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The Role of Monitoring in Stream Restoration

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The Role of Monitoring in Stream Restoration

Introduction

Definition of Stream Restoration Monitoring:

"The systematic collection and analysis of data that provides information useful for measuring project performance, determining when modification of efforts is necessary, and building long-term public support for habitat protection and restoration."
(Thayer et al. 2005)

The Role of Monitoring in Stream Restoration

Introduction

On the Need for Stream Restoration Monitoring:

- All parties involved with stream restoration projects, from grantor to practitioner to land manager, are vested in the outcomes of these projects and therefore benefit from feedback on project successes and failures
- Feedback is critical for expanding our collective knowledge of the relatively young science of stream and watershed restoration, fine tuning techniques, and enhancing maintenance regimes
- By directing the maintenance of existing projects and improving the design of future projects, such evaluation may increase the credibility of restoration efforts in the eyes of participating landowners and project "investors"
- Grant administrators are requiring an increased level of accountability from grantees, including documentation that financial resources were used for the purposes requested and that they produced the desired results

The New York Times Science Times

Tuesday, June 24, 2008

"Follow the Silt"

By Cornelia Dean

"Stream restoration is a big business with increasing popularity but patchy success. Since 1990, more than a billion dollars have been spent annually on stream restoration. Scientists wonder if it's being done right."
-Cornelia Dean, *New York Times*

"Many hydrologists and geologists say people embark on projects without fully understanding the waterways they want to restore and without paying enough attention to what happens after a project is finished."
-Cornelia Dean, *New York Times*

"An awful lot of stream restoration, if not the vast majority of it, has no empirical basis. It is being done intuitively, by looks, without strong evidence. The demand is in front of the knowledge. Most agencies want to spend the money making things happen and not spending the money finding out if they work."
-Dr. William E. Dietrich, Geomorphologist, University of California-Berkeley and NCED

"Unfortunately, we have not done enough monitoring to know what works and what doesn't."
-Chris Conrad, Environmental Engineer, United States Geological Survey

"Most people agree that the best approach is to create landforms and water flows that streams can maintain naturally. But how you translate that into action and at this stream rather than that stream really requires a lot of work to figure out."
-Dr. David R. Montgomery, Geomorphologist, University of Washington

"Efforts are underway to bring more academic rigor to the stream restoration business. Many opportunities to learn from successes and failures, and thus to improve future practices, are being lost."
-Cornelia Dean, *New York Times*

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Developing a Monitoring Program

Project Goals and Objectives:

- Clear project goals and objectives and evaluation of achievement determine ecological success
- Project goals and objectives should be specific, measurable, achievable, relevant, and time-based
- Project goals and objectives should clearly state desired outcomes that are measurable through monitoring
- Project goals and objectives determine monitoring goals and objectives
- Monitoring objectives should be integrated with the project, starting with project design

Pine Creek, Wisconsin

Project Goals and Objectives

Measurable project objectives include:

- Restore 3,500 feet of stream bank and habitat in Pine Creek
- Reduce stream bank erosion to 10% of pre-existing conditions
- Reduce fine sediment and increase coarse bottom substrate by 50%
- Increase numbers of Eastern Brook Trout by 40-50%
- Increase numbers of Eastern Brook Trout ≥ 10 inches by 50-100%
- Increase aquatic macrophyte growth by 25%

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Developing a Monitoring Program

Project Funding and Resources:

- Confirm the amount and duration of funding needed to implement monitoring
- Funding availability will determine whether monitoring objectives are achievable
- Prepare and submit a monitoring budget as a part of the project proposal
- Many grantors are recommending monitoring as a component of the project budget
- Monitoring window may be short when tied to the grant period
- Target 1 pre-restoration, 1 post-restoration, and 1 effectiveness monitoring survey within the project grant period
- Long-term monitoring provides best confirmation of project outcomes

Pine Creek Macroinvertebrate Assessment

Kick Sampling (Pre- and Post-Restoration)

6 Sites in Upper and Lower Pine Creek

2 Sites in North and South Tributaries

Pine Creek Macroinvertebrate Assessment

Mini-LUNKERS (Post-Restoration)

Dimensions: 8” W x 11.5” L x 2” T

SA = Hester-Dendy Artificial Substrate

2 “Mini-LUNKERS” per LUNKER

4 LUNKER Structures

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Developing a Monitoring Program

Understanding and Selecting Monitoring Types:

4 basic monitoring types as they relate to restoration monitoring:

1. Pre-Project Assessment Monitoring
2. Implementation Monitoring
3. Effectiveness Monitoring
4. Validation Monitoring

Understanding and Selecting Monitoring Types:

1. Pre-Project Assessment Monitoring

Principal Monitoring Question:

What are the existing site conditions and reasons for implementing a project at the site?

Monitoring documents current site conditions and how they support project selection and design

Stream Bank Erosion

"Reduce stream bank erosion to 10% of pre-existing conditions"

- **Stream bank height**
- **Stream bank slope**
- **Stream bank soil type**
- **Vegetative type and areal coverage**

Understanding and Selecting Monitoring Types:

2. Implementation Monitoring

Principal Monitoring Question:

Was the project installed according to design specifications, permits, and landowner agreements?

Monitoring can determine if the project work is completed as planned

Monitoring can identify any potential threats to project success so they can be immediately addressed

