LEOPOLD INSTITUTE CASE STUDY ON ECOLOGICAL RESTORATION IN WILDERNESS

Saint Mary's Wilderness

Depositing limestone sand in the Saint Mary's River to buffer the effects of acid deposition on aquatic organisms

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Case Study of Ecological Restoration in Wilderness

2013

UNITED STATE FOREST SERVICE, GEORGE WASHINGTON AND JEFFERSON NATIONAL FORESTS

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This case study is part of a collaborative partnership between the Aldo Leopold Wilderness Research Institute and The Wilderness Society to describe ecological restoration actions that have been implemented within the National Wilderness Preservation System. The specific case studies were selected to represent a mix of wilderness agencies, geographic regions, restoration issues and complexities. The case studies were written by staff at the Leopold Institute, in consultation with wilderness managers.

Cover photo: St. Mary's Falls, source <http://www.wilderness.net/NWPS/wildView?WID=513>

SUPPORTING GRAPHICS

Acronym Key

EA: Environmental Assessment
EPA: Environmental Protection Agency
MRDG: Minimum Requirements Decision Guide
NWPS: National Wilderness Preservation System
USFS: United States Forest Service

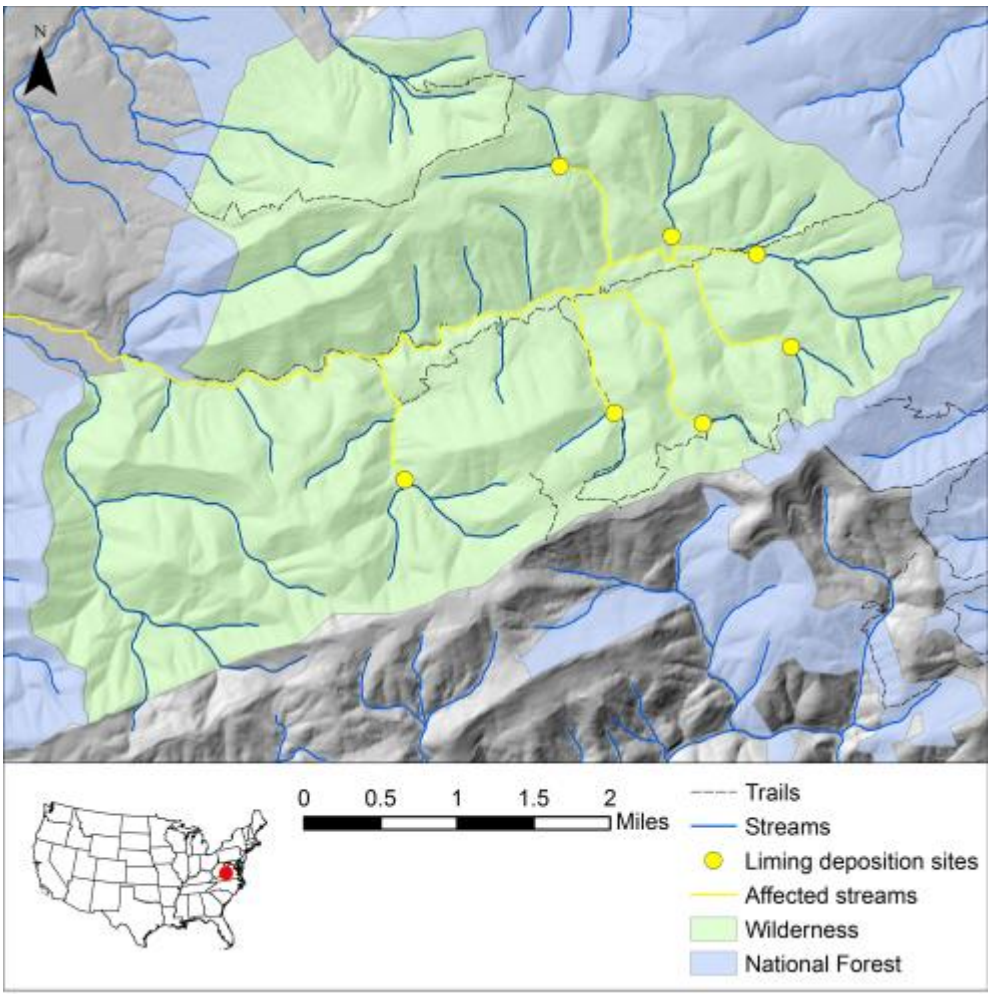

Figure 1 Limestone deposition sites and affected streams in Saint Mary's Wilderness.

INTRODUCTION

The passage of the Wilderness Act by Congress in 1964, followed by President Lyndon Johnson signing the Act into law, marked a new era in protected area designation and public land management for the United States. Under the newly established National Wilderness Preservation System (NWPS), wilderness was, "recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions…" (PL 88-577).

Fifty years after the passage of the Wilderness Act, a combination of major ecological stressors-including invasive species and climate change-are creating new and unprecedented challenges for wilderness managers. Today, ecological restoration has become one of the most important, ethically complex, and potentially litigious wilderness stewardship issues in the history of the Wilderness Act. More specifically, the legal mandate to preserve the natural quality of wilderness character is leading managers to consider increasingly intrusive management interventions in place of historically minimal management. The dynamics and uncertainties of this management shift call into question traditional planning approaches, such as the use of historic conditions to define management targets; and require the incorporation of diverse legal, scientific and ethical considerations into management planning.

