Climate Change Adaptation White Paper Series

Climate Change and Vermont's Waters

Sacha Pealer and Gwen Dunnington, April 2011

Scientists have noted some key climate trends in the last few decades, including changes in air and water temperatures and precipitation patterns. In particular, Vermont and the region are expected to experience warming temperatures, increased annual precipitation (by as much as 30%), more extreme rainfall events, altered timing and duration of seasonal floods, less snowpack and lake ice, and more short-term droughts (Frumhoff et al., 2007; Hayhoe et al., 2007; Stager and Thill, 2010; Barnett et al., 2005). These changes could have critical consequences for hydrology, water quality and availability, ecological integrity, and human infrastructure.

What changes are in store for Vermont waters?

Flooding

With a warmer, wetter climate and more extreme precipitation events, flooding and erosion concerns are likely to become more pressing. Vermont communities have already experienced an increase in the frequency of damaging floods in recent years (Figure 1) (NCAR, VEM). This trend is likely exacerbated by greater development in flood-prone areas, as well as chronic instability from historic and current channelization practices, including channel straightening, dredging, bank armoring, and berm construction. These activities can limit a stream's floodplain access and create more runoff, which can actually increase flood power, velocity, and contact with infrastructure (VRMP). With further climate shifts in the coming decades, we could see still more stream channel erosion, lakeshore fluctuation, sedimentation, and loss of human investment.

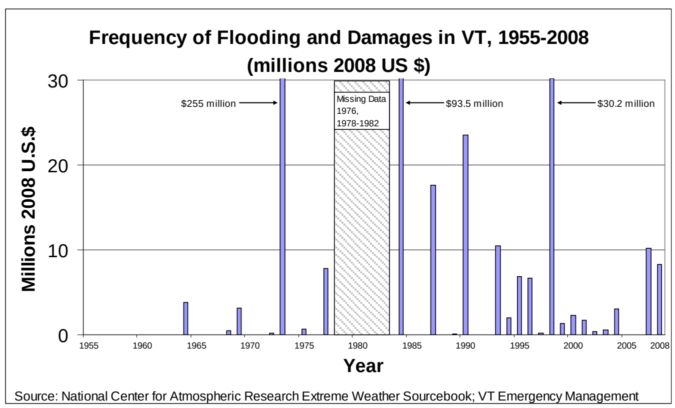

Figure 1. Frequency of flooding and magnitude of damages in Vermont. Damaging floods may be occurring more frequently.

Water Quality

In addition to flooding, water quality may be threatened as precipitation patterns change and waters warm (USGCRP, VWQD). Intensified storm water runoff may increase water pollution as flows carry fertilizers, road sands, eroded sediments, animal wastes, inundated septic systems, combined sewage overflow and other nutrient-rich materials into rivers and lakes. Runoff can also increase the amounts of toxins, such as mercury, that end up in rivers and lakes (Gao et al. 2006). In turn, higher water temperatures can allow for greater incidence of mercury methylation, resulting in increased mercury accumulation in fish and fish-eating animals, including humans (Stager and Thill 2010). Wastewater treatment facilities that are not completely disconnected from storm sewers may be overwhelmed by storm water volumes, allowing for the possibility of contamination of lakes or rivers. Warmer, nutrient-rich waters may encourage more frequent cyanobacterial blooms and elevated populations of the bacterium *E.coli.*

Ecosystems

Aquatic life could face severe challenges. Of primary concern is that warmer waters hold less dissolved oxygen. This low-oxygen condition can be detrimental to many aquatic species, especially those species, e.g. trout, that are already restricted to cold-water habitats because of their oxygen requirements. If low flows become more prevalent in summer, aquatic habitats may become reduced, more isolated, and more oxygen-poor. Furthermore, changes in the timing and duration of high and low flows could interfere with the life cycles of migratory fish or aquatic insects. Species interactions may be disrupted, as more tolerant species gain competitive advantages, and aquatic communities become less resistant to invasive species. Research from the Great Lakes and Lake Champlain suggests that even minor changes in temperature regime can result in shifts in prevalent lake fish species, away from coldwater spawners such as salmonids, to tolerant species like bass (Ficke et al., 2007, Frumhoff et al., 2007, Stefan et al., 2001., Stager and Thill 2010).

Availability

Vermont waters may also have reduced availability for human use, especially during droughts when demand increases and flows are low. For instance, a month-long increase in summer low-flow periods may challenge communities which depend on streams and rivers for their water supply. The timing of precipitation and the form it takes (snow vs. rain) plays a strong role in how much water becomes stored in surface waters and aquifers. Increased runoff caused by soil saturation and impervious surfaces found in developed areas may lead to reductions in aquifer replenishment and in increased risks of waterway contamination as result of flooding. Additionally, many wells in the northeast are drilled into bedrock, and bedrock aquifers may be extremely vulnerable to extended periods of drought (Frumhoff et al., 2007). Water withdrawals or other stream flow alterations may become more common, and human uses may compete with aquatic management needs.