Valley Creek Restoration
Afton, MN

Project design by
Barr Engineering

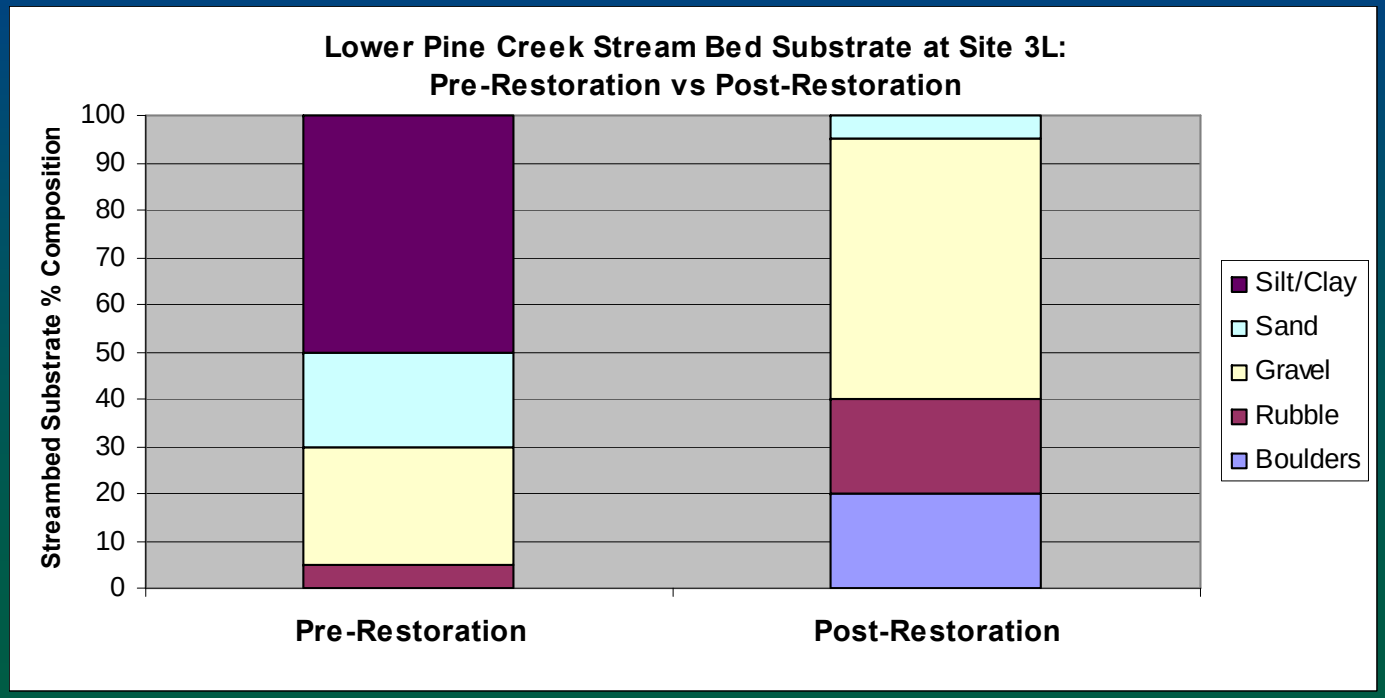
Understanding and Selecting Monitoring Types:

3. Effectiveness Monitoring

Principal Monitoring Question:

Did attributes and components at the project site change in magnitude as expected over the appropriate time frame?

Monitoring assesses post-project site conditions and documents changes and trends over time, via comparison to pre-project conditions



Streambed Substrate

"Reduce fine sediment and increase coarse bottom substrate by 50%"

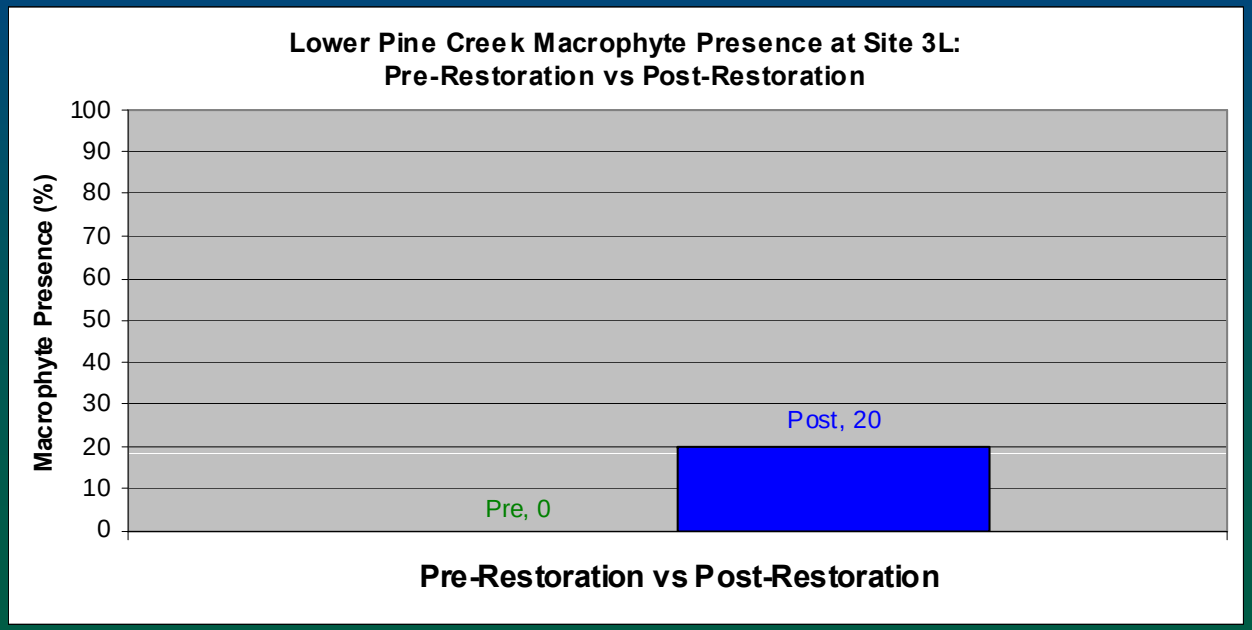
Understanding and Selecting Monitoring Types:

4. Validation Monitoring

Principal Monitoring Question:

Did the restoration project achieve the desired change in biotic assemblages and/or water quality response?

