The Heat Is On:

From Subways to Dairy Barns,

Is New York Ready for Climate Change?

Climate change is happening, and it will transform how New Yorkers live, work, and play in the coming decades. CALS is at the forefront of helping New York both prepare for the challenges and seize the opportunities of a climate in flux. By Amanda Garris

In 2080, will New York City residents take a submarine to work instead of the subway? Will vast irrigation networks be as commonplace in western New York as they are today throughout the western United States? Will once rare catastrophic flooding in the Southern Tier, such as that recently experienced throughout the region, become the norm?

More than 20 College of Agriculture and Life Sciences scientists—including representatives from the departments of Earth and Atmospheric Sciences, Natural Resources, Horticulture, Plant Pathology and Plant-Microbe Biology, Ecology and Evolutionary Biology, and Animal Science—recently addressed these questions, predicting climate trends for the next century and assessing their potential impacts in a comprehensive climate change response analysis focused on New York. The ClimAID report, funded by the New York State Energy Research and Development Authority (NYSERDA), is a roadmap to prepare the state.

Floods and extreme weather are immediate, headline-making examples of how incremental increases in the earth's temperature are already affecting New Yorkers, but the real impact will be seen over the coming decades. Shifting weather patterns are poised to affect everything from food and drinking water quality to the snowpack for winter recreation.

Across the state, heat waves are predicted to be more frequent and intense, requiring a greater power supply to keep air conditioners humming, particularly in the urban heat island of New York City, which presently accounts for half of the state's energy use. The sea level rise—predicted to be from 8 to 55 inches by 2080 depending on the degree of polar ice cap melting—would jeopardize New York City's low-lying, coastal power plants, railways, and transportation hubs. In other parts of the state, irrigation systems might be regularly required to chaperone crops through heat waves.

Working with colleagues from Columbia, Rutgers, the City University of New York, and the Mount Sinai School of Medicine, Cornell experts applied climate models and predicted the outcomes for New York's farms, transportation systems, waterways, energy sector, ecosystems, telecommunications, public health, coastal zones, and wildlife.

"Our goal was to provide decision-makers with cutting-edge information on New York's vulnerability to climate change and stimulate planning for adaptation," says Art DeGaetano, professor of earth and atmospheric sciences and one of three principal investigators for the report. "We have the capacity to address many of the risks ahead, buffer the negative impacts, and embrace new opportunities."

A New Climate for Farming

Farming contributes nearly $5 billion annually to the state's economy and occupies about 23 percent of the state's land. Many of New York's iconic and economically important farm products—including dairy products, apples, and maple syrup—will require some strategic adaptations to maintain current levels of production.

Art DeGaetano Credit: University Photo

Average temperatures—expected to increase 4 to 9°F well before the end of the century—will drive many of these changes. While uncomfortable for humans, these temperatures are downright detrimental to milk yields.

"Cows produce maximum milk between 30 and 75°F," says Larry Chase, professor of animal science. "With heat stress, cows spend more time standing and walking and less time resting. A decrease of one hour of resting time is associated with a 2-3 pound decrease in milk-production per cow. Ultimately, climate change is predicted to cause a 5-15 percent decline in milk production."

The solution: retrofitting barns with ventilation fans and sprinkler systems to keep cows calm, cool, and collected.

For the state's tree crops—including apples and maples—trends in winter temperatures rather than summer highs present a challenge. Ironically, despite the overall warming trend, extreme temperature swings in recent winters have led to an increase in cold damage.

"Variable winter temperatures can 'de-harden' plants and make them more susceptible to mid-winter freeze damage," says horticulture professor David Wolfe. "Or they may leaf out prematurely in early spring and then get hit by a frost event."

A recent analysis of weather over the past 30 years by the National Oceanic and Atmospheric Administration showed that average annual temperatures have increased in every state in the continental United States, and climate models predict the trend will continue. In New York, climate change is predicted to affect phenomena as diverse as the varieties of apples that will grow to the runway length required for airplane takeoff.

Warmer winter temperatures also affect maple syrup production, which requires an alternation between cold nights and warm days to drive the sap for tapping. Maple producers are already experiencing impacts from climate change.

"Maple yields have been slowly decreasing for 30 years," says professor of ecology and evolutionary biology Brian Chabot. "Studying the climate models, we anticipate that producers will at least need to begin tapping earlier—in January or February—instead of waiting until March."

He added that growers have options, from the simple—plant a few more maple trees—to the technological; using a vacuum tapping system, for example, has been shown to double or even triple sap yield.

