Vermont Agency of Natural Resources

Climate Change Adaptation Framework

May 31, 2013

Appendix 4

Appendix 4A

Upland forest handouts from the December 11 adaptation strategies workshop

Upland Communities Adaptation Strategies Breakout Group

TERMINOLOGY

Effects – ecological responses to a given climatic exposure (or combination of exposures); these can be direct or indirect.

Adaptation strategies – actions taken to prepare for climate change, helping to reduce adverse impacts or take advantage of beneficial ones (Rosenzweig et al. 2011).

Mediating factors - factors that will lessen or worsen the degree of impact. Some are naturally occurring and cannot be altered (i.e. elevation, latitude), while others can be influenced by human factors (i.e. shading/riparian buffer).

FORMAT FOR DISCUSSIONS

First we will give a **quick overview** (5-10 minutes) of **FRP (forest plan), SWAP (wildlife plan)** and **SCORP (recreation plan)** as an umbrella for applying these results to existing actions by ANR.

Next, we will discuss 3 climate scenarios: 1. **Warming temperatures**; and 2. **Precipitation change and increased temperatures; and 3. Increase in extreme events.**

For each scenario, we will go through the following steps:

1. **Review ecological effects** (5 minutes for each scenario) and mediating factors as presented in the attached tables and conceptual diagrams. The information in the tables and diagrams is essentially the same for each scenario, but in different formats. We will ask the group whether you have any suggested edits or additions to these tables and diagrams.
2. **Brainstorm adaptation strategies** that would improve upland community resilience to impacts, or other adaptation strategy. This is a broad category of actions that would strengthen the abilities of sites, habitats, and species to resist stress under changing climate scenarios. Example: limit the spread of invasive plant species.
3. For each strategy, **brainstorm on-the-ground management actions that support these strategies, whether currently in place or not** (example: identify locations of invasive exotic plants throughout Vermont). As you go through this, please keep in mind the following general categories of management actions - Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach - and please make notes on the feasibility of implementation.
4. If any of the **actions are currently being implemented**, note which program/entity is doing so. Also consider potential partners, timeframe for implementation and scale (local, regional, etc.).
5. In some situations, preservation action may not fully mediate impacts in the long term; change will occur eventually. We will discuss implications of some of these **anticipated changes**, as well as steps that VANR could potentially take to manage/plan for these anticipated changes.
6. Identify key **research needs/data gaps** that would need to be completed to support each management strategy, and discuss potential ways to address these needs and gaps.
7. At the end of the first session, the group will identify **top pick(s) for on-the-ground management actions**. Following lunch, the group will discuss/rate the following about those top pick(s):

- Effectiveness at mitigating (i.e. scientific basis for recommending this action)
- Operational feasibility (i.e. Amount of $, resources required to implement)
- Degree of current implementation (Describe)
- Level of alignment with current policies, procedures, BMPs (describe)
- Social/political acceptability and feasibility
- Potential for securing funding

SCENARIO 1: INCREASED TEMPERATURES – Ecological effects and Mediating Factors

Ecological Effects	Mediating Factors (+/-)
1. Compositional changes associated with changes in thermally suitable habitat (loss of cold-adapted species and increase in warm-adapted species). Timeframe: long-term, but localized effects could occur on a shorter timescale 2. Increase in overwinter survival of pests, such as balsam and hemlock woolly adelgid. Timeframe: immediate. 3. Increased physiological stress, resulting in increased susceptibility to pests and disease, decreased productivity and increased tree mortality. Timeframe: immediate. 4. Increased evapotranspiration, resulting in a decrease in soil moisture; moisture limitation/stress negatively impacts productivity and survival in many species. Timeframe: immediate. 5. Increased decomposition rate of organic material may enrich soils and make them more suitable for competitors. Timeframe: long-term, but localized effects could occur on a shorter timescale 6. Decrease in winter snow pack, leading to change in deer and moose browsing patterns, which affects regeneration. Timeframe: immediate. 7. Lengthening of growing season resulting in changes in species competitive, especially favoring non-native invasive plants. Timeframe: immediate. 8. Early spring thaws/late frosts can damage buds, blossoms & roots, which affects regeneration 9. Change in freeze/thaw cycles could disrupt regular periodicity of cone cycles. Timeframe: immediate. 10. Asynchronous changes in phenology may negatively impact some migratory species and pollinators. Timeframe: immediate.	• orientation (north/south facing) • topography/slope • elevation • latitude • soil type • geology • ability of species to migrate to suitable habitat • browsing preferences
Others?	

SCENARIO 2: PRECIPITATION CHANGE AND INCREASED TEMPERATURES–
Ecological effects and Mediating Factors

Ecological Effects	Mediating Factors
11. Increase in number of short-term droughts resulting in decline in forest productivity and tree survival associated with water limitation. Timeframe: long-term	• soil type • soil depth • aspect • water availability • tree species
12. Earlier and warmer springs and smaller snow packs, and hotter drier summers conducive to increased fire risk. Timeframe: immediate.	
13. Loss of fire intolerant species and increase in fire tolerant species, such as red and pitch pines. Timeframe: immediate.	
Others?	

SCENARIO 3: INCREASE IN EXTREME STORM EVENTS - Ecological effects and Mediating Factors

<table>
<tr><th>Ecological Effects</th><th>Mediating Factors</th></tr>
<tr><td>14. Increased physical damage and disturbance, leading to declines. Timeframe: immediate.</td><td rowspan="2">topography/slope
stand density
soil depth
root structure</td></tr>
<tr><td>15. Increased gap formation, which facilitates the spread of invasive plants. Timeframe: immediate.</td></tr>
<tr><td>Others?</td><td></td></tr>
</table>

SCENARIO 1: WARMING TEMPERATURES – ADAPTATION STRATEGIES FOR MANAGING RESILIENCE

Identify the broad adaptation strategies that would strengthen the abilities of sites, habitats, and species to resist stress under a changing climate. For each strategy identify specific on-the-ground actions, considering the following categories: monitoring, conservation, technical assistance, education/outreach.

Ecological Effects	**Adaptation Strategies** ***Please note if they are existing (E) or new (N)**	**On-the-ground management actions** ***Please note if they are existing (E) or new (N)**
Compositional changes associated with changes in thermally suitable habitat (loss of cold-adapted species and increase in warm-adapted species). Timeframe: long-term, but localized effects could occur on a shorter timescale	*Examples: VT Forestry Plan - Strategy 7: Monitor and report current forest health and evaluate potential threats.* *VT SWAP - 6) Identify, prioritize and maintain existing contiguous forest blocks and associated linkages that allow for upward and northward movement in response to climate change.*	
Increase in overwinter survival of pests, such as balsam and hemlock woolly adelgid. Timeframe: immediate.		
Increased physiological stress, resulting in increased susceptibility to pests and disease, decreased productivity and increased tree mortality. Timeframe: immediate.		
Increased evapotranspiration, resulting in a decrease in soil moisture; moisture limitation/stress negatively impacts productivity and survival in many species. Timeframe: immediate.		
Increased decomposition rate of organic material may enrich soils and make them more suitable for competitors.		

Timeframe: long-term, but localized effects could occur on a shorter timescale		
Decrease in winter snow pack, leading to change in deer and moose browsing patterns, which affects regeneration. Timeframe: immediate.		
Lengthening of growing season resulting in changes in species competitive, especially favoring non-native invasive plants. Timeframe: immediate.	*Example: VT Forestry Plan - Strategy 12: Prevent the introduction and slow the spread of invasive exotic species.*	
Change in freeze/thaw cycles. Timeframe: immediate.	*Example: VT SCORP - •Design trails for the degree of anticipated use, or greater capacity, by that user group.*	

SCENARIO 2: PRECIPITATION CHANGE AND INCREASED TEMPERATURES – ADAPTATION STRATEGIES FOR MANAGING RESILIENCE

Identify the broad adaptation strategies that would strengthen the abilities of sites, habitats, and species to resist stress under a changing climate. For each strategy identify specific on-the-ground actions, considering the following categories: monitoring, conservation, technical assistance, education/outreach.

Ecological Effects	Adaptation Strategies *Please note if they are existing (E) or new (N)	On-the-ground management actions *Please note if they are existing (E) or new (N)
Increase in number of short-term droughts resulting in decline in forest productivity and tree survival associated with water limitation. Timeframe: long-term		
Earlier and warmer springs and smaller snow packs, and hotter drier summers conducive to increased fire risk. Timeframe: immediate		
Loss of fire intolerant species and increase in fire tolerant species, such as red and pitch pines. Timeframe: immediate		

SCENARIO 3: INCREASE IN EXTREME STORM EVENTS – ADAPTATION STRATEGIES FOR MANAGING RESILIENCE

Identify the broad adaptation strategies that would strengthen the abilities of sites, habitats, and species to resist stress under a changing climate. For each strategy identify specific on-the-ground actions, considering the following categories: monitoring, conservation, technical assistance, education/outreach.

Ecological Effects	Adaptation Strategies *Please note if they are existing (E) or new (N)	On-the-ground management actions *Please note if they are existing (E) or new (N)
Increased physical damage and disturbance, leading to declines. Timeframe: immediate.		
Increased gap formation, which facilitates the spread of invasive plants. Timeframe: immediate		

Anticipated Climate Changes To Upland Forests And Direct And Indirect Responses

Temperature increases

- Warmer winters
- Earlier springs
- Hotter summers
- Later falls

Severity and frequency of Storms (hard to predict)

- Increased wind, ice and heavy snow events
- Increased flooding

Precipitation changes (less certain)

- Increased precipitation
- Increased heavy precipitation events

- Increased survival of cold-sensitive plants and animals
- Asynchrony in spring phenology
- Heat stress during growing season
- Lengthened growing season
- Change in plant hardiness zones
- Increase freeze/thaw cycles

- Decrease snow pack
- Increased evapotranspiration
- Increased short term droughts
- Increased fire risk
- Decreased soil moisture

Potential Effects

- *Increased productivity of invasive plants*
- *Increased vulnerability to late spring frosts*
- *Spring asynchrony changes negatively impact migratory species and pollinators*
- *Increased forest fire risk*

- *Change in tree productivity and regeneration*
- *Change in deer & moose browsing patterns*
- *Increased forest gap formations*
- *Increased damage from hemlock woolly adelgid and balsam woolly adelgid*

Natural Communities

The following climate adaptation strategies could be applied across all Natural Forest Communities:

1) Sustain fundamental ecological functions: protect soil quality, nutrient cycling, and hydrology (resiliency)
2) Reduce impact of existing biological stressors: increase pest and pathogen resistances, prevent herbivory, prevent invasive species
3) Prevent severe fire and wind disturbance
4) Maintain or create refugia
5) Increase ecosystem redundancy
6) Maintain species and structural diversity
7) Facilitate community adjustments through species transition
8) Promote Landscape Connectivity

Summary of Northern Hardwood Strategies

a. Retain or establish species with high nutrient cycling capability: basswood, ash, aspen, pin cherry, and rubus.
b. Retain or enhance coarse and fine woody material for added nutrient cycling, soil protection
c. Limit single tree selection harvests or harvests where tending in the matrix occurs to winter conditions.
d. Monitor jobs for temporary closure due to weather and soil conditions
e. Encourage the use of cut to length systems, forwarders, and smaller skidders for steep terrain
f. Manage deer populations to prevent herbivory
g. Install deer exclusion fencing when necessary
h. Monitor for early detection of invasive species, eradicate or control with IPM
i. Identify and protect refugia across the landscape, cove hardwoods, Talus woodlands
j. Protect unusual and rare natural communities in reserves or in UVA ESTA categories
k. Manage for age and structural diversity
l. Restore riparian areas and upland forest adjacent to riparian area
m. Plant hedgerows and fencelines wider and with a greater diversity of climate adapted species
n. Favor for retention species at the north edge of their range, that may be better suited to future conditions, i.e. red oak, hickory, white pine, disease resistant chestnut, tulip poplar in the southern counties.
o. Retain long-lived species as Biological legacies. Sugar maple, Oaks, Hickory, Hemlock

General Adaptation Strategies

1) Create a network of conserved lands across the state that represent the array of biological and geophysical conditions within each biophysical region.

2) Develop a coordinated system of monitoring of ecological response and ongoing sharing of current information with land managers.

3) Develop goals and objectives that maintain options (hedging) by creating a diversity of species, ages, and condition at a parcel and regional level.

4) Promote a regional discussion regarding the validity and required investment needed to practice 'assisted migration' of key tree species.

5) Instill a focus on successful regeneration development of key legacy species (northern hardwood and boreal species) and projected species that could be dominant in a change climate (oaks-pines-black birch-red maple).

6) Develop silvicultural and operational techniques that increase biomass retained on site for carbon storage, increased stand level retention, minimal site disturbance where scarification is not an objective, and extended rotations and cutting cycles to develop late successional stands comprised of a diversity of species.

7) Develop and coordinating a statewide control effort to limit the success of invasive trees, shrubs, grasses, and herbs that outcompete native species.

8) Management planning conducted through the Current Use program and on State Lands typically include an assessment of forest health and some form of goals, objectives, and land use allocation. Changes to the breadth, scope, and focus of this aspect of planning and decision making are important to developing a resilient forest.

9) Assess the suitability of trees and forest stands for the sites they occupy and managing natural communities for long-term stability on appropriate sites.

10) Focus on developing regeneration.

11) Evaluate parcels for the presence of key matrix and unique communities on key geophysical settings and developing plans for conservation and management of these areas on public land, and voluntarily, particularly through ESTAs, on private lands in Current Use.

12) Our changing environment warrants an update of the *2010 Vermont Forest Resources Plan* to include a specific section on adapting forestry and monitoring forest and land management in response to climate change.

13) The 2001 report *'Conserving Biological Diversity in the Green Mountain State'* offers a framework for conserving the breadth of biodiversity in the state that should enhance ecosystem resiliency to climate change. Its full implementation should be a priority of the Agency of Natural Resources, conservation organizations, and land managers.

Adaptation Strategy #1: Maintain species, structural, and age class diversity. Sustainable management strategies that maintain species, structural, and age class diversity are important in the face of climate change because they can create a mosaic of habitats for existing wildlife species and new species that may shift into the area, diversify stands with species and age classes that are less vulnerable to climate impacts, protect against widespread damage and financial loss due to disturbance events, and create economic opportunities by managing for species that are well suited to changing climatic conditions.

Best Management Practices:

1. Create multi-aged stands
2. Plan to diversity species mix of red pine plantations
3. Retain areas with no or limited harvesting
4. Use short-rotation forestry when appropriate

Adaptation Strategy #2: Conduct sustainable timber harvests. A shortened winter logging period, extended mud season, and increasingly frequent and severe storm events are likely to reduce the number of days with conditions favorable for low-impact logging, increase logging costs as machinery sits idle during marginal and unfavorable conditions, and increase pressure on managers to operate during marginal or unfavorable conditions, risking damage to soil and water quality.

Best Management Practices:

1. Continue to apply best management practices (BMPs) and sustainable forestry practices
2. Create infrastructure that can withstand a variety of weather conditions
3. Track and respond to changing soil and weather conditions

Adaptation Strategy #3: Maintain and increase red oak and white pine on site. Red oak and white pine are well suited for the warmer temperatures and altered precipitation patterns expected under climate change in Maine and are highly valued for forest products.

Best Management Practices:

1. Use shelterwood harvest systems to increase red oak and white pine

Adaptation Strategy #4: Be aware of and plan for threats facing hemlock stands. Infestations of Hemlock Woolly Adelgid (HWA) … and temperature stress have profoundly negative implications for the long-term survival of hemlock in Allen-Whitney Forest.

Best Management Practices:

1. Track HWA in Vermont and on-site
2. Reduce risk of introduction and spread of HWA
3. Be prepared to implement hemlock management options if HWA arrives

Adaptation #5: Promote regeneration of native tree species. Invasive plants are expected to thrive under a changing climate, allowing these species to outcompete native trees and quickly colonize forestland.

Best Management Practices:

1. Track existing and emerging threats of invasive species
2. Develop a modest but effective monitoring program for invasive species
3. Control invasive species at the early stages of infestation

Adaptation Strategy #6: Minimize negative impacts of disturbance events. The frequencies and intensities of widespread disturbances are predicted due to climate change, resulting in injury or death of canopy trees and loss of economic value.

Best Management Practices:

1. Identify stands most vulnerable to disturbance events
2. Monitor regeneration and invasive species after stand-replacing events

Adaptation Strategy #7: Create a low-impact recreational trail system. Winter recreation is highly vulnerable to climate change. Decreases in the depth and duration of snow cover and increases in extreme precipitation events associated with climate change may degrade trail quality and become a significant source of sediment to water bodies.

Best Management Practices:

1. Maintain low-impact and high quality trails
2. Clearly communicate permitted recreational uses

Adaptation Strategy #8: Encourage deer management. As winters warm and the depth and duration of snow cover decreases, herd size and deer density will increase. Increased deer herds can damage vegetation, interfere with forest regeneration, and increase the abundance of deer ticks and instances of Lyme disease.

Best Management Practices:

1. Continue to provide hunting opportunities.

Adaptation Strategy #9: Be aware of the need for cross-sector adaptation planning at landscape, state, and regional scales. Climate change impacts multiple economic sectors (e.g. natural resources, transportation, and public health), requiring coordination among government agencies, non-profits, and other stakeholders to effectively prepare for these changes. In addition, climate change adaptation must include regional and statewide approaches to fully protect forestland.

Best Management Practices:

1. Be aware of landscape-scale adaptation planning efforts
2. Be aware of interdisciplinary adaptation efforts

Forest Operational Strategies

- Use seasonal weather forecasts to understand probable conditions and plan operations.
- Reduce soil disturbance during harvesting and site prep to:
    - Reduce invasive spread
    - Reduce compaction and forest floor displacement to retain soil water holding capacity
- Anticipate changing harvesting season as snow pack and frozen soils are less dependable (longer spring and fall shut downs are possible)
- Chip debris for mulch (improve soil moisture holding capacity and add nutrients

  The increased frequency of extreme precipitation events, major storms, snow accumulation and melt and freeze thaw action will result in likelihood of soil saturation and slope instability, as well as risk to drainage system failures
- Assess road drainage systems, and upgrade where necessary

Planning for the protection of the Forest Operation Site (Where the opportunities exist to plan for operational considerations at the site level with climate change in mind)

- At the Management Plan level (Ownership Scale) – broad strategies can be developed here and some of the specific elements maybe discussed for the 10 – 15 year term of the plan
- Annual work planning (if done for a specific property/owner) actual site conditions and silvicultural treatments are discussed and fine tuned.
- Operational layout (on-site planning), this is truly the on the ground portion where the forest manager will be looking to evaluate the site characteristics along with the environmental conditions and silvicultural prescription to indentify the best management practices to protect the site.
- Actual operation – Communicating how the timber harvesting is to be performed and any specific steps that need to be taken to address operational modifications. Use a timber sale contract to provide written documentation
- Stream Crossings – consider the use of temporary skidder bridges over other temporary crossing methods. See http://www.vtfpr.org/watershed/initiative.cfm
- Manage and maintain riparian buffers to protect water quality

Herbivory Adaptation Strategies

- Continued balance of focus between hunter satisfaction and forest sustainability with a focus on controlling populations aggressively where native regeneration success is hampered by browsing.
- Incorporation of USFS FIA results in population planning by F&W and regeneration planning by managers.

Invasive Plant Species Adaptation Strategies

It is imperative that efforts be made to control the spread of invasive plant species as we move toward the novel forest. With no intervention the invasive species problem could be the greatest driver in ecosystem collapse. Strategies that should be employed to address the problem include:

- Continue to educate the public (landowners, forester, loggers, landscapers) on the identification and control of Invasive species; encourage annual scouting
- Prevent introduction of invasive plants: avoid or limit activity including in infested areas, clean equipment before moving from one site to another; carry out forest management activities when conditions limit spread, such as on frozen ground or snow cover
- Require invasive species detection and control to be part of the inventory and silvicultural prescriptions in all UVA plans
- Develop an Integrated Pest Management Plan to address infestations based on level and severity of infestation, difficulty to kill, potential impacts, and feasibility to eradicate or control
- Provide funding to landowners for invasive plant species control
- Require Town Road crews to remove invasive plants within the town road Right of Way as part of a biannual roadside maintenance and during road repair and construction

Excerpts from the VT SCORP, 2010 Vermont Forest Resources Plan, and 2008 VT SWAP

From: Vermont Department of Forests, Parks and Recreation. 2005. VERMONT OUTDOOR RECREATION PLAN, 2005-2009. Vermont Department of Forests, Parks and Recreation, Waterbury, Vermont.

B. Vermont's natural resources base, which provides the foundation for outdoor recreational pursuits, is conserved and enhanced.

Strategy: The conversion of forested and agricultural lands to development is minimized.

Actions:

- Local, regional, state, and federal agencies in Vermont coordinate growth planning efforts as well as the development of growth management policies to determine the best places for growth to occur.
- Regional commissions provide assistance to towns and municipalities in developing land use plans that encourage the conservation of forests, aquatic resources, and open space.
- Public agencies and nonprofit organizations protect important forested and agricultural lands from development by acquiring conservation easements on them.

Strategy: Overuse and misuse of Vermont's natural resources are avoided.

Actions:

- Communication occurs between natural resources managers and recreational users when overuse and other impacts on natural resources are anticipated or occurring.
- Strategies are in place for modifying recreational uses when impacts on natural resources occur.

Strategy: Management efforts that improve Vermont's natural resources are encouraged.

Actions:

- Existing resources within communities are leveraged to address common goals regarding natural resources and associated recreational opportunities.
- Natural resource managers learn how to make adjustments in management due to impacts from climate change.

C. The quality of existing outdoor recreation facilities, programming, staffing, and operations is high.

Strategy: Outdoor recreation providers and user groups apply a variety of methods to support the maintenance of existing outdoor recreation facilities.

Actions:

- Recreation providers seek assistance from volunteers who may assist with maintenance tasks when appropriate.
- User groups serve as stewards for existing recreation resources.

Strategy: Outdoor recreation providers and user groups apply a variety of methods to maintain safe facilities, operations, and programs.

Actions:

- Strategic plans of organizations and agencies that provide recreation resources highlight the importance of maintaining these resources in safe condition.
- Managers conduct research to better understand user safety concerns.
- Providers establish life-cycle maintenance schedules for facilities and tie them to their operational budgets and capital improvement plans.
- Staff and volunteers receive proper training in safety procedures.

Strategy: Access to existing water and land resources for outdoor recreation is improved.

Actions:

- Agencies and organizations identify and suitably publicize access locations.
- Work with private landowners in securing access locations, especially where public resources can be accessed only from private land.

D. Vermont meets increasing needs for outdoor recreation by making more resources and a wider variety of programs available, especially for public lands and facilities.

Strategy: Suitable lands and properties are acquired for the public, new facilities are built, and new programs are created to meet public recreation needs, especially in areas of high demand.

Actions:

- Recreation providers and user groups participate in regional recreational needs assessments, including cost-benefit analyses, which are used to set priorities for new recreational facilities, programs, and open spaces.
- Outdoor recreation projects reflect state, regional, and local recreation planning processes.
- Communities plan for the conservation of outdoor space and natural areas for outdoor recreation in or near areas of population concentration.
- Recreation providers offer more access to outdoor recreational sites, where needed and appropriate.

