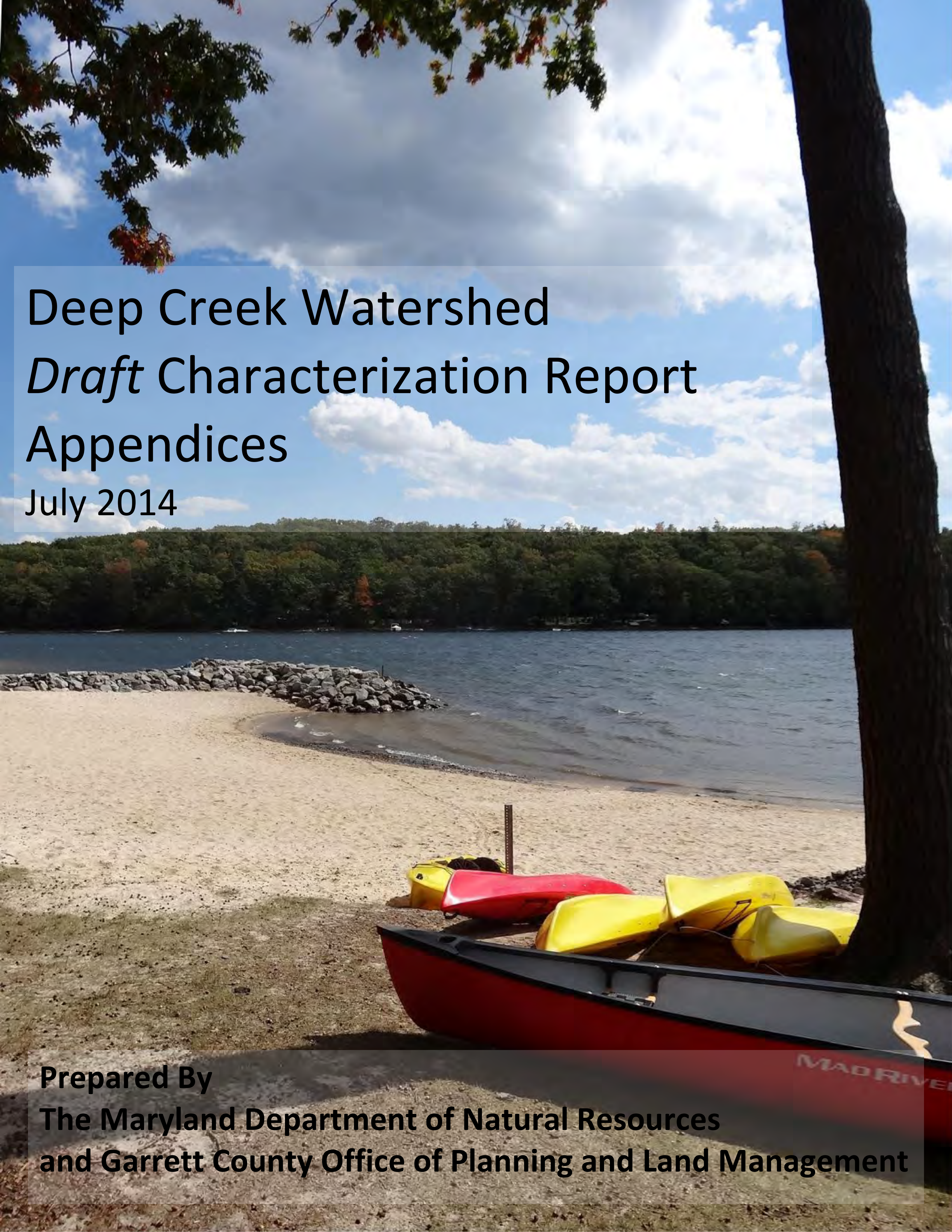


Deep Creek Watershed *Draft* Characterization Report Appendices

July 2014

Prepared By
The Maryland Department of Natural Resources
and Garrett County Office of Planning and Land Management

DEEP CREEK WATERSHED CHARACTERIZATION REPORT
Appendices

APPENDIX 1 - STREAM WATER QUALITY AND HABITAT CONDITION 2

Appendix 1-A: Studies, Reports, Data Sets, and Monitoring Programs Associated with Deep Creek Lake Streams 2

Appendix 1-B: Historic and Current Conditions of Cherry Creek...11

Appendix 1-C - Stream fauna in the Deep Creek Lake Watershed 14

Appendix 1-D Prioritizing Streams for Protection and Restoration..22

APPENDIX 2 SUBMERGED AQUATIC VEGETATION 26

Appendix 2-A Deep Creek Lake Hydrilla verticillata Survey Results 2013...26

Appendix 2-B: Deep Creek Lake SAVand Macroalgae Transect Results 2010-2013..28

Appendix 2-C: Deep Creek Lake Myriophyllum Survey Results 2012 and 2013 32

APPENDIX 3: FORESTRY 39

Appendix 3-A: Explanation of Species Rank and Status Codes..39

Appendix 3-B: Ecologically Significant Area Summaries...43

Appendix 3-C: Specific Protection Measures for Wildlife and Rare Species Habitats 57

Appendix 3-D: Important Key Wildlife Habitats of Deep Creek Lake Watershed..62

APPENDIX 4: RECOMMENDED ACTION STRATEGIES FROM DNR:..................... 66

Recommendations related to Streams: 66

Recommendations related to Lake Water Quality: 67

Recommendations related to Rare Species and Habitats:..68

Recommendations to Incorporate Resiliency into Water Resources: 69

APPENDIX 5: ADDITIONAL REFERENCES...76

Appendix 1 - Stream Water Quality and Habitat Condition

Appendix 1-A: Studies, Reports, Data Sets, and Monitoring Programs Associated with Deep Creek Lake Streams

1. Description: May 1973 Report on Cherry Creek and Casselman River Watersheds

--Skelly and Loy. 1973. Mine drainage pollution watershed survey – Cherry Creek and Casselman River watersheds, Garrett County, Maryland. Report to MD/DNR. 368 pgs.

This report on a comprehensive, multi-purpose project includes a brief discussion of aquatic biota, with a focus on mining. The purpose of the project was to develop and recommend an abatement plan designed to eliminate the deleterious effects of mine drainage (AMD) on streams in the Casselman River and Cherry Creek watersheds. Field investigations were conducted to locate, map, and evaluate all coal and clay mines in the study area, and develop abatement plans for each mine. The report appendices contain stream flow, water chemistry, and weather data collected between December 1971 and November 1972.

2. Description: 1974 DNR Report on Cherry Creek and Casselman River Basins

---Maryland DNR. 1974. The Cherry Creek-Casselman River environmental improvement plan.

The report describes a survey conducted sometime between October 25, 1971, and January 1974. The survey's goal was to gather the information needed to develop a plan for environmental improvement in the Cherry Creek Basin and in the MD portion of the Casselman River Basin, by abating AMD impacts. The report presents a nice overview of existing physical environmental conditions in the two basins, provides a description of current activities that are altering the environment, discusses environmental problems in the two basins, and recommends priorities for improving current environmental conditions.

3. Description: Series of Five Reports (1980-1984) on DCL and Tributaries
(see References section for report citations)

From September 1980 through August 1984, Drew Ferrier and colleagues at Garrett Community College conducted water chemistry studies at four sampling sites in DCL and in 13 tributaries to the lake. They also measured pH in precipitation samples and flows in some streams. Sampling was conducted monthly and year round. The study was supported by DNR's Power Plant Research Program, and intended to describe acid inputs to DCL and determine the contributions of the two anthropogenic sources of acidity: AMD vs. atmospheric deposition. pH, hydrogen ion concentration, conductivity, chloride, and sulfate were measured in precipitation samples. pH, conductivity, alkalinity, sulfate, and chloride were measured in lake and stream samples.

4. Description: 1985 DNR Report on DCL

---Pavol, K. 1985. Deep Creek Lake, Fisheries Survey and Management Plan. Final Report. Federal Aid in Fish Restoration , Project F-29-R, Study IV. MD/DNR, 10 pgs.

Although this report is focused on fishes in DCL, it is relevant to this compilation of information on tributaries to the lake because of what's included in the report under the section FISH MANAGEMENT HISTORY (pg. 1).

5. Description: 1987 Maryland Synoptic Stream Chemistry Survey (MSSCS)

---Knapp, C.M., W.P. Saunders Jr., D.G. Heimbuch, H.S. Greening, and G.J. Filbin. 1988. Maryland Synoptic Stream Chemistry Survey: Estimating the number and distribution of streams affected by or at risk from acidification. PPRP-AD-88-2.
Report prepared for DNR.

This statewide survey was designed to estimate the number and extent of streams in Maryland that were affected by or at risk from acidification. The survey included 559 randomly-selected stream sites that were sampled during spring 1987. Water samples collected by volunteers at each site were analyzed for ANC, pH, conductivity, dissolved organic carbon, dissolved inorganic carbon, and color. Six of the randomly-selected stream sites were in the Deep Creek Lake watershed: Pawn Run, two sites in the mainstem Cherry Creek, an unnamed tributary to Cherry Creek, Marsh Run, and Gravelly Run.

6. Description: 1994 Report on Cherry Creek

Simply titled "Acid Mine Drainage" and dated "1994", with no listed author, this report, prepared by MDE/BOM staff, contains historical and background information on the Cherry Creek watershed and a description of AMD formation and its impacts on streams.
The report also contains data on several water chemistry analytes (pH, iron, manganese, aluminum, calcium, total acidity, sulfate) that were measured at 15 stations in 1971, 1972, 1988, 1989, 1990, 1991, and 1994----including five "seeps" near old coal mines. The frequency of water sample collection varied from monthly in 1972 to three times in 1988 to twice a year in 1989, 1990, 1991, and 1994. No chemistry data were collected in 1992 and 1993.

7. Description: 1996 DNR Study in Cherry Creek

---Pavol, K.W., A.W. Klotz, and S. Rivers. 1997. Baseline biological stream studies: Cherry Creek-Garrett County, Elklick Creek-Garrett County, Winebrenner Run, Allegany County. MD/DNR.

The objective of this DNR study was to collect baseline biological data from three western MD streams affected by AMD. All three streams were candidates for AMD abatement actions being taken or to be taken by MDE/BOM. Fish were collected in Cherry Creek between June 12 and September 3, 1996, at four stations, using a battery-powered back electro-fisher in stream segments at least 100m long. Two stations were located upstream from a limestone doser installed to mitigate AMD and two stations were located downstream of the doser. Benthic macroinvertebrates were collected at the same four stations, also from June-September 1996, using a D-frame kick net. The report also includes a brief history of fishes in Cherry Creek.

8. Description: 1997-1998 UMD/AL Study in Cherry Creek

---Morgan, R.P. II, D.M. Gates, and M.J. Kline. 1999 (revised 2000). Analysis of Cherry Creek water quality, benthic macroinvertebrates, fishes, and physical habitat. Prepared for MDE/Bureau of Mines.

The purpose of this study was to describe the benthic macroinvertebrate and fish communities in Cherry Creek, establish a baseline prior to new AMD abatement actions, and also assess water quality and physical habitat within the watershed. Water quality samples were collected in November 1997 (high flow conditions) and September 1998 (low flow) at 34 stations in the Cherry Creek watershed that were established by BOM. Water samples were analyzed for 13 analytes, including pH, acidity, and alkalinity. Benthic macroinvertebrate samples were collected at these same 34 stations in November 1997 and at a subset of 12 stations in May 1998 using a D-frame net and RBP III methods. Benthic macroinvertebrate samples were also collected from three bog system reference streams: Cranberry Swamp, Cunningham Swamp, and Wolf Swamp—plus from Braddock Run, an AMD-stressed stream. Fish community and physical habitat data were collected at these same 12 stations during summer 1998 using MBSS protocols.

9. Description: Rapid Bioassessment Program and 1997 Report

Beginning in 1989, the Maryland Department of the Environment maintained a network of about 350 statewide non-tidal stream monitoring stations on primarily 3rd order streams at road crossings. This Rapid Bioassessment Program was transferred to the Maryland Department of Natural Resources in 1995 and it ended in 1996. The Program used a rotating basin design and the entire State was covered every two years. Benthic macroinvertebrates were used as stream health indicators and data from the Program were intended to provide ambient stream quality data to scientists, researchers, and decision makers. Because this was a fixed station network, data could be used on a site-by-site basis to evaluate changes resulting from the installation of best management practices.

Methods: Benthic Macroinvertebrate Community

Benthic macroinvertebrate communities were sampled in the summer (June – September) using a 1 square meter kick seine (rocky bottom streams) or a 1 foot wide D net (muddy bottom streams). Methods were based on US EPAs Rapid Bioassessment Protocols for use Streams and Wadeable Rivers (see http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm**).** Organisms were subsampled (approximately 100) and identified in the field to family level of taxonomy. In the lab, data were entered into spreadsheets and six metrics (Taxa Richness, Hilsenhoff Biotic Index, % Scraperer/Filterer, EPT Index, EPT/Chironomidae, % Dominant Taxon, Similarity Index) were calculated using regionally-developed reference conditions. A Benthic Index of Biotic Integrity was applied and data were reported annual in internal technical memos (paper copies are on file with DNR/MANTA staff).

Methods: Physical Habitat Assessment

Physical habitat assessments were conducted at each site sampled for benthic macroinvertebrates. Parameters included Local Watershed Erosion, Bank Stability, Streamside Cover, Channel Character, Bottom Substrate and Habitat Variety. These visual habitat assessments resulted in a scoring of each site as Poor, Fair, Good or Excellent. Each site visit included photodocumentation as well. Details on habitat assessment methods can be found in http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm. Paper copies of Annual Reports are on file with DNR/MANTA staff.

1997 DNR RBP Report

This technical memorandum describes the 1995-1996 results from a benthic rapid bioassessment (RBP) project that was started in 1990 when the author was with MDE.
A total of 244 stream stations (specifically the most downstream 3rd order reaches with a road crossing) were identified and sampled using EPA's RBP II protocols. A 1-meter wide kick seine was used to sample riffles for benthic macroinvertebrates. In coastal plain stream lacking riffles, a 30-cm wide dip net was used. The objectives of this RBP project were to identify streams with impacted benthic macroinvertebrate communities, determine if the impacts were caused by water quality problems or physical habitat degradation, and target impacted streams for further study or for remedial actions. One of the RBP project sites, Cherry Creek in the DCL watershed, was sampled in 1995. Benthic macroinvertebrate samples were collected between May 1 and September 15.

10. Description: 2001 MDE/Bureau of Mines Report

---MDE/BOM. 2001. Cherry Creek Acid Drainage Mitigation Plan: Report on Results. Report to U.S. EPA.

The goal of this report was to continue the incremental development and implementation of an effective watershed plan for abatement of abandoned mine drainage discharges and restoration of living resources in the Cherry Creek watershed.

---This report includes the July 1999 report by Morgan et al. that is described above.

11. Description: Maryland Department of the Environment/Science Service Administration (MDE/SSA) Monitoring Efforts

MDE/SSA collected extensive water quality data from 8 streams that flow into Deep Creek Lake from 2000-2008. For more information on their monitoring program/protocols and data, please contact:

Timothy C. Rule

Maryland Department of the Environment
Chief, TMDL Technical Coordination and
Biological Stressor Identification Division
Maryland Department of the Environment
1800 Washington Boulevard, Suite 540
Baltimore, MD 21230-1718
Voice: **(410) 537-3688**

12. Description: Maryland Department of the Environment/Bureau of Mines (MDE/BOM) Monitoring Efforts

MDE/BOM collected extensive water quality data (pH and metals) from 7 sites on Cherry Creek from 2000-2012. For more information on BOM's monitoring program/protocols and data, please contact:

Joe Mills
Maryland Department of the Environment
Bureau of Mines
160 Water Street
Frostburg, MD 21532
Voice: (301) 689-1440

13. Description: 2003 Report by MDE

---MDE. 2003. Total Maximum Daily Loads to Address Low pH in Cherry Creek in the Deep Creek Watershed, Garrett County, Maryland. Report to U.S. EPA. 22 pgs.

The report concludes that four factors affect the pH in Cherry Creek: ANC, atmospheric deposition, presence of bogs—natural sources of acidity, and low buffering capacity.
Report can be found here:
http://www.mde.maryland.gov/assets/document/Cherry%20Creek%20pHTMDL_final.pdf

14. Description: 2004 DNR Fisheries Study

---Klotz, A.W. and K.W. Pavol. 2004. Trout studies in the Youghiogheny River tributaries – Cherry Creek. MD/DNR.

This report includes data on fish, benthic macroinvertebrates, and water quality collected during 2004 at two stations in Cherry Creek located upstream of the limestone doser and at two stations located downstream from the doser. The goal of the 2004 sampling was to determine if any improvements in the aquatic biota associated with several AMD mitigation projects by BOM that first became operational in 1986. Fish populations were sampled by backpack electro-fishers. Benthic macroinvertebrates were collected with a D-frame kick net in riffle areas and pools. Water samples were collected by BOM staff and analyzed for pH, iron, manganese, acidity, aluminum, and sulfate.

15. Description: 2012 Report by MDE

---MDE. 2012. Watershed report for biological impairment of the Deep Creek watershed in Garrett County, Maryland—biological stressor identification analysis, results and interpretation. Report to U.S. EPA. .

The goal of this report was to identify and discuss the stressors that have led to the biological impairment of streams to Deep Creek Lake. The Science Services Administration (within MDE) has developed a biological stressor identification (BSID) analysis that uses a case-control, risk-based approach to determine the predominant cause of reduced biological conditions.

The report can be found here:
http://www.mde.state.md.us/programs/Water/TMDL/Documents/BSID_Reports/DeepCreek_BSID_Report_012412_revisedfinal.pdf

16. Description: Poland Run Study

Poland Run, a small stream that flows into Deep Creek Lake, has experienced rapidly changing land use (from forest to developed land) in its watershed (~ 0.5 sq. miles). To assess stream loads of nutrients and sediment flowing into the lake from Poland Run, DNR collected water quality samples for analysis of nutrients and sediments each month (from 2009 – 2012) and during storm flows at a USGS stream gage on Poland Run. Additional information on this special study can be found at http://md.water.usgs.gov/preview/deepcreek/stream/

17. Description: 2012 Maryland Synoptic Stream Chemistry Survey

---Methratta, L., G. Rogers, and M. Southerland. 2013 (draft). Maryland Synoptic Stream Chemistry: a comparison of stream chemistry between Round 1 (1987) and Round 2 (2012). Report to MD/DNR. 37 pgs.

The purpose of this study was to re-sample 197 of the original 559 randomly-selected stream sites sampled in 1987. The goal of the 1987 study was to estimate the miles on non-tidal streams in Maryland that were either acidic or sensitive to acid inputs. The goal of the 2012 study was to document any changes in the acid-base chemistry of these streams over the 25 year interval between 1987 and 2012.

The six stream sites within the DCL watershed that were sampled in 1987 were sampled again during April in 2012. We can compare these two data sets and look for significant changes in ANC, pH, conductivity, dissolved organic carbon, dissolved inorganic, and color over the 25 year interval. In addition to these acid-base chemistry analytes, the 2012 survey also measured chloride, nitrate, total nitrogen, total phosphorous, and sulfate at these six stream sites.

18. Description: Deep Creek Lake (DCL) Management Office Sampling

Staff from the Deep Creek Lake Management Office sampled ten Deep Creek Lake tributaries quantitatively for benthic macroinvertebrates and water chemistry in fall 2011 and spring 2012. These ten tributaries were the largest and most recognized tributaries. The objective of the survey was to determine if poor Benthic Index of Biotic Integrity scores determined by the Maryland Biological Stream Survey and Maryland Stream Waders Program were due to water quality degradation from land use or were regional outliers due to their surrounding geology. A draft report on the survey titled Quantitative Macroinvertebrate Sampling of the Deep Creek Lake Tributaries can be obtained from the Deep Creek Lake Management Office.

Methods: Benthic Macroinvertebrates

Benthos were collected in the most downstream riffle of each tributary following methods described in the MDNR's Core/Trend report found here **http://www.dnr.state.md.us/streams/pubs/mn0901_CTbenthic.pdf**. At each site, three 0.3 meter X 0.3 meter square Surber Samples were collected and pooled. All organisms were identified to lowest practical taxon (typically genus) and enumerated. Several standard benthic macroinvertebrate metrics were calculated (e.g., Percent EPT Taxa, Hilsenhoff Biotic Index, Mean Diversity, Percent Dominant Taxon, Taxa Richness, and Total Individuals). Bioassessment results were included in the report titled Quantitative Macroinvertebrate Sampling of the Deep Creek Lake Tributaries. Electronic copies are on file with staff from Deep Creek Lake Management Office.

Methods: Water Chemistry

Water chemistry samples were collected and analyzed in the field at each site during both samplings. The parameters assessed were pH, temperature, conductivity, total dissolved solids, and alkalinity. The pH, specific conductivity temperature and TDS were measured using a HANNA combo pH&EC meter. The alkalinity was measured using a LaMotte direct read alkalinity titration kit. Water chemistry results were included in the report titled ***Quantitative Macroinvertebrate Sampling of the Deep Creek Lake Tributaries***. Electronic copies are on file with staff from Deep Creek Lake Management Office.

19. Description: Core\Trend Program

The Maryland Department of Natural Resources (MDNR) maintains a long-term water quality and benthic macroinvertebrate monitoring network referred to as the Core/Trend Program. This monitoring program was initiated in the mid 1970s and allows MDNR to assess trends in water quality and river health through time. Monitoring stations are located on major non-tidal, freshwater rivers in the Choptank, Gunpowder, Patapsco, Patuxent, Susquehanna, Potomac and Youghiogheny River basins.