A warmer climate could have mixed effects for New York vineyards, major contributors to the state economy. The $50 million industry is currently restricted to grape varieties that survive the upstate's mid-winter cold and ripen in its short growing seasons. Warmer winters and longer growing seasons may allow growers to produce a wider range of cold-tender European grapes, such as Cabernet Sauvignon or Zinfandel. However, it may become warmer than desired for the coolest season grape varieties like Riesling or Pinot noir, today's stars. More hot spells and downpours between drought periods will also challenge growers.

A potential advantage for New York under the climate predictions is a longer growing season, which may bring opportunities for farms to diversify into new crops and varieties. Cool season crops such as broccoli, spinach, and peas may be replaced by heat lovers like tomatoes. European wine grapes, grown in several parts of the state, would likely grow better with a change in climate.

Shifting Species

While farmers are starting to learn about the array of options available to them to adjust to climate change, native species are responding on instinct to earlier springs and warmer summers.

"Researchers at the Lab of Ornithology have observed earlier arrival of migrating birds as well as bird populations moving northward within their traditional ranges," says Wesley Hochachka, assistant director of the Lab of Ornithology and an expert in bird population studies. "They are trying to understand thermal constraints on birds, from direct heat stress to effects on the number of eggs they incubate."

While birds can take flight in search of more hospitable areas, other species will be limited by their ability to move into suitable habitats. Accordingly, large shifts in species composition are expected in natural landscapes, and loss of unique habitats in New York such as spruce-fir forests and alpine tundra is predicted.

Wolfe, the lead author of the Ecosystems and Agriculture chapters of the ClimAid report, says this creates a need to preserve wildlife corridors to allow animals to migrate out of areas that no longer provide hospitable habitat.

"As habitat disappears, an important policy is to establish migration corridors that would allow animals from insects to large mammals avenues to move to a new environment," says Wolfe. "Because much of the forested land is privately owned, there will be greater opportunities for citizen science and monitoring."

Also targeted for monitoring: invasive weeds and insects that will be drawn to the warmer climate. Kudzu, a vine native to China and Japan which already blankets entire landscapes in parts of the American South, will likely climb its way into New York. On the fauna side, new statewide tracking systems will be needed to monitor and manage newly arrived pests like the hemlock woolly adelgid, which kills or weakens the trees with a toxin it injects while feeding.

"When considering the changes in ecosystems, we need to think about ecosystem services, like air and water purification and flood control," notes Wolfe. "We'll need to manage for ecosystem services and biodiversity instead of strict species conservation."

Water, Water Everywhere?

Will storms like Hurricane Irene, which deposited 10 inches of rain in less than 24 hours, become more frequent? Although storm prediction was not part of the analysis, DeGaetano's data consistently shows more extreme precipitation, with more rain falling in flash-flood-prone heavy downpours and less in gentle showers.

Heavy rains and flooding don't just affect crop yields—flash floods threaten infrastructure and personal property, as more than 120,000 residents in the Binghamton area and northern Pennsylvania found out when they evacuated their homes in the wake of the latest tropical storm.

Overall, precipitation in New York is predicted to increase by 15 percent by 2080, but the pattern of precipitation will change, with more rain falling during the winter months and periods of drought occurring during the summer.

Reductions in the flow of large rivers and lower groundwater tables during summer heat waves could lead to conflicts among competing water users, including farmers, homeowners, and industries.

CALS faculty are already working directly with municipalities to shore up their long-term planning of water resource infrastructure in light of climate predictions.

Susan Riha Credit: University Photo

"We are coaching municipalities on adaptive management—also called non-optimal management—to help them consider possible changes in climate when making decisions regarding when and where to invest," says Susan Riha, professor of earth and atmospheric sciences and director of the Cornell Water Resources Institute.

Communities can make critical decisions now

about increasing the size of storm pipes, siting wastewater treatment plants outside of high-risk flood plains, and even moving homeowners out of high-risk areas.

The predictions for a plentiful and seasonally variable water supply puts New York in an enviable position for agriculture and summer recreation, compared to other parts of the country. But managing the excess water is key, says Riha.

Closer to campus, a research associate who works with DeGaetano has been applying climate models to make decisions on the future source of Ithaca's drinking water: Six Mile Creek Reservoir or Cayuga Lake?

"Climate change was not really a factor in decision-making before now," says DeGaetano. "But using the climate projections, it's clear that a larger body of water is a much less risky water source in the long term."

Tools for Decision-Making

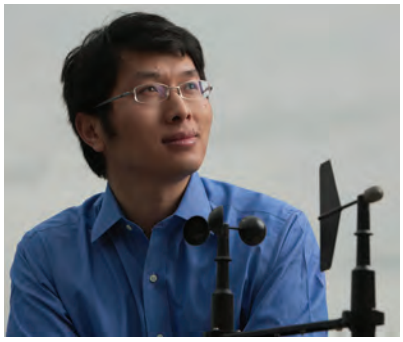
Climate change solutions come at a price, which presents a challenge—at what point does a new climate pattern justify action by a New York farmer or a town?

