Water Resource Assessment

Green Mountain National Forest Plan Revision

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ABSTRACT

The Green Mountain National Forest (GMNF) Water Resource Assessment presents past and existing water resource conditions within the Forest proclamation boundary, public values and expectations relating to water resources, and water resource public issues and information needed for revision of the National Forest Land and Resource Management Plan (Forest Plan).

The assessment outlines the legal and administrative regulations and guidelines for water resource management from the 1972 Clean Water Act to the current GMNF Forest Plan direction that is the foundation for the current management of the GMNF's water resources. The past human-induced and natural disturbances that have affected the current land condition are summarized. In addition, the assessment addresses establishing Desired Future Conditions and the capabilities for comparing reference conditions to current, disturbed conditions.

An analysis of the existing aquatic ecosystem on the GMNF is important to determine the overall condition of the water resources, to assess the need for future monitoring, and for comparison to the watershed conditions in the entire state of Vermont.

The assessment addresses in detail certain public issues and questions relating to water resources. The identification of restoration areas is a very important result from the water resource assessment. Over the last decade, many projects were implemented on the GMNF to improve water quality and riparian areas by eliminating erosion and sedimentation problems, and by revegetating and stabilizing bare soil areas. There has also been many stream habitat restoration projects that appear to be benefiting macroinvertebrates and fish populations.

The GMNF will continue to use state-of-the-art methods for aquatic resource protection and restoration within a framework that includes multiple management approaches and alternatives such as passive restoration (corridor protection and riparian revegetation) and active restoration (corridor protection and in-channel improvements).

Item A. Public Values and Expectations

Introduction

The purpose of the Public Values and Expectations section is to provide an overview of the public values related to water resources on the Green Mountain National Forest (GMNF). These values can be gleaned from the Federal and Vermont State regulations/guidelines, the recommendations of town and regional plans, a summary of the comments and concerns from public meeting issue papers, and the current GMNF Forest Plan direction.

Federal and State laws, and regional and town plans reflect a range of public values regarding the role of the GMNF. These values are important because they are long-term perspectives that affect government laws and regional policy. The GMNF's issue papers from public meetings present what people value most about the national forest, and what management actions or conditions concern them.

Federal and GMNF Regulations and Guidelines

The 1972 Clean Water Act, as amended by the Water Quality Act of 1987, provides for the identification and protection of outstanding waters in every state, and is designed to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. To achieve this objective, it is the national goal to: eliminate the discharge of pollutants into navigable waters; provide water quality for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, prohibit the discharge of toxic pollutants in toxic amounts; and develop and implement programs for the control of point and nonpoint sources of pollution. Waters of the United States protected by the Clean Water Act include rivers, streams, estuaries, territorial seas, and most ponds, lakes and wetlands. Wetlands include swamps, marshes, bogs, and similar areas (U.S. EPA, 1989).

Section 404 of the Clean Water Act regulates the discharge of dredged and fill material into waters of the United States, including federally classified wetlands. Activities that are regulated under this program include: filling water bodies for development, water resource projects, such as dams and levees, infrastructure development, such as highways and airports, and wetland conversion to uplands for farming and forestry (U.S. EPA, 1999). All the wetlands on the GMNF are federally classified wetlands, regardless of size. Executive Order 11990 (1977) protects federally classified wetlands by stating that "Each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities." The National Forest Management Act includes the management requirement (36CFR 219.27(a)(4) and (e)):

> "To protect streams, streambanks, shorelines, lakes and wetlands, and other bodies of water..special attention shall be given to land and vegetation for approximately 100 feet from the edges of all perennial streams, lakes and other bodies of water. This area shall correspond to at least the recognizable area

dominated by riparian vegetation. No management practices causing detrimental changes in water temperature or chemical composition, blockages of water courses or deposits of sediment shall be permitted within these areas which seriously and adversely affect water conditions or fish habitat" (Ilhardt and Parrott, 1990:28).

This management requirement is a standard and guideline (S&G) of the GMNF forest plan in Section 4.19 A3. The GMNF's standards and guidelines for soil and water resource protection are implemented and monitored for timber sales, downhill ski areas, snowmobile trail construction/reconstruction projects, and forest roads. A monitoring study was done between 1992 and 1999 on the GMNF to better understand the effects of timber harvesting on soil, water and fisheries resources (GMNF, 2000). The study showed that the S&Gs were effective in protecting the soil, water and fishery resources and that harvest activities done according to the S&Gs had little or no effect on macroinvertebrate and fish populations, and stream turbidity.

The Federal Wild and Scenic Rivers Act protects and enhances the wild, remote, scenic, and recreational characteristics of free flowing, high-quality water streams, and surrounding lands and resources. The process to designate a Wild and Scenic River involves an inventory of candidate Wild and Scenic Rivers, and subsequent eligibility and suitability evaluations. A candidate river is eligible if it is free-flowing and possesses one or more Outstandingly Remarkable Values (ORVs). The ORVs include significant scenic, recreational, geological, fish, wildlife, historical, cultural, or ecological characteristics. On the GMNF, there are 11 eligible Wild and Scenic Rivers. In addition, the GMNF has identified and is in the process of evaluating the eligibility of 38 significant streams as potential candidates for Wild and Scenic Rivers. The purpose for the GMNF forest plan Management Prescription 9.4 is intended to protect the characteristics of the land and water resources, which may make certain sections of the 11 eligible streams and the 38 significant streams potential candidates to be included in the National Wild and Scenic Rivers System. None of the 11 eligible streams have been evaluated for suitability, and the 38 significant streams are presently being evaluated for eligibility.

<u>State of Vermont Regulations and Guidelines</u>

The State of Vermont Water Quality Policy (10 V.S.A. Chapter 47 Section 1250) is intended to:

1. Protect and enhance the quality, character and usefulness of its surface waters and to assure the public health;
2. Maintain the purity of drinking water;
3. Control the discharge of wastes to waters, prevent degradation of high quality waters, and prevent, abate or control all activities harmful to water quality;
4. Assure the maintenance of water quality necessary to sustain existing aquatic communities;
5. Provide clear, consistent and enforceable standards for the permitting and management of discharges;

6. Protect from risk and preserve in their natural state certain high-quality waters including fragile high-altitude waters, and the ecosystems they sustain;
7. Manage waters to promote a healthy and prosperous agricultural community, to increase the opportunities for use of the state's forest, parks and recreational facilities, and to allow beneficial and environmentally sound development.

It is also the state's policy over the long-term to seek to upgrade the quality of waters and to reduce existing risks to water quality.

The State of Vermont, ANR, 'Streambank and Lakeshore Vegetation Management Procedure' (VT ANR, 1996) recognizes the importance of conserving riparian vegetation adjacent to surface waters to provide benefits that include, but are not limited to: a) shading of surface water to maintain cooler summer temperatures; b) reducing soil loss, streambank and shoreline erosion, and sedimentation of aquatic habitat; c) filtering sediment, nutrients, and pollutants in runoff; and d) providing cover habitat for aquatic biota.

In 1986, Vermont adopted the Vermont Wetland Rules (10 V.S.A., Chapter 37) for the protection and management of wetlands. Wetland rules determine the level of protection for three classes of wetlands:

- Class 1 wetlands are those wetlands that, based on an evaluation of their functions, are exceptional or irreplaceable in their contribution to Vermont's natural heritage and are therefore so significant that they merit the highest level of protection with a 100 foot buffer area;
- Class 2 wetlands are those wetlands that, based on an evaluation of their functions, are so significant, either taken alone or in conjunction with other wetlands, that they merit protection with a 50 foot buffer area; and
- Class 3 wetlands are those wetlands that have not been determined to be so significant that they merit protection either because they have not been evaluated, or because when last evaluated were determined not to be sufficiently significant to merit protection (VT Water Resource Board, 2002).

The GMNF contains 240 acres of Class 2 wetlands and no acres of Class 1 wetlands. The GMNF consults with Vermont Department of Environmental Conservation (DEC) water quality specialists when there is a proposed activity, such as trail construction or skid trail crossings, near or in a wetland. When needed, the GMNF acquires a Conditional Use Determination (CUD) from the DEC for the proposed activity.

<u>The State of Vermont Water Classifications on the Forest</u>

The State of Vermont adopted new Water Quality Standards in 1999 which provide for a classification system to better manage and protect the State's water bodies. Table 1 (pages 5-8) describes the water quality standards necessary to achieve or maintain specific conditions for aquatic biota, habitat and recreational uses. A small portion of the headwater streams on the GMNF are presently Class A1, streams located above 2500 feet in elevation, and Class A2, tributaries for town water supplies. The remainder of the streams on the GMNF are presently Class B, streams with high-quality aquatic habitat.

Water Quality Division Interpretation of Water Quality Standards - November 3, 2000

Table 1. Under the Vermont Water Quality Standards, each type must be protected to the degree necessary to achieve or maintain specific conditions for aquatic biota, habitat and recreational uses. Bold type denotes text taken from the Water Quality Standards and regular type is suggested language to be used in explaining Stream Types to the public. All types in Class A and Class B waters must achieve the same level for all other criteria listed in the Standards.

Type *Management Objectives/Criteria*	**A1**	**A2**	**B1**	**B2**	**B3**
Management Objectives **Aquatic Biota**	**"Consistent with waters in their natural condition."**	**"High Quality aquatic biota"**	**"Aquatic biota[1] and wildlife sustained by high quality aquatic habitat with additional protection in those waters where these uses are sustainable at a higher level based on Water Management Type designation."**		
Criteria **Aquatic Biota** (measured by indexes of biological integrity, for fish and bugs)	**"Change from the natural condition limited to minimal impacts from human activity. Measures of biological integrity for aquatic macroinvertebrates and fish assemblages are within the range of the natural condition."** Change from the natural condition limited to minimal impacts from human activity. These waters are our waters in watersheds without significant human activities. Silvicultural practices consistent with AMP's are presumed to meet water quality standards.	**"Change from the reference condition for aquatic macroinvertebrates and fish assemblages shall not exceed moderate changes in the relative proportions of taxonomic, functional, tolerant and intolerant components[2]. All expected functional groups are present in a high quality habitat and none shall be eliminated."** Change from natural condition allowed; however, still supports a diverse community. These waters are protected for use as water supplies. There may be a reduction of biota due to flow reduction, but the remaining populations are of high quality and in the same proportions and functional groups as the reference condition.	**"Change from the reference condition for aquatic macroinvertibrates and fish assemblages shall be limited to <u>minor</u> changes in the relative proportions of taxonomic and functional components. Relative proportions of tolerant and intolerant components are within the range of the reference conditions."** Almost natural condition must be maintained. Human activities in these watersheds can be more intense than A1 waters, but of a scale that results in little change to the aquatic biota.	**"Change from the reference condition for aquatic macroinvertibrates and fish assemblages shall be limited to <u>moderate</u> changes in the relative proportions of tolerant, intolerant, taxonomic, and functional components..[3]"** Change from natural condition allowed; however, still supports a diverse community. The change in aquatic biota distribution from reference conditions is slightly more than A2 waters.	

[1]Assumed to be "high quality aquatic biota" since the criteria for B3 waters is the same as the criteria for A2 waters. Management Objectives for A2 waters are "high quality aquatic biota".

[2]This wording is different from that found in B2 and B3.

[3]Since the criteria in B2 waters is identical to that in A2 waters except that the wording which prohibits the elimination of functional groups is dropped, water quality impacts which may eliminate a functional group may be allowed.

Type Management Objectives/Criteria	**A1**	**A2**	**B1**	**B2**	**B3**
Management Objectives **Aquatic Habitat**	**"Consistent with waters in their natural condition."**	**"High quality aquatic habitat."**	**"Aquatic biota and wildlife sustained by high quality aquatic habitat with additional protection in those waters where these uses are sustainable at a higher level based on Water Management Type designation."**		
Criteria **Aquatic Habitat** (physical, chemical, and biological components of the water environment)	**"Change from the natural condition limited to minimal impacts from human activity."** **"Uses related to either the physical, chemical, or biological integrity of the aquatic habitat or the composition or life cycle functions of aquatic biota or wildlife are fully supported."** Change in the chemical composition, morphological form, or biological components from natural conditions is limited to minimal change. Only minimal fluctuations in lakes, ponds, reservoirs, and impoundments permitted. Natural flow shall not be diminished by more than 5% of 7Q10. Increases in natural flows shall not result in more than a minimal change in flow.	**"Changes in the aquatic habitat shall not exceed <u>moderate</u> differences from the reference condition consistent with the full support of all aquatic biota and wildlife uses."** High quality habitat maintained. Flow fluctuations permitted when in compliance with Agency rules or procedures or after acceptance of a site-specific flow study. Fluctuations of lakes, ponds, reservoirs, and impoundments permitted to the extent they fully support uses. Increase in natural flow regime shall not result in a change in frequency, magnitude or duration of flows adversely affecting channel integrity or prevent full support of uses.	**"Changes in the aquatic habitat shall be limited to <u>minimal</u> differences from the reference condition consistent with the full support of all aquatic biota and wildlife uses."** Almost natural condition. Flows shall not be diminished more than a minimal amount but not more than 5% of 7Q10 whenever natural flows are equal to or less than 7Q10. Increases in natural flows shall not result in more than a minimal change in flow. Only minimal fluctuations in lakes, ponds, reservoirs, and impoundments permitted.	**"Changes in the aquatic habitat shall be limited to <u>minor</u> differences from the reference condition consistent with the full support of all aquatic biota and wildlife uses."** Small change in the width of the wetted area of streams and in the physical characteristics of the stream such as water depth and velocity. Increase in natural flows regime shall not result in a change in frequency, magnitude or duration of flows adversely affecting channel integrity or prevent full support of uses. Fluctuations in water levels are permitted to the extent that uses are fully supported.	**"Changes in the aquatic habitat shall be limited to <u>moderate</u> differences from the reference condition consistent with the full support of all aquatic biota and wildlife uses. When such habitat changes are a result of hydrological modification or water level fluctuation, compliance may be determined on the basis of aquatic habitat studies**." Substantial change in the wetted area of the stream and the physical characteristics of the stream such as depth and velocity; however, change is limited by the need to maintain aquatic biota as described above. Increase in natural flows regime shall not result in a change in frequency, magnitude or duration of flows adversely affecting channel integrity or prevent full support of uses.

Type Management Objectives/Criteria	**A1**	**A2**	**B1**	**B2**	**B3**
Management Objectives **Recreation** (Boating & Fishing)	**"Highest quality as compatible with waters in their natural condition."**[4]	**"Suitable for good quality boating, and other recreational uses."**	**"Suitable for these uses with additional protection in those waters where these uses are sustainable at a higher level based on Water Management Type designation."**		
Criteria **Recreation** (Boating & Fishing)	**"Highest quality as compatible with waters in their natural condition."** Recreation of waters in their natural condition. This does not preclude management of the fishery by the Agency but does preclude artificial flows for recreation and habitat enhancements and artificial physical impediments.	**"Suitable for good quality boating, and other recreational uses."** Good quality boating, fishing, and other recreational uses. Swimming in these waters pose negligible risk of illness but this use is managed as necessary for consistency with a public water supply.	**"To the full extent naturally feasible without degradation due to artificial flow and water level management or artificial physical impediments"** Boating in the natural condition. Flow fluctuations as defined in aquatic habitat above. No artificial structures are permitted.	**"To the extent naturally feasible with no more than minor degradation due to artificial flow and water level management or artificial impediments, and with appropriate mitigation for artificial physical impediments."**[5] Water withdrawals can interfere with recreation to a minor extent: natural boating with no need for portage unless portage was naturally required (waterfalls). Boating over existing structures must be mitigated.	**"To the extent feasible, and with appropriate mitigation for artificial physical impediments."** Water-level fluctuations or dams can interfere with recreation if mitigation is adequately provided.