Methods: Benthic Macroinvertebrate Community

Benthic macroinvertebrate communities have been sampled regularly at 111 monitoring stations as early as 1976. Benthic samples are collected during summer low flow periods using either a

Surber or Hester-Dendy multiplate sampler. Samples are processed and identified to genus or species level by professional MDNR biologists. Four benthic community measures are calculated with these data. These community measures allow MDNR to examine trends in benthic macroinvertebrate community health at all monitoring stations. Trends in community health have been examined from 1976 through 2006. A link to the complete report can be downloaded at: http://www.dnr.state.md.us/streams/pubs/mn0901_CTbenthic.pdf**.**

Methods: Water Quality Methods

Water quality samples have been collected monthly at 54 monitoring stations since 1986. There are 17 parameters measured at each station, including total nitrogen, total phosphate, total suspended solids, turbidity, pH, and water temperature. For more details collection and analytical methods, refer to the Quality Assurance Project plan (March 2009), which can be downloaded at http://www.dnr.state.md.us/streams/pubs/106_qc_doc.pdf**.**

20. Description: Maryland Biological Stream Survey (MBSS)

The Maryland Biological Stream Survey (MBSS) was started by the Maryland Department of Natural Resources in 1995. Data collected include fish, benthic macroinvertebrates, herpetofauna, invasive plants, physical habitat, water chemistry, and land use. The MBSS is Maryland's first probability-based or random design stream sampling program intended to provide unbiased estimates of stream conditions with known precision at various spatial scales ranging from large 6-digit river basins and medium-sized 8-digit watersheds to the entire state. The basis of the MBSS design is lattice or multi-stratification sampling that ensures all 1st through 3rd order (now 1st through 4th order), non-tidal streams in the sampling frame have a non-zero and known probability of being sampled. A stratified random design is a cost-effective way to characterize Maryland's 15,000+ miles of freshwater streams. MBSS also samples several targeted sites each year. The fourth round of the Survey is scheduled to commence in 2014, with about 250 sites from Rounds 1 through 3 being resampled to evaluate trends. An overview of the MBSS can be found here http://www.dnr.state.md.us/streams/MBSS.asp

Methods: Biological

MBSS sampling crews collect benthic macroinvertebrates in the spring and fish, herpetofauna, mussels, and exotic plants in the summer. Benthos are collected using a 0.3 meter wide D net in the best available habitats within each 75 meter site. Each 20 square foot sample is pooled and organisms are processed and identified (to genus, if possible) in MDNR’s laboratory in Annapolis. A benthic Index of Biotic Integrity is calculated for each benthic sample. Fish are collected using backpack electofishing units or barge shocker and a 2-pass depletion. All fish over 2.5 cm are counted and identified. Individual gamefish are measured and weighed. A fish Index of Biotic Integrity is calculated for each site. Herpetofauna are collected using a visual “herp search” technique in the stream channel and riparian zone. Details of MBSS field methods can be found in the MBSS Sampling Manual at
http://www.dnr.state.md.us/streams/pdfs/ea-07-01b_fieldRev2013.pdf

Methods: Physical Habitat

MBSS crews conduct a visual, multi-parameter physical habitat assessment at each site during summer sampling. Protocols are based on those found in EPA's Rapid Bioassessment Protocols (see http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm). Parameters include Instream Habitat, Riffle/Run Quality, Embeddedness, Pool/Glide/Eddy Quality, and Shading. A Physical Habitat Index summarizes the rankings of these parameters. Additional information about MBSS physical habitat assessment protocols can be found in http://www.dnr.state.md.us/streams/pdfs/ea-07-01b_fieldRev2013.pdf

Methods: Water Chemistry

Water Chemistry samples are collected during the spring and include Acid Neutralizing Capacity, pH, water temperature, nitrate, total phosphorus, sulfate and chloride. Additional information about MBSS water chemistry sampling protocols can be found in http://www.dnr.state.md.us/streams/pdfs/ea-07-01b_fieldRev2013.pdf

21. Description: Maryland Stream Waders Volunteer Monitoring Program

Beginning in 2000, MDNR began recruiting and training adult volunteers to sample wadeable streams using benthic macroinvertebrate sampling methods and analytical techniques employed by the Maryland Biological Stream Survey. About 200 volunteers are trained each year and 300 – 500 sites are sampled across the State. Data from the approximately 7,000 sites sampled by Stream Waders volunteers are used to support those collected by the MBSS in stream restoration and protection programs. Details can be found at http://www.dnr.state.md.us/streams/streamWaders.asp

Methods: Benthic Macroinvertebrate Community

Benthic macroinvertebrates are sampled using a 0.3 meter wide D net during March and April (the same index period used by MBSS). Twenty square feet of best available habitat are sampled, pooled and preserved in the field. Samples are processed and identified (primarily to family level of taxonomy) by DNR laboratory staff. A Family-level Benthic Index of Biotic Integrity is calculated for each site. A manual of Stream Waders sampling protocols can be found at http://www.dnr.state.md.us/streams/pdfs/SW_Manual2011.pdf

22. Description: Maryland Marcellus Shale Stream Monitoring Coalition (MMC)

In March 2012, MDNR organized the Marcellus Shale Stream Monitoring Coalition (MMC), a network of non-profit organizations, colleges, and interested citizens, with a goal of collecting weekly water quality (conductivity, total dissolved solids, and temperature) and biological data (benthic macroinvertebrate community – once/year in spring) from streams in the Marcellus Shale region to help characterize baseline conditions in advance of Marcellus Shale natural gas development (if permitted). Currently, almost 100 MMC volunteers are monitoring 73 stream reaches in Garrett County with direct oversight by MDNR staff. In the DCL watershed, 4 sites are currently being monitored (Cherry Creek = 3 sites, Shingle Camp Run = 1 site). The baseline stream data collected by MMC volunteers are available at

Appendix 1-B: Historic and Current Conditions of Cherry Creek

Cherry Creek, Historical Conditions (Pre-2000)

Prepared by Joe Mills
Maryland Department of the Environment
Bureau of Mines
160 Water Street
Frostburg, MD 21532
(301-689-1440)

September 2013

Cherry Creek, named for its deep reddish color produced by bog tannins, is a naturally acidic, low-gradient, slow-flowing, wadeable stream in its upper reaches and a fast-flowing mountain stream in its lower reaches. The Cherry Creek watershed covers 14 square miles of area. Cherry Creek once supported a naturally reproducing brook trout population. Mining began in Cherry Creek in the early 1800's as small local deep mines. By 1980, extensive pre-law underground and surface mining had produced many sources of uncontrolled acid mine drainage (AMD) throughout the watershed. In addition, the basin contains an assemblage of boreal bogs, remnants of four Pleistocene glaciations, and other wetlands that contribute organic acidity to Cherry Creek. Several studies documented the degradation of miles of Cherry Creek by acid mine drainage from abandoned underground and surface coal mines (Skelly and Loy, 1973, Morgan et al, 1984). By 2000, several mine abatement and wetland treatment projects have been completed to address the quality of water in the Cherry Creek. Construction of the wetland systems proved successful in improving the quality of the water at small AMD discharges. Larger problems still existed. By 2000, treatment wetlands were constructed at the Everhart Seep, the Teets Seep and at the Final Cut Lake Seep, additionally, a treatment system incorporating, an Anoxic Limestone Drain, a Alkaline Producing Cell and a Treatment Wetland was constructed at the Glotfelty Seep. These systems were installed to address and abate the effects of AMD from four separate AMD sites.

Water samples of Cherry Creek and individual acid sources have been collected, with the parameters tested being:

<u>Acid Sources Parameters</u>	<u>Stream Sample Parameters</u>
Flow, pH, DO, Temperature	Flow, pH, Temperature
Total Iron, Ferric and Ferrous	Iron, Total
Manganese, Aluminum	Manganese, Aluminum
Sulfate, Acidity, Alkalinity	Sulfate, Acidity, Alkalinity

Macro invertebrate and fish sampling data were collected from the main stem and selected locations in the tributaries. Biotic sampling of macro invertebrates and fish occurred in Fall 1997 and Spring 1998 using standard EPA protocol procedures.

In their sampling, (Herb et al. 1981) found no macroinvertebrates in 1981. The good news is that, by 2000, the lower section of Cherry Creek had recovered to a degree. Fish populations are also present here, but their presence is driven partially by the closeness of Deep Creek Lake. Physical habitat near Deep Creek Lake is good but generally poor throughout most of the upper basin.

During low flow, Cherry Creek main stem maintains a net alkalinity (pH range 6.37 – 7.46) until approximately 5.75 miles downstream from the headwaters. Cherry Creek was able to absorb all acid inputs. At that point Cherry Creek became degraded for about a quarter of a mile until good water inputs once again dilutes the stream for another one mile downstream (pH 6.50). At approximately 6.8 miles from the headwaters, Cherry Creek again becomes net acidic (pH 3.63) and remained that way until it drained into Deep Creek Lake with a pH of 6.37 and an acid loading of 102.1 lbs/day during low flow conditions.

During high flow situations, the Cherry Creek main stem exhibited slight net acidity from the headwaters to its drainage into Deep Creek Lake (pH 5.49). The pH values range between 5.06 and 5.74. Acid producing sites all flowed and when, combined with the organic acid inputs, prevented the stream from diluting their inputs to net alkaline values. Cherry Creek is contributing an acid load of 1083.6 lbs/day to Deep Creek Lake during high flow conditions.

Cherry Creek, Current Conditions (2000 to 2013)

By 2002, advances in the science of Passive AMD Treatment, led to changes at both the Everhart and Teets Wetland Systems. An Alkaline Producing Cell System was constructed at the Everhart Seep and a Limestone Leach Bed, inoculated with the Pyrolucite Process©, was constructed at the Teets Seep. In 2002, a water powered, Tipping Bucket Limestone Doser was installed approximately 200 yards below the dam on Cherry Creek. Collectively, with few exceptions, these systems have helped to maintain a circum-neutral pH along the entire length of Cherry Creek.

There remains one major, unabated, AMD input in Cherry Creek. It is located on a tributary that enters Cherry Creek just below the dam and about 175 yards above the Limestone Doser.

Small discharges into the headwater section of Cherry Creek also have a negative impact on the chemistry of that section. The flows in that section are very small and the section dries up during low flow times of the year.

Location Description of the 90% Acid Producers – Low Flow

Site #6-4-C is a wetland tributary to Cherry Creek located approximately 2.75 miles from the headwaters. This site exhibited a pH of 3.8 and contributed 59.64% of the acid during low flow conditions.

Site #5-2-C is an AMD seep located approximately 2.5 miles from the headwaters. With a pH of 3.26, this site contributes 21.05% of the total acidity of all the contributing streams and measured AMD discharges during low flow conditions.

Site #10-4-C is a wetland tributary approximately 5 miles downstream from the headwaters of Cherry Creek. This site exhibited a pH of 2.84 and contributed 19.31% of the total acid when calculated during low flow conditions.

Location Description of the 90% Acid Producers – High Flow

Site #14-4-C is a tributary to Cherry Creek located approximately 5.25 miles downstream from the headwaters. This stream runs parallel to a reclaimed surface mine and has one seep contributing to it. This site exhibited a pH of 4.41 and contributed 39.57% of the acid during high flow. The acid produced at this site is most likely the result of non-AMD sources.

Site #6-4-C is a wetland tributary to Cherry Creek located approximately 2.75 miles from the headwaters. This site exhibited a pH of 4.38 and contributed 27.91% of the acid during high flow conditions when calculated with all tributary type sources. When calculated with only suspect AMD source sites, this site contributed 66.53% of the total acid.

Site #15-2-C is a tributary to Cherry Creek approximately 6.25 miles downstream from the headwaters. This site exhibited a pH of 4.19 and contributed 18.47% of the acid during high flow. The acid produced at this site is most likely the result of non-AMD sources. This site was dry during low flow.

Site #4.5M is part of the main stem of Cherry Creek located approximately 2 miles from the headwaters. This portion of the stream has a pH of 5.67 and contributes 6.71% of the acid in Cherry Creek when calculated with all tributary type sources. When calculated with only suspect AMD sources this site contributed 16.01% of the total acid.

Site #10-4-C is a wetland tributary approximately 5 miles downstream from the headwaters of Cherry Creek. This site exhibited a pH of 3.55 and contributed 9.03% of the total acid when calculated with only suspect AMD sources.

References

Herb, W.J., L.C. Shaw, and D.E. Brown. 1981. Hydrology of area 5, eastern coal province, Pennsylvania, Maryland, and West Virginia. U.S. Geological Survey, Water Resources Investigations 81-538. Harrisburg, PA.

Morgan, et al. 1994. To be added

Skelly and Loy. 1973. Mine drainage pollution watershed survey: Cherry Creek and Casselman River watershed, Garrett County, Maryland. Report prepared for Maryland Department of Natural Resources, Annapolis. 368 pages

Appendix 1-C - Stream fauna in the Deep Creek Lake Watershed

Cumulative list of stream fauna in the Deep Creek Lake Watershed. Data sources included MBSS, Stream Waders, DCL Lake Management Office, CORE/Trend, and DNR Fisheries Service. Data presented below were collected between 2000 and 2013.

HERPETOFAUNA

Family	Common Name	Scientific Name
Bufonidae		
	Eastern American Toad	*Anaxyrus americanus americanus*
Ranidae		
	American Bullfrog	*Lithobates catesbeianus*
	Northern Green Frog	*Lithobates clamitans clamitans*
Hylidae		
	Northern Spring Peeper	*Pseudacris crucifer crucifer*
Plethodontidae		
	Eastern Red-backed Salamander	*Plethodon cinereus*
	Long-tailed Salamander	*Eurycea longicauda longicauda*
	Northern Dusky Salamander	*Demognathus fuscus*
	Northern Two-lined Salamander	*Eurycea bislineata*
	Seal Salamander	*Demognathus monticola*
Salamandridae		
	Eastern Red-spotted Newt	*Notophthalmus viridescens viridescens*

CRAYFISH

Common Name	Scientific Name	Native or Introduced	Status
Allegheny Crayfish	*Orconectes obscurus*	Native	
Rock Crawfish	*Cambarus carinirostris*	Native	
Upland Borrowing Crayfish	*Cambarus dubius*	Native	
Virile Crayfish	*Orconectes virilis*	Introduced	Invasive
White River Crawfish	*Procambus acutus acutus*	Introduced	Not Invasive
Little Brown Mudbug	*Cambarus thomai*	Introduced	Not Invasive

FISH

Family	Common Name	Scientific Name	Native or Introduced	Gamefish	Status	Tolerance	Trophic Position
Pickerels							
	Chain Pickerel	*Esox niger*	Introduced	Game		Moderate	Top Predator
	Redfin Pickerel	*Esox americanus*	Introduced	Non-Game		Tolerant	Top Predator
	Northern Pike	*Esox lucius*	Introduced	Game		Moderate	Top Predator
Catfish							
	Yellow Bullhead	*Ameiurus natalis*	Native	Non-Game		Moderate	Omnivore
	Brown Bullhead	*Ameiurus nebulosus*	Native	Non-Game		Moderate	Omnivore
Trout							
	Brook Trout	*Salvelinus fontinalis*	Native	Game	Watch List	Intolerant	Top Predator
	Rainbow Trout	*Oncorhynchus mykiss*	Introduced	Game		Moderate	Top Predator
	Brown Trout	*Salmo trutta*	Introduced	Game		Moderate	Top Predator
Suckers							
	White Sucker	*Catostomus commersoni*	Native	Non-Game		Tolerant	Omnivore
Minnows							
	Common Carp	*Cyprinus carpio*	Introduced	Non-Game		Moderate	Omnivore
	Golden Shiner	*Notemigonus crysoleucas*	Native	Non-Game		Tolerant	Omnivore
	Creek Chub	*Semotilus atromaculatus*	Native	Non-Game		Tolerant	Generalist
Perches							
	Walleye	*Sander vitreum*	Native	Game		Moderate	Top Predator
	Yellow Perch	*Perca flavescens*	Native	Non-Game		Moderate	Generalist
	Johnny Darter	*Etheostoma nigrum*	Native	Non-Game	Watch List	Moderate	Invertivore
Sunfishes							
	Smallmouth Bass	*Micropterus dolomieu*	Native	Game		Moderate	Top Predator
	Largemouth Bass	*Micropterus salmoides*	Native	Game		Tolerant	Top Predator
	Rock Bass	*Amblopites rupestris*	Native	Non-Game		Moderate	Generalist
	Pumpkinseed	*Lepomis gibbosus*	Native	Non-Game		Tolerant	Invertivore
	Bluegill	*Lepomis macrochirus*	Native	Non-Game		Tolerant	Invertivore
	Black Crappie	*Pomoxis nigromaculatus*	Native	Non-Game		Moderate	Generalist

BENTHIC MACROINVERTEBRATES

Phylum	Order	Family	Genus	Species
Annelida	Pharyngobdellida (worm leeches)	Erpobdellidae		
	Rhynchobdellida (jawless leeches)	Glossiphoniidae		
Annelida				
	Haplotaxida	Enchytraeidae		
		Naididae		
	Lumbriculida (aquatic earth worms)	Lumbriculidae		
	Tubificida	Tubificidae		
		Tubificidae	*Limnodrilus*	*sp.*
Arthropoda	Coleoptera (beetles)	Dryopidae		
		Dytiscidae		
		Dytiscidae	*Neoporus*	*sp.*
		Elmidae		
			Dubiraphia	*sp.*
			Microcylloepus	*sp.*
			Optioservus	*sp.*
			Optioservus	*ovalis*
			Promoresia	*sp.*
			Promoresia	*elegans*
			Promoresia	*tardella*
			Stenelmis	*sp.*
		Erirhinidae	*Stenopelmus*	*sp.*
			Stenopelmus	*rufinasus*
		Gyrinidae		
		Gyrinidae	*Gyrinus*	*sp.*
		Haliplidae		
		Hydrophilidae		
		Psephenidae		
		Ptilodactylidae		
		Scirtidae		
	Collembola (springtails)	Isotomidae		
	Diptera (true flies)	Athericidae	*Atherix*	*sp.*
		Blephariceridae	*Blepharicera*	*sp.*
		Ceratopogonidae		
		Ceratopogonidae	*Ceratopogon*	*sp.*
		Chaoboridae		
		Chironomidae		
		Chironomidae	*Apsectrotanypus*	*sp.*
		Chironomidae	*Brillia*	*sp.*
		Chironomidae	*Cardiocladius*	*sp.*

Chironomidae	*Cardiocladius*	*obscurus*
Chironomidae	*Chironomini*	*sp.*
Chironomidae	*Cladopelma*	*sp.*
Chironomidae	*Clinotanypus*	*sp.*
Chironomidae	*Conchapelopia*	*sp.*
Chironomidae	*Cricotopus*	*sp.*
Chironomidae	*Cricotopus*	*bicinctus*
Chironomidae	*Cricotopus*	*tremulus*
Chironomidae	*Cricotopus*	*trifascia*
Chironomidae	*Cricotopus / Orthocladius*	*sp.*
Chironomidae	*Cryptochironomus*	*sp.*
Chironomidae	*Diamesa*	*sp.*
Chironomidae	*Dicrotendipes*	*sp.*
Chironomidae	*Eukiefferiella*	*claripennis*
Chironomidae	*Micropsectra*	*sp.*
Chironomidae	*Microtendipes*	*sp.*
Chironomidae	*Nanocladius*	*sp.*
Chironomidae	*Orthocladiinae*	*sp.*
Chironomidae	*Orthocladius*	*sp.*
Chironomidae	*Parakiefferiella*	*sp.*
Chironomidae	*Parametriocnemus*	*sp.*
Chironomidae	*Paratanytarsus*	*sp.*
Chironomidae	*Phaenopsectra*	*sp.*
Chironomidae	*Polypedilum*	*sp.*
Chironomidae	*Polypedilum*	*illinoense*
Chironomidae	*Procladius*	*sp.*
Chironomidae	*Psectrocladius*	*sp.*
Chironomidae	*Rheocricotopus*	*sp.*
Chironomidae	*Rheosmittia*	*sp.*
Chironomidae	*Rheotanytarsus*	*sp.*
Chironomidae	*Rheotanytarsus*	*exiguus*
Chironomidae	*Tanypodinae*	*sp.*
Chironomidae	*Tanytarsus*	*sp.*
Chironomidae	*Thienemanniella*	*sp.*
Chironomidae	*Thienemanniella*	*xena*
Chironomidae	*Thienemannimyia*	*sp.*
Chironomidae	*Thienemannimyia group*	*sp.*
Chironomidae	*Trissopelopia*	*sp.*
Chironomidae	*Tvetenia*	*sp.*
Chironomidae	*Tvetenia*	*bavarica*
Chironomidae	*Tvetenia*	*discoloripes*
Chironomidae	*Zavrelimyia*	*sp.*
Dixidae		

	Empididae		
	Empididae	*Chelifera*	*sp.*
	Empididae	*Hemerodromia*	*sp.*
	Ephydridae		
	Ptychopteridae		
	Simuliidae		
	Simuliidae	*Prosimulium*	*sp.*
	Simuliidae	*Simulium*	*sp.*
	Simuliidae	*Simulium*	*venustum*
	Simuliidae	*Stegopterna*	*sp.*
	Tabanidae		
	Tabanidae	*Chrysops*	*sp.*
	Tabanidae	*Merycomyia*	*sp.*
	Tabanidae	*Tabanus*	*sp.*
	Tipulidae		
	Tipulidae	*Antocha*	*sp.*
	Tipulidae	*Dicranota*	*sp.*
	Tipulidae	*Hexatoma*	*sp.*
	Tipulidae	*Limonia*	*sp.*
	Tipulidae	*Pedicia*	*sp.*
	Tipulidae	*Pseudolimnophila*	*sp.*
	Tipulidae	*Tipula*	*sp.*
Ephemeroptera (mayflies)	Ameletidae		
	Ameletidae	*Ameletus*	*sp.*
	Baetidae		
	Baetidae	*Acentrella*	*sp.*
	Baetidae	*Baetis*	*sp.*
	Baetidae	*Pseudocloeon*	*sp.*
	Ephemerellidae		
	Ephemerellidae	*Attenella*	*sp.*
	Ephemerellidae	*Ephemerella*	*sp.*
	Ephemerellidae	*Eurylophella*	*sp.*
	Ephemerellidae	*Serratella*	*molita*
	Ephemeridae		
	Ephemeridae	*Hexagenia*	*sp.*
	Ephemeridae	*Litobrancha*	*sp.*
	Heptageniidae		
	Heptageniidae	*Epeorus*	*sp.*
	Heptageniidae	*Stenacron*	*sp.*
	Heptageniidae	*Stenacron*	*interpunctatum*
	Heptageniidae	*Stenonema*	*sp.*
	Isonychiidae	*Isonychia*	*bicolor*
	Leptophlebiidae		
	Leptophlebiidae	*Habrophlebia*	*sp.*
	Leptophlebiidae	*Leptophlebia*	*sp.*