- Leaders in every town understand the tax and economic benefits and consequences of conserving land in their town.
- Outdoor recreation acquisitions and projects help relieve pressures for use in areas where there are user conflicts or where demand is excessive or anticipated to become so.
- Public access and use are secured through acquisition of property and land and rights to use of land.

Strategy: The benefits to the environment and future generations are considered in the development of outdoor areas, facilities, and programs.

Action:

- Providers and user groups identify linkages between existing recreational resources to determine where to focus new acquisitions, which may serve multiple functions such as conserving wildlife and preserving historic resources.

Strategy: Funding and staff are available for expanding recreational facilities and programming.

Actions:

- Statewide coordination is provided for volunteer activities, including recruitment and training, organizing friends groups for parks, watersheds, and other recreational resources, obtaining insurance, and publicizing volunteer "job" descriptions in a central database for all levels of agencies and organizations.
- Providers find alternative funding sources, including grants and funds from state and federal agencies that support the development of new facilities and programming efforts.

Strategy: Traditional recreational offerings are expanded to other venues and to coincide with special events.

Actions:

- Providers establish partnerships for providing complementary and expanded recreation programs, services, and resources.
- Providers expand program opportunities to include related resources, such as historic and agricultural, which may be of interest to some recreationists.

E. Vermont outdoor recreation providers and users develop creative solutions for resolving outdoor recreation conflicts.

Strategies (e.g., ATVs using snowmobile trails):

Actions:

- Whenever recreation issues are to be discussed or services changed, all stakeholders should be involved in those discussions so that potential conflicts can be resolved as early in the process as possible.
- Vermont should build on the successful resolutions of conflicts that have occurred here and should look for other models to follow when needed.
- Participants who engage in recreational activities that use the same resources or locations are encouraged to find ways of sharing, including usage on alternating days or adjustments for time-of-day.

I. Information about Vermont's outdoor recreation opportunities is provided in user-friendly ways and directs people to appropriate places.

Strategy: Recreation providers have accurate and up-to-date information about experience types and user trends at Vermont recreation sites.

Actions:

- Recreation providers monitor and report site conditions to a central location.

A. Vision, Desired Conditions, and Strategies: The Action Plan

2. Strategies for Developing Trail Resources

Providers and user groups employ the following strategies when developing new trails:

- Coordinate with pertinent town, regional, and transportation plans.
- Minimize impacts to wildlife and habitats, waters, and other natural resources.
- Follow laws and procedures for siting trails in safe locations, using proper materials and signage.
- Design trails for the degree of anticipated use, or greater capacity, by that user group.
- Assist private landowners with permits and other requirements that may be needed for trails on their lands, e.g., Act 250 and storm water runoff.

3. Strategies for Managing and Maintaining Trail Resources

Providers and user groups employ the following strategies when managing and maintaining trail resources:

- Encourage shared use of trail resources and designate multi-use trails wherever possible, where appropriate, and by considering the interests of all users.
- Ensure the safety of trails through the use of effective trail design standards, education of users, and by keeping trails in good condition.

- Maintain trails, including Class 4 roads, in good condition so that impacts to natural resources, including adjacent waters, are minimized.
- Monitor trail use and condition, determine the carrying capacity of trails, and set up a reporting system for heavily-used and/or popular trail resources.
- Retire or rest overused areas and/or divert use to other areas.
- Promote the use of environmentally-friendly equipment and maintenance techniques.
- Anticipate conflicts and involve all stakeholders in seeking solutions.
- Publicize trail resources appropriately so that overuse does not occur, damage to fragile natural resources is avoided, and people are directed to the experience(s) they prefer.

5. Strategies for Providing Support for Trail Resources

- More funding sources are sought and made available to trail providers and user groups for trail protection, development, management, and use.

2010 Vermont Forest Resources Plan – State Assessment and Resource Strategies

Desired Future Condition 1: *Biological Diversity*

Conserve biological diversity across all landscapes

Goal 1: Maintain a mix of forest structure and complexity across the landscape.

Strategy 1: Encourage management activities that sustain a diversity of forest conditions and ages.

Strategy 2: Maintain a mix of programs aimed at keeping forests in forests including UVA2, Forest Legacy, local and regional planning and land acquisition.

Goal 2: Protect and conserve natural communities, genetic diversity, rare and endangered species, unique habitats, corridors and buffers.

Strategy 3: Work with partners to identify landscapes and support species of greatest conservation need.

Strategy 4: Conserve genetic diversity of species of concern.

Strategy 5: Support activities and leverage resources to protect and conserve landscapes and species of greatest conservation need.

Desired Future Condition 2: *Forest Health and Productivity*

Maintain and enhance forest ecosystem health and productivity

Goal 1: Identify trends in forest ecosystem health and productivity.

Strategy 6: Work with partners to understand Vermont's forested ecosystem.

Strategy 7: Monitor and report current forest health and evaluate potential threats.

Goal 2: Maintain productive capacity of forests.

Strategy 8: Encourage appropriate forest management that maintains health and productivity.

Strategy 9: Maintain and enhance soil productivity.

Strategy 10: Rehabilitate degraded landscapes to restore ecosystem health.

Strategy 11: Support wildland fire preparedness planning and suppression activities.

Goal 3: Retain native flora and fauna across the landscape.

Strategy 12: Prevent the introduction and slow the spread of invasive exotic species.

Strategy 13: Support monitoring and programs that maintain Vermont's common flora and fauna.

Strategy 14: Encourage retention and planting of native plant species.

Desired Future Condition 3: *Forest Products and Ecosystem Services*

Maintain and enhance forest contribution to ecosystem services

Goal 1: Maintain and enhance the production of forest products.

Strategy 15: Work with partners to assess Vermont's capacity to produce raw materials for forest products.

Strategy 16: Support the forest-based economy including maintaining and diversifying markets to encourage forest management activities and local production and use of forest products.

Strategy 18: Encourage stable solid wood and biomass supply to support forest industry.

Goal 2: Maintain and enhance water resources.

Strategy 19: Encourage inclusion of soil and water conservation considerations by foresters, forest landowners and loggers through appropriate forest planning and practices.

Strategy 20: Encourage trees and forests for flood mitigation and storm water management.

Strategy 21: Identify, conserve, restore and protect priority forested watersheds valued for water resources.

Goal 3: Maintain and enhance recreational opportunities.

Strategy 22: Build partnerships that enhance forest-based recreational opportunities.

Strategy 23: Work with partners to maintain forest access, land stewardship awareness and outreach, and well-maintained trail networks that support recreational opportunities.

Goal 4: Maintain and enhance forest carbon.

Strategy 24: Support research that improves the understanding of measuring, monitoring and trends in forest carbon, including applications for forest carbon marketing.

Strategy 25: Work with partners to enhance forest carbon market opportunities.

Goal 5: Maintain and enhance air resources.

Strategy 26: Support research and monitoring that improves the understanding of trends in air quality, weather, climate and how they affect forests.

Strategy 27: Work with partners to enhance opportunities for improving air resources.

Strategy 28: Monitor changes in forests in relation to air resources.

Desired Future Condition 4: *Land Ethic*

Maintain and enhance an ethic of respect for the land, sustainable use and exemplary management

Goal 1: Encourage public understanding of forest systems.

Strategy 29: Encourage the understanding of different forest systems and how they interact.

Strategy 30: Enhance public education and outreach on forest health and productivity issues.

Goal 2: Increase public awareness of the critical role trees and forests play in sustaining Vermont communities and residents.

Strategy 31: Enhance public awareness and education of the components of functioning urban ecosystems.

Strategy 32: Strengthen public media outreach opportunities related to forest issues.

Strategy 33: Support forestry education activities and programs.

Strategy 34: Provide information to all stakeholders on ecosystem services and the importance of forests to all ownerships.

Strategy 35: Promote wildland fire prevention to protect forested communities.

Goal 3: Increase public understanding and the application of exemplary forest management, conservation and protection.

Strategy 36: Educate the public on the value of keeping forest land forested.

Strategy 37: Promote forest stewardship through educational efforts to all citizens.

Strategy 38: Encourage citizen involvement in forest health and protection.

Strategy 39: Support environmental literacy programs by forest professionals that

improve natural resource management, conservation and protection.

Strategy 40: Educate natural resource professionals and promote management practices that maintain forest productivity and ecosystem services.

Strategy 41: Partner with State Parks, Green Mountain National Forest and other organizations to support forest-based recreational opportunities.

Goal 4: Maintain and enhance forest contribution to communities.

Strategy 42: Work with partners to encourage land use planning that maintains a working landscape.

Strategy 43: Promote and support the planning and management of urban forests at state, regional and local levels.

Strategy 44: Support local and regional efforts that encourage community forestry, economic development and strengthen land tenure.

Goal 5: Demonstrate exemplary forest management on state lands and encourage sustainable use across all landscapes.

Strategy 45: Implement forestry practices that demonstrate sustainable forest management.

Strategy 46: Expand educational opportunities on public lands.

Strategy 47: Utilize public lands as demonstration forests.

Desired Future Condition 5 : *Legal, Institutional and Economic Framework*

Vermont has a legal, institutional and economic framework in place for forest conservation and sustainability

Goal 1: Maintain an organizational structure within the Division of Forests to support management, protection, conservation and enhancement of Vermont's forests.

> **Strategy 48:** Ensure that all programs are consistent with its mission and our indicators are used to monitor progress towards maintaining healthy forests.
>
> **Strategy 49:** Maintain infrastructure, staff and an organizational structure to achieve Desired Future Conditions.
>
> **Strategy 50:** Enhance program management and program integration to improve efficiencies and effectiveness.
>
> **Strategy 51:** Facilitate effective and enduring communications within the Division and with other state and federal agencies and organizations.
>
> **Strategy 52:** Create and maintain an environment of professional development and continued learning.
>
> **Strategy 53:** Encourage an organizational culture that rewards excellence, actively encourages teamwork and provides mentoring to achieve maximum job performance and job satisfaction.

Goal 2: Expand financial opportunities to support forest stewardship.

> **Strategy 54:** Strengthen Division of Forests capacity to seek grant funding.
>
> **Strategy 55:** Provide opportunities and incentives to accept private contributions.
>
> **Strategy 56:** Support partners efforts to seek and maintain financial resources.
>
> **Strategy 57:** Keep state legislature abreast of current financial status, program efforts, opportunities and challenges.
>
> **Strategy 58:** Enhance financial collaboration with USDA Forest Service and Natural Resource Conservation Service, and others to fulfill Plan goals.

Goal 3: Strengthen, implement and enforce Vermont's forestry policies, rules and laws.

Strategy 59: Encourage a voluntary approach for attaining compliance.

Strategy 60: Support enforcement of Vermont’s laws and regulations working within Vermont’s legal system.

Strategy 61: Support an open, inclusive and deliberate process when assessing current and proposed legislation affecting forestry interests.

Goal 4: Encourage and support policies, programs and initiatives that assist private forest landowners in maintaining the working landscape.

Strategy 62: Continue to support and enhance participation in the Use Value Appraisal program as a stable tax equity program that promotes forest land retention and management.

Strategy 63: Encourage voluntary adoption and field application of best management practices for timber harvesting.

Strategy 64: Support forest landowners and the forest products industry on third-party certification and chain-of-custody marketing opportunities.

Strategy 65: Support and plan for cost-share and grant programs that assist forest landowners in management of the working forest.

VT 2008 SWAP

Birds

Research & Monitoring Needs

1. Better determine habitat requirements and habitat availability.

2. Better determine the distribution and relative abundance of populations in

Vermont.

3. Better identify and evaluate problems.

4. Obtain better knowledge of basic life history traits.

Conservation Strategies

1) Habitat Restoration via efforts on public lands and conservation payments or other financial incentives, fee simple purchase, easements, management guidelines, and cooperative agreements with user groups and private landowners. Existing technical assistance/cost-share programs (WHIP, LIP, CRP) were frequently identified as potential funding sources to implement conservation on private lands. Important Bird Area designations can aid in the development of needed funds. Common habitat restoration themes include incentives and planning to slow the rate of fragmentation and development and maintain blocks of contiguous forest, grasslands, early and late-successional habitats.

2) Species Restoration projects, which may involve active translocation of individuals or eggs from a source population into suitable Vermont habitats, and/or may involve efforts to provide suitable nesting sites and reduce predation or human disturbances around nesting sites.

3) Raising awareness within the general public to build support and opportunities for conservation techniques. Important Bird Area designations can help focus public attention on opportunity areas.

4) Developing and evaluating forestry practices that can enhance habitat suitability such as maintain or increasing aspen stands or the retention of coarse woody debris and snags. Provide technical assistance to landowners and communities about best management practices.

5) Initiate an international effort to maintain large blocks of undeveloped forests linked together by habitat corridors in order to provide a network of interconnected habitats throughout northeastern New England and southeastern Canada.

6) Identify, prioritize and maintain existing contiguous forest blocks and associated linkages that allow for upward and northward movement in response to climate change.

7) Participate in existing regulatory processes (e.g., Act 250) to protect and restore critical habitats.

Mammals

Research and Monitoring

1. Determine the distribution and relative abundance of populations in Vermont.

2. Determine critical habitat needs and connectivity requirements.

3. Identify and evaluate problems.

4. Determine life history requirements.

Conservation Strategies

1. Develop outreach and education programs that promote the conservation of SGCN and the habitats that they depend on, and increase awareness of the importance of maintaining or restoring these species.

2. Identify the habitat requirements of SGCN and develop strategies for conservation and protection through fee simple purchase, easements, management guidelines, and cooperative agreements with user groups and landowners, etc. (i.e. bat hibernaculums and maternity roost trees, bobcat denning sites, reverting field habitat for New England cottontail, bear-scarred beech stands, connective corridors, etc.).

3. Initiate an international effort to maintain large blocks of undeveloped forests linked together by habitat corridors in order to provide a network of interconnected habitats throughout northeastern New England and southeastern Canada.

4. Maintain riparian buffers along streams (see ANR 2005).

5. Maintain and restore habitat connectivity and minimize fragmentation of forest blocks. Identify and prioritize wildlife road crossing locations. Work with the Agency of Transportation and adjacent landowners to reduce wildlife mortality and increase the potential for movement from one side of the road to the other.

6. Work to eliminate pollution that causes acid rain, the deposition of heavy metals, and global climate change.

7. Continue to work cooperatively with landowners, towns, and communities to protect critical habitats and maintain connectivity. Provide Conserving Vermont's Natural Heritage to municipal and regional planners (Austin et.al. 2004)

8. Participate in existing regulatory processes (e.g., Act 250, stream alteration permits) to protect and restore critical habitats.

Reptiles and Amphibians

Research & Monitoring Needs

1. Better determine habitat needs, identify significant breeding sites, vernal pools and habitat connections.

2. Better determine the distribution and relative abundance of populations in Vermont.

3. Better identify and evaluate problems.

4. Monitor trends in population size, distribution and habitat.

Conservation Strategies

1. Help people better value reptiles and amphibians and to understand the essential needs of all life stages, especially upland habitat in proximity to breeding pools.

2. Encourage reports of road-killed specimens, road crossings, and road basking areas to VFWD, VTrans, and the Vermont Reptile and Amphibian Atlas Project. Develop safer crossings at significant sites when roads are being upgraded.

3. Maintain habitat through appropriate management, direct habitat disturbance and site roadways away from sensitive sites such as breeding pools.

4. Continue to work cooperatively with landowners, habitat management agencies, towns and communities to protect habitat and maintain connectivity. Develop management guidelines for owners and managers of appropriate habitat.

5. Conserve known critical habitat through fee simple purchase, development rights or easements, management agreements and education of private landowners and managers.

6. If loss of important sites is likely due to development, consider creating or enhancing other pools that might allow some adults to transfer to the new site if they encounter it or develop a new breeding population from dispersal of colonizers.

7. Protect turtle nests and adults by predator trapping.

8. Work with biologists to minimize impacts to SGCN populations and habitats during and following management activities for sport fish and game wildlife.

9. Participate in existing regulatory processes (e.g., Act 250, stream alteration permits) to protect and restore critical habitats.

Appendix 4B

Rivers handouts from the December 11 adaptation strategies workshop

TERMINOLOGY

Effects – ecological responses to a given climatic exposure (or combination of exposures); these can be direct or indirect.

Adaptation strategies – actions taken to prepare for climate change, helping to reduce adverse impacts or take advantage of beneficial ones (Rosenzweig et al. 2011).

Mediating factors - factors that will lessen or worsen the degree of impact. Some are naturally occurring and cannot be altered (i.e. elevation, latitude), while others can be influenced by human factors (i.e. shading/riparian buffer).

FORMAT FOR RIVERS BREAKOUT SESSION

10:00-10:15 Introductions, overview of format, discussion of how information gathered during these discussions will tie into **Vermont's existing management strategies (surface water management strategy, river corridor easement program, healthy watersheds initiative, SWAP plan)**
10:15-11:00 Scenario 1: **warming temperatures**
11:00-11:30 Scenario 2: Increase in **heavy/extreme precipitation** events that could potentially lead to flooding and large hydrologic inputs
11:30-12:00 Scenario 3: extended summer **low flow** conditions

We realize this schedule may be too ambitious, so we'll see how things go and adapt as the group sees fit.

For each scenario, we will go through the following steps:

1. **Review ecological effects** (5 minutes for each scenario) and mediating factors as presented in the attached tables and conceptual diagrams. The information in the tables and diagrams is essentially the same for each scenario, but in different formats. We will ask you whether you have any suggested edits or additions to these tables and diagrams.
2. **Brainstorm adaptation strategies** that would manage river habitats for greater resilience to impacts. This is a broad category of actions that would strengthen the abilities of sites, habitats, and species to resist stress under changing climate scenarios (such as increased temperature and more frequent large precipitation events). Example: conserve existing cold water refugia.
3. For each strategy, **brainstorm on-the-ground management actions that support these strategies, whether currently in place or not** (example: pursue an active tree planting program along shorelines). As you go through this, please keep in mind the following general categories of management actions - Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach - and please make notes on the feasibility of implementation.
4. If any of the **actions are currently being implemented**, note which program/entity is doing so. Also consider potential partners, timeframe for implementation and scale (local, regional, etc.).
5. In some situations, preservation action may not fully mediate impacts in the long term; change will occur eventually (example: in some rivers, warming temperatures associated with climate change will result in the eventual loss of cold water species, regardless of what management actions are taken). We will discuss implications of some of these **anticipated changes**, as well as steps that VANR could potentially take to manage/plan for these anticipated changes.
6. Identify key **research needs/data gaps** that would need to be completed to support each management strategy, and discuss potential ways to address these needs and gaps.

7. At the end of the first session, the group will identify **top pick(s) for on-the-ground management actions**. Following lunch, the group will discuss/rate the following about those top pick(s):

    - Effectiveness at mitigating (i.e. scientific basis for recommending this action)
    - Operational feasibility (i.e. Amount of $, resources required to implement)
    - Degree of current implementation (Describe)
    - Level of alignment with current policies, procedures, BMPs (describe)
    - Social/political acceptability and feasibility
    - Potential for securing funding

SCENARIO 1: WARMING TEMPERATURES - River Habitat Vulnerabilities

<table>
<tr><th>Ecological Effects</th><th>Mediating Factors (+/-)</th></tr>
<tr><td>1. Loss of cold water (in-stream) habitat, resulting in compositional changes (loss of cold-adapted species like brook trout, slimy sculpin and eastern pearlshell) and increase in warm-adapted species). Timeframe: Long-term, but localized effects could occur on a shorter timescale.

2. Increase in overwinter survival of hemlock woolly adelgid, resulting in loss of riparian shading. Timeframe: Immediate.

3. Increased physiological stress, resulting in increased susceptibility to pests and disease, decreased productivity and increased mortality. Timeframe: Immediate.

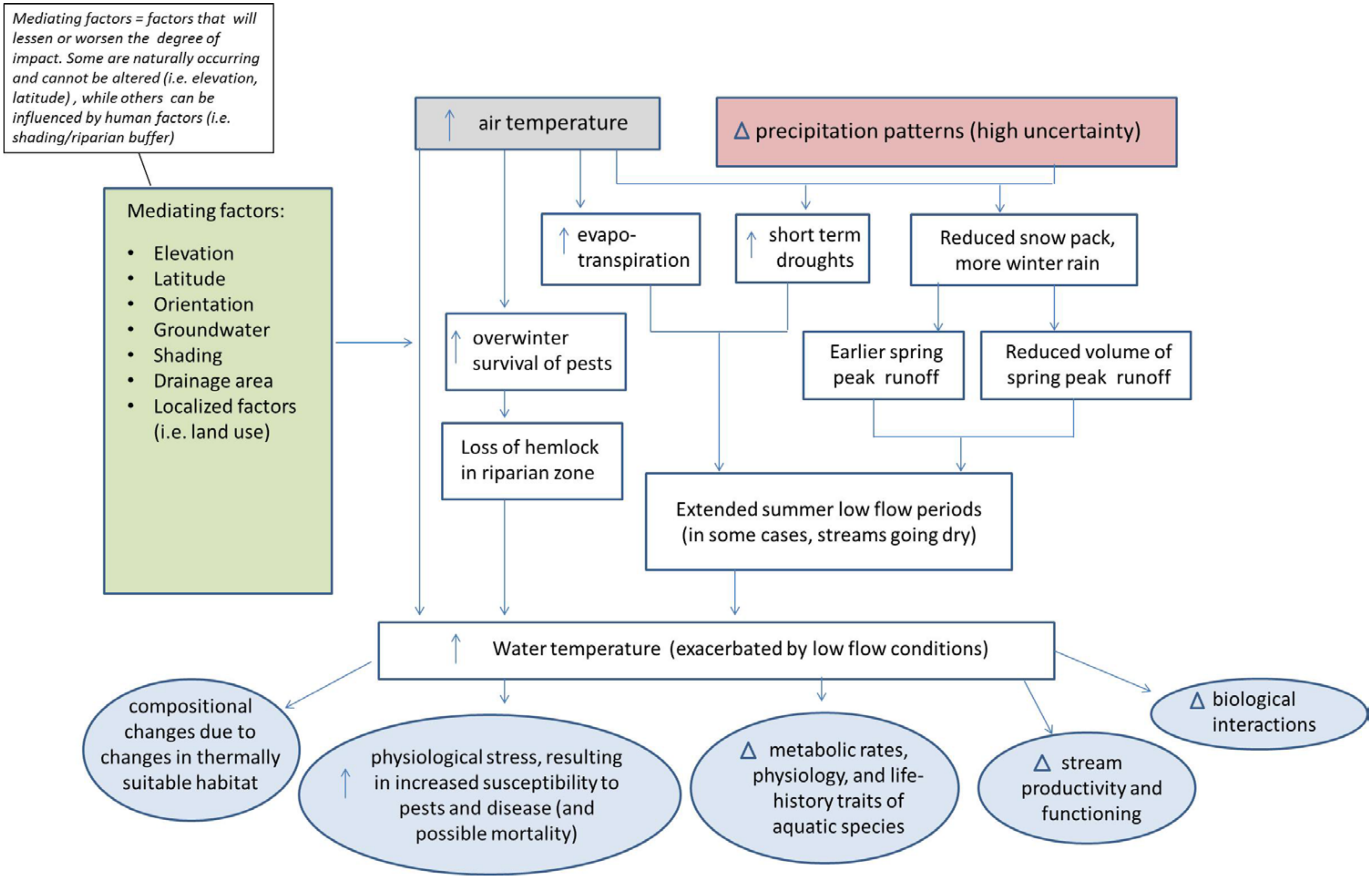
4. Increased evapotranspiration, resulting in a decrease in soil moisture in riparian areas (and potentially in a decrease in the water table); certain organisms are particularly vulnerable to moisture limitations. Timeframe: Immediate.