[4]For the recreation category in A1 and A2 waters, the language is taken from the management objectives in the Standards. For all other categories and for all Class B waters, language is taken from the water quality criteria section in the Standards.

[5]It is assumed here that existing artificial impoundments must provide mitigation.

Type Management Objectives/Criteria	**A1**	**A2**	**B1**	**B2**	**B3**
Management Objective **Aesthetics**	**"Water character, flows, water level, bed and channel characteristics, and flowing and falling waters in their natural condition."**	**"Water character flows, water level, and bed and channel characteristics consistently exhibiting excellent aesthetic value."**	**"Water character, flows, water levels, bed and channel characteristics, exhibiting good aesthetic value and, where attainable, excellent aesthetic value based on Water Management Type designation."**		
Criteria **Aesthetics**	**"Water character, flows, water level, bed and channel characteristics, and flowing and falling waters in their natural condition."**	**"Water character flows, water level, and bed and channel characteristics consistently exhibiting excellent aesthetic value."**	**"Consistently exhibit excellent aesthetic values."**	**"Consistently exhibit very good aesthetic value."**	**"Seasonal and temporal variability may be allowed provided that good aesthetic value is achieved."**
Management Objectives **Recreation** (Swimming)	**"Highest quality as compatible with waters in natural condition."**	**"Negligible risk of illness due to conditions that are a result of human activities, but managed as necessary for consistency with use as a public water supply."**	**"Suitable for swimming and other forms of water based recreation where sustained direct contact with the water occurs and, where attainable, suitable for these uses at a very low risk of illness based on Water Management Type designation."**		
Specific Restrictions	Waste management zones not permitted. On site septic systems greater than 1000 gallons not permitted.		Dams or artificial impediments not permitted.		

Regional and Town Plans

The majority of town and regional plans within the GMNF proclamation boundary mention the value of high quality water resources and the importance of their protection under the Clean Water Act and Vermont state regulations. Specific values and protection measures for towns and regional plans are listed in Appendix A (the list of town plans used is not comprehensive). Four town plans, Arlington, Shaftsbury, Pittsfield, and Manchester, specifically recommend 50 foot buffers along waterways and water bodies.

The Towns of Stratton, Wilmington, Hancock, Stamford, Jamaica, Weston, Stockbridge, and Rochester have stated the importance of maintaining water quality. The importance of maintaining and protecting riparian vegetation is acknowledged in the Towns of Landgrove, Stratton, Hancock, Stamford, Jamaica, Weston, Stockbridge, Killington, Rochester, and Pittsfield.

Issue Papers from Public Meetings

Between 1996 and 1998, the GMNF held a series of public meetings to gather comments and concerns from the public regarding management of the national forest.

The public concerns about aquatic resources and the role of water resource management on the GMNF were:

- Changes in watershed hydrology, including instream flows, stream ecology, quantity, quality and timing;
- Riparian area definition, management, and restoration;
- Recreational and timber management impacts on waterways and water bodies.

The public comments and management concerns regarding the GMNF providing fisheries habitat to sustain viable populations of species were:

- Managing for viable populations of aquatic species;
- Managing aquatic habitat;
- Implementing monitoring and restoration needs.

Current GMNF Forest Plan Direction

It is the role of the GMNF, as stated in the forest plan, "as stewards of public land for present and future generations, we must be particularly careful to maintain the productivity of the soil, to keep streams free of sediments and pollutants, and to maintain vegetative diversity and viable populations of wildlife species" (Section 4.03). The goals for resource protection are to:

> "Manage watersheds in order to protect municipal water supplies, provide adequate flood control, ensure high water quality, sufficient quantity, and benefit important fish and wildlife habitats; and supply the finest quality water that can naturally occur within the nine municipal watersheds on the GMNF while managing these 17,530 acres for multiple uses. Do not allow water quality to be

unacceptably compromised by any management activities or public uses" (Section 4.04).

The importance of high-quality water and the benefits from high-quality fish habitat is realized due to their protection from Federal and State laws. Their values are also acknowledged in protection measures of the Regional and Town Plans. The GMNF provides stewardship of the public land and management of watersheds for resource protection.

Literature Cited:

Arlington (1997) "Town Plan"

Dover (2001) "Town Plan"

GMNF (2000) "Soil, Water and Fish Monitoring on Timber Sales on the Green Mountain National Forest 1992-1999", U.S. Department of Agriculture, Forest Service.

Hancock (1992) "Town Plan"

Ilhardt, B., and Parrott, H. (1990) "Riparian Management Assessment, Eastern Region", U.S. Department of Agriculture, Forest Service.

Jamaica (2001) "Town Plan"

Killington (1999) "Killington Town Plan"

Landgrove (2001) "Town Plan"

Manchester (1997) "Town Plan"

Pittsfield (2000) "Town of Pittsfield Municipal Plan"

Rochester (1996) "Rochester Town Plan"

Stamford (1998) "Town Plan"

Stockbridge (1998) "Resolution of the Board of Selectmen of the Town of Stockbridge"

Stratton (1998) "Stratton Town Plan"

University of Vermont Extension System (1990) "Wetlands Rules and Regulations: What they mean to your logging operation in Vermont".

U.S. Environmental Protection Agency (1989) "Highlights of Section 404: Federal Regulatory Program to Protect the Waters of the United States", U.S. EPA Office of Wetlands Protection.

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Vermont Agency of Natural Resources (1996) "Streambank and Lakeshore Vegetation Management Procedure".

Vermont Resources Board (2001) "Vermont Wetland Rules".

Vermont Water Quality Standards (2000)

Weston (2001) “Weston Town Plan”

Wilmington (1998) “Wilmington Town Plan”

Appendix A: Town Plan water resource values and protection measures.

Township	Provides recognition that a rich and varied natural resource base is an asset	Outlines strategies for protection of water resources	States importance of maintaining water quality	Provides buffer distances along waterways and water bodies	Addresses development concerns on sensitive landscapes	Provides for maintenance and protection of riparian vegetation	Protects wetlands, floodplains, and groundwater
Arlington	X	X		X			
Dover	X	X					X
Glastenbury				X			
Hancock	X	X	X		X	X	X
Jamaica	X	X	X		X	X	X
Killington						X	X
Landgrove					X	X	X
Manchester	X	X		X			
Pittsfield		X		X	X	X	X
Rochester		X	X			X	
Shaftsbury				X			
Stamford	X	X	X		X	X	X
Stockbridge	X	X	X			X	X
Stratton	X	X	X			X	X
Weston			X			X	
Wilmington	X		X				X

Item B. Reference Conditions

Introduction

The purpose of the Reference Conditions Section is to provide: a definition of reference condition, an overview of past disturbances, both human-induced (anthropogenic) and natural, and a review of the effects of past disturbances on the water resources.

Landforms at the surface of the earth reflect a delicate balance between forces acting to uplift the landscape and forces acting to wear down the landscape. Equilibrium conditions occur when the force of erosive agents, including water, wind, or ice are balanced by the resistance of the land surface (Leopold et al., 1992). Geomorphic theory holds that landscape change and the evolution of landforms results during deviations from this state of equilibrium (Ritter et al., 1995). Human activity can contribute to such deviations through alteration of the land surface resistance to erosion. Agricultural and forestry practices, including removal of soil-stabilizing vegetation, road building, urban development, and damming of waterways are just a few of the human activities that can affect the balance of landform shaping processes.

> "Over the last 300 years, the bedrock of Vermont's mountains and valleys has endured, unchanging, while the landscape upon it has been in constant and fascinating flux. With the turning of the centuries, hillsides have gone from thickly forested, to open and cleared, and back again to forested. Generation by generation, there have been the additions – and subtractions – of roads and bridges and dams, homes and churches and factories, farms and villages and cities" (Albers, 2000:8).

The acknowledgement of these processes helps in learning strategies "for the sustainable restoration and management of both aquatic systems and riparian forests" and to acquire the knowledge "to be able to read the land and read the river" (Verry, et al., 2000:19).

Definition

Reference condition is a natural area that has experienced the least impact from anthropogenic disturbances. Reference conditions can be used for establishing Desired Future Conditions (DFCs) and for comparison to current, disturbed conditions. Understanding the reference condition and realizing how past land-use has affected the current land condition is very important to land managers.

As Jan Albers states in her book, *Hands on the Land*:

> "A history of the landscape is the story of how different cultures saw fit to alter the earth to meet their needs, express their beliefs, and satisfy their whims. While geography, biology, and climate will all be major characters, the heart of a landscape history is how human cultures take physical form on the land" (Albers, 2000:14).

Human-induced Disturbances

With settlement early in the 18th century, increased logging activities promoted a drying effect on the local water supplies. Many small streams dried up, leaving many mills useless. The drying effect however had a positive impact for farmers because the bogs and large swamps became fertile agricultural land (Albers, 2000:120). These changes occurred within two to three years of clear-cutting (Albers, 2000). By the late 1700s, growth in most of Vermont had been fast, with agricultural ditching, stream snagging and boulder clearing, and mill dams and diversions. The landscape resulted in nutrient-depleted soil, dry mountain streams, wood smoke pollution, and sewage and industrial chemical pollution dumped into adjacent streams. In the early 1800s, the forested Vermont wilderness and its many native sounds had been replaced with the sounds of human settlement (Albers, 2000).

The development of Vermont's landscape progressed through intensive agricultural use, to farm abandonment, to a period of natural forest succession and then to active forest management (Foster and O'Keefe, 2000). As the forests revegetated, clearcut logging became wide-spread. Streams were used to transport huge quantities of logs. Log transportation was a major factor in river widening, loss of sinuosity, and loss of habitat (Verry, et al., 2000). The introduction of the railroad in the mid-1800s lessened the need for log transportation in the streams, but the railroad encouraged a negative view of rivers as being obstacles that needed "to be bridged, straightened, or used to lay track in" (Verry, et al., 2000:2). As transportation problems were alleviated with the building of new roads, the Champlain canal, and the railroad, "Vermont's soils, natural resources and commercial energies" had all been depressed (Albers, 2000:171).

George Perkins Marsh was the first to speak for land and water conservation in the late 1800s in his book, *Man and Nature* (Verry, et al., 2000). Marsh examined the many ways man had altered the natural world by clear-cutting trees, which led to climate warming, soil erosion, and cycles of flash flood and drought in mountain streams (Albers, 2000). Many towns in Vermont began asking the state legislature to develop hunting and fishing regulations because the seemingly bottomless supply of animals in the woods was disappearing. Fish restocking of local streams occurred in several towns.

Streams were further altered by channelization and straightening, dredging, and loss of access to their floodplains, in many cases. Straightened streams and the land use expectations they engendered led to massive post-flood channelization projects in Vermont. While there is still public concern for maintaining historic "channel works," there is a growing interest in balancing these concerns with the desire to restore the geomorphic equilibrium and ecological function in Vermont streams. More recently, projects using natural channel design techniques have been used to restore channel form, dimension, and profile to streams impacted by channelization and straightening. Many people believe this is a better alternative for stream restoration projects. Restoring the natural sinuosity of a stream that has been channelized has been shown to decrease the sediment load and the volume of water transported through the stream channel, adding stability to the stream (Dunne and Leopold, 1998).

Another human-induced disturbance, besides agricultural and forestry practices, road building, urban development, and damming of waterways, is acid deposition. Acid deposition is the input of acids from the atmosphere, generally associated with the burning of fossil fuels, onto the earth's surface (Hubbard Brook, 2000). Acid deposition impairs the water quality of lakes and streams in three ways:

- lowers pH levels by increasing the acidity,
- decreases the acid-neutralizing capacity,
- increases aluminum concentrations.

Species diversity and the abundance of aquatic life have been reduced because of the increased acidity and aluminum concentrations resulting from acid deposition (Hubbard Brook, 2000). Many streams and some ponds on the GMNF have shown evidence of being impaired due to acid deposition. For example, Branch Pond Brook, Lye Brook, Bourn Brook, Bickford Hollow Brook, Lamb Brook, Skylight Pond, and Stratton Pond have all shown negative effects of acid deposition.

Natural Disturbances

Natural disturbances, such as forest fires and hurricanes, affect the landscape through removal of large numbers of trees. In the case of a hurricane, the large volume of rainfall that occurs increases the rate of soil erosion and the number of trees entering a stream (large woody debris). The increase in soil erosion adds sediment into the streams which can be detrimental to fish habitat and aquatic species survival. In 1938, a hurricane with winds exceeding 100 mph and torrential rain, traveled from Long Island, up the Connecticut River Valley into Northwest Vermont (Foster and O'Keefe, 2000). Approximately 70 % of the standing volume of timber, which was a small amount due to prior extensive land clearing, was wind-thrown. Research of major storms has documented that severe hurricanes occur in New England every 50 to 150 years (Verry, et al., 2000).

Forest fires remove understory vegetation, and can cause the soil surface to crust, preventing rainfall from soaking into the ground, and consequently increasing run-off into the streams. Floods resulting from forest fires and hurricanes had an impact on the landscape of Vermont.

The November 1927 flood is the largest flood of record for Vermont. Many towns, especially in the north central part of the state, had water-depths up to 15 feet deep. A September 1938 flood occurred in the same area of the 1927 flood and it was recorded to be greater than the 100-year recurrence interval flood. Other major floods recorded to be greater than the 50-year recurrence interval flood occurred in Vermont in March of 1936, and summer of 1973, and 1998. Spring 1976, and 1987 floods are recorded to be 10-year recurrence interval floods (Donna and King, 2001). Floods of these magnitudes can result in stream channel relocations and landslides. The floods of 1927 and 1938 (and others) were so damaging because these "natural disturbances" occurred on a human-altered landscape. When natural disturbances occur to completely forested watersheds that do not contain hundreds of mill dams, diversions, sediment loaded and channelized

streams, the effects may be very different than when the "buffering" capacity of the watershed has been so altered or removed completely.

Due to high flow events, the introduction of large woody debris into the stream channel from landslides and bank undercutting has, in the past and present, triggered many stream cleaning projects, which involved removing all the woody debris from the stream channel. Only in the past thirty years has it become apparent that large woody debris in streams is beneficial to aquatic habitats (Verry, et.al, 2000). Large woody debris in a stream encourages the formation of pools and stream bottom scouring, provides cover and isolation for many species, and influences stream velocity, channel shape, sediment deposition, and routing (Verry, et.al, 2000).