	Leptophlebiidae	*Paraleptophlebia*	*sp.*
	Potamanthidae		
	Siphlonuridae		
Hemiptera (true bugs)	Corixidae		
	Gerridae		
	Veliidae		
	Veliidae	*Rhagovelia*	*sp.*
Lepidoptera (moths)			
	Pyralidae		
Megaloptera (dobsonflies, alderflies, and fishflies)	Corydalidae		
	Corydalidae	*Chauliodes*	*sp.*
	Corydalidae	*Corydalus*	*cornutus*
	Corydalidae	*Nigronia*	*sp.*
	Sialidae		
	Sialidae	*Sialis*	*sp.*
Odonata (dragonflies and damselflies)	Aeshnidae		
	Aeshnidae	*Boyeria*	*sp.*
	Calopterygidae		
	Coenagrionidae		
	Cordulegastridae		
	Cordulegastridae	*Cordulegaster*	*sp.*
	Gomphidae		
Plecoptera (stoneflies)	Capniidae		
	Capniidae	*Capnia*	*sp.*
	Capniidae	*Paracapnia*	*sp.*
	Capniidae	*Utacapnia*	*sp.*
	Chloroperlidae		
	Chloroperlidae	*Suwallia*	*sp.*
	Chloroperlidae	*Sweltsa*	*sp.*
	Leuctridae		
	Leuctridae	*Leuctra*	*sp.*
	Leuctridae	*Leuctra*	*ferruginea*
	Leuctridae	*Leuctra*	*tenuis*
	Nemouridae		
	Nemouridae	*Amphinemura*	*sp.*
	Nemouridae	*Amphinemura*	*nigritta*
	Peltoperlidae		
	Peltoperlidae	*Peltoperla*	*sp.*
	Perlidae		
	Perlidae	*Acroneuria*	*sp.*
	Perlidae	*Attaneuria*	*sp.*
	Perlidae	*Beloneuria*	*sp.*
	Perlidae	*Paragnetina*	*sp.*

	Perlodidae		
	Perlodidae	*Clioperla*	*sp.*
	Perlodidae	*Cultus*	*sp.*
	Perlodidae	*Diploperla*	*sp.*
	Perlodidae	*Isoperla*	*sp.*
	Taeniopterygidae		
	Taeniopterygidae	*Taeniopteryx*	*sp.*
Trichoptera (caddisflies)	Dipseudopsidae		
	Dipseudopsidae	*Phylocentropus*	*sp.*
	Glossosomatidae		
	Glossosomatidae	*Glossosoma*	*sp.*
	Goeridae		
	Hydropsychidae		
	Hydropsychidae	*Ceratopsyche*	*bronta*
	Hydropsychidae	*Ceratopsyche*	*morosa*
	Hydropsychidae	*Ceratopsyche*	*walkeri*
	Hydropsychidae	*Cheumatopsyche*	*sp.*
	Hydropsychidae	*Diplectrona*	*sp.*
	Hydropsychidae	*Diplectrona*	*modesta*
	Hydropsychidae	*Hydropsyche*	*sp.*
	Hydropsychidae	*Hydropsyche*	*betteni*
	Hydroptilidae	*Leucotrichia*	*pictipes*
	Lepidostomatidae		
	Lepidostomatidae	*Lepidostoma*	*sp.*
	Lepidostomatidae	*Theliopsyche*	*sp.*
	Limnephilidae		
	Limnephilidae	*Hydatophylax*	*sp.*
	Limnephilidae	*Platycentropus*	*sp.*
	Limnephilidae	*Pseudostenophylax*	*sp.*
	Limnephilidae	*Pycnopsyche*	*sp.*
	Molannidae		
	Molannidae	*Molanna*	*sp.*
	Odontoceridae	*Psilotreta*	*sp.*
	Philopotamidae		
	Philopotamidae	*Wormaldia*	*sp.*
	Phryganeidae		
	Polycentropodidae		
	Polycentropodidae	*Cyrnellus*	*sp.*
	Polycentropodidae	*Nyctiophylax*	*sp.*
	Polycentropodidae	*Polycentropus*	*sp.*
	Psychomyiidae		
	Psychomyiidae	*Lype*	*sp.*
	Psychomyiidae	*Psychomyia*	*sp.*
	Rhyacophilidae		
	Rhyacophilidae	*Rhyacophila*	*sp.*

		Rhyacophilidae	*Rhyacophila*	*fuscula*
		Rhyacophilidae	*Rhyacophila*	*invaria*
		Uenoidae		
		Uenoidae	*Neophylax*	*sp.*
	Amphipoda (scuds)	Crangonyctidae		
		Crangonyctidae	*Crangonyx*	*sp.*
		Gammaridae		
		Gammaridae	*Gammarus*	*sp.*
		Gammaridae	*Gammarus*	*fasciatus*
		Hyalellidae		
		Hyalellidae	*Hyalella*	*sp.*
		Taltridae		
	Decapoda (srayfishs)	Cambaridae		
		Cambaridae	*Cambarus*	*sp.*
		Cambaridae	*Cambarus*	*bartonii*
		Cambaridae	*Orconectes*	*sp.*
		Cambaridae	*Procambarus*	
	Isopoda (aquatic sow bugs)	Asellidae		
		Asellidae	*Asellus*	*sp.*
		Asellidae	*Caecidotea*	*sp.*
Mollusca				
	Veneroida (bivalves)	Pisidiidae		
		Pisidiidae		
		Pisidiidae	*Musculium*	*sp.*
		Pisidiidae	*Pisidium*	*sp.*
	Basommatophora (snails)	Ancylidae	*Ferrissia*	*sp.*
		Ancylidae	*Ferrissia*	*rivularis*
		Lymnaeidae		
		Lymnaeidae	*Fossaria*	*sp.*
		Physidae		
		Physidae	*Physella*	*sp.*
		Planorbidae		
Platyhelminthes	Tricladida (free-living flat worms)	Dugesiidae		

Appendix 1-D Prioritizing Streams for Protection and Restoration

Prioritizing Streams for Protection and Restoration Based on a Triage System

(*Ronald Klauda and Patrick Graves, Maryland Department of Natural Resources)*

Background

Although Maryland is a small state (9,974 square miles), it has a dense drainage network of 10,000 to 17,000 miles of perennial streams and rivers (depending on the map scaled used). The human population in 2010 was 5,773,552 (an increase of 9.0% since 2000), making Maryland the seventh most densely-populated state in the U.S. (595 people per square mile). Urbanization and other land use changes are major stressors on the State's waters.

Protecting healthy and restoring degraded streams are goals of local, state, and federal agencies in Maryland. Protecting streams before they become degraded is especially important because protection is less costly than trying to restore them after they decline. But with so many miles of streams to deal with and agency budgets being cut and stretched to the limit, there are far more miles of streams to be restored than there are available dollars to allocate.

A prioritization strategy is needed to decide when, where, and how limited dollars should be spent to achieve maximum benefit. The prioritization strategy should embrace the fact that the benefits per restoration dollar spent (the costs) will be highest for slightly-degraded streams and lowest for severely and critically-degraded streams impacted by many stressors and having a very low probability of recovery.

This situation is analogous to a hospital emergency room, a battle field, or the site of a natural disaster---all places where the number of sick, injured, or wounded people often exceeds the available medical staff and/or supplies needed to treat them all in a timely manner. To prioritize patients' treatments based on the severity of their injuries and their chances of recovery, a sorting process or system called "triage" is performed (Kennedy et al. 1966; Rutherford 1989).

Triage comes from the French word "trier", meaning to sort, separate, select, choose, or cull. Triage was first used by Dominique Jean Larrey, a surgeon in Napoleon's army. Larrey used a triage system to ration limited medical resources for optimal benefit and achieve the greatest good for the largest number of sick, injured, and wounded soldiers.

Triage has been used in species protection and biodiversity conservation for many years (e.g., Bennett 1986; Hobbs and Kristjanson 2003; Wilson et al. 2006; Turner and List 2007; McDonald-Madden et al. 2008, Hilderbrand et al. 2010, Schneider et al. 2012).

This approach has been much less frequently used to prioritize habitat restoration projects (e.g., Holt and Vinney 2001; Bottrill et al. 2008).

Methods for Using a Triage System to Sort and Group Maryland Streams

Between 2000 and 2009, the Maryland Department of Natural Resources (DNR) sampled 1,370 randomly-selected, 1^{st} through 4^{th} order, non-tidal stream sites statewide with the Maryland Biological Stream Survey (MBSS). Data from this survey were used to calculate multi-metric biological indicators of stream condition. These indicators, called indices of biotic integrity (IBI), were calculated for benthic macroinvertebrate and fish assemblages.

Stream Ecological Condition categories needed for development of a triage system were calculated by averaging the benthic and fish IBI scores for each sampled site, expressed as a Combined Biotic Integrity (CBI) score, that ranged from 1.0 (worst) to 5.0 (best). CBI scores from the 1,370 stream sites sampled by the MBSS between 2000 and 2009 were used to estimate the total miles of streams, statewide, that fall into each of the five Stream Ecological Condition (SEC) categories (see table below).

For the triage system approach, we viewed these SEC categories as being analogous to five medical condition triage categories. This system was used to sort Maryland streams into five priority groups (1 through 5) that were also color-coded for mapping purposes. For each SEC category, we suggested appropriate management actions for streams that ranged from Protect to Do Nothing.

Conclusions

The triage system described above is a suggested first step in targeting stream protection and restoration actions. Triage can sort out those streams with still mostly intact ecological integrity (i.e., mostly healthy or only slightly-degraded) that do not require restoration actions, but deserve protection/preservation actions that should be taken. Nature is resilient, so with adequate protection, many slightly degraded streams can restore themselves. Triage can also sort out those streams that are moderately-degraded and whose ecological integrity should be restored with modest management actions, if the key stressors are first removed and appropriate actions taken fairly soon. And, perhaps most importantly, a triage system can sort out those streams whose ecological integrity is severely compromised or irretrievably lost and restoration is not possible, even if much money and other resources are expended in the attempt. The most effective strategy for these streams is to implement the minimal necessary management actions to improve their appearance and ensure they do not endanger human health and safety. Allocating public resources to stream restoration actions should consider the value of the degraded system, the benefits if restoration is successful, the probability of success, and the total costs.

Medical Condition for Triage	Triage Group Priority and Color	Stream Ecological Condition	Range of CBI Scores* (Total Miles)
•Routine or minor but not serious injuries •walking wounded •little or no treatment needed •delayed care is OK •can return to duty in short period of time	Priority 3	•Mostly healthy •comparable to minimally-disturbed reference stream •reduce and prevent threats •**PROTECT**	4.0 to 5.0 (1804)
•Moderate to serious but non-life threatening injuries •treatment can be delayed •in stable condition but requires medical assistance	Priority 2	•Slightly degraded •minimize threats •**PROTECT** so stream can heal itself	3.0 to < 4.0 (3263)
•Severe life-threatening injuries •will probably survive if treated soon •cannot wait but must have 1st priority	Priority 1	•Moderately degraded •significant deviation from reference streams •**RESTORE soon then PROTECT**	2.3 to < 3.0 (1759)
•Critical injuries, beyond help, expectant •likely to die regardless of care received •low priority for treatment •care required is beyond medical personnel capability and time •administer drugs to reduce pain	Priority 4	•Severely degraded •lost cause •**STABILIZE** then take short-term remedial actions to eliminate hazards to human health, improve aesthetics •DO NOT attempt extensive/expensive restoration	1.6 to < 2.3 (1562)
•Deceased with no vital signs, beyond help	Priority 5	•Critically degraded •only most tolerant biota present, if any; **DO NOTHING**	1.0 < 1.6 (807)

<u>References</u>

Bennett, D.H. 1986. Triage as a species preservation strategy. Environmental Ethics 8:47-58.

Botrill, M.C. and 13 co-authors. 2008. Is conservation triage just smart decision making. Trends in Ecology and Evolution 23(12):649-654.

Hilderbrand, R.H., R.M. Utz, S.A. Stranko, and R.L Raesly. 2010. Applying thresholds to forecast potential biodiversity loss from human development. Journal of the North American Benthological Society 29(3):1009-1016.

Hobbs, R.J. and L.T. Kristjanson. 2003. Triage: How do we prioritize health care for landscapes? Ecological Management and Restoration 4:39-45.

Holt, D. and H. Vinney. 2001. Targeting environmental improvements through ecological triage. Eco-management and Auditing 8:154-164.

Kennedy, K. R.V. Aghabagian, L. Gans, and C.P. Lewis. 1996. Triage techniques and applications in decision making. Annals of Emergency Medicine 28:136-144.

McDonald-Madden, E., P.W.J. Baxter, and H.P. Possingham. 2008. Subpopulation triage: How to allocate conservation effort among populations. Conservation Biology 22(3):656-665.

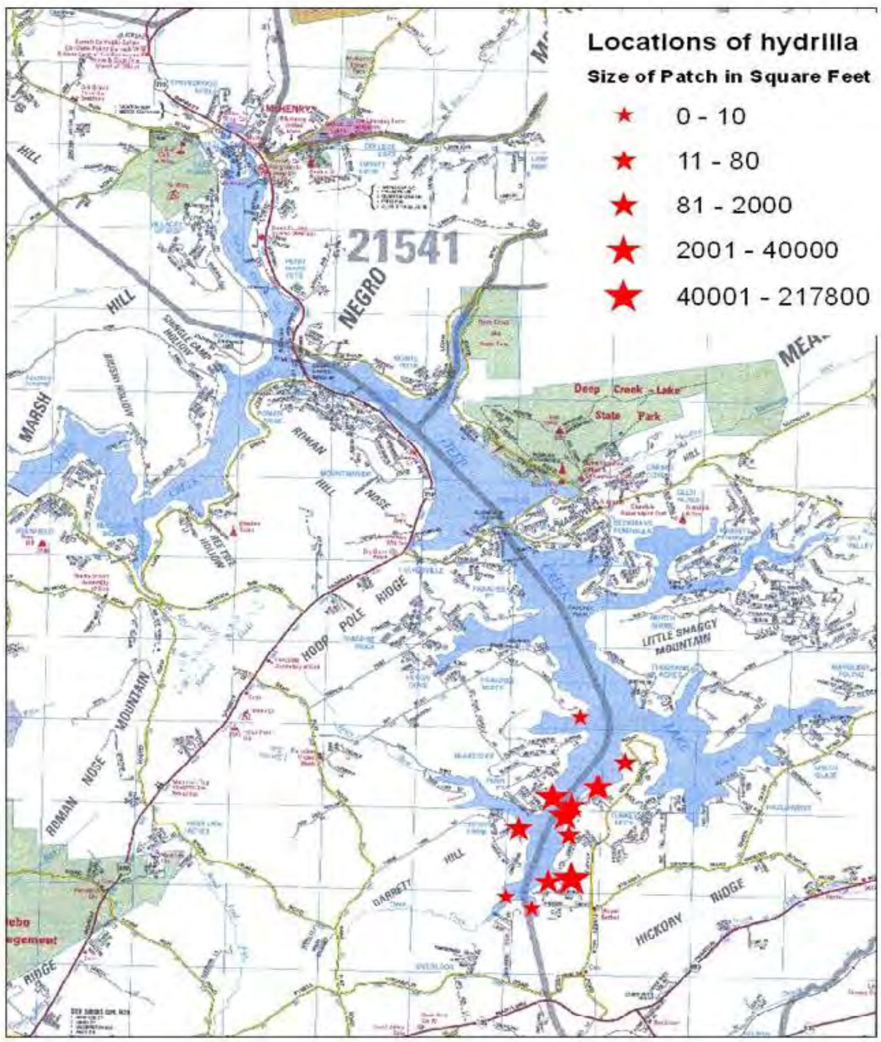
Schneider, R.R., G. Hauer, W.L. Adamowicz, and S. Boutin. 2010. Triage for conserving populations of threatened species: The case of woodland caribou in Alberta. Biological Conservation 143(7):1603-1611.

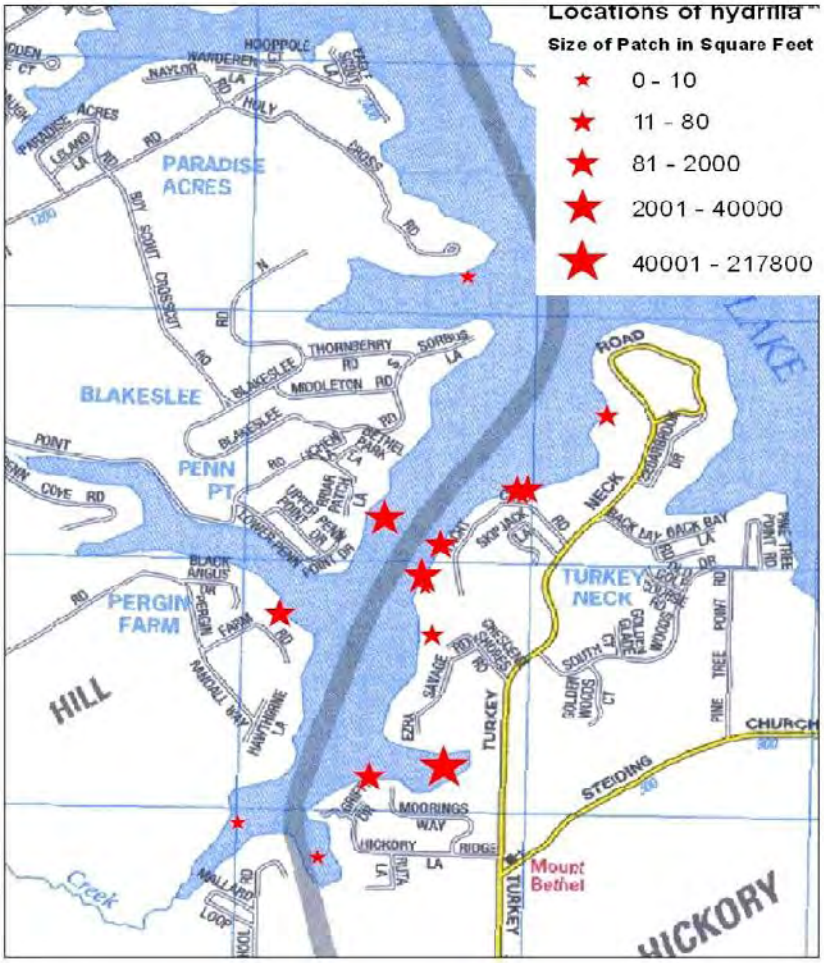
Turner, D.S. and M.D. List. 2007. Habitat mapping and conservation analysis to identify critical streams for Arizona's native fish. Aquatic Conservation: Marine and Freshwater Ecosystems 17:737-748.

Wilson, K.A., M.F. McBride, M. Bode et al. 2006. Prioritizing global conservation efforts. Nature 440:337-340.