The four agencies that manage wilderness—the Department of the Interior Bureau of Land Management (BLM), U.S. Fish and Wildlife Service (USFWS), National Park Service (NPS), and the Department of Agriculture U.S. Forest Service (USFS)—receive hundreds of proposals to implement ecological restoration and other types of intervention actions within the NWPS every year now, including an increasing number of proposals generated by climate adaptation objectives. Ecological interventions that are currently proposed and implemented within wilderness include:

1. Actions that sustain, restore, or manage vegetation (e.g., chemical and mechanical removal of invasive plants, planting trees, spreading seed and fertilizer);
2. Actions that sustain or restore fish and wildlife, or manage insects and disease (e.g., biological control agents, fish stocking, animal removal, fish barriers, water guzzlers, introducing animals);
3. Actions that manage soil and water issues (e.g., diverting water for irrigation, mine site reclamation, spreading lime to buffer acid deposition); and,
4. Actions that manage fire (e.g., suppressing naturally-caused fire, mechanical fuels reduction treatments, prescribed fire).

Current laws and policies do not provide an explicit, decision-making framework for wilderness stewardship in the face of these new threats, but require wilderness managers to evaluate the effects of proposed restoration actions while simultaneously preserving wilderness character. Based on the legal definition of wilderness, National Wilderness Preservation Managers agree on five fundamental qualities of wilderness character: (1) Untrammeled; (2) Undeveloped; (3) Natural; (4) Solitude or primitive and unconfined recreation, and, (5) Other features of value. As defined by the Wilderness Act, wilderness lands were intended to be protected in their "natural condition" (i.e. species, patterns, and processes that evolved in the area) and "untrammeled by man" (i.e. free from intentional modern human control and manipulation). Balancing the natural and untrammeled qualities of wilderness character is a persistent wilderness stewardship challenge that may force a decision tradeoff. In addition, the accumulation of seemingly small-scale decisions and management actions has the potential to change wilderness character over time.

In this document, we present a case study of an ecological restoration action that has been implemented within a designated wilderness area in an attempt to preserve its wilderness character. The intent of these case studies is to provide detailed information about the tradeoffs involved in making decisions that simultaneously affect the natural and untrammeled qualities of wilderness, characterize similarities in management activities across projects, learn more about the basis for proposed ecological restoration, and quantify the extent to which climate adaptation is cited as the motivation for taking action.

FRAMING THE ECOLOGICAL PROBLEM

History of the Saint Mary's Wilderness

Figure 2: Stream inventory and monitoring. Photo credit, SRS CATT, USDA Forest Service

Saint Mary's Wilderness was designated in 1984 through the Virginia Wilderness Act (Public Law 98-586). Managed by the George Washington and Jefferson National Forests, the 9,835 acre Wilderness lies in the Blue Ridge Mountains of west central Virginia. This southern Appalachian hardwood ecosystem includes the Saint Mary's River and the many tributaries that feed into it, all of which eventually flow into the Chesapeake Bay. Popular with day hikers and anglers, Saint Mary's Wilderness is relatively easy to access, includes a substantial network of trails, and contains the attractive destination of Saint Mary's Falls.

The decision to protect Saint Mary's through Wilderness legislation was based on widespread public recognition of the many wilderness values contained within the area. The eastern deciduous forest and Forest Service land surrounding Saint Mary's hosts over 40 tree species, and provides habitat for more than 2,000 species of native shrubs and herbaceous plants. White-tailed deer, black bears, and less common species such as the smooth green snake and big levels salamander thrive in these forests, while rhododendron and mountain laurel line the gorge that surrounds the river. Saint Mary's River is considered a priority watershed in the Revised George Washington National Forest Land and Resource Management Plan and is listed as a Class I Native Trout Stream[1] (USFS 2014, Wilderness.net). In the words of the legislative committee that reviewed the draft legislation, "This river is recognized throughout the State for its sparkling cascades and superb trout fishery" (USFS 2011, p. 15).

Historical activities in the area have shaped the ecosystem during the last several centuries include manganese and iron mining in the 1800s and early 1900s, as well as periodic logging as recently as the 1950s. Extensive gypsy moth defoliation occurred from 1991 to 1994 leading to heavy oak tree mortality; subsequent defoliation significantly increased nitrate concentrations and decreased pH levels in the stream water (USFS 2011). Occasional wildfires have occurred in the area, most recently in 2008, when a significant fire burned nearly a third of the wilderness. Fire suppression efforts in 2008 included the authorized use of chainsaws, portable pumps, helicopters and other motorized equipment. Evidence

Figure 3: Ovenbirds are just one of many birds that call Saint Mary's Wilderness home. Photo credit, Terry Slater, USDA Forest Service

[1] "A stream of outstanding natural beauty possessing wilderness or at least remote characteristics, an abundance of large deep pools, and excellent fish cover. Substrate is variable with an abundance of coarse gravel and rubble. Stream contains a good population of wild trout or has the potential for such" (USFS 2011).

of human activities, while fading, is still observable in this area today.