5. Complex, interacting changes in stream productivity (primary productivity, respiration, decomposition) and function. Timeframe: Immediate.

6. Changing metabolic rates, physiology, and life-history traits of aquatic species. Timeframe: Immediate.

Others?</td><td>• Orientation (north/south)
• topography/slope
• latitude
• elevation
• groundwater influence
• shading
• watershed size
• color
• connectivity (ability for organisms to disperse locally and regionally)
• availability of refugia
• warming from human constructed impoundments
• localized factors (i.e. surrounding land use)

Others?</td></tr>
</table>



Conceptual Diagram
SCENARIO 1: WARMING TEMPERATURES - River Habitat Vulnerabilities

SCENARIO 1: WARMING TEMPERATURES - ADAPTATION STRATEGIES FOR MANAGING RESILIENCE

These are broad strategies that will strengthen the abilities of sites, habitats, and species to resist stress under a changing climate). Please consider the following categories of on-the-ground management actions: Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach.

Strategy	On-the-ground management actions	New or existing	Notes
Promote shading	Riparian **buffer** protection (Education? Regulation? Incentives?)		
	Pest control for **woolly adelgid**, **emerald ash borer, Japanese knotweed** (or anticipate planting new tree species to provide shading?)		
Conserve existing refugia	Identify watersheds with **cold water refugia** and high resiliency (strong groundwater influence, north-facing, good shading, land ownership (federal or state), watershed size, representation of elevational and topographical gradients); make these high priority for protection, and preserve connectivity in these watersheds		Potential partner: Green Mountain National Forest
Restore watersheds to provide more refugia/ Reduce other stressors to help make watersheds more resilient	**Tree plantings** along riparian corridors		
	Minimize **impervious surface** in watersheds with cold water refugia (regulatory?)		
	Retrofit culverts to allow for passage of aquatic organisms (where appropriate); prioritize so that connectivity is established in watersheds that have been identified as key cold water habitat.		

Strategy	On-the-ground management actions	New or existing	Notes
Improve monitoring, measurement, and data gathering and distribution to provide the information needed to adapt	Gather continuous water **temperature data** at sentinel sites to track whether changes are occurring as projected and to gain a better understanding of how big a difference mediating factors (i.e. groundwater influence, orientation, color) make		
	Support the continued operation of **USGS gages**		
	Install **pressure transducers** at sentinel sites to track long-term hydrologic changes in small to medium-sized, high quality streams; collect biological data at these sites as well, as this will help further our understanding of biological-hydrologic interactions		
	Consolidated database with information on VT's **groundwater** resources and water withdrawals?		
Examine and revise **regulatory mechanisms** and land use policies such as zoning, setbacks, building codes, and incentives, taking climate change into account			

SCENARIO 1: WARMING TEMPERATURES - <u>ANTICIPATING CHANGES</u>

In some situations, preservation actions are likely going to be unsuccessful in the long term: some changes will occur eventually. Here we discuss implications of some of these anticipated changes, as well as steps that VT ANR could potentially take to manage/plan for these changes.

Compositional changes may result in some species being placed on the ***threatened or endangered species list*** *for climate change. What are the implications of this? Would you potentially have to relocate some species, like the eastern pearlshell mussel?*

The loss of coldwater habitat will result in the ***loss of cold water taxa*** *like brook trout and slimy sculpin from some streams. This compositional change could have regulatory implications under the Clean Water Act, since it is possible that some sites (even reference sites) will no longer meet the* ***bioassessment criteria*** *required to attain aquatic life use standards established for a given stream. Are there any pro-active steps that VT ANR can take in anticipation of these situations (i.e. do you foresee doing use attainment analyses (UAAs))?*

What if an assemblage retains full functionality but loses some rare native species (i.e. brook trout drop out but another top predator moves in; for those of you familiar with the **Biological Condition Gradient***, this means dropping from a Level 2 to a Level 3)?*

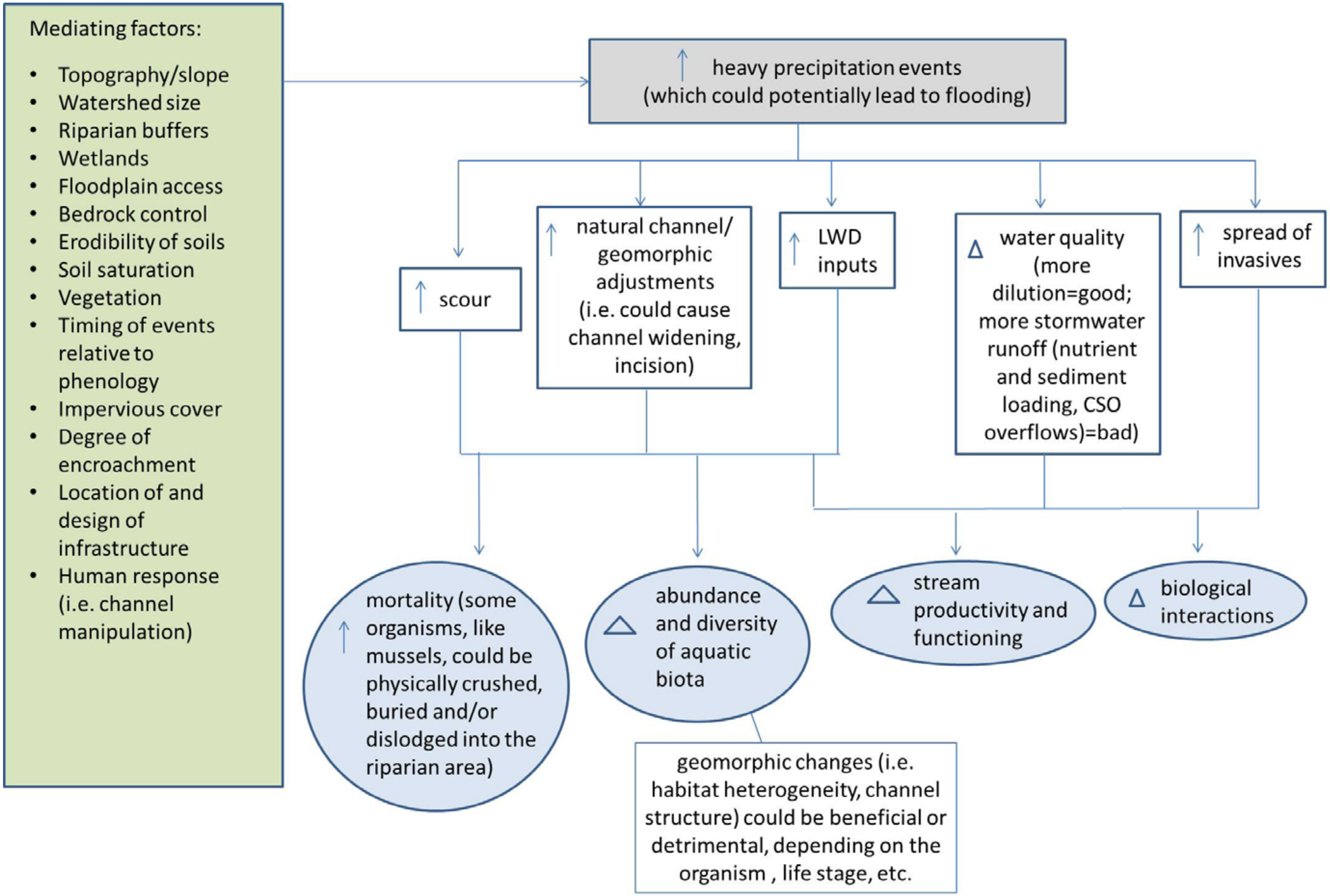
KEY RESEARCH NEEDS/DATA GAPS AND THOUGHTS ON HOW TO ADDRESS THEM

Better understanding of groundwater resources and groundwater-surface water interactions

Ecological thresholds/tipping points

SCENARIO 2: INCREASE IN EXTREME/HEAVY RAINFALL EVENTS THAT COULD POTENTIALLY LEAD TO FLOODING) - River Habitat Vulnerabilities

<table>
<tr><th>Ecological Effects</th><th>Mediating Factors (+/-)</th></tr>
<tr><td>1. Increased mortality (some organisms, like mussels, could be physically crushed, buried and/or dislodged into the riparian area). Timeframe: immediate.</td><td rowspan="7">Availability of refugia,
capacity of catchment to absorb water (i.e. open water and wetlands, floodplain access)
topography/slope
watershed size
erodibility of soils
soil saturation
bedrock control
vegetation
timing of events relative to phenology
localized factors (i.e. impervious surface, degree of encroachment, buffers)
location of and design of infrastructure (i.e. culverts, bridges)
human maladaptive response (i.e. instream channel manipulation following floods)
Others?</td></tr>
<tr><td>2. Scour could negatively impact long-lived species that are slow to recolonize (i.e. mussels, mosses); impacts on fish and macroinvertebrates would be shorter-lived (i.e. 1-year). Timeframe: immediate.</td></tr>
<tr><td>3. Facilitates spread of invasives like knotweed. Timeframe: immediate.</td></tr>
<tr><td>4. Natural channel/geomorphic adjustments (i.e. channel widening, channel incision) could be beneficial or detrimental to aquatic habitat (and biota), depending on the organism and localized conditions (i.e. channel widening could lead to a decrease in riparian shading and LWD input; in the short term, channel incision could decrease the frequency of floodplain access during moderate flood events, resulting in higher power/scouring flooding and longer intervals between disturbance events that maintain floodplain/riparian habitats). Depending on the pace of climate changes and if/when climate re-stabilizes, rivers may eventually complete an adjustment process, leading to a less erosive, more stable form that includes beneficial floodplain access. Timeframe: immediate to long term.</td></tr>
<tr><td>5. Increase in large woody debris inputs, which could be beneficial or detrimental, depending on the organism and localized conditions (Langford and Langford 2012). Timeframe: immediate.</td></tr>
<tr><td>6. Changes in water quality; these could be detrimental in some cases (i.e. more stormwater runoff means more nutrient, sediment and toxin loading flowing into receiving lakes) and beneficial in others (i.e. more dilution, flushing of sediments, benthic algae could benefit).</td></tr>
<tr><td>Others?</td></tr>
</table>



Conceptual Diagram

SCENARIO 2: INCREASE IN HEAVY RAINFALL EVENTS (WHICH COULD POTENTIALLY LEAD TO FLOODING) - Vulnerabilities

SCENARIO 2: INCREASE IN HEAVY/EXTREME RAINFALL EVENTS - MANAGING RESILIENCE

These are broad strategies that will strengthen the abilities of sites, habitats, and species to resist stress under a changing climate). Please consider the following categories of on-the-ground management actions: Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach.

Strategy	On-the-ground management actions	New or existing	Notes
Conserve existing refugia	Protect ecologically and physically functioning floodplains, especially those with intact riparian forests/wetlands		
Restore watersheds to provide more refugia/ Reduce other stressors to help make watersheds more resilient	Protect and restore key floodplains within the watershed to act as flood relief valves to store floodwaters, sediment, LWD, etc.		
Examine and revise regulatory mechanisms and land use policies such as zoning, setbacks, building codes, and incentives, taking climate change into account			

Strategy	On-the-ground management actions	New or existing	Notes
Improve monitoring, measurement, and data gathering and distribution to provide the information needed to adapt			

SCENARIO 2: INCREASE IN HEAVY RAINFALL EVENTS (WHICH COULD POTENTIALLY LEAD TO FLOODING) - ANTICIPATED CHANGES

Extreme events like flooding could have regulatory implications under the Clean Water Act, since it is possible that some sites (even reference sites) might not meet the ***bioassessment criteria*** *required to attain aquatic life use standards during a year when an extreme event occurs. In these situations, should these sites be listed on the 303d list? Are there any pro-active steps that VT ANR can take in anticipation of these situations?*

How do we determine needs for ***meander belt width****, knowing that more heavy rainfall events (and potentially more flooding) are projected to occur?*

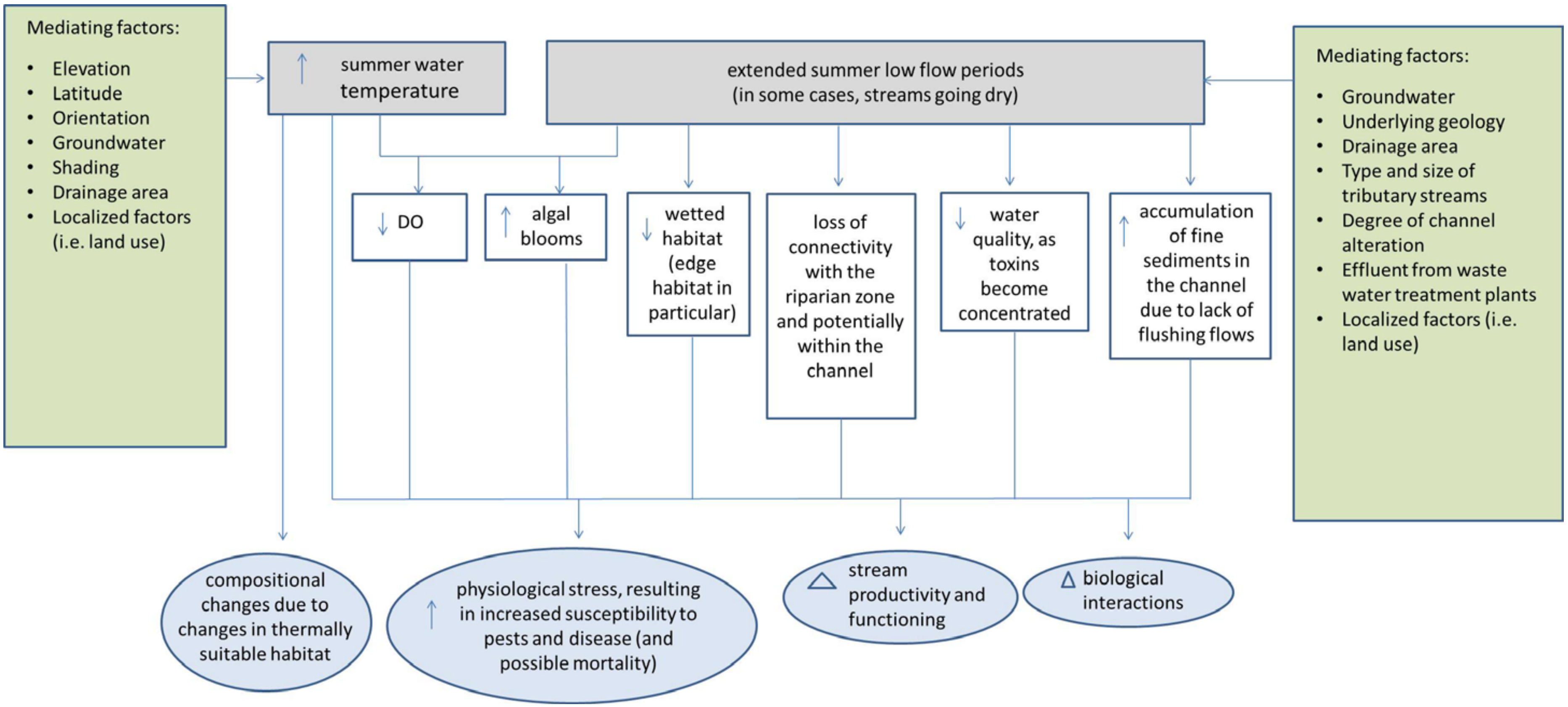
We know that ***human responses to flood events*** *can exacerbate ecological impacts, and because of current land use expectations along river corridors, some channel management may be deemed necessary to protect human safety and investments in some locations, such as in our downtown areas Are there things that we can do in anticipation of what some term 'human maladaptive responses' to help lessen these potential impacts?*

KEY RESEARCH//DATA GAPS AND HOW TO ADDRESS THEM

Better projections for precipitation

SCENARIO 3: EXTENDED SUMMER LOW FLOWS, INCREASE IN SHORT-TERM DROUGHTS - River Habitat Vulnerabilities

Ecological Effects	Mediating Factors (+/-)
1. Reduction in amount of **wetted habitat** (edge habitat in particular), which leads to more predation and more competition for limited resources. Timeframe: immediate to long-term.	• Groundwater • watershed size • underlying geology • type and size of tributary streams • degree of channel alteration • surrounding land use (i.e. impervious cover) • effluent from waste water treatment plants Others?
2. **Loss of connectivity** with the riparian zone and potentially within the channel (i.e. channel-pools may become disconnected from riffles due to drying), which affects inputs into the stream (i.e. large woody debris, leaf litter) and processing of those inputs. Timeframe: immediate to long-term.	
3. Increased accumulation of **fine sediments** in the channel, which could impact species with life stages that are sensitive to sedimentation (i.e. eggs and larvae of many invertebrates and fish require flushing flows to remove and transport fine sediments that would otherwise fill the interstitial spaces in productive gravel habitats (Poff et al. 1997)). Timeframe: immediate to long-term.	
4. Reduced **dissolved oxygen** (particularly when low flow conditions occur in combination with warm temperatures) which causes physiological stress and in some instances, mortality. Timeframe: immediate to long-term.	
5. Changes in **algal dynamics** (i.e. composition, frequency of blooms (more blooms are likely to occur when low flow conditions occur in combination with warm temperatures), which affects dissolved oxygen dynamics (i.e. diurnal flux). Timeframe: immediate to long-term.	
6. Decrease in water quality due to increased concentration of **pollutants and toxins** (i.e. from waste water); also, changing temperature and flow conditions can affect the toxicity of some substances (i.e. ammonia). Timeframe: immediate to long-term.	
Others?	



Conceptual Diagram

SCENARIO 3: EXTENDED SUMMER LOW FLOWS, INCREASE IN SHORT-TERM DROUGHTS - River Habitat Vulnerabilities

SCENARIO 3: EXTENDED SUMMER LOW FLOWS - ADAPTATION STRATEGIES FOR MANAGING RESILIENCE

These are broad strategies that will strengthen the abilities of sites, habitats, and species to resist stress under a changing climate). Please consider the following categories of on-the-ground management actions: Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach.

Strategy	On-the-ground management actions	New or existing	Notes
Conserve existing refugia			
Restore watersheds to provide more refugia/ Reduce other stressors to help make watersheds more resilient			
Examine and revise regulatory mechanisms and land use policies such as zoning, setbacks, building codes, and incentives, taking climate change into account			

Strategy	On-the-ground management actions	New or existing	Notes
Improve monitoring, measurement, and data gathering and distribution to provide the information needed to adapt			

SCENARIO 3: EXTENDED SUMMER LOW FLOWS, INCREASE IN SHORT-TERM DROUGHTS - ANTICIPATED CHANGES

*Extended summer low flow conditions could have regulatory implications under the Clean Water Act, since it is possible that some sites (even reference sites) might not meet the **bioassessment criteria** required to attain aquatic life use standards during a year when an extreme condition, like drought, occurs. In these situations, should sites be listed on the 303d list? Are there any pro-active steps that VT ANR can take in anticipation of these situations?*

*Warmer temperatures and extended summer low flow periods will pose great challenges for **waste water treatment plants**. Are there things that we can do to help prepare for these challenges?*

*Human responses to drought (i.e. increased **water withdrawals**) could potentially exacerbate ecological impacts. Are there things that we can do in anticipation of what some people term 'human maladaptive responses' to help lessen these potential impacts?*

KEY RESEARCH NEEDS/DATA GAPS AND THOUGHTS ON HOW TO ADDRESS THEM

Better projections for precipitation

Better understanding of groundwater resources and groundwater-surface water interactions

Ecological thresholds/tipping points

TOP PICKS
On-the-ground management action:
New or existing?

Considerations	**Rating (low/medium/high)**	**Notes**
Effectiveness at mitigating (i.e. scientific basis)		
Operational feasibility (i.e. Amount of $, resources required to implement)		
Degree of current implementation (Describe)		
Level of alignment with current policies, procedures, BMPs (describe)		
Social/political feasibility		
Potential for funding		

List habitat groups that this strategy has relevance to:

Other Comments:

Appendix 4C

Lakes handouts from the December 11 adaptation strategies workshop

TERMINOLOGY

Effects – ecological responses to a given climatic exposure (or combination of exposures); these can be direct or indirect.

Adaptation strategies – actions taken to prepare for climate change, helping to reduce adverse impacts or take advantage of beneficial ones (Rosenzweig et al. 2011).

Mediating factors - factors that will lessen or worsen the degree of impact. Some are naturally occurring and cannot be altered (i.e. elevation, latitude), while others can be influenced by human factors (i.e. shading/riparian buffer).

FORMAT FOR DISCUSSIONS

First we will give a **quick overview** (5-10 minutes) of **Vermont's surface water management strategy, SWAP plan** and **ANR white paper** on water resources and how information gathered from these discussions will tie into these.

Next, we will discuss 2 scenarios: 1. **Warming temperatures**; and 2. Increase in **heavy/extreme precipitation** events which could potentially lead to flooding and large hydrologic inputs. If time permits, we will open the discussion up to add additional scenarios.