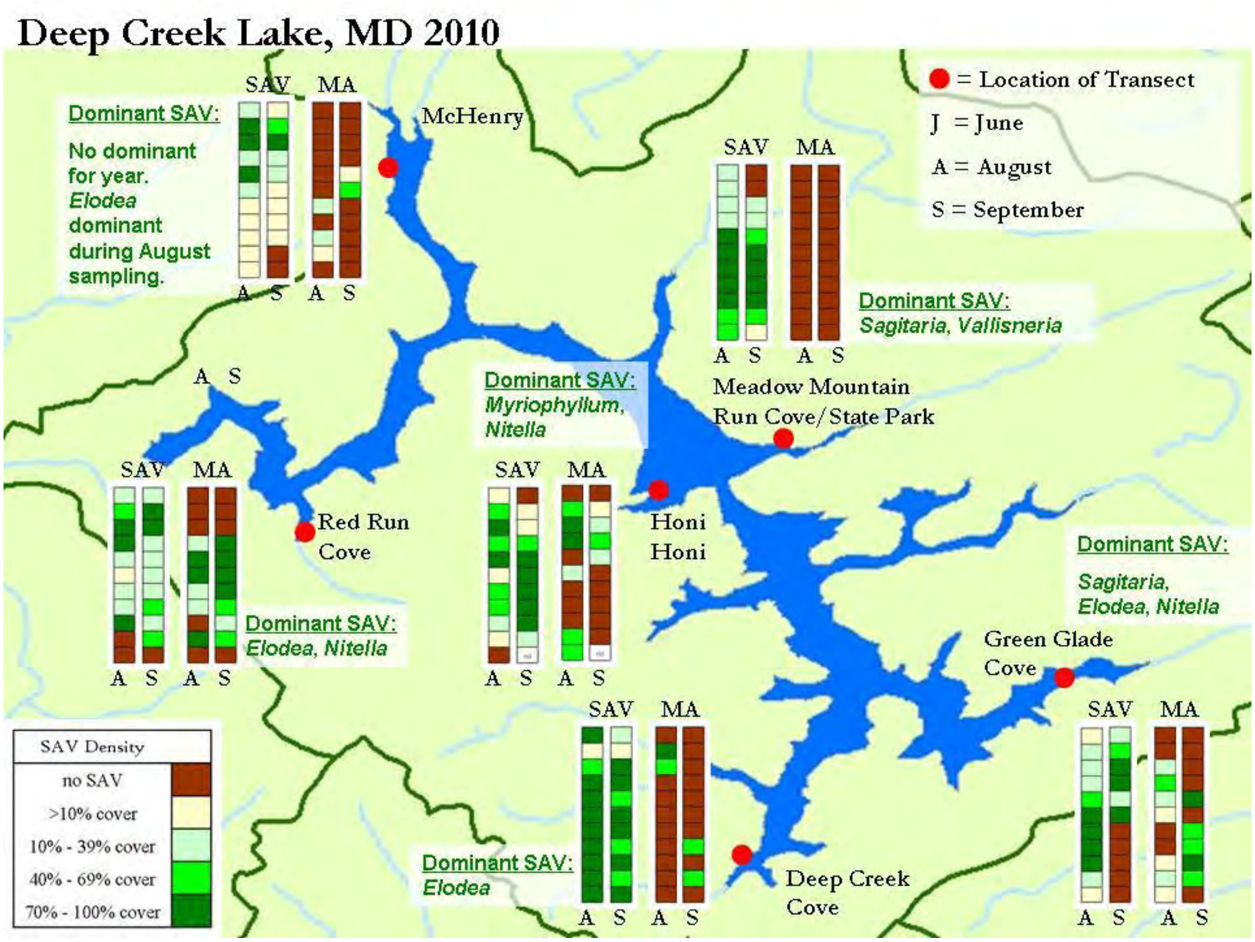
Appendix 2 Submerged Aquatic Vegetation

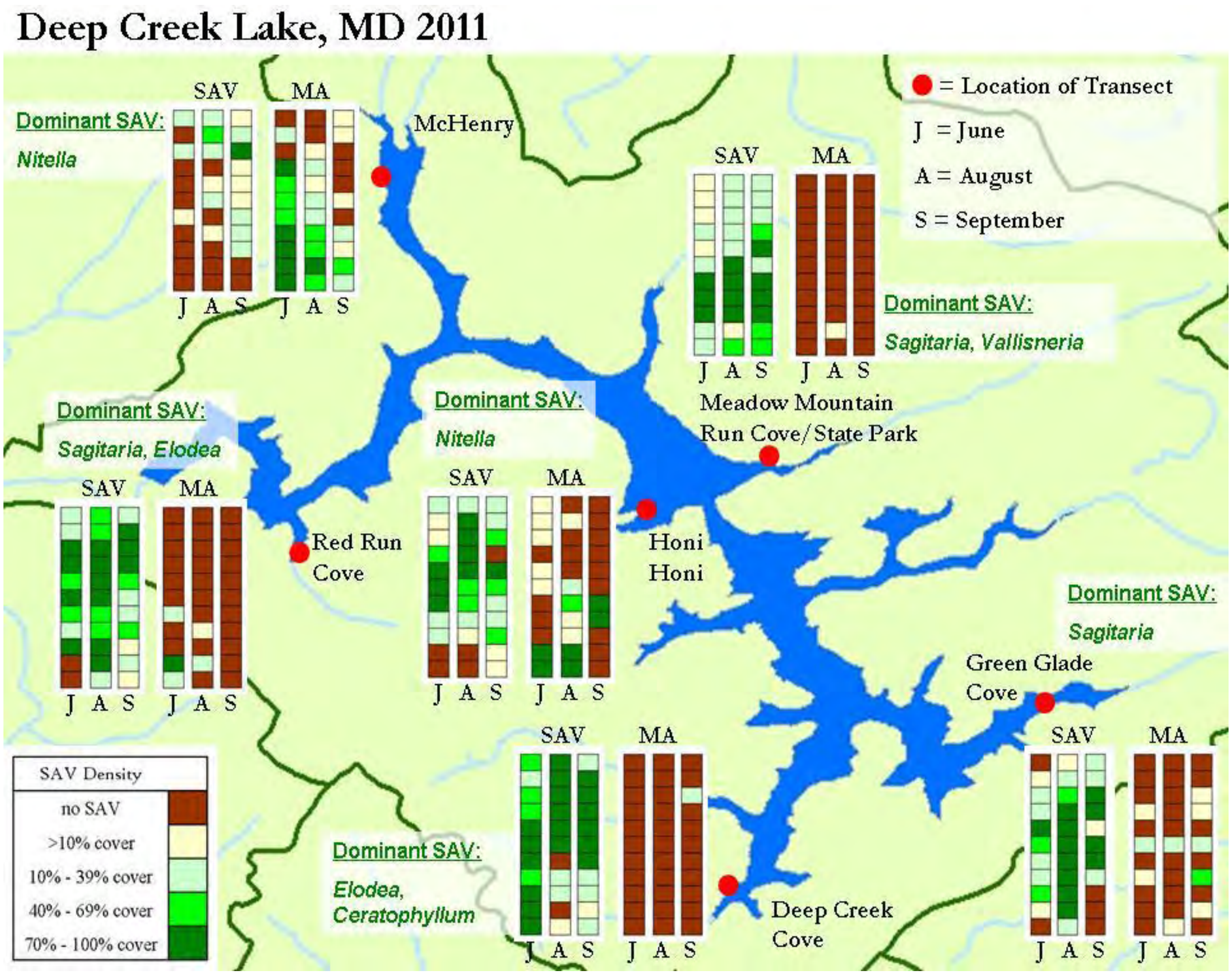
Appendix 2-A Deep Creek Lake Hydrilla verticillata Survey Results 2013

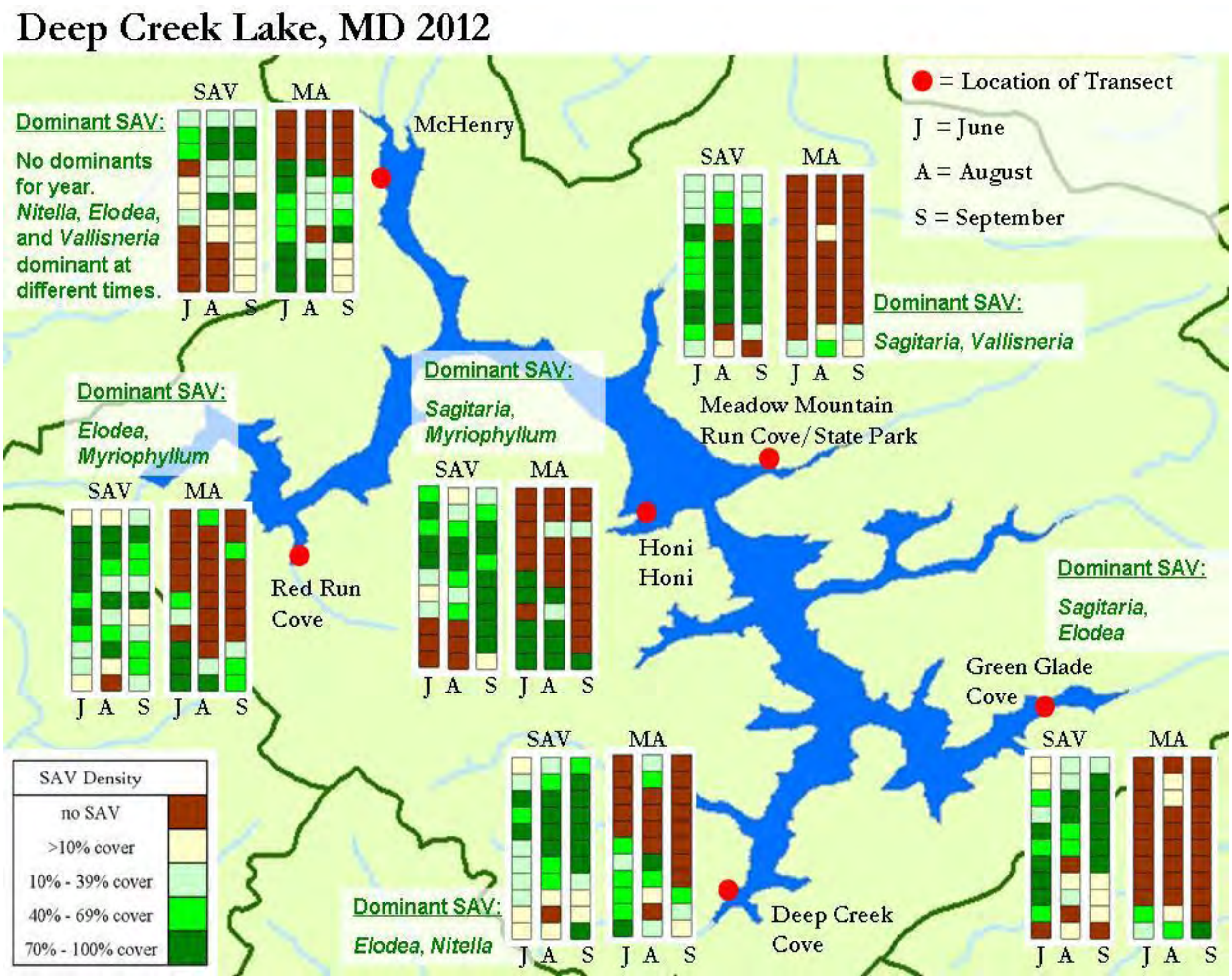


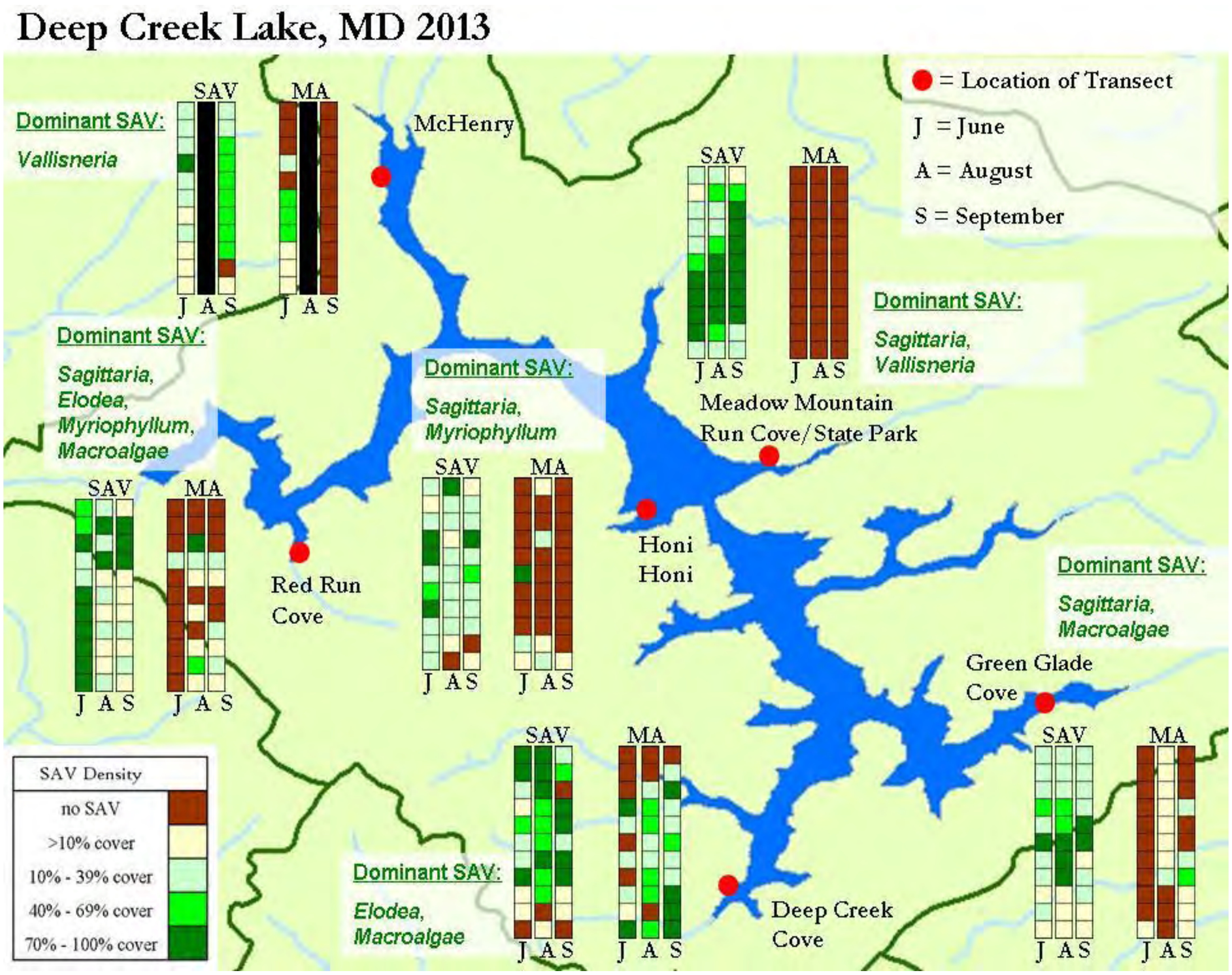

Locations of hydrilla
Size of Patch in Square Feet
0 - 10
11 - 80
81 - 2000
2001 - 40000
40001 - 217800
PARADISE ACRES
BLAKESLEE
PENN PT
PERGIN FARM
HILL
TURKEY NECK
LAKE
Mount Bethel
HICKORY
Creek

Appendix 2-B: Deep Creek Lake SAVand Macroalgae Transect Results 2010-2013



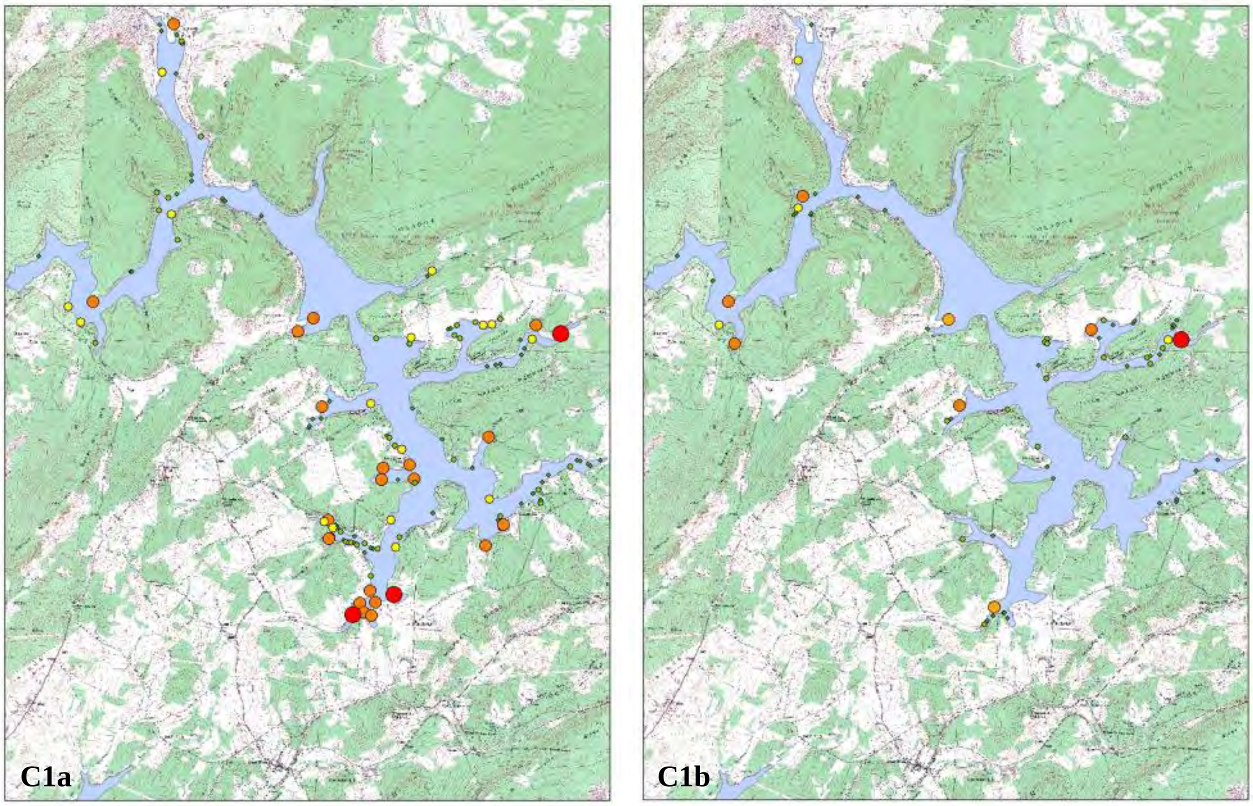

Deep Creek Lake, MD 2011
= Location of Transect
J = June
A = August
S = September
McHenry
Dominant SAV:
Nitella
SAV
MA
J A S
Meadow Mountain Run Cove/ State Park
Dominant SAV:
Sagitaria, Vallisneria
Dominant SAV:
Sagitaria, Elodea
Red Run Cove
Dominant SAV:
Nitella
Honi Honi
Dominant SAV:
Sagitaria
Green Glade Cove
Dominant SAV:
Elodea, Ceratophyllum
Deep Creek Cove
SAV Density
no SAV
>10% cover
10% - 39% cover
40% - 69% cover
70% - 100% cover


Deep Creek Lake, MD 2012
= Location of Transect
J = June
A = August
S = September
McHenry
Dominant SAV:
No dominants for year. Nitella, Elodea, and Vallisneria dominant at different times.
Dominant SAV:
Sagitaria, Vallisneria
Meadow Mountain Run Cove/State Park
Dominant SAV:
Sagitaria, Myriophyllum
Dominant SAV:
Elodea, Myriophyllum
Red Run Cove
Honi Honi
Dominant SAV:
Sagitaria, Elodea
Green Glade Cove
Deep Creek Cove
Dominant SAV:
Elodea, Nitella
SAV
MA
J A S
SAV Density
no SAV
>10% cover
10% - 39% cover
40% - 69% cover
70% - 100% cover


Deep Creek Lake, MD 2013
= Location of Transect
J = June
A = August
S = September
SAV
MA
J A S
Dominant SAV:
Vallisneria
McHenry
Dominant SAV:
Sagittaria, Vallisneria
Meadow Mountain Run Cove/ State Park
Dominant SAV:
Sagittaria, Elodea, Myriophyllum, Macroalgae
Dominant SAV:
Sagittaria, Myriophyllum
Red Run Cove
Honi Honi
Dominant SAV:
Sagittaria, Macroalgae
Green Glade Cove
SAV Density
no SAV
>10% cover
10% - 39% cover
40% - 69% cover
70% - 100% cover
Dominant SAV:
Elodea, Macroalgae
Deep Creek Cove

Appendix 2-C: Deep Creek Lake Myriophyllum Survey Results 2012 and 2013

2012 **2013**

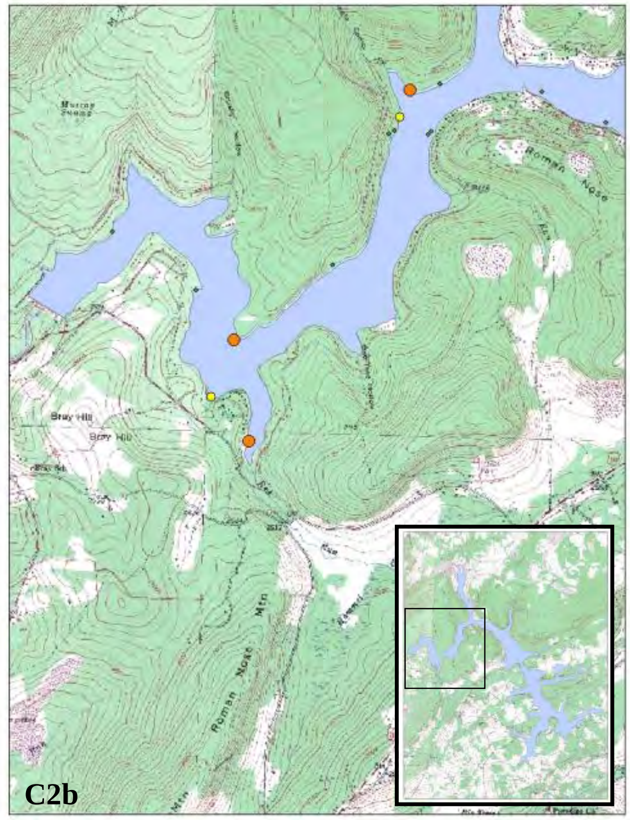


***Myriophyllum* observations**

Less than 0.1 acre	0.1 – 0.5 acres	0.5 – 1.0 acres	1.0 – 5.0 acres	5.0 – 15 acres

2012

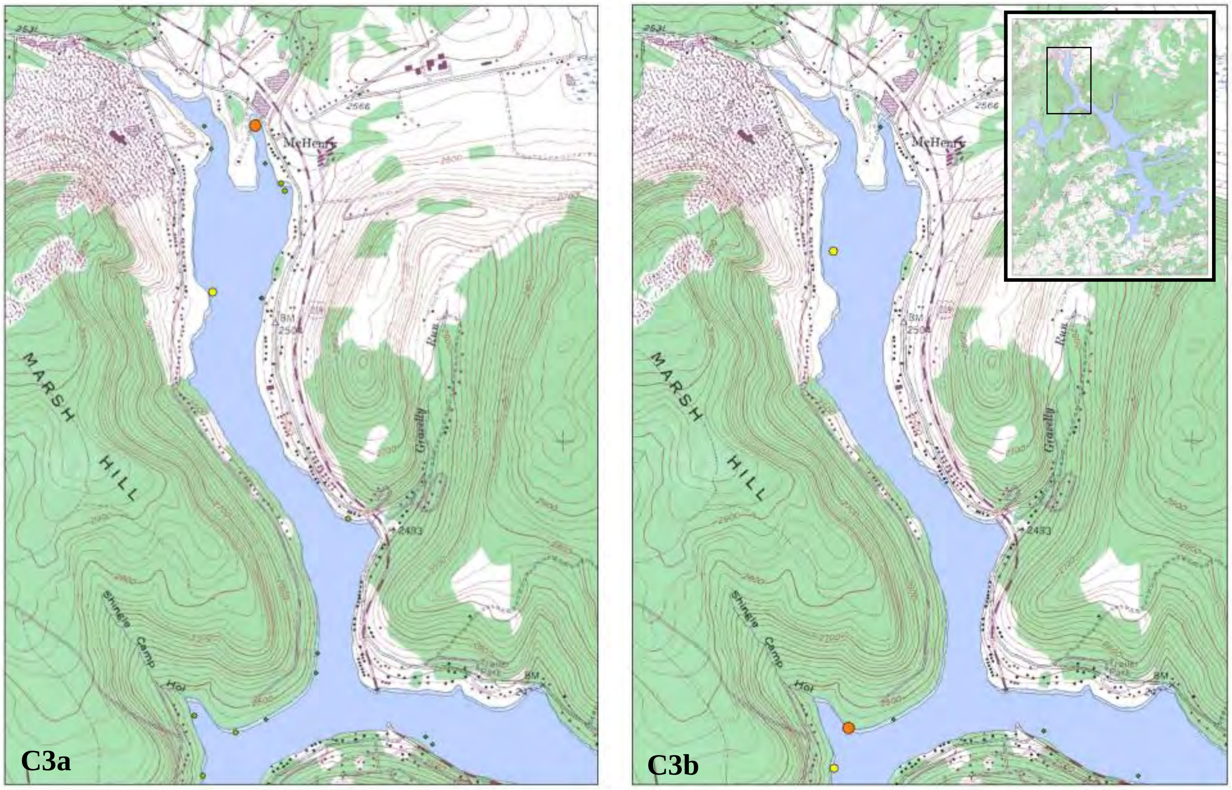
2013



***Myriophyllum* observations**

Less than 0.1 acre | 0.1 – 0.5 acres | 0.5 – 1.0 acres | 1.0 – 5.0 acres | 5.0 – 15 acres