Reference Condition

The Vermont Agency of Natural Resources has developed Stream Geomorphic Assessment protocols to provide an overview of the general physical characteristics of a watershed, and to quantify physical channel form and processes in detail on stable "reference reaches." The reference condition reaches are stable (equilibrium) areas of streams that have good riparian buffers on both sides, and coarse sediments, large woody debris, and channel geometry features that give structure to the stream (VT ANR, 2003). These stable reference sites are used as a guide for what geomorphically unstable reaches will look like as they evolve back to equilibrium conditions.

The streams on the GMNF that have been surveyed and are being evaluated to determine if they are suitable to be classified as state reference condition stream reaches are:

Surveyed in 1999
- Michigan Branch of Tweed River
- Deer Hollow Brook
- Hancock Branch
- Robbins Branch
- South Branch Middlebury River

Surveyed in 2000
- Hancock Branch
- Utley Brook
- Mad Tom Brook
- Jones Brook
- Jenny Coolidge Brook

Surveyed in 2001
- Goshen West Brook – 2 monitoring sites
- Corporation Brook
- Hale Brook - 2 monitoring sites
- West Branch White – 2 monitoring sites
- Bingo Brook
- Brandon Brook – 2 monitoring sites

Surveyed in 2002

Steam Mill Brook
Sucker Brook – 2 monitoring sites
Clark Brook

Surveyed in 2003

Pussnkill Brook
Dutton Brook
Chittenden Brook
Brandon Brook

Currently, none of the streams have been selected as reference condition streams because the data has not yet been totally evaluated.

The GMNF is using land use management strategies to maintain and improve the ecological integrity (composition, sediment transport and storage, diversity of habitats, stream complexity, and vegetated riparian zones) of the National Forest's streams. Because water quality recovers faster than aquatic habitat conditions, macroinvertebrates, one of the State of Vermont's indicator species for the health of streams, have shown very good biotic indexes in the measurement of water quality. However, the fluvial geomorphology and aquatic habitat of the streams are generally not as good, as some streams, in response to the disturbances described above, are deepening, widening, shallowing, and warming, causing negative impacts on fish habitat.

There are several factors that characterize a reference condition, and they all have to be considered. These factors have been defined as ecological functions by the U.S. Army Corps of Engineers (Fischenich, 2003) and include:

Stream Dynamics involving stream evolution processes, energy management, and riparian succession

Hydrologic Balance involving water storage processes, surface/subsurface water exchange, seasonal flow condition (hydrodynamic character)

Sediment Processes involving sediment continuity, substrate and structural processes, and quantity and quality of sediment

Biological Support involving biological communities and processes, necessary habitats for all life cycles, and trophic structures and processes

Chemical Processes and Pathways involving water and soil quality, chemical processes and nutrient cycles and landscape pathways

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Item C. Existing Aquatic Ecosystem Condition

Introduction

The purpose of the Existing Aquatic Ecosystem Condition section is to provide an overview of the current status of:

- water quality,
- aquatic biota,
- stream habitat,
- riparian area,
- habitat restoration,
- other human influences,
- fluvial geomorphology,
- special river designation,
- watershed assessment,

A complete look at the existing aquatic ecosystem on the GMNF is a vast undertaking to compile and, once compiled, to comprehend and understand. It is important to look at the overall condition of the aquatic ecosystem and to assess the need for future monitoring.

Monitoring natural resources involves an inventory of present conditions, subsequent identification of problem areas, and a determination of the best method of monitoring to track changes over time for better management and decision-making in the future. Baseline data is the valuable result of monitoring an area for the first time. Future monitoring can then be compared to the baseline to analyze the dynamic processes occurring in a study area.

Water Quality

The headwaters of many streams and rivers are located on the GMNF where the streams have steep slopes, narrow stream beds with large boulders, and dense, forested riparian area vegetation. The majority of lakes and ponds on the GMNF are located at mid to high elevations, in a forest setting, with a mix of coniferous and deciduous forested vegetation. The overall condition of the water quality on the GMNF is good. A major concern affecting the water quality on the GMNF is acid-deposition, which is being monitored and analyzed very closely in select areas. Some streams are very acidic with low productivity (fish and invertebrate population abundance), while other streams are high in productivity. Many streams, however, have never been tested for water quality parameters and have never been monitored.

Although water quality is good on the forest, there is a need for improving aquatic habitat. Water quality recovers faster than aquatic habitat conditions. Macroinvertebrate communities, a State of Vermont indicator for water quality and the health of streams, are very good in the biotic indexes, but the geomorphology and habitat of the streams are generally not as good. Some streams have lost floodplain and riparian connection

(through deepening), have widened, and have become more shallow, and warm, which is not good for fish and other aquatic communities.

Lakes and Ponds:

The majority of lakes and ponds on the Forest are located on the Manchester District, in the southern half of the Forest. They are generally found at higher elevations including several in designated wilderness areas. The major concern with water quality in these ponds is acid deposition, which has been monitored annually by Vermont Agency of Natural Resources (VTANR) since the inception of the United States Environmental Protection Agency's (USEPA) acid rain program in the 1980s. For example, Branch and Bourne Ponds have been monitored since 1981 and 1982, respectively. Both ponds have acidified due to acid deposition. However, the ponds contain high levels of dissolved organic matter that gives the water a tea "stained" color. These dissolved organic compounds can bind to dissolved aluminum and reduce toxicity to fish and invertebrates. In contrast, clear water acid ponds are more likely to be characterized by toxic levels of free aluminum which adversely affects aquatic biota.

The current management strategy is to continue monitoring the ponds on a regular basis to determine water quality trends. This work is primarily conducted by VTANR with assistance from GMNF, Forest Service Research and the Vermont Monitoring Cooperative. Over the years, there has been limited discussion about treating acidified ponds with an acid neutralizing material such as limestone, which has been done in neighboring New York State's Adirondack Mountains. But to date, Federal and State Agencies have not pursued this course of action.

Other ponds on the Forest exhibit greater buffering capacity because of higher alkalinity in surrounding soils. One such pond is Wallingford Pond, which has been monitored since 1988, and has been shown to be less sensitive, although still susceptible, to acidification in comparison to other high elevation ponds previously described.

There have been other observed water quality concerns at various times in GMNF ponds. For example, an annual algae bloom occurs at Stratton Pond. Monitoring data collected in 1997 indicated the pond was in a transitional state and had likely experienced an increase level of nutrients from an unknown source. Currently, a monitoring program is in place to track phosphorous loading in five inlet streams and one outlet during the summer recreational use period.

Rivers and Streams:

Diverse bedrock types underlie the GMNF. Bedrock ranges from calcium-rich to acid, producing wide variations in water pH, alkalinity, and biologic aquatic communities. Surficial geologic deposits are also diverse, ranging from glacial till, to glacial outwash (sediments deposited by moving water) and lacustrine (sediments deposited in lakebeds). These deposits directly influence stream characteristics such as channel configuration and location.

Overall, water quality in GMNF streams is good. Some streams have relatively low productivity due to them being very acidic, while other streams are more productive because of some buffering capacity. Generally, the headwater streams on the GMNF have higher levels of aluminum, lower levels of base cations, and lower pH primarily due to the type of bedrock and higher precipitation levels. The valley bottom streams on the Forest tend to have lower levels of aluminum, and increased levels of base cations and pH. It is also well documented that GMNF and other Vermont streams experience a reduction of pH, alkalinity, and calcium during spring runoff in mid to late April. Streams such as Bourn and Branch Pond brooks tend to have higher concentrations of aluminum and lower concentrations of base cations. These streams will continue to be monitored because of the "'flashy' nature of their discharge and the resultant effects on water chemistry" (VTANR, 1994:16).

Although most perennial streams have had some level of water quality sampling performed in them over the past 20 years, there are many small unnamed and intermittent streams that have never been sampled. Most of these smaller tributaries are located in the headwater areas of Forest watersheds. At the sites adjacent to active or completed timber sales that have been monitored for the past ten years by VTANR, GMNF streams continue to show improvements in water quality based on turbidity, chemistry and macroinvertebrate (organisms without a spine that live in the stream bed) sampling results. This is an expected outcome from a maturing forest with good riparian habitat, which is the case throughout much of the Forest. It also indicates Forest management practices, such as timber sales, are being conducted in a manner that maintains water quality. Other management practices, such as eliminating erosion and sedimentation problems, and revegetating and stabilizing bare soil areas, improve water quality conditions. This is demonstrated by VTANR monitoring results where macroinvetebrate index ratings (indicator species) are relatively high overall for GMNF streams.

The VTANR is also recommending GMNF streams receive upgraded status under a recent proposal to re-classify streams in the State of Vermont. In addition, monitoring by Forest soil, water, air and fisheries specialists at timber sales over the past 10 years have also concluded that water quality can be maintained and improved in conjunction with implementation of forest management and recreation projects.

Other examples of water quality and biomonitoring results over the past five years include stream sampling in 1997, 1999 and 2000 for macroinvertebrate biomonitoring (VTANR , 1999, 2000)

1997 Results*:*
Lamb Brook, Austin Brook, Bear Wallow Brook, and upper Baker Brook rated in good or excellent condition over the three to four year monitoring period. All four stream sites' biometrics remained relatively stable and represent reference level background conditions.

1999 Results*:*
Several GMNF streams were severely affected by a devastating flood that occurred in June and July 1998. Macroinvertebrate populations in Austin and Bear Wallow Brooks have fully recovered from this devastating flood, evident in the density, richness, and Ephemeroptera-Plecoptera-Trichoptera (EPT) species observed following the flood in comparison to those of previous years.

Bingo Brook was also found to have a good-excellent biological integrity rating. Smith Brook was sampled before and after Hurricane Floyd and was found to be unaffected by the high water event. The stability of the Smith Brook macroinvertebrate community was probably due, in part, to its nearly completely forested watershed and excellent riparian zone habitat condition. "This stream represents an exceptional example of a small high elevation stream in Vermont" (VTANR , 1999:3). Howe Brook was very low in species density, and rated fair-good. The community integrity is highly threatened by habitat sedimentation, which may have been due to a nearby local road. Howe Brook is not on national forest land, but is in a watershed that crosses the GMNF proclamation boundary.

2000 Results*:*
Smith Brook had a biological community rating of excellent and continues to be at or above the median values for reference streams. The biological community in Bingo Brook rated excellent. The habitat sedimentation problem in Howe Brook improved, which resulted in a greater density number of macroinvertebrates and a decrease in the percent of sand in the substrate. The decrease in the percent of sand could be due to Hurricane Floyd flushing the streambed in 1999. Howe Brook's rating was upgraded to good. The West Branch of the Tweed River was sampled for the first time in 2000 and rated very good.

Numerous ponds and stream sections within the proclamation boundary of the GMNF were classified as "impaired" by the VTANR and USEPA (see Table 1 below). Those water bodies found on national forest land had problems directly associated with acid deposition. This suggests that Green Mountain National Forest management did not contribute to water quality problems and that the source of the pollution is emissions from distant facilities. Other stream sections outside national forest ownership had water quality problems more readily linked to specific local problems such as low flows, excessive erosion, or toxic substances.

The acid deposition problem in Vermont, and in New England, is responsible for acidification of lakes and streams to the point of rendering some of them incapable of supporting aquatic life. In addition, the acid deposition may: impair visibility in our national forest, cause respiratory problems in people, and degrade monuments and buildings. Through efforts by the EPA's Acid Rain Program, sulfur dioxide emissions are declining and nitrogen oxide emissions are level (EPA, 1999). The Lye Brook Wilderness Area, on national forest land, is a monitoring site for the Interagency Monitoring of Protected Visual Environments (IMPROVE) network. Lye Brook Wilderness has shown slight improvements in visibility in the 1993 –1995 IMPROVE

monitoring data. Improvements have occurred, but there is still much work to be done to totally eliminate the harmful effect of acid deposition on New Englands' rivers, lakes, and forests.

Downhill ski areas are another potentially significant anthropogenic impact. The annual monitoring of national forest lands at Sugarbush, Mount Snow, and Bromley Ski Areas normally show only minor erosion and sedimentation concerns, which are promptly corrected. In 1998, the State of Vermont classified two streams at Sugarbush and one stream at Mount Snow as impaired due to land use in the base area and on adjacent private lands. At Sugarbush, impaired stream sections of Clay Brook are on private land, and of Rice Brook are along the Forest boundary. We have been working with these ski areas to evaluate and seek long-term solutions to these complex water impairment problems.

Table 1: The impaired waters of the GMNF in watersheds that cross the proclamation boundary of the GMNF.

Draft Total Maximum Daily Load (TMDL) Development (VT DEC Water Quality Division, 2003)) (See Figure 1 and 1A)			
Stream/Pond Name	**Miles**	**Watershed Name**	**Water Quality Problem[1]**
Sucker Brook *	0.2	**Otter Creek**	low dissolved oxygen (DO)
Middlebury River	2.0		agricultural runoff
Otter Creek	4.0		agricultural runoff
Moon Brook	2.3		erosion/urban runoff
Big Mud Pond *			acid deposition
Griffith Lake *			acid deposition
Little Mud Pond *			acid deposition
Long Hole Pond *			acid deposition
Gilmore Pond *		**New Haven River**	acid deposition
North Pond *			acid deposition
Rice Brook *	1.3	**Mad River**	sediment
Clay Brook *	0.1		iron/sediment
Folsom Brook	4.1		pathogens
East Branch Roaring Brook	0.5	**Ottauquechee River**	erosion/road runoff
Roaring Brook	1.5		erosion/road runoff
Lye Brook *	4.9	**Batten Kill**	acid deposition
Branch Pond Brook *	3.1		acid deposition
Bourn Pond *			acid deposition
Lye Brook Meadow North *			acid deposition
Lye Brook Meadow South *			acid deposition

Branch Pond *			acid deposition
Styles Brook *	2.0	**West River**	sediment
West River	5.2		sediment
North Branch Ball Mountain Brook	4.4		manganese
Ball Mountain. Brook	10.2		acid deposition
Tributary #1, North Branch Ball Mountain Brook *	3.43		sediment
Moses Pond *			acid deposition
Stratton Pond *			acid deposition
Little Pond *			acid deposition
Forester Pond			acid deposition
Hoosic River	7.4	**Hoosic River**	polychlorinated biphenyls (PCBs)
East Branch Deerfield River	5.7	**Deerfield River**	acid deposition
Deerfield River	4.6		acid deposition
No. Branch Deerfield River	0.2		sediment
Iron Stream	0.3		iron
Stamford Pond *			acid deposition
Somerset Reservoir			acid deposition /mercury
Grout Pond *			acid deposition /mercury
Haystack Pond			acid deposition
Adams Reservoir			acid deposition
Howe Pond			acid deposition

[1]Based on field work and monitoring, none of these problems appear to be directly related to USFS management activities.

*Located on National Forest land.

