Water Resources

Introduction

The Water Resource section consists of three sections: (1) *Physical features* of lakes, streams, wetlands and their riparian areas (2) *Water quality* of lakes, streams, wetlands and their riparian areas, and (3) *Biological integrity* for native, desired non-native, and Regional Forester Sensitive aquatic species. Forest Plan direction regarding watershed health and other closely related resources can be found on pages 2-10 through 2-18.

Physical Features of Aquatic, Riparian, and Wetland Ecosystems

Monitoring the physical features of aquatic, riparian and wetland ecosystems includes four components: hydrologic connectivity, riparian integrity, effectiveness of best management practices (BMP's), and in-stream impacts of logging activity.

Hydrologic connectivity

Maintaining connectivity of a stream laterally with its floodplain and longitudinally along its course is important to maintaining its ecological function. Stream crossings for trails and roads have historically been designed to accommodate vehicular and foot traffic at the lowest cost. This has lead to some of the culverts blocking the ability of aquatic organisms to move upstream. This can reduce the ecological function of the stream because organisms use different reaches of the stream at different times of the year and/or during different life stages. The presence, prevalence, and relative impact of these potential obstructions are an important component of understanding of hydrologic connectivity.

Riparian integrity

Healthy aquatic systems require healthy riparian corridors. The presence of long-lived tree species within the near-riparian area is considered a measure of riparian integrity. Hence, the Superior National Forest (SNF) generally encourages the establishment and maintenance of long-lived tree species in appropriate riparian corridors. The species composition of riparian areas of the forest is inventoried and effectiveness of buffer strip prescriptions and underplanting is monitored.

Effectiveness of best management practices

The use of best management practices is a means to minimize the impact of activity on the water quality of lakes, streams, and wetland systems. This is reflected in guideline G-FW-1 regarding consistency with the Minnesota Forest Resource Council (MFRC) guidelines.

BMP's include managing the intensity of activity within the near riparian area and the use of specific design elements to minimize the effect of logging activities. The use of these practices has been documented to be effective by the MFRC and others. Monitoring activities include the use of BMP's and their effectiveness as installed.

In-stream impacts of logging activity
The substrate and channel dimensions of streams downstream of logging projects are monitored to evaluate potential effects of introduction of fine substrate and changes in hydrology that induce a change in channel dimensions.

Land use practices such as timber harvest have the potential to impact water resources through the introduction of fine sediment which is associated with runoff from disturbed project sites. Measures that reduce the potential for impact have been identified and adopted in the Forest Plan and the MFRC voluntary guidelines. These measures include the use of filter strips, set-backs from open-water resources, management of slash, seasonal limitations on activity, management of logging traffic, and design of crossings. Understanding the ability to apply these measures and their effectiveness is important for resource management.

Monitoring Question

Water resources monitoring is related to watershed and riparian health monitoring question listed in Forest Plan Chapter 4 Forest Plan direction

> To what extent is Forest management affecting water quality, quantity, flow timing and the physical features of aquatic, riparian, or wetland ecosystems?

Legal direction pertinent to this question includes the Clean Water Act (P.L. 92-500). Applicable Forest Plan direction includes the following desired conditions: D-WS-5: Water quality, altered stream flow, and channel stability do not limit aquatic biota or associated recreational uses. Water in lakes, streams, and wetlands meets or exceeds water quality requirements. D-WS-6: Watersheds provide an appropriate quantity, quality, and timing of water flow. Stream channels and lakeshores are stable. Stream temperatures are maintained within their natural range and are not increased by lack of shading or because of channel instability. Stream channels, including those in wetlands, are able to transport water and sediment without changing their pattern, dimension, and profile. Sensitive stream types are protected and improved. Management activities protect or promote quality of habitats that occur in the riffle areas of streams, improving stable channel characteristics. D-WL-1: Aquatic and terrestrial wildlife habitats are diverse, productive, and resilient.

Related guidance from other program areas includes G-FW-1, O-RWA-1, D-PH-3, D-PH-4, O-PH-3, O-TS-4 and O-TS-5.

There are four units of measure for the *physical* elements of water resource management: (a) hydrologic connectivity (b) riparian integrity (c) effectiveness of best management practices and (d) in-stream impacts of logging activity. The unit of comparison is the annual change or trend of physical water resource features since 2004.