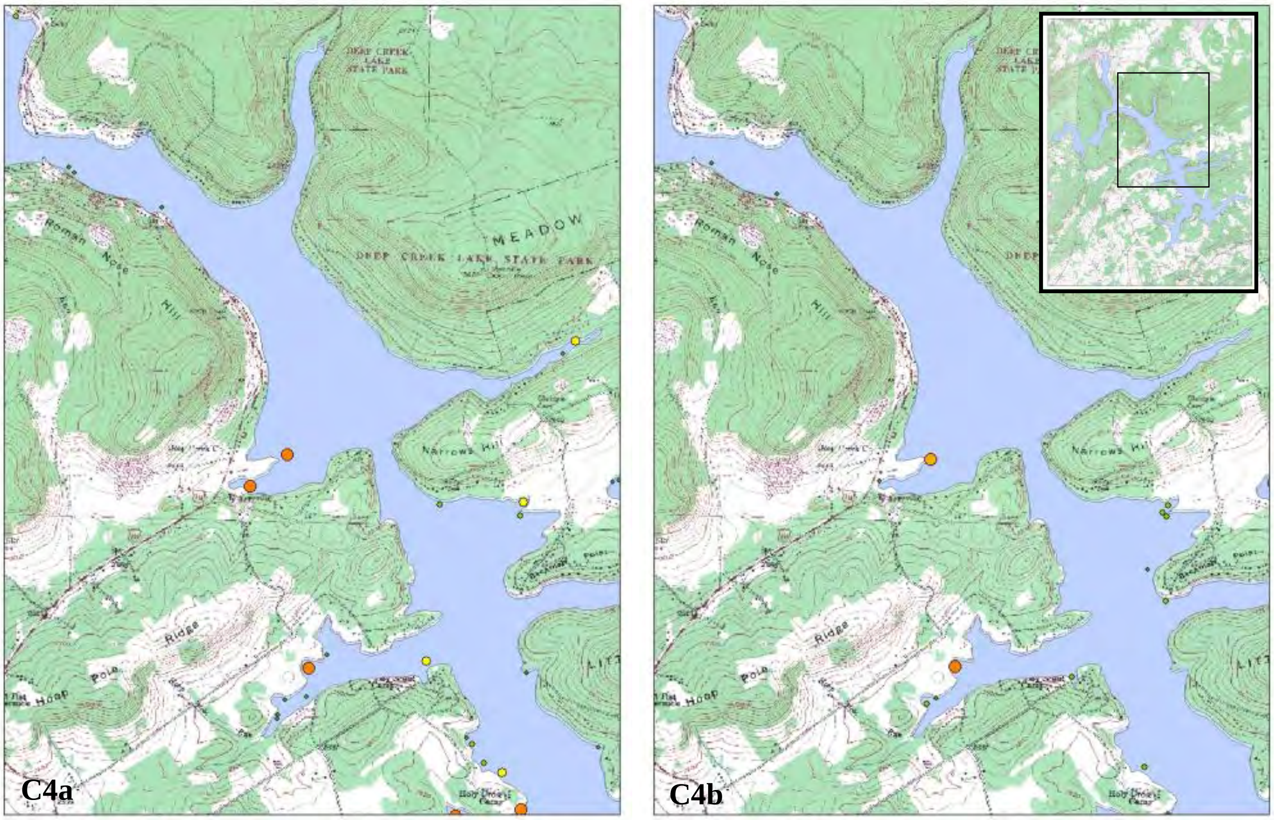
2012 **2013**



***Myriophyllum* observations**

Less than 0.1 acre	0.1 – 0.5 acres	0.5 – 1.0 acres	1.0 – 5.0 acres	5.0 – 15 acres

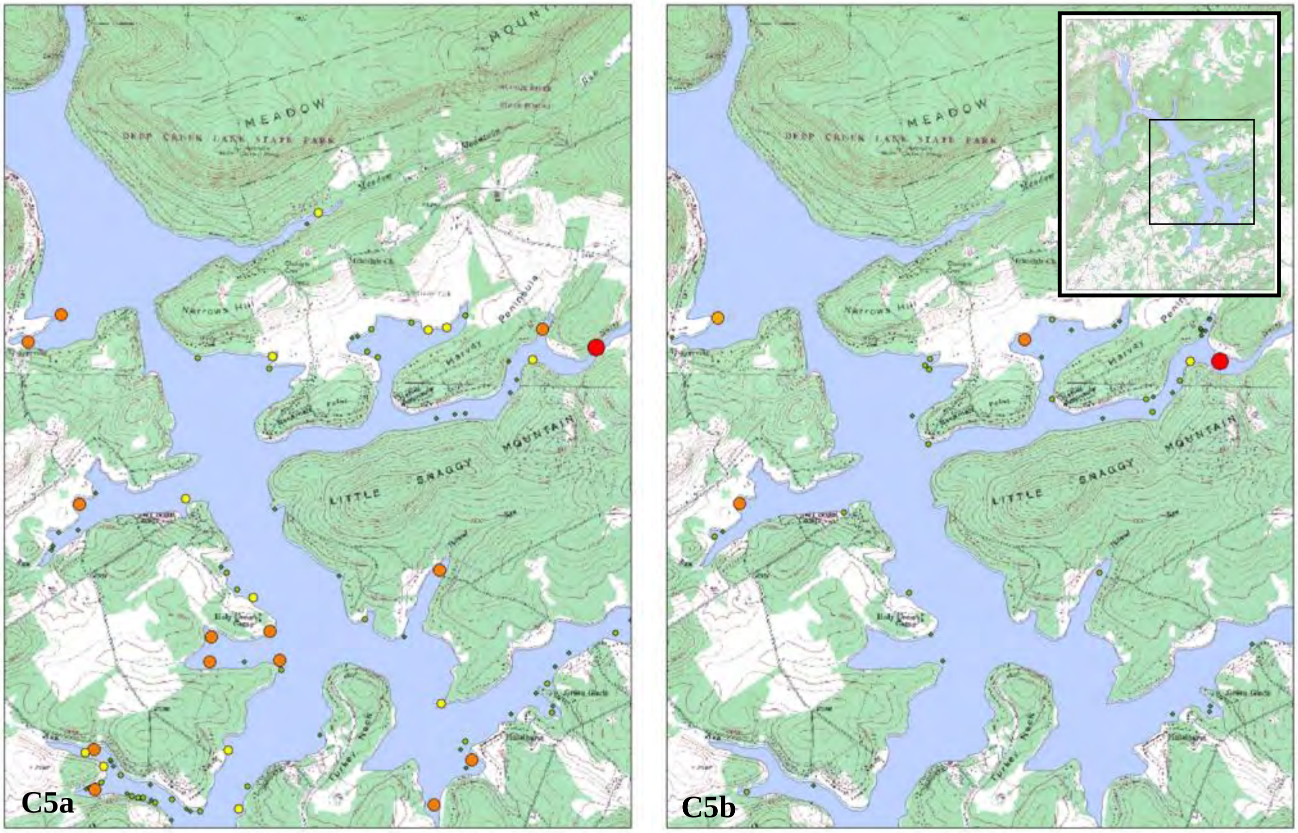
2012 **2013**



***Myriophyllum* observations**

Less than 0.1 acre	0.1 – 0.5 acres	0.5 – 1.0 acres	1.0 – 5.0 acres	5.0 – 15 acres

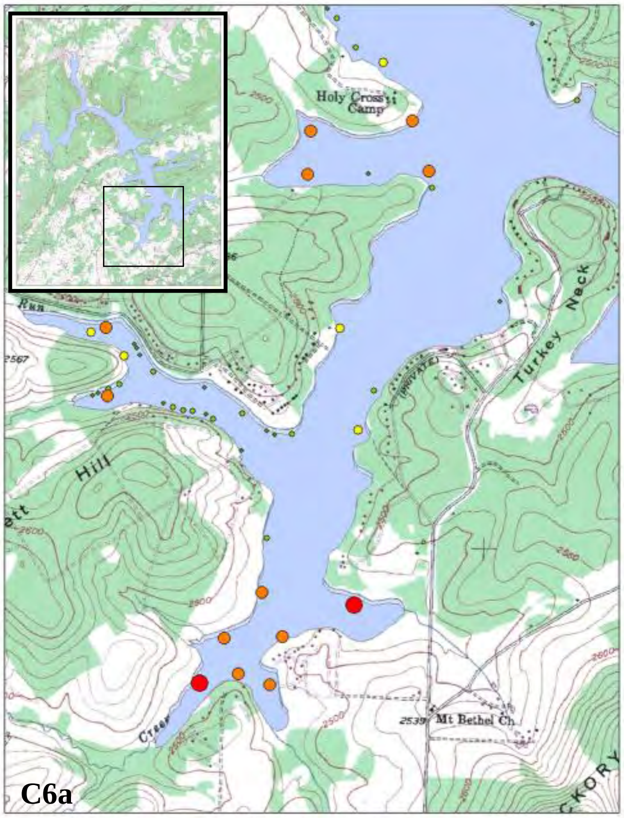
2012 **2013**



***Myriophyllum* observations**

Less than 0.1 acre	0.1 – 0.5 acres	0.5 – 1.0 acres	1.0 – 5.0 acres	5.0 – 15 acres

2012

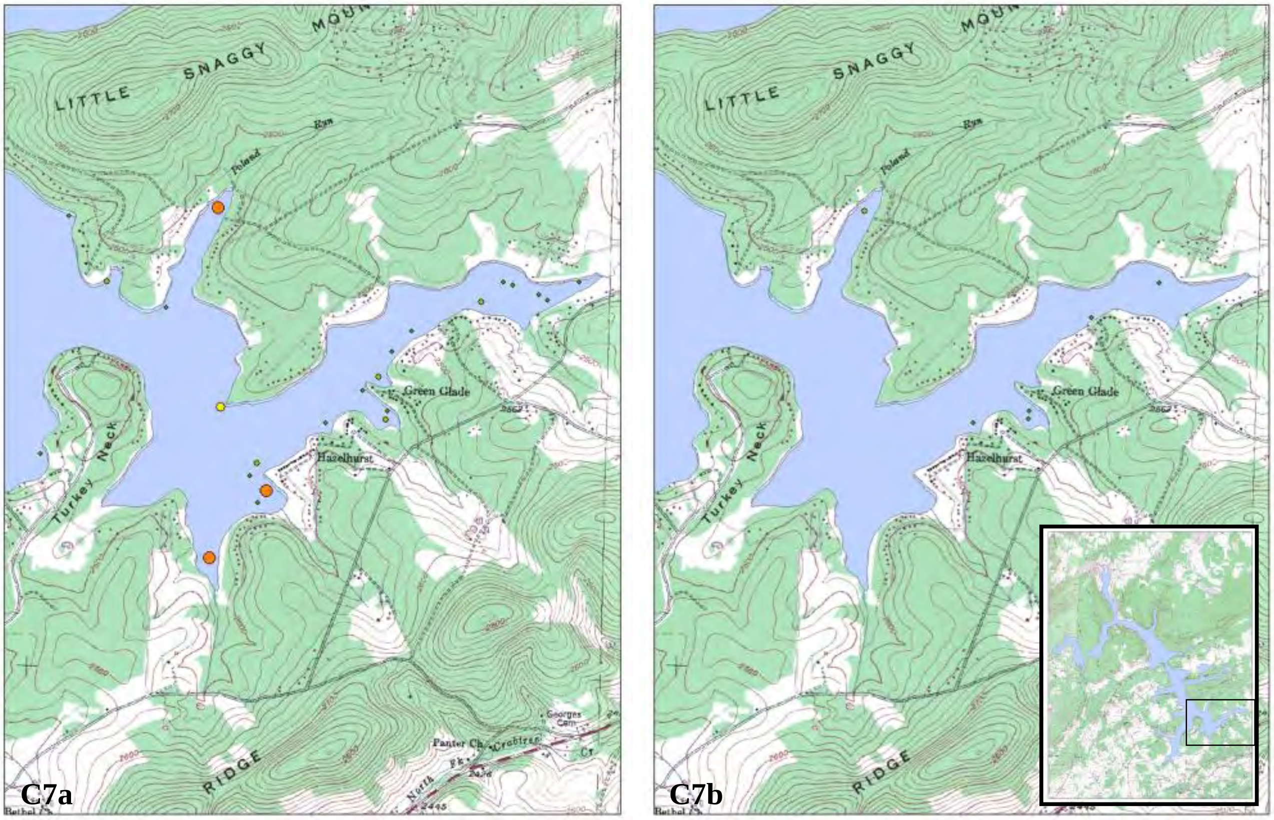


2013

***Myriophyllum* observations**

Less than 0.1 acre	0.1 – 0.5 acres	0.5 – 1.0 acres	1.0 – 5.0 acres	5.0 – 15 acres

2012 **2013**



***Myriophyllum* observations**

Less than 0.1 acre	0.1 – 0.5 acres	0.5 – 1.0 acres	1.0 – 5.0 acres	5.0 – 15 acres

Appendix 3: Forestry

Appendix 3-A: Explanation of Species Rank and Status Codes

The global and state ranking system is used by all 50 state Natural Heritage Programs and numerous Conservation Data Centers in other countries in this hemisphere. Because they are assigned based upon standard criteria, the ranks can be used to assess the range-wide status of a species as well as the status within portions of the species' range. The primary criterion used to define these ranks is the number of known distinct occurrences, with consideration given to the total number of individuals at each locality. Additional factors considered include the current level of protection, the types and degree of threats, ecological vulnerability, and population trends. Global and state ranks are used in combination to set inventory, protection, and management priorities for species at the state, regional, and national levels.

GLOBAL RANK

G1 Highly globally rare. Critically imperiled globally because of extreme rarity (typically 5 or fewer estimated occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2 Globally rare. Imperiled globally because of rarity (typically 6 to 20 estimated occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 Either very rare and local throughout its range or distributed locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; typically with 21 to 100 estimated occurrences.

G4 Apparently secure globally, although it may be quite rare in parts of its range, especially at the periphery.

G5 Demonstrably secure globally, although it may be quite rare in parts of its range, especially at the periphery.

GH No known extant occurrences (i.e., formerly part of the established biota, with the expectation that it may be rediscovered).

GU Possibly in peril range-wide, but its status is uncertain; more information is needed.

GX Believed to be extinct throughout its range (e.g., passenger pigeon) with virtually no likelihood that it will be rediscovered.

G? The species has not yet been ranked.

_Q Species containing a "Q" in the rank indicates that the taxon is of questionable or uncertain taxonomic standing (i.e., some taxonomists regard it as a full species, while others treat it at an infraspecific level).

_T Ranks containing a "T" indicate that the infraspecific taxon is being ranked differently than the full species.

STATE RANK

S1 Highly State rare. Critically imperiled in Maryland because of extreme rarity (typically 5 or fewer estimated occurrences or very few remaining individuals or acres in the State) or because of some factor(s) making it especially vulnerable to extirpation. Species with this rank are actively tracked by the Natural Heritage Program.

S2 State rare. Imperiled in Maryland because of rarity (typically 6 to 20 estimated occurrences or few remaining individuals or acres in the State) or because of some factor(s) making it vulnerable to becoming extirpated. Species with this rank are actively tracked by the Natural Heritage Program.

S3 Watch List. Rare to uncommon with the number of occurrences typically in the range of 21 to 100 in Maryland. It may have fewer occurrences but with a large number of individuals in some populations, and it may be susceptible to large-scale disturbances. Species with this rank are not actively tracked by the Natural Heritage Program.

S3.1 A species that is actively tracked by the Natural Heritage Program because of the global significance of Maryland occurrences. For instance, a G3 S3 species is globally rare to uncommon, and although it may not be currently threatened with extirpation in Maryland, its occurrences in Maryland may be critical to the long term security of the species. Therefore, its status in the State is being monitored.

S4 Apparently secure in Maryland with typically more than 100 occurrences in the State or may have fewer occurrences if they contain large numbers of individuals. It is apparently secure under present conditions, although it may be restricted to only a portion of the State.

S5 Demonstrably secure in Maryland under present conditions.

SA Accidental or considered to be a vagrant in Maryland.

SE Established, but not native to Maryland; it may be native elsewhere in North America.

SH Historically known from Maryland, but not verified for an extended period (usually 20 or more years), with the expectation that it may be rediscovered.

SP Potentially occurring in Maryland or likely to have occurred in Maryland (but without persuasive documentation).

SR Reported from Maryland, but without persuasive documentation that would provide a basis for either accepting or rejecting the report (e.g., no voucher specimen exists).

SRF Reported falsely (in error) from Maryland, and the error may persist in the literature.

SU Possibly rare in Maryland, but of uncertain status for reasons including lack of historical records, low search effort, cryptic nature of the species, or concerns that the species may not be native to the State. Uncertainty spans a range of 4 or 5 ranks as defined above.

SX Believed to be extirpated in Maryland with virtually no chance of rediscovery.

SYN Currently considered synonymous with another taxon and, therefore, not a valid entity.

SZ A migratory species which does not inhabit specific locations for long periods of time.

S? The species has not yet been ranked.

-B This species is migratory and the rank refers only to the breeding status of the species. Such a migrant may have a different rarity rank for non-breeding populations.

-N This species is migratory and the rank refers only to the non-breeding status of the species. Such a migrant may have a different rarity rank for breeding populations.

Ranks that are depicted as ranges (e.g., S1S2) are generally rounded up to the first rank for discussion and analysis purposes.

STATE STATUS

This is the status of a species as determined by the Maryland Department of Natural Resources, in accordance with the Nongame and Endangered Species Conservation Act. Definitions for the following categories have been taken from Code of Maryland Regulations (COMAR) 08.03.08.

E Endangered; a species whose continued existence as a viable component of the State's flora or fauna is determined to be in jeopardy.

I In Need of Conservation; an animal species whose population is limited or declining in the State such that it may become threatened in the foreseeable future if current trends or conditions persist.

T Threatened; a species of flora or fauna which appears likely, within the foreseeable future, to become endangered in the State.

X Endangered Extirpated; a species that was once a viable component of the flora or fauna of the State, but for which no naturally occurring populations are known to exist in the State.

* A qualifier denoting the species is listed in a limited geographic area only.

PE Proposed Endangered; a change is COMAR is pending that would list the species as Endangered (see definition above).

PT Proposed Threatened; a change is COMAR is pending that would list the species as Threatened (see definition above).

PX Proposed Endangered Extirpated; a change is COMAR is pending that would list the species as Endangered Extirpated (see definition above).

PD Proposed to be deleted or removed from the State Threatened & Endangered Species list within COMAR.

FEDERAL STATUS

This is the status of a species as determined by the U.S. Fish and Wildlife Service's Office of Endangered Species, in accordance with the Endangered Species Act. Definitions for the following categories have been modified from 50 CRF 17.

LE Taxa listed as endangered; in danger of extinction throughout all or a significant portion of their range.

LT Taxa listed as threatened; likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

PE Taxa proposed to be listed as endangered.

PT Taxa proposed to be listed as threatened.

C Candidate taxa for listing for which the Service has on file enough substantial information on biological vulnerability and threat(s) to support proposals to list them as endangered or threatened.

Appendix 3-B: Ecologically Significant Area Summaries

Included in this Appendix is a summary description of each of the 16 Ecologically Significant Areas (ESAs) within the Deep Creek Lake Watershed in Garrett County. Each summary provides information on the ecological significance of the area, a list of the Key Wildlife Habitats and other Key Elements, and a description of the ecological significance of the area.

Ecologically Significant Areas contain the locations of rare species and significant natural communities. ESAs may harbor one or more rare plant, animal, or ecological community occurrences. The size and configuration of the ESA are based upon proximity of the occurrences, life history needs of the species, and the type and extent of the supporting habitats. Many rare species occur within declining or limited habitats, such as bogs or seepage swamps. Others live in high-quality remnants of more common habitats. ESAs are designed to contain not only the rare resource itself, but also their habitats and appropriate buffers (i.e., adjacent lands needed to conserve the species and habitats). Thus, they are intended to be used as conservation boundary guidelines for the resources within them. ESAs are then assigned to BioNet Priority Tiers based on the rarity and viability of the species and habitats, as well as the number of these resources within them.

The Ecologically Significant Area boundaries should be considered as guidance maps rather than “hard” or unchanging boundaries. In fact, these boundaries are updated regularly as additional information is learned about the locations of rare species in areas that perhaps had not been surveyed previously. Also, the prioritized BioNet Tier rankings will change as new information becomes available on the resources and the viability of the resources within each area.

The following Ecologically Significant Areas are described in this Appendix:

1. Negro Mountain Powerline Bog
2. North Cherry Creek Bog
3. Anvil Bog
4. Rock House Bog
5. South Cherry Creek Complex
6. Meadow Mountain Bog North
7. Highest Bog
8. Meadow Mountain Run Swamp
9. Rhodes Fields
10. Warren’s Beech Grove
11. Potato Farm Coves
12. Deep Creek Spillway
13. Lower Deep Creek Complex
14. Hammel Glade
15. Keystone Swamp

16. McHenry Wetland South

1. Negro Mountain Powerline Bog BioNet Tier: 5 Size: 73 ac

Key Wildlife Habitats and other Key Elements

- Bog and Fen Wetland Complex
- Forested Seepage Wetlands
- Tawny Cottongrass and other uncommon plants
- Core habitat for Forest Interior Dwelling Species (FIDS)

Ecological Significance

Forming the headwaters of Cherry Creek, which is one of the tributaries feeding Deep Creek Lake, this small wetland is primarily a forested wetland. The dominant tree species found in the canopy are red maple, black gum, and eastern hemlock. This wetland also has a dense shrub layer of great laurel. However, the forest is broken by a powerline right-of-way that crosses the wetland, and it is in this narrow open-canopy area that the typical herbaceous bog plants grow, such as tawny cottongrass (*Eriophorum virginicum*, watchlist). Small numbers of red spruce (*Picea rubens*, watchlist) and American mountain-ash (*Sorbus americana*, watchlist) can also be found at Negro Mountain Powerline Bog.

The upland slopes surrounding this wetland complex are mostly forested. These plant communities are important for maintaining the water quantity and quality of the bog. They filter nutrients and chemicals and trap excess sediments that could damage bog vegetation in erosive runoff events.

The forests buffering Negro Mountain Powerline Bog are embedded within a larger contiguous block of forest that was identified as meeting the criteria for core habitat (or highest quality habitat) for Forest Interior Dwelling Species (FIDS) based on the size and configuration of the forest. Species of Greatest Conservation Need (GCN), such as Acadian flycatcher, wood thrush, and scarlet tanager are likely to nest within these forests.