Monitoring confirms the cause and effect relationship between the project and biotic and/or water quality response, via change in use, presence, or abundance of aquatic flora and fauna



Aquatic Macrophytes

"Increase aquatic macrophyte growth by 25%"

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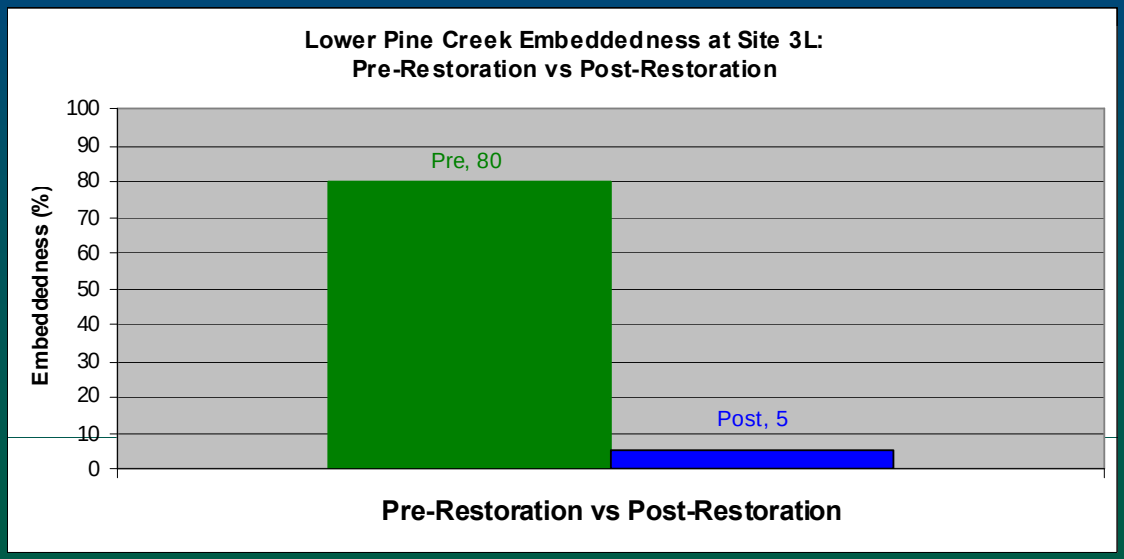
Monitoring Techniques

Qualitative and Quantitative Monitoring Approaches:

- Each monitoring type can be conducted in a qualitative or quantitative manner
- Qualitative and quantitative monitoring approaches each have their place and purpose and can be complimentary to each other



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Monitoring Techniques

Water Quality Monitoring:

- Water quality improvement is a common goal for watershed restoration projects (reduce delivery of sediment, nutrients, pathogens, and other pollutants to a stream)
- Monitoring pollutant reductions (concentrations and/or loads) is an intensive task
- Factors influencing water quality operate at a larger scale than the project site
- Upstream conditions often hinder the ability of a monitoring program to detect changes in pollutant levels above and below a particular project site as a result of the restoration project
- A strategic approach is recommended to validate water quality improvements where projects are implemented at a large scale or numerous projects connect over time

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Additional Considerations

Project Location Documentation and Photographic Monitoring:

- Pictures are "worth a thousand words" and are particularly valuable when sharing project results with the public

Monitoring Timeframe:

- The monitoring timeframe should reflect the time necessary for identified attributes to change as a result of the restoration project

Control and Reference Sites:

- Control and reference sites can provide a useful context for interpreting project success and informing how soon attributes will reach a "pre-disturbance condition"

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Kent's Parting Thoughts

Why Monitor?

- Current Stream Restoration Monitoring Efforts
- Development and Application of Stream Restoration Monitoring Protocols
- Prioritizing Stream Restoration Projects
- Informing Project Planning and Management
- Demonstrating Success

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Kent's Parting Thoughts

Why Monitor?

Current Stream Restoration Monitoring Efforts

- TUDARE is conducting some stream restoration monitoring
- National Fish Habitat Action Plan (NFHAP) grants encourage monitoring
- Very little geomorphic and/or biological monitoring is being conducted
- Stream restoration monitoring efforts are "patchy", relatively uncoordinated, and lacking sound, scientifically-derived metrics that clearly link stream restoration to biological improvement
- Timing is excellent for the development of standardized and scientifically-grounded monitoring protocols for evaluation of stream restoration success

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Kent's Parting Thoughts

Why Monitor?

Development of Stream Restoration Monitoring Protocols

- PRRSUM could establish pilot locations throughout the Upper Midwest, for the development and application of stream restoration monitoring protocols
- Sites could be located within the Twin Cities Metro Area, within the TUDARE network, and at other Upper Midwest locations identified with partner input
- Both warm- and cold-water streams should be included
- Selection criteria for pilot streams could consider multiple factors influencing stream disposition (geology, hydrologic scale, ecoregion, watershed size, land use)
- Establish a toolbox of standardized monitoring protocols that span a range from simple to complex, yet relevant geomorphic and biological metrics
- Are common metrics and standard monitoring methods possible for comparing restoration project techniques and outcomes regionally or nationally?
- Expand stream restoration monitoring protocols to include the riparian area

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Kent's Parting Thoughts

Why Monitor?