The selected monitoring question and drivers are appropriate because they help assess whether Forest management is meeting the Forest Plan desired conditions, most generally expressed in D-WS-1 which states in part that the desired condition is that watersheds "*are part of healthy ecosystems that….provide for unique plant and animal communities, special habitat features, habitat linkages, wildlife corridors, aquatic ecosystems and riparian ecosystems*".

Monitoring Method(s)

Hydrologic connectivity

Road crossings are inventoried for potential impedance to aquatic organism passage. This inventory is used to:

- *Quantify* the scale of the problems that need to be addressed
- *Prioritize* where additional information is required, and
- *Develop a long-term implementation strategy* to reduce the impacts to aquatic organism passage.

The inventory has progressed forest-wide and it is anticipated that most of the USFS roads and many of the trails will be inventoried by the end of 2010 using the *Coarse Level Stream Crossing Assessment*. Over 1,000 crossings have been inventoried on the SNF using this assessment since 2002. The monitoring continued through 2010.

Riparian integrity

Assessment of riparian areas is typically performed as part of site investigations associated with proposed vegetative management projects. Areas of potential vegetative management activity or likely candidate areas are visited and evaluated. Based upon these site visits, sites are selected to be planted with long-lived species.

After the sites have been planted, additional activity (such as installation of browse protection, thinning, or releasing) are performed to decrease long-lived species mortality. Monitoring of previously planted sites is performed to determine the effectiveness of the planting and overall mortality of planted material.

Effectiveness of best management practices

Site visits were made of recently completed logging operations on the SNF. The protocol used for evaluation is similar to the tools used by the MFRC to determine BMP effectiveness. Timber harvest units that were monitored were derived from a pool of candidate sites harvested (or final treatment conducted) during the past four years. Units containing or adjacent to wetlands or streams and those containing Ecological Land Types (ELT) 1-6 were prioritized for monitoring. These six ELTs describe differing conditions of lowlands including ELTs 1-4 which typically possess hydric soils, wetlands, and/or riparian areas. Water resources such as these are functionally linked to adjacent uplands and many forest invertebrate and vertebrate species are influenced by site level activities.

In-stream impacts of logging activity

Stream monitoring reaches were established to evaluate the effects of logging operations on water quality, flow timing, and the physical features of aquatic, riparian, or wetland ecosystems. Since 2005, twenty reference reaches have been established and measured to represent a range of stream conditions found on the Superior National Forest as well as varying degrees of adjacent management based on specific projects and proposed actions.

At present, eight reference reaches have sufficient data to warrant analysis based on number of measurements (three years of data within a five year period). These sites include three with no

adjacent management activity and five with adjacent harvest. For sites with adjacent harvest activity, both pre-treatment and post-treatment data are analyzed.

Fluvial geomorphic measurements were taken at each reference reach including:

- Cross-sections measurement,
- Longitudinal profiles,
- Bank full dimensions, and
- Streambed material

This data was collected using surveying levels and tapes. Bed material data was collected using "Wohlman" pebble counts. Metrics collected include cross-sectional area, bankful width, bankful elevation, mean depth, maximum depth, width-to-depth ratio, wetted perimeter, hydraulic radius, and substrate distribution.

Results

Hydrologic connectivity

In 2009, 106 culverts were assessed on the Superior National Forest. Of these, approximately 20 percent of the culverts may be a physical barrier to passage because they are in poor condition or are placed too high (See Figure 2.1). Overall, approximately 27 percent of the 1,169 culverts assessed by the end of 2009 may be a barrier to passage and will require a more detailed assessment to determine:

- *If* replacement or reconstruction is warranted,
- What the *dimensions* should be for the new culvert(s), and
- Priority for eventual implementation.

Figure 2.1. Example of a Barrier to Aquatic Organism Passage

While a minority of these identified culverts may be a barrier to *all passage at all flows*, many of the culverts are a barrier to *some passage some of the time*.

Prioritization for eventual modification of the culverts includes the following considerations:

- Degree of the passage barrier
- Type of fishery or aquatic resources associated with the stream
- Context of the crossing (is it the only crossing that is a problem or are there others on the stream, is there a natural barrier immediately downstream, etc.),
- Other considerations regarding the adequacy of the crossing, such as the physical condition of the culvert (is it in poor condition and needs to be replaced anyway?) and safety.