Are we ready for climate change? What water resources are most vulnerable?

Vermont is just beginning to identify the water resources most vulnerable to climate change, which is an important step toward planning adaptation efforts. Vulnerabilities may be found in human communities and aquatic ecosystems where the resource is already highly stressed, or in particular species that are rare or highly sensitive due to specialization.

Human communities

In human communities, vulnerabilities may include locations of infrastructure already at risk. For example, flood-prone shorelines and streams with high levels of encroachment may be especially susceptible. Significant and costly structures (e.g., bridges, culverts, roads, ditches, homes, and embankments) could be damaged by erosive flooding, and stormwater systems could be overwhelmed during high rainfall events. Similarly, dams may be subject to changing flow regimes, accelerated sediment buildup behind structures, and elevated risk for catastrophic failure during high flow events. Because of the potential for increased pollution and short-term droughts, drinking water availability and quality may also be at risk, creating additional costs associated with storage and/or treatment.

Aquatic ecosystems

Aquatic ecosystems may be especially vulnerable wherever habitats are already compromised. For example, locations with little or no vegetated buffer will experience higher thermal stress. Also, habitats may be fragmented by barriers to aquatic species movement, such as culverts, berms, or dams. Critical ecosystem processes that have been altered (e.g., where floodplain function is diminished by flow regulation or excessive encroachment) may already limit habitat diversity and availability. Particular species vulnerabilities may include species sensitive to warmer temperatures and oxygen-poor waters (e.g., brook trout), rare species or species sensitive to sedimentation (e.g., freshwater mussels), species with pronounced susceptibility to mercury contamination (e.g., loons), or species that may provide benefits to other species (e.g., tree species important for riparian buffers that may themselves be vulnerable to warming temperatures) (Stager and Thill, 2010; Frumhoff et al., 2007).

What are we already doing?

In most cases, the challenges posed by climate change are not new, only expected to become more intense in the upcoming decades. Therefore, management strategies already utilized by the Water

Quality Division may become increasingly critical for climate change adaptation and mitigation, now and in the future. Some existing programs that may be useful in addressing climate change include:

1. Monitoring biological, chemical, and physical conditions of lakes, rivers, and wetlands, to establish baseline conditions and help maintain the health and quality of local waterways.

2. River corridor, floodplain, and shoreline protection to reduce encroachment, and river, lake, and wetlands vegetated buffer promotion.

3. Stormwater regulation and promotion of low impact development/ best management practices.

4. Improving and protecting existing infrastructure near waterways. This includes upgrading of undersized culverts and bridges, regulating uses that alter stream flows, and the strategic removal of obsolete, inoperative dams.

Working considerations of climate change into these existing management strategies will be one efficient way of utilizing the systems already in place to deal with new challenges.

What more can be done to protect Vermont's waters in the short term? What research would help?

Climate changes are already in motion, and further change may occur rapidly. To protect our vital water resources, we must respond quickly. Going forward, Vermont could implement these strategies:

- Ensure climate change is an important consideration in water resources policy and decision-making.
- Participate in climate change discussions and planning at the regional (Northeastern U.S. and Canadian provinces) level.
- Support and refine existing efforts to protect water resources.
- Improve lakeshore protection and ecologically appropriate shoreline stabilization policies.
- Re-establish and maintain physical stability ("geomorphic equilibrium") of streams. Protect river corridors and floodplains to accommodate river adjustment and floodplain processes.
- Protect and restore vegetated buffers on lakes, streams, and wetlands.
- Develop education and outreach programs concerning climate change as a water resources issue.
- Establish policies that set new infrastructure further back from waterbodies and retains naturally vegetated buffers to protect the infrastructure from the predicted higher frequency and magnitude of flooding and lake level fluctuations.

Understanding climate trends and their impacts to Vermont's water resources will be essential to making wise decisions about adaptation. Much of what we know can be refined through planned research efforts:

- Continue to evaluate how precipitation changes may affect stream flow and flooding.
- Analyze buffer characteristics needed for maintaining adequate microclimate over Vermont water bodies, map thermal risks throughout watersheds, and monitor water temperature and dissolved oxygen in lakes, rivers, and wetlands.
- Conduct species vulnerabilities and create monitoring and/or "rescue" plans.
- Assess ecological functions and vulnerabilities by watershed, and prioritize locations for additional protection, buffering, and/or restoration.
- Enhance monitoring programs for toxins in wastewater, ground water, and water bodies.

What next?

Vermont would benefit from a thorough vulnerability study of human communities, aquatic habitats, and species. This vulnerability analysis can be used to inform an adaptation strategy for all watersheds in Vermont. In order to be most effective, existing water resources management programs must be coordinated and integrated with any climate change adaptation strategy.

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