Prioritizing Stream Restoration Projects

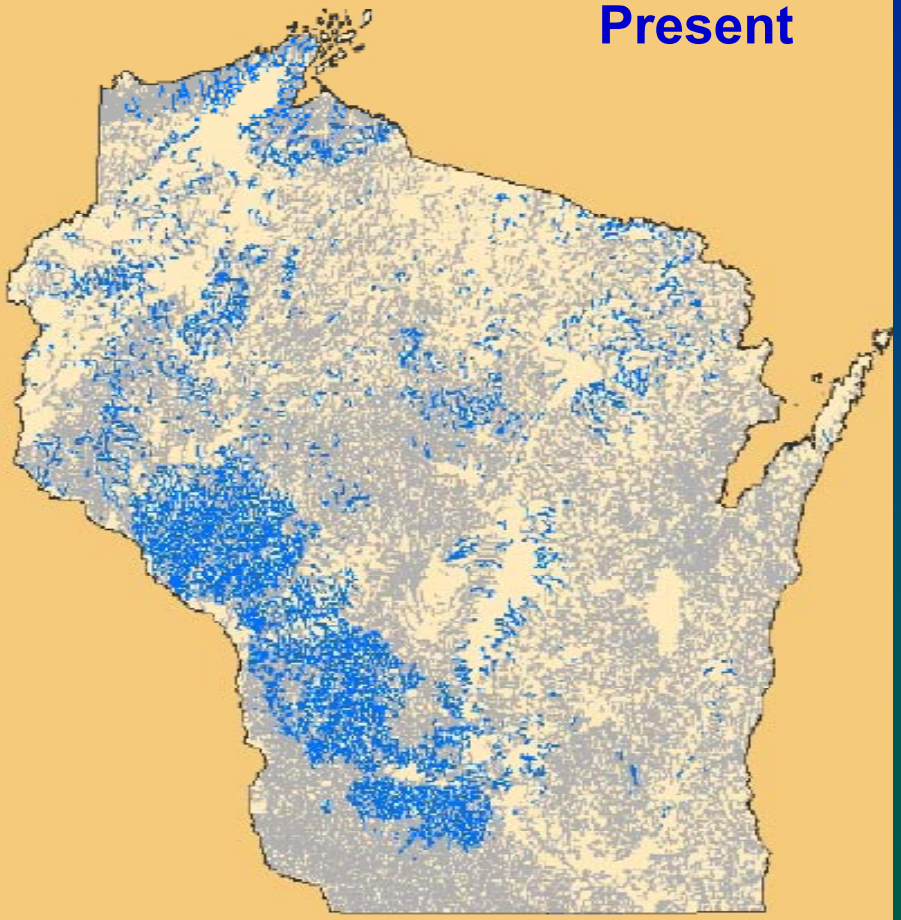
- With limited resources for stream restoration work, can we establish a prioritization scheme for targeting streams, to achieve the greatest benefits for the resources invested?
- Can synoptic monitoring play a role in this prioritization process?
- Trout Unlimited and the National Fish Habitat Action Plan (NFHAP) have established a Driftless Area Restoration Effort (DARE) to restore and protect the coldwater streams of Minnesota, Wisconsin, Iowa, and Illinois
- Considerable stream restoration work is occurring throughout the Driftless Area, primarily driven by local interest and capability
- Informed by synoptic monitoring, can a more strategic approach be developed for targeting and prioritizing Driftless Area stream restoration, thereby maximizing both ecological outcomes and resources invested?

Mitro, Lyons, and Stewart (2007)

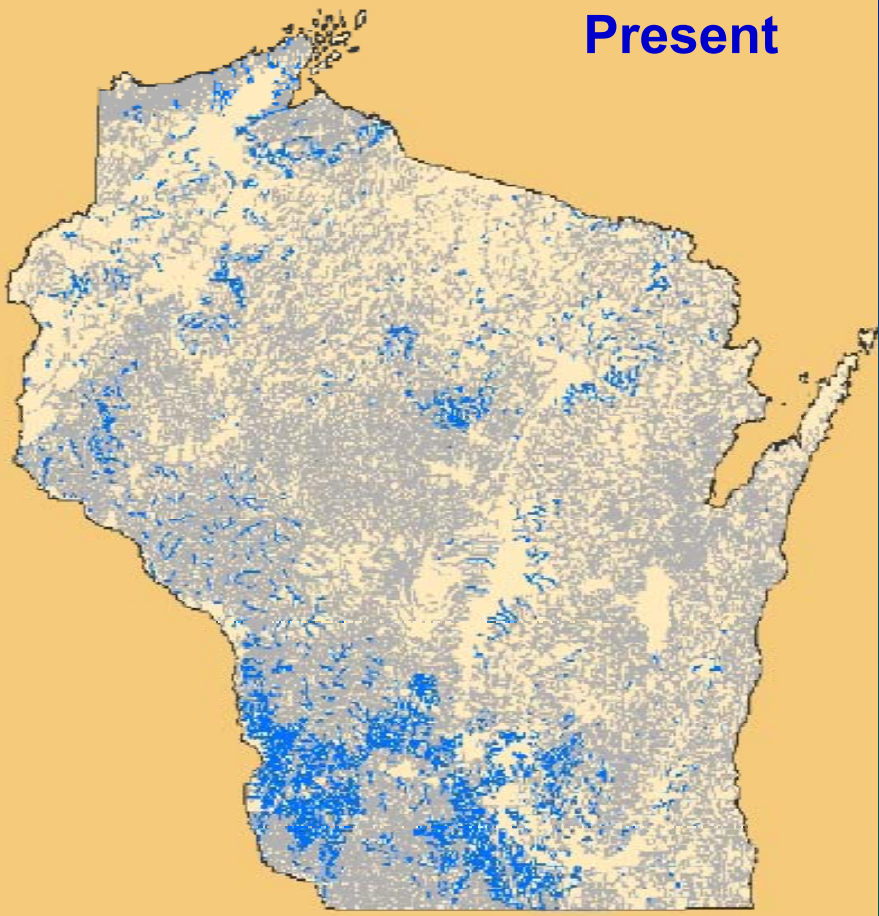
Climate Change, Trout Ecology and the Future of Inland Trout Management in Wisconsin

- Stream temperature is the most important factor that determines where trout can live and cannot live
- A warming climate will affect the distribution of trout
- Extreme precipitation events associated with climate change may limit trout recruitment
- Drought conditions associated with climate change will limit stream flows and fish habitat