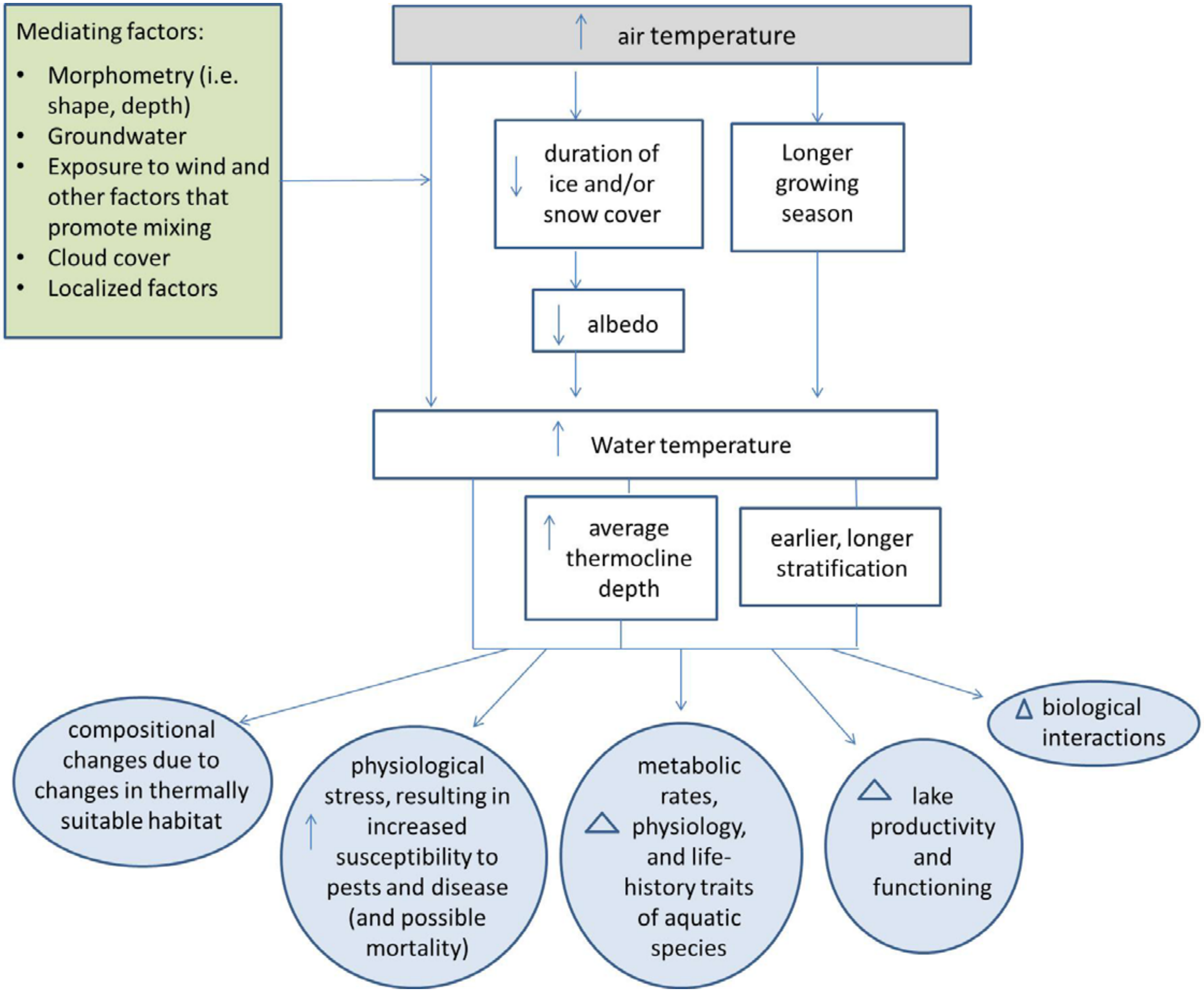
For each scenario, we will go through the following steps:

1. **Review ecological effects** (5 minutes for each scenario) and mediating factors as presented in the attached tables and conceptual diagrams. The information in the tables and diagrams is essentially the same for each scenario, but in different formats. We will ask the group whether you have any suggested edits or additions to these tables and diagrams.
2. **Brainstorm adaptation strategies** that would manage lake habitats for greater resilience to impacts. This is a broad category of actions that would strengthen the abilities of sites, habitats, and species to resist stress under changing climate scenarios (notably increased temperature and more frequent large precipitation events). Example: conserve existing cold water refugia; reduce human impacts on lakeshore habitat areas.
3. For each strategy, **brainstorm on-the-ground management actions that support these strategies, whether currently in place or not** (example: pursue an active tree planting program along shorelines). As you go through this, please keep in mind the following general categories of management actions - Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach - and please make notes on the feasibility of implementation.
4. If any of the **actions are currently being implemented**, note which program/entity is doing so. Also consider potential partners, timeframe for implementation and scale (local, regional, etc.).
5. In some situations, preservation action may not fully mediate impacts in the long term; change will occur eventually (example: in some lakes, warming temperatures associated with climate change will result in the eventual loss of cold water species, regardless of what management actions are taken). We will discuss implications of some of these **anticipated changes**, as well as steps that VANR could potentially take to manage/plan for these anticipated changes.
6. Identify key **research needs/data gaps** that would need to be completed to support each management strategy, and discuss potential ways to address these needs and gaps.
7. At the end of the first session, the group will identify **top pick(s) for on-the-ground management actions**. Following lunch, the group will discuss/rate the following about those top pick(s):

    - Effectiveness at mitigating (i.e. scientific basis for recommending this action)
    - Operational feasibility (i.e. Amount of $, resources required to implement)
    - Degree of current implementation (Describe)
    - Level of alignment with current policies, procedures, BMPs (describe)
    - Social/political acceptability and feasibility
    - Potential for securing funding

SCENARIO 1: WARMING TEMPERATURES - Lake Habitat Vulnerabilities

Ecological Effects	Mediating Factors (+/-)
1. **Loss of cold water (in-lake) habitat**, resulting in compositional changes (loss of cold-adapted species and increase in warm-adapted species). Timeframe: Long-term, but localized effects could occur on a shorter timescale.	• Morphometry (i.e. shape, depth) • shading • groundwater supply • exposure to wind and other factors that promote mixing • cloud cover • elevation • latitude • orientation, topography/slope • contributing watershed • localized factors (i.e. surrounding land use, buffers) • availability of refugia Others?
2. Increase in **decomposition** of algae and zooplankton on the lake bottom, which could increase the change of **late season hypoxia**. Timeframe: Immediate.	
3. Complex changes in the **food web**, changing **biological interactions** Timeframe: Immediate.	
4. Increase in suitable habitat for some aquatic **invasive species**. Timeframe: Immediate.	
5. **Altered habitat** and **nursery function** of **littoral zones**. Timeframe: Immediate.	
6. Longer growing seasons will allow for greater annual **primary production** in littoral areas, more **organic matter accumulation**, greater **macrophyte growth** and **shallowing**. Timeframe: Immediate.	
7. Increase in **algal blooms**, especially when warm temperatures occur in combination with low flow/low lake level conditions. Timeframe: Immediate.	
8. (Stratified lakes) Increase in average **thermocline** depth, resulting in the **loss of cold, deep water hypolimnetic habitat** and the eventual **loss of cold-water species** such as lake trout. Timeframe: Long-term, but localized effects could occur on a shorter timescale.	
9. (Stratified lakes) Earlier onset of **thermal stratification**, which could produce greater **hypolimnetic hypoxia** at the end of the summer, which would cause mortality and promote **greater phosphorus release** from the sediments. Timeframe: Immediate	
Others?	



Conceptual Diagram
SCENARIO 1: WARMING TEMPERATURES – Lake Habitat Vulnerabilities

SCENARIO 1: WARMING TEMPERATURES - ADAPTATION STRATEGIES FOR MANAGING RESILIENCE

These are broad strategies that will strengthen the abilities of sites, habitats, and species to resist stress under a changing climate). Please consider the following categories of on-the-ground management actions: Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach.

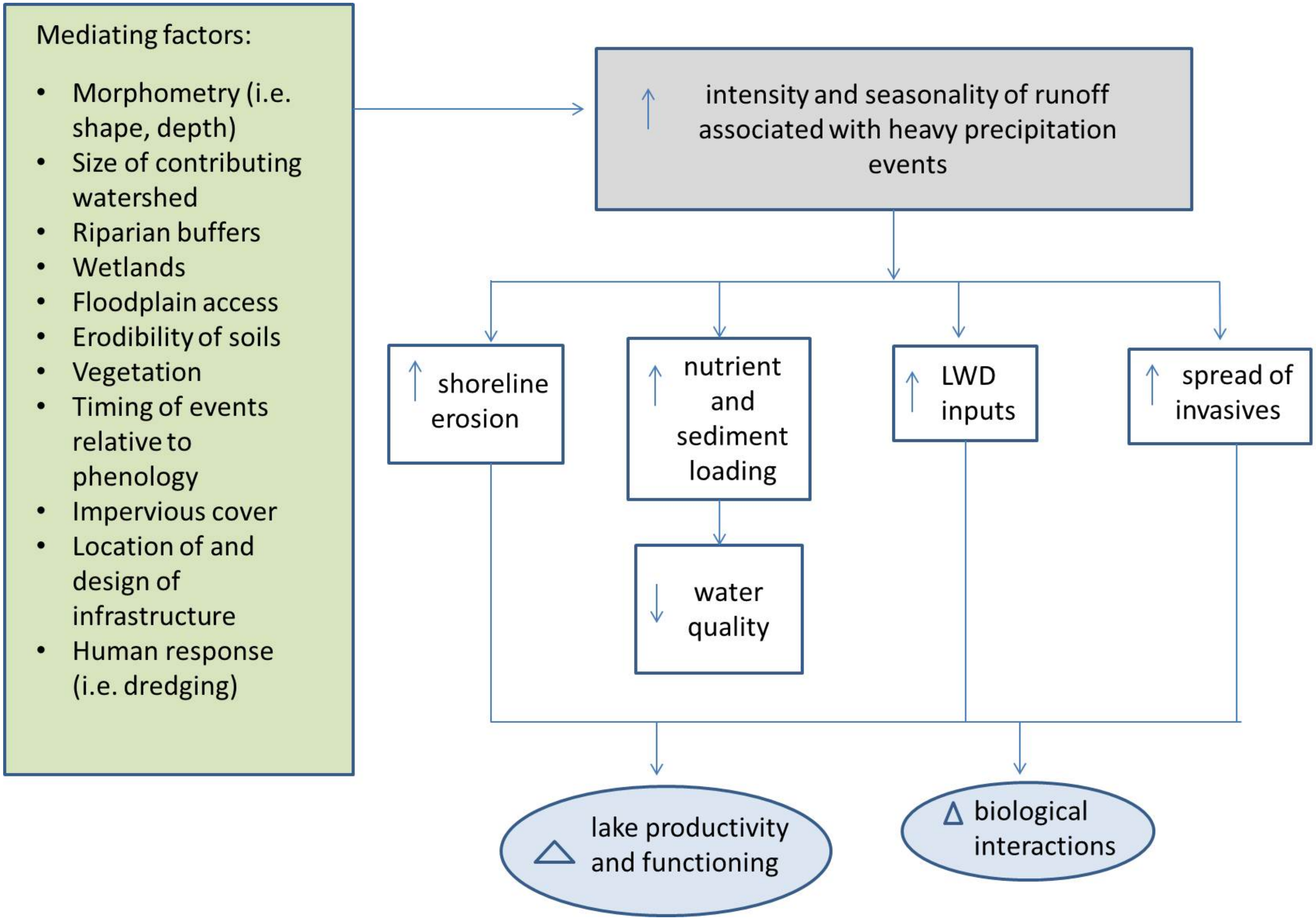
Strategy	On-the-ground management actions	New or existing	Notes
Conserve existing refugia			
Restore watersheds to provide more refugia/ Reduce other stressors to help make watersheds more resilient			
Improve monitoring, measurement, and data gathering and distribution to provide the information needed to adapt			

Strategy	On-the-ground management actions	New or existing	Notes
Examine and revise **regulatory mechanisms** and land use policies such as zoning, setbacks, building codes, and incentives, taking climate change into account			

ANTICIPATED CHANGES – MITIGATION NOT APPLICABLE		
NATURE OF CHANGE	**IMPACTS**	**IMPLICATIONS FOR STRATEGIES**

SCENARIO 2: INCREASE IN EXTREME/HEAVY RAINFALL EVENTS THATCOULD POTENTIALLY LEAD TO FLOODING – Lake Habitat Vulnerabilities

Ecological Effects	Mediating Factors (+/-)
1. Increased **hydrologic and nutrient loading**, including increased intensity and seasonality of runoff. Timeframe: immediate.	• Capacity to absorb water (i.e. surrounding wetlands & open water) • topography/slope • watershed size • morphometry (i.e. shape, depth) • contributing watershed • shoreline substrate • upstream hydrologic controls • localized factors (i.e. surrounding land use) Others?
2. **Shoreline erosion, structural damage**. Timeframe: immediate.	
3. Facilitates spread of **invasives**. Timeframe: immediate.	
4. Increase in **large woody debris inputs**. Timeframe: immediate.	
5. (Small, shallow lakes) Hydrologically sensitive to individual **flood events** and associated **sediment and nutrient loading**. Timeframe: immediate.	
6. (Large, stratified lakes) Very large flood events and associated sediment and nutrient loading could increase **turbidity**, reduce **light penetration** with both positive and negative influences on **productivity**, e.g., increased nutrients vs. reduced light. Timeframe: immediate.	
Others?	



Conceptual Diagram

SCENARIO 2: INCREASE IN HEAVY RAINFALL EVENTS (WHICH COULD POTENTIALLY LEAD TO FLOODING) - Vulnerabilities

SCENARIO 2: INCREASE IN HEAVY/EXTREME RAINFALL EVENTS - MANAGING RESILIENCE

These are broad strategies that will strengthen the abilities of sites, habitats, and species to resist stress under a changing climate). Please consider the following categories of on-the-ground management actions: Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach.

Strategy	On-the-ground management actions	New or existing	Notes
Conserve existing refugia			
Restore watersheds to provide more refugia/ Reduce other stressors to help make watersheds more resilient			
Improve monitoring, measurement, and data gathering and distribution to provide the information needed to adapt			

Strategy	On-the-ground management actions	New or existing	Notes
Examine and revise **regulatory mechanisms** and land use policies such as zoning, setbacks, building codes, and incentives, taking climate change into account			

ANTICIPATED CHANGES – MITIGATION NOT APPLICABLE

NATURE OF CHANGE	IMPACTS	IMPLICATIONS FOR STRATEGIES

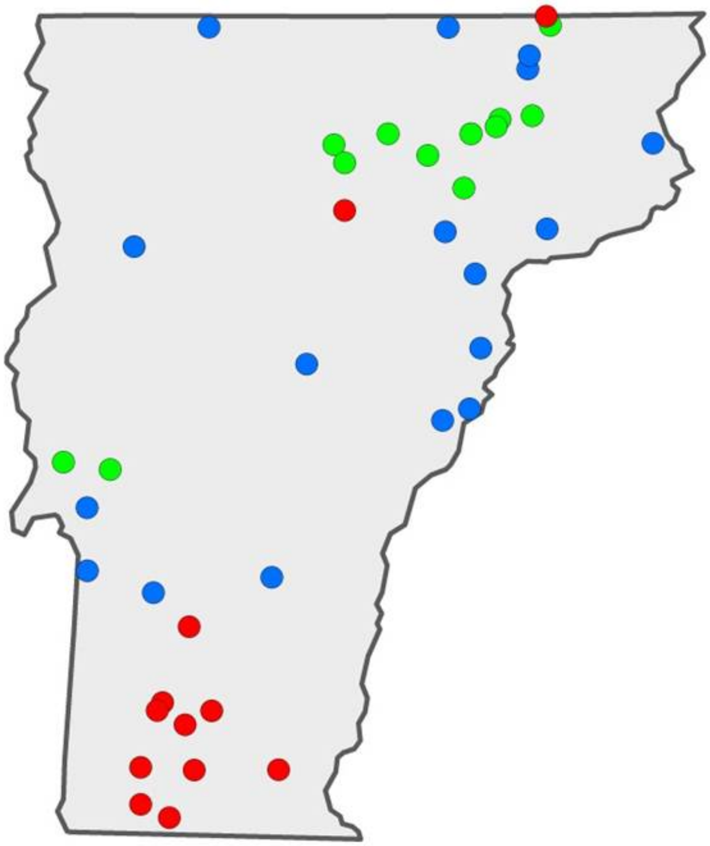
TOP PICKS

On-the-ground management action:
New or existing?

Considerations	**Rating (low/medium/high)**	**Notes**
Effectiveness at mitigating (i.e. scientific basis)		
Operational feasibility (i.e. Amount of $, resources required to implement)		
Degree of current implementation (Describe)		
Level of alignment with current policies, procedures, BMPs (describe)		
Social/political feasibility		
Potential for funding		

List habitat groups that this strategy has relevance to:

Other Comments:



Lakes - long-term monitoring sites (9/20/2012)

Program

- Acid Rain
- Ice Out
- Sentinel

Appendix 4D

Wetlands handouts from the December 11 adaptation strategies workshop

TERMINOLOGY

Effects – ecological responses to a given climatic exposure (or combination of exposures); these can be direct or indirect.

Adaptation strategies – actions taken to prepare for climate change, helping to reduce adverse impacts or take advantage of beneficial ones (Rosenzweig et al. 2011).

Mediating factors - factors that will lessen or worsen the degree of impact. Some are naturally occurring and cannot be altered (i.e. elevation, latitude), while others can be influenced by human factors (i.e. shading/riparian buffer).

FORMAT FOR DISCUSSIONS

First we will give a **quick overview** (5-10 minutes) of **Vermont's surface water management strategy, SWAP plan** and **ANR white paper** on water resources and how information gathered from these discussions will tie into these.

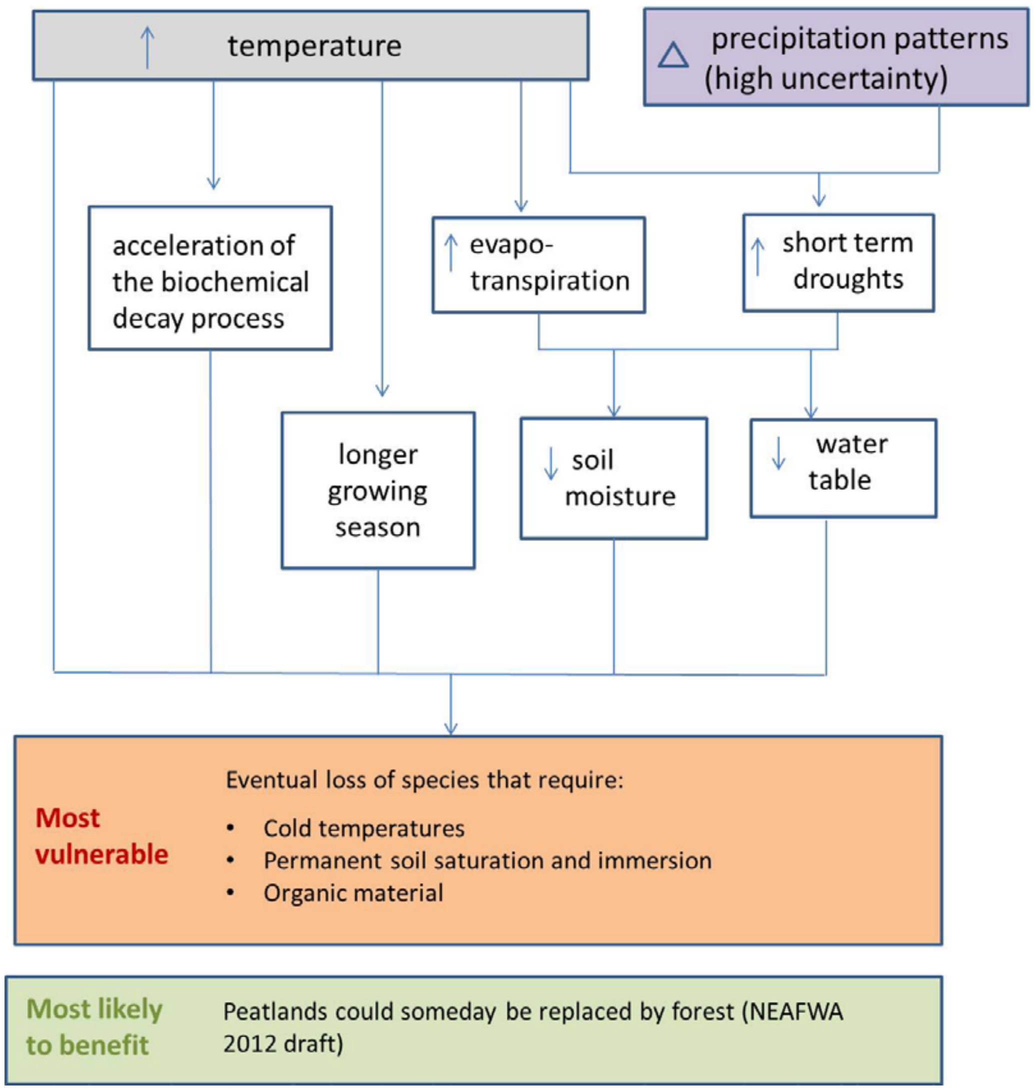
Next, we will discuss a scenario with **warming temperatures**. We will go through the following steps:

1. **Review ecological effects** and mediating factors as presented in the attached table and conceptual diagram, with a specific focus on peatlands. We will ask the group whether you have any suggested edits or additions to these tables and diagrams.
2. **Brainstorm adaptation strategies** that would manage wetland habitats for greater resilience to impacts. This is a broad category of actions that would strengthen the abilities of sites, habitats, and species to resist stress under changing climate scenarios (notably increased temperature and changing precipitaton patterns). Example: reduce other stressors to help make wetlands more resilient.
3. For each strategy, **brainstorm on-the-ground management actions that support these strategies, whether currently in place or not** (example: educate landowners about the importance of wetlands). As you go through this, please keep in mind the following general categories of management actions - Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach - and please make notes on the feasibility of implementation.
4. If any of the **actions are currently being implemented**, note which program/entity is doing so. Also consider potential partners, timeframe for implementation and scale (local, regional, etc.).
5. In some situations, preservation action may not fully mediate impacts in the long term; change will occur eventually (example: in some wetlands, warming temperatures associated with climate change will result in the eventual loss of cold adapted species, regardless of what management actions are taken). We will discuss implications of some of these **anticipated changes**, as well as steps that VANR could potentially take to manage/plan for these anticipated changes.
6. Identify key **research needs/data gaps** that would need to be completed to support each management strategy, and discuss potential ways to address these needs and gaps.
7. At the end of the first session, the group will identify **top pick(s) for on-the-ground management actions**. Following lunch, the group will discuss/rate the following about those top pick(s):

   - Effectiveness at mitigating (i.e. scientific basis for recommending this action)
   - Operational feasibility (i.e. amount of $, resources required to implement)
   - Degree of current implementation (describe)
   - Level of alignment with current policies, procedures, BMPs (describe)
   - Social/political acceptability and feasibility
   - Potential for securing funding

SCENARIO 1: WARMING TEMPERATURES - Wetland Habitat Vulnerabilities

Ecological Effects	Mediating Factors (+/-)
1. **Compositional changes** (loss of cold-adapted species and increase in warm-adapted species). Timeframe: Long-term, but localized effects could occur on a shorter timescale.	• Orientation (north/south facing) • elevation • latitude • topography/slope • groundwater influence • water depth • size and connectivity of wetland • localized factors (i.e. surrounding land use, buffers) Others?
2. Increase in **overwinter survival of pests** like hemlock woolly adelgid. Timeframe: Immediate.	
3. Increased **physiological stress**, resulting in increased **susceptibility to pests and disease**, decreased productivity and increased mortality. Timeframe: Immediate.	
4. Increased evapotranspiration, resulting in a **decrease in soil moisture**; this could result in the loss of species that require permanent soil saturation and immersion. Timeframe: Immediate to long-term.	
5. Increased **decomposition rate of peatlands/organic material**, which, in combination with drier soils and a longer growing season, could lead to significant changes in overall species composition of peatlands and the eventual conversion to a different habitat type (i.e. replacement by more forested wetlands or non-wetland habitats). Timeframe: Immediate.	
Others?	