Ecological Restoration Issue

The primary cause of ecological degradation in the Saint Mary's Wilderness is acid deposition, stemming from human-induced air pollution from the region and the region and the Ohio River Valley. More specifically, fossil fuels create sulfur and nitrogen oxides when burned, generating strong acids (HNO_3 and H_2SO_4) through chemical reactions in the atmosphere. These compounds subsequently return to earth's surface in the form of highly acidified precipitation (i.e. pH of 4.3); and acid rain in this region is known to be extremely potent, or ten times more acidic than the unpolluted rainfall of the nearby Shenandoah Valley of Virginia (Webb et al 1989a). The Environmental Assessment for Saint Mary's Aquatic Mitigation Project reports that "Although sulfur deposition is decreasing, modeling studies have shown that recovery of streams in the Saint Mary's watershed will take over one hundred years under the current air regulations[2]" (USFS 2011, p. 3). Acidification of Saint Mary's River has been further exacerbated by the underlying geology of the area, which offers little buffering to neutralize the acid.

Scientific studies have demonstrated that aquatic organisms are extremely sensitive to acidic water, which affects sodium regulation and can lead to asphyxiation (Olem 1991). According to one analysis, "acid deposition was determining what species of aquatic life could exist in the Saint Mary's Wilderness. At least 20 indigenous aquatic species were extirpated from the streams. There was a concern that continued loss of components of the aquatic ecosystem severely threatened the long term biological integrity and stability of this wilderness river" (USFS 2011, p. 2). Acid sensitive macro-invertebrates, once comprising 40-50% of the insect community within streams, fell to 1-2%. As the situation deteriorated over time, the need to increase the pH (i.e. by reducing the acidity in the river and streams) became pressing in the eyes of managers. Many species of fish, insects and macro-invertebrates had declined substantially, and the loss of so many species was rapidly leading to an impaired ecosystem, degrading the natural qualities of the Saint Mary's Wilderness.

Historically, the pH of the Saint Mary's River was 6.8, but by the mid-1990's, acid rain had lowered the pH substantially to 4.9-5.6. The greater than 100-fold increase in acidity has had dramatic consequences for the overall health of the aquatic system and biodiversity. In 1999, managers began to use targeted management actions to combat the acidification and loss of species.

[2] See http://www.epa.gov/castnet/charts/shn418ts.gif and SAMI final report

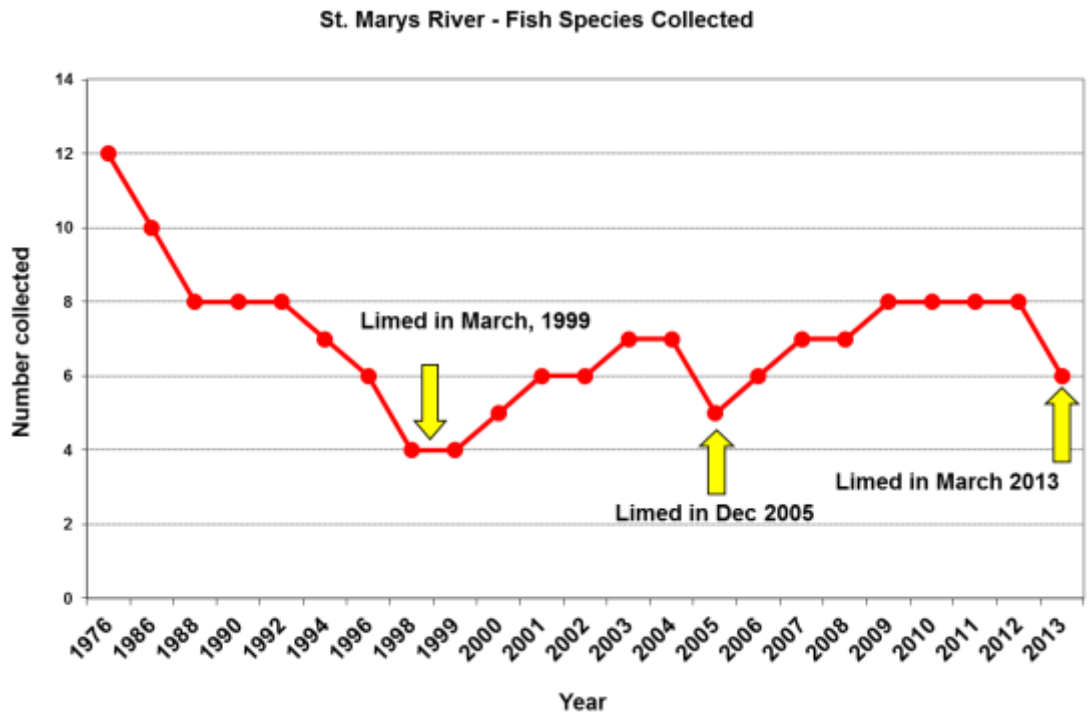

Figure 4: By the early 1990s, 12 species of native fish dwindled to four species as a direct result of acid rain, which transformed the waterways from a neutral pH level of 6.8 to a highly acidic pH level of 4.9-5.6. Graph provided by D. Kirk, USDA Forest Service.

RESTORATION PROPOSAL & IMPLEMENTATION

In this section we review the legal and political framework guiding the restoration actions of Saint Mary's Wilderness Managers, along with the restoration objectives, ecological criteria for restoration, monitoring plans, management alternatives, values and ethics, and the effects analysis.