The forested slopes of Negro Mountain also provide habitat for countless wildlife species that are dispersing from breeding grounds or migrating to new areas. Movement corridors from lower elevations to higher elevations and from southern latitudes to northern latitudes will enable species to better adapt to shifting environmental conditions that are occurring as part of climate change.

2. North Cherry Creek Bog BioNet Tier: 2 Size: 711 ac

Key Wildlife Habitats and other Key Elements

- Bog and Fen Wetland Complex

- Forested Seepage Wetlands
- Bog Fern, Small Cranberry, and other rare plants
- Alder Flycatcher, Southern Water Shrew, and other rare animals

Ecological Significance
Located at the headwaters of Cherry Creek, one of the tributaries feeding Deep Creek Lake, North Cherry Creek Bog is one of Maryland's significant mountain peatland complexes. Despite nearby disturbances, the large central portion of this area remains a high quality wetland with very significant ecological attributes, such as a high diversity of plant communities and areas with a high degree of ecological integrity. Because of these attributes, North Cherry Creek Bog supports a greater diversity of plants and animals than many Garrett County wetlands, including numerous rare or uncommon species.

Beavers are active along the main stem of Cherry Creek and an unnamed side tributary. Some open areas are dominated by Sphagnum mosses. Meadows of sedges and other herbaceous plants give way to low shrub swamp areas of glade St. John's-wort, scattered patches of taller shrubs, such as mountain holly, and thickets of speckled alder. Forested wetlands contain eastern hemlock and red spruce or hardwoods such as red maple. Under these shaded canopies grows bog fern (*Thelypteris simulata*, Threatened). The shrubby areas provide habitat for rare breeding birds, such as alder flycatcher (*Empidonax alnorum*, In Need of Conservation). Because of the large size of this wetland and its close proximity to other large wetlands such as South Cherry Creek Complex, it provides habitat for area-sensitive species and wide-ranging animals, such as bobcat (*Lynx rufus*, In Need of Conservation). Southern water shrews (*Sorex palustris punctulatus*, Endangered) find good habitat along steep-banked streams passing through thickets of great laurel. These tiny mammals are among the most aquatic of their kind, having fur that traps air bubbles to help them change buoyancy while swimming. Also, a fringe of stiff hairs on the hind feet traps bubbles that allow this animal to run on top of the water.

3. Anvil Bog **BioNet Tier: 2** **Size: 364 ac**

Key Wildlife Habitats and other Key Elements
- Northern Conifer – Hardwood Forest
- Mesic Deciduous Forest
- Floodplain Forest
- Bog and Fen Wetland Complex
- Forested Seepage Wetlands
- Rose Pogonia, Small Cranberry, and other rare plants
- Ski-tailed Emerald, Henslow's Sparrow and other rare animals

Ecological Significance
Located between North Cherry Creek Bog and South Cherry Creek Complex, Anvil Bog is part of the extensive wetland complex along Cherry Creek, which drains eventually

into Deep Creek Lake. Despite nearby degraded lands from past mining activities, much of this area remains a high-quality wetland with significant ecological attributes, such as a high diversity of plant communities, some being rare or locally significant. Because of this diversity, Anvil Bog supports a number of rare and uncommon plant and animal species.

Cherry Creek meanders through the middle of this rather open wetland, and it has occasional pools created by downstream beaver dams, as well as associated large sedge meadows. On the west side of the stream are some high quality streamside and spring fed fens and peatlands, with large mats of sphagnum moss, tall sedges, small cranberry (*Vaccinium oxycoccos*, Threatened), and large cranberry (*V. macrocarpon*, watchlist). Bog clubmoss (*Lycopodiella inundata*, rare), a low, moss-like plant, thrives in several areas. This species is adapted to acidic wetlands and is found at high elevations in Maryland. Rose pogonia (*Pogonia ophioglossoides*, watchlist) is more frequently found on Maryland's Coastal Plain, but it is a rare associate in high elevation plateau wetlands.

The open waters and meadows also provide habitat for rare dragonflies, such as ski-tailed emerald (*Somatochlora elongata*, rare) and Canada darner (*Aeshna canadensis*, rare). Once found throughout the State, Henslow's sparrow (*Ammodramus henslowii*, Threatened) is a grassland specialist and is now found breeding only in the old fields and reclaimed stripmines in Western Maryland.

Along the edges and scattered within the open meadows are shrubby thickets of speckled alder. Patches of eastern hemlock and a few red spruce (*Picea rubens*, watchlist) trees are among the species found in forested sections. Future surveys of this wetland are likely to find additional rare species, such as alder flycatcher (*Empidonax alnorum*, In Need of Conservation) and Nashville warbler (*Vermivora ruficapilla*, In Need of Conservation).

4. Rock House Bog — BioNet Tier: 2 — Size: 191 ac

Key Wildlife Habitats and other Key Elements

- Bog and Fen Wetland Complex
- Northern Conifer – Hardwood Forest
- Floodplain Forest
- Mesic Deciduous Forest
- Bog Fern
- Tawny Cottongrass

Ecological Significance

Draining into Cherry Creek about a mile upstream from Deep Creek Lake, Rock House Bog is bisected by Rock Lodge Road. A variety of the acidic wetland communities characteristic of Garrett County are found here. Some of these habitat types include open wet sedge and grass fens fed by mineral-rich surface water or groundwater, peatlands dominated by Sphagnum moss, other mosses, and other bog plants including the purple pitcher plant (*Sarracenia purpurea*, Threatened), and scattered shrubby areas primarily covered by glade St. John's-wort and speckled alder. Rock House Bog is also home to small areas of high-quality swamp forest dominated by eastern hemlock and red spruce (*Picea rubens*, watchlist). This conifer forest provides habitat for other rare species such as bog fern (*Thelypteris simulata*, Threatened).

The area offers potential habitat for several other types of rare wildlife, in addition to providing excellent habitat for a variety of more common wetland species. Due to the high quality, diversity of wetland communities, and the corresponding number of rare and endangered species present, this wetland is considered a high protection priority.

Rock House Bog is part of a forest block that was identified as meeting the criteria for core habitat for Forest Interior Dwelling Species (FIDS) based on the size and configuration of the forest.

5. South Cherry Creek Complex BioNet Tier: 1 Size: 949 ac

Key Wildlife Habitats and other Key Elements

- Bog and Fen Wetland Complex
- Forested Seepage Wetlands
- American Yew, Bog Clubmoss and other rare plants
- Bobcat, Zebra Clubtail and other rare animals

Ecological Significance

South Cherry Creek Complex is one of the largest and most diverse high-altitude wetlands in Maryland. Most, if not all, of the acidic wetland communities characteristic of Garrett County are represented somewhere within this large wetland matrix and many of these are considered highly significant globally and locally. Some of these types include open wet sedge and grass dominated fens fed by mineral-rich surface water or groundwater, peatlands dominated by Sphagnum moss, and other "bog" plants, shrub-dominated wetlands primarily covered by glade St. John's-wort and speckled alder, and forested seepage wetlands with trees such as eastern hemlock, red spruce and pitch pine. A small population of American yew (*Taxus canadensis*, Threatened) occurs along an upland edge. Bog clubmoss (*Lycopodiella inundata*, rare), a low, moss-like plant, thrives in several areas. This species is adapted to acidic wetlands and is found at high elevations in Maryland.

Because of the large size of this wetland and its close proximity to other large wetlands just to the north, it provides habitat for area-sensitive species and wide-ranging animals, such as bobcat (*Lynx rufus*, In Need of Conservation). The coldwater streams running through some wetland areas provide habitat for the highly rare dragonfly, zebra clubtail (*Stylurus scudderi*). Future surveys of this extensive wetland are likely to find numerous additional rare species, such as alder flycatcher (*Empidonax alnorum*, In Need of Conservation) and Nashville warbler (*Vermivora ruficapilla*, In Need of Conservation).

The northern end of South Cherry Creek Complex is owned and protected by The Nature Conservancy. Parts of the Complex have been impacted by road building associated with timbering operations and coal mining. Toxic seeps from nearby mines have severely affected sections of the wetland. However, this area's large size and topographic position in addition to a few management measures have helped to neutralize much of the past disturbances.

6. Meadow Mountain Bog North BioNet Tier: 3 Size: 327 ac

Key Wildlife Habitats and other Key Elements

- Northern Conifer – Hardwood Forest
- Mesic Deciduous Forest
- Floodplain Forest
- Bog and Fen Wetland Complex
- Forested Seepage Wetlands
- Bog Clubmoss and other rare plants
- Crimson-ringed Whiteface and other rare animals
- Core habitat for Forest Interior Dwelling Species (FIDS)

Ecological Significance

Located on the north side of Meadow Mountain, east of Deep Creek Lake, Meadow Mountain Bog North is a diverse high-elevation wetland system. This wetland is found in the headwaters of the South Cherry Creek Complex and contains numerous springs and seeps scattered within upland forest. This area supports several high quality significant or rare plant communities and thriving populations of several plant species characteristic of northern bog habitats. The Cottongrass Fen (globally rare) and Pitch Pine Peat Swamp (highly globally rare) communities are just two examples of the many that have been described for this location. The matrix of diverse habitats includes great laurel thickets and forests of pitch pine, oak, northern hardwoods, eastern hemlock, and white pine. Scattered red spruce and other conifers are remnants of an earlier conifer swamp forest. Openings in wetter areas dominated by Sphagnum moss and sedges are interspersed with shrubby areas in old beaver meadows undergoing different stages of succession. Beaver activity also provides a series of open water ponds along small streams. These areas support breeding populations of damselflies and dragonflies, including crimson-ringed whiteface (*Leucorrhinia glacialis*, highly rare) and Canada darner (*Aeshna canadensis*, rare).

The upland slopes north of this wetland complex are almost entirely forested. These plant communities are important for maintaining the water quantity and quality of the adjacent wetland. They filter nutrients and chemicals and trap excess sediments that could damage the plant life in erosive runoff events.

The forests buffering Meadow Mountain North Bog are embedded within a larger contiguous block of forest that was identified as meeting the criteria for core habitat (or highest quality habitat) for Forest Interior Dwelling Species (FIDS) based on the size and configuration of the forest. In fact, it is among the largest contiguous blocks of forest in the State. Species of Greatest Conservation Need (GCN), such as acadian flycatcher, wood thrush, and scarlet tanager are likely to nest within these forests.

The forested slopes of Meadow Mountain also provide habitat for countless wildlife species that are dispersing from breeding grounds or migrating to new areas. Movement corridors from lower elevations to higher elevations and from southern latitudes to northern latitudes will enable species to better adapt to shifting environmental conditions that are occurring as part of climate change.

7. Highest Bog **BioNet Tier: 3** **Size: 259 ac**

Key Wildlife Habitats and other Key Elements

- Northern Conifer – Hardwood Forest
- Mesic Deciduous Forest
- Floodplain Forest
- Bog and Fen Wetland Complex
- Forested Seepage Wetlands
- Bog Clubmoss and other rare plants
- Ski-tailed Emerald and other rare animals
- Core habitat for Forest Interior Dwelling Species (FIDS)

Ecological Significance

Forming the headwaters of a main tributary of Cherry Creek, flowing into Deep Creek Lake, the wetland complex of Highest Bog is compact but still ecologically significant. Although not as large as other nearby mountain peatlands at The Glades or South Cherry Creek Complex, Highest Bog is relatively secluded, undisturbed, and has excellent ecological integrity. Like nearby acidic peatland communities, this site contains an expansive mosaic of open sedge or grass dominated peatlands, and dwarf to tall shrublands; many being state or globally rare. These habitats in turn support a number of vulnerable species. In the emergent wetlands adjacent to the beaver-made ponds, bog clubmoss (*Lycopodiella inundata*, rare) is found in among the peat moss. The scattered alder dominated shrublands support species such as alder flycatcher (*Empidonax alnorum*, In Need of Conservation). And the small forested stream flowing from the western-most beaver pond provides habitat for a dragonfly called ski-tailed emerald (*Somatochlora elongata*, rare).

The upland slopes north and south of this bog are almost entirely forested. These plant communities are important for maintaining the water quantity and quality of the bog. They filter nutrients and chemicals and trap excess sediments that could damage bog vegetation in erosive runoff events.

The forests buffering Highest Bog are embedded within a larger contiguous block of forest that was identified as meeting the criteria for core habitat (or highest quality habitat) for Forest Interior Dwelling Species (FIDS) based on the size and configuration of the forest. In fact, it is among the largest contiguous blocks of forest in the State. Species of Greatest Conservation Need (GCN), such as acadian flycatcher, wood thrush, and scarlet tanager are likely to nest within these wooded slopes.

The forested slopes of Meadow Mountain also provides habitat for countless wildlife species that are dispersing from breeding grounds or migrating to new areas. Movement corridors from lower elevations to higher elevations and from southern latitudes to northern latitudes will enable species to better adapt to shifting environmental conditions that are occurring as part of climate change.

8. Meadow Mountain Run Swamp BioNet Tier: 3 Size: 604 ac

Key Wildlife Habitats and other Key Elements

- Bog and Fen Wetland Complex
- Nontidal Shrub Wetlands
- Alder Flycatcher and other rare animals
- Buxbaum's Sedge and other rare plants
- Core habitat for Forest Interior Dwelling Species (FIDS)

Ecological Significance

Meadow Mountain Run is an eastern tributary of Deep Creek Lake, and Meadow Mountain Run Swamp has formed near its headwaters. This somewhat linear wetland is a large, stream-fed, sedge and grass fen with both acidic and near neutral water influences. The wetland mosaic includes an open, emergent meadow dominated by tussock sedge, blue-joint reedgrass, and reed canarygrass. Buxbaum's sedge (*Carex buxbaumii*, Threatened) lives near the stream running through the middle of the meadow. Other areas are shrubby, especially along the wetland border. Perhaps the most unique attribute of this wetland is large areas of meadowsweet (or pipestem, *Spirea alba*), along with glade St. John's-wort and speckled alder. These shrub thickets are home to alder flycatchers (*Empidonax alnorum*, In Need of Conservation), which sing from the tops of the shrubs to attract mates and defend their territories. The mucky, wet areas around seeps harbor an abundance of Sphagnum moss.

Large snags of white pine in areas of standing water provide additional structure and wildlife habitat. The surrounding uplands include extensive white pine plantations, apparently from the Civilian Conservation Corps era, probably planted on old fields. Upland openings have cherries, hawthorns, and old apple trees among goldenrods and other wildflowers. There is a rather abrupt transition from conifer plantation to wetland around most of the edge.

The upland slopes north and east of this wetland complex are mostly forested. These plant communities are important for maintaining the water quantity and quality of the bog. They filter nutrients and chemicals and trap excess sediments that could damage bog vegetation in erosive runoff events.

The forests buffering Meadow Mountain Run Swamp are embedded within a larger contiguous block of forest that was identified as meeting the criteria for core habitat (or highest quality habitat) for Forest Interior Dwelling Species (FIDS) based on the size and configuration of the forest. In fact, it is among the largest contiguous blocks of forest in the State. Species of Greatest Conservation Need (GCN), such as acadian flycatcher, wood thrush, and scarlet tanager are likely to nest within these forests.

The forested slopes of Meadow Mountain also provide habitat for countless wildlife species that are dispersing from breeding grounds or migrating to new areas. Movement corridors from lower elevations to higher elevations and from southern latitudes to northern latitudes will enable species to better adapt to shifting environmental conditions that are occurring as part of climate change.

9. Rhodes Fields BioNet Tier: 4 Size: 77 ac

Key Wildlife Habitats and other Key Elements

- Grasslands
- Northern Harrier

Ecological Significance

Rhodes Fields is at the headwaters of an unnamed tributary to North Glade Run, which flows into Deep Creek Lake. This area consists of large, flat open expanse of hayfields adjacent to a ditched, marshy emergent and shrubby wetland along the unnamed tributary. These meadows provided habitat during the breeding season for northern harrier (*Circus cyaneus*, rare). This area also provides potential habitat for a suite of nearly ten species of grassland breeding birds that are considered Species of Greatest Conservation Need in Maryland. Many of these grassland breeding specialists are considered “area sensitive” in that they require large, contiguous grasslands and other open habitats for successful breeding. The male northern harrier defends an average breeding territory of 1 sq. mile (or 2.6 sq. km).

10. Warren’s Beech Grove BioNet Tier: 4 Size: 61 ac

Key Wildlife Habitats and other Key Elements

- Mesic Deciduous Forest
- Floodplain Forest
- Core habitat for Forest Interior Dwelling Species (FIDS)

Ecological Significance

Located along Meadow Mountain Run, this small patch of forest represents a forest type not typically seen on Savage River State Forest. It harbors a stand of very old beech trees. This site was suggested as a special area by the former State Forest manager for Savage River, Warren Groves.

Warren's Beech Grove is embedded within a large forested area that was identified as meeting the criteria for core habitat (or highest quality habitat) for Forest Interior Dwelling Species (FIDS) based on the size and configuration of the forest. In fact, it is among the largest contiguous blocks of forest in the State.

The forested corridor along Meadow Mountain also provides habitat for countless wildlife species that are dispersing from breeding grounds or migrating to new areas. Movement corridors from lower elevations to higher elevations and from southern latitudes to northern latitudes will enable species to better adapt to shifting environmental conditions that are occurring as part of climate change.

The forests along Meadow Mountain Run also are important for maintaining water quality in Deep Creek Lake downstream. These plant communities filter nutrients and chemicals and trap excess sediments that could otherwise cloud the water in erosive runoff events. Forested corridors along rivers also mediate the destructive impact of floods and storm surges.

11. Potato Farm Coves **BioNet Tier: 2** **Size: 66 ac**

Key Wildlife Habitats and other Key Elements

- Nontidal Emergent Wetlands
- Jacob's-ladder and other rare species

Ecological Significance

Nestled on the western side of Deep Creek Lake are two adjacent coves that comprise Potato Farm Coves. These coves have seasonally wet meadows that catch the drainage from relatively flat lands nearby. The open, herbaceous portion of this area is floristically diverse with flat-topped white aster and a variety of grasses and sedges, along with some scattered shrubs. Rare species living here include Jacob's-ladder (*Polemonium vanbruntiae*, Endangered) and linear-leaved willowherb (*Epilobium leptophyllum*, rare). The presence of Jacob's-ladder indicates that the water within these wetlands has a near-neutral pH, unlike the more acidic bogs and other wetlands commonly found in Garrett County. This alkalinity is caused by the Greenbrier formation, which is bedrock underlying the wet meadow and the cove that includes a band of limestone. Jacob's-ladder is important as an indicator of environmental health; its presence indicates that despite nearby roads and other landscape impacts, these disturbances are not so great as to eliminate the habitat for this Endangered plant.

These wet meadows not only provide habitat for rare plants, butterflies, and other wildlife, but they provide critical ecosystem functions, such as filtering pollutants, catching sediments from disturbed areas, and slowing surface water flows to increase groundwater infiltration. Thus the water quality within Deep Creek Lake is being protected by natural vegetated areas like Potato Farm Coves.

12. Deep Creek Spillway **BioNet Tier: 3 Size: 39 ac**

Key Wildlife Habitats and other Key Elements

- Highland Streams
- A Flatworm

Ecological Significance

Just north of the Deep Creek Lake spillway, near the edge of Deep Creek Lake, are two small streams. These first-order streams have a slow flow of clear water running over sand, gravel, pebbles, and cobbles. Rhododendrons grow along the stream banks. These streams are home to a very tiny animal called a flatworm (*Planaria dactyligera*, rare). One of the most primitive forms of animal life, this flatworm lives beneath rocks and woody debris.

13. Lower Deep Creek Complex **BioNet Tier: 1 Size: 613 ac**

Key Wildlife Habitats and other Key Elements

- Cliffs and Rock Outcrops
- Northern Conifer – Hardwood Forest
- Mesic Deciduous Forest
- Floodplain Forest
- Numerous rare plants and animals
- Core habitat for Forest Interior Dwelling Species (FIDS)

Ecological Significance

Lower Deep Creek Complex features a highly scenic and pristine section of lower Deep Creek that begins about a mile below the outflow of Deep Creek Lake and includes the area surrounding its confluence with the Youghiogheny River. Deep Creek is a high-quality trout stream situated in a moist sandstone ravine lined with large boulders, cliffs, and outcrops. The forests are dominated by mature eastern hemlock and yellow birch with dense thickets of rhododendron. Of particular significance is the presence of two rare small mammals, the southern water shrew (*Sorex palustris punctulatus*, Endangered), which is a globally vulnerable subspecies, and long-tailed shrew (*Sorex dispar*, In Need of Conservation). Additionally, within a spring seepage along Deep Creek lives a tiny crustacean called Allegheny isopod (*Caecidotea alleghenyensis*, globally imperiled), a newly described species.

An equally important feature of the Lower Deep Creek Complex is the two-mile long section of the Youghiogheny River. This remote river corridor includes extensive sandstone rock outcrops along the confluence of Deep Creek. This outcrop area contains an exceptionally large turkey vulture roost and evidence of what appears to have been one of the largest Allegheny woodrat (*Neotoma magister*, Endangered) colonies known in Maryland. Upstream from the confluence with Deer Creek is the stand of towering old trees at Swallow Falls State Park. Hugging the Youghiogheny River is Maryland's oldest grove of eastern hemlock and white pine, some of which are reported to be at least 360 years old. Wehrle's Salamander (*Plethodon wehrlei*, In Need of Conservation) and four rare birds find breeding habitat along the Youghiogheny: winter wren (*Troglodytes troglodytes*, rare), red-breasted nuthatch (*Sitta canadensis*, highly rare), golden-crowned kinglet (*Regulus satrapa*, rare) and Blackburnian warbler (*Dendroica fusca*, Threatened). The rare invertebrates documented from this significant natural area include Spruce Knob threetooth (*Triodopsis picea*, highly rare), a globally vulnerable land snail, and ocellated darner (*Boyeria grafiana*, highly rare), one of many dragonflies that patrol the Youghiogheny River in their constant search for prey and suitable breeding habitat.

The extensive area of undisturbed forest and proximity to other natural areas, especially along the Youghiogheny River, provides suitable habitat and a dispersal corridor for far-ranging, area-sensitive animals like black bear and bobcat (*Lynx rufus*, In Need of Conservation), and a variety of other forest dwelling wildlife and plants. The extensive forest in which Lower Deep Creek Complex lies was identified as meeting the criteria for core habitat for Forest Interior Dwelling Species (FIDS) based on the size and configuration of the forest. In fact, it is among the largest contiguous blocks of forest in the State.