Conceptual Diagram
SCENARIO 1: WARMING TEMPERATURES – Peatland Habitat Vulnerabilities

SCENARIO 1: WARMING TEMPERATURES - ADAPTATION STRATEGIES FOR MANAGING <u>RESILIENCE</u>

These are broad strategies that will strengthen the abilities of sites, habitats, and species to resist stress under a changing climate). Please consider the following categories of on-the-ground management actions: Monitoring, Conservation, Technical Assistance, Regulation, Education/Outreach.

Strategy	On-the-ground management actions	New or existing	Notes
Conserve existing refugia			
Restore wetlands to provide more refugia/ Reduce other stressors to help make wetlands more resilient			
Improve monitoring, measurement, and data gathering and distribution to provide the information needed to adapt			

Strategy	On-the-ground management actions	New or existing	Notes
Examine and revise **regulatory mechanisms** and land use policies such as zoning, setbacks, building codes, and incentives, taking climate change into account			
Other?			

ANTICIPATED CHANGES – MITIGATION NOT APPLICABLE

NATURE OF CHANGE	IMPACTS	IMPLICATIONS FOR STRATEGIES
Loss of cold-adapted species due to warming temperatures	Compositional changes may result in some species being placed on the **threatened or endangered species list** for climate change.	?

TOP PICKS

On-the-ground management action:
New or existing?

Considerations	**Rating (low/medium/high)**	**Notes**
Effectiveness at mitigating (i.e. scientific basis)		
Operational feasibility (i.e. Amount of $, resources required to implement)		
Degree of current implementation (Describe)		
Level of alignment with current policies, procedures, BMPs (describe)		
Social/political feasibility		
Potential for funding		

List habitat groups that this strategy has relevance to:

Other Comments:

Appendix 4E

Top picks feasibility worksheet from the December 11 adaptation strategies workshop

TOP PICKS

On-the-ground management action:
New or existing?

Considerations	**Rating (low/medium/high)**	**Notes**
Effectiveness at mitigating (i.e. scientific basis)		
Operational feasibility (i.e. Amount of $, resources required to implement)		
Degree of current implementation (Describe)		
Level of alignment with current policies, procedures, BMPs (describe)		
Social/political feasibility		
Potential for funding		

List habitat groups that this strategy has relevance to:

Other Comments:

Appendix 4F

Results from the upland forest brainstorm session at the December 11 adaptation strategies workshop

Upland Communities Breakout Group – Climate Change Adaptation Workshop

Strategies

General discussion: what are the high level concepts that we want to consider –

- Interconnected habitats across the landscape : representation of all community types, large blocks, connectivity, unmanaged areas
- Need for more land conservation – develop a broad conservation strategy
- Long term goals might be to create stability
- Short term is about creating strategies
- Determining what areas for land conservation
- Climate change creates a shorter time frame, speed up the process

Strategy Topic 1: Conserve biodiversity

- Conserve lands of an array of biological and **physical** conditions fully representing each of the nine biophysical regions
- Conserve large forest blocks (place where evolutionary processes can occur; self adaptation process)
- Connectivity of lands across ownerships, across nations and regions
- Identify and maintain climate change refugia
- Have unmanaged and managed large forest blocks (management by objective)
- Create/maintain a broad representation of ownerships of conserved lands; each landowner (public and private) has different management styles
- Restrict introduction of non-native organisms

Strategy Topic 2: Manage natural resources (some are specific to climate change, others are generally good management)

- Focus on successful regeneration techniques for warm adapted species, especially in areas prone to warmer conditions or where current regeneration failures are occurring.
- Maintain current species where they are growing
- Improve forest transportation networks to withstand extreme events; look to improve those in the right place and eliminate failures (i.e. culverts, roads, bridges)
- Develop unified approaches for ANR on items that are important or make a difference (on culverts, or regeneration…)
- Monitor changes in natural communities in a systematic, long term, rigorous effort including all natural communities statewide (look into collaboration with GMNF long term plot system)
- Monitor habitat and species changes in a long term system, which might be different from natural community type of monitoring
- Maintain our ability to manage animal populations, relying on existing programs such as North America Wildlife Management Model
- Create or enhance species, structural and age class diversity
- Maintain healthy trees
- Maintain ecosystem functions
- Manage invasive plant distribution to prevent the spread

- Develop prescribed fire plans for areas vulnerable to increased fire risk (MIST)
- Protect soil fertility and structure
- Conserve high quality examples of natural communities and RTEs (management is to reduce other stresses on these areas). The high quality areas now may be indicative of good sites for the future.

Strategy Topic 3: Education

- Prepare educational materials on climate change for various audiences
- Create demonstration areas on climate change resource management on state and federal lands
- Emphasize activities that connect people to the land, show the value of maintaining high quality natural resources (through recreation, hunting, outdoor education, etc)
- Educate on what a resilient forest landscape should look like (see biodiversity and natural resource management sections for what makes a resilient forest)
- Develop strategies for private landowners that illustrate to them their role in landscape diversity
- Educate public and users of lands on what is involved in forest harvesting and other land management (e.g. winter harvesting preferred on some lands) to improve communications about climate change effects on normal operations
- Educate legislature and policy makers on climate change, biodiversity and natural resource management

Moving ahead, the Forestry group will be looking for more input from Fish & Wildlife; this should include a more in-depth look at impacts from deer browsing (per JS call with Sandy on 12/20)

Strategy Topic 2: Manage Natural Resources

Strategy: Manage invasive plant seed distribution to prevent the spread

On the ground	Effectiveness	Feasibility	Current Implementation	Alignment	Acceptability	Funding potential
Survey for locations of existing plants	H	M	L	H	M	M
Adopt BMP for invasive plant management	H	M	L	H	M	M
Cost share programs for invasive plant management and other funding incentives	M	H	L	H	H	L
Educate consulting foresters, landowners, public						
Fund research on long term biology and ecology, this will lead to improved management						

options						
Prioritize species to address in each area of the state						
Follow up strategies to continue management						
Coordinated effort between adjacent landowners, landscape level						
Identify new species before introduction						
CISMAs						

We deferred discussion on recreation opportunities, but recognized that recreation is dependent on healthy upland communities.

Submitted by Sandy Wilmot, December 12, 2012

Appendix 4G

Results from the rivers brainstorm session at the December 11 adaptation strategies workshop

DEC 11 WORKSHOP - NOTES FROM RIVERS BREAKOUT SESSION

Review of vulnerability assessment –

Effects to add in:

- Increase in extreme/heavy precipitation events will result in mobilization of legacy sediments, thus impacting sediment and hydrologic regimes
- As channels widen in response to water and sediment inputs, waters will become shallower

Mediating factors:

- Infiltration (retention vs. runoff), with particular relevance to stormwater

Adaptation strategies

Promote shading

- keep trying to get statewide buffer requirement within corridors
    - note: report should include information on scientific basis supporting riparian buffers
- consider redefining what we mean by buffer areas (i.e. define based on location in relation to meander belt width line; this is part of what the rivers program has been doing)
    - note of caution: while the meander belt width line may provide sufficient channel width to protect bank stability and some shading, it may not cover all of the other functions we care about
    - as streams become more dynamic, are we going to need to expand/change how we define the meander belt width line?
    - the 50-ft buffer has gained some traction with landowners and is simple to understand; should we abandon this?
    - fluvial erosion hazard (FEH) - limitation: delineations don't include a buffer component
    - make stream size a consideration? small high gradient streams do not require buffers of the same width as larger streams; buffer guidance policy currently in place would likely be suitable for protecting these types of streams
- consider changing the regulatory sphere (i.e. make part of stormwater, beyond Act 250)
- should consider land cover in upstream catchment, not just the immediate buffer
- pest control for invasives (i.e. woolly adelgid, emerald ash borer, Japanese knotweed)
    - biocontrol efforts currently underway in Pownal (beetles recently released to combat woolly adelgid)
- anticipate planting new tree species to provide shading
- wetland reserve program (WRP) – dependent on Farm Bill (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/wetlands/) – riparian areas that link protected wetlands are eligible, as are lands adjacent to protected wetlands that contribute significantly to wetland functions and values

Conserve refugia

- protect ecologically and physically functioning floodplains, especially those with intact riparian forests/wetlands
- develop process for identifying and protecting watersheds with cold water refugia and high resiliency; this process must have a sound **scientific basis**
    - characteristics to consider:
        - groundwater influence
        - orientation (north-facing)
        - shading
        - land ownership (federal or state)
        - watershed size
        - representation of elevational and topographical gradients
        - channel condition - narrow, deeper stream channel in equilibrium would retain water better and stay cooler than degraded stream
- work to protect these watersheds; where possible, piggyback with other existing efforts
    - tie into tactical watershed planning/surface water management plan
    - use BioFinder to identify biodiversity hot spots
    - work with outside organizations like VHCB to align resources/get more funding allocated for ecosystem restoration
    - consider Mark Anderson's resiliency work at TNC and how this might be used
    - educate & work with conservation commissions, regional planning commissions
        - inform project selection criteria for town conservation funds
    - minimize impervious surface in these watersheds
    - preserve connectivity in these watersheds
        - culvert retrofits
- hire agency hydrologist; allow them to devote time to high elevation streams
- consider entire watershed, not just stream reach; identify upland areas that can be managed successfully, that are open at the landscape scale

Restore watersheds to provide more refugia/reduce other stressors to help make watersheds more resilient

- protect and restore key floodplains within the watershed to act as flood relief valves to store floodwaters, sediment, LWD, etc.
- recognize that localized impacts are affected by larger scale processes; examples: peak flow events may create more dynamic, braided stream conditions and will mobilize legacy sediments in the floodplains; encroachment & channel management will prevent equilibrium conditions from being restored over time
- tree plantings along riparian corridors to improve shading
- retrofit culverts to allow for passage of aquatic organisms (where appropriate); prioritize so that connectivity is established in watersheds that have been identified as key cold water habitat
- wetland reserve program (WRP) (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/wetlands/) –
- research restoration techniques; has their effectiveness been documented?

Improve monitoring, measurement, and data gathering and distribution to provide the information needed to adapt

- participate in regional reference/climate change stream monitoring network (EPA GCRP/Tetra Tech) – track whether conditions at reference sites are changing over time

- gather continuous water temperature data at sentinel sites to track whether changes are occurring as projected and to gain a better understanding of how mediating factors (i.e. groundwater influence, orientation, color) influence conditions
    - install pressure transducers at sentinel sites to track long-term hydrologic changes in small to medium-sized, high quality streams
    - biological data
- support the continued operation of USGS gages
- groundwater
    - mapping & modeling statewide
        - effort is currently underway to investigate models
        - need funding to test model, develop scenarios (climate change could be a potential scenario to test; another would focus on watersheds where demand is expected to grow)
            - would test 2 watersheds, would take 2 years to complete
    - sentinel monitoring network
    - impact of withdrawals
    - consolidated database
    - integrate surface and groundwater planning within the state

- Brook trout – design statewide, cross-sector long-term monitoring plan
- LIDAR
    - surveys of the Mississquoi & half of Otter Creek were recently completed
    - ANR plans to map state incrementally, as funding permits
    - uses of these data
        - update FEMA & fluvial erosion maps
        - identify potential hot spots for nutrient loading
        - understanding movement of legacy sediment
    - other states have multiple day and/or multiple year LIDAR data to track mass balance estimates

<u>Examine and revise regulatory mechanisms and land use policies such as zoning, setbacks, building codes, and incentives, taking climate change into account</u>

- Act 138 (currently in development)
    - as streams become more dynamic, will we need to redefine/expand the meander belt width zone?
    - does it adequately account for climate change, and ecological considerations?
    - require towns to adopt these bylaws or ordinances?
- Anti-degradation rule - include climate change considerations?
- Use value program/current use – potential mechanism for providing incentives
- New regulations: examine jurisdictional thresholds of certain permitting programs
    - maybe limit to critical, sensitive areas

<u>Education</u>

- Technical assistance to towns (this requires adequate staffing at ANR; may need new hires)
    - increase communications with towns/municipalities and increase their authority to implement/plan/mandate buffers
        - consider holding a workshop through the VT League of Cities and Towns

- guidance for town plans
    - templates, draft ordinances that conservation commissions can adopt (i.e. no build zones, greater flood-proofing)
    - river corridor maps for all streams in towns, that incorporate meander belt and riparian buffer (currently being worked on by the Rivers program)
    - groundwater maps – these have been very useful in the towns where ANR has provided assistance; expand these efforts? (past $ has come from towns and from geologic mapping funds)
  - make sure towns understand what they have authority over
    - towns are fully authorized to act, create by-laws, and adopt floodplain rules beyond the current minimum requirements (Act 138)
      - state covers floodplain activities excluded from purview of municipalities, towns
    - Act 199 – gave towns the ability to regulate groundwater
      - VNRC staff have taken that down to the town level and have provided guidance at the planning-level
- Proper messaging
  - add climate change message into the overall surface water message that existing staff are already giving
  - emphasize that we are not asking local officials to do something totally new; show how climate change ties into existing efforts
- Provide technical assistance to support towns – incentivize; if that doesn't work, disincentivize (penalties); if that doesn't work, then regulate
  - Tax abatement programs in towns? How to compensate for loss in grand list value?
  - Use value (current use) – expand to properties in flood plains?

Funding

- seek grants, manage them (this may require additional staff)
- Act 138 - requires agency to come up with way to finance water quality initiatives
- difficult to find money to fund ecological efforts; best bet is to piggyback with efforts (like Act 138) that address impacts on humans

Anticipated changes (note: we did not have time to discuss these in depth)

- If projections hold true, some streams will go dry; humans will likely respond in a way that will exacerbate the problem (i.e. increase in water withdrawals; increase in irrigation); what can we do to get out in front of this?
  - Look at what other states have done
    - environmental flows/ELOHA
    - Maine's sustainable flow rule
  - Regulate withdrawals
  - Protect streams that are in equilibrium (narrow, deep channels)
- Compositional changes may result in some species being placed on the threatened or endangered species list for climate change. What are the implications of this?
  - May have to relocate some species, like the eastern pearlshell mussel
- The loss of coldwater habitat will result in the loss of cold water taxa like brook trout and slimy sculpin from some streams. This compositional change could have regulatory implications under

the Clean Water Act, since it is possible that some sites (even reference sites) will no longer meet the bioassessment criteria required to attain aquatic life use standards established for a given stream. Are there any pro-active steps that VT ANR can take in anticipation of these situations
    - collect baseline data
    - think about how use attainment analyses (UAAs) might be used
- What if an assemblage retains full functionality but loses some rare native species (i.e. brook trout drop out but another top predator moves in; for those of you familiar with the Biological Condition Gradient, this means dropping from a Level 2 to a Level 3)?
- Extreme events like flooding and drought could have regulatory implications under the Clean Water Act, since it is possible that some sites (even reference sites) might not meet the bioassessment criteria required to attain aquatic life use standards during a year when an extreme event occurs. In these situations, should these sites be listed on the 303d list? Are there any pro-active steps that VT ANR can take in anticipation of these situations?
    - evaluate historic data (limited to IBI calibration dataset?) to quantify/define extreme; use this as a basis for determining whether to list or not list
- How do we determine needs for meander belt width, knowing that more heavy rainfall events (and potentially more flooding) are projected to occur?
- We know that human responses to flood events and drought can exacerbate ecological impacts. Are there things that we can do in anticipation of what some term 'human maladaptive responses' to help lessen these potential impacts?
- Warmer temperatures and extended summer low flow periods will pose great challenges for waste water treatment plants. Are there things that we can do to help prepare for these challenges?
    - Revisit 7Q10s

TOP PICKS

On-the-ground management action: Groundwater monitoring, analysis, and regulation
New or existing? Under development

Considerations	Rating (low/medium/high)	Notes
Effectiveness at mitigating (i.e. scientific basis)	High	This is an important linkage in our conceptual models.
Operational feasibility (i.e. Amount of $, resources required to implement)	High	Feasible statewide, currently targeting predicted growth areas. Need to target vulnerable cold-water habitats, areas with high base flow.
Degree of current implementation (Describe)		Two test watersheds are being analyzed. The models could be changed to simulate climate change scenarios.
Level of alignment with current policies, procedures, BMPs		Ground water is not now integrated/related to surface water – this is an opportunity to do so.

(describe)		
Social/political feasibility	High	Considering that banning hydro-fracking was easy, groundwater analysis should be acceptable and regulation may follow without unreasonable resistance.
Potential for funding	High	There should be grant money available – this should be a high priority.

List habitat groups that this strategy has relevance to: Refugia for cold-water species

Other Comments: This would answer the question: How would high yield wells near streams affect stream temperatures (and then cold-water species)?

TOP PICKS

On-the-ground management action: Increase communications with towns/municipalities and increase their authority to implement/plan/mandate buffers.
New or existing? Under development

Considerations	**Rating (low/medium/high)**	**Notes**
Effectiveness at mitigating (i.e. scientific basis)	High	Buffer and corridor functionality are important in our conceptual models of stream and river habitat protection.
Operational feasibility (i.e. Amount of $, resources required to implement)	Medium	First offer incentives, then disincentives (penalties), then mandates.
Degree of current implementation (Describe)		Act 138 is a bill under development that addresses encroachment in stream and river corridors. It includes buffers, upland management, and municipal authority.
Level of alignment with current policies, procedures, BMPs (describe)	High	Towns respond strongly to issues related to public safety. That is one good reason (besides ecological integrity) that may encourage town participation.
Social/political feasibility	High to Low, depending on focus	The near-channel land owners would probably respond positively to incentives, negatively to disincentives, and resist mandates.

Potential for funding	High?	Regional Planning Commissions are already devoting time to towns for technical assistance. They would likely continue to do so. What more could ANR contribute?

List habitat groups that this strategy has relevance to: All stream and river corridors, riparian areas, and some wetlands.

Other Comments: This is an outreach component that climate change stakeholders should encourage.

Appendix 4H

Results from the lakes brainstorm session at the December 11 adaptation strategies workshop

Lakes Notes

Scenario 1: warming temperatures

Effects:

- Timing of reproduction and change in phenology
- Loss of habitat area in specific lake layers
- Basic DO cycle change with warming
- Migration of cold water species to refugia/specific habitat areas

Mediating factors:

- Boat traffic
  - Risk for invasives
- Soil and sediment type (could go either way)
- Flushing rate (key factor, could go either way)
- Watershed practice and impoundments
  - Multiple instream and upstream ponds create nutrient, thermal input
- Locus of controls
  - Who is in charge of the lake and its watershed and how many of them are there
- Management of reservoirs
  - Affects levels in adjacent/hydrologically connected lakes
  - Deep water reservoirs can provide cold water habitat but the DO is lousy
- Groundwater withdrawal and recharge rates

Data gaps:

Modeling

- Modeling of change in ice, stratification being done in WI to predict change based on morphometry, wind and temperature

Monitoring

- Johnson State College (JSC) professor has long-term temperature probe (where?)
- Very little winter lake data!
  - This year, first data from Missisquoi
- What can VT borrow from the upper Great Lakes region?
- Are relevant satellite data available?
- Ice IN is much different than ice OUT – it should be tracked

Stratified vs. unstratified

- Will change rates in biological processes be different?
- Will there be greater changes from historic conditions in stratified vs. non-stratified lakes?

Lakes used as water supplies – what happens under stress?

Strategies

Develop a hypothesis-driven monitoring and modeling effort to better adapt management strategies to expected future temperature and temperature duration change. Why?

- Need to model the thermal regime of different kinds of lakes
- Still need to measure what we measure now
- Connect with public about lakes used as water supplies – what happens under stress? (received a star)
- Make concerted effort to identify and GET the data that we will have to have
- Continue existing so long-term profiles are available (received a star)
- Take a long view (received a star)

Develop cold water species strategy (track biological indicators)

- Where are they, what depth, what temperature?
- What is the projected change?
- Higher priority for species that could make it if conservation, other measures are in place; these will inform refugia identification and conservation
- Study reproductive and growth cycle of a species and how it reacts to temperature change
    - Historic data available – how quickly do the species adapt biologically and where?

Monitoring

- Sentinel lake network to develop long-term datasets
    - develop monitoring approach for temperature probes
    - use these as reference condition lakes (just did macroinvertebrates, have chemistry profiles as well)
- use WI, other data (i.e. satellite) to project drought conditions, especially in shallow lakes without groundwater inputs; identify where these most vulnerable lakes are
- Develop lake watershed-specific surface water management plans
    - Anything that increases infiltration is going to be beneficial to lake temperature
    - Reduce thermal inputs
- Shading and canopy mapping/canopy deficiency analysis
    - Differentiate cover types
- Protect groundwater resources especially in areas where there are groundwater fed lakes
    - This is one of our only ways to support a key mediating factor in lakes temp

Management actions and tools

- Central data/clearinghouse and coordinator on lake data (including partner data from outside Vermont) and issues including crowdsourcing (deliberate, not just accidental)
    - Important to connect with public (digitizing records, etc. making historic data available to the public

Lakeshore buffer regulation
Wetland regulations

- Do they need to be more explicit in protecting groundwater recharge?
- More low impact development (LID)/green infrastructure and resilient surface water management-permeability

Educational programs and/or regulations to develop tree/canopy restoration (partner with forest and parks?)

- Key point of contact with the public
- Needs competent technical support

Improved groundwater mapping/modeling (notably where lakes are groundwater influenced)

Scenario 2: increase in extreme/heavy precipitation events and flooding

Effects:

- Toxics: potential for increase in methyl mercury absorption in food chain as reservoir/lake levels are managed in response to precipitation extremes (drought and flood)
- More water=more assimilative capacity for some pollutants
- Impact of sedimentation in near shore habitats on reproductive and rearing/larval fish
- Flooding can give fish access to additional backwater habitats
- Potential net loss of woody structures especially in shore areas that are not well buffered; increase in other areas
- Changes in littoral zones, many unanticipated/unpredictable

Mediating factors:

- Land use/encroachment/cover in immediately adjacent area
- Land use in contributing watershed
- Presence of in-stream impoundments (and types) upstream; degree of flood control
- Stream geomorphology/stability upstream
- Soil type and erodibility/substrate
- In-lake management practices

Strategies

Maximize natural mitigation

- Forest canopy
  - Reducing floodplain development/interference
  - Geomorphology/modification of surface waters feeding lakes of all sizes
- Lakeshores need to be in a condition to allow lake levels to fluctuate without introducing pollutants
  - Vegetation
- Protect/enhance buffer/maybe create more wetlands

What did we learn from Irene?

- What are appropriate emergency response procedures?
- Lake specific as well as channels
- Documenting post-Irene lake effects
- Technical assistance/mutual aid/technology transfer (=key public engagement point)

Manage anthropogenic inputs and issues

- Keep water in dirt
  - Urban and ag

- Minimize E.I.?
- Use of created wetlands – restoring historic wetlands

Keep dirt out of water

- Stream stability
- Ag BMPs!
  urban BMPs!
- Forestry A/B/CMPs
- Backroad/culvert grading (regs?)

Reduce infrastructure/development in floodplain and wherever possible and stop socializing the cost!

