Maple Syrup Case Study - Extract from Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State: Final Report. (2011). Annals of the New York Academy of Sciences, 1244(1), 2–649. https://doi.org/10.1111/j.1749-6632.2011.06331.x

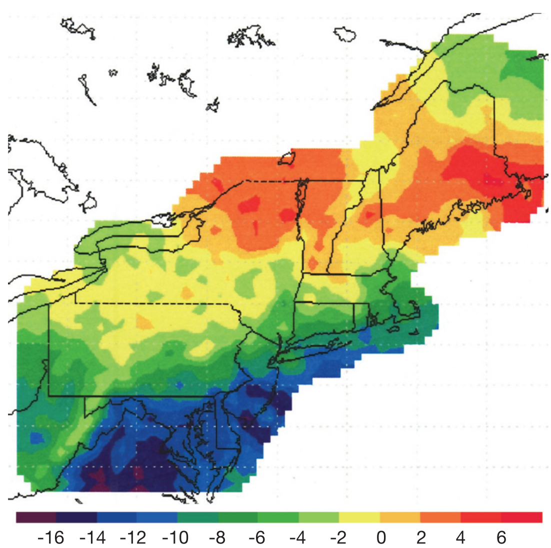
coordination and the in-kind support of partners. A strong communication network has also developed within and among PRISM partners to share educational resources, promote outreach events, and rapidly disseminate information about new invasions.

Other key Invasive Species Task Force recommendations now implemented as part of the State invasive species program include the following:

- The New York Invasive Species Research Institute, located at Cornell University. This group serves the scientific research community, natural resource and land managers, and State offices and State-sponsored organizations by promoting information-sharing and developing recommendations and implementation protocols for research, funding, and management of invasive species (http://nyisri.org).
- Use of iMapInvasives, an online, GIS-based, all-taxa invasive species mapping tool, coordinated by the New York Natural Heritage Program. The tool aggregates species records and locations from new observations and previously existing databases to provide a real-time, fully functional tool to serve the needs of volunteers and professionals working to manage invasive species (http://imapinvasives.org).
- The New York Invasive Species Information Clearinghouse, which is coordinated by the New York Sea Grant and Cornell Cooperative Extension. The Clearinghouse website is a comprehensive, online information portal (http://nyis.info) that provides stakeholders with links to scientific research, State and federal invasive species management programs and policy information, outreach education, and grassroots invasive species action in and around New York.

Case Study C. Maple Syrup Industry: Adaptation to Climate Change Impacts

Production of maple sugar products is based on sap flow from maple trees caused by positive internal sap pressures. These pressures are mostly from a physical process caused by freezing and thawing of a tree's woody tissues (Tyree, 1983). One analysis used historical data and climate models for individual states to project maple distribution and sugar production (Rock and Spencer, 2001). The study predicted an end to both the presence of sugar maple and to the maple industry in the northeastern United States by the end of this century. Another analysis, which used historical data from four northeastern states, concluded that, over the past 30 years, trees are being tapped for sap increasingly earlier and that sap flow is also ending earlier (Perkins, personal communication). The sap flow season is becoming shorter; the movement of the end of the season to earlier in the year is outpacing its earlier onset. A more recent study coupled a simple model for sap flow with downscaled global climate model results to project the number of sap flow days during the spring period and annually for about 10,000 locations across the northeastern United States (Skinner et al., 2010). This fine-scale analysis revealed that different parts of New York are likely to experience different impacts of climate warming on sugar production (**Figure 6.10**). Areas in New York at lower elevations and in southern counties have fewer days with freezing temperatures. In these areas, climate warming will force a continuing decrease in freezing temperatures with a resulting loss of sap production. In contrast, cooler parts of the state, at higher elevations and in northern New York, currently have fewer thawing days. The model predicts that, with warming, the number of days with sap flow will initially increase in these areas through the end of this century,