Table 2: The problem waters of the GMNF as determined by Macroinvertebrate Community Metrics

(VT DEC Biomonitoring, 2002 and VT DEC, 2000)		
Stream Name	**Assessment**	**Community Threats**
Branch Pond Brook	impaired	pH, low alkalinity, acid deposition
Lye Brook	impaired	pH, low alkalinity, acid deposition

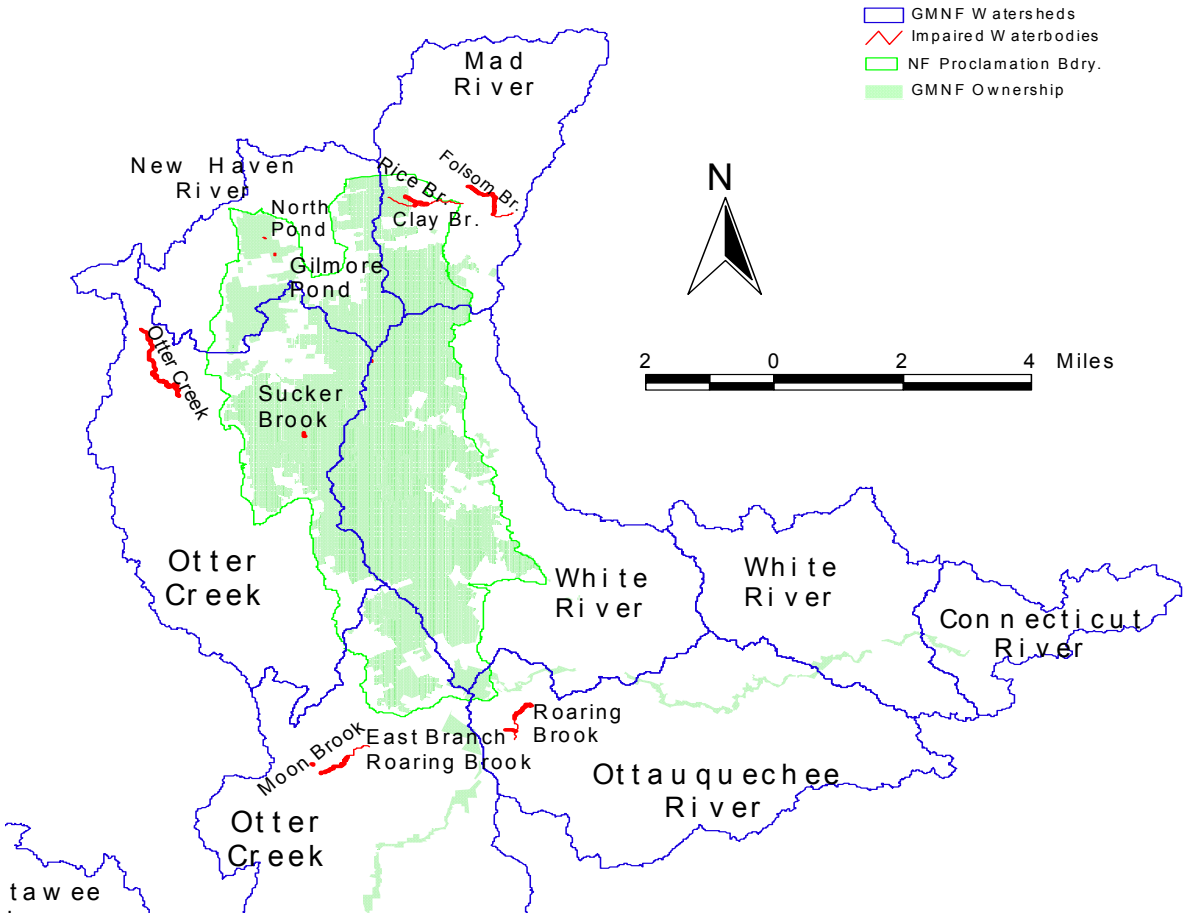

Figure 1: Impaired water bodies in the north half watersheds that cross the GMNF proclamation boundary

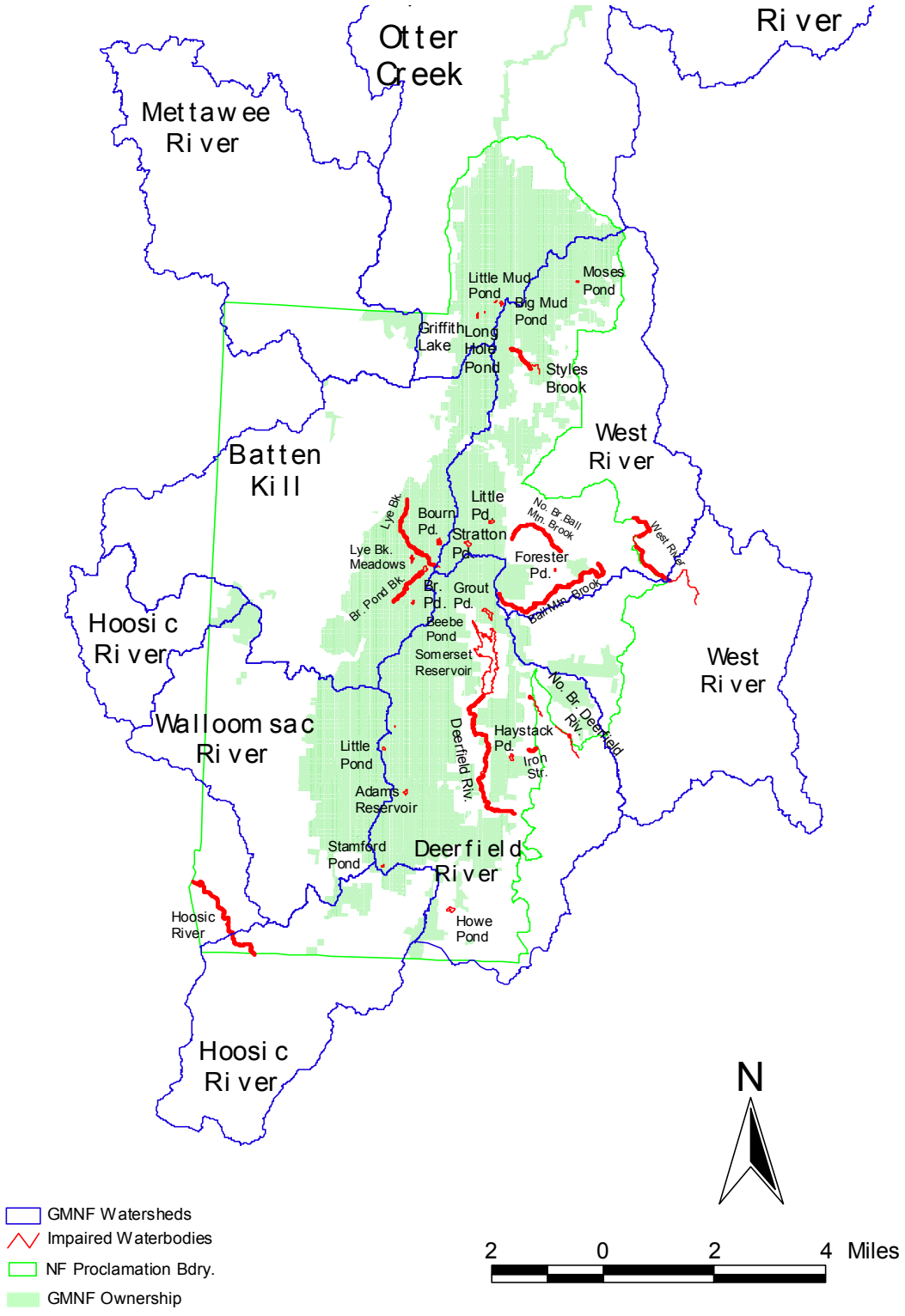

Figure 1A: Impaired water bodies in the south half watersheds that cross the GMNF proclamation boundary

Aquatic Biota

In 1989, the GMNF amended the forest plan (Amendment #6) to provide fisheries management direction, particularly for restoration of anadromous Atlantic salmon, Brook trout and other native inland fish species. The amendment called for the Forest Service to determine existing habitat capability and identify limiting factors for these fish in GMNF waters. It also provided standards and guidelines designed to afford riparian and stream habitat protection in those areas of the GMNF where timber harvesting, silviculture practices (includes activities such as: tree planting, site preparation, timber stand improvement, timber harvesting), and recreation uses occur. Long-term direction was provided to maintain, enhance and restore spawning and rearing habitat used by native fish species and other aquatic organisms, and provide for recovery of streamside riparian habitat for improving stream temperatures and habitat conditions.

There appears to be a notable distinction between water quality, and channel morphology and habitat in terms of their rates of recovery. Physical habitat conditions have not improved as rapidly as water quality has in most GMNF streams. Stream buffers for filtering pollution and canopy cover for thermal benefits have likely contributed to accelerating water quality improvements. However, stream habitat recovery relies in part to the input of trees and large woody debris (LWD) from riparian areas. The length of time it takes riparian forests to mature, die, and fall apart, and have that wood fall into the stream, is longer than that needed for water quality recovery. It is estimated that full recovery of this riparian area function is many decades away. However, current forest management direction provides the basis for recovery of riparian forest and a long-term source of woody debris to restore channel morphology and stability and habitat diversity. As reforestation has been key to restoring base flows in streams, the return of wood to streams will benefit the watershed by increasing the sediment storage and reducing the large sediment discharges that deposit and contribute to instability in downstream valley locations.

The GMNF is involved in the restoration of Atlantic salmon to Forest streams including the enhancement of stream habitat. Restoration is conducted in cooperation with Vermont Department of Fish and Wildlife (VDFW), Vermont Department of Environmental Conservation (VTDEC), United States Fish and Wildlife Service (USFWS), numerous partner organizations, and volunteers under the guidance of the Connecticut River Atlantic Salmon Commission. The GMNF staff stocks approximately 600,000 to 800,000 salmon fry annually into 18 streams (White River and West River watersheds) on, and adjacent to, GMNF lands. Monitoring salmon populations and their habitat in GMNF streams is also an on-going activity. Annual observations have indicated that there is considerable variability in survival of salmon from year to year based on numerous biotic and abiotic factors (eg. floods, drought, predation). Figure 2 shows the 10 year trend for juvenile salmon populations in GMNF streams. It is unclear if this represents an actual decline or is simply within the expected range of variation in juvenile salmon abundance. Biologists expect this figure to fluctuate in future years. GMNF monitoring has shown that national forests streams can support salmon

populations and produce young salmon "smolts" that emigrate from headwater streams to the Atlantic Ocean.

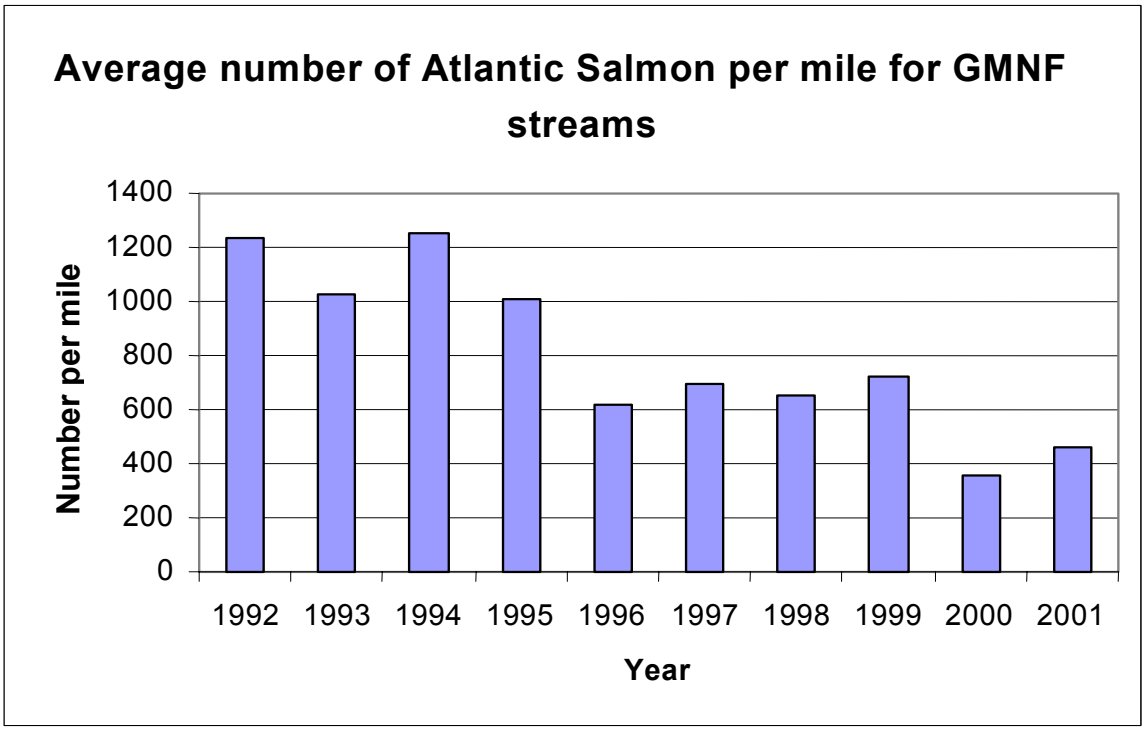

Figure 2: 10 year trend for juvenile salmon populations in GMNF streams.

The Brook trout is a Management Indicator Species for the GMNF. It occupies most upland streams throughout the Forest where clear, cold water with rocky stream bottoms, and well-vegetated stream banks are found. Brook trout populations are currently monitored in approximately 35 streams in the GMNF. In the Forest, Brook trout are widespread and secure, and population viability is being maintained. However, there are streams where natural reproduction of wild trout populations is very low. Conversely, there are streams with high trout populations. Figure 3 depicts the forest-wide annual population averages over a 10 year period. The overall trend in brook trout population is stable. In Vermont, Kirn analyzed brook trout in 12 Vermont watersheds (53 streams) and came to a similar conclusion (Kirn, 2000). However, he did state that "the long-term viability of wild brook trout stream populations will depend on the protection and enhancement of suitable physical habitat and water quality." The GMNF, through implementation of the Forest Plan, has been striving to achieve the resource protection and enhancement values described by Kirn.

