AQUATIC

MISSION: *To maintain native habitats and endemic aquatic species in their current locations or support these as they migrate with land use and climate changes in the future.*

[Science objective] Quantitatively describe current and future hydrologic and structural habitat conditions, and aquatic population trends (in order).

[Management objective] To set conservation goals for both.

A. HEADING: REGIONAL LEVEL

1. PROGRAM: Landscape-level Disturbances & System-level Response

Examines major disturbances (includes climate change) as well as the impacts associated with these, regardless of ecological organization (e.g., community, species, population).

PROGRAM DESCRIPTION: *This Program looks at biological integrity, ecological flows and ecological function in response to large-scale, transformation/alteration of the system + change of state (generally beyond the Focal Management Level) and large-scale or regional planning tools.*

a. Climate Change: Using existing CC models, work with NOAA and the USGS Climate Science Centers to develop down-scaled climate change models and observational data for the LCC that can: (1) help managers predict likely impacts to the region's water resources, aquatic species, and human systems that rely upon those resources; (2) facilitate the development of more robust regional mitigation, monitoring and management plans; and (3) help managers provide meaningful input to future revisions of state and Federal water regulations.

b. Expanding Energy and Related Infrastructure and Roads

c. Urbanization and Population Growth

d. Effects of Air Pollution

(Grouping) – *Foundational/Stock-taking Assessment/Classification System*

- **Project Description:** [N] Conduct a comparative analysis of existing landscape planning tools.
- **Project Description:** [S] Conduct stream habitat and riparian corridor classification at fine scale [e.g. catchment level] to allow modeling that can be expanded to the landscape scale. Have adequate data at the catchment scale [and] link models to GIS to make the data more visual and available to partners. *[COP Comment: TNC, TN, has a good example of this (compiling, not field-collecting) catchment data and linking to GIS. Includes projections of urban growth, energy*

development, agricultural land-use, riparian habitat quality mapped onto areas of species diversity.]

- **Project Description:** [S] Using a science-based methodology, identify priority species for the App LCC, around which partners can collaborate to address and remove or minimize threats. *[COP Comment: Consider the use of environmental mapping to match species and changes in climate with mapping tools as a component of threats analysis—USFWS RAMP. This tool could be used to look at environmental changes and changes to species-matched environments.]*

(Grouping) – *Climate Change Science and Abiotic or Mechanical Aspects*

- **Project Description: [S]** Develop a regional comprehensive description of seasonal and diurnal thermal and flow characteristics of surface waters including effects of climate change. *[COP Comments: 1) Would need to be tied to a classification scheme (e.g., cold headwaters, warm medium rivers, etc.) to be more descriptive rather than overly generalized. 2) Have seen something like this for flows and precipitation, from VA southward to GA Atlantic drainage streams, in Dec 2012 JAWRA article, "Streamflow changes in the South Atlantic, United States during the mid – and late 20th century".]*

- **Project Description: [S]** Develop models/analytical tech to bridge the gap between down-scaled Global Climate Models and watershed based projections of climate change effects on aquatic species and habitats.

- **Project Description: [S/N]** Project the impact of land-use and climate change on the delivery of key aquatic ecosystem services, including the loss of cold/cool water habitats in response to thermal regime shift.

(Grouping) – *Climate Change Impacts on Ecological Function and Response to Changes.*

- **Project Description:** Develop a web-based tool for riparian restoration based on variables indicative of climate change resiliency.
  [**AppLCC FY11/12 Funded Project:** (Nislow/USFS) "Web-Based Tool for Riparian Restoration Prioritization to Promote Climate Change Resilience (RPCCR) in Eastern US Streams"]

- **Project Description:** [N] Identify riparian and floodplain vegetation with climate change effects on aquatic community and the food chain. Of particulate interest is the ability of riparian and floodplain vegetation to moderate changes to food webs in species composition and changes to aquatic communities. *[COP Comment: Consider also the impact by invasive or nuisance species or species (Asian carp, zebra mussels, New Zealand mud snail); these species impact food webs, energy flows, etc.]*