Law and Policy

Saint Mary's Wilderness is managed in accordance with the provisions of the following laws and policies.

Laws

The Wilderness Act of 1964[3] *(PL 88-577)*

Section 4(b) of the Wilderness Act states that, "each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area and shall so administer such area for such other purposes for which it may have been established as also to preserve its wilderness character." Section 2(c) defines wilderness and states that "An area of wilderness...which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable" (PL 88-577).

Virginia Wilderness Act of 1984[4] *(PL 98-586) and Virginia Wilderness Act of 1988*[5] *(PL 100-326)*

These acts provide the designating legislation for Saint Mary's Wilderness which now compromises 9,835 acres. There are no special provisions in the legislation that effect the proposed restoration action.

Policies and Management Directives

Forest Service Manual 2320, Wilderness Management[6] *(2007)*
Forest Service Manual 5100, Fire Management[7] *(2014)*
10-Year Wilderness Stewardship Challenge[8] *(2005)*

The policy cited in the planning documents for this action emphasizes the importance of protecting wilderness resources. Forest Service Manual 2320, the Wilderness section of this manual, is cited multiple times showing agency guidance related to protecting natural conditions, "where a choice must be made between wilderness values and visitor or any other activity, preserving the wilderness resource is the overriding value" (USFS 2007). Section 2320.2 of the Wilderness Management section of Forest Service Manual 2300 states that an objective of managing wilderness is to "maintain wilderness in such a manner that ecosystems are unaffected by human manipulation and influences so that plants and animals develop and respond to natural forces" (USFS 2007).

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[3] http://www.wilderness.net/NWPS/documents//publiclaws/PDF/16_USC_1131-1136.pdf
[4] http://www.gpo.gov/fdsys/pkg/STATUTE-98/pdf/STATUTE-98-Pg3105.pdf
[5] http://www.gpo.gov/fdsys/granule/STATUTE-102/STATUTE-102-Pg584/content-detail.html
[6] https://www.wilderness.net/NWPS/documents/FS/FS_wilderness_policy.pdf
[7] http://www.fs.fed.us/cgi-bin/Directives/get_dirs/fsm?5100
[8] http://www.wilderness.net/NWPS/documents/FS/10YWSC%20Brochure.pdf

Wilderness managers at George Washington and Jefferson National Forests have interpreted these management directives as a justification for addressing the stream acidification of Saint Mary's River. In their Environmental Assessment they state, "As illustrated by the Wilderness Management Model (USFS 2007), 'each designated wilderness is affected by a variety of human influences that vary in intensity...The number and intensity of these influences cause a gap between the attainable legislative wilderness and the conditions that exist on a wilderness. The goal of wilderness management is to identify these influences, define their causes, remedy them, and close the gap...Where a choice must be made between wilderness values and visitor or any other activity, preserving the wilderness resource is the overriding value.' The chemical treatment of the headwater streams of the Saint Mary's River will restore and maintain the aquatic ecosystem health and biodiversity of the Saint Mary's Wilderness. The cause has been defined (acid deposition), the remedy is before us waiting to close the gap" (USFS 2011, p. 9).

The George Washington and Jefferson National Forests acknowledged the potential conflict between the preservation of the untrammeled and natural qualities of wilderness character. They also acknowledged that while the liming action would entail trammeling of the wilderness, the Forest Service policy allows for agency prerogative to take action to preserve natural conditions in wilderness areas (USFS 2011).

Site-Specific Planning Documents

Final Revised Land and Resource Management Plan, George Washington National Forest (referred to as the Forest Plan), (2014)

The George Washington National Forest Final Revised Land and Resource Management Plan standard 8-46 allows for mitigation of acid deposition effects on a case-by-case basis.

Figure 5:3/4/13 Helicopter contract staff attach a one ton bucket of limestone to the helicopter line. Photo credit, USDA Forest Service.

Restoration Objectives and Mandate to Preserve Wilderness Character

The objective and desired future outcome of the liming restoration is to allow the wilderness to consist of ecosystems that are the result of natural succession and processes, as established in the Final Revised Land and Resource Management Plan (USFS 2014). The addition of limestone sand was proposed as a means of mitigating human-induced acidification because it had been demonstrated to temporarily restore stream water chemistry to levels conducive to survival by indigenous aquatic species (Olem 1991, Downey 1997a). Specifically, the alkaline character of the limestone rapidly offsets the

acidity of the water. The main purpose of the management action was to preserve natural stream conditions and prevent future degradation.

The Forest Service ultimately decided that the benefits to the natural quality of wilderness character—reducing the water acidity to facilitate the recolonization of indigenous species—outweighed impacts to the untrammeled quality of wilderness character. The 2011 Environmental Assessment for Saint Mary's Aquatic Mitigation Project acknowledged this dilemma by stating, "It can be argued that preserving the aquatic resource by recurrent liming is an additional 'trammeling' which degrades the 'wildness' of the area to the point of being antithetical to the wilderness concept. The question is whether to allow continued degradation and even loss of the aquatic biota while preserving the wilderness concept or ideal of 'untrammeled', or compromise the wilderness ideal, to preserve the aquatic resource?" (USFS 2011, p. 8).