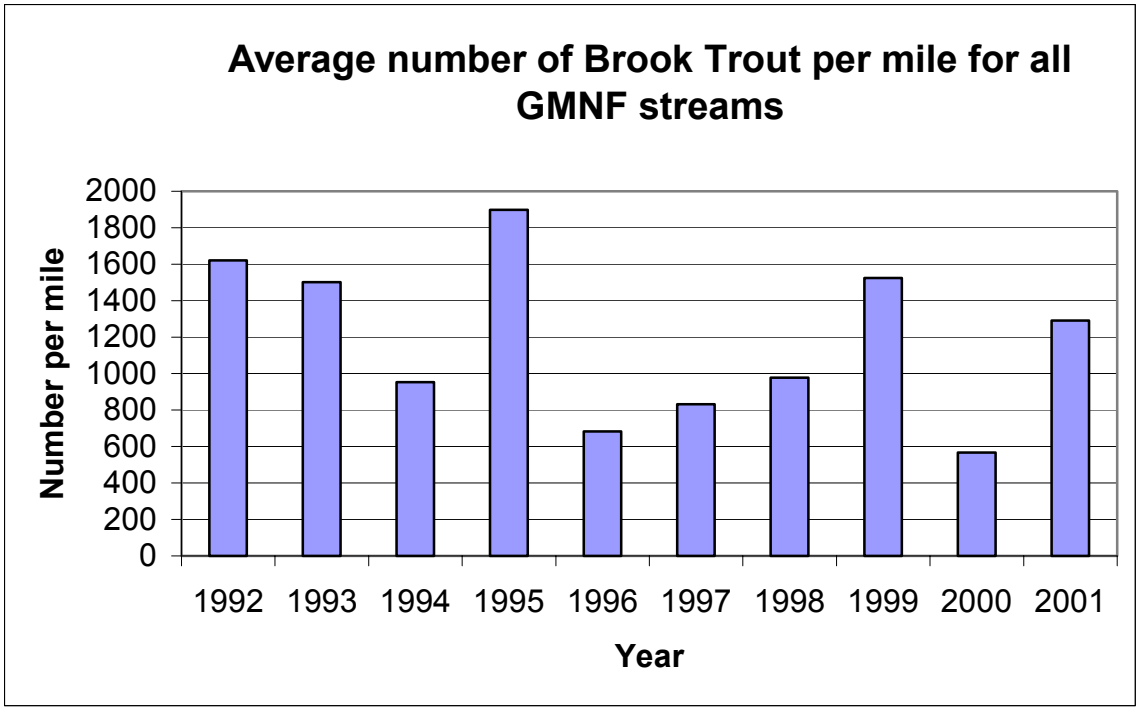

Figure 3: Forest-wide annual population averages over a 10 year period.

In the future, the GMNF will contribute towards the management of stable and improving populations and habitat through resource protection strategies and active habitat enhancement and restoration. This is particularly important as the GMNF works with federal and state agencies and organizations to meet brook trout management objectives.

Stream Habitat Condition

Stream stability, erosion from road and stream banks, stream sedimentation and degradation of aquatic habitat continue in many watersheds to be concerns expressed by the general public and natural resource management agencies. A large portion of current channel and bank instability and stream sedimentation can be attributed to the removal of riparian vegetation for such land uses as roads, in-channel alterations to accommodate land uses, intensively used recreation sites, forest management, and agricultural production. Channelization following floods and past mill operation and commercial gravel extractions have also contributed to the problem. All these factors are likely significant contributors to reductions in fish populations, loss of habitat, and channel instability.

Beavers provide aquatic habitat for fish and aquatic organisms on the GMNF. Beaver activity in upland streams has a positive influence on aquatic habitat. In lower elevations and valley environments, though, beaver activity can be detrimental to native aquatic species due to higher water temperatures and the creation of sediment sinks.

The GMNF monitors stream habitat conditions annually to identify habitat trends and analyze opportunities to improve aquatic resource conditions. For example, GMNF and

FS research biologists have been monitoring the accumulation of fine sediment (material <0.25 inches in diameter) in trout spawning habitat in the White River. Preliminary results suggest that higher fine sediment levels in the upper White River may be having a negative affect on fish reproduction. In addition, the VTANR has conducted stream monitoring in Howe brook, a tributary to the upper White River, and found high levels of sedimentation. This work will continue over the next few years.

Riparian Area Condition

Riparian forests include trees and other plants that live and grow near water on the banks of streams, rivers, ponds, and lakes. Prior to European human settlement, riparian vegetation along streams was probably more abundant than it is today. Early settlements and land clearing, log drives associated with logging in the late 1800s to mid-1900s, and extensive in-river alterations had profound impacts on riparian vegetation, channel morphology and aquatic habitat. Robert Pike (1967) described the practice:

> *"*So, having put part of his crew to work building the camp, the lumberman would take another batch and set them to work clearing the stream of sunken trees, boulders, and drift wood so it would be ready for the drive in the spring… The accumulations of centuries in the form of driftwood and fallen trees frequently covered the stream-bed for miles, and all had to be cleared away… Tree by tree, stick by stick, the obstructions had to be lifted out…islands and shoals had to be dug away; stumps, bedded deep in the mud, had to be grubbed out; embankments had to be made at sharp bends."

Recent work by VT DEC has quantified the amount of historic channel alterations in several Vermont streams (personnel communication, Mike Kline, VT DEC).

Also during the 1900s, the accepted practice was to construct new roads along rivers and tributaries, removing streambank-stabilizing riparian vegetation. Agriculture, urbanization and development, and post-flood channelization and berming also resulted in the removal of substantial amounts of riparian vegetation. The degradation of riparian and stream habitats likely persisted for several decades, and continues today at a lesser extent. Fortunately, land use and cultural changes in watersheds have occurred and continue to occur throughout Vermont.

Today, much of the forest cover loss during those early years has regenerated. As a result, most GMNF streams are bordered by second growth riparian forest. For the most part, only recently acquired GMNF riparian land, in river valleys such as in the White River, lack sufficient riparian vegetative buffers. A GMNF priority is to acquire easements or fee simple acquisitions along streams to enhance reforestation in riparian area buffers. In addition, the majority of riparian lands currently lacking adequate riparian vegetation are generally where agricultural practices and road corridors are the predominant land uses.

The Forest road system directly affects riparian communities where it encroaches on riparian areas or at crossings where significant breaks are made in the riparian corridor. Roads can affect riparian communities by intercepting surface and subsurface flows and routing these flows so that riparian areas dry up and the riparian vegetation is replaced with upland vegetation. There are very few areas in this condition on the Green Mountain National Forest. In a small number of areas, though, the road is immediately adjacent to the stream, preventing any vegetation from growing in the riparian area.

Riparian forest on the GMNF and the higher elevations of Vermont are generally 120 years old or younger. This situation allows the riparian area to function in numerous ways including serving as a buffer to filter fine sediment from entering streams and providing a canopy over streams to maintain desirable temperatures for native aquatic biota. Today however, there is a limited natural process of wood inputs into stream channels. Trees are certainly falling into stream channels, but not enough of them are of sufficient size to form stable jams and create stream habitat. Large dead and dying trees that are believed to have existed historically along streams are no longer there to function in the creation of diverse and complex stream habitats.

Many of Vermont's river resource professionals believe that the morphology of most Vermont rivers has been altered by decades of river and floodplain alterations and dramatic land use changes. A resultant lack of channel sinuosity and large woody debris input has left stream habitat more homogenous and less complex than past periods when this function persisted. Scientific literature indicates large woody debris plays a very large role for in-channel storage of sediment and significant amounts of the total sediment yield of a watershed can be in storage behind large woody debris. Large woody debris also plays an important role in forming pools and accumulating gravel beds that can be used for spawning.

Today's second growth forests have not yet reached a state of maturity whereby over-mature trees fall into the stream to provide important elements to natural stream channels. Unfortunately, there are few undisturbed riparian forests in New England today for scientists and interested citizenry to study and model desired future conditions for stream ecosystems. However, the notion that riparian forests of the past likely functioned differently than today's riparian forest (eg. provided more large wood) is generally supported by current research literature as well as historic accounts such as those from Zadocks Thompson's Natural History of Vermont (1853). Thompson wrote:

> "Before the country was cleared, the whole surface of the ground was deeply covered with leaves, limbs, and logs and the channels of all the smaller streams were much obstructed by the same. But since the country has become settled and the obstructions, which retarded the water, removed by freshets, when the snow melts or the rains fall, the waters run off from the surface of the ground quickly, the streams are raised suddenly, run rapidly, and soon subside."

Habitat Restoration

Over the past 10 years, the GMNF has implemented many stream habitat and river morphology restoration projects designed to mimic natural river processes, enhance habitat, and recruit large woody debris to stream channels. Monitoring of approximately 12 stream projects has resulted in valuable information on how large woody debris (LWD) affects stream ecosystems including changes in fish and macroinvertebrate populations, channel morphology and structure, and habitat diversity. Project monitoring continues but initial findings indicate that stream enhancement and restoration projects result in desirable habitat changes including 2-5 fold increases in pool area, pool frequency and LWD quantities in affected streams. The slow water, depositional habitats are important features for stream biota and are extensively used throughout the extreme range of seasonal environmental conditions present in New England streams.

Nislow described significant increases in aquatic insects abundance and diversity observed at restoration project sites as well as positive responses by fish populations (Nislow, 1997). Figure 4 depicts changes in aquatic insects at habitat restoration sites.

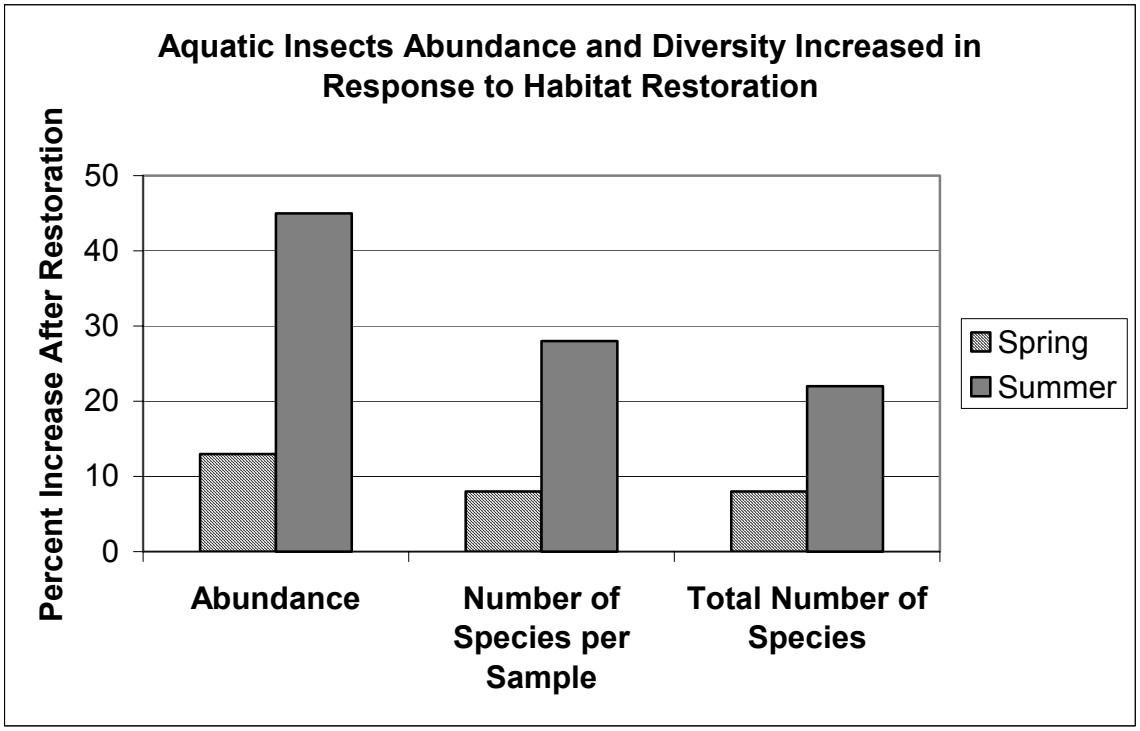

Figure 4: Changes in aquatic insects at habitat restoration sites.

Finally, restoration of the "natural wood regime" when and if it is allowed to happen in Vermont and New England, will significantly affect stream ecosystems" (GMNF, 2000). The lag time between riparian forest and large woody debris (LWD) recovery will likely be a significant factor in the effects of land-use on streams in this region. In order to mitigate these potential effects, measures may need to be incorporated for the retention

and recruitment of LWD into stream buffer and filter strip standards and guidelines, such as the GMNF has done in the forest plan. As riparian forests mature on the GMNF and throughout Vermont, there will be an increase in the amount of wood in streams. This will be a change from what we have seen in the past. The public will become more aware of wood in streams and will have to decide if management measures are needed. Using natural channel design techniques in stream restoration efforts can also improve river morphology and stream habitats, resulting in long-term benefits to the aquatic ecosystem.

Other Human Influences

The presence of dams and diversion structures on streams can significantly alter the hydrologic characteristics of the drainage basin. There are a variety of uses for dams and diversion structures, such as: hydropower, water supplies, flood control, recreation, and aesthetics. There are six dams located on the GMNF under three ownerships: Silver Lake, Chittenden Reservoir, Goshen Dam, and Sucker Brook (owned by Central Vermont Public Service Corp./Middlebury District), Kent Pond (owned by the State of Vermont/ Rochester District), Lefferts Pond (owned by GMNF/Middlebury District), and Hapgood Pond (owned by GMNF/Manchester District). The GMNF has no current plan to remove any of the existing dams on the national forest. Some of the existing dams on the GMNF are planned for upgrading. Benefits from dams for hydropower and recreation are evident at Silver Lake, Chittenden Reservoir, and Sucker Brook dams. Recreation and aesthetic affects are demonstrated at Lefferts and Hapgood Pond dams.

Negative impacts of dams are due to the deposition of large amounts of sediment in the reservoir from essentially creating a settling pond (still water). Also, the deposition of sediment results in an increase in upstream bank erosion due to fluctuations in the water level, and erosion downstream due to decreased load and decreased peak discharges. This increase in sediment in the river bed adversely affects aquatic habitat. A study in 1999 of 13 rivers with diversion structures in the Connecticut River watershed showed several areas of ecological concern (Magilligan and Nislow, 1999). Due to differences in flood magnitude and frequency as a result of the impoundment structures, the herbaceous plant communities were impacted and fragmented, leaving them more vulnerable to invasion and random extinction.

Problems associated with the presence of mercury in the atmosphere and in freshwater environments is a concern for human health, aquatic species, and water quality. There are fish consumption advisories from current research into mercury across the Vermont-New Hampshire region, including USEPA studies and fish tissue monitoring activities, suggesting that mercury contamination is present across the southern part of Vermont, especially in the Lye Brook Wilderness area (Kamman, 2002). Four lakes in the Lye Brook Wilderness area, Bourn, Grout, Branch, and Stratton Ponds, were investigated for mercury accumulation in 2002 by Vermont Department of Environmental Conservation (VTDEC). All four lakes "are relatively high-elevation, forested waters occupying small watersheds, and characterized by similar water chemistry" (Kamman, 2002: 12). The study showed that mercury accumulation was elevated in all four lakes compared to a

separate similar study of 10 Vermont-New Hampshire lakes. Mercury continues to be monitored and analyzed throughout the Forest.

