IS EXTREME THE NEW NORMAL?

Long-time observers of the estuary claim that — as often as they visit the Hudson — the river is never the same. That said, most people think of the Hudson in terms of averages — "normal" conditions encountered through the seasons. But the five years since the last State of the Hudson report have seen a succession of events that pushed conditions past the norm. Did this run of extreme events come together due to random bad luck, or will such extremes be the new normal?

"A HARD RAIN'S GONNA FALL"

The Mohawk River carries 500,000 tons of sediment to the Hudson each year, on average. After Tropical Storm Irene and the remnants of Tropical Storm Lee deluged the watershed in 2011, it delivered three times that amount — 1.5 million tons — in just eighteen days. Tributaries entering the estuary below the dam at Troy contributed another 1.16 million tons. This load greatly exceeded what the estuary's submerged aquatic vegetation usually deals with; these plant beds virtually disappeared in 2012 and 2013.

Irene and Lee also had a major impact on the defining feature of the estuary — the salt water entering the Hudson from the Atlantic Ocean. The salt front generally ranges from Newburgh Bay upriver (during dry summer weather and prolonged winter cold spells) to the Tappan Zee downriver (during spring runoff and periods of wet weather). Due to massive runoff after the storms, the river ran fresh all the way south to New York Harbor.

TREND: Precipitation is falling in more intense events, causing damaging flooding in the Hudson's tributaries.

Steve Stanne/DEC

Irene's runoff caused severe flooding along the Rondout Creek in Kingston.

THE HUDSON'S UPS AND DOWNS

Barely rising above sea level all the way to the Capital Region, the Hudson estuary is influenced by the rise and fall of ocean tides from New York harbor to Troy. At the southern tip of Manhattan, the average range between high and low tide is about four-and-a-half feet, with the average high tide rising a bit more than two feet above mean sea level there. At Troy, the average range between high and low tides is nearly five feet.

More extreme water levels occur when nor'easters and hurricanes push storm surge into the coast. The highest water level ever recorded at the Battery — more than 11 feet above mean sea level — occurred during Superstorm Sandy in 2012. In addition to the destruction and loss of life in New York City, that storm surge — like the tide — continued up the Hudson, wreaking havoc in low-lying communities. The U.S. Geological Survey's gauge at Poughkeepsie likewise recorded its highest water level ever during Sandy. With sea level rising due to climate change, lesser storms will be capable of pushing water levels to similar heights in the future.

TREND: Surge from coastal storms is a growing threat given rising sea levels and the increasing frequency of intense storms.

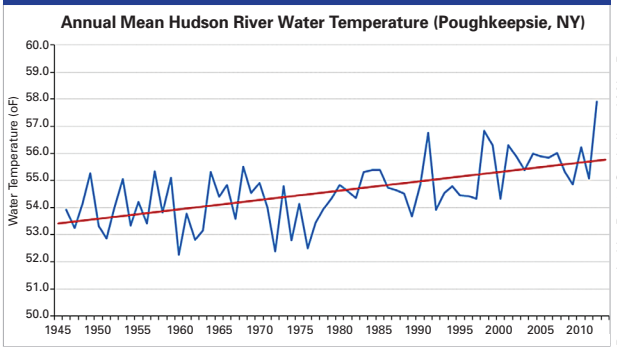
DEC

Sandy's storm surge caused extensive damage in Piermont and other river communities.

A WARMING RIVER

Climate change is also warming the river. At Albany, water temperature records go back to 1972 (with a gap from 1976-1981). Prior to October 2007, the highest temperature on record was 83.3° F, observed in the summers of 2002, 2005, and 2007. Higher temperatures have been observed since; in July 2011, the river reached a temperature of 84.9° F. A longer record at Poughkeepsie's water treatment plant also shows a clear trend of rising water temperatures.

TREND: The Hudson is becoming warmer.



Data compiled by David Seekell and Mike Pace, Cary Institute of Ecosystem Studies. *Journal of Environmental Monitoring*, 2011.

RIVER INVADERS

Biological events also impact the estuary in major ways. The most well-studied instance is the zebra mussel invasion of the early 1990s. In less than two years. the population of this non- native mollusk went from zero to 500 billion, with dramatic impacts on plankton, native mussels, fish, dissolved oxygen concentrations, and other components of the river ecosystem.