Regional Forester Liz Agpaoa, in the record of decision for the 2013 project, states,

> *"I also acknowledge that at some time in the future, additional liming may be needed to the same streams. Treatments were previously made in 1999 and 2005. Liming does not solve the larger problem. It serves to keep aquatic species alive until air pollution is decreased. The question is whether to allow continued loss of the aquatic biota while preserving the wilderness concept or ideal of "untrammeled", or compromise the wilderness ideal, to preserve the aquatic resource? I maintain that society has already compromised eastern wilderness values by allowing air polluting emissions to continue that lead to acid precipitation. In my judgment, liming will not further compromise the wilderness values of St. Mary's, but instead will help to preserve one of the values that led to its wilderness designation in the first place" (USFS 2011b, p. 2).*

Restoration Treatment and Affected Environment

The 2013 limestone application was the third time that the Saint Mary's River was treated. In this most recent application, 230 tons (209 metric tons) of high-grade limestone sand was deposited from a helicopter into seven streams at discrete locations (including Sugartree Branch, Mine Bank Creek, Bear Branch, Chimney Branch, Hogback Creek, North Tributary and Upper Saint Mary's River). Each limestone treatment affects 20-33 feet (6-10 meters) of the stream bed before being washed downstream 492-984 feet (150-300 meters) by the current. Over time the limestone sand dissolves into the stream, creating a timed release affecting approximately 10 river miles (16 river kilometers) (USFS 2011).

Figure 6: 2/4/13 Limestone sand settles into a tributary of Saint Mary's River post-treatment. Photo credit, USDA Forest Service.

Fewer than 10 trees were felled (using crosscut saws) across all of the sites in advance of the first limestone application in 1999 to allow the helicopter load to safely reach the desired release zone. The 2013 operation was staged outside of the wilderness boundary and in 36 hours of flight time over three days, the helicopter never landed inside the borders of the wilderness area. Treatment sites were identical to those used during the two prior applications, and streamside disturbance at each of the seven treatment sites was estimated to be 20

feet (6 meters) (USFS 2011).

There is no known scientific controversy over the impacts of the treatment, primarily because the past two treatments have proven successful in raising the pH of the stream waters. This action also supports the conservation purpose of wilderness cited in section 4(b) of the Wilderness Act: the Environmental Assessment states, “This action will maintain a wild population of native brook trout, other non-game fish species, and aquatic macro invertebrates in the Saint Mary’s River system, which will conserve the native and most natural aquatic ecosystem” (USFS 2011).

Monitoring

Extensive monitoring has been undertaken to monitor the effects of the limestone treatment, including quantitative fish surveys as well as other stream health indicators. The Shannon Diversity Index is a measure of aquatic index species diversity, and has been a major tool analyzing the effects of acid deposition in the Saint Mary’s watershed on the aquatic biological community. After the first limestone treatment in 1999, the index rebounded to 1976 levels within three months (and has remained at that level during the entire study period) (USFS 2011).

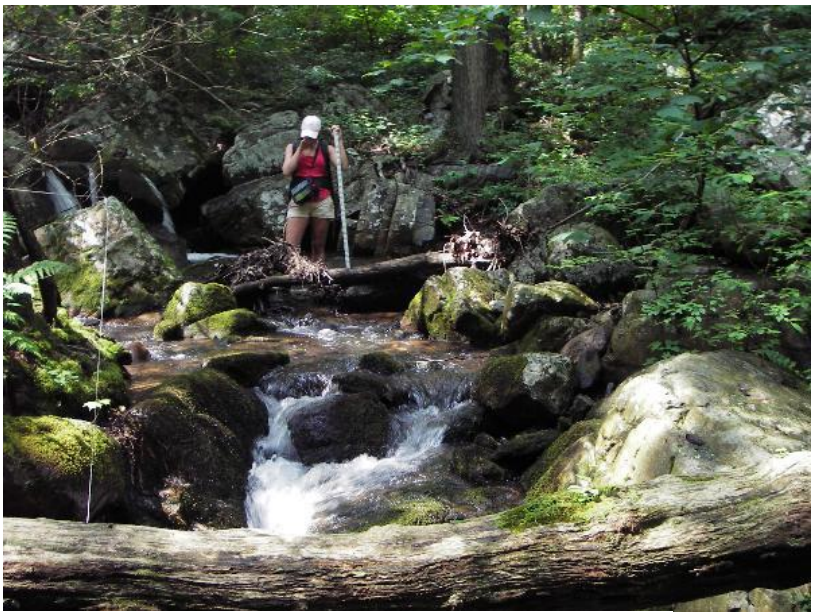

Figure 7: A Forest Service researcher conducts stream monitoring (2005). Photo credit, USDA Forest Service.

Following the first limestone sand deposit, post-treatment monitoring included quarterly collection of 22 water samples both upstream and downstream of the liming treatment, to measure pH, bases, and total aluminum (AlT) concentrations. In addition, three sample locations (one at St. Mary’s and two at control streams) were monitored weekly.

Following the second and third limestone sand deposits, quarterly water quality sampling was conducted as well as occasional watershed-wide sampling.

As a result of the limestone treatment, the pH rose from 5.4 in 1999 (pre-liming) to 6.1 in 2005 (post liming); the calcium/hydronium and calcium/magnesium ratios also increased.