Riparian integrity

In 2009 riparian areas within the Twins, Toohey, and Tracks project areas were evaluated for opportunities to establish long-lived species as prescribed by the Forest Plan. Based upon these evaluations, we have proposed planting between 50 and 100 acres of riparian areas along lakes, wetlands, and streams in these projects. The implementation of these planting projects is awaiting the completion of NEPA documents and will likely occur by 2015.

Monitoring of previously planted areas did not occur in 2009. However, previous monitoring has shown high variability in the success rate. This is due to the inherently dynamic nature of riparian areas as well as traditional stressors of competition and deer browse. In addition, many of these plantings are within transitional habitats and by definition at the fringe of upland environment. For the above reasons, the success rate of these plantings is measured differently than the commonly applied metric used for upland replanting after a site has been logged. Ultimate success may range from a dense stand of long-lived conifers providing shade on a small stream to a 'handful' of white pine that survive to full maturity and provide nest sites for bald eagles.

Effectiveness of best management practices

The results of visits to fourteen sites in the fall of 2008 have been expanded since the 2008 Monitoring Report. The result of this monitoring activity is briefly summarized below:

"We visited fourteen sites and found little evidence depicting negative impacts upon most water resources. Generally most sites visited were well mitigated to protect water resources and ameliorate any temporary intrusions resulting from silvicultural activities. No evidence of sustained sedimentation into wetlands and riparian areas was found despite some cutting into these areas. Some areas contained shallow rutting and may have held water but these areas were well away from permanent water resources." (Ossman and Brennan, 2008).

Additional site visits were conducted in 2009. The result of this monitoring effort is briefly summarized below:

"In field season 2009, we observed a wide array of visible and corollary factors from timber harvest operations. The majority of sites did not display negative impacts to water resources resulting from timber harvest. Moreover, most sites visited had very minimal impacts that were visible, and those sites that were bordering a lake, stream, or permanent wetland provided sufficient buffers to minimize impacts of timber harvest activity". (Ossman and Thompson, 2009).

Overall, monitoring efforts have shown that any impacts of logging to water resources on the Superior National Forest have been relatively local in nature. The monitoring to date has generally shown that the application of Forest Plan standards and guidelines adequately protect water resources.

In-stream impacts of logging activity

Changes in metrics measured in the field can be attributed to a combination of precision limitations in the measurement and analysis of physical features, natural variability of the system, and modifications associated with logging activity. Specifically, these changes are described as:

- Systematic uncertainty (associated with limitations of the instruments, methods, and personnel)
- Random uncertainty (natural variability of the physical characteristics of the stream),
- Changes within the stream that are a result of logging including:
  - modified driving forces (peak flow magnitude, timing, or duration),
  - modified resistant forces (change in the type or amount of riparian vegetation), or
  - Local influences such as the introduction of woody debris or sediment.

Collection and analysis of data at sites where no logging has occurred provides an opportunity to estimate the systematic and random uncertainty. Understanding the presence and magnitude of these precision limitations are important in discerning the effects of logging.

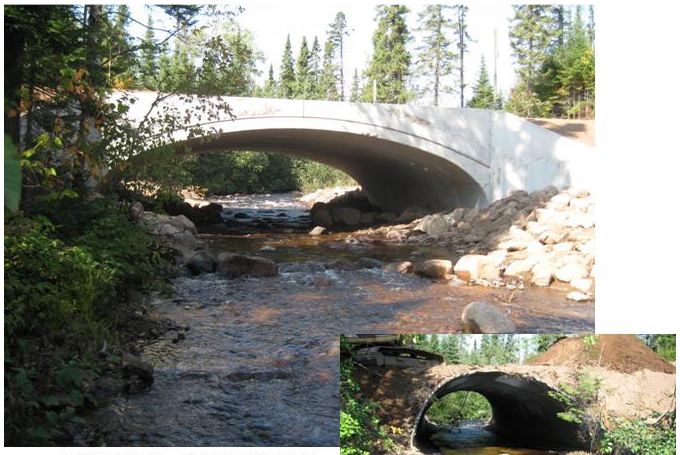
Data and metrics calculated for the eight reference reaches suggest all sites are within normal ranges of variability. The changes in the stream metrics near logging sites were similar to sites where no logging had occurred. This indicates that the logging activity within the upstream watershed has not impacted the channel shape or substrate in these reaches to date.