- **Project Description: [N]** Document the effects of extreme events on key habitat (specifically changes in structure & composition). *[COP Comments: 1} Need to clarify if focus is general weather? Hydrologic events? 2) This would require information on how peak rainfall and runoff events are changing with climate and land use change.]*

- **Project Description: [S]** Identify temp and flow tolerance limits of species. *[COP Comments: 1) How would this be narrowed? Narrow to a taxonomic group or group of keystone/priority/ surrogate species. 2) See https://nccwsc.usgs.gov/display-project/4f8c648de4b0546c0c397b43/ 50070884e4b0 abf7ce733fee; this CSC project on spatial and temporal variability of fishes in response to climate change may be a good guide for work related to benthics or other target species.]*

- **Project Description:** Determine species/taxa contaminants/toxicity thresholds.

- **Project Description: [N]** Model and identify, for T&E species, where natural refugia are likely to occur in light of changing climate or altered environments and where there is potential for reserves and captive holding of Evolutionary Significant Units (ESU).

- **Project Description: [S]** Develop a method to utilize mussels and their habitat as an indicator to identify multi species refugia, restoration sites for priority species, monitoring, and watershed restoration.

- **Project Description: [S]** Develop methods to rank taxonomically-related groups of species resistance and resiliency to climate change using generic traits.

- **Project Description: [S]** Develop a rigorous predictive understanding of the net water quality outcomes from aquatic species restoration/augmentation.

(Grouping) – *Energy and Related Infrastructure and Roads*

- **Project Description:** Develop flow-ecology relationships to enable states to redirect or change their flow standards to ensure adequate protection of aquatic ecosystems. Review existing information. Compile and make information available.

  [**AppLCC FY11/12 Funded Project:** (Fisher & Walter/Cornell University) "Development of a hydrologic foundation and flow-ecology relationships for monitoring riverine resources in the Marcellus Shale region"]

- **Project Description:** Determine the effects of resource extraction – related to energy development.

  o **(related/component)** Sitings; physical landscape; effects of fragmentation, and network refugia and connectivity sedimentation.

o **(related) [N]** Create an interactive GIS-based decision support tool useful in the planning and impact analysis stage for siting energy-related projects and for reducing environmental impacts of the footprint of these projects.

o **(related)** Vulnerability and impacts of aquatic species from the quantity of water extraction for the various methods of gas shale development in Appalachia.

• **Project Description: [S]** Determine if dissolved ion/ions and or heavy metals discharged downstream of surface and underground mining sites are toxic to aquatic organisms, mollusks or fishes. Specifically, identify the effects of chemicals constituents associated with coal processing and storage, fly ash, and discharges from settling ponds on survival, condition and reproduction of fish and aquatic invertebrates; especially lacking this information for all stages of freshwater mussels. *[COP Comment: Lab work is underway or completed but many questions unanswered. Lacking is in situ mesocosm studies. USFWS funded USGS to do this with surrogate lab organisms; manuscript written. But does it translate to indigenous Appalachian fauna?]*

(Grouping) – *Urbanization, Population Growth and (Domestic or Industrial) Water Demands*

• **Project Description: [N]** Predict the influence of major land use changes (e.g. urbanization, etc.) on flow regimes within the context of climate change. Include all major water withdrawals, e.g. energy extraction.

o **(related) Project Description: [N]** Evaluate the effects of future predicted water withdrawals and return flows on aquatic resources and populations.

(Grouping) – *Agricultural Expansion and (Ag-related) Water Demands*

(Grouping) – *Effects of Air Pollution*

• **Project Description: [N]** Effects of atmospheric deposition on aquatic ecosystems.

• **Project Description: [N]** Improve understanding of the synergistic effects of complex mixtures (air contaminants).