Health Alert for Fish on or near the GMNF (from VT Department of Health Website)		
General Advisory:	**WOMEN OF CHILDBEARING AGE** (particularly pregnant women, women planning to get pregnant, and breastfeeding mothers) and **CHILDREN AGE 6 OR YOUNGER**	**ALL OTHER INDIVIDUALS**
Brown Bullhead Pumpkinseed	No Advisory	No Advisory
Walleye	0 Meals	No more than 1 meal/month
Lake Trout Smallmouth Bass Chain Pickerel American Eel	No more than 1 meal/month	No more than 3 meals/month
Largemouth Bass Northern Pike	No more than 2 meals/month	No more than 6 meals/month
Brook Trout Brown Trout Rainbow Trout Yellow Perch	No more than 3-4 meals/month	No Advisory
All Other Fish	No more than 2-3 meals/month	No more than 9 meals/month
Special Advisory: **Deerfield Chain (Grout Pond, Somerset Reservoir, Harriman Reservoir, Sherman Reservoir, Searsburg Reservoir)**		
Brown Bullhead Brook Trout	No Advisory	No Advisory

Rainbow Trout Brown Trout (smaller than 14 inches) Rock Bass Rainbow Smelt Yellow Perch	No more than 1 meal/month	No more than 3 meals/month

Source Protection Areas (SPA) and Well Head Protection Areas (WHPA) are areas of drinking water sources used by municipalities and/or private use. These areas require protection in order to maintain the highest water quality standard. The protection areas that are totally or partially within the National Forest ownership by watershed (Figure 5) include:

1. Mountain Water Company – Mad River
2. South Village and Club Sugarbush – Mad River
3. Bristol – New Haven River
4. Middlebury – New Haven and Otter Creek
5. Cove Point Trailer Park – Otter Creek
6. Brandon – Otter Creek
7. Proctor – Otter Creek
8. East Rd. Mobile Home – Otter Creek
9. Rutland City – Otter Creek
10. Wallingford – Otter Creek
11. So. Wallingford Co-op – Otter Creek
12. North Side Condos – Otter Creek
13. East Dorset – Otter Creek
14. Pristine Springs of Vt. – White River
15. Wintergreen at Killington – White River
16. Hawk Mtn. #1 – White River
17. Rochester – White River
18. Bromley Water Company – West River
19. Oak Knoll Community Care – Batten Kill
20. Manchester – Batten Kill
21. Winhall/Stratton – West River
22. Mountaindale – Deerfield River
23. Cold Brook – Deerfield River
24. Readsboro – Deerfield River
25. Bennington – Walloomsac River
26. Unabella Trailer Park – Walloomsac River
27. North Adams – Hoosic River

The Forest Plan clearly states that drinking water protection is of high importance in managing watersheds, supplying the finest quality water that can naturally occur, and in

protecting the land and vegetation for approximately 100 feet from the edges of all streams, lakes, and other bodies of water (Section 4.04, items 4 and 5, and Section 4.19, item A.3).

Another human impact affecting the water resource is alpine snowmaking. There is one alpine snowmaking pond on the GMNF, Carinthia Pond, located at Mount Snow. It is about 2 acres in size, with ¾ acres located on GMNF land. It has a capacity of 3,000,000 gallons. Carinthia Pond is fed from an unnamed stream.

Recreational activities have a minor affect on the national forest's surface water. Out of an estimated 3.4 million visits (+/- 13.1%) for calendar year 2000, 6 % of the visitors used water for recreational activities, such as, swimming, boating, fishing, canoeing, and kayaking (GM/FL National Forest, 2001). These activities do not cause pollution or degradation to any noticeable degree.

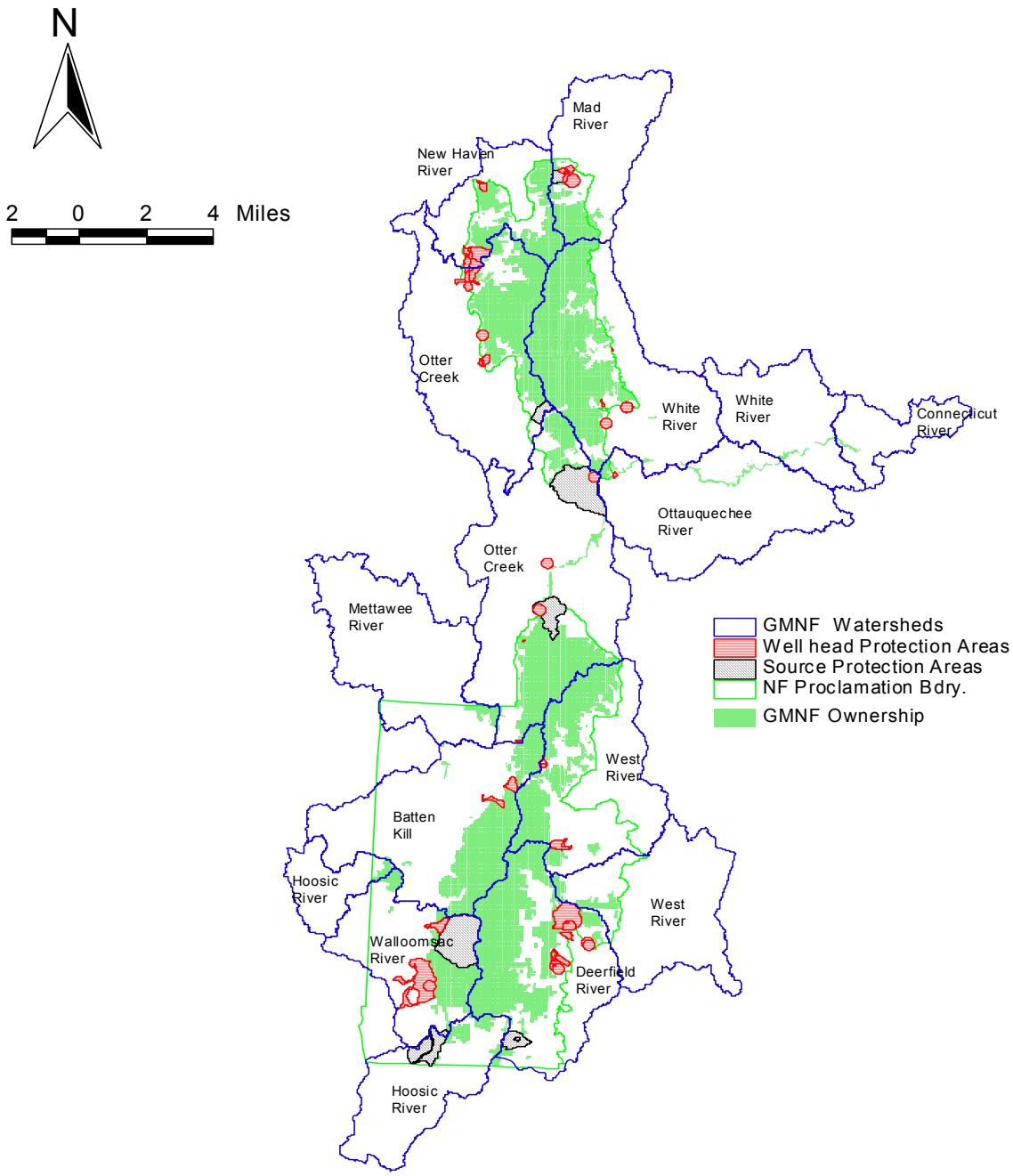

Figure 5: Water Source Protection Areas

Fluvial Geomorphology

Fluvial Geomorphology studies are important in identifying the physical processes and features that characterize streams and watersheds, which physical processes and features are more sensitive to change over time, and which processes and features are needed for sustaining quality aquatic habitat. The forest plan, amendment #6, called for the Forest Service to determine existing habitat capability and identification of limiting factors for anadromous Atlantic salmon, Brook trout and other native inland fish species in GMNF waters. Fluvial Geomorphology studies are a tool for determining habitat capabilities and limiting factors for fisheries management.

Some sediment and stream morphology studies of areas on the GMNF have been undertaken to analyze the dynamics of bank erosion and channel change. A 1999 study of Stetson Brook and Clay Brook, areas with various land use histories, (Jaquith, 1999) showed that the watersheds are comprised primarily of glacial till with areas of bedrock outcrops. The Stetson Brook watershed is part of the Breadloaf Wilderness Area and was moderately logged, prior to being designated a Wilderness Area. The Clay Brook watershed includes the Sugarbush ski area, condominiums, and recreational facilities. The Jaquith study showed that major mass wasting (the slow or fast movement of large masses of earth material) and bank erosion occurred in both streams after a major storm event, which aggraded (the building up of the stream bed by sediment deposition) the stream beds. The Clay Brook watershed had a greater supply of sediment transported to the stream, which was due to the different land use activities occurring in the watershed.

Another stream morphology study of the main stem of the Upper White River in 2002 (Donna, 2002) showed that floods of varying recurrence intervals, 2-year to 50-year events, affected the channel configuration. Over a 50-year study period, channel change consistently occurred downstream of major tributary junctions. These tributaries contributed additional water volume and sediment load that the main stem had to transport through the channel. Topography within the study area also influenced channel morphology with the transition between the steep slope of the headwater stream changing to the low gradient valley floor. The steep floodplain valley wall also influenced channel morphology by limiting lateral movement of the channel. Land use changes during the study period showed an increase in forested land from pasture and shrub land. The loss of channel and floodplain function with respect to sediment transport would result in the type of observed channel changes whether or not riparian vegetation and reforestation of the watershed had occurred. However, Nislow (2000) found that fine sediment in fish spawning gravel is higher in streams adjacent to agricultural and developed lands than upland forested sites, suggesting vegetated stream banks help reduce stream sedimentation and habitat degradation. The increased presence of forested land provides improved aquatic habitat beyond channel stabilization, with benefits such as: large woody debris, cooler stream temperatures, and organic food matter for macroinvertebrates. The Donna (2002) study highlighted the dynamic character of the main stem of the Upper White River and gave some insights into the important modes of sediment transport and deposition within the study area.

The national forest is working with the State of Vermont to develop a geomorphologic database. The Stream Geomorphic Assessment project includes three phases:

- **Phase 1,** the remote sensing phase, involves the collection of data from topographic maps and aerial photographs, from existing studies, and from very limited field studies, called "windshield surveys." Geomorphic reaches and provisional reference stream types are established based on valley land forms and their geology. Predictions of channel condition (departure from reference), adjustment process, and reach sensitivity are based on evaluations of watershed and river corridor land use and channel and floodplain modifications.
- **Phase 2,** the rapid field assessment phase, involves the collection of field data from measurements and observations at the reach or sub-reach (segment) scale. Existing stream types are established based on channel and floodplain cross-section and stream substrate measurements. Stream geomorphic condition, physical habitat condition, adjustment processes, reach sensitivity, and stage of channel evolution are based on a qualitative field evaluation of erosion and depositional processes, changes in channel and floodplain geometry, and riparian land use/land cover.
- **Phase 3,** the survey-level field assessment phase, involves the collection of detailed field measurements at the sub-reach or site scale. Existing stream types and adjustment processes are further detailed and confirmed based on quantitative measurements of channel dimension, pattern, profile, and sediments. Phase 3 assessments are completed with field survey and other accurate measuring devices. Phase 3 assessments are typically pursued to augment data requirements for the design and implementation of river corridor protection or restoration projects. (VTANR, 2003, *www.vtwaterquality.org/riversgeo.htm)*

Phase 1 and 2 assessment projects are currently ongoing in some streams on the national forest, besides the Phase 3 assessment streams mentioned in Item B, Reference Condition. Overall, this Stream Geomorphic Assessment project is a lengthy study that will result in the collection of broad factors in the geomorphic condition of the watersheds on the national forest.

Special River Designation Status

The purpose of the special river designations is to protect the uniqueness of potential wild, scenic, or recreational rivers, which are eligible for inclusion in the National Rivers System. The Green Mountain National Forest continues to protect these areas as outlined in the forest plan standards and guidelines. Limited progress has been made on suitability studies for the eleven streams identified in the forest plan and the eligibility studies for the 38 significant streams due to personnel reductions and priority shifts to nationally directed initiatives. The GMNF continues emphasis on protection of the waterways as outlined in the 1987 forest plan standards and guidelines. The GMNF is now in the process of doing the eligibility study for the 38 significant streams.

The federal Wild and Scenic Rivers Act requires agencies to consider and evaluate rivers on lands they manage for potential designation while preparing their broader land and resource management plans under Section 5(d)(1) of the Act. A candidate river is eligible if it is free-flowing and possesses one or more Outstandingly Remarkable Values (ORVs). The ORVs include significant scenic, recreational, geological, fish and wildlife, historical, cultural or ecological characteristics. Once a river is determined eligible, the river is analyzed as to its current level of development and is placed into one or more of three classes: wild, scenic, or recreational. A suitability analysis is used to determine whether a river should be recommended as part of the national system. Suitable rivers are either designated or not designated. This process adds the river to the National Wild and Scenic Rivers System by an act of Congress or by administrative action Section 2(a)(ii). Each component of the river system shall be managed to protect and enhance the values which caused it to be included in the system and it must remain free-flowing.

There are 11 eligible streams and 38 significant streams on the GMNF. The following 11 streams have potential for designation as Wild, Scenic, or Recreational Rivers:

- Wild — Lye Brook
  Winhall River
- Scenic — Bolles Brook
  Deerfield River
  Wardsboro Brook
  West River
  Winhall River
- Recreational — Bolles Brook
  New Haven River
  Otter Creek
  Roaring Branch
  City Stream (Walloomsac)
  Wardsboro River
  White River
- Undetermined Potential Classification (addition due to new acquisition of property since 1987 Plan):
  Batten Kill
  Mad River
  Ottauquechee River

The purpose of the GMNF forest plan management prescription 9.4 is intended to protect the characteristics of the land and water resources which may make certain sections of the 11 streams eligible for the National Wild and Scenic Rivers System. The management prescription for potential recreational rivers is applied to the 38 significant streams for their outstanding recreational and fishery values. Some of these streams may be eligible for Outstanding Resource Water designation under Vermont state law, and would be managed consistently with state policies protecting these waters.

The criteria for Outstanding Resource Water designation is that the water body is both Class A and Class B waters (see Section A: The State of Vermont Water Classifications on the Forest), having exceptional natural, recreational, cultural, or scenic values (State of Vermont, 2000). There are two rivers within the proclamation boundary that are designated Vermont Outstanding Resource Waters: BattenKill, including the West Branch, and North Branch of Ball Mountain Brook. National Forest land is along 1200 feet of the BattenKill, and the Town of Jamaica owns the North Branch of Ball Mountain Brook.

Watershed Assessment Status

A watershed assessment is a watershed scale ecosystem analysis to identify a prioritized list of recommendations to address the most important ecosystem issues in the restoration of a watershed. Specific ecological issues are identified for the analysis area. Current and reference conditions of the resources related to the issues are identified and the reasons for change from reference condition are explained. Actions are recommended to address each issue.

The GMNF completed watershed assessments in 2001 on the Upper White River Watershed on the Rochester Ranger District (GMNF, 2000, 2001). The following information was found for the aquatic and riparian areas: many riparian areas lack forested buffer strips, flow peaks and volumes have increased, and there is a high sediment load in the main stem of the Upper White River. In addition, acid deposition has decreased the pH of some streams and lakes in the watershed, and there is a lack of large woody debris in the streams. Strategic recommendations for these outcomes include working with partnerships to establish forested buffer strips, identifying actions that could be taken to reduce the need for channel management activities that work against the geomorphic stability of the river, decreasing the flow volumes and the peak flows, and determining the main sources of sediment. Additionally, the Forest Service needs to support efforts to reduce acid deposition by fulfilling responsibilities for implementation of the regional haze regulations. Finally, the Forest Service needs to restore large woody debris and the fluvial processes that maintain woody debris to the streams to improve the water quality and aquatic habitat. As these recommendations are implemented, monitoring the results will indicate if the correct action has been applied to achieve the desired future condition.

