the Corps spent billions on bolstering New Orleans' defenses, including a $14.3 billion project called "Defense in Depth," completed in 2011.

Following Sandy the Corps completed 25 huge emergency beach repair projects, the largest repair and restoration effort in its history. The Corps moved 26 million cubic yards of sand onto beaches from Rhode Island to Virginia over two years at a cost of $455 million.

This is but one of many post-Sandy projects that illustrate the significant scope of Corps activities in coastal defense. Other post-Sandy projects included 30 undertakings to repair damaged navigation channels, others to "unwater" 475 million gallons of saltwater from critical infrastructure in New York City, one to install over 200 generators in critical facilities such as hospitals, another to return ports to operation, another to distribute 9 million liters of bottled water, and over 200 others to "reduce risk." In press releases the Corps boasts that all of these are "100% federally funded." While the author was unable to determine the total cost of Corps activities following Sandy, the amounts were substantial and required emergency appropriations.

Warnings Unheeded

History is full of examples of societies ignoring warnings of looming problems with catastrophic consequences. A useful example relevant to this discussion involves the "Hurricane Pam" exercise held in 2004 by FEMA with the cooperation of the National Weather Service, the U.S. Army Corps of Engineers, the Louisiana State University Hurricane Center, and other government agencies.

The exercise simulated the effects of a strong hurricane making landfall near New Orleans. A 2004 press release on the exercise reads:

> BATON ROUGE, La.—Hurricane Pam brought sustained winds of 120 mph, up to 20 inches of rain in parts of southeast Louisiana and storm surge that topped levees in the New Orleans area. More than one million residents evacuated and Hurricane Pam destroyed 500,000-600,000 buildings. Emergency officials from 50 parish, state, federal and volunteer organizations faced this scenario during a five-day exercise held this week at the State Emergency Operations Center in Baton Rouge.

Unfortunately, the key finding of the exercise—that the nation was woefully unprepared for a hurricane hitting near New Orleans—was not acted upon other than to create contingency plans for emergency response. Less than a year later Hurricane Katrina tore through the area and generated losses bearing an uncanny similarity to those simulated in the Hurricane Pam exercise. No one should have been surprised by Katrina.

This failure was well documented in a 2006 special report to Congress titled "Hurricane Katrina: A Nation Still Unprepared." The report's preface notes that "All of this happened ... after a closely observed hurricane struck when and where forecasters said it would. ... We knew Katrina was coming. ... Hurricane Katrina found us—still—a nation unprepared for catastrophe."

Sandy also created more surprise than it should have. According to Moody's Analytics, direct storm losses totalled more than $30 billion, with another $20 billion of lost business activity. While the timing of the storm (in late October) and its track were unusual, the exposure of the New Jersey shore and New York City to severe loss from a tropical system is well understood, particularly with regard to flood.

Parts of the New Jersey shore have experienced serious beach erosion in recent decades, with winter storms causing significant damage requiring expensive beach renourishment. The bathymetry (underwater topography) of Long Island Sound and New York City make a flooding event likely when large storms push water from the ocean westward toward the coast.

As with Katrina, discussions of the exposure and how to mitigate it occurred well before the storm. Following Hurricane Floyd in 1999, the Stony Brook Storm Research Group was formed to study New York's vulnerability to coastal flooding. The city's Vision 2020 plan includes a section on climate resilience and coastal protection strategies. At the American Society of Civil Engineers meeting in 2009, several engineering firms

were asked to present ways to protect New York City from a Category 3 hurricane. Proposals included floodgates to be placed north of the Verrazano Narrows Bridge, a barrier on the East River, a storm surge barrier between Staten Island and New Jersey, and a causeway with a series of underwater gates between New Jersey and the Rockaways. Costs for these projects were in the billions of dollars. Other proposals include schemes to cover tunnels and waterproofing the city's electrical system.