Note: The average change shown here is based on climate projections from the HadCM3 climate model (one of the 16 used in ClimAID), using the B1 emissions scenario. Northern areas in New York show an increase in sap flow days and southern areas a small decrease. Source: Based on data from Skinner et al., 2010

Figure 6.10 Average change in the total number of days (see color-coded scale at bottom) of modeled sap flow per season comparing the 1969–1999 historical climate data with projections for 2069–2099 period followed by a decrease of days with sap flow with further warming after the end of this century. This analysis also shows that the sap flow season is moving earlier in the year such that by the end of the century tapping will begin in January rather than March. Eventually, it will merge with temperature conditions in November and December that are favorable for sap production.

Contrary to the prediction that the maple industry in New York will disappear by the end of the century (Rock and Spencer, 2001), this ClimAID analysis suggests that with adaptation to climate change the industry can remain viable for at least the next 100 years. There are several approaches to adaptation:

1) *Maintain attention on tree health through good forest management.* Competition from other tree species and pest impacts can be substantially reduced by existing management options. Research projects are under way to examine the optimal tree spacing for maximal growth and sugar production. Effective methods to control competing woody vegetation are also being studied.
2) *Begin tapping trees earlier in the year.* It is both essential and possible to move the sap production period to earlier in the season as the climate warms. Maple producers already pay considerable attention to weather forecasts to determine when to begin tapping. One analysis mentioned above (Skinner et al., 2010) predicts that the loss of production could amount to 14 days, if tapping begins at traditional times; normal seasons are 24 to 30 days long. If tapping begins earlier, there could be no net loss in number of sap flow days in warmer areas and there could be a net gain of sap flow days in cooler areas.
3) *Increase the sap yield from trees.* Recent research regarding why tap holes "dry up" has led to the introduction of a new type of spout. The main cause for loss of production from a tap hole relates to microorganisms plugging the xylem elements, which are the water-conducting elements of the tree. This is accelerated by increases in temperature and, thus, could be affected by a warming climate. The new spout has a check valve that prevents backflow of sap from the tubing into the tree, thus reducing the rate of microbial plugging. Initial results show a substantial production increase that could offset declining production from climate warming.
4) *Bring more maple trees into production.* One study, which uses U.S. Forest Service Forest Inventory Analysis data, estimates that in New York there are about 138 million sugar and 151 million red maples that are the correct size for tapping (Farrell, 2009). About 0.5 percent of these are currently used in sugar production. Vermont taps about 2 percent of its potential trees; Quebec taps about 30 percent of its trees. Thus, the potential to compensate for loss of production by bringing more trees into production and better utilizing red maples is enormous. Increasing the number of trees tapped seems to be occurring in response to economic incentives, as the price of syrup has increased dramatically in recent years.
5) *Increase use of red and silver maples for sugar production.* Whereas producers are currently tapping roughly 80 percent of the sugar maples on their own property, they are only using 20 percent of the available red maples (Farrell and Stedman, 2009). One of the main objections to using red and silver maples has been the lower sugar concentrations in the sap. However, with increased use of reverse osmosis to remove 80 to 90 percent of the water before boiling, this concern is not as great as it once was. Red maple (*Acer rubrum*) has a broader environmental tolerance than does sugar maple and is becoming the dominant tree species throughout the Northeast. It will be affected less by climate warming and tends to grow faster than sugar maple on a variety of sites. Thus, even if sugar maple disappears from New York's forests, syrup production could continue with better use of red maples.

Case Study D. Brook Trout: Reduction in Habitat Due to Warming Summers

The historical abundance of brook trout, New York's state fish, is likely to be severely reduced by climate warming, since it is currently located near the southern extent of its habitable range.

To examine the effects of regional warming on brook trout populations, three classes of water bodies in the Adirondack region were considered by ClimAID: 1) unstratified lakes, which have extensive water mixing during the summer and minimal temperature gradients with depth, 2) stratified lakes, which have deep zones that remain cold and unmixed with surface waters throughout mid-summer, and 3) streams and rivers.