The forested stream corridor also provides habitat for countless species that are dispersing from breeding grounds or migrating to new areas. Movement corridors from lower elevations to higher elevations and from southern latitudes to northern latitudes will enable species to better adapt to shifting environmental conditions that are occurring due to climate change.

14. Hammel Glade BioNet Tier: 1 Size: 1,534 ac

Key Wildlife Habitats and other Key Elements

- Northern Conifer – Hardwood Forest
- Mesic Deciduous Forest
- Floodplain Forest
- Bog and Fen Wetland Complex
- Forested Seepage Wetlands
- Southern Water Shrew, Alder Flycatcher, and other rare animals
- Buckbean, Yellow Avens, and other rare plants

Ecological Significance
One of the most significant wetlands in western Maryland, Hammel Glade forms the headwaters of Red Run, which flows into Deep Creek Lake. This large wetland occupies a triangular valley between Roman Nose Mountain and Hoop Pole Hill. Hammel Glade sits in a low-lying hollow, or frost pocket, that harbors more cold-adapted species than most other areas; it supports a pocket of boreal life, a relic from the last Ice Age 15,000 years ago.

Hammel Glade has a number of high-quality significant and rare wetland habitat types, including a variety of open sedge-dominated glades, shrub swamps, and forested swamps. A Red Spruce – Eastern Hemlock – Great Laurel peatland swamp (globally rare) borders the shrub swamp and open beaver meadows, of varying stages of succession, in the center of the wetland. Much of the open meadow is comprised of dense blue-joint reedgrass (*Calamagrostis canadensis*) with a patchwork mosaic of other habitat types that dot the landscape. Found along streamsides or in low-lying margins, the Lake sedge fen (*Carex lacustris* State Rare) is an indicator of underlying calcium rich substrate.

Hammel Glade is one of the most botanically diverse mountain peatland in Western Maryland, because of underlying Greenbrier formation geology that is rich in argillaceous limestone. While much of this wetland is acidic, springs originating from within the site do appear to increase the pH significantly in areas, as evidenced by the types of plants growing in patches in specific areas throughout. At least eleven rare plants have been documented here, including seven that are listed as Endangered or Threatened. Among the numerous rare plants that live here are Jacob's-ladder (*Polemonium van-bruntiae*, Endangered), yellow avens (*Geum aleppicum*, Endangered), and buckbean (*Menyanthes trifoliata*, Endangered).

Much of the central and southern portions of Hammel Glade are protected by The Nature Conservancy. However, human disturbances within the wetland and its drainage include livestock grazing, widespread timbering, commercial development along the US 219 corridor, and residential development along the other two sides, especially along Foster Road.

15. Keystone Swamp BioNet Tier: 3 Size: 57 ac

Key Wildlife Habitats and other Key Elements
- Bog and Fen Wetland Complex
- Alder Flycatcher and Small Cranberry

Ecological Significance
Keystone Swamp is at the headwaters of a small drainage into Deep Creek Lake just west of Thayerville. This wetland is a small but diverse shrubby, minerotrophic acidic fen. Dense stands of speckled alder and skunk cabbage cover the majority of the wetland. The dense alder stands provide breeding habitat for alder flycatcher (*Empidonax alnorum*, In Need of Conservation). One open area with sedges and sphagnum moss

occurs at the northern edge of the wetland. Other rare species live here, including thick mats of large cranberry (*Vaccinium macrocarpon*, watchlist) and some small cranberry (*V. oxycoccos*, Threatened). Acidic seepage springs keep the entire wetland permanently wet in most places. A few red spruce persist and the wetland edge. Although this wetland is relatively undisturbed, silt has entered the stream from human activities, such as limestone crushing and development, on the adjacent upland slopes.

16. McHenry Wetland South **BioNet Tier: 4** **Size: 6 ac**

Key Wildlife Habitats and other Key Elements

- Highland Stream
- A Flatworm

Ecological Significance

South of the town of McHenry, near the edge of Deep Creek Lake, is a small stream. This very small stream has a slow flow of clear water running over pebbles, cobbles, and pieces of wood. A few willow trees grow along its banks. This stream is home to a very tiny animal called a flatworm (*Planaria dactyligera*, rare). One of the most primitive forms of animal life, this flatworm lives beneath rocks and woody debris.

Appendix 3-C: Specific Protection Measures for Wildlife and Rare Species Habitats

Water Quality and Hydrological Protection Measures

Many of the Ecologically Significant Areas harbor rare species and habitats that are directly dependent on wetlands or aquatic systems. The following recommendations pertain to maintaining the hydrology and water quality of the rare species' habitats found throughout the watershed. Pursuing these measures regarding stormwater management, the extent and location of impervious surfaces, forest retention and sediment/erosion control is very important to the conservation of the rare species' wetland and aquatic habitats.

1. Pursue environmentally sensitive design to address stormwater runoff by promoting the use of nonstructural best management practices to the maximum extent. The goal is to mimic natural infiltration patterns across the site in order to maintain natural hydrology.
    a. Methods to pursue include the use of sheet flow to buffers, vegetated channels to convey road runoff (i.e. roadside swales), disconnection of roof and non-roof runoff, methods of bioretention such as rain gardens.
    b. Reduce impervious cover as outlined in the MDE stormwater management manual section 5.1.3.1, which is available online at their website: (http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Documents/www.mde.state.md.us/assets/document/Design%20Manual%20Chapter%205%2003%2024%202009.pdf). In addition to these methods, options to pursue include the use of shared parking/driveways and pervious materials wherever possible.
    c. Locate impervious surfaces as far as possible from permanent and intermittent streams and their floodplains.
2. In order to minimize risk of sedimentation in the aquatic and wetland habitats and to minimize changes to the hydrology of these habitats:
    a. Minimize clearing and retain forest - The limits of disturbance should be the minimum needed to build homes, allow access and provide fire protection. Conduct clearing and construction in phases in order to avoid having large areas cleared at one time. Pursue clustered development in order to allow retention of large blocks of contiguous upland forest along streams and wetlands.
    b. Stabilize soil - Stabilization should occur immediately (within 24 hours). Special effort should be made to retain fine particle silt, sand and clay sediments including the incorporation of redundant/additional control measures in the sediment and erosion control plan to ensure maximum filtration of any sediment-laden

runoff (e.g., accelerated stabilization, super silt fence instead of silt fence, etc.).
    c. Inspect frequently - All measures should be inspected daily to ensure that they are functional from the very initial stages through final construction, and any problems should be corrected immediately.
    d. Provide a minimum 100 ft undisturbed forested upland buffer to permanent and intermittent streams and nontidal wetlands.
    e. Avoid disturbing steep slopes (15% slope or greater) and areas of highly erodible soils.
3. Where instream work is unavoidable, provide adequate passage for fish, reptiles and amphibians. Further consultation with the Natural Heritage Program should be sought in order to minimize impacts from instream work in or upstream from rare species' aquatic and wetland habitats.

Potential Forest Interior Dwelling Species (FIDS) Habitat

Within the Chesapeake Bay Critical Area, habitat protection for forest interior dwelling birds is mandated through regulations authorized by the Chesapeake Bay Critical Area Law (Natural Resources Article 8-1808, Annotated Code of Maryland). The regulations require that management programs be developed to protect and conserve riparian and upland forests used for breeding by FIDS within the Critical Area. DNR strongly encourages that protection programs for FIDS be extended beyond the Critical Area. Guidelines for determining FIDS habitat and conserving these areas are found in two publications:

Bushman, E. S., and G. D. Therres. 1988. Habitat management guidelines for forest interior breeding birds of coastal Maryland. Maryland Department of Natural Resources, Wildlife Technical Publication 88-1. 50pp.

Jones, C., J. McCann, and S. McConville. 2000. A guide to the conservation of forest interior dwelling birds in the Chesapeake Bay Critical Area. Chesapeake Bay Critical Area Commission, Annapolis, Md. 58pp.

In addition, the following specific protection measures should also be considered when development projects are being evaluated for potential ecological impacts to FIDS habitat:

1. Restrict development to nonforested areas.
2. If forest loss or disturbance is unavoidable, concentrate or restrict development to the following areas:
    a. the perimeter of the forest (i.e., within 300 feet of existing forest edge)
    b. thin strips of upland forest less than 300 feet wide
    c. small, isolated forests less than 50 acres in size

   d. portions of the forest with low quality FIDS habitat, (i.e., areas that are already heavily fragmented, relatively young, exhibit low structural diversity, etc.)

3. Maximize the amount if forest “interior” (forest area >300 feet from the forest edge) within each forest tract (i.e., minimize the forest edge:area ratio). Circular forest tracts are ideal and square tracts are better than rectangular or long, linear forests.
4. Minimize forest isolation. Generally, forests that are adjacent, close to, or connected to other forests provide higher quality FIDS habitat than more isolated forests.
5. Limit forest removal to the “footprint” of houses and to that which is necessary for the placement of roads and driveways.
6. Minimize the number and length of driveways and roads.
7. Roads and driveways should be as narrow and as short as possible; preferably less than 25 and 15 feet, respectively
8. Maintain forest canopy closure over roads and driveways.
9. Maintain forest habitat up to the edges of roads and driveways; do not create or maintain mowed grassy berms.
10. Maintain or create wildlife corridors.
11. Do not remove or disturb forest habitat during April-August, the breeding season for most FIDS. This seasonal restriction may be expanded to February-August if certain early nesting FIDS (e.g., Barred Owl) are present.
12. Landscape homes with native trees, shrubs and other plants and/or encourage homeowners to do so.
13. Encourage homeowners to keep pet cats indoors or, if taken outside, kept on a leash or inside a fenced area.
14. In forested areas reserved from development, promote the development of a diverse forest understory by removing livestock from forested areas and controlling white-tailed deer populations. Do not mow the forest understory or remove woody debris and snags.
15. Afforestation efforts should target a) riparian or streamside areas that lack woody vegetative buffers, b) forested riparian areas less than 300 feet wide, and c) gaps or peninsulas of nonforested habitat within or adjacent to existing FIDS habitat.

Invasive Species

Invasive species are non-native species that cause economic and environmental problems. Invasive species have been ranked as the second greatest threat to biodiversity because many invasives can displace native species. In the United States, it is estimated that the current 50,000 non-native species cause economic losses totaling $120 billion per year. Furthermore, it has been estimated that 57% of all imperiled plant species are affected by invasive species. Common invasive species in southern MD include common reed grass (*Phragmites australis*) and virile crayfish (*Orconectes virilis*). Many times, managing established invasives is costly and time consuming. Therefore, the best way to control invasive species is by preventing invasion and through early detection and response.

Prevention BMP's

If construction or logging equipment is to be used within 500 ft of a seepage wetland, then thorough washing of equipment offsite is recommended. Only non-weedy, native species and weed-free mulch and soils should be used for landscaping and gardening and for soil stabilization. Time logging and other land disturbance to avoid the fruiting/dispersal period of any highly invasive species that are common in the immediate area in order to reduce the spread of these species. Where possible, pursue control measures for highly invasive species that occur on site during the year prior to logging or clearing in order to further minimize spread. After logging or construction, it is recommended that bare soils are revegetated with non-weedy, native species. Survey lands occasionally to see if any invasive species have colonized, and attempt to eradicate any new populations to prevent further invasion.

1. When hiking to a new area, try to clean boots and bags to get rid of hitchhiking seeds and pests.

2. Don't move firewood into new areas as it can harbor invasive wood-boring insects such as the emerald ash borer.

3. Fishermen are advised to never release live, unused bait or to transport live fish or crayfish from one body of water to another. Similarly, never dispose of aquarium plants or fish or other pets into the wild.

Management BMP's

Species-specific control measures should be implemented to manage established invasive species. Herbicide applications should be limited and only chemicals approved for wetland use should be used. Through the use of wipers and droppers, managers can apply targeted chemical applications. After invasive plants have been removed, non-weedy native vegetation should be planted in any areas with exposed soil.

Useful Links:

- ***Recommended native species to plant; MD Native Plant Society***
  http://www.mdflora.org/publications/natives2plant_lists.html
- ***Maryland Invasive Species Council (MISC)***
  http://www.mdinvasivesp.org/
- ***Plant Invaders of Mid-Atlantic Natural Areas***
  http://www.nps.gov/plants/alien/pubs/midatlantic/

- ***Rusty crayfish brochure***
  http://www.dnr.state.md.us/invasives/RustyCrayfishBrochure.pdf
- ***Virile crayfish brochure***
  http://www.dnr.state.md.us/invasives/virilecrayfish.pdf
- ***Emerald Ash Borer ID sheet***
  http://www.goodcamper.info/files/E2944.pdf

- ***Landowner's Guide to Phragmites control***
  http://www.michigan.gov/documents/deq/deq-ogl-Guide-Phragmites_204659_7.pdf
- ***Best Management Practices for Canary Reed Grass (Phalaris arundinacea* L.)**
  http://www.fws.gov/shorebirdplan/downloads/ReedCanaryGrassReport2004.pdf

Appendix 3-D: Important Key Wildlife Habitats of Deep Creek Lake Watershed

A. Bog and Fen Wetland Complexes

Description:

Bogs and fens are open seepage wetlands supporting a patchwork of saturated shrub and herbaceous vegetation. The term "bog" is actually a technical misnomer, and in strict usage applies only to peatlands that are fed by rainwater (ombrotrophic). We have adopted it here for consistency since this term is so widely used throughout much of the region to describe open, acidic seepage wetlands. In Maryland, bogs and fens are groundwater-fed (minerotrophic) and best developed on seepage slopes, along headwater streams, oxbows of streams, and margins of beaver ponds, established millponds, and sandpits. Bog soils vary from mineral to deep peat, are extremely acidic, nutrient-poor, and often support a variety of sphagnum mosses. Bogs on the Appalachian Plateau are uncommon habitats, often occurring in openings on seepage slopes and along streams bordered by forests of red spruce, eastern hemlock, white pine, larch, red maple, and black gum. Shrubs common to these habitats include speckled alder, narrow-leaved meadowsweet, mountain holly, and black chokeberry. Small openings interspersed amongst the shrub growth support dense mats of sphagnum and haircap mosses and herbaceous species such as Virginia cotton-grass, rose pogonia, round-leaved sundew, and a variety of ferns, rushes, and sedges.

Current Condition:

A significant portion of Maryland's bogs and fens have been destroyed or seriously impacted by strip mining, agricultural conversion, lake and pond construction, and development. Although the ecological dynamics of these habitats are not fully understood, many have suffered from shrub and tree succession. Factors that may have been responsible for creating and maintaining these habitats include fire, grazing, beavers, and deep deposition of unstable soils. Bog and fen habitats are most numerous in Garrett County where some of the best remaining examples are found on property owned and managed by the Nature Conservancy.

Threats and Stressors:

a. Conversion to agriculture that results in loss of habitat
b. Development and land use, including roadways, that result in fragmentation and isolation
c. Incompatible agricultural practices, such as ditching, channelization, pond construction, livestock grazing, and inadequate buffers, that result in habitat degradation
d. Hydrologic changes from residential development, agricultural practices, mining, and other impacts such as ditching, water withdrawal, and pond construction
e. Reduced water quality through chemical contamination, siltation, and pollution
f. Invasive species that result in degradation of habitat
g. Pesticide use and contamination that directly or indirectly affects plants and animals
h. Acid mine drainage

i. Incompatible silviculture practices that results in habitat degradation
j. Timber harvesting that results in loss of northern conifers (red spruce, eastern white pine, balsam fir, eastern hemlock)
k. Hemlock wooly adelgid that causes loss of eastern hemlock component
l. High deer densities resulting in overbrowsing and loss of understory plants
m. Habitat degradation by ORV's and other human disturbances
n. Altered natural disturbance patterns or lack of certain management practices
o. Acid precipitation that results in habitat degradation
p. Nontarget impacts of gypsy moth control
q. Increase in nutrients as a result of septic and stormwater runoff
r. Lack of adequate buffers in development areas

Conservation Actions:

a. Establish and maintain protected networks of bog-fen wetlands and provide sufficient landscape connectivity within an extensive forest matrix
b. Avoid or minimize timber harvesting impacts in wetland areas and surrounding forest matrix
c. Protect wetlands through acquisitions and easements
d. Incorporate wetland conservation actions into land planning efforts and public land management plans
e. Protect wetlands from drainage, ditching, filling, water withdrawal, and other damaging practices that alter hydrology
f. Work with farming community to restore and protect wetlands
g. Develop and implement protocols to control invasive species and prevent their establishment
h. Enforce and improve, as needed, nontidal wetland protection regulations, especially as it relates to Nontidal Wetlands of Special State Concern
i. Restore northern conifer component of bog wetlands
j. Prohibit ORV's in and around wetland sites
k. Limit development impacts within wetland areas and surrounding watershed
l. Minimize runoff from roads, including silt, salt and contaminants
m. Minimize and reduce habitat fragmentation
n. Manage or control livestock grazing within the wetlands
o. Strictly enforce existing federal and state wetland protection laws
p. Restore wetlands affected by acid mine drainage
q. Educate the public to reduce impacts and disturbances to wetlands
r. Implement nitrogen and phosphorus reduction strategies for septic and stormwater runoff
s. Develop and implement protocols to control deer populations to reduce browsing levels
t. Work with watershed groups, watershed-based initiatives, landowners, and federal programs to expand and coordinate wetland conservation efforts
u. Restore wetlands where appropriate
v. Implement controlled burn programs as appropriate
w. Avoid gypsy moth control in wetland areas and the surrounding forest buffer

x. Work with landowners and farming community to develop and encourage BMPs for agricultural practices
y. Work with Maryland DOT to minimize wetland impacts and explore offsite mitigation for wetland complexes

B. Northern Conifer - Hardwood Forests

Description:

This habitat comprises two sub-boreal forest types, northern conifers and northern hardwoods. In Maryland, northern conifer-hardwood forests grow primarily on the Allegheny Plateau, typically on mesic sites above 600 m, as forest ecotones bordering high elevation wetlands, along stream bottoms and north-facing slopes, and in deep ravines. In northern conifer forests, eastern hemlock, red spruce, and/or white pine is co-dominant or dominant, and often mixed with northern hardwoods. Northern hardwood forests are dominated by sugar maple, yellow birch, and black cherry. Associates include basswood, white ash, northern red oak, red maple, American beech, and northern conifers. In both forest types, common midstory and understory species include striped maple, witch hazel, maple-leaf viburnum, and frequently dense patches of great laurel and mountain laurel. The herb layer is often quite diverse, especially in less acidic soils.

Current Condition:

Most of the state's remaining northern conifer-hardwood forests occur on the Allegheny Plateau. The overall extent and quality of this habitat has been greatly diminished by logging, conversion to agriculture, strip mining and residential development. During the late 19th and early 20th centuries, logging all but eliminated most remaining tracts of old growth condition of this forest. On the Allegheny Plateau, red spruce was nearly logged out. Most of the few remaining forests containing red spruce are now confined to high elevation bog wetland systems. The extent and dominance of white pine, a highly sought after and formerly much more common tree species, has also been greatly reduced. In recent years, eastern hemlock has been impacted by infestations of hemlock wooly adelgid an accidentally introduced insect pest. Widespread declines in hemlock could have severe ripple effects on other flora and fauna dependant on hemlock-dominated forests.

Threats and Stressors:

a. Conversion to other land uses or forest types that results in loss of habitat
b. Pesticide use and contamination that directly or indirectly affects plants and animals
c. Incompatible silviculture practices that result in degradation of habitat
d. Development and land use, including roadways and trails that results in forest fragmentation and isolation
e. Deer overbrowsing or other causes that result in loss of forest structural diversity
f. Forest pest species that may have landscape level effects

g. Invasive/exotic species that result in degradation of habitat
h. Forest pests that cause loss of spruce component of forests
i. Hemlock wooly adelgid and other forest pests that cause loss of hemlock component of forests
j. Deer overbrowsing or other causes that result in loss of forest structural diversity
k. Acid precipitation that results in habitat degradation
l. Development (e.g., wind farms) on ridgetops that result in loss of habitat

Conservation Actions:

a. Maintain conifer component of forest or restore such where appropriate
b. Conserve large blocks of contiguous forest where appropriate
c. Minimize fragmentation of large, unbroken forest blocks
d. Establish and maintain landscape-scale protected habitat and movement corridors
e. Develop and implement protocols to control invasive species in a manner compatible with GCN species
f. Work through the Public Service Commission to reduce impacts of wind farms on this habitat and associated GCN species
g. Incorporate forest conservation actions into land use and land planning efforts by local, state, and federal agencies
h. Develop habitat management guidelines for use by foresters and land managers and work with them to implement such
i. Develop and implement protocols to control deer populations to reduce browsing levels
j. Implement appropriate Integrated Pest Management (IPM) practices to minimize the damage of serious forest pest species and the effects of pesticides on non-target species
k. Restore degraded habitats through appropriate techniques
l. Work with Maryland DOT to improve transportation planning for new roads to minimize fragmentation of habitat

Appendix 4: Recommended Action Strategies from DNR:

Recommendations related to Streams:

Below are management recommendations that should be implemented as part of the DCL watershed management plan (and associated strategies). Implementation of these recommendations will facilitate the preservation, enhancement and restoration of streams in the DCL watershed (and will provide direct benefits to DCL).