Invasive species continue to arrive in the Hudson Valley. The emerald ash borer, found in Ulster County in 2010, is now present in at least five counties along the estuary; eradication is impossible. This insect has destroyed over 50 million ash trees in the U.S. since being discovered in Michigan in 2002. Most trees die within two to four years of becoming infested. Our ash trees are likely to go the way of the American elm and chestnut; the ecological consequences of their loss are not yet known.

Steve Stanne/DEC

A water chestnut bed at Beacon.

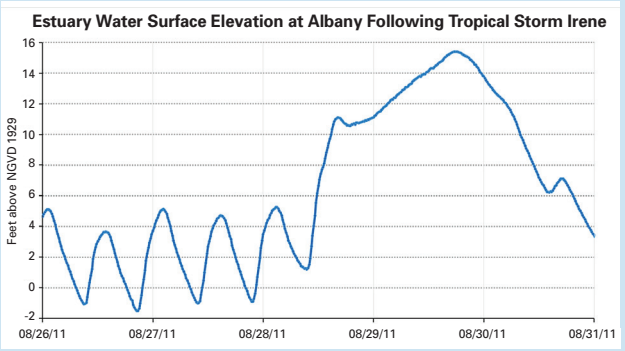
Hydrilla was discovered near the mouth of the Croton River in 2013, joining a list of plant invaders of the Hudson headed by the Eurasian water chestnut. Floating mats of water chestnut can limit dissolved oxygen levels and block sunlight to plants below, displacing native species like water celery. *Hydrilla* has likewise disrupted aquatic habitats around the country; it remains to be seen whether it will do so here.

When confined to a limited area, invaders may be eradicated. In 2008, northern snakeheads were found in an Orange County lake in the Wallkill River basin. This fish grows up to three feet long and feeds voraciously on other fish. To prevent the population from expanding downstream and into the Hudson, DEC applied rotenone, a chemical toxic to fish, in 2008 and again in 2009. Hundreds of snakeheads large and small were killed; none have been found there since.

RESPONDING TO EXTREMES

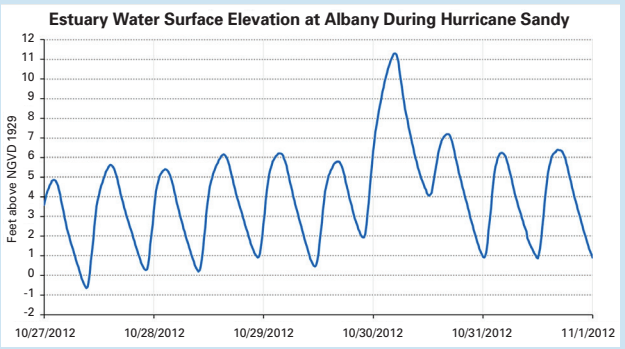
While such counterattacks are of limited use, retreat is not an option. Responding to invasive species, intense storms, and increasing temperatures requires comprehensive approaches that accept the reality of change, attempt to moderate impacts, and formulate long-term plans for adapting to new conditions. For example, in July 2014, the New York State Department of Environmental Conservation (DEC) adopted a regulation prohibiting or regulating the possession, transport, importation, sale, purchase, and introduction of select invasive species, including the examples above. Scheduled to go into effect in March 2015, it aims to slow the introduction of new non-native species and the spread of existing populations.

TWIN FLOODING THREATS: Storm Surge and Runoff



Data from U.S. Geological Survey

While Irene did push storm surge up the Hudson, the flooding associated with the storm came mostly from heavy rains and the resulting runoff. In the Hudson near Albany, this flooding persisted over several days as runoff worked its way down tributaries to the mainstem.



Data from U.S. Geological Survey

Sandy drove a surge of water up the Hudson, combining with high tide to lift water levels more than 11 feet above the baseline datum at Albany. Along the estuary, flooding due to surge from coastal storms is usually relatively brief in duration.

In addition to reviewing the state of the Hudson, the remaining sections of this report describe plans and actions spurred by the extreme events nature has visited on the estuary over the past five years. They underline the potential for conservation of the region's ecosystems, habitats, and biodiversity to promote resilience, economic stability, and quality of life in human communities along the Hudson estuary and in its watershed.

Governor Cuomo has provided the vision to address the challenges of climate change and invasive species, implementing policies that protect the Hudson and preserve its beauty and natural resources.

Governor Andrew M. Cuomo