Management Alternatives

The 2011 Environmental Assessment provided one alternative to the proposed liming treatment, which was to take no action. Since this option would not meet the Forest’s objective of achieving a naturally functioning ecosystem, this alternative was dismissed for further consideration. For the proposed liming action, several different methods were considered to carry out the proposed action. As an alternative to using helicopters to bring limestone to the points of application in the stream, managers considered

using pack animals. However, leading pack animals in to seven specific locations would have required the construction of seven miles of new trail and take many months at a cost of $140,000; this option was not selected because it would have degraded the undeveloped quality of wilderness character and was also deemed cost prohibitive. Additionally, the use of stock in wilderness areas creates the potential for introducing invasive plant species to the wilderness via their excrement, which would further degrade the natural quality of wilderness. Consideration for this range of management alternatives led managers to conclude that the use of a helicopter to deposit limestone sand had the highest likelihood for achieving project objectives, while simultaneously minimizing the potential for unintended negative impacts (USFS 2011).

Stakeholder Values

Groups in favor of the initial liming proposal in 1999 included the Virginia Department of Game and Inland Fisheries, the International Federation of Fly Fishers, some members of Trout Unlimited, and some local wilderness users. Groups against the project included the Sierra Club, the Virginia Wilderness Committee, some local wilderness users and some members of Trout Unlimited. Scoping comments for the proposed second liming treatment in 2004 were generally in favor of treatment, as evidence of the success of the initial liming was demonstrated. Scoping for the third treatment included only positive comments related to the project. Some of the environmental groups who originally opposed the initial action did so on Wilderness Act grounds, citing the need to uphold the untrammeled quality of wilderness and limit human control in these special areas. Groups in favor of the treatment also included some environmental groups—as well as individual citizens—who were concerned over the growing acidification levels in the river and supported improving the ecological integrity of the watershed. Internally, forest managers expressed serious concern about wilderness values being upheld throughout the limestone treatments.

Effects Analyses

In the following effects analysis section, we observe how the restoration act affected the five qualities of wilderness character. The five qualities are derived from the legal definition of wilderness cited in The Wilderness Act of 1964, and are used as a management tool for agencies to comply with law and policy, and improve wilderness stewardship by assessing the implications of management actions[9].

Untrammeled

- This action constitutes a trammeling on wilderness due to the fact that it is attempting to control the ecosystem, albeit from anthropogenic acid deposition.
- Specific trammeling actions include 36 hours of helicopter time and releasing 230 tons (209 metric tons) of limestone sand (600 tons (544 metric tons) cumulatively), a non-native substance to this area.
- Monitoring the condition of Saint Mary's River by taking 22 water samples on a quarterly basis also constitutes trammeling of wilderness.

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9 http://www.wilderness.net/toolboxes/documents/WC/Keeping%20it%20Wild%20Interagency%20Strategy%20GTR-212.pdf

- This treatment will need to be repeated every five to nine years to maintain natural conditions.

Natural

- Natural conditions improved as a result of this action due to the increase in pH level, which allows for the return of several indigenous aquatic species that otherwise may have been extirpated (USFS 2011).
- During the initial 1999 application five trees were cut down, using a crosscut saw, to allow for a safe delivery zone (USFS 2014b).

Opportunities for Solitude and Unconfined Recreation

- The wilderness area was closed for three days during the limestone deposition, negatively affecting opportunities for recreation and visitation during this time.
- The result of the action increased angling opportunities for visitors as trout populations have rebounded since the addition of limestone (USFS 2011).
- The application was conducted mid-week and in a low visitation month (March) to minimize negative effects on opportunities for solitude and unconfined recreation for visitors.
- After the application, a few piles of limestone sand were visible in Mine Bank Creek from Mine Bank Trail.

Timeline

November 1998- Environmental Assessment (EA) completed, no Minimum Requirements Analysis (MRA), Wilderness=top issue

March 1999- First limestone sand application, 170 tons (154 metric tons), 6 locations

December 2004- EA and MRA completed

November 2005- Second limestone sand application, 230 tons (209 metric tons), 7 locations

December 2011- EA and MRA completed

March 2013- Third limestone sand application, 230 tons, 7 locations

Figure 8: 3/4/13 A helicopter picks up a one ton bucket of limestone sand to deposit in Saint Mary's River. Photo credit, USDA Forest Service.

Undeveloped

- This quality was not affected by the action.

Risks and Uncertainties of the Restoration Treatment

The stakeholders identified in this project include local, state, and federal agencies as well as national wilderness groups and advocates.

Public residents who live downstream of this mitigation effort are directly influenced by the success of the project and at risk due to the potential human health impacts that could affect them. However, public health and safety were deemed not affected by this project because there are no known health impacts from limestone (USFS 2011b).

The initial application in 1999 was the second time that the Forest had used a helicopter to deposit limestone sand into a remote area to combat stream acidification. Certainty about the likelihood of

success of the initial and subsequent applications was high because six other streams had been successfully treated with limestone sand using non-aerial delivery mechanisms on the Forest prior to 1999.

Scoping comments during the initial liming in 1999 revealed opinions both in support of, and against, the watershed restoration project. One main concern was the potential for aluminum leaching from the streambed as the pH level rose, as this had been an issue witnessed in several European watershed treatments. Aluminum is toxic to aquatic organisms. Water and sediment samples following other liming applications on the Forest showed this was not a problem for treated streams in Virginia, and was not witnessed in Saint Mary's River.