With the predictions from the NYSERDA report in place, climate science is transitioning from a focus on projection to strategies for adaptation, mitigation, and modeling of complex weather patterns.

Wolfe is working with colleagues to develop online decision-making tools to help farmers evaluate when to invest in adaptations such as expanded irrigation capacity or improved drainage systems.

"Farmers will be able to play out scenarios tailored to the unique climate projections for their farm," says Wolfe. "They will be able to evaluate the difference in profits if they wait five years to invest in irrigation compared to waiting 10 years. We want to give farmers tools to optimize how much and when they invest in adaptation strategies."

From not enough water to too much, Gang Chen MS '96 PhD '98, assistant professor of earth and atmospheric sciences, is developing



Gang Chen Credit: University Photo

new methods to predict the location and severity of snow storms. Powerful winter storms can be very expensive to cities due to the cost of snow removal, and were identified in the ClimAID report as a particular threat to citizens in remote rural locations due to service disruptions in power and telecommunications.

The first of four new joint interdisciplinary hires made in conjunction with the David R. Atkinson Center for a Sustainable Future, Chen uses physics to analyze global-scale weather phenomena like El Niño and La Niña cycles and the jet stream.

"The jet stream is like a train moving from west to east, with winter storms as the passengers," says Chen. "Where they disembark, they can deposit massive amounts of snow like that experienced in Washington, D.C., last winter."

Predicting the jet stream's path will help predict where storms will occur in the future.

Another key partner for decision-makers is the Northeast Regional Climate Center directed by DeGaetano. It is one of six federal centers that collect climate data and develop tools for analysis.

"For years, we have been a trusted source of current and historical weather information for everyone from farmers to lawyers to engineers, and lately we are providing more information about the future climate," he says.

"One of our goals is to let people know that the weather conditions they take for granted have not only already changed, they will continue to be a moving average." •

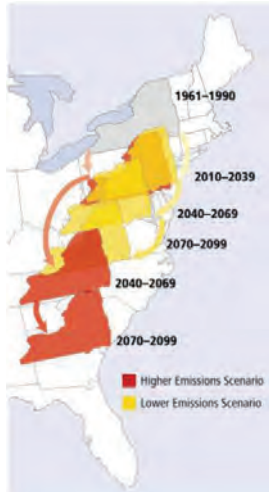
Looking to the future, CALS is recruiting researchers who complement existing expertise with new approaches. In conjunction with the Atkinson Center, CALS will be seeking an expert in mitigation strategies and a terrestrial biogeochemist.

Also on the list of new hires: a social scientist, an indication of the importance of public participation in any climate change solution.

"Scientists have been providing information about the impacts of climate change for decades, but what we really could use at this stage is research on coping with the social, economic, and communication challenges," says Wolfe, who is heading the search for the position.

Climate Predictions by Region:

The ClimAID analysis recognizes that each region within New York will face unique challenges. Here's a sample of what's predicted by 2080.



Credit: Union of Concerned Scientists/NECIA

Western New York & the Great Lakes Plain: This region brings in the highest agricultural revenues in the state, but the increasing risk of summer drought will make irrigation a commonplace safeguard.

Catskill Mountains and the Hudson River Valley: New York City's watershed will no longer have a climate suitable for spruce and fir forests, and hemlock trees are threatened by the hemlock woolly adelgid—an insect pest moving northward as the climate warms. Cool-water-loving brook trout will be replaced by bass. While winter recreation will be reduced by lower snow pack, it will be offset by increased summer opportunities.

Southern Tier: This dairy-dominated agricultural economy will need barns retrofitted with cooling systems. Flooding along the Susquehanna River may increase, and the region will be the first line of defense against invasive species migrating north.

New York City and Long Island: The coastal zone, which pairs high population density with vulnerability to storms, will experience the greatest economic impact in the state. The upper-end prediction for sea level rise by 2080—two feet—would flood the subways and put 25 percent of New York City streets under water. The heat-absorbing properties of concrete and pavement can make the city 10°F higher than the surrounding rural areas.

Hudson and Mohawk River Valley: The Hudson River will be vulnerable to saltwater ingress. Popular apple varieties may decline because winters are insufficiently cold.

Tug Hill Plateau: Hydropower currently provides 19 percent of New York's energy, much of it generated in this region. While lake-effect snows could increase in the short term, water levels in the Great Lakes could decline.

Adirondack Mountains: The midwinter snowpack in the Adirondacks is predicted to barely surpass 4 inches by 2080—compared to the current average of 16 inches—decreasing winter recreation opportunities and threatening many of the region's unique alpine plant and animal species.

The final report is expected in November 2011.