28,802 km
Present

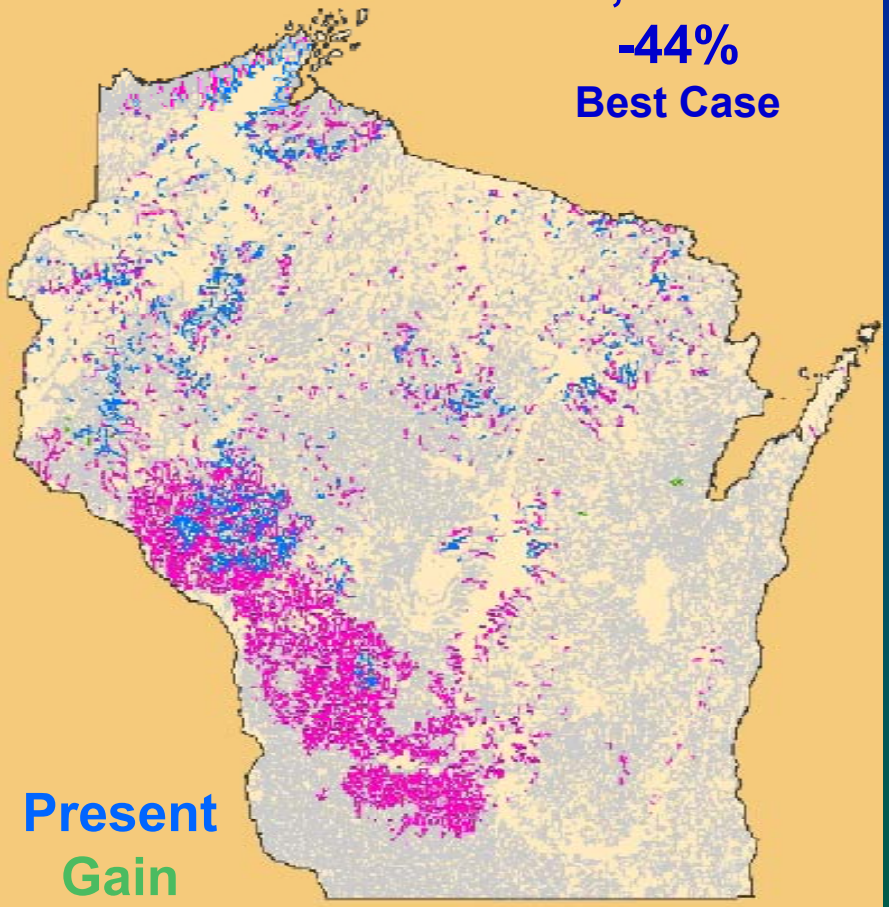


37,241 km
Present



+1°C

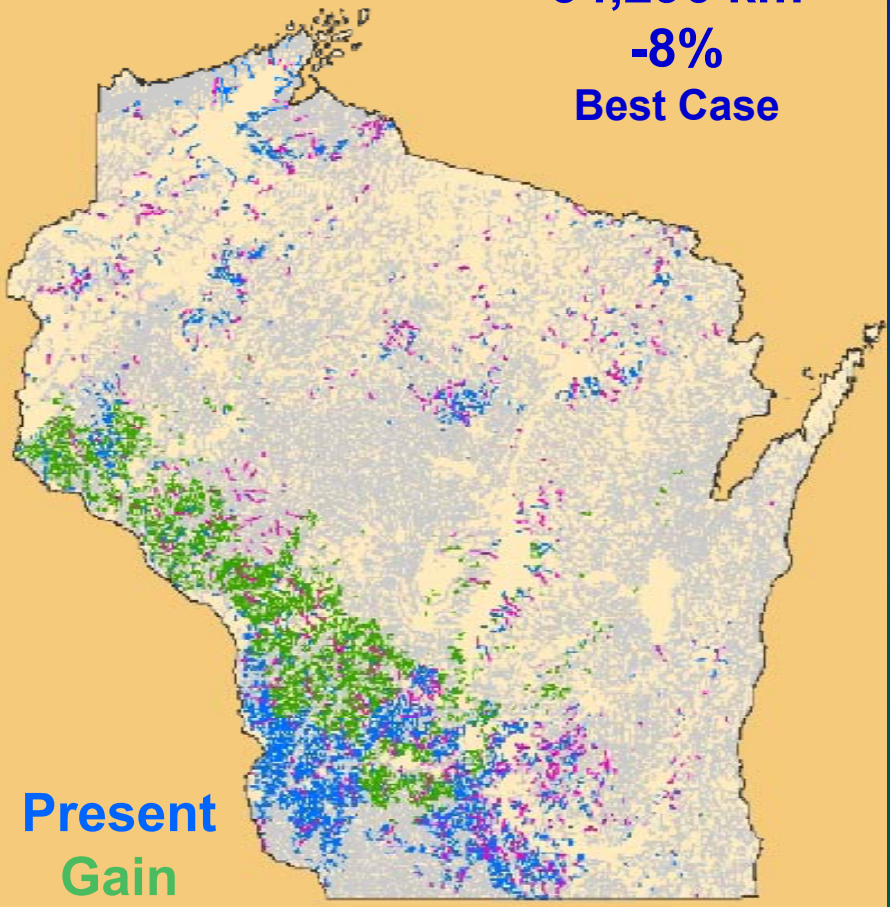
16,245 km
-44%
Best Case



Present
Gain
Loss

+1°C

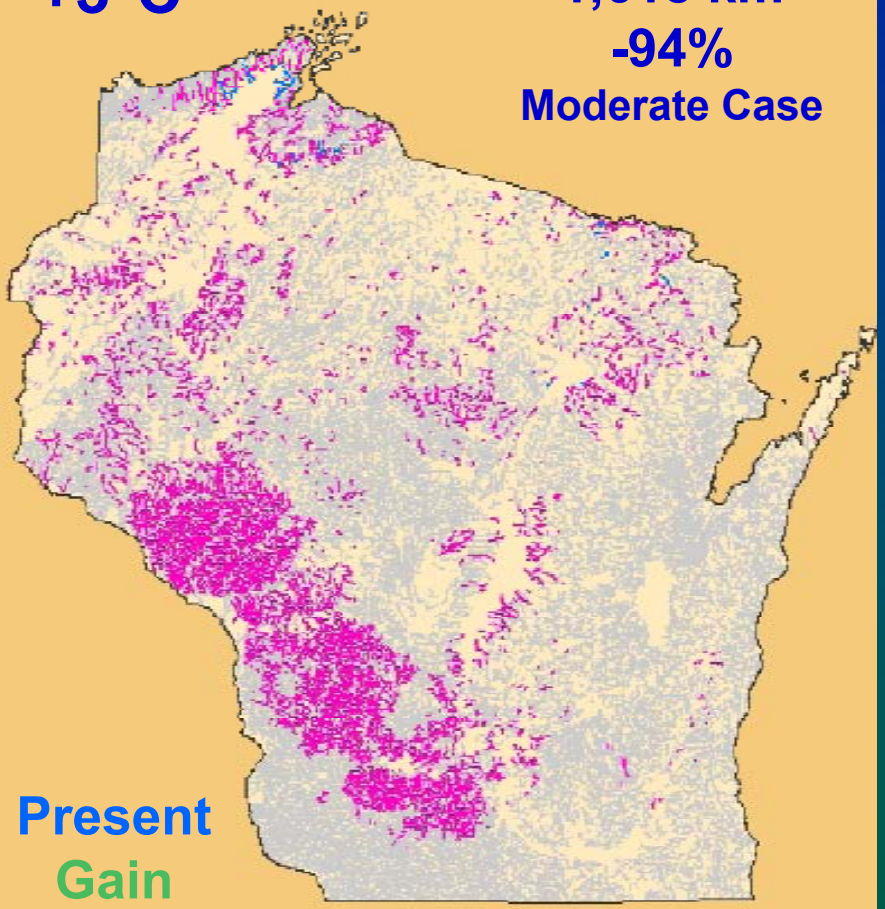
34,296 km
-8%
Best Case



Present
Gain
Loss

+3°C

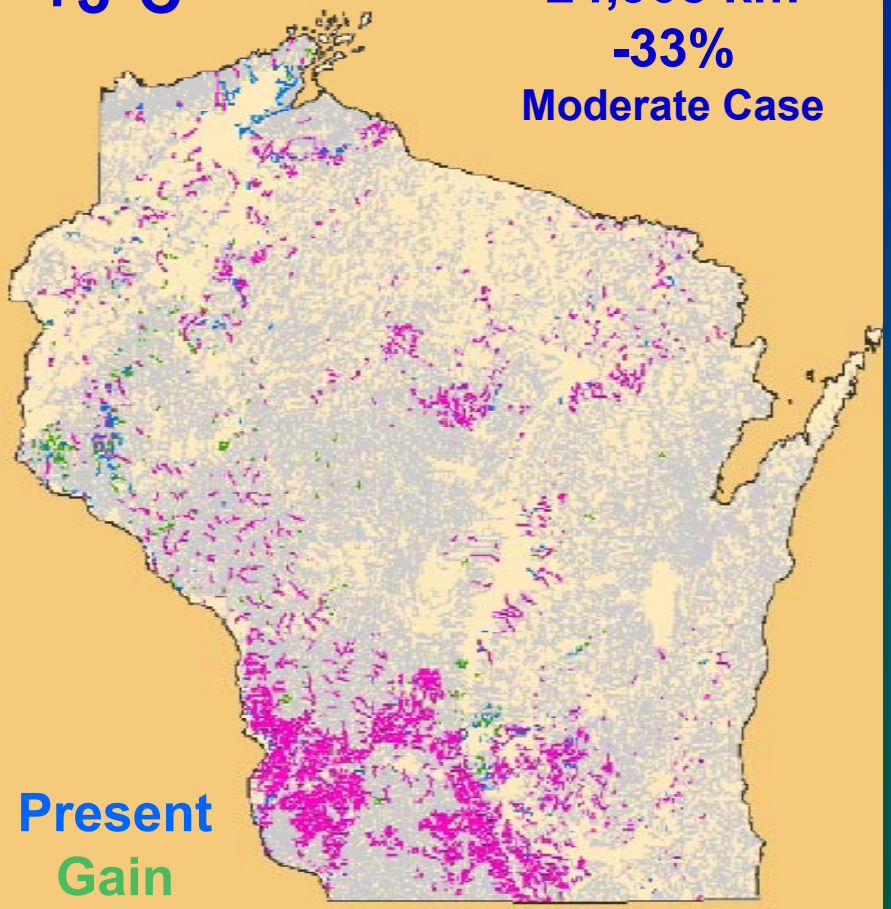
1,618 km
-94%
Moderate Case



Present
Gain
Loss

+3°C

24,908 km
-33%
Moderate Case



Present
Gain
Loss

Mitro, Lyons, and Stewart (2007)

Climate Change, Trout Ecology and the Future of Inland Trout Management in Wisconsin

- Use stream temperature data and fish distribution models to direct habitat restoration efforts to streams most likely to realize long-term benefits

The Role of Monitoring in Stream Restoration

Kent's Parting Thoughts

Why Monitor?

Informing Project Planning and Management

- Should we be conducting pre-restoration monitoring to inform project planning efforts, including the establishment of restoration goals/objectives and development of the restoration plan?
- What are the underlying geological, hydrological, and morphological conditions that will impact project success?
- What are the critical factors for developing a successful restoration plan?
- Is post-restoration monitoring useful for identifying and managing any problems that arise after restoration work is complete (adaptive management)?

The Role of Monitoring in Stream Restoration

Kent's Parting Thoughts

Why Monitor?

Demonstrating Success

A Study of Washington (State) Restoration Projects (Bash and Ryan 2002):

- "While stream restoration and enhancement projects in Washington State often share the goal of improving habitat for salmon, it is not immediately clear whether the projects are achieving this aim"
- "There is a perception within the natural resource community that many restoration and enhancement projects are planned and implemented with little or no monitoring of their effectiveness"
- "Although monitoring appears to be taking place in slightly more than half of the projects surveyed, the nature of the data collected varies widely across projects, and in most cases the monitoring effort is voluntary"
- "Project sponsors, funders, and managers must consider the issues involved in requiring appropriate monitoring, establishing standardized monitoring guidelines, setting time frames in which to monitor, providing other incentives for conducting monitoring, and ensuring adequate funding for monitoring efforts"

Questions?