Implications

Hydrologic connectivity

Based on the results of the coarse level culvert assessment, additional field work is needed to confirm initial observations about potential impedances to aquatic organism passage. Follow-up or detailed site assessment has confirmed the need to modify numerous crossings. As a result of this assessment process, the SNF has implemented a program to modify culverts on an annual basis as funding allows. Since the adoption of the Forest Plan in 2004, twenty nine culverts have been successfully modified or replaced in accordance with established design criteria to accommodate aquatic organism passage. See figure 2-2. As problem crossings are modified over time the stream connectivity will be restored and the ecological function of the streams will be improved.

Figure 2-2. Poplar River Culvert Replacement



Poplar River—After Construction

Poplar River— *Prior to Construction*

Riparian integrity

Surveys of riparian areas have found opportunities to implement Forest Plan direction to increase the long-lived species within riparian areas. Planting these areas as prescribed will help meet Plan objectives.

The effectiveness of planting strategies has been measured. However continued monitoring is important to obtain more information on the suitability of various planting strategies and long-term viability.

Effectiveness of best management practices

Monitoring of the implementation of the Forest Plan standards and guidelines appears to adequately protect the water resources of the forest. These standards and guidelines should continue to be implemented as part of forest management.

In-stream impacts of logging activity

Some of the identified sites have recently been logged and the effects analysis can be monitored over the next several years. Any effects to the morphology of the stream may take several years to manifest themselves because (1) gradual processes take time to accumulate to show an effect on the landscape, and (2) natural disturbances (such as floods, etc.) occur randomly over time and the longer the monitoring period the higher probability that an event will occur and the related effects will manifest themselves.

The results of monitoring efforts to date help define the variability in the undisturbed physical conditions and uncertainty in the data collection, and analysis procedures. Understanding this inherent variability in systems on the Forest is extremely important in performing a departure analysis for systems that have been logged to ensure (1) that a causal effect is appropriately attributed to an activity and (2) the magnitude of a change is put into the context of natural variability and precision limitations.

The lack of any discernable physical change (aside from natural variability) at reference sites implies that recent management activity has had no effect on the physical integrity of streams to date. Continued monitoring efforts will evaluate whether best management practices, forest plan standards and guidelines, and project design features are effective at protecting in-stream aquatic resources.

Recommendations

1. Hydrologic connectivity

The coarse level and more detailed assessment of crossings for potential blockages to aquatic organism passage should continue. This information is important in identifying and prioritizing projects. Continued financial support of the modification or reconstruction of crossings to accommodate aquatic organism passage provides improved ecological function of streams as directed by the Forest Plan.

2. Riparian integrity

The Superior National Forest should plant the riparian areas identified to date. It should continue to assess other riparian areas during the mid-level process to look for additional opportunities to establish long-lived species in riparian areas as appropriate.

3. Effectiveness of best management practices

One of the main recommendations that resulted from the monitoring in the fall of 2008 was to perform additional monitoring immediately after the logging has occurred. This recommendation was incorporated into the 2010 monitoring.

4. In-stream impacts of logging activity

As more time passes the streams will be subject to more flows and larger events, and additional logging activity will occur. Thus, changes to the streams *may* be expressed in the future. Continued monitoring will allow a stronger departure analysis to occur over the next several years because more sites will have adjacent logging occur and more post-treatment sampling data will be collected.

The results of this departure analysis will help discern whether the implementation of Forest Plan management strategies are adequately protecting aquatic and water resources. In addition, it is important to continue to monitor physical attributes to evaluate the variability and uncertainty in the natural system, data collection techniques, and analysis methods.

Water Quality of Aquatic, Riparian, and Wetland Ecosystems

Monitoring Question

The following monitoring question was selected to evaluate the water quality aspect of water resources monitoring.

> What is the existing water quality? Is it changing? and is the USFS land management activity causing a change?

The above question is driven by the Clean Water Act (P.L. 92-500) and the following Forest Plan direction: Desired Conditions D-WS-2, D-WS-4, D-WS-5, and objectives O-WS-1, O-WS-7.

The units of measures selected were mercury concentrations in air, soil, water, and fish along with other chemical information, such as nutrients in aquatic systems. These units of measure were compared in an analysis of paired watersheds. The following units of comparison were addressed: trend analysis of fish tissue concentration, base-line water quality information, and trend analysis of water quality constituents.