Despite the extreme devastation caused by Sandy, most of these proposals are still on the drawing board—mired in bureaucratic inertia, subject to environmental impact studies, and lacking sufficient funding. In the meantime, the combination of warmer sea surface temperatures and rising sea levels make events similar to Sandy more likely.

An area where experts have been sounding warning alarms but which has not (yet) experienced a catastrophic flooding event is south Florida. Here the problem is somewhat different than in New Orleans or New York. Where those cities are exposed to rapid catastrophic flooding due to their geography, south Florida's porous limestone substructure allows water dumped on the area by hurricanes to drain relatively quickly. Unfortunately, that same limestone allows subsurface water to flow into basements and street drains, which is beginning to happen regularly in places like Miami Beach during astronomical high tides. Already parts of Miami are experiencing small-scale street flooding several times a year, a problem that will gradually worsen in coming decades.

The combination of warmer sea surface temperatures and rising sea levels make events similar to Sandy more likely.

According to a report titled "Analysis of the Vulnerability of Southeast Florida to Sea Level Rise," in Monroe County (home to the Florida Keys) three of four hospitals, 65 percent of schools, and 71 percent of emergency shelters will be below mean sea level with just a one-foot rise. South Florida is particularly vulnerable to rising sea levels and will begin to experience significant, albeit gradual, difficulties in coming decades. Even NASA is concerned that its launch facilities in Florida are vulnerable.

These examples involve only three locations among many along the coast of the United States, where trillions of dollars of property are exposed. Large expenditures will be required in the future to protect these areas.

The Federal Budget

The NFIP and Corps examples following Katrina and Sandy above should serve as a warning about the potential liabilities that may arise for the federal government along the nation's coasts as sea levels rise. Government agencies are taking note, but to date there has not been an explicit provision made in long-term budget analyses.

The 2015 Long Term Budget Outlook prepared by the Congressional Budget Office providing projections through 2040 includes these statements:

> CBO's extended baseline does not explicitly incorporate the effects of climate change. It implicitly includes some small effects by reflecting historical spending on such programs as federal crop insurance, federal flood insurance, and the Federal Emergency Management Agency's disaster relief program. ...
>
> CBO has not undertaken a full analysis of the budgetary costs stemming from climate change, but it is currently analyzing the potential costs of future hurricanes. That analysis suggests that the costs of future hurricane damage will rise at a faster rate than GDP; however, the amount of additional hurricane damage is likely to remain small enough, on average, that the resulting federal expenditures would not significantly affect the general budget categories in which hurricane-related spending falls. ...
>
> In addition to uncertainty about the magnitude of disasters caused by climate change, there is uncertainty about how lawmakers would respond to them. In the future, lawmakers could increase funding above the amounts in CBO's projections if the effect of climate change on the frequency and magnitude of weather-related disasters became significantly larger. ... Or lawmakers could amend existing laws to reduce federal spending on weather-related disasters. ... But CBO's baseline projections, which are built on current law, cannot capture such possible changes.

The points to note here are that government budget projections do not include a significant provision for potential costs of rising sea levels, and to the extent they do, the focus is on the *damage* that weather events may cause, not the *investment* that might be required to erect defenses. Given looming issues with social programs and limited scope to raise revenue to fund adaptation projects, efforts to prepare for rising sea levels may need to focus on building codes and land use to limit the exposure in harm's way.

Insurance Industry Exposure

Notably absent from this discussion is the exposure of the insurance industry to this problem. Globally, the insurance industry has experienced huge losses from flooding, as was seen in Thailand in 2011. Despite this trend, it is unlikely that the insurance industry, particularly in the United States, will be on the front lines of this battle.

Most importantly, any issues that emerge from rising sea

Four days after Hurricane Katrina made landfall on the Gulf Coast, many parts of New Orleans remained flooded.

levels will occur gradually (though in a blink of an eye in geologic terms). Most insurance contracts are issued for annual terms, allowing prices, terms, and availability to be constantly recalibrated to current conditions. While insurers will no doubt suffer large losses from sudden catastrophes, absent draconian government intervention it is unlikely insurers will sustain long-term financial harm.