("White Paper" Available)

Lower Pine Creek

Post-Restoration Brookie (≥ 10")

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Monitoring Techniques

Qualitative and Quantitative Monitoring Approaches:

Choice to use qualitative methods, quantitative methods, or both depends upon:

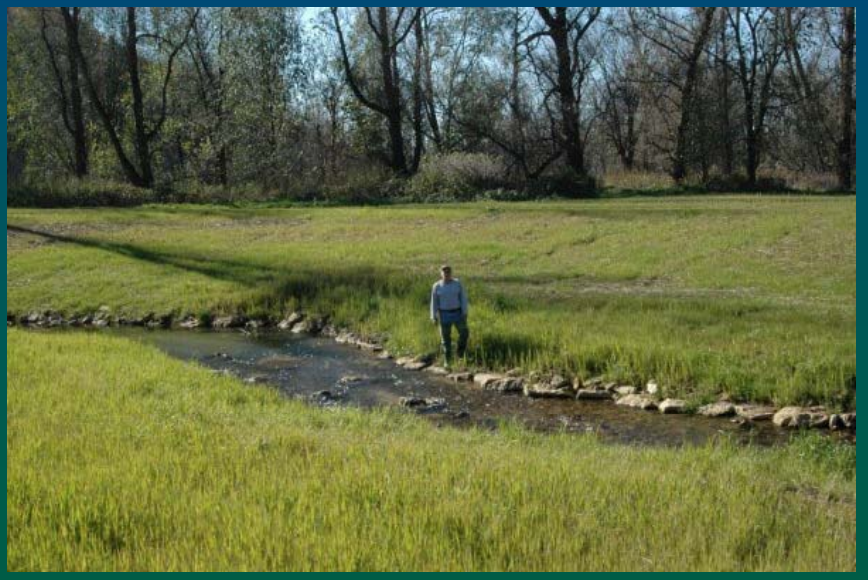
- **Which principal monitoring questions should be answered and at what level of detail to assess project outcomes**
- **Funding availability and duration**
- **Time, effort, level of expertise, and resources available to conduct monitoring**
- **Where resources allow, qualitative monitoring should be conducted in conjunction with quantitative monitoring**
- **Qualitative monitoring is better able to identify a broad range of project concerns that might not be detected by a more narrowly focused quantitative approach**
- **Quantitative monitoring provides objective data that is less subject to varying interpretations of project outcomes**

The Role of Monitoring in Stream Restoration

Monitoring Techniques

Qualitative Monitoring:

- Provides subjective observations of pre-project conditions and implementation, effectiveness, and validation outcomes
- Observations may include a broad assessment of project site conditions with information pertaining to multiple project objectives
- Photopoint monitoring is a very useful qualitative technique



Measurement of Pine Creek Improvements: Criteria for Selection of Metrics

With Trout Unlimited volunteer involvement, 5 E's should apply to measurement metrics:

- Easy (to understand and apply)
- Economical (to purchase the monitoring equipment)
- Educational (for the volunteers)
- Extrapolated (to other TU projects across the Driftless Area)
- Ecologically relevant (to demonstrate restoration success)!

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Monitoring Techniques

Quantitative Monitoring:

- Data driven and assesses changes in project site characteristics as a means of objectively measuring project outcomes
- Select attributes that are appropriate indicators of changes in site conditions as a result of the restoration project
- Attribute selection and monitoring methods, timing, and frequency should be driven by project goals and objectives
- Level of expertise and resource availability must be carefully considered during monitoring plan development
- Monitoring guidance documents and basic field training may be needed
- Biological (validation) monitoring (macrophytes, macroinvertebrates, fish, amphibians) requires more complex protocols and expertise and special agency permits
- Are common attributes and standard monitoring methods possible for comparing restoration project techniques and outcomes regionally or nationally?

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Additional Considerations

Project Location Documentation and Photographic Monitoring:

- All qualitative and quantitative monitoring should occur in conjunction with proper documentation of project location (Gerstein et al. 2005 and Collins 2007)
- Photopoint monitoring (Gerstein and Kocher 2005) is recommended at all stream restoration sites, regardless of the monitoring type employed

1. Pictures are “worth a thousand words” and are particularly valuable when sharing project results with the public
2. Locate photo points so that they allow for repeated unobstructed photos once vegetation becomes well established
3. Detailed notes on the precise location and direction of photo points are also critical

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Additional Considerations

Monitoring Timeframe: General Observations

- The monitoring timeframe should reflect the time necessary for identified attributes to change as a result of the restoration project
- Baseline data should be collected shortly before the project begins or immediately following its completion
- Implementation monitoring should occur as soon as possible within the first year after project initiation
- For effectiveness and validation monitoring, site conditions three to five years post-implementation may be reasonable indicators of whether the restoration project has achieved goals/objectives
- Monitoring should not be confused with maintenance. Ideally, a visual evaluation of the project site should be conducted annually by the contractor, project manager, or landowner to assess maintenance needs

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Additional Considerations

Monitoring Timeframe: Effectiveness and Validation Monitoring

- Monitoring duration should depend upon the expected amount of time required to reasonably determine whether project objectives have been met
- Depending upon the attribute, monitoring project sites for ten years or more may be desirable; but this is generally longer than funding for most projects will allow
- Site conditions three to five years post-implementation may be reasonable indicators of whether the restoration project has achieved goals/objectives
- Ideally, subsequent visits at a minimum of three to five year intervals are recommended to document ongoing changes and trends in site response
- Because of their potential to influence monitoring survey results, environmental stresses, project maintenance, and seasonal factors should also be considered when planning the timing of effectiveness and validation monitoring
- Structural integrity is a concern for any type of stream restoration project. Ideally, stream bank structures and riparian vegetation should be assessed after high flow events to determine the project's ability to maintain its integrity following extreme physical conditions

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Additional Considerations

Control and Reference Sites

- A control site is a stream reach in the vicinity of a project site that is similar to the project site with regard to disturbance and impact but has not been restored
- A reference site is an unimpacted site that serves as an example of ideal restored conditions
- Control and reference sites can provide a useful context for interpreting project success and how soon the trajectory of each attribute will reach the "pre-disturbance condition"

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Additional Considerations

Control Sites

- A control site is generally an unrestored stream reach with similar conditions and scale as the project site prior to treatment
- Control sites serve to illustrate changes occurring naturally as a result of climatic and site conditions versus those occurring as a result of the restoration project
- An alternative form of a control site, useful for documenting the effect of specific restoration techniques, is a site with similar conditions that was treated with a different restoration method. This type of control site allows for the evaluation of restoration technique effectiveness
- Monitoring appropriate control sites along with restored sites documents whether changes in site conditions are a result of the restoration project or a natural occurrence
- Control sites are valuable for evaluating trends and isolating long-term project benefits
- Control sites that are directly comparable to restoration sites are often difficult to locate and access. Usually unrealistic to monitor control sites in conjunction with each restoration site