- Buyout program is good
- maintain and ensure proper function of WW treatment and infrastructure around point sources
- In some cases, design resilience into structures and uses that have public values and must/will be on lakes and in floodplain areas

Protect and restore immediate lakeshores

- Regulation and enforcement
- Purchase and stewardship
- Easements and stewardship
- Public education and outreach
- Lakewise program modeled after Maine
- Small lake conservancies and associations – land trust model?
- Money for technical assistance

Current conditions mapping

- Land cover, habitat, existing encroachments
- Predicted conditions modeling
    - Great point for public outreach and engagement

Managing water quantity/volume (this is going to happen and it is tricky)

- Lake level management
    - Drawdowns in advance of severe storms
    - May use more lakes for water supply if drought occurs
- May create more lakes and ponds for ecosystem functions, irrigation, etc. on a landscape level in response to extended summer low flows, short term droughts

TOP PICKS

1. Lakeshore law
2. Get out of the floodplain and stay out
3. Protect water quality via infiltration, storage and prevention
4. Central data clearinghouse and crowdsourcing (cold water info; species info; annual cycles; sediment/response to Irene; partner research and data)
5. Tree canopy/forest/urban forest health central to strategies
6. Upstream river geomorphology matters to lakes (even small ones)

Appendix 4I

Results from the wetlands brainstorm session at the December 11 adaptation strategies workshop

Notes from wetland session at Dec 11 workshop

Strategies for precipitation-dependent, open peatlands

- Site conservation plan that identifies these locations in watershed plan
- manage hydrology and landscape to preserve them
- Include buffers in conserving small wetland parcels
- Increase Class I definition to include vulnerable wetlands: increase minimum buffer (100 feet now), at least double
- Identify large potential Class I wetlands and prioritize and protect them
- Simplify and clarify Class I process
- Add staff
- Prescribed burn regime, if appropriate
- Change guidelines for Class II
- Increase institutional support for wetlands division
- New funding area/organization (Wetlands Trust) for climate change vulnerable wetlands; Another land trust/conservation vehicle to identify, conserve wetlands: prioritization for state significant wetlands
- Restore drained peatlands
- Encourage role of local conservation commission in preserving vulnerable wetlands

Strategies for basin swamps/wetlands

- Current Use program allows after approval, to apply to smaller pieces; doesn't have to be 25 acres
- Base taxes on current use at the town level
- Eliminate agriculture and silviculture exceptions in wetland permitting programs
- Protect floodplain wetlands for flood resiliency: ex. Greenseams program in WI
- Need for increased personnel in ANR, F&W to do outreach, education, etc.
- Current personnel: allocate a portion of time to climate change mitigation work (wetlands, etc.)
- Add Climate change planner in each section of the agency (DEC, FPR, F&W)
- Communicate to partners, departments which wetlands should be targeted for protection and conservation based on criteria determined in this group
- having personnel which could facilitate oversight of funding (ex. SWIG funds are not sought b/c can't be managed)
- Convene and continue climate change adaptation group
- Add staff for monitoring programs (reference wetlands)
- Collaborate with Heritage Program: additional staff, add a guaranteed funding source
- Surface runoff: don't cut off flows
- maintain wetlands: don't fill them in, esp. vernal pools
- Cutting around wetlands: maintain existing shade, keeping forest on one side for habitat and connectivity
- State contributing to federal wetland efforts: get more funding from state level, make easements,etc. more attractive

- Discourage encroachment on wetlands: keep people out of floodplains and wetlands
- Buffers: definition changed to include both terrestrial habitat and buffer to guarantee species biodiversity
- Raise awareness of biodiversity of species which are dependent on wetlands and connected landscapes
- Identify and protect species which are dependent on a mosiac of communities and in therefore protect coupled system habitats: more outreach

TOP PICK

Management action: discourage encroachment on wetlands: keep people out of floodplains and wetlands

Considerations	**Rating (Low/Medium/High)**	**Notes**
Effectiveness at mitigating (ie. scientific basis)	High	Good for river and lake flooding; large community benefits
Operational Feasibility	High for protection (lower cost and resistance) and low for restoration (cost and resistance)	Depends on accounting: long term effects are worth the initial cost. Need to support current system
Degree of current implementation	Medium/Low	Full staffing would allow targeting of these areas. Restoration: doing more than we were. Low in terms of total floodplain wetlands that are lost
Level of alignment with current policies, procedures, BMPs	High	Policies for Class I wetlands designation should be simplified, institutional support, staffing
Social/political feasibility	Medium	Improving with each catastrophic flood
Potential for funding	Medium	River Easement, NRCS easement,

Habitat Groups: oxbow wetlands, floodplain forest, flooded swamps, rivers, lakes

Comments: benefit to human infrastructure. Development of funding sources, personnel for grant management.

Appendix 4J

Tools for managing in light of uncertainty *from Staudinger et al. 2012 -*

Planners can fortunately turn to a number of familiar tools for making management decisions in light of uncertainty. Commonly-used tools for addressing uncertainty that increasingly are being applied to climate change planning include:

- adaptive management (for example, Conroy and others, 2011)
- scenario-based planning (for example, Peterson and others, 2003)
- structured decision-making (for example, Ohlson and others, 2005)
- Risk management (for example, Willows and Connell, 2003)

Adaptive management is a concept that has been applied to resource management for many years (Williams and others, 2009), but recently has received renewed attention as a tool for helping resource managers make decisions in response to climate change. Adaptive management seeks to improve and inform decisions in the face of uncertainty by learning from management outcomes and incorporating that information into a structured process of flexible decision making. Specifically, this approach encourages management actions to be framed as hypotheses that can be tested and evaluated against expected results. Adaptive management frequently is invoked within the context of climate adaptation as a way to address and respond to the inherent uncertainties associated with predicting human and biological responses to climate change. Because of the semantic similarity between adaptation and adaptive management, these two concepts are sometimes confused with one another. In short, adaptive management may be used in the implementation of an adaptation strategy, but adaptation does not require adaptive management, nor does adaptive management necessarily lead to adaptation

Scenario-based planning has received increasing attention as an important tool for adaptation planning because of its usefulness in situations where uncertainties are high and uncontrollable (Peterson and others, 2003). In this context, the IPCC (2007b) defines a scenario as "a coherent, internally consistent, and plausible description of a possible future state of the world". Scenarios are not meant to be a forecast or prediction of the future, but rather are intended to describe alternate, plausible trajectories for the future (Mahmoud and others, 2009). A key goal of scenario planning is to identify those conservation actions that are recommended across all or most future scenarios. These actions—sometimes called "no regrets" or "low regrets" actions (Willows and Connell, 2003)—are then considered relatively robust to uncertainty in how climate change will play out in a given location.

Structured decision making is an organized approach to identifying and evaluating alternatives that focuses on engaging stakeholders, experts and decision makers in productive decision-oriented analysis and dialogue and that deals proactively with complexity and judgment in decision making. It provides a framework that becomes a decision-focused roadmap for integrating activities related to planning, analysis and consultation (http://www.structureddecisionmaking.org). It is appropriate for situations in which there are:

- Complexity and Uncertainty - multiple objectives and stakeholders, overlapping jurisdictions, short and long term effects, cumulative effects and high levels of uncertainty

- Difficult Judgments – including both subjective technical judgments made by experts about the potential consequences of proposed alternatives, and difficult value-based judgments made by decision makers about priorities, preferences and risk tolerances
- High stakes – including economic, environmental, social and political stakes – and, as a result – intense scrutiny from technical public and political domains
- Limited resources – a need to do more with less, often on short timelines
- Growing expectations - for quality, consistency and transparency in decision making

Risk management can have different frameworks – i.e. the Framework for Ecological Risk Assessment (EPA/63-/R-92/001), *Guidelines for Ecological Risk Assessment* (EPA/630/R-95/002F). The framework consists of three phases (problem formulation, analysis, and risk characterization) with analysis consisting of the following two parts: characterization of exposure and characterization of effects. Another example of a risk management framework can be found in Willows and Connell, 2003 (UK – forestry example).

Appendix 4K

Steps in generalized adaptation planning and implementation

The Climate-Smart Conservation workgroup convened by the National Wildlife Federation has identified the following phases in a generalized adaptation planning and implementation cycle (Stein et al. written communication 2012, in Staudinger et al. 2012):

1. Identify existing conservation goals and objectives
2. Assess climate change impacts and vulnerabilities
3. Review conservation goals and objectives in light of climate vulnerabilities and revise as necessary
4. Identify adaptation options (that is, strategies and actions capable of reducing vulnerabilities to achieve stated goals)
5. Evaluate and prioritize adaptation options
6. Implement priority actions
7. Track effectiveness of actions and ecological responses (that is, review and refine actions, strategies, and goals based on monitoring and other new information)

Based on guidance from the Association of Fish and Wildlife Agencies, climate adaptation planning can include the following steps (AWFA 2009):

1) Engage diverse partners and coordinate across state and regional boundaries
2) Take action now on strategies effective under both current and future climate conditions
3) Clearly define goals and objectives in the context of future climate conditions
4) Consider appropriate spatial and temporal scales when assessing wildlife adaptation needs
5) Consider several likely or probable scenarios of future climate and ecological conditions
6) Use adaptive management to help cope with climate change uncertainties

Table 4K-1 shows the phases of adaptive management from EPA's National Water Program 2012 Strategy: Response to Climate Change (EPA 2012).

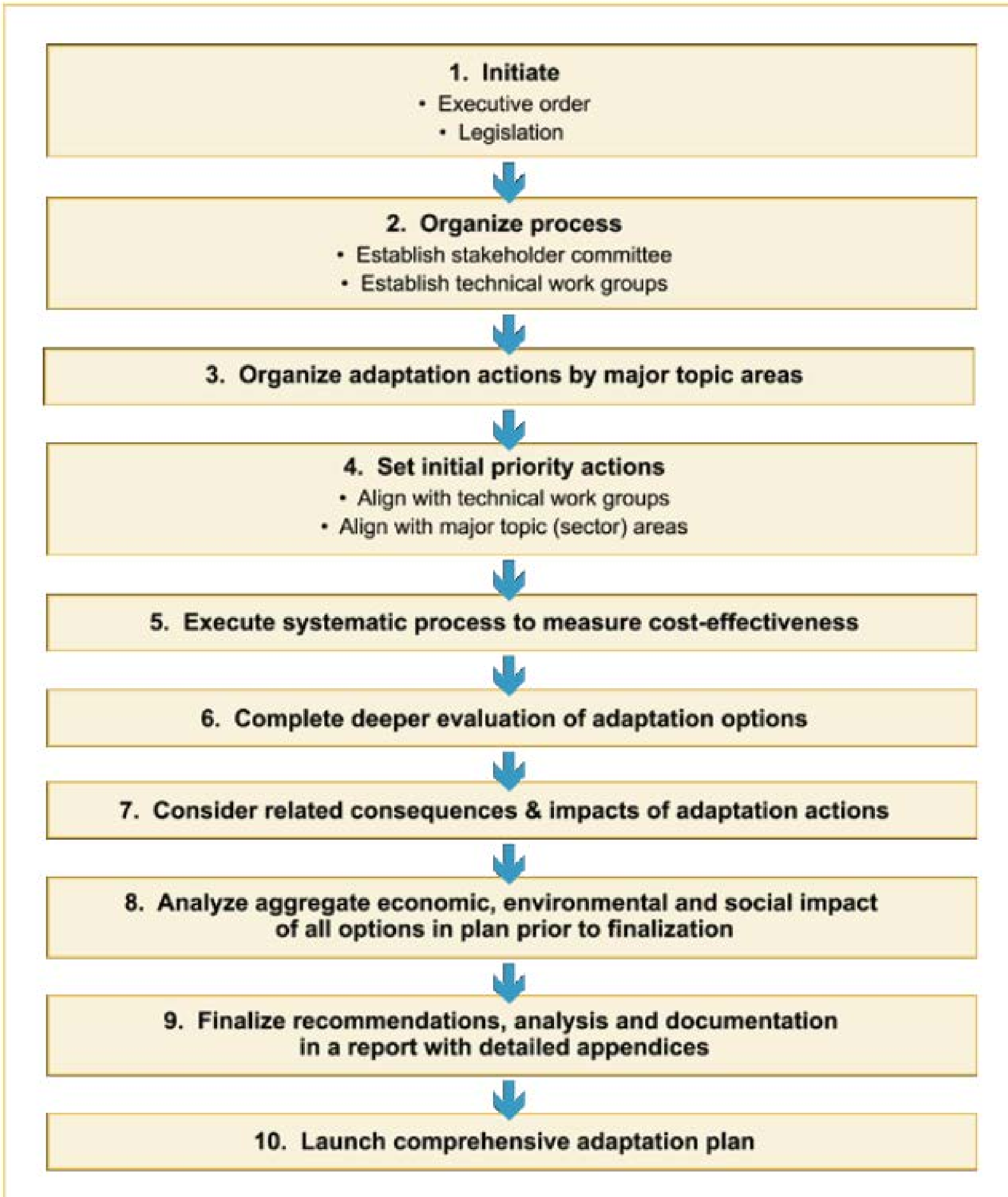
Table 4K-1. Phases of Adaptive Management (from Table 5 in EPA 2012).

Phase	Explanation	Examples of Evidence of Achievement
Initiation	Conduct a screening assessment of potential implications of climate change to mission, programs, and operations	Preliminary information is developed to evaluate relevance of climate change to the mission or program; a decision is made as to whether to prepare a response to climate change; further exploration of climate change implications has been authorized Accountabilities and responsibilities are assigned at appropriate levels within the organization and resources are available to develop a more in-depth assessment
Assessment	Conduct a broader review to understand how climate change affects the resources in question. Work with stakeholders to develop an understanding of the implications of climate change to the mission, programs, and operations.	Review science literature and assessments to understand how climate change affects the resources being protected (threat to mission); Engage internal staff and external stakeholders in evaluation. Identify climate change issues and concerns and communicate with internal and external stakeholders and partners Identify which specific programs are threatened and what specific information or tools need to be developed Communicate findings to partners and stakeholders and engage them in dialogue on building adaptive capacity.
Response Development	Identify changes necessary to continue to reach program mission and goals. Develop initial action plan. Identify and seek the research, information, and tools needed to support actions. Begin to build the body of tools, information, and partnerships needed to build capacity internally and externally.	Develop initial program vision and goals for responding to climate change. Identify needed response actions or changes that will allow the organization to begin to address climate impacts on its mission. Initiate strategies and actions in a few key areas to begin to build organizational ability to use climate information in decision processes. Identify program partners' needs for building adaptive capacity. Begin working with an external "community of practice" to engage in tool and program development. Rudimentary methods are put in place to track progress. Develop a research strategy and partnerships to obtain additional needed research.
Initial Implementation	Initiate actions in selected priority programs or projects.	Make it clear within the organization that incorporating climate change into programs is critical. Initiate actions and plans identified in Step 3.

		Initiate cooperative projects with partners. Develop a range of needed information and tools. Begin to institute changes to incorporate climate change into core programs. Some program partners have begun to implement response actions.
Robust Implementation	Programs are underway and lessons learned are being applied to additional programs and projects.	Lessons learned are evaluated and strategies are refined. Efforts are initiated to consider climate change in additional, or more complex, program elements. Continue to institute institutional changes to incorporate climate change into core programs. External communities of practice are in place to support ongoing capacity development.
Mainstreaming	Climate is an embedded, component of the program	The organization's culture and policies are aligned with responding to climate change. All staff have a basic understanding of climate change causes and impacts. All relevant programs, activities, and decision processes intrinsically incorporate climate change. Methods for evaluating outcomes are in place.
Monitoring and Adaptive Management	Continue to monitor and integrate performance, new information, and lessons learned into programs and plans.	Progress is evaluated and needed changes are implemented. As impacts of climate change unfold, climate change impacts and organizational responses are reassessed.

Table 4K-2. Center for Climate Strategies Adaptation Planning Process (www.climatestrategies.us).

Figure ES-1: CCS Climate Adaptation Planning Process



Appendix 4L

Starter lists for potential working groups

Table 4L-1. List of potential candidates for the **forestry** work group (these are people who were invited to at least one of the workshops; x=attended).

Last Name	First Name	Affiliation	Email	Vulnerability workshop (x=attended)	Adaptation workshop (x=attended)
Annes	Elise	Vermont Land Trust	elise@vlt.org		x
Briggs	Jeff	VT ANR - Forests, Parks and Recreation	jeff.briggs@state.vt.us		x
Burbank	Diane	Green Mountain National Forest (GMNF)	dburbank@fs.fed.us	x	x
Burns	Barbara	VT Forests, Parks & Recreation	barbara.burns@state.vt.us	x	x
Coster	Billy	VT ANR - Planning and Legal Affairs	billy.coster@state.vt.us		x
Decker	Kathy	VT Forests, Parks & Recreation	kathy.decker@state.vt.us	x	x
Hanson	Trish	VT Forests, Parks & Recreation	trish.hanson@state.vt.us	x	
Hilke	Jens	VT ANR - Fish & Wildlife	jens.hilke@state.vt.us		
Horton	Jim	VT Forests, Parks & Recreation	jim.horton@state.vt.us	x	x
Hughes	Jeffrey	University of Vermont (UVM)	Jeffrey.Hughes@uvm.edu		
Keeton	Bill	University of Vermont (UVM)	william.keeton@uvm.edu		
Langlais	Matt	VT Forests, Parks & Recreation	matt.langlais@state.vt.us		
Morton	Tim	VT Forests, Parks & Recreation	tim.morton@state.vt.us	x	x
O'Leary	Ed	VT ANR - Forests, Parks and Recreation	ed.oleary@state.vt.us		x
Paganelli	David	VT Forests, Parks & Recreation	david.paganelli@state.vt.us	x	
Patch	Nancy	VT Forests, Parks & Recreation	nancy.patch@state.vt.us	x	
Plumb	Sharon	The Nature Conservancy (TNC)	splumb@tnc.org	x	
Rimmer	Chris	Vermont Center for Ecostudies	crimmer@vtecostudies.org	x	
Scott	Mark	VT ANR - Fish & Wildlife	mark.scott@state.vt.us		x
Sinclair	Steve	VT Forests, Parks & Recreation	steve.sinclair@state.vt.us	x	
Snyder	Michael	VT Forests, Parks & Recreation	michael.snyder@state.vt.us		
Sorenson	Eric	VT Fish & Wildlife	eric.sorenson@state.vt.us	x	x
Thompson	Liz	Vermont Land Trust (VLT)	liz@vlt.org	x	x
Twery	Mark	US Forest Service	mtwery@fs.fed.us		
Wallin	Kimberly	University of Vermont (UVM)	kwallin@uvm.edu	x	

Whipple	Craig	VT ANR - Parks	Craig.whipple@state.vt.us		x
Whitman	Andy	Manomet Center for Conservation Sciences	awhitman@manomet.org	x	x
Willard	Kate	VT ANR - Forests, Parks & Recreation	kate.willard@state.vt.us		x
Wilmot	Sandy	VT Forests, Parks & Recreation	sandy.wilmot@state.vt.us	x	x

Table 4L-2. List of potential candidates for the **rivers** work group (these are people who were invited to at least one of the workshops; x=attended).

Last Name	First Name	Affiliation	Email	Vulnerability workshop (x=attended)	Adaptation workshop (x=attended)
Alexander	Gretchen	VT DEC - Rivers	gretchen.alexander@state.vt.us	x	
Anderson	Ginger	VT Forests, Parks & Recreation	ginger.anderson@state.vt.us	x	
Becker	Larry	VT ANR - Geology	laurence.becker@state.vt.us		x
Dewoolkar	Mandar	University of Vermont (UVM)	mdewoolk@uvm.edu		x
Dolan	Kari	VT DEC - Ecosystem Restoration	Kari.Dolan@state.vt.us	x	x
Ferguson	Mark	VT Fish & Wildlife	mark.ferguson@state.vt.us	x	x
Fiske	Steve	VT DEC - Monitoring, Assessment and Planning	steve.fiske@state.vt.us	x	x
Fitzgerald	Brian	VT DEC - Rivers	brian.fitzgerald@state.vt.us	x	
Fitzgerald	Evan	Fitzgerald Environmental Associates	evan@fitzgeraldenvironmental.com	x	
Greenwood	Kim	VNRC	kgreenwood@vnrc.org		x
Hammer	Kris	VHCB	kris@vhcb.org		x
Hamshaw	Scott	University of Vermont (UVM)	shamshaw@uvm.com		x
Illick	Marty	Lewis Creek Association	marty.illick@gmail.com		x
Jessup	Ben	Tetra Tech	benjamin.jessup@tetratech.com	x	
Johnson	Ian	VTrans	ian.johnson@state.vt.us	x	
Kamman	Neil	VT DEC - Monitoring, Assessment and Planning	Neil.kamman@state.vt.us	x	x
Kelley	Ernie	VT DEC - Wastewater	ernie.kelley@state.vt.us		
Kilpatrick	Bill	University of Vermont (UVM)	C-William.Kilpatrick@uvm.edu	x	
Kirn	Rich	VT Fisheries	Rich.Kirn@state.vt.us		
Kline	Mike	VT DEC - Rivers	mike.kline@state.vt.us		x
Langdon	Rich	VT DEC - Monitoring, Assessment and Planning	richard.langdon@state.vt.us		
Marangelo	Paul	The Nature Conservancy (TNC)	pmarangelo@tnc.org	x	

McKearnan	Sarah	VT DEC	Sarah.McKearnan@state.vt.us	x	
Pealer	Sacha	VT DEC - Rivers	Sacha.Pealer@state.vt.us	x	x
Rizzo	Donna	University of Vermont (UVM)	drizzo@uvm.edu		x
Schiff	Roy	Milone and Macbroom	roys@miloneandmacbroom.com	x	
Shanley	Jamie	US Geological Survey	jshanley@usgs.gov		
Smith	Chris	US Fish & Wildlife Service	Chris_E_Smith@fws.gov	x	x
Stamp	Jen	Tetra Tech	Jen.Stamp@tetratech.com	x	
Underwood	Kristen	University of Vermont (UVM)	southmountain@gmavt.net		x
Wemple	Beverley	University of Vermont (UVM)	Beverley.Wemple@uvm.edu		

Table 4L-3. List of potential candidates for the **lakes** work group (these are people who were invited to at least one of the workshops; x=attended).

Last Name	First Name	Affiliation	Email	Vulnerability workshop (x=attended)	Adaptation workshop (x=attended)
Brooks	Art	Vice-President - The Federation of Vermont Lakes and Ponds; Professor Emeritus, University of Wisconsin-Milwaukee	ABROOKS@uwm.edu	x	
Deeds	Jeremy	VT DEC - Lakes & Ponds Management/Protection	Jeremy.Deeds@state.vt.us	x	
Fisher	Lori	Lake Champlain Committee	lorif@lakechamplaincommittee.org	x	
Howe	Eric	Lake Champlain Basin	EHowe@lcbp.org		
Howland	Bill	Lake Champlain Basin	whowland@lcbp.org		
Merrell	Kellie	VT DEC - Lakes & Ponds Management/Protection	Kellie.Merrell@state.vt.us	x	x
Monks	Padraic	VT DEC - Stormwater	padraic.monks@state.vt.us		x
Shambaugh	Angela	VT DEC - Lakes & Ponds Management/Protection	Angela.Shambaugh@state.vt.us	x	x
Smeltzer	Eric	VT DEC - Lakes & Ponds Management/Protection	Eric.Smeltzer@state.vt.us	x	x
Warren	Sue	VT DEC - Lakes & Ponds Management/Protection	susan.warren@state.vt.us		
Will	Lael	VT ANR - Fish & Wildlife	lael.will@state.vt.us		x
Winslow	Mike	Lake Champlain Committee	Mikew@lakechamplaincommittee.org		x

Table 4L-4. List of potential candidates for the **wetlands** work group (these are people who were invited to at least one of the workshops; x=attended).