This monitoring question and driver are appropriate because they assess whether Forest management is meeting the Clean Water Act requirement of non-degradation and Plan requirements to protect water quality on the Superior National Forest. Consideration of water quality parameters allows us to estimate how well O-WS-1 is being integrated into Forest Plan implementation. Understanding the mercury cycle in forest systems is important to put mercury concentrations in context with forest management activities.

Mercury (Hg)

Mercury is a chemical that is of concern because it can concentrate in food chains to levels that can damage nervous systems, particularly developing systems such as those of young children and fetuses. There is a statewide fish consumption advisory for all waters based on mercury. In addition, 289 lakes and nine streams have been specifically identified by the Minnesota Pollution Control Agency (MPCA) as containing fish with mercury levels over state consumption thresholds.

Mercury generally enters the soil through atmospheric deposition, and makes its way to aquatic systems through erosion. There is little that the Superior National Forest can do to control atmospheric deposition. Emission controls at coal-fired power plants and other sources are needed to manage atmospheric deposition. However, to minimize any potential negative impacts, activities that disturb soils and allow the soil organic matter to leave a site should be minimized. Prescribed fire and controlled burns may also affect mercury transport to aquatic resources.

Nutrients and Other Water Quality Parameters

Nutrients and other water quality parameters are appropriate because they are regulated by the Clean Water Act and elevated values can impair use and ecological function. The primary government agencies that have monitored water quality on the Superior National Forest are the Environmental Protection Agency (EPA), Minnesota Department of Natural Resources (MnDNR), Minnesota Pollution Control Agency (MPCA), and the U.S. Forest Service. The EPA tends to conduct nationwide surveys of water quality conditions that will include a few lakes on the Forest and the MPCA has a number of ongoing surveys for different purposes.

Monitoring Methods

Monitoring of water quality was performed for lakes in the Superior National Forest. The general water quality constituents monitored are mercury, nutrients and other constituents.

Mercury (Hg)

There are two means of monitoring mercury on the SNF. First, the SNF continued its 30+ year partnership with the MN DNR by providing funds to test game fish from lakes within the SNF for mercury and other contaminants. The data from this work are included in the Minnesota Department of Health's fish advisory database where it is accessible to the public (MDH 2010).

Second, in an attempt to answer the question of how mercury in fish is affected by wildland fire, the Superior National Forest is currently participating in a monitoring study led by Northern Research Station. This study assesses mercury cycling processes in both pre- and post-burned watersheds in the Boundary Waters Canoe Area Wilderness (BWCAW). The study focuses on burns associated with the prescribed burning program developed in response to the 1999 blowdown event. The blowdown area provides a rare opportunity to study fire/ecosystem Hg interactions in a wilderness that is dominated by lakes and wetlands. We have selected 5 pairs of undeveloped lakes in watersheds planned to be burned and watersheds not planned to be burned. Within these watersheds, we measure total-Hg, methyl-Hg (bioaccumulative form of Hg) and other important ions in precipitation, throughfall, soil, lake water and in 1+ year fish (perch) both pre-burn and post-burn, to assess sources of Hg and determine if changes in sources alters the concentration of Hg in fish.

Nutrients and Other Water Quality Parameters

Watershed Assessments

The MPCA has a number of ongoing surveys for different purposes. They recently started an intensive watershed monitoring program that includes a systematic sampling of the watershed to assess ability of the aquatic systems to support aquatic life, aquatic recreation and human consumption. This process will also prioritize subwatersheds based on measured impairments for Phase II monitoring. The goal of Phase II monitoring is to identify stressors and pollution sources and to provide data for the development of cleanup plans (Total Maximum Daily Loads).

Lake Assessments

The MPCA also has a lake assessment program that was developed in 1985 in response to requests from lake associations that were interested in cooperatively assessing the condition of their lake. The lakes on the Superior National Forest that have been assessed (2000 to 2010) are listed below in Table 2.1.

Table 2.1. SNF Lakes by MPCA

Vermilln	Devil Track	Greenwood	Wilson
Moose	Caribou	Clearwater	Trout (Vermillion)
Flour	Gunflint	Tait	Trout (Gunflint Trail)
Poplar	Ban	Crane	Little Vermillion
Pelican	Elbow	Elephant	White Iron Chain
Echo	Fall	Shagawa	Eagles Nest
Birch	Bearhead	Whiteface Reservoir	

Sustaining Lakes in a Changing Environment (SLICE)
A third program the MPCA, DNR, and SNF support is the Sentinel Lakes partnership. The Sentinel Lakes are the focus of a long-term, collaborative monitoring effort led by the DNR. The overall program, referred to as "SLICE – Sustaining Lakes in a Changing Environment," is designed to understand and predict the consequences of land use and climate change on lake habitats. This program will involve long-term monitoring of water chemistry, fisheries, habitat and other factors in these lakes as well as detailed assessments of watersheds and related characteristics. The study began in 2008. Five lakes on the Forest are part of this study.