(Grouping) – *Cumulative Impacts*

B. HEADING: HUMAN DIMENSIONS

2. PROGRAM: Social Component

PROGRAM DESCRIPTION: *Determine direct and intrinsic socioeconomic benefits of aquatic species and resources.*

(Grouping) – *Value/Ecosystem Services and Conflict*

- **Project Description: [N]** Anticipate potential water rights conflicts between various user groups and develop alternative solutions to resolve conflicting needs (e.g. water supply versus ecological flow), using a structured decision making approach that considers the values of the various stakeholders in making land use decisions.

- **Project Description:** For threats often politically difficult to address (agriculture, forestry, urban growth, mining, etc.), conduct sociological studies to serve as the foundation to develop and communicate culturally viable solutions across the landscape.

- **Project Description:** Evaluate relative risks associated with invasive/non-native species in the context of social behaviors that value these species (aquaculture, pay lakes and streams, religious releases of species), and thereby increase threats to native fauna and flora.

- **Project Description: [N] [S]** Collect data and model ecosystem services (e.g. clean water) and social values (e.g. open space) to quantify and establish thresholds for ecosystem functions.

  o **(related) Project Description: [S]** Measure and map the capacity to provide, and flow of, key aquatic ecosystem services (i.e., we need basic inventories of ES so we can formulate management questions and approaches).

(Grouping) – *Recreational, Commercial, Subsistence Use*

- **Project Description: [N]** Determine the economic and social value of various fisheries. *[COP Comment: USFWS Fisheries Program has completed an economic evaluation for fisheries, but this did not include mussels.]*

- **Project Description: [N]** What is the magnitude of current use and trends of recreational use?

- **Project Description: [N]** What is the magnitude of current use and trends of commercial use?

- **Project Description: [N]** What is the magnitude of current use and trends of subsistence use?

C. HEADING: SYSTEM LEVEL

SYSTEM LEVEL DESCRIPTION: *Compile data to help partners and stakeholders better understand the types of aquatic habitats that occur within the LCC, the distribution and condition of those habitats, issues threatening the quality of those habitats, the relative importance of those habitats for species conservation within each of the states, and techniques that can be used to restore those habitats after they have been degraded.(e.g., connectivity, water quality, habitat quality including riparian habitat, instream, and structural habitat, habitat quantity, hydrology including water quantity and timing, distribution.)*

3. PROGRAM: Ecological Functions of Managed/Human-Altered Systems

PROGRAM DESCRIPTION: *Describe how altered systems function and how they can best be managed.*

(Grouping) – *Foundational/Stock-taking Assessment/Classification System*

- **Project Description:** Assessment of common hydrologic models/hydrologic data (models like stream stats for non-gauged streams) (common to both Program 3 & 4). *[COP Comment: This is quite important. Prediction in ungagged basins (PUB) has been a big trend in hydrology lately, mainly because there is concern that we will miss important changes if we only rely on very limited and increasingly sparse (temporally) gage data.]*

(Grouping) – *Barriers (Flows and Species Movement) and Fragmentation (Populations and Habitats)*

- **Project Description:** Develop models to show where barrier removal would be most effective in species recovery and improving resiliency in the face of climate change.

  o **(related) [S]** Develop a method to evaluate the effect of barriers (chemical, physical, and biological) and the interaction between those barriers. *[COP Comment: Several COP members said this was a lower priority than the primary Project Description above; and, for these evaluations to move forward, more specific language would have to be developed for this science need.]*

  o **(related) [N]** Evaluate the effects of fragmentation (connectivity) on aquatic species – evaluate the genetic and demographic effects on population viability and resiliency, and the effect on animal movement and dispersal.

  o **(related) [N]** Develop barrier removal prioritization scheme with multiple criteria. Include assessment of when is it desirable and undesirable to remove barriers.

- **Project Description [S]** Understand the influence of hydrology and sediment transport around dams.