1. Develop and implement a comprehensive DCL stream monitoring plan with clearly defined goals and objectives. Objectives could include: the identification of areas in need of restoration (e.g., erosion issues) or protection (e.g., high quality waters) and the establishment of baseline conditions that will serve as a reference point for comparison in the future (e.g., in response to restoration or development). Monitoring components could include:
    - Stream Corridor Assessment (SCA) – SCA is stream survey method used to identify a variety of environmental problems (e.g., erosion sites, fish migration barriers, discharge pipes, riparian buffer breaks) within a watershed's stream network. SCA helps guide future monitoring, restoration and conservation efforts. For more information, see here: **http://www.dnr.state.md.us/irc/docs/00005291.pdf**
    - Synoptic Survey – collect water quality samples (focus – nutrient parameters) from all streams within the DCL watershed (just upstream of the confluence with DCL) within a very short time period prior to the growing season. Data generated from this survey will help identify streams with high (or very low) nutrient concentrations. Data will help confirm the current consensus that DCL streams do not suffer from nutrient over-enrichment. Data will help guide management actions in the streams (and their watersheds) where nutrients are an issue.
    - MBSS – implement a random design stream sampling approach (with adequate sample size) to provide an unbiased estimate of stream conditions in DCL watershed. In addition, targeted monitoring could be conducted based on previously collected data and data generated from the monitoring outlined above. For example, some Stream Waders sites have benthic IBI scores in the Good category. The MBSS program could target these streams to determine if they meet the Tier II requirements. If so, they would be afforded additional protection by MDE regulations – additional management actions could be taken to exceed existing regulations to protect these waterbodies.
2. Forested Riparian Buffers – As described above, intact riparian buffers are a vital component of watersheds and provide important ecological services. Buffers serve to protect surface and groundwater quality from impacts associated with human land uses, and provide food and habitat for an array of plants and animals (i.e., they support high biodiversity). DNR recommends that adequate forested buffers exist along all streams contained within the DCL watershed. Riparian buffer plantings can be targeted in two ways. ArcGIS could be used to identify

areas (and the extent in acres or miles) that lack adequate forested buffers. Stream Corridor Assessment results will also aid in the identification of areas that should be targeted for riparian buffer tree plantings. Planting trees in riparian areas is an excellent and relatively inexpensive way to maintain or improve stream health.

3. Address Future Growth in the DCL watershed (how and where to grow) - this should be a major charge of the DCL Impacts of Growth Subcommittee: To maintain and improve the current conditions of DCL streams (and the lake), the following steps should be implemented:
    - Provide education related to urbanization (and associated imperviousness) and other human alterations that impact aquatic resources (both streams and rivers). There is a tremendous amount of information available in the literature that should be communicated to all residents and visitors in the DCL watershed.
    - Identify and implement comprehensive best management practices to help reduce impacts of development and other anthropogenic disturbances/impacts. Note: regardless of the BMPs implemented, there will still be direct and indirect impacts to aquatic resources due to human activities. What is acceptable? Other Maryland county programs (e.g., Montgomery) could be used as models for how to control and direct development in the DCL watershed.
    - Zoning should consider development density and impervious surface thresholds – thresholds for imperviousness have been established and are presented in the literature – DNR has developed thresholds.
    - Identify and protect streams (and their associated watersheds) of better quality. This will require protecting undeveloped areas and the preservation of large tracks of forested land.
    - Prioritize stream protection over restoration.
    - Implement DNR's triage approach to prioritizing stream restoration actions. Using this approach, those streams that are moderately impaired and have the best chance for recovery are targeted first. Appendix C presents DNR's methodology for Prioritizing Streams for Protection and Restoration Based on a Triage System.

Recommendations related to Lake Water Quality:

- Continue baseline monitoring around summer season.
- Continue monitoring streamflow at USGS gage site at Cherry Creek and continue to collect water quality samples monthly and during stormflow events to help define the relationship between streamflow and nutrient and sediment concentrations so that loads of these pollutants can be determined. Long term monitoring at this site will help define trends in water quality as land use changes occur in the Cherry Creek watershed.
- Add additional stream sites for assessing nutrient and sediment loading - exploring other flow measurement approaches (e.g., Bay Trust Fund sites).

- DNR's 2009-2014 monitoring effort was designed to assess spatial and temporal condition of Deep Creek Lake. Other specific questions have been raised (monitor shallow water areas (near shore, shallow bars or transition zone) , but other than collecting data and looking for "problems", monitoring is too expensive unless clear, quantitative goals are defined.
- Define and prioritize other management questions that may be addressed by specific monitoring studies or methods. As an example, one or more continuous water quality sensors to provide real-time data that can be used to help assess short-term variability that cannot be addressed by monthly samples, and provide some basic water quality information to Park Service staff and the public. With two or more continuous water quality monitors, quantitative estimates of productivity can be made as well as special studies addressing other real-time or short-term issues, like frequency/intensity of nearshore turbidity events. Continuous measurements of water levels under different wind conditions can help determine how wind may affect water levels around the lake.

Streams in the DCL watershed are not free from human-related alterations and there are numerous anthropogenic stressors that have caused or are causing stream degradation (i.e., impacts to water quality, physical habitat, biodiversity, stream health). DNR has compiled data and information from multiple sources to summarize the historic conditions and also describe the current conditions of streams in the DCL watershed. It is important to note that although these studies provide valuable information, most are focused in select areas of the watershed, cover different time periods, and were designed to answer different management questions (as indicated by the kinds of data collected). DNR and MDE have identified the primary stressors causing stream degradation (as well as future threats). Stressor identification has come from reports generated by MDE as well as the development trends (i.e., urbanization) in the DCL watershed described in this report. As mentioned earlier, numerous scientific investigations unequivocally report severe impacts to streams due to urbanization and associated increases in impervious land cover. There are other direct and indirect stressors/threats to streams due to human activities (some of which are captured in the previous section).

Recommendations related to Rare Species and Habitats:

- Utilize Maryland's Biodiversity Conservation Network, BioNet, to prioritize Deep Creek Lake Watershed locations for terrestrial and freshwater biodiversity conservation activities and as a tool for targeting acquisitions and easements, locating appropriate areas for project mitigation or habitat restoration, and planning for areas that require special considerations to sustain declining species and habitats.

- Target overall protection efforts within the Deep Creek Lake Watershed on the BioNet tiered sites because of the ecological services they provide and the rare species and habitats they support.

- Work with Maryland DNR to institute measures to protect the 16 Ecologically Significant Areas (ESA's) that are either contained within or that overlap the Deep Creek Lake Watershed.

- Reduce forest loss and fragmentation to conserve and protect habitat for Forest Interior Dwelling Species (FIDS). Also, maintaining forest cover is one of the best ways to protect water quality within the watershed. Follow the specific protection measures and guidelines included in Appendix C.

- Protecting headwater wetlands and intermittent and perennial tributaries is vital to maintaining the hydrology and water quality of the rare species' aquatic and wetland habitats downstream. Headwater wetlands and their upland buffers regulate stream flow and maintain the hydrology and water quality of downstream wetlands and aquatic habitats, including Deep Creek Lake itself. Headwater wetlands and their upland buffers are also vital to the aquatic food chain. Specific measures pertaining to hydrological and water quality protections can be found in Appendix C.

- Protect known Wetlands of Special State Concern (WSSC) and any which are considered potential WSSC's. These wetlands are regulated by the Maryland Department of the Environment under the authority of COMAR.

- Prevent and eliminate the spread of invasive plant and animal species. Because these organisms can displace native species and reduce overall biodiversity, they present an on-going management challenge. Specific recommendations to combat these serious ecological threats can be found in Appendix C.

Recommendations to Incorporate Resiliency into Water Resources:

The following strategies, when adopted would reduce the risk of the county and the Deep Creek watershed to future water quality degradation, and increase the resilience of the built water systems in light of the increase in fall and winter precipitation already occurring. Many of these recommendations originate from a multi-stakeholder effort to increase the resiliency of Maryland's water resources.[i]

1. **The first step in assessing any risk is to determine the vulnerability of the system to increases in temperatures and fall and winter storms as well as a decrease in summer baseflows. The county is encouraged to assess the vulnerability of water infrastructure to impacts of climate change and utilize natural infrastructure such as wetlands, when possible, to address any deficits. For example, wetlands can be used to recharge groundwater, reduce downstream flooding, and in some cases store carbon. To move forward with this recommendation, the county is encouraged to:**

- Conduct water supply studies that evaluate available water supplies, and the cumulative impacts of withdrawals on the resource and other users. The County should consider using climate change scenarios to model likely impacts during the development of water plans and WREs. Doing so will benefit the county by ensuring a sustained long-term water supply and reduced costs in the future for infrastructure upgrades and costs associated with flooding.
- Evaluate the costs and benefits of updating flood hazard, topographic maps, and design manuals based on future predictions, not historical data.
  - Periodically update estimates of high water profiles based on revised rainfall data.
  - This evaluation could lead to the protection of additional natural resources such as wetlands and forests to reduce the impacts of flooding.
- Identify at-risk stream-crossings and develop maintenance and high water contingency plans. Using a 100 year flow event or a recent hurricane to assess at risk crossings is recommended.
- Given the importance of detecting changes, evaluate monitoring networks and opportunities to increase the likelihood of detecting changes in temperature, precipitation, and streamflows and develop a systematic approach to adaptation and assessment of the cumulative impacts on watersheds.

2. **During revisions and creation of codes and regulations, examine potential barriers to adaptation and adjust for projected impacts associated with altered rainfall and temperature.**

- Update codes for parking lot landscaping, perimeter site buffering, and/or open space preservation to incorporate tree canopy development, native species, xeriscaping, and integrated stormwater management.
- Incorporate energy efficiency and green infrastructure into building design standards.
- Evaluate floodplain maps in regards to sea level rise and increasing storm intensity.
- Engage in comprehensive hazards management planning and include climate change adaptation in hazards management mitigation plans, land use planning, natural resource conservation plans, development review, and community visioning.

3. **Protect natural resources and drinking water sources**

- Encourage comprehensive watershed management strategies that integrate water resource objectives with economic, environmental, cultural, and social goals.

- Implement measures to protect vulnerable drinking water sources, including implementation of source water assessments.[1] The protection and conservation of upstream forests should be evaluated.
- Restrict development and redevelopment in areas prone to significant risk from climate change to minimize future loss of human life and impacts to property. These include 500 year floodplains and roads that experience significant flooding.
- Minimize water runoff by increasing the construction of retention structures on existing properties
  - The design of green buildings and landscapes can improve the infiltration of water to recharge groundwater and can minimize runoff that results in flooding.
- Restore and protect headwater streams and ephemeral habitats
  - Headwater streams and vernal pools have been identified as some of the most vulnerable habitats in a changing climate. Efforts should be made to develop standardized field protocol and mapping efforts for these resources and to protect them through the comprehensive planning process and other regulations.
  - Small streams can be reestablished by daylighting the channels in appropriate situations to increase the infiltration and recharge of groundwater while slowing the downstream transport of water and dissolved nutrients from nonpoint sources.
- Restore and prevent the losses of wetlands to increase adaptive capacity of communities to resist the impacts of climate change. Wetlands are an essential tool for managing high water, providing flood storage capacity for overflowing streams and rivers, and precluding runoff that would occur if low-lying areas were to be developed. Designate these areas as flood storage areas on development and landuse maps.

4. Improve the resilience of water utilities

To build resilience into the water supply, the County is encouraged to:

- Evaluate the risk of current and planned infrastructure (wastewater and drinking water treatment plants, pipes, culverts) to flooding and incorporate climate change criteria and design standards into engineering codes and standards.
- Upgrade buildings, distribution systems, and other infrastructure to withstand flooding events.
- Identify backup and alternative water sources
- Develop and implement comprehensive emergency response plans for utilities and wastewater treatment plants.

[1] http://cfpub.epa.gov/safewater/sourcewater/sourcewater.cfm?action=Publications&view=filter&document_type_id=103

5. **Reduce impacts of heat on human health and aquatic ecosystems**

- Designate special heat reduction districts where data indicate that the heating of surface water temperatures may impact sensitive species. Implement design and performance standards that reduce heat and promote energy efficiency, including green/cool roofs and walls and tree plantings.
- Encourage green landscaping components, such as a set % canopy cover over parking lots.

6. **Manage water demand**

Implementing water conservation and reuse as part of a restoration strategy could buffer the potential impacts of droughts and changes in rainfall. Incorporating water conservation through the following strategies will maintain resiliency and increase water storage in the watershed.

- Adaptation approaches for water should address water conservation and reuse, both to reduce water flow through sewers and to reduce energy consumption and the impacts of drought.
- Encourage water conservation for residential and commercial users in codes and ordinances
- Identify and implement ways to reduce industrial and agricultural water use and encourage accountability for water used through irrigation.
- Use pricing strategies to decrease demand, such as incentives for water use below a baseline standard and a sliding scale fee system.
- Promote beneficial reuse of reclaimed wastewater.
- Implement comprehensive programs to reduce water leaks through detection, repair, and replacement of inadequate distribution piping.
- Encourage onsite water reuse.
- Broaden the capacity for rainwater harvesting as a supplement for local uses in watersheds and encourage the release during droughts to enhance baseflow in streams and waterways.

7. **Take climate change into account during infrastructure upgrades and repairs**

Incorporating resiliency into water infrastructure has the potential to save the County a large expense in the future, as increases in flooding and drought can overwhelm pipes. Incorporating climate impacts into infrastructure repairs can reduce long-term capital costs and prepare the County for impacts from population growth and changes in climate that the State is already experiencing.

- Develop post-disaster redevelopment plans that discourage the reconstruction of buildings and infrastructure in hazard zones following climate and weather related disasters

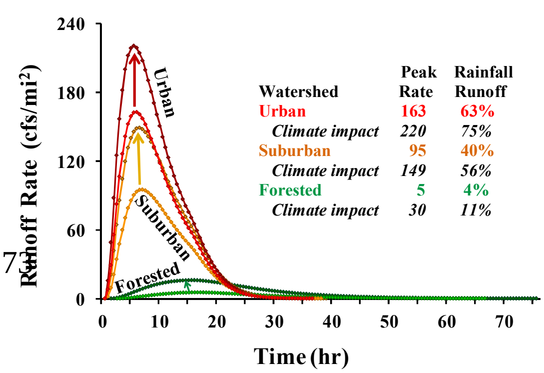
- Upgrade storm drainage systems based on climate predictions.
  - Manage systems to minimize high flow volume impacts during high storm flows.
  - Assess impacts of high flow events on sewage treatment plant process viability, and evaluate impacts of bypassing high storm flows around the treatment plant's biological processes.
  - Flood-proof vulnerable buildings and infrastructure first in the 100 year floodplain and manage for the 500 year floodplain.
  - Build capacity for drinking water quality emergency assessment and response.
- Reduce impacts on transportation infrastructure in light of altered precipitation and temperature regimes
  - Increase infiltration along all roads at appropriate locations and in medians during any construction process to reduce flooding but to also maintain structural integrity of the road.
  - Evaluate flood risk along roads and explore opportunities to increase infiltration.
  - Build roads and sidewalks from porous materials to adapt to more frequent flooding.
  - Consider sizing culverts to include a range of expected impacts of climate change on flows to reduce risks of upstream flooding and loss in built infrastructure. Efforts could incorporate recent climate data as well as account for potential increases in rainfall (e.g. include an additional 10-20% increase in rainfall in models).

8. Incorporate climate change into stormwater design principles and BMPs:

Climate change will reduce the ability to manage stormwater using current infrastructure and design systems. Based on anticipated impacts of climate change, it is reasonable to assume that pipe diameters and storage volumes will need to increase. However, other externalities and non- climate related issues must be considered as well. For example, aging infrastructure, population growth, and changing public perceptions and expectations may all impact stormwater management to an extent equal or greater than climate change.

Perhaps of greatest concern to stormwater designers is the change in rainfall intensity. Rain will probably come in more intense bursts, and changes in the peak intensity of rainfall can impact the design and storage characteristics of stormwater practices. In the comprehensive planning process, development should be reevaluated from a climate change perspective. Modeling in other eastern states suggests that climate will make runoff from suburban systems look like urban and dramatically increase runoff from urban systems.

- Examine existing design criteria and methodology in light of potential climate



change and incorporate climate change as one of several uncertainties.

- Incorporate adaptive planning and design, providing some overcapacity in at risk areas.
- Establish trigger points and sliding scales for reevaluation or design alteration.
- Encourage consultants to design for more intense storms, anticipating that the trend in Maryland is toward wetter periods in September and January and lower summer baseflows. Evaluate the impacts of rainfall intensity on bypass of stormwater BMPs and facilities and the expected impacts on TMDLs and flooding.
    - The Stormwater Management Act of 2007 requires Environmental Site Design to maximum extent practicable (ESD to the MEP). The Act states that if potentially negative downstream impacts are likely to occur, runoff from events larger than 10 year storms may need to be addressed. In addition, the County should address climate impacts in planning for downstream impacts based on the best available climate science at the time of evaluation.
    - Examine recommended BMPs for their sensitivity to climate change, their adaptation potential, and their longevity. In general, the following practices are sensitive to climate change and when implemented will increase adaptive capacity, however the county should evaluate its own practices that may be sensitive to more intense precipitation, temperature changes, or storms. This is a preliminary list, for instance urban areas are generally more sensitive to more intense precipitation. The state is in the process of assessing existing best management practices that increase a community's resiliency to climate changes:

        POTWs Standards for Discharge Permits
        Stormwater Management - Filtering Practices
        Stormwater Management - Infiltration Practices
        Urban Stream Restoration
        Urban Riparian Tree Buffers

- Site designs should, at a minimum, use conservative assumptions when designing a conveyance system and should build a certain amount of additional freeboard into drainage and overland flow path designs. The core of this should involve implementing MDE's model floodplain ordinance.
- Evaluate impacts of increased rainfall intensity on conversion of sheetflow to concentrated flow.

• Suggested improvements…

- Support upgrades/data quality of local weather monitoring (Garrett College)
- Seasonally monitor nutrients discharged through the power plant (assess nutrient mass withdrawn from the hypolimnion/lake)

- Establish a thermistor array to assess internal wave theory, define/estimate fall turnover to monitor possible post-turnover phytoplankton blooms
- Implement/evaluate assessment approach for lake shore habitat quality (fisheries focus) and define critical habitat effects from seasonal water level changes
- Establish a continuous monitoring site in the lake - linked to the Discovery Center and Internet (e.g., temperature, wind, wave, dissolved oxygen, fish-cam, buoy cam)

-

Appendix 5: Additional References

Geology/Soils:

Amsden, T.W., 1953, Geologic map of Garrett County: Baltimore, Maryland, Maryland Geological Survey, single sheet.

Banks, W.S., Davies, W.J., Gellis, A.C., LaMotte, A.E., McPherson, W.S., and Soeder, D.J., 2010, Hydrologic Data for Deep Creek Lake and Selected Tributaries, Garrett County, Maryland, 2007-08: U.S. Geological Survey Open-File Report 2010-1092, available online at **http://md.water.usgs.gov/deepcreek/**

Brezinski, D.K. and Conkwright, R., 2013, Geologic Map of Garrett, Allegany, and western Washington Counties, Maryland, Maryland Geological Survey, single sheet.

Edwards, J., 1981, A brief description of the geology of Maryland: Maryland Geological Survey, pamphlet series, 1 p.

MDE (Maryland Department of the Environment), 2002, Total Maximum Daily Load of Mercury for Deep Creek Lake, Garrett County, Maryland, Final Rpt submitted to US EPA, Region III.

MDE (Maryland Department of the Environment), 2010, Watershed report for Biological Impairment of the Deep Creek Lke Watershed in Garrrett County, Maryland: Biological Stressor Identification Analysis _Results and Interpretation, Final report submitted to US EPA, Region III

NRCS (Natural Resources Conservation Service), 1976, Soil Survey of Garrett County, MD.

Wells, D.V. and Ortt, Jr., R.A., 2011, Deep Creek Lake Sediment Study: Physical and Chemical Characteristics of Lake Sediment, Maryland Geological Survey, Coastal and Estuarine Geology Program, File Report 11-05, 46 p.

Streams:

Campbell, S. 1985. Chemical composition of precipitation and watershed samples collected at Deep Creek Lake, Garrett County, Maryland—Final Report, PPSP-AD-12. Prepared for Maryland Department of Natural Resources, Annapolis.

Davis, R.M. 1072. The affects of acid mine drainage on the water quality and benthic macroinvertebrates and fish populations in streams in Maryland. University of Maryland, Natural Resources Institute. Ref. No. 72:53.

DNR (Maryland Department of Natural Resources). 1974. The Cherry Creek-Casselman River environmental improvement plan. Report prepared for the Appalachian Regional Commission.

Ferrier, M.D. 1981. An assessment of acid inputs to Deep Creek Lake, Garrett County, Maryland – First Annual Report, PPSP-MP-37. Prepared for Maryland Department of Natural Resources, Annapolis.

Ferrier, M.D. 1984. Assessment of acid inputs to Deep Creek Lake, Garrett County, Maryland – Third Annual Report, PPSP-AD-8. Prepared for Maryland Department of Natural Resources, Annapolis.

Ferrier, M.D. and M.L. Risoldi. 1983. Assessment of acid inputs to Deep Creek Lake, Garrett County, Maryland – Second Annual Report, PPSP-AD-4. Prepared for Maryland Department of Natural Resources, Annapolis.

Ferrier, M.D., and M.J. Biedka. 1985. Assessment of acid inputs to Deep Creek Lake, Garrett County, Maryland – Fourth Annual Report, PPSP-AD-10. Prepared for Maryland Department of Natural Resources, Annapolis.

Knapp, C.M., D.G. Heimbuch, H.S. Greening, and G.J. Filbin. 1988. Maryland Synoptic Stream Chemistry Survey: Estimating the number and distribution of streams affected by or at risk from acidification, AD-88-2. Report prepared for Maryland Department of Natural Resources, Annapolis.

Morgan, R.P. II, D.M. Gates, and M.J. KIein. 1999 (revised 2000). Analysis of Cherry Creek water quality, benthic macroinvertebrates, fishes, and physical habitat. Report prepared for Maryland Department of the Environment, Baltimore.

Pavol, K. 1985. Deep Creek lake, Fisheries Survey and Management Plan. Final Report. Federal Aid in Fish Restoration, Project F-29-R, Study IV. Maryland Department of Natural Resources, Annapolis.

Pavol, K.W., A.W. Klotz, and S. Rivers. 1997. Baseline biological studies: Cherry Creek – Garrett County, Elklick Run – Garrett County, Winebrenner Run – Allegany County. Maryland Department of Natural Resources, Annapolis.

Powell, A.M. 1967. Historical information of Maryland Commission of Fisheries with some notes on game. Maryland Department of Natural Resources, Annapolis.

Primrose, N.L. 1997. Benthic Rapid Bioassessment Program: 1995-1996 stream assessments. Maryland Department of Natural Resources, Annapolis.

Roth, N.E., plus 8 co-authors. 1999. State of the streams: 1995-1997 Maryland Biological Stream Survey results. Report prepared for Maryland Department of Natural Resources, Annapolis.

Skelly and Loy. 1973. Mine drainage pollution watershed survey: Cherry Creek and Casselman River watershed, Garrett County, Maryland. Report prepared for Maryland Department of Natural Resources, Annapolis.