Results

Mercury (Hg)

Monson (2009) recently analyzed Minnesota's fish-mercury data and found a year (1992) that divided a period of generally decreasing concentrations (1982 to 1992) from one of increasing concentrations (1992-2006). The reason for this change is not immediately obvious although climate change factors, such as increases in temperature, rainfall intensity, runoff, and water level fluctuations, could alter either the methylation or the mobilization of mercury.

The study with the Northern Research Station began in 2004 and to date only two pairs of lake watersheds have been burned (one just last fall). Even after burning, it may take a number of years for the effects to be seen. Therefore a comprehensive summary of results from the study are not expected for a number of years. A number of ancillary questions have been answered in peer-reviewed papers and these papers are included in the references. As monitoring results become available more detailed assessments can be drawn regarding the impact of controlled burning.

Nutrients and Other Water Quality Parameters

Watershed Assessments
Detailed reports on lake and watershed condition and trends are developed as a part of these studies. These reports can be found at http://www.pca.state.mn.us/water/lakereport.html.

Lake Assessments
Five lakes were monitored in 2006 by the USFS and MPCA including Greenwood Lake, Devil Track Lake, Wilson Lake, Moose Lake, and Trout Lake. The assessment concluded that, "*Based on these data, water quality has not changed significantly over the period of record (1980's to the present). Also a comparison with sediment diatom-reconstructed TP values based on 20 Northern Lakes and Forest (NLF) lakes suggests that all five lakes are well within the typical range of pre-European TP values for NLF lakes."* No reports are available for assessments that may have occurred in 2009.

Sustaining Lakes in a Changing Environment (SLICE)
Five SLICE lakes were sampled for aquatic vegetation, including Tait, Trout Lake, Echo Lake, Elephant Lake, and White Iron Lake. Because 2008 was the first year of the five year monitoring effort, only summary and baseline data are available. In general, these lakes represent the natural range of lake and watershed conditions within the Northern Lakes and Forest Ecoregion. Future monitoring and evaluation reports will include analysis of trends in the biological (fish and aquatic plants) communities and chemical (nutrients) components over time. Partners on the project (Minnesota Department of Natural Resources and Minnesota

Pollution Control Agency) will analyze data and use the results to develop a long term monitoring plan for additional lakes on a rotating survey schedule. This data set will be used to determine long term changes in the environment such as climate.

Summary of Results:
Overall, the water quality is very good within the lakes and streams of the Superior National Forest. There are some isolated water resources that have been identified as impaired and mercury continues to be an issue for nearly all lakes within the region and nation. There does not appear to be a negative trend in water quality associated with USFS land management practices.

Implications

Mercury (Hg)
Fish consumption advisories may change in the future if there is a marked change in the mercury concentrations of fisheries. This may also provide additional impetus for emission control at pollution sources.

The eventual results of the study with the Northern Research Station will provide additional information regarding the role of fire in the mercury process. This information will be valuable for the prediction of impacts of wildfire.

Nutrients and Other Water Quality Parameters
Lake assessments reviewed have not indicated a negative impact to water quality associated with USFS land management activity including logging activity.

Recommendations

1. Mercury (Hg)
The Superior National Forest should continue to support the mercury studies and the source reduction strategies administered by other state and federal agencies.

2. Nutrients and Other Water Quality Parameters
The Superior National Forest should continue to support the MPCA in their lake assessment program.

Biological Integrity of Aquatic Species

Biotic integrity is defined as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley 1981).

Monitoring Question

This section discusses monitoring of the biological integrity of lakes and streams in the context of the following monitoring questions:

To what extent is Forest management providing ecological conditions to maintain viable populations of native and desired non-native species? To what extent is Forest management contributing to the conservation of sensitive species and moving toward short term (10-20 years) and long-term (100 years) objectives for their habitat conditions and population trends?