(Grouping) – *Mitigating Ag and Forestry Impacts*

(Grouping) – *Protection & Restoration Approaches*

- **Project Description: [S/N]** Evaluate the relative effectiveness of various stream restoration techniques including riparian protection measures across different scales and land use practices - to restore both function and structure, and to protect water quality and habitat. Need to identify reference reaches to properly design and evaluate restoration projects. *[COP Comment: Focus should be on instream barriers.]*

  o **(related/component): [S]** ID factors and elements of unsuccessful and successful restoration techniques.

  o **(related/component):** Develop a protocol using these factors to identify areas for restoration. (Compare against control sites).

- **Project Description: [N]** Determine the effects of stormwater management/impervious surfaces on aquatics habitats and how these might vary for different types of aquatic organisms (benthic macroinvertebrates (mussels) vs. benthic fishes, vs. mid-water fishes, vs. fishes with different types of spawning requirements.

- **Project Description: [N]** Evaluate the upstream and downstream effects of natural channel design on ecosystems.

- **Project Description: [N]** Monitor effectiveness of BMPs/water quality standards/criteria – is it effective for target species?

- **Project Description: [N]** [Investigate approaches/]improvements to fish sterilization techniques (triploidy technology).

- **Project Description: [N]** Improve, refine, and test efficiency of captive propagation techniques.

- **Project Description: [N]** Develop criteria for relocation/augmentation (genetics, disease, etc.)

4. PROGRAM: Ecological Functions of Natural/Intact Systems

PROGRAM DESCRIPTION: *Develop understanding of natural systems interrelatedness and interdependency, focusing on ecological flows, fluvial geomorphology, and species/habitat responses. Accounting for natural differences in flow variability among rivers, and understanding the importance of this for the protection of freshwater biodiversity and maintenance of goods and services that rivers provide. Understanding how flow variability sustains river ecosystems.*

(Grouping) – *Foundational/Stock-taking Assessment/Classification System*

- **Project Description:** Produce an assessment of common hydrologic models / hydrologic data (models like stream stats for ungauged streams) (common to both Program 3 & 4).

- **Project Description:** Establish a stream classification system
  [**AppLCC FY11/12 Funded Project:** (Anderson et al., The Nature Conservancy & ORNL) "A Stream Classification System for the Appalachian Landscape Conservation Cooperative"]

- **Project Description:** Develop a rapid assessment program and ground-truthing for assessing riparian and floodplain vegetation. *[COP Comment: I don't know how rapid it is, but perhaps TNC's active river concept, with delineation methodology discussed in Chapter 4 in Smith, M.P., Schiff, R., Olivero, A. and MacBroom, J.G., 2008. THE ACTIVE RIVER AREA: A Conservation Framework for Protecting Rivers and Streams. The Nature Conservancy, Boston, MA is a way to do this?]*

(Grouping) – *Effects of Fire on Ecosystems*

- **Project Description: [N]** Effects of fire on aquatic ecosystems e.g., nutrient cycling / loading, temperature regimes, plant communities, etc. (especially in areas with prescribed burning).

(Grouping) – *Relationship/Ecological Flows and Nutrient Dynamics*

- **Project Description: [N]** Identify the role of Freshwater Mussels (aquatic organisms) in nutrient cycling, removal of suspended sediments, bioturbation, bottom stabilization and enrichment, and creating stable aquatic habitats.

- **Project Description: [N]** Identify the relationship between specific suites of benthic biodiversity and paired conditions of nutrient dynamics.

(Grouping) – *Ecosystem Integrity/Resiliency*

D. HEADING: COMMUNITY LEVEL

5. PROGRAM: Community Level (Description and Function or Basic Community Ecology)

PROGRAM DESCRIPTION: *[NEEDED: none given]*

(Grouping) – *Basic Ecology/Ecological Relationships*

- **Project Description: [N]** Document the effect of non-native species on native biota.

- **Project Description: [N]** Identify interspecies relationships (pollinators, host fish, etc.).

- **Project Description:** [S] Assess levels and patterns of most fundamental form of biodiversity from the intra-specific to the community level.

- **Project Description:** [N] Document the impacts of density of aquatic vegetation (i.e., native or non-native) on fish community composition.

