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Climate change research in Massachusetts, U.S.A.: searching for phenology in the historical record.

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The United States does not have as many large, well-researched sets of phenological records as can be found in Europe. Such phenological research is important both scientifically to investigate the effects of climate change and, just as importantly, for convincing the public that climate change is really happening and is already affecting our environment. Scientists in the United States are currently uncovering a wealth of data from a variety of unconventional sources on the effects of climate on the phenology of a wide range of organisms, with many studies being published on birds and plants. For the past six years, we have been investigating the impact of climate change in Massachusetts, a region with a particularly strong tradition of science and natural history. We are able to use combinations of herbarium specimens, photographs, diaries of individual naturalists, records from research stations, and current observations of our own to document the effects of climate change. Each of these data sources has certain limitations, but the overall message is the same: a warming climate is causing plants to flower earlier and certain migratory birds to arrive earlier. Such data has to be interpreted carefully due to issues of changing population sizes and changing sampling methods and intensity. The single most valuable source of data for our research has been the observations of flowering times of hundreds of plant species from 1852 to 1858 in Concord, Massachusetts, made by Henry David Thoreau. Thoreau is the most famous environmental philosopher in the United States, and most students read his book Walden. Later botanists also recorded flowering times and the abundance of plant species in Concord, and we recorded flowering times and species abundances in Concord starting in 2004. The project has shown that spring flowering species are the most responsive to temperatures, and that these plant species are now flowering seven days earlier than they were in the 1850s. Numerous species have declined in abundance since the time of Thoreau and 27 % of the species can no longer be found in Concord. A further 36 % of the species seen by Thoreau are now locally rare, only occurring as one or two populations, and are in danger of going locally extinct. A synthesis of these separate data sets from Concord was carried out using a phylogenetic approach that controls for the evolutionary history of the species. The surprising result is that species that are most responsive to temperature in their flowering times have tended to persist in Concord; in contrast, species with flowering times that are not responsive to temperature have tended to decline and go locally extinct in Concord. This significant result demonstrates that the warming temperature associated with climate change is partially responsible for the loss of biodiversity in Concord, along with other such well-known factors such as forest succession, habitat destruction, habitat fragmentation, invasive species, the overabundance of deer, and pollution. Records of bird arrival times in Concord, starting with Thoreau and continuing up to the present, show that birds are also responding to a warming climate, but not as much as spring-flowering plants. Throughout the project, special efforts have been made to publicize this work by writing press releases, working with science journalists, and producing dramatic, high-quality photographs and figures. These results have turned out to have great interest for the American public who greatly revere Thoreau, and this research has been widely reported by newspapers, magazines, radio programs, and websites.