Another consideration is the current or future existence of government pools. Increased risk of flooding may lead to either availability or affordability problems for coastal risks. When this happens, governments often create pools to address a perceived market failure. The United States already has such a program, the NFIP, which covers coastal flooding for certain types of property (predominantly residential).

Because of these mitigating factors, the insurance industry is unlikely to be the primary funding mechanism for any issues that might result from rising seas.

Tools to Help Us Understand the Problem

It is impossible in a short article to properly summarize the numerous tools available to help public policymakers quantify potential problems and develop adaptation strategies. Two examples are offered here.

The University of Florida has developed the Florida Sea Level Scenario Sketch Planning Tool to identify transportation infrastructure that may be affected by rising sea levels.[2] The tool combines Geographic Information System (GIS) technology, a range of estimates of future sea-level rise, detailed databases of transportation infrastructure (such as roads, rail lines, ports, etc.), and high-resolution maps of topology to offer a view of what infrastructure is vulnerable. This tool can help planners prioritize projects to protect that infrastructure or identify areas that should be avoided in planning future assets. Interested readers are encouraged to look up the tool to see an example of available technology.

Another interesting tool is described in *Modernizing FEMA's Flood Hazard Mapping Program: Recommendations for Using Future-Conditions Hydrology for the National Flood Insurance Program*.[3] The methodology has been available since 2001 and has been used to a point in developing maps for the NFIP. The tool helps local communities to see the results of land-use planning on future flood risk. It was part of a FEMA initiative to increase local community involvement in the development of flood maps and to help communities see the results of land-use decisions on future exposure.

The tool was designed to show conditions projected 10 to 20 years into the future given projected development in a watershed. It can help inform decisions on drainage networks, the effect of buildings and parking lots on runoff patterns, and so forth. While the tool does not currently contemplate future sea-level rise in coastal areas or natural changes in local hydrology, it could be adapted to do so.

These examples illustrate that existing technology, if properly applied, can be used to offer detailed local projections of potential problems from rising seas. This information could easily be used in adjusting land-use and building codes to contemplate future conditions, as was suggested in "Demographics, Development, and Disasters."

Taking Small Steps

Fundamentally, controlling large investments in the future requires that we re-examine what, and where, we are building today. Every structure erected on low-lying coastal property may require expensive protection measures during its design lifetime. As with many other challenges we face, this one involves a trade-off between current cost (or short-term freedom to enjoy beachfront living) and the long-term price of protection. In many cases, future costs are not being properly considered when decisions are made to build. It is important that planning commences so that policymakers have better information to make informed decisions.

As was demonstrated by Katrina and Sandy, damage due to rising water is not likely to gradually emerge in the form of tiny annual changes in high tides. Instead, slowly rising seas will change the probability of inundation from large storms, particularly if the location is unlucky enough to experience a storm at

U.S. NAVY

high tide. Levees and other defenses judged adequate to withstand foreseeable events today may be breached when stressed by storms in the future, making it likely that the effect of rising seas will be felt through increasingly likely extreme events.

If society waits until so-called 100-year events are experienced every decade, individuals and communities will suffer needlessly, and the nationwide costs of responding will greatly exceed the forgone costs of mitigation.

A study titled "Coastal flood damage and adaptation costs under 21st century sea level rise" by Jochen Hinkel, et al., summarizes the issue as follows (the numerical values are global):

> Without adaptation, 0.2-4.6% of global population is expected to be flooded annually under 25-123 cm of global mean sea level rise, with expected annual losses of 0.3-9.3% of gross domestic product. Damages of this magnitude are unlikely to be tolerated by society and adaptation will be widespread. **The global cost of protecting the coast with dikes are significant ... but much smaller than the global cost of avoided damages even without accounting for indirect costs of damage to regional production supply.** (emphasis added).