- **Project Description:** [N] Conduct an evaluation of macro-habitat features influence on biodiversity distribution.

- **Project Description:** Develop mussel/fish habitat models that relate occupancy and abundance to habitat characteristics.

- **Project Description:** [N] Describe the temporal and spatial scale relationships to aquatic communities (headwater disturbances, land use/cover associated with aquatic communities – can be temporal component).

  o **(related) Project Description:** [N] Assess the effects of headwater stream disturbance from energy extraction practices or climate change on downstream fish/mussel communities, aquatic salamanders and macro invertebrates.

E. HEADING: SPECIES/POPULATION LEVEL

6. PROGRAM: Basic Biological Understanding (Species-level)

PROGRAM DESCRIPTION: *[NEEDED: none given by COP] [… refers to basic, broadening our understanding of the biology of organisms]*

(Grouping) – *Basic Biological Information*

- **Project Description:** [N] Conduct an inventory/status assessment of priority/keystone species (Identify at risk species within the AppLCC).

  o **(related) Project Description** [N] Rigorous understanding of population dynamics/ viability for species of conservation concern.

  o **(related) Project Description:** [S] Develop range-wide genetic assessment of key-stone/priority aquatic species.

  o **(related) Project Description:** [N] Identify key limiting factors and stressors for priority/keystone aquatic taxa.

- **Project Description:** [N] Describe the dispersal abilities of aquatic animals. *[COP Comment: Unless need focus on keystone or priority species, generalized academic work on this has been published.]*

- **Project Description: [N]** Describe environmental flow requirements for species and populations for the region. Determine relationship between flow, habitat and aquatic life (ecological flows).

  [**AppLCC FY11/12 Funded Project:** (Fisher & Walter/Cornell University) "Development of a hydrologic foundation and flow-ecology relationships for monitoring riverine resources in the Marcellus Shale region"]

- **Project Description: [N]** Monitor effectiveness of BMPs/water quality standards/criteria – is it effective for target species?

- **Project Description: [N]** Investigate approaches/improvements to fish sterilization techniques (triploid technology).

- **Project Description: [N]** Map remaining suitable and free flowing riverine habitat for freshwater mussels and rare endemic fishes.

- **Project Description: [N]** Examine relationships between sedimentation rates and biological response, e.g. survival rates, breeding success of aquatic organisms.

- **Project Description: [N]** Develop additional IBIs tailored to basins/regions/additional species in order to establish baseline conditions and track changes over time, which might be linked to causes. *[COP Comments: Realize some have tried or are currently trying, but there remains a science need for a mussel IBI. Mussel IBIs will have to be tailored within basins nested within physiographic provinces in the AppLCC region. Common metrics would include richness, density, recruitment as indicated by number of age-classes (cohorts), and species sensitivities/tolerances. Heidi Dunn, Ecological Specialists , Inc.is developing a mussel community index for assessing overall health of a mussel community, and indeed it needs to adapt to the watershed and size of water body. I also believe Teresa Newton and USGS Lab have done some work, but this needs further study in Appalachia.]*

- **Project Description: [N]** Improve, refine, and test efficiency of captive propagation techniques. *[COP Comment: Already has been done for fishes (see recent publication in AFS), and also has been done for mussels.] [LCC Staff Comment: COP needs to review again and determine if there remain outstanding needs.]*

- **Project Description: [N]** Develop criteria for relocation/augmentation (genetics, disease, etc.)

(Grouping) – *At-Risk Species/Populations & Endemics*
- **Project Description: [N]** Conduct research to populate a genetics database for at-risk species.