Last Name	First Name	Affiliation	Email	Vulnerability workshop (x=attended)	Adaptation workshop (x=attended)
Andrews	Jim	Middlebury College	jandrews@middlebury.edu	x	x
Crehan	Ryan	US Fish & Wildlife Service	ryan_crehan@fws.gov	x	x
Hilke	Chris	National Wildlife Federation (NWF)	hilkec@nwf.org	x	x
Kellogg	Jim	VT DEC - Monitoring, Assessment and Planning	jim.kellogg@state.vt.us	x	
Leonard	Neahga	Staying Connected Initiative	Neahga.Leonard@gmail.com	x	
Parren	Steve	VT Fish & Wildlife	steve.parren@state.vt.us	x	x
Paul	Rose	The Nature Conservancy (TNC)	rpaul@TNC.ORG	x	x
Popp	Bob	VT Fish & Wildlife	bob.popp@state.vt.us	x	x
Quackenbush	Alan	VT DEC - Wetlands	Alan.Quackenbush@state.vt.us	x	x
Royar	Kim	VT ANR - Fish & Wildlife	kim.royar@state.vt.us		

Table 4L-5. List of potential candidates for the **weather and climate** work group.

Last Name	**First Name**	**Affiliation**	**Email**	**Vulnerability workshop (x=attended)**	**Adaptation workshop (x=attended)**
Betts	Alan	Atmospheric Research	Akbetts@aol.com	x	x
Dupigny-Giroux	Lesley-Ann	Associate Professor (UVM) & VT State Climatologist	ldupigny@uvm.edu		

List of potential candidates for the **species** work group, taken from the 2005 Vermont SWAP plan (Kart et al. 2005).
Any efforts with this group should be coordinated with the SWAP updates that are currently underway (contact: Steve Parren).

Reptile & Amphibian Team

Steve Parren, Vermont Fish & Wildlife Dept (team leader)
Jim Andrews, Middlebury College
Steve Faccio, Vermont Institute of Natural Science
Chris Slesar, Vermont Agency of Transportation

Mammal Team Members

Kimberly Royar, Vermont Fish & Wildlife Dept. (team leader)
Patrick Bartlett, forester
Thomas Decker, Vermont Fish & Wildlife Dept.
Dr. William Kilpatrick, University of Vermont
Susan Morse, Keeping Track
John Sease, U.S. Forest Service
Dr. Peter Smith, Green Mountain College
Dr. Charles Woods, biologist

Invertebrate Team

Mark Ferguson, Vermont Fish & Wildlife Dept. (team leader)
Steve Fiske, Vermont Dept of Environmental Conservation
Trish Hanson, Vermont Forest Parks & Recreation Dept
Kent McFarland, Vermont Institute of Natural Science
Bryan Pfeiffer, Wings Environmental

Fish Team

Kenneth Cox, Vermont Fish & Wildlife Department (team leader)
Dr. Douglas Facey, Saint Michael's College
Anne Hunter, Vermont Fish & Wildlife Department
Richard Langdon, Vermont Department of Environmental Conservation
John Lepore, Vermont Agency of Transportation
Craig Martin, U.S. Fish & Wildlife Service
Dr. Donna Parrish, Vermont Fish & Wildlife Cooperative Research Unit
Steven Roy, U.S. Forest Service, Green Mountain National Forest

Birds Team

Cedric Alexander, Vermont Fish & Wildlife Dept. (team leader)
Eric Derlath US Fish & Wildlife Service
Patrick Doran, Wildlands Project
Dave Frisque, US Fish & Wildlife Service
Margaret Fowle, National Wildlife Federation
John Gobeille, Vermont Fish & Wildlife Dept.
Paul Karczmarczyk, Ruffed Grouse Society

Mark Labarr, Audubon Society
Chris Rimmer, Vermont Institute of Natural Science
Dr. Allan Strong, University of Vermont

Appendix 4M

Resources for conducting species-level vulnerability assessments

Results from the NatureServe CCVI can vary depending on climatic projection, life history and distribution data that are used. Thus, we recommend that the input data come from critically-reviewed, primary sources. This table contains potential sources for life history and distribution information.

Taxonomic Group	Source	Description	Web Link
Fish	Fishes of Vermont (Langdon et al. 2006)	Comprehensive handbook for identifying fishes across Vermont; contains natural history accounts for 92 species	NA
	FishNet	Open access to data housed in fish collections in natural history museums, universities and other institutions.	http://fishnet2.net/
	FishBase	A comprehensive fish database for research scientists, fisheries managers, zoologists and many more; currently supported by a consortium of nine research institutions.	http://www.fishbase.org/search.php
	FishTraits (Frimpong and Angermeier 2009)	A database of > 100 traits for 809 fish species found in freshwaters of the conterminous United States; include information on 4 major categories of traits: (1) trophic ecology; (2) body size, reproductive ecology, and life history; (3) habitat preferences; and (4) salinity and temperature tolerances, as well as information on geographic distribution and conservation status.	www.cnr.vt.edu/fisheries/fishtraits
Birds	Ornis	Open access to data housed in bird collections in natural history museums, universities and other institutions.	http://www.ornisnet.org/
Mammals	MaNIS	Open access to data housed in mammal collections in natural history museums, universities and other institutions.	http://www.manisnet.org/

Taxonomic Group	Source	Description	Web Link
Reptiles/ Amphibians	HerpNet	Open access to data housed in herpetological collections in natural history museums.	http://www.herpnet.org/
	AmphibiaWeb	Online system that provides access to information on amphibian declines, conservation, natural history, and taxonomy.	http://amphibiaweb.org/
	The Vermont Reptile & Amphibian Atlas	Contains species accounts, distribution maps and observational records for the amphibians and reptiles of Vermont.	http://community.middlebury.edu/~herpatlas/
Invertebrates	The Vermont Invertebrate Database Alliance (VIDA)	Natural history museums, research biologists, universities, environmental groups, and dedicated individuals are uniting to create the most complete database of Vermont invertebrates.	vtinverts.org/
	Freshwater Traits Database (US EPA 2012)	Contains traits data for 3857 North American macroinvertebrate taxa, and includes habitat, life history, mobility, morphology and ecological trait data.	http://www.epa.gov/ncea/global/traits/
	Lotic invertebrate traits for North America (Vieira et al. 2006)	A total of 14,127 records for over 2,200 species, 1,165 genera, and 249 families have been entered into the database from 967 publications, texts and reports.	http://pubs.water.usgs.gov/ds187
Multiple	NatureServe	Conservation data on more than 70,000 plants, animals, and ecological communities of the United States and Canada; *note: some of this may be secondary data.*	http://www.natureserve.org/getData/

Invasives	Vermont Department of Forests, Parks and Recreation, in partnership with UVM and The Nature Conservancy	Online resource with information on non-native plants and tree pests	http://vtinvasives.org/

Appendix 4N

Inventory of long-term ecological monitoring data

Long-term ecological monitoring data

In addition to species-level vulnerability assessments, we also did an inventory of long-term ecological monitoring data currently being collected in Vermont. Results are summarized in Table 4N-1. Few if any of these data are being collected with the intent of monitoring for climate change; nevertheless, these types of long-term data provide insights as to how abundance and distributions of biota are changing over time, whether these changes are occurring in association with changing climatic conditions and whether these responses are consistent with model projections and/or expert opinion.

BASS recently established a sentinel stream network consisting of 10-15 sites at which they collect macroinvertebrate and water chemistry data annually (potentially fish as well). Site locations are listed in Table 4N-2and shown in Figure 4N-1.The Vermont Division of Fisheries also has a number of monitoring sites with over 20 years of data but the Fisheries group does not have a formal statewide plan for continuing long-term monitoring at these sites. The Lakes program recently established a sentinel monitoring network as well; locations of the sites can be found in Table 4N-2 and Figure 4N-2.

The Vermont Department of Forests, Parks and Recreation has been monitoring the timing of spring flowering and leaf out of sugar maple trees at the Proctor Maple Research Center at the base of Mount Mansfield since 1991, and conducts annual aerial statewide surveys to monitor forest insect and disease conditions. The Vermont Fish & Wildlife Department could potentially derive population trend data from sites they revisit during their Natural Heritage Inventory. Various groups within ANR are also involved in the Vermont Monitoring Cooperative, which conducts research projects pertaining to air, forest, soil, water and wildlife at 4 long-term forest and stream monitoring sites (Camel's Hump, Sleepers River, Mount Mansfield, and Lye Brook Wilderness area). In addition, outside entities such as the Vermont Center for Ecostudies (VCE), the Fairbanks Museum, the Nature Conservancy, Audubon, the USA National Phenology Network and Jim Andrews at Middlebury College (Vermont Reptile & Amphibian Atlas) collect valuable long-term ecological monitoring data (Table 5).

Table 4O-1. Summary of long-term ecological monitoring data that are currently being collected in Vermont.

Entity	Program	Description	Link
Biomonitoring and Aquatic Studies (BASS)	Routine and sentinel monitoring	Long-term stream monitoring data for aquatic invertebrates, fish and water chemistry (records dating back to 1981)	NA
Vermont Division of Fisheries	Routine monitoring	Long-term fish monitoring data for streams and lakes (records dating back to 1953)	NA
Vermont Department of Forests, Parks and Recreation	Tree phenology	Timing of spring flowering and leaf out of sugar maple trees at the Proctor Maple Research Center at the base of Mount Mansfield (monitoring began in 1991)	http://www.uvm.edu/~pmrc/
	Forest insect and disease conditions	Annual aerial statewide surveys to monitor forest insect and disease conditions, in partnership with U.S. Forest Service	http://vtinvasives.org/
Proctor Maple Research Center	Sugar maple tapping surveys	Tapping survey results for sugar maples	http://www.uvm.edu/~pmrc/
Vermont Monitoring Cooperative	Multiple	Various research projects pertaining to air, forest, soil, water and wildlife; includes 4 long-term forest and stream monitoring sites (Camel's Hump, Sleepers River, Mount Mansfield, and Lye Brook Wilderness area)	http://www.uvm.edu/vmc/
Vermont Fish & Wildlife Department	Natural Heritage Inventory	Could potentially derive population trend data (increasing, stable, or decreasing) from revisited sites	NA
The Nature Conservancy	iMapInvasives	Vermont invasive species public map	http://imapinvasives.org/vtimi/map/
Jim Andrews, Middlebury College	Vermont Reptile & Amphibian Atlas	Contains over 73,000 observational records; of these, roughly 58,000 are amphibians and 15,000 are reptiles.	http://community.middlebury.edu/~herpatlas/

Table 4O-1. continued…

Entity	Program	Description	Link
Vermont Center for Ecostudies*	Mountain Birdwatch	Citizen science initiative launched in Vermont in 2000 to establish a long-term monitoring program for Bicknell's Thrush and other high-elevation forest birds. Monitoring also occurs in New York, New Hampshire, Maine, Québec, and the Canadian Maritimes.	http://www.vtecostudies.org/MBW/
	Vermont Forest Bird Monitoring Program (FBMP)	Initiated in 1989, this program tracks long-term changes in populations of interior forest songbirds. As of 2005, monitoring sites have been established at 29 mature forest tracts representing 9 different forest communities across Vermont and New Hampshire.	http://www.vtecostudies.org/FBMP/
	Vermont Breeding Bird Atlas	Statewide population surveys conducted from 1976-1981 and from 2003-2007, using a grid-based design.	http://www.vtecostudies.org/vbba/
Audubon Society	Audubon's Annual Christmas Bird Count	Annual survey conducted by tens of thousands of volunteers nationwide from December 14 through January 5.	http://birds.audubon.org/christmas-bird-count
Cornell Lab of Ornithology and National Audubon Society	eBird	Launched in 2002, this simple and intuitive web-interface engages tens of thousands of participants to submit their bird observations or view results via interactive queries into the database.	http://ebird.org/content/ebird/
Fairbanks Museum	Community of Observers	Citizen scientists watch and record the habits of specific birds, butterflies and wildflowers in the fields, forests and wetlands they know best and set up a weather station to measure temperature and precipitation.	http://communityobserver.fairbanksmuseum.org/

* In addition, there are data that have been/are being collected by VCE that could serve as baseline data if future surveys are conducted. These include the statewide butterfly survey that was conducted from 2002-2007 (McFarland and Zahendra 2010), the Vernal Pool Mapping Project, and the Bumblebee survey that is currently underway.

Table 4O-1. continued…

Entity	Program	Description	Link
USA National Phenology Network	Nature's Notebook	A national plant and animal phenology observation program that provides a place for people to enter, store, and share their observations on phenological events like leaf out, flowering, migrations, and egg laying; participants include citizen scientists, government agencies, non-profit groups, educators and students of all ages.	http://www.usanpn.org/
American Lyme Disease Foundation	Ticks	Nationwide map of infected tick areas	http://www.aldf.com/usmap.shtml

Table 1. Sentinel lake/pond and stream monitoring sites in Vermont.

Longitude	Latitude	Station Name	Site Type	Program	Year_Start	Contact
-71.98000	44.73000	Bald Hill	Lakes	Sentinel	2012	Kellie Merrell
-72.07000	44.72000	Blake (Sutton)	Lakes	Sentinel	2012	Kellie Merrell
-73.15000	43.75000	High (Sudbry)	Lakes	Sentinel	2012	Kellie Merrell
-71.93000	44.98000	Holland	Lakes	Sentinel	2012	Kellie Merrell
-72.38000	44.68000	Little Hosmer	Lakes	Sentinel	2012	Kellie Merrell
-72.27000	44.62000	Long (Grnsbo)	Lakes	Sentinel	2012	Kellie Merrell
-72.15000	44.68000	Long (Shefld)	Lakes	Sentinel	2012	Kellie Merrell
-72.15000	44.68000	Round (Shefld)	Lakes	Sentinel	2012	Kellie Merrell
-72.53000	44.65000	Schofield	Lakes	Sentinel	2012	Kellie Merrell
-73.28000	43.77000	Spruce (Orwell)	Lakes	Sentinel	2012	Kellie Merrell
-72.17000	44.53000	Stannard	Lakes	Sentinel	2012	Kellie Merrell
-72.08000	44.70000	Vail	Lakes	Sentinel	2012	Kellie Merrell
-72.50000	44.60000	Zack Woods	Lakes	Sentinel	2012	Kellie Merrell
-71.94167	45.00528	Beaver	Lakes	Acid Rain	1980	Heather Pembrook
-72.93111	43.31444	Big Mud	Lakes	Acid Rain	1980	Heather Pembrook
-73.00444	43.10444	Bourn	Lakes	Acid Rain	1980	Heather Pembrook
-73.01944	43.08222	Branch	Lakes	Acid Rain	1980	Heather Pembrook
-72.86833	43.08111	Forester	Lakes	Acid Rain	1980	Heather Pembrook
-72.94278	43.04278	Grout	Lakes	Acid Rain	1980	Heather Pembrook
-72.50056	44.46778	Hardwood	Lakes	Acid Rain	1980	Heather Pembrook
-72.91722	42.91722	Haystack	Lakes	Acid Rain	1980	Heather Pembrook
-72.98611	42.78500	Howe	Lakes	Acid Rain	1980	Heather Pembrook
-73.06556	42.92500	Little	Lakes	Acid Rain	1980	Heather Pembrook
-73.06556	42.82222	Stamford	Lakes	Acid Rain	1980	Heather Pembrook
-72.68333	42.91778	Sunset	Lakes	Acid Rain	1980	Heather Pembrook
-72.21480	43.64347	Lake Bomoseen	Lakes	Ice out	1957	Amy Picotte
-72.87601	44.97507	Lake Carmi	Lakes	Ice out	2008	Amy Picotte
-71.99277	44.85926	Echo Lake (Charleston, VT)	Lakes	Ice out	1970	Amy Picotte

Table 1. continued…

Longitude	Latitude	Station Name	Site Type	Program	Year_Start	Contact
-72.22886	43.88605	Lake Fairlee	Lakes	Ice out	1975	Amy Picotte
-72.12265	44.08582	Halls Lake	Lakes	Ice out	1987	Amy Picotte
-72.13834	44.29212	Lake Harvey (Harvey's Lake)	Lakes	Ice out	1946 (with gaps)	Amy Picotte
-73.08383	44.36787	Lake Iroquois	Lakes	Ice out	1994	Amy Picotte
-72.22167	44.40851	Joe's Pond	Lakes	Ice out	1988	Amy Picotte
-71.64599	44.65405	Maidstone	Lakes	Ice out	1973	Amy Picotte
-72.70232	43.45146	Lake Rescue	Lakes	Ice out	1995	Amy Picotte
-71.98840	44.89694	Lake Seymour	Lakes	Ice out	1983	Amy Picotte
-73.03019	43.40850	Chipman - Tinmouth Pond	Lakes	Ice out	2005	Amy Picotte
-72.15448	43.91759	Lake Morey	Lakes	Ice out	1977	Amy Picotte
-73.21320	43.46902	Lake St Catherine	Lakes	Ice out	1933	Amy Picotte
-72.21344	44.97429	Lake Memphremagog	Lakes	Ice out	1992	Amy Picotte
-71.93950	44.41687	Stile's Pond	Lakes	Ice out	1970	Amy Picotte
-72.60499	44.04218	Colts Pond/Sunset Lake	Lakes	Ice out	1933	Amy Picotte
-72.93194	43.13833	Winhall River	Streams	Biomonitoring	2011	Steve Fiske
-72.74389	43.76667	White River	Streams	Biomonitoring	2011	Steve Fiske
-72.74639	43.77083	White River	Streams	Biomonitoring	2011	Steve Fiske
-72.89518	43.87139	Bingo Brook	Streams	Biomonitoring	2011	Steve Fiske
-72.94583	43.85556	Smith Brook	Streams	Biomonitoring	2011	Steve Fiske
-72.15417	43.99167	Waits River	Streams	Biomonitoring	2011	Steve Fiske
-72.16139	44.49111	Pope Brook	Streams	Biomonitoring	2011	Steve Fiske
-71.63556	44.75222	Nulhegan River	Streams	Biomonitoring	2011	Steve Fiske
-71.63564	44.75499	Nulhegan River	Streams	Biomonitoring	2011	Steve Fiske
-72.78194	44.50361	Ranch Brook	Streams	Biomonitoring	2011	Steve Fiske
-73.23361	44.24861	Lewis Creek	Streams	Biomonitoring	2011	Steve Fiske
-73.22917	44.24833	Lewis Creek	Streams	Biomonitoring	2011	Steve Fiske
-72.74722	42.74694	East Branch North River	Streams	Biomonitoring	2011	Steve Fiske
-71.78528	44.58417	Moose	Streams	Biomonitoring	2011	Steve Fiske
-72.54089	44.44180	North Branch Winooski	Streams	Biomonitoring	2011	Steve Fiske

Table 1. continued…

Longitude	Latitude	Station Name	Site Type	Program	Year_Start	Contact
-72.66250	42.76389	Green	Streams	Biomonitoring	2011	Steve Fiske

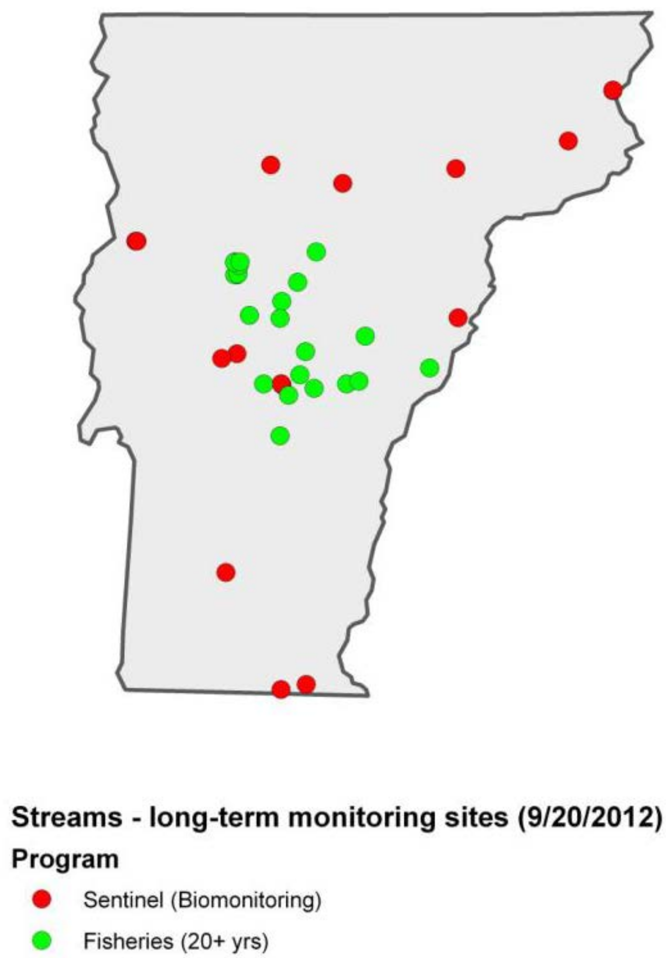


Figure 4N-1. Locations of long-term stream biomonitoring sites. Fisheries sites in central Vermont that have >20 years of data are also shown (contact: Rich Kirn). These Fisheries sites are current not part of a long-term monitoring network.