A similar point was made by the Congressional Budget Office in "Potential Cost Savings from the Pre-Disaster Mitigation Program," a 2007 study that concluded that future losses are reduced by about $3 for each $1 spent on FEMA's pre-disaster mitigation program (measured in discounted present value).

Findings such as this strongly argue for a long-range view of coastal development and land use so that the benefits of development (usually apparent in the near term due to increased economic activity) can be balanced with costs (often not apparent in the near term due to increasing costs for risk transfer or changing climatic conditions). There is ample precedent for such an approach using previously cited analyses of Social Security and Medicare costs over a multi-decadal time horizon.

An obvious first step in that process is to improve and use tools to assess potential exposure, in particular estimates of future inundation potential during the design lifetime of structures. As pointed out above, such tools are available. Gathering this information and analysis will not halt development nor force prohibitively expensive mitigation measures. Instead, development may be channeled into areas more easily defended against rising seas; structures may be concentrated in order to reduce the extent of required defenses; or individual building characteristics may be adjusted. If ongoing coastal development will require increased expenditures in coming decades for adaptation, at least such costs should be identified and planned for before construction commences.

With regard to property or infrastructure already in place, potential costs for adaptation should be understood so investments can be made gradually, minimizing disruption to the economy. Doing so is analogous to adjusting taxes, benefits, or the retirement age gradually to maintain the financial solidity of the Social Security program. Ignoring needed investments in coastal defenses until cities are experiencing ruinous flooding is no more appropriate than ignoring problems with the Social Security trust funds until cash runs out.

Concluding Thoughts

The key issue underlying this article and its companion "Demographics, Development, and Disasters" is that the combination of rapid development in high-risk areas and changing hazards is combining to pose serious macroeconomic challenges for many countries. Wealthy countries with large coastal populations such as the United States or Australia have an opportunity to manage these issues with a practicable mix of affordable adaptation strategies. Developing countries with growing populations, increasing wealth, and/or extreme hazards face a much more daunting challenge.

Melting glaciers and high-latitude ice can be easily observed, making it hard to argue with predictions of future difficulties. A reasonably clear scientific consensus exists as to the likely range of future states. Fortunately, major problems are several decades in the future. Tools exist that have proved effective in quantifying exposure and informing decisions about which adaptation strategies are cost-effective. Regrettably, despite a number of catastrophes that should have served as a wake-up call for action, relatively little is being done to make meaningful changes in exposure or to invest in defenses.

Tackling this problem requires new ways of thinking, particularly with regard to building codes and land-use policies. We face difficult choices, including abandoning property, restricting development in coastal areas, significantly increasing requirements for mitigation (such as higher elevation requirements on new and rebuilt structures), or investing tens of billions of dollars in defenses. All of these options will generate strong opposition from various affected parties, making it likely that little will be done until a series of disasters provides the impetus to overcome inertia. Unfortunately, as we learned from Katrina, ignoring warnings can be very expensive.

The successful example of a long-term planning process in the Social Security and Medicare programs can serve as a road map of how the government can analyze a problem with similar potential for long-term economic consequences and act to reduce the likelihood of disaster. As is the case with social programs, relatively small changes made now can result in large long-term benefits. If Ronald Reagan was able to raise taxes to protect Social Security for future generations, perhaps a future president can champion policies that require moderate sacrifice in the short run to mitigate ruinous flooding in the future. □

RADE MUSULIN is an Academy volunteer with decades of research in this area who currently serves on the Academy's Extreme Events Committee.

Endnotes

1. NASA's Earth Observatory; http://www.earthobservatory.nasa.gov/
2. Florida Sea Level Scenario Sketch Planning Tool; http://sls.geoplan.ufl.edu/
3. "Recommendations for Using Future-Conditions Hydrology for the National Flood Insurance Program"; http://www.fema.gov/media-library-data/20130726-1545-20490-3997/frm_frpt.pdf