(Grouping) – *Contaminants/Pollutants Effects on Species/Populations*
- **Project Description: [N]** Document the synergistic effects of complex mixtures (water contaminants) on aquatic organisms and their reproductive and survival rates.

o **(related) Project Description: [N]** Conduct a comparative assessment of relative sensitivity of biota to contaminants suspected of impairing survival or reproductive capacity.

o **(related) Project Description: [S]** Collect data on toxic effects on reproduction and growth of priority aquatic species *[COP Comment: This is a priority because most water standards are based on tests with species that are extremely tolerant.]*

- **Project Description: [S]** Projecting effects of wastewater effluent on aquatic species and populations in light of continued human population growth projections. *[COP Comment: Two projects above should be done in conjunction with understanding future habitat conditions and planning for connectivity between current and future habitats when possible.]*

(Grouping) – *Invasive Organisms Effect on Species and Populations*

- **Project Description: [N]** Effect of invasive species on ecological function (lakes, riparian zone and instream) (e.g. Japanese knotweed). *[COP Comment: Some of this work should be linked to biological integrity and system function not just non-native species impacting native species.]*

- **Project Description:** Identify distribution of invasive species across watersheds and identify how and to what extent they threaten native aquatic species.

o **(related/component)** Complete a threats analysis of invasive species on aquatic species (refine threats to examine: hybridization, competition, disease, habitat alteration, and predation, potential impact of climate change and human perturbation?).

o **(related/component)** Gather data on how states regulate exchange between states or intra-state movement of species in relation to non-indigenous species or move between watersheds.

o **(related) Project Description: [S]** ID risks associated with pathways for introduction and spread of invasive species as well as the techniques to manage the risks. *[COP Comment: A literature review, or what? The Pest Plant Councils already have these.]*

o **(related) Project Description: [S]** Quantify the amount of critical habitat occupied by invasive species and identify which invasive species they are.

- **Project Description: [S]** Assess aquatic species diversity utilizing eDNA and contemporary monitoring tools (see URL for reference to "environmental DNA" http://environmental-change.nd.edu/programs/asian-carp/) basically to take water samples and filter out shed DNA to give an early warning of an invasive species moving into a previously undetected area. *[COP Comment: Before this can be really used, much more work needs to be done in determining detection rates by eDNA and factors affecting detection rates. Work on this front is ongoing, but more*

funding would help. If the bugs are worked out with eDNA technology, it could be a very powerful tool. Perhaps a better project description would state further development and refinement of eDNA techniques.]

(Grouping) – *Effects of Disease (on a Species or Taxonomic Group)*

- **Project Description: [N]** Describe the effects of disease and parasites. *[Editor: Vague, COP needs to elaborate/explain]*

F. HEADING: "HOW (THE LCC) SHOULD DO BUSINESS"

- **[N]** Encourage BMPs for riparian zone management.

- Encourage standard monitoring protocol where not available but appropriate.

- **[S]** Support and add value to ongoing efforts to establish methods for assessing cumulative watersheds impacts.

- **[N]** Support USFWS with updating recovery plans for those species already identified.

- **[N]** Develop conservation genetic management plans for aquatic species being captively managed or being transplanted / supplemented with stocking of wild and / or cultured animals.

    o **Project Description: [N]** Improve, refine, and test efficiency of captive propagation techniques.

    o **Project Description: [N]** Develop criteria for relocation / augmentation (genetics, disease, etc.).

- **[N]** Develop technology and protocols for restoring ecologically functional mussel communities in order to enhance ecosystem goods and services provided by functional aquatic ecosystems. *[COP Comment: This is also recommended in the UTRB strategic plan, and National Strategy for Conservation of Freshwater Mollusks… some technology and protocols exist; however, a comprehensive understanding of population dynamics, trophic interactions, inter and intra species feeding interactions, and ecological function is needed to inform appropriately designed mollusk community restoration management protocols/plans.]*

- Develop a way to access privately collected monitoring data from the permitted community.

    AppLCC's Web Portal offers to host most data sets and these can be shared narrowly or widely, as controlled by the content source.

- Develop a phone book or list of data, expert advice, etc. and make it available to all partners.

    AppLCC's Web Portal includes an Experts Database that has been compiled from attendees at the November 2011 Projects Workshop and from members.

- **[N]** Develop efficient environmental inventory tools.

- Need to develop NHD data at 1:24K.