The initial liming treatment received significant scrutiny from outside entities and individuals, as well as various program areas within the Forest Service. The second liming treatment proposal, five years later, received much less scrutiny, either external or internal to the agency. The third liming treatment was proposed five years after the second application, and 12 years after the initial analysis and decision, which was completed prior to the development and interagency adoption of the Minimum Requirement Decision Guide (MRDG). The MRDG is the interagency tool used to determine if actions are necessary with Wilderness; and if so, what actions are the "minimum necessary" to administer an area as wilderness. In the time period between the initial and third proposals, several changes had occurred. These included changes in agency personnel at several levels of the organization, and the evolution of agency wilderness stewardship thinking, and changes in analysis and documentation requirements.

Once the liming proposal was approved, the greatest challenge for project implementation was the need to obtain funding for effective project execution. Forest Service personnel and partners were able to raise funds from several outside sources including the Virginia Department of Game and Inland Fisheries, National Fish and Wildlife Foundation, Eastern Brook Trout Joint Venture and Dominion Power Company. Due to the success of these funding raising initiatives, the limestone treatment did not use any Congressionally-appropriated funding for contracting and purchase of material[10].

[10] Personal communication, Dawn Kirk and Peter Irvine, 1/13/15

RESTORATION OUTCOMES

The 1999 liming treatment proved to be successful, shown by a dramatic improvement in water quality and aquatic biota. Knowing that this original treatment was only a temporary fix with a five to eight year life span, subsequent treatments were applied in 2005 and 2013, providing similar positive effects to the stream chemistry. Project objectives were accomplished as measured by the number of fish species increasing from four species pre-treatment to eight species post-treatment, as well as an increase in fish and insect species and diversity. Along with the rebound of fish and macro-invertebrate species, water chemistry also improved. The first liming was considered a restoration of the aquatic ecosystem from a heavily degraded state. Since this first application of limestone was so successful, both subsequent limings have been deemed "mitigation" to maintain the ecosystem that was reinvigorated by the initial liming in 1999. Positive results from the first two liming treatments include (USFS 2011):

- pH, ANC (acid neutralizing capacity), calcium concentrations and calcium/hydronium ratios increased and remained at acceptable levels.
- Aquatic invertebrate diversity recovered to levels not seen in 30 years.
- Brook trout numbers increased initially and then settled to levels 50% higher than long-term pre-treatment averages.
- Non-game fish species increased and are dispersing to their historic habitat (from an initial four species pre-treatment to eight species post-treatment).
- Overall fish abundance and diversity has increased, with better survival of eggs and young (Menendez 1996), and in better condition and fitness (Simmons et al. 1996).
- No negative effects were documented on eggs incubated in limestone sediments (Simmons 1996).
- Macro invertebrates and insect abundance and diversity increased.
- Swamp pink, a federally threatened plant species, was not affected by the limestone treatment because the limestone did not leave the stream channel and collect in the floodplain (despite the destruction of Hurricane Isabel in 2003).

Negative effects that occurred as a result of the liming action

- To date there have been no negative effects documented to the ecology of the Saint Mary's Wilderness.