The Role of Monitoring in Stream Restoration

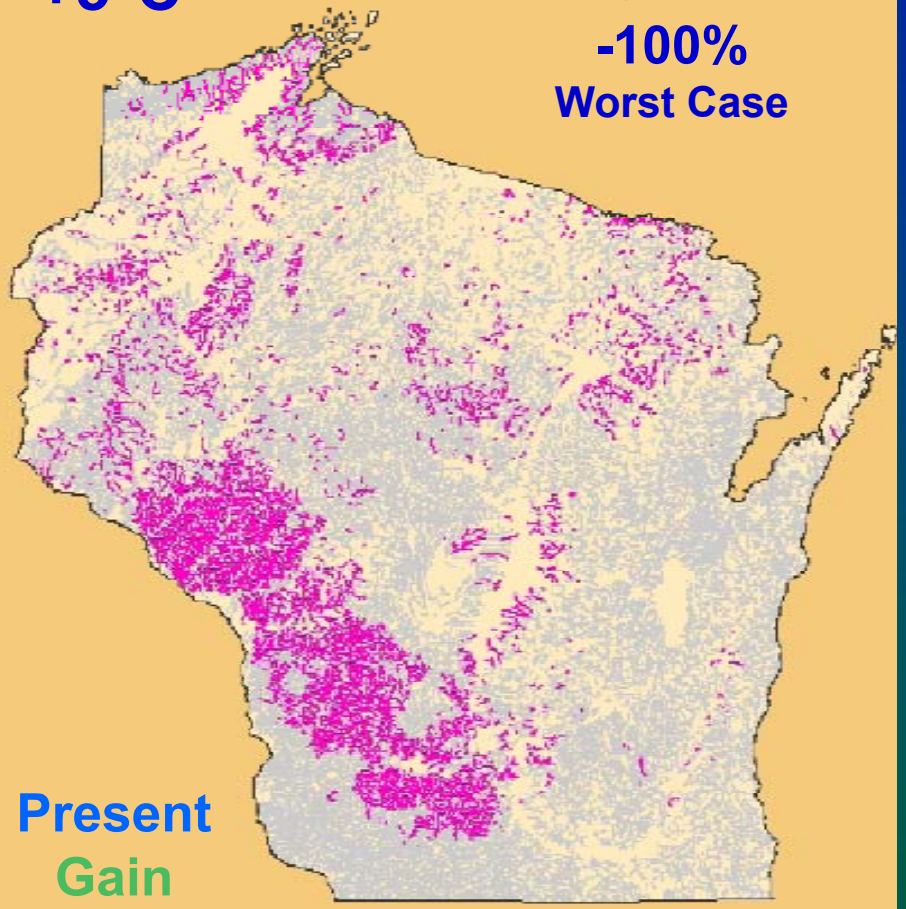
Additional Considerations

Reference Sites

- Reference sites illustrate ecological features of a pre-disturbance state and have been useful for both planning restoration projects and establishing quantifiable project objectives
- Reference sites are elusive and difficult to find
- In many cases, watershed scale impacts such as stream channelization or aggradation have precluded the ability of any stream reach to represent reference conditions for all attributes
- The debate and lack of agreement as to what pre-disturbance conditions are hinder reference site selection
- Because of this difficulty, expending resources to identify and monitor such sites, beyond gathering input for project design, is not recommended

+5°C

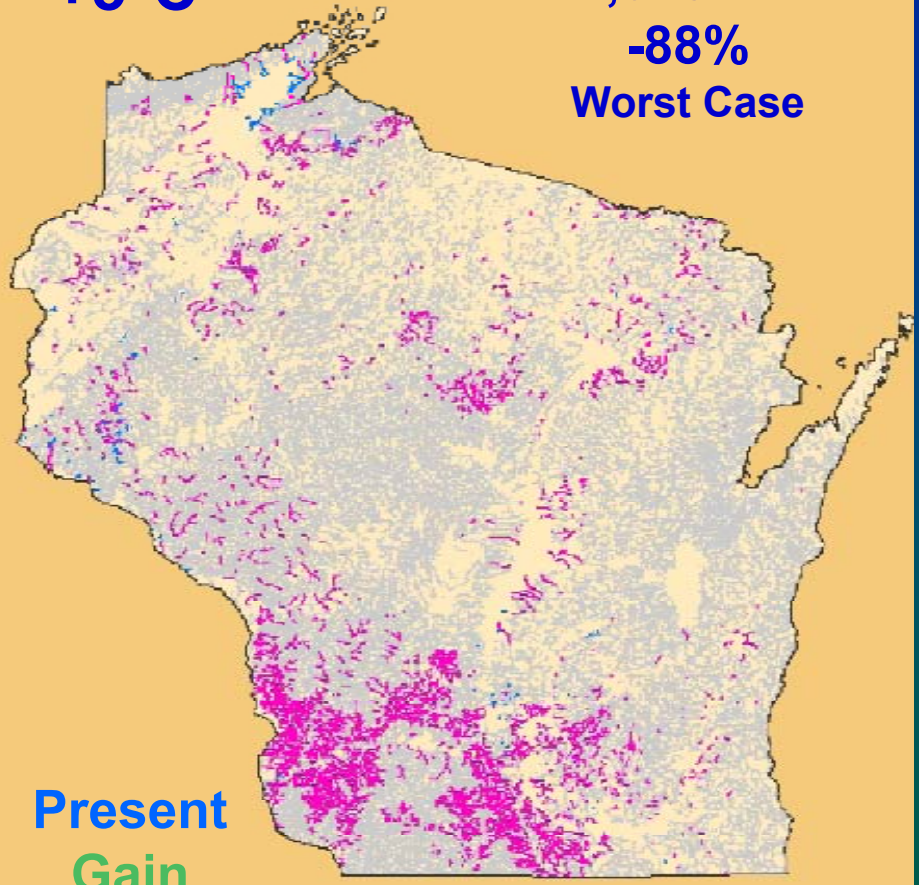
0 km
-100%
Worst Case



Present
Gain
Loss

+5°C

4,378 km
-88%
Worst Case



Present
Gain
Loss