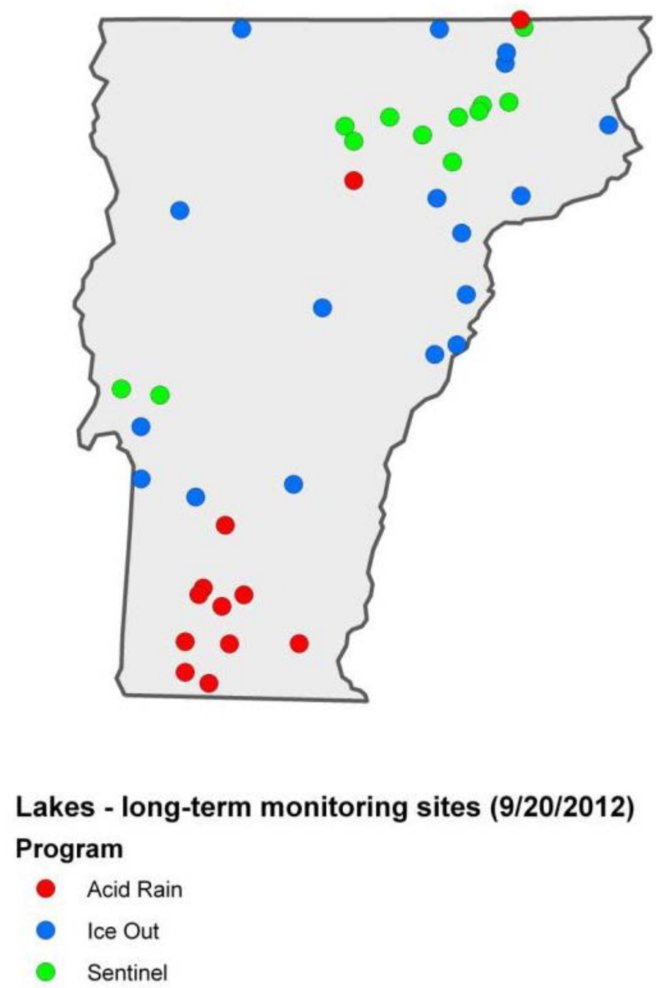


Figure 4N-2. Locations of long-term lake monitoring sites

Other long-term monitoring data

In addition to ecological and climatic data, we also inventoried other types of long-term monitoring data being collected in Vermont that might be useful for detecting climate change effects. The Rivers Program collects various types of geomorphic data, such as measures of channel erosion, rates of channel migration and enlargement of the channel over time. While these types of channel cross section data are available for many locations throughout the state, they are not measured regularly. Moreover, it would be extremely difficult to separate climate effects from land use effects since the Rivers Program focuses their efforts in third order or higher streams that are commonly impacted by encroachment and/or other anthropogenic stressors. In addition to geomorphic assessment data, the Rivers Program also partners with VTrans, Department of Fish and Wildlife and the Fisheries Division to collect culvert/stream crossing structure data. This includes an assessment of the structures' potential impact to aquatic organism passage (Milone and MacBroom 2009).

Long-term water quality data are being collected in many lakes throughout Vermont. The Acid Lakes program has been sampling 12 lakes for 3 seasons per year since 1980 (Heather Pembrook, personal communication, 2012). They collect a variety of parameters, including temperature profiles, Secchi depth, pH, alkalinity, and a variety of other water chemistry measures (i.e. anions, cations, metals, nutrients). Locations of these lakes can be found in Figure 5 and Appendix C. The Lakes Program also has a long-term sampling program called 'Spring P;' each spring they measure phosphorus concentrations at lakes throughout the state (typically on a 5-year cycle) at or near the time the lakes turn over. Another long-term lake monitoring programs is the Vermont Lay Monitoring Program (LMP), which is a citizen monitoring program that monitors approximately 40 lakes and 25 Lake Champlain stations per year. Most locations are sampled weekly during the summer for chlorophyll-a, total phosphorus, and Secchi disk transparency. An additional program is the Long-Term Water Quality and Biological Monitoring Project for Lake Champlain, which began in 1992 and monitors 15 stations on Lake Champlain and 21 major tributaries to the lake. They collect a variety of chemical and biological parameters, including temperature, oxygen, conductivity and pH profiles, and information on cyanobacteria and zebra mussels). UVM also conducts monitoring in Lake Champlain and its tributaries, including efforts currently underway by the RACC team.

Long-term air quality data are being collected at 7 sites as part of the Vermont Air Pollution Division Ambient Air Monitoring Network. Ozone levels, which are being measured at 2 sites (Bennington airport and Underhill Proctor Maple Research Center), may increase with climate change as plants produce more volatile organic compounds, which then react with nitrogen oxides to produce ozone (Rustad et al. 2012).

Appendix 4O

Inventory of data gaps

We compiled a list of data gaps/needs based on results from our inventory and on feedback that was received during the July 9th climate change vulnerability workshop. Data needs for climatic parameters are listed in Table 4P-1, and data needs for ecological parameters are listed in Table 4P-2. These lists are not all-encompassing; there are many more data gaps that will need to be filled, and there are many complex interacting factors and feedback cycles that we do not fully understand (i.e. the effects of climate change will be felt to differing degrees relative to land use change). In order to effectively track climate change effects over time, it is important that we make better use of existing data and do our best to make new data accessible.

Table 4O-1. Data needs related to climatic variables.

Variable	**Data Needs**
Precipitation	Improvements in future projection data
	Data from more locations
Water temperature	Year-round, continuous data from more locations, and improved understanding of interacting factors (i.e. impacts of color (tannic, clear))
Flow	Data from more locations, particularly in smaller (<100 km^2 drainage area), moderate to high gradient streams
Ice	River ice data from more locations; key variables: annual first day of ice-affected flow in the winter, the last day of ice-affected flow in the spring, total number of days of ice-affected flow, frequency of ice jams, annual river-ice thickness for set winter dates (Hodgkins et al. 2009)
Snowpack	Snowpack data from more locations; key variables: magnitude of late-winter water equivalent, depth, and density for selected dates (Hodgkins et al. 2009)
Groundwater	Improvements in our understanding of groundwater resources and groundwater-surface water interactions; key variables: amount of winter recharge, amount of spring recharge, base-flow component of summer streamflows (Hodgkins et al. 2009)
Soil moisture	Data from more locations
Evapotranspiration	Data from more locations
Cloud cover/solar radiation & wind	Explore data availability from power companies (i.e. from solar farms and grid-intertie systems); if insufficient, collect data from more locations

Table 4O-2. Data needs related to climatic variables

Variable	Data Needs
Baseline	More baseline biological data for lakes and wetlands
Natural variability	Better understanding of seasonal and annual variability in biotic assemblages and how these fluctuations are associated with climatic conditions
Biological interactions	Improved ability of future projection models to take biological interactions (i.e. competition, dispersal) into account
Thresholds	Improved understanding of ecological thresholds (i.e. will a 1.7° C increase in air temperature cause stream temperatures to change to a point that will cause certain taxa to drop out?)
Lag year effects	Improved understanding of how climatic conditions from previous years can impact biota and how long these impacts persist
Winter function	Improved understanding of ice and winter function in wetlands, rivers and lakes, and the importance and function of snow cover in forests (root systems, soil biota)
Productivity & nutrient dynamics	Improved understanding of how climatic conditions affect productivity and nutrient dynamics in lakes
Stratification patterns	Improved understanding of how climatic conditions impact stratification patterns in lakes
Phenology	More types of data from more locations (i.e. timing of insect emergence, bud break, leaf off data); explore data availability from outside organizations (i.e. citizen scientist projects such as the Fairbanks Museum Community of Observers)
Traits	Better understanding of key points/cues in life cycles and which traits make some biotic better able to adapt to changing climatic conditions than others; lack of sufficient traits data for many taxonomic groups
Adaptive capacity	Better understanding of what makes some biota better suited to adapt to changing climatic conditions than others
Climatic/ecological interactions	Improved understanding of which climatic variables are most closely tied to ecological variables (i.e. hydrologic/ecological interactions in streams)

Appendix 4P

Environmental flow (E-flow) status of states that have taken action

State	E-Flow Status
Alaska	More than 15,000 water bodies support anadromous and resident fish species in Alaska (USA). To maintain these valuable fisheries, in 1980 the state established a clear legal framework for reserving environmental flows. Yet, 18 years later, only 237 applications for reservation of water had been completed; only 11 had been granted. With a single person funded to assess flow needs, file for water reservations, and perform other duties, the Alaska Department of Fish and Game was woefully under-equipped to implement the environmental flow policy its legislature enacted (Estes, 1998). Progress finally began in 2002, when the Department of Natural Resources agreed to fund a new staff position to adjudicate water reservations.
Arizona	These efforts to bring the environment to the table as a water using sector also tie in to a new WRRC project: Connecting Environmental Water Needs to Arizona Water Planning (EnWaP). Using information from the WRRC's recent assessment of environmental water needs for Arizona and other resources, we are collaborating with individuals and groups at the local, regional and state level to explore what it means to consider the environment in water planning. Ultimately, we aim to establish dialogue among water users about voluntary, stakeholder-driven options for addressing the environment in the context of limited water supplies and existing water rights. Our outreach and assessment efforts will be focused on four Arizona regions; a map of these regions is shown to the right.
Arkansas	Current Instream Flow Policy: Arkansas Game and Fish Commission established the "Arkansas Method" in 1987 as their instream flow policy. The policy informs permitting of surface water withdrawals to riparian users by the Arkansas Natural Resource Commission. The "Arkansas Method" sets seasonal minimum flows as: 60% mean monthly flow (MMF) November-March; 70% MMF April-July; and 50% MMF or median monthly flow July-October.
California	On May 4, 2010 the State Water Board adopted a policy for water quality control titled "Policy for Maintaining Instream Flows in Northern California Coastal Streams". The policy contains principles and guidelines for maintaining instream flows for the purposes of water right administration. The geographic scope of the policy encompasses coastal streams from the Mattole River to San Francisco and coastal streams entering northern San Pablo Bay and extends to five counties: Marin, Sonoma, and portions of Napa, Mendocino, and Humboldt Counties. Office of Administrative Law approval was received on September 22, 2010. A Notice of Decision was filed with the Secretary for Resources on September 28, 2010. The Policy is now effective. A three-year Predecisional Trial Program has been implemented.
Colorado	The Colorado ELOHA project demonstrates (1) using flexible approaches to develop flow-ecology curves based on studies reported in the literature and (2) using flow-ecology curves to inform basin-scale water-resource planning. Sanderson et al (2011) provide a useful overview of the entire project.

Connecticut	A major component of The Nature Conservancy's Connecticut River Program to restore important river processes, thereby improving the health of declining native species and diverse habitats along the river and its tributaries. The objective of the ecosystem flow restoration component is to modify management of dams and water supply systems to provide environmental benefits while continuing to supply water, reduce flood risk, and generate hydropower (Zimmerman et al. 2008). It is collaboratively managed and funded by the Corps New England District Office through a Congressionally authorized (in Water Resource Development Act, or WRDA) study budgeted at $3 million. The Nature Conservancy is an authorized cost-share partner and has raised its $1.5 million share through a private donation. The modeling team is building a hydrologic model and decision–support tool (figure 1) for integrated water resource management to evaluate environmental and economic outcomes of various water management and climate change scenarios. The tool also will be useful for upcoming Federal Energy Regulatory Commission FERC relicensing actions, for setting individual dam operations in their regional context. Model construction began in 2009 and is nearing completion. The DSS includes two simulation models, one built by University of Massachusetts Amherst (UMass) modelers, and the other by the US Army Corps of Engineers (Corps). The UMass model uses STELLA system-dynamics software to directly represent current reservoir operations and economic outcomes in sub-basins. In 2012, project efforts will focus on implementation.
Florida	Some 237 minimum flows and levels have been established for water bodies, including 19 rivers and estuaries and 13-15 large first-magnitude springs, since 1992. Technical requirements for flow assessments match the relative priority of each water body. Although the word "Minimum" is still retained, in actuality the term has been reinterpreted to mean seasonally variable minimum and maximum flows, as needed to provide for ecosystem health. Florida policy allowed the progressive development of environmental flows over time in line with advances in science and capacity, so many of the initial limits have been revisited and refined (Wade and Tucker, 1996; D. Shaw, personal communication, 20 January 2009). Thus, the policy implementation has evolved with—and arguably helped to lead—the scientific advances that now recognise the importance of varying flows seasonally and inter-annually. The 1997 Water Act further strengthened the link between water resource development and environmental flow protection by requiring Water Management Districts to facilitate resource development in basins where available water is already fully allocated and withdrawals have been capped. This requirement has launched Florida to the international forefront in innovative engineering approaches, such as artificial recharge and aquifer storage and recovery (ASR), and dispersed water storage6 to manage the timing of environmental flows.

Idaho	Idaho's Minimum Stream Flow Program was approved by the Legislature in 1978 to preserve stream flows and lake elevations for public health, safety, and welfare. The minimum stream flow is the amount of flow necessary to preserve desired stream values, including fish and wildlife habitat, aquatic life, navigation and transportation, recreation, water quality, and aesthetic beauty. Minimum stream flow water rights are held by the Idaho Water Resource Board in trust for Idaho citizens (Chapter 15, Title 42, Idaho Code). Any person or entity can make a request to the Idaho Water Resource Board to file an application for stream flow on any water body within the state.
Maine	In 2007, Maine became the first state in the USA to adopt statewide environmental flow and lake level standards based on principles of natural flow variation necessary to protect aquatic life resources and important hydrological processes. Five years of public debate shaped the policy between the time the authorising statute passed and the time the regulatory standard was adopted. Because Maine lacks a statewide water abstraction management program, the new standards are implemented by staff from a pre-existing state water quality standards programme. New river condition goals did not have to be established; instead, the new seasonal flow standards are associated with existing river condition tiers, or goals, that were previously instituted under the water quality programme. Currently, Maine is helping water users meet the flow standards by providing expedited permitting and financial support for off-stream reservoir projects for storing water when excess is available, for use during low-flow periods.

Massachusetts	The Massachusetts Sustainable Water Management Initiative demonstrates the use of (1) a durationcurve regression approach to build a hydrologic foundation, (2) bioperiods as a temporal basis for setting flow criteria, (3) quantitative flow-ecology response curves to inform decision-making, and (4) a management framework that associates implementation actions with different condition goals. It is a work in progress. The hydrologic foundation is the Massachusetts Sustainable-Yield Estimator (SYE), a statewide, interactive decision-support tool (Archfield et al. 2010). SYE first estimates the 1960-2004 series of unregulated (baseline), daily streamflow at ungaged sites using a duration-curve regression approach. A Technical Committee of stakeholders identified four seasonal bioperiods necessary to support life histories and biological needs of resident fish communities and fluvial-dependent diadromous species: overwintering and salmonid egg development, spring flooding, rearing and growth, and fall salmonid spawning. Flow-ecology relations were evaluated by Armstrong et al. (2010) using data from 756 fish-sampling sites in the Massachusetts Division of Fisheries and Wildlife fish-community database. Literature review guided the selection of a set of flow-sensitive fish metrics, including two fish-community metrics (fluvialfish relative abundance and fluvial-fish species richness) and five indicator species metrics (relative abundance of brook trout, blacknose dace, fallfish, white sucker, and redfin pickerel). Using quantile regression (Cade and Richards 2005) and generalized linear models, they quantified fish response to August median flow alteration, water-use intensity, and withdrawal and return-flow fractions.
Michigan	In July 2009, Michigan passed the Natural Resources and Environmental Protection Act mandating use of the tool to screen potential impacts of all future high-capacity groundwater and surface-water withdrawals. Scientists used the best available science to relate flow alteration to ecological condition, but stakeholders still had to make the social decision of what ecological condition is acceptable. Both the science and the social decision are incorporated into the tool. This tool was "piloted," and stakeholders were given the chance to test the system and comment for one year before its use became mandated for all new water allocations. The Council of Great Lakes Governors is currently providing technical assistance to encourage other compact signatories to follow Michigan's leadership in rigorously incorporating environmental flow protection into their water management programmes to meet the Compact requirements (Herbert and Seelbach, 2009).

Minnesota	Develop recommendations and indicators for ecological criteria for instream flow protection in Minnesota, with special attention to rivers and streams in Minnesota's Great Lakes basin. Products were developed through a collaborative process with public agencies in Minnesota and other experts, building on partnerships between the Conservancy and U.S. Geological Survey (USGS) across the Great Lakes. The report using the ELOHA framework assesses available data, tools and approaches that can be used to establish ecologically based instream flow protections in Minnesota. Specifically, the report: · Describes the current situation in Minnesota regarding the status of aquatic resources and water management practices that affect ecosystem health (Section 1) · Outlines the ELOHA framework, highlighting seven case studies and exploring options for Minnesota (Section 2 and Section 4) · Summarizes work completed to date, including preliminary conceptual models upon which to build flow-ecology relationships (Appendix 3) · Recommends next steps (Section 3)
Missouri	2009: The Missouri Department of Conservation is working towards an instream flow policy. As a first step, a river hydrologic classification system is being developed. Under Hydroecological Integrity Assessment Process (HIP), 147 gages were evaluated using cluster analysis of 171 hydro indices (all a function related to 10 flow components). Yielded 6 types, intermittent, perennial runoff-flashy, perennial runoff-low baseflow, perennial runoff-moderate baseflow, and perennial groundwater-stable, perennial groundwater-super stable. Classification does not include Missouri or Mississippi Rivers or ephemeral streams. 2010:While we have no official instream flow program within MDC, there are a few of us who spend a portion of our time on instream flow issues. MDC was able to weather the economic downturn via voluntary retirements and normal attrition, but since many retirements were at the upper levels of the agency, there is a need for a new round of upward educational efforts.

Montana	A series of small policy advances over three decades reformed Montana's (USA) deeply entrenched water rights system to protect, and then to restore environmental flows. Once the environmental flow needs were assessed for instream flow reserves, it became apparent that water in many of the state's basins was already overallocated. In response, the state legislature statutorily closed (capped) overappropriated basins to further allocations in the 1990s. Ultimately, a 2006 Montana Supreme Court ruling required the state to strengthen the basin closures by conjunctively managing withdrawals of groundwater and surface water (Ziemer et al., 2006; Smith, 2009). A variety of creative legal and financial mechanisms became available to convert valuable senior water rights—typically for agricultural irrigation—to senior instream flow rights, while protecting existing water users. Lawyers for non-governmental organisations like the Montana Water Trust and Trout Unlimited help mediate these water transactions. The USA states of Colorado, Oregon, and Washington have made similar strides (MacDonnell, 2009) in successfully adapting their traditional prior appropriation system of water allocation to transfer water voluntarily from existing users to environmental flow, and to protect those restored flows from future appropriation.
Nebraska	The Nebraska Game & Parks Commission staff has been studying the need for an instream flow water right to protect some of the remaining flows in the Niobrara so they continue to provide recreation, fish, and wildlife benefits. At its October, 2009, meeting, the Commissioners discussed but delayed asking staff to move forward with a water rights application that would protect some of the remaining flows in the Niobrara River. Under Nebraska law, irrigators, industries, cities and other water users have been able to apply for and get rights to take water out of Nebraska's rivers for more than a century. Only in recent years did the State Legislature recognize that there is tremendous value in leaving water in streams, where it can provide flows needed to float canoes or kayaks, and to support fish and wildlife.
North Carolina	The North Carolina General Assembly enacted legislation in 2010 directing the Department of Environment and Natural Resources to develop hydrologic models for each river basin in N.C. An important part of this bill requires the department to determine the flows needed to maintain ecological integrity in surface waters. The bill further authorized the creation of a Science Advisory Board to assist the department in assessing these ecological flows. The members and alternates of the board all have a strong background in aquatic ecology and represent a diversity of water use interests. The board has a charter that will help guide them through this process. Meetings of the Ecological Flows Science Advisory Board are open to the public. Persons interested in receiving meeting announcements and materials distributed prior to meetings can register here Register.

Ohio	Ohio's development of ecological flow protection standards stems from its commitment to comply with the Great Lakes Compact (see Michigan case study). It is a work in progress. The process outlined below was carried out independently by a non-profit research institute (Midwest Biodiversity Institute) with funding and guidance from The Nature Conservancy. A coalition of environmental groups is using the results to secure ecologically-based low flow protection in the ongoing Ohio Great Lakes Compact Implementation process. Additionally, the Ohio Department of Natural Resources has expressed interest in using the flow-ecology response curves developed during this process to evaluate proposed water withdrawals once a regulatory program is in place.
Texas	Texas has established an environmental flow policy process with clearly defined state and local roles. State environmental agencies and an ad hoc statewide environmental flows science committee provide technical guidance, information, and data for basin environmental flow science teams. Basin science and stakeholder teams recommend environmental flows in their respective basins. The Texas Commission on Environmental Quality (TCEQ) considers the basin recommendations when it sets enforceable standards and implements them through a state water allocation system. The Texas Department of Parks and Wildlife provides technical support. This process is currently nearing completion in the first test basins.
Utah	(i) If the state engineer, because of information in the state engineer's possession … has reason to believe that an application to appropriate water … will unreasonably affect public recreation or the natural stream environment, or will prove detrimental to the public welfare, it is the state engineer's duty to withhold approval or rejection of the application until the state engineer has investigated the matter. (ii) If an application does not meet the requirements of this section, it shall be rejected. (UCA73-3-8)
Washington	Rule making for flows is done through Ecology's rule-making authority in the Administrative Procedure Act Chapter 34.05 RCW. When stream flows are set in rule, the effective date (also called a "priority date") is thirty days after the date of rule adoption. An instream flow is, in essence, a water right for fish and other instream resources. While an instream flow does not affect existing water rights, water rights issued after the rule adoption are junior to the instream flow, and can only be exercised when the instream flow is being met.

West Virginia	With a mean elevation of 1500 feet, West Virginia has a higher elevation than any other state east of the Mississippi River. This quality along with its longitude and latitude place the state in a transition position. According to the West Virginia state wildlife action plan, habitats are dominated by contiguous forests, pristine rivers and streams, housing a broad array of fish, mussels, and other invertebrates. Only 12% of the land is publically owned. About 364,000 hunters and anglers live in West Virginia, according to a National Shooting Sports Foundation [link to www.nssf.org/07report/index.cfm] report. The $1.5 billion a year they spend while hunting and fishing directly supports 25,000 jobs and generates $172 million in state and local taxes. The action plan focuses on 128 species of concern, and is the state's first step in developing a continuous adaptive management process for collaborative conservation of the state's fish and wildlife and the habitats that sustain them. Current Instream Flow Policy: Although Ch. 22 of the West Virginia State Code describes the policy to protect and conserve water resources for the state and provide for the public welfare, it has no standard for water withdrawal 'permitting." West Virginia uses 7Q10 for water quality permitting at this time.
Wyoming	In 1986, the State of Wyoming enacted legislation defining "instream flow" as a beneficial use of water and stipulated how instream flow water rights would be filed, evaluated, granted or denied, and ultimately regulated (Wyoming Statutes at Section 41-3-1001 to 1014). The law allows for instream flow water rights to be filed and granted on unappropriated water originating as natural flow or from storage in existing or new reservoirs. For natural flow sources, the flow amount is defined as the minimum needed to "maintain or improve existing fisheries". The language relating to stored water is slightly different, defining the minimum needed to "establish or maintain new or existing fisheries". Instream flow is generally considered a nonconsumptive beneficial use. The WGFD first selects the stream segment on which to file for a right. This is done using biological reports, knowledge of the fisheries, and stream flow models, along with determination of how much flow will be required.
Wyoming	In 1986, the State of Wyoming enacted legislation defining "instream flow" as a beneficial use of water and stipulated how instream flow water rights would be filed, evaluated, granted or denied, and ultimately regulated (Wyoming Statutes at Section 41-3-1001 to 1014). The law allows for instream flow water rights to be filed and granted on unappropriated water originating as natural flow or from storage in existing or new reservoirs. For natural flow sources, the flow amount is defined as the minimum needed to "maintain or improve existing fisheries". The language relating to stored water is slightly different, defining the minimum needed to "establish or maintain new or existing fisheries". Instream flow is generally considered a nonconsumptive beneficial use. The WGFD first selects the stream segment on which to file for a right. This is done using biological reports, knowledge of the fisheries, and stream flow models, along with determination of how much flow will be required.