The above questions are driven by the Clean Water Act (P.L. 92-500) and the following Forest Plan direction Desired Conditions D-WL-3 and objectives O-WL-1, O-WL-2, O-WL-3, O-WL-18, O-WL-28, O-WL-29 and O-WL-36 (MIH 14).

The units of measure chosen are the number of aquatic organism passage barriers identified and assessed on the SNF and fish community data that were collected at reference sites for multiple years. Reference sites represent the SNF range of streams and management activities.

The unit of comparison selected for aquatic organism passage was the number of aquatic organism passage barriers removed. The units of comparison selected for fish community data was departure in fish community diversity and similarity measures at sites between sample periods.

Aquatic organism passage barriers, particularly road crossings, are one of the largest potential impacts to aquatic resources on the forest. Efforts to remove or replace crossing structures to accommodate organism passage restore the connectivity of aquatic systems and benefits aquatic species (also see Hydrologic Connectivity).

Changes in fish community diversity and similarity between years at identical sites can indicate changes in the larger aquatic community. These changes may be due to natural or anthropogenic stressors. By using a series of reference sites with and without adjacent forest management activities, natural variability can be separated from changes due to impacts from forest management activities.

Monitoring Method(s)

Aquatic Organism Passage

Road crossings are inventoried for potential barriers to aquatic organism passage. Crossings are prioritized for redesign and replacement based on factors including organism passage capability. See Hydrologic Connectivity section for complete discussion.

Fish Community Data

Stream monitoring reaches were established to evaluate the effects of forest management activities on biologic features of aquatic ecosystems. Since 2005, twenty reference reaches have been established and measured to represent the range of stream conditions found on the Superior National Forest as well as varying degrees of adjacent management based on specific projects and proposed actions. At present, eight reference reaches have sufficient data to warrant analysis based on number of measurements (three years of data within a five year period). These sites include three with no adjacent management activity and five with adjacent harvest. For sites with adjacent harvest activity, both pre-treatment and post-treatment data are analyzed. Fish community data were taken at each reference site using single pass electrofishing. Analysis of the fish community included measures of diversity and statistical

analysis (ordination) using the species matrixes (type and relative abundance of fish species) at each site and for each year of sampling. Timing and sampling effort was kept similar for each site during each sampling event.

Results

Aquatic Organism Passage

Since the adoption of the Forest Plan in 2004, twenty-nine culverts have been successfully modified or replaced in accordance with established design criteria to accommodate aquatic organism passage. As problem crossings are modified over time, the stream connectivity will be restored and the biological integrity of aquatic systems will be improved.

Fish Community Data

Fish diversity and community similarities for the eight reference reaches suggest no significant shift in community structure between years at any of the sites. Sites were differentiated from each other using statistical similarities and ordinations of each site and each year of sampling. Similarity was generally higher among sampling years at the same site rather than between different sites. Samples with higher numbers of species and abundances (generally warm- or cool-water fish communities) had higher similarities than sites with fewer species and abundances (cold water communities). Data also show that catch per unit effort are similar at sites between years for most fish species. Species that are present at a site in one year and absent in the other years have low relative abundance and low detection rates (low catch per unit effort), indicating that these species are subject to greater sampling variability. Overall, these sites represent the range of species expected in wadeable streams on the SNF.

Implications

Aquatic Organism Passage

Aquatic organism passage barriers that have been successfully removed, modified, or replaced will benefit aquatic organisms and biological integrity. As problem crossings are modified over time the stream connectivity will be restored and the biological integrity of aquatic systems will be improved. These improvements will also benefit several Regional Forester Sensitive Species (RFSS) of fish and mussels.

Fish Community Data

Continued monitoring will allow a stronger departure analysis to occur over the next several years as more sites experience adjacent management and more post-treatment sampling events are made. The results of this departure analysis will help discern whether the implementation of Forest Plan management strategies is adequately protecting aquatic and water resources.

Recommendations

1. Aquatic Organism Passage

By continuing to assess, design, and implement aquatic organism passage projects, stream connectivity will be restored and the biological integrity of aquatic systems will be improved. These improvements will also benefit several RFSS fish and mussel species.

2. Fish Community Data

It is important to continue to monitor the biological attributes of aquatic systems to evaluate the variability and biological integrity of the resource. In addition, as some of the watersheds have now had some logging activity, continued monitoring will allow a departure analysis to occur over the next several years. The results of this departure analysis will help discern whether the implementation of Forest Plan management strategies is adequately protecting aquatic and water resources.

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