Many other watersheds on the GMNF have similar existing conditions, such as: the lack of forested buffer strips along riparian areas, the lack of large woody debris in the streams, geomorphically unstable channels, high sediment loads (possibly due to mass wasting especially in steep watersheds with large amounts of thick glacial till present), and acid deposition. The lack of forested buffer strips along riparian areas usually occurs along private ownership within the proclamation boundary. Due to the lack of forested buffer strips and channel management practices, the amount of large woody debris in streams has declined. High sediment loads in streams are due to a variety of sources such as gravel roads near streams, land-use activities, eroding stream banks, and the channel adjustments associated with geomorphically unstable channels. The decrease in the pH

of streams and lakes due to acid deposition is a regional concern throughout New England. Some areas are less affected by acid deposition because of natural buffering capabilities in the existing bedrock. Those areas are still exposed to acid deposition but, they are able to maintain a normal pH level. Not all areas have a natural buffering capability, so they are adversely affected by acid deposition.

The desired future condition for the Upper White River watershed is a watershed that contains a variety of vegetative conditions and types to enhance diversity, meet habitat needs for wildlife, and to provide wood products for people. The Forest Service, as land stewards, must continue to nurture and protect the complex, interrelated forest ecosystem and the riparian and aquatic ecosystems' functions, structures, and processes. The Forest Service must restore the ecosystems to the extent possible, considering the social, spiritual, and economic needs of society. Decisions about timber harvesting and other management activities that involve use and conservation of natural resources must provide for sustained and enhanced diversity of plant and animal communities as well as maintained soil productivity.

The Forest Service must continue to meet water quality standards (chemical, physical, and biological), including putting riparian buffer strips in place, and maintaining stream flows at necessary levels to maintain a properly functioning channel (a state of dynamic equilibrium). The GMNF must insure major sources of sediment and pollution are minimized, thus resulting in improved aquatic habitats and native aquatic species' populations due to enhanced habitat components such as large woody debris, appropriate stream temperatures, spawning gravels, and pools. It is necessary for the GMNF to insure water and soil resources are recovering from the negative effects of acid deposition and that future land uses and management in the watershed support achievement of the desired future condition with improved quality of life in the watershed.

From our present watershed assessments and our knowledge of existing conditions in other watersheds within the proclamation boundary, the GMNF has developed strategic recommendations to improve the existing condition of the assessed watersheds and indicators are in place to track the progress of watershed improvement. The recommendations can be applied in other watersheds and tracked for watershed improvement progress. The watershed assessments are used as a tool in future project planning and to implement the forest plan.

The GMNF has planned to study either the Deerfield River or the Batten Kill watershed in the Manchester Ranger District as the next proposed watershed for assessment in the near future.

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Item D. How the Green Mountain National Forest Fits into the Broader Context

Introduction

The purpose of this section is to provide an overview of the aquatic ecosystems and watershed conditions on the GMNF as they compare to those in the State of Vermont. This comparison required knowledge of the watershed conditions in the entire state.

How do GMNF aquatic ecosystems/watershed conditions compare to those in Vermont?

In general, much of the GMNF's geographical region is natural, but not immune to the environmental stresses and perturbations affecting water quality in other regions of Vermont. Much of Vermont has experienced increased levels of development to accommodate an increasing human population and changing land uses. Traditional land uses such as family farming and broad-scale forest management have slowly given way to public demands for more housing, transportation, and recreation infrastructure in suburban-urbanizing areas. The result has been increased sedimentation, storm water runoff and flooding, and other factors that threaten water quality in Vermont waterways.

Although not exempt, the GMNF has experienced fewer of the environmental problems than the state of Vermont that often result in degraded lakes and streams. The greatest impact to water quality on the GMNF comes from pollution sources outside the immediate area and GMNF control, namely atmospheric pollutants such as lake and stream acidification. Highly developed GMNF lands, such as ski areas and recreational facilities, can also negatively affect watersheds. However, the GMNF works extensively and successfully to minimize their impacts on water quality and biological communities.

Throughout Vermont, there is growing public concern about the condition of GMNF river corridors. Managing the conflict between people's land use expectations and river dynamics is requiring new approaches to balance goals for natural resource protection, active land management, and river and riparian habitat restoration. Moreover, there is a heightened public awareness that rivers are in a constant balancing act between the river's energy and the work that must be done by the river to convey the runoff of sediment and debris produced in watersheds.

Changes to the shape of a river channel, or changes in the amount of sediment and water input lead to instability or imbalance, and cause adjustments in river and floodplain conditions. Natural channel adjustments have occurred over time following large floods and climatic changes. These natural adjustments however, have been overshadowed or magnified over the past two hundred years by those resulting from human-imposed changes, particularly changes to the depth and slope of rivers related to intensive watershed-wide land uses. Nearly every Vermont watershed has unstable streams "in adjustment" from a sequence of events that include deforestation, reforestation, snagging and ditching, villages, road and railroad developments, floods and post-flood work, gravel removal, and storm water and urbanization (VTDEC, 2003).

By comparison, streams and rivers in the GMNF have been subjected to fewer of these human-imposed changes over time, and as a result do not have the range of problems associated with streams elsewhere in Vermont primarily because there is less development, less agriculture, and more natural vegetation on the Forest. However, this does not imply that on-going physical processes (or lack of them) and the circumstances leading to their existence today does not need to be addressed through Forest Service watershed planning and the implementation of restoration activities. For example, it has been widely recognized that removal of vegetation from streamside (riparian) areas, even a century or so ago, has left a conspicuous lack of woody material and debris in GMNF stream channels. The loss of this important stream ecosystem function has had profound impacts including alterations of: existing aquatic habitat quality and quantity, sediment storage and transport, and overall channel pattern, dimension, and profile. These issues, and others such as adequate riparian buffers, are currently being addressed by GMNF protection and management strategies and actions. The management actions provide benefits such as cold, clean water to sustain water quality and native fisheries in stream reaches downstream of the Forest along private lands.

Is there anything special or unique about our aquatic ecosystems?

The GMNF is centered along a long spine of Vermont known as the Green Mountains. This chain of mountains is a major geographical boundary between the east and the west. Vermont is fortunate to have the GMNF protecting the headwaters of so many miles of important streams and lakes. Without this protection, it is possible that the sensitive high elevation watersheds and the shorelines gracing many of the ponds would have long ago been developed. The protection assured to the GMNF lands means people have incredible opportunities to fully appreciate our natural resources. Communities of plants and animals that inhabit these areas can, for the most part, remain undisturbed. Rare species and communities can exist or be restored, and exotics are less likely to get a foothold. Few better remote fishing, camping and hiking experiences can be found in New England, and, except for a portion of the Northeast Kingdom, none better in Vermont. The attributes that make the GMNF special for humans are vital for the rest of its inhabitants.

How do watershed conditions on the GMNF compare to reference conditions?

"A considerable portion of Vermont remains undeveloped. Much of the GMNF is a prime example of undeveloped landscape and its waters often reflect this condition. Watersheds that can best be described 'as naturally occurs' are critical habitats. The waterbodies found in the GMNF are often Vermont's best examples of 'pristine reference waterbodies'. The streams, lakes and wetlands of much of the GMNF are premier examples of these waterbody types. Some of these very waterbodies were used to help establish Vermont's biological standards of what constitutes reference conditions. These reference waterbodies are used to determine to what extent watershed disturbances are having an impact on waters throughout Vermont. In the absence of atmospheric deposition and other localized disturbances, all waters within the GMNF would currently either be, or have the potential to attain reference status" (Kellogg, 2002).

Potable water supplies and recreational activities provided by the GMNF

The specific towns that are reliant on GMNF watersheds to provide municipal water include: Bristol, Middlebury, Brandon, Proctor, Rutland City, Wallingford, Rochester, Manchester, Winhall/Stratton, Readsboro, Bennington, and North Adams, MA. These "municipalities do rely on GMNF lands either as a direct source of surface water or indirectly as recharge zones for groundwater. In addition to the regulated authorities are the considerable numbers of private water users who pipe from streams and drill wells in aquifers generally protected by GMNF lands. These users expect the GMNF to be a provider of high quality drinking water. Though localized problems may exist and some areas are likely predisposed to harbor waters naturally high in metals (i.e., iron), base cations (conditions frequently found throughout Vermont) and bacteria (natural or otherwise), one can assume the GMNF waters generally provide good water. At least one municipality (Bennington) that uses GMNF waters has been affected by atmospheric deposition to the point the streams used are impacted by acidity. The town manages to continue using the sources, but at a considerable expense in chemically neutralizing and treating its raw water" (Kellogg, 2002).

Humans have the opportunity to recreate within the GMNF on relatively undisturbed lands and waters. The GMNF provides a quiet, relaxing experience that cannot be found at most developed water bodies in Vermont. GMNF waters are frequently managed in such a way as to allow a haven to the recreational user who appreciates solitude and a wilderness-like experience. Still, there are fishing concerns as some waters have been affected by water pollution such as acidification and metal contamination (i.e., mercury) as a result of atmospheric deposition.

How do watershed conditions on the GMNF land compare to nearby private land within the proclamation boundary?

Activities that occur within the GMNF are subject to considerable scrutiny. Plans must be approved and monitoring and adherence to the GMNF standards and guidelines (S&Gs) is required. If an operation fails to maintain acceptable environmental objectives it can be curtailed. In the case of silvicultural activities, the S&Gs and Acceptable Management Practices (AMPs) have very specific requirements that delineate erosion control practices and minimum buffer widths to protect water bodies. Lands outside the GMNF's current ownership, but within their proclamation boundary, are less subject to review and are theoretically more prone to impacts.

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VTDEC (2003) "Alternatives for River Corridor Management Paper".

Item E. Compliance with Water and Fish Resource Regulations

Areas not in Compliance

The major impact to water quality on the Forest is acid-deposition, which is being monitored and analyzed very closely in select areas. The ponds and stream sections within the proclamation boundary of the GMNF that have been classified as "impaired" by the Vermont Agency of Natural Resources (VTANR) and United States Environmental Protection Agency show that 54% of the total water bodies listed have problems directly associated with acid deposition. This suggests that national forest management has not contributed to water quality problems and that the sources of the pollution emissions are from distant facilities. A small number of streams adjacent to the GMNF that are listed as located on national forest land are impaired due to sediment resulting from development. Other stream sections outside GMNF ownership have water quality problems more readily linked to specific local problems such as low flows, excessive erosion, or toxic substances.

Non-point source pollution issues addressed in the Clean Water Act including: lack of stream geomorphic stability, erosion from road and stream banks, stream sedimentation, and degradation of aquatic habitat continue to be concerns in many watersheds expressed by the general public and natural resource management agencies. A large portion of current channel and bank instability and stream sedimentation can be attributed to the removal of riparian vegetation for such land uses as roads, in-channel alterations to accommodate land uses, intensively used recreation sites, forest management, and agricultural production. Channelization following floods, and past mill operations and commercial gravel extractions have also contributed to the problem. All these factors have been significant contributors to reductions in fish populations, loss of habitat, and channel instability.

Since 1987, approximately 50 streams totaling over 250 miles in the GMNF have been inventoried for habitat quantity and quality. Based on the collected data, most streams do not meet current forest plan standards and guidelines (S&Gs) for desired habitat conditions. Recognizing the situation, the GMNF implemented a management program in the late 1980s that is working toward meeting desired habitat conditions for GMNF streams through active habitat restoration projects. In addition, we are using a passive approach through riparian area protection that provides the basis for recovery of riparian forest as a long-term source of woody debris to restore channel stability and habitat complexity and diversity.

Watershed Conditions Compared to Water Quality Standards Classification Criteria

Relative to private lands, watershed conditions on the GMNF are good. The State of Vermont's Water Quality Standards Classification Criteria (Table 1, Item A) calls for almost natural conditions for aquatic habitat for Class B1 waters. For A1 and A2 waters, the Standards call for minimal change from natural conditions, and maintaining high quality habitat, respectively. Many watersheds on the GMNF have existing conditions

similar to Class B1 waters, at a minimum. There are some areas, though, with existing conditions that affect aquatic habitat, such as the lack of forested buffer strips along riparian areas, the lack of large woody debris in the streams, and high sediment loads. The lack of forested buffer strips along riparian areas usually occurs along private ownership, within the proclamation boundary. Due to this lack of forested buffer strips, the amount of large woody debris in streams has declined. High sediment loads in streams are due to a variety of sources, such as gravel roads near streams, land-use practices, and unstable channels and stream banks.

Strategic recommendations for these existing watershed conditions include working with partnerships to establish forested buffer strips, determining the main sources of sediment, restoring large woody debris to the streams, and working with the public to frame the debate and develop alternatives for short and long term goals for river corridor management in Vermont. The GMNF has recognized that collaboration with watershed groups is a necessity at every scale of aquatic restoration and resources stewardship. The importance of working with watershed organizations and building a network of relationships has been a goal of the GMNF for more than a decade. The Forest currently maintains a working relationship with at least 5 watersheds group that are geographically distributed across the Forest.

The White River Partnership (WRP), which came into existence in 1996, is one example of this community collaborative. This National award winning, community-based watershed restoration project demonstrates how Forest Service financial and technical resources, along with those of some Vermont State agencies, have led to the development of this strong non-profit watershed organization. The WRP now serves as the link between more than 20 organizations and 21 communities within the White River watershed.

As strategic recommendations are implemented to address the existing watershed conditions in some areas, as mentioned above, project monitoring will indicate if the correct action was applied to achieve the desired future condition, as well as compliance with state standards.

Item F. Public Issues

Introduction

The purpose of the Public Issues section is to address concerns that were raised during public involvement meetings. Concerns were organized by similarities of subject-matter, and resulted in major topic questions that are answered below.

Are there better aquatic indicator species to reflect overall ecosystem health?

Under the current GMNF Land and Resource Management Plan, the brook trout is the only aquatic management indicator species (MIS). The brook trout was selected as a MIS because it is a native species that has high water quality and habitat requirements and it is widely distributed throughout the Forest. The forest plan uses rainbow trout as a surrogate MIS in streams where they dominate the brook trout population, primarily in the White River watershed. In addition, Atlantic salmon are considered a species of concern and as such, are monitored very similarly to MIS for population abundance and trend data. Rainbow trout and Atlantic salmon also have high water quality requirements and are sensitive to impacts of acidification. Given the range of habitat and environmental conditions encompassed by these three species, it is reasonable to say they are good indicators of overall aquatic ecosystem health.

During the forest plan revision process, the GMNF will evaluate the opportunities to use other aquatic species and/or communities (possibly other fish, salamanders, and macroinvertebrates) in the aquatic resources monitoring program.

What are the impacts from recreation, agriculture, development and roads to stream banks and shorelines?