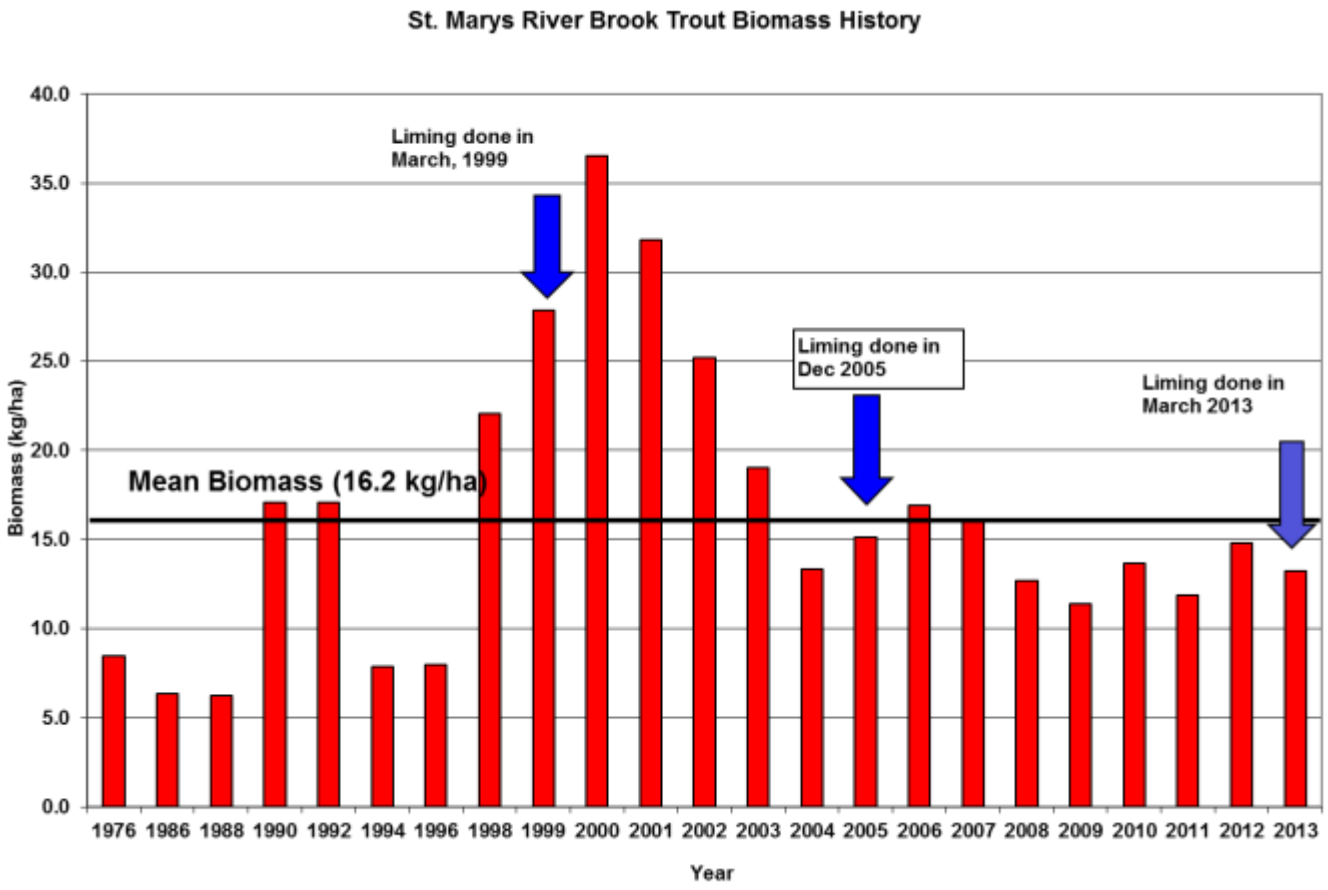

Figure 9: After each of the limestone sand treatments, brook trout biomass increased. Graph provided by D. Kirk, USDA Forest Service

Cumulative Effects

Cumulative effects analyses attempt to capture the overall administrative, visitor, commercial and scientific impact to a wilderness area by thinking holistically about all of these actions collectively over space and time. Saint Mary's Wilderness does not currently possess or collect this data specific to the wilderness area within George Washington and Jefferson National Forests.

Cost Breakdown

Direct Costs, Third Application

Helicopter Contract (Summit Helicopters) $100,000
Limestone Sand, Delivered $ 15,000

Direct Contributions, Third Application

Forest Stamp Funds (paid by public, admin by VDGIF) $30,000
Dominion Power Company $25,000
Eastern Brook Trout Joint Venture (admin by USFWS) $ 55,000
U.S. Forest Service $5,000

Other Partners: Virginia Council of Trout Unlimited, Skylark Farm, Cheek Family, NPS-BLRI, James Madison University, Dept. of Game & Inland Fisheries.

CONCLUSIONS

Project managers at the George Washington and Jefferson National Forests clearly saw a conflict between the need to preserve the natural qualities of the Saint Mary's Wilderness and the need to use restraint when attempting to "control" the environment. This conflict is discussed extensively in the Environmental Assessment, and concludes that the overriding need is to protect natural conditions.

> *The acidification of the St. Mary's River presents an unfortunate wilderness management dilemma. The Wilderness Act of 1964 includes phrases within its definition of wilderness that seem contradictory from a management standpoint, particularly in considering a proposal such as this. The contradiction occurs when the need to manage the area "to protect and preserve natural conditions" conflicts with the direction to manage the area as "untrammeled by man". Section 2(c) of the Act states, "A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." Untrammeled is the key word and it means uncontrolled or ungoverned by man. On the other hand, the Act goes on to say, "An area of wilderness is further defined to mean in this Act an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation which is protected and managed so as to preserve its natural conditions and which (1) generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable..." Here, the key phrase is, "protected and managed so as to preserve its natural conditions. (USFS 2011, p. 8)*

A main factor limiting success of the overall project is that the limestone treatment does not solve the larger regional problem of continuing acid rain deposition that is causing the ecological degradation of Saint Mary's Wilderness values. In response to this issue, project managers at the George Washington and Jefferson National Forests explain that although this project is not directly involved in reducing air pollution, they are involved in reducing dangerous air pollution in other ways. For example, the United States Forest Service (USFS) works with state regulatory agencies and the Environmental Protection Agency (EPA) to review and comment on new permit proposals that would affect air quality. These comments may influence the final emission levels set in the permit. In dealing with existing air pollution sources, the EPA and the states review air quality standards routinely to incorporate the most recent scientific findings. The USFS reviews and comments on changes that the EPA and Virginia Department of Environmental Quality propose to mitigate air quality concerns. The Forest is also involved with several other regional initiatives to reduce air pollution and study the effect of emissions on forest resources (USFS 2011).

Adaptive management is a major component of this project, and a vital lesson learned. During the first application, thresholds were set up to determine when future liming would need to take place based on water chemistry and biota. As a result of post-monitoring treatment documenting the improvement in stream chemistry, and also the duration of limestone effectiveness, future treatments were able to be appropriately calculated. The improvement in air quality from the 1970s to today has made project leaders hopeful that in the long term, the Saint Mary's watershed will eventually recover on its own.

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