It is widely recognized that recreation, agriculture, development, and roads can have direct and indirect impacts on streams and lakes. On the GMNF, riparian area impacts can result from recreational use, water quality can be affected by agriculture, and water body health can be affected by nearby gravel roads and resultant runoff, sediment delivery, and turbidity.

The overall hydrology in a watershed, particularly the quantity and timing of flow, can be affected by roads and development by:

- expanding the channel network,
- converting subsurface flow to surface flow, and
- reducing infiltration due to creation of impervious surfaces.

Road-stream crossings also have the potential to directly and indirectly affect local stream channels and water quality. Poorly designed crossings directly affect hydrologic and sediment/debris continuity functions when they constrict the channel, are misaligned relative to the natural stream channel, or have improperly sized culverts installed. Road-

stream crossings also act as "connected disturbed areas" where water and sediment are delivered directly to the stream channel.

Opportunities to improve stream crossings, culverts, and drainage structures include:

- Design crossings to pass fish, sediment and bed load, and large woody debris, not just water;
- Realign crossings that are not consistent with channel patterns;
- Change the type of crossing to better fit the situation, for example: consider bridges on streams with floodplains and consider bottomless arch culverts in place of round pipe culverts;
- Include the use of floodplain culverts to help pass water at high flows;
- Add cross-drains near road stream crossings to reduce the potential for direct discharge of sediment into streams;
- Increase the number and effectiveness of drainage structures, especially on maximum grade roads;
- Design the drainage structures to discharge surface runoff onto vegetated buffers, not directly into streams or ponds; and
- Relocate structures where possible to avoid crossings where the structure is incompatible with geomorphic depositional areas such as alluvial fans.

A road adjacent to, or within 100 feet of, a perennial stream, pond, or wetland is a good indicator of where the road system could potentially be affecting the hydrology, slope, planform, or floodplain of the water body. The approximate percent of forest road miles within 100 feet of perennial streams and existing ponds and wetlands is 16%.

Over the last decade, many projects were implemented to improve water quality and riparian areas by eliminating erosion and sedimentation problems, and by revegetating and stabilizing bare soil areas. Several low-use campsites were closed and revegetated to correct erosion, landslides along streams were revegetated, old roads with erosion problems were closed and revegetated, gravel pits were closed and revegetated, and bridges and culverts were removed along old, closed roads because these structures were causing, or had the potential to cause, stream blockage. Also, several projects on trails and roads were implemented to correct erosion and sedimentation problems by installing water bars, culverts, and rehabilitating gullies.

The GMNF continues to monitor water quality at several sites throughout the GMNF in order to determine problem areas where management activities may be adversely affecting stream banks and shorelines.

<u>Have the GMNF land management activities caused erosion?</u>

Monitoring of the effects of management activities on soil, water, and fishery resources was conducted on 1992-1999 timber sales, as well as other GMNF projects. Monitoring consisted of visually checking active sales to see if standards and guidelines (S&Gs) for soil and water protection were implemented and effective in minimizing soil erosion and stream sedimentation. Fisheries population monitoring was performed at selected

streams within and adjacent to sale areas. Water and biological monitoring was also conducted at selected streams by the State of Vermont. Monitoring results showed that overall soil, water, and fisheries resources adjacent to timber sales were being protected.

For 2000 and 2001, soil and water monitoring for turbidity on timber sales showed that there were no serious violations of S&Gs and no sedimentation problems were reported from on-going or completed timber sales.

For 2002, water quality monitoring for chemistry, biology, and turbidity was conducted at 20 sites on the Green Mountain National Forest in dispersed camping areas, campgrounds, future watershed assessment drainage basins, and selected past and future timber sales (turbidity only). The monitoring trends showed that the S&Gs were being implemented and were effective in protecting the soil and water resources. This is also true for fisheries where results showed similar trends and annual variability between trout populations in streams within a sale area and those lying immediately outside the sale area.

Forest roads (state, town, and Forest Service roads) may be the largest long-term source of stream sedimentation on the GMNF. Road location is the primary cause, with road use, design, and lack of adequate maintenance also contributing to this problem. Sedimentation remains a problem at some locations on GMNF roads and continual work will be needed to correct these problems.

To work toward our goal of minimizing the sediment contribution to streams from roads, the GMNF continues to identify and correct sedimentation problems on roads. Three projects were implemented in 2001 to correct sedimentation problems, and planning was initiated to implement approximately six road-related sediment control projects in 2002. Similar work is expected to continue for many years to come.

<u>Have forest management activities caused positive and/or negative hydrological impacts?</u>

Roads affect the overall hydrology in a watershed, particularly the quantity and timing of flow by:

- expanding the channel network,
- converting subsurface flow to surface flow, and
- reducing infiltration on impervious road surfaces.

The channel network is expanded by road ditches creating stream channels in portions of the hillside that were previously unchannelized. Road ditches also intercept subsurface flow and convert it to surface flow. The road density of an area is an indicator of the road system's relative potential for modifying surface and subsurface hydrology.

The stream habitat restoration projects conducted on the GMNF have had a positive effect on stream hydrology by increasing the number of pools (slow water habitat). Increased pool frequency has also resulted in greater water depths and subsequently more water volume being retained in streams. This is very important for aquatic biota during

low flow periods when available wetted channel area and water depth are critical habitat features. Pool habitat also serves to reduce water velocity, dissipate stream energy, and enhance bed load storage during normal high flows and floods. In addition, stream banks and channel bottoms appear to be more stable after large woody debris (LWD) habitat improvements have been implemented.

Soil and water improvement projects and the implementation of management activities on the GMNF have had a positive hydrologic effect on streams such as: stream bank stabilization, landslide restoration, bridge and culvert removal, and riparian area plantings. All these activities reduce erosion, prevent drainage structure failures, and improve infiltration rates.

<u>What type of management do we need to coordinate with and enhance the attainment of the Vermont Water Quality Standards (VWQS) management goals?</u>

The GMNF continues to monitor stream habitat restoration projects implemented over the past decade to evaluate their effects, particularly large woody debris additions on fluvial processes, effectiveness in trapping sediment which improves water quality downstream, habitat, fish, and macroinvertebrates. The projects were designed to mimic the natural woody debris process for streams. The GMNF is also monitoring stream habitat and channel morphology in streams where no habitat restoration is occurring. By monitoring these varying stream conditions, critical links can be made between land uses, river morphology, stream and riparian habitats, and stream biota. The GMNF will continue to coordinate with watershed and basin planning groups and non-government organizations to evaluate project effectiveness in achieving resource protection, enhancement/restoration goals and objectives, and compliance with the forest plan requirements, as well as Vermont's Water Quality Standards for aquatic biota and habitat.

<u>What type/size of buffers are needed to protect surface waters and to provide suitable aquatic habitat?</u>

The forest plan S&Gs (see Forest Plan, page 4.19, item A.4) provides riparian area protection with a filter strip. The filter strip width varies, depending on the land slope and soil erosion potential (Table 1.):

Table 1: Filter strip width based on percent land slope.

Land Slope	Filter Strip Width
1%	50 ft.
10%	65 ft.
20%	95 ft.
30%	125 ft.
40%	155 ft.
50%	185 ft.
60%	215 ft.

During the forest plan revision process, the GMNF will evaluate the filter strip width needed to provide for riparian area protection and suitable aquatic habitat.

Riparian forests include trees and other plants that live and grow near water on the banks of streams, rivers, ponds, and lakes. Prior to European settlement, riparian vegetation along streams was probably healthier than it is today. Early settlements and land clearing, log drives associated with logging in the late 1800s to mid-1900s, and extensive in-river alterations had profound impacts on riparian vegetation, channel morphology, and aquatic habitat. Recent work by VT DEC has quantified the amount of historic channel alterations in several Vermont streams (personnel communication, Mike Kline VT DEC).

Also during the 1900s, the accepted practice was to construct new roads along rivers and tributaries, removing streambank stabilizing riparian vegetation. Agriculture, urbanization and development, and post-flood channelization and berming also resulted in the removal of substantial amounts of riparian vegetation. The degradation of riparian and stream habitats likely persisted for several decades, and continues today at a lesser extent. Fortunately, land use and cultural changes in watersheds have occurred and continue to occur throughout Vermont.

Today, much of the forest cover lost during those early years has regenerated. As a result, most GMNF streams are bordered by second-growth riparian forest. For the most part, only recently acquired GMNF riparian land, in river valleys such as in the White River, lack sufficient riparian vegetative buffers. A GMNF priority is to acquire easements or fee simple acquisitions along streams to enhance reforestation in riparian area buffers. In addition, the majority of riparian lands currently lacking adequate riparian vegetation are generally where agricultural practices and road corridors are the predominant land uses.

Riparian forest on the GMNF and the higher elevations of Vermont are generally 120 years old or younger. Under these conditions, riparian areas can function to capture soil from erosion and prevent it from entering streams, as well as provide a good canopy over streams to maintain desirable temperatures for native aquatic biota. Under these conditions however, there is limited input of large wood into stream channels. Large, old

dead and dying trees that are believed to have existed historically along streams are no longer there to fall into streams and create diverse and complex aquatic habitats.

Many of Vermont's river resource professionals believe that the morphology of most Vermont rivers has been altered by decades of river alterations and dramatic land use changes. A resultant lack of sinuosity, floodplain, and large woody debris input has left stream habitat more homogenous and less complex than past periods when this function persisted. Scientific literature indicates large woody debris is responsible for in-channel storage of sediment and significant amounts of the total sediment yield of a watershed can be in storage behind large woody debris. Large woody debris also plays an important role in forming pools and accumulating gravel beds that can be used for spawning.

As today's second growth forests mature they will become a source of large woody debris with benefits to both terrestrial and aquatic ecosystems. Unfortunately, there are few, if any, undisturbed riparian forests in New England today for scientists, resource managers and interested citizens to study. Rather, we must rely on historical information, current demonstration projects, and modeling efforts to predict future LWD loading in order to create a range of desired conditions for streams. However, the contemporary thinking that historic riparian forests functioned much differently than present riparian forests is becoming more widely supported by natural resource professionals and current research literature, as well as historical accounts like this one from Zadocks Thompson's Natural History of Vermont (1853). Thompson wrote,

> "Before the country was cleared, the whole surface of the ground was deeply covered with leaves, limbs, and logs and the channels of all the smaller streams were much obstructed by the same. But since the country has become settled and the obstructions, which retarded the water, removed by freshets, when the snow melts or the rains fall, the waters run off from the surface of the ground quickly, the streams are raised suddenly, run rapidly, and soon subside."

Item G. Restoration Opportunities

Problem Areas

The major impact on the water quality in the GMNF is acid-deposition, which is being monitored and analyzed very closely in select areas. The ponds and stream sections within the proclamation boundary of the GMNF that have been classified as "impaired" by the Vermont Agency of Natural Resources (VTANR) and United States Environmental Protection Agency (USEPA) show that 54% of the total water bodies listed have problems directly associated with acid deposition. This suggests that GMNF management has not contributed to water quality problems and that the sources of the pollution emissions are from sources originating off the national forest. Other stream sections outside national forest ownership have water quality problems more readily linked to specific local problems such as low flows, excessive erosion and sedimentation, toxic substances, E.coli, and agricultural runoff. GMNF personnel can contribute to acid deposition reduction by fully implementing legislation governing air quality, monitoring air quality and its effects on forest ecosystems, and sharing this information with the public and policy makers.

Despite the acidification problem in some portions of the GMNF, studies show that overall water quality ranks as some of the highest in Vermont. Reforestation and generally good forest stewardship over the past century, under the guidance of Forest Service natural resource professionals, have contributed significantly to the recovery of water quality. However, the recovery of stream habitats and geomorphic (physical) processes lag behind that of water quality. As a result, streams on the GMNF and elsewhere in Vermont are still decades away from realizing the full range of benefits associated with mature riparian forests, adequate floodplains, and their interactions and relationships with stream channels. For example, streamside vegetation buffers for filtering pollution, and canopy cover for adding thermal benefits, have likely contributed to accelerating water quality improvements. Whereas, the benefits of having mature and dying trees from riparian areas falling into streams as large woody debris to trap sediment and spawning gravel, create pools and diversify habitats, and add protective cover for aquatic organisms, are only beginning to occur in our streams. Current GMNF forest management direction provides the basis for recovery of riparian forest and a long-term source of woody debris to restore channel morphology, stability (equilibrium), and habitat diversity.

The general public and natural resource management agencies continue to express concern for the lack of stream stability (equilibrium), erosion from road and stream banks, stream sedimentation, and degradation of aquatic habitat in many watersheds. A large portion of current channel and bank instability and stream sedimentation can be attributed to the removal of riparian vegetation for such land uses as roads, trails, intensively used recreation sites, in-channel alterations to accommodate land uses, forest management, and agricultural production. Channelization following floods and past mill operations and commercial gravel extractions have also contributed to the problem. All these factors have been significant contributors to reductions in fish and macro-

invertebrate populations, loss of habitat, and channel instability. Current GMNF soil and water management direction provides the basis for protecting and improving water quality and riparian area vegetation with buffer and filterstrips, monitoring water quality, and eliminating erosion and sedimentation problems.

Successes

Over the last decade, many projects were implemented to improve water quality and riparian areas by eliminating erosion and sedimentation problems, and by revegetating and stabilizing bare soil areas. Several low-use campsites were closed and revegetated to correct erosion, landslides along streams were revegetated, old roads with erosion problems were closed and revegetated, gravel pits were closed and revegetated, and bridges and culverts were removed along old, closed roads because these structures were causing, or had the potential to cause, stream blockage.

In addition, several projects on trails and roads were implemented to correct erosion and sedimentation problems by installing water bars, culverts, and rehabilitated gullies. Instream habitat benefited from fish passage improvement projects at various road crossings.

The GMNF continues to monitor stream habitat restoration projects implemented over the past decade to evaluate their effects, particularly the addition of large woody debris on habitat, fish, and macro-invertebrates. The projects were designed to mimic the natural woody debris process for streams. By monitoring habitat restoration projects, critical links can be made between land uses, river morphology and habitats, and stream biota. The GMNF can also evaluate project effectiveness in achieving project goals and objectives, as well as compliance with forest plan requirements and Vermont's Water Quality Standards for aquatic biota and habitat.

Results indicate a 5-fold increase of large woody debris in restoration project sites with significant changes to habitat composition (percent of stream area in pool, riffle and run habitat) and complexity (structural makeup and protective cover). Many of the desired habitat conditions identified in the forest plan are being met and overall habitat capabilities appear to be improving. There has also been an increase in aquatic insect diversity (taxa richness), community structure, and total abundance, as well as preliminary findings that trout populations are benefiting from the stream restoration projects.

Stream restoration efforts using "natural channel design" techniques can greatly influence river morphology and stream habitats with long term benefits to the aquatic ecosystem. Stream restoration provides compliance with forest plan requirements for providing the highest water quality and enhancing Vermont's Water Quality Standards for aquatic habitat, aesthetics, and recreation. In future years, the GMNF will continue to use state-of-the-art methods for aquatic resource protection and restoration within a framework that includes multiple management approaches and alternatives such as passive

restoration (corridor protection and riparian revegetation) and active restoration (corridor protection and in-channel improvements).