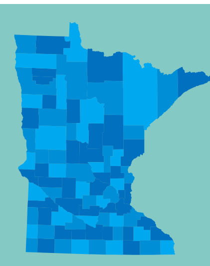
Use Designation

October 2018

Technical Guidance for Reviewing and Designating Aquatic Life Uses in Minnesota Streams and Rivers

MINNESOTA POLLUTION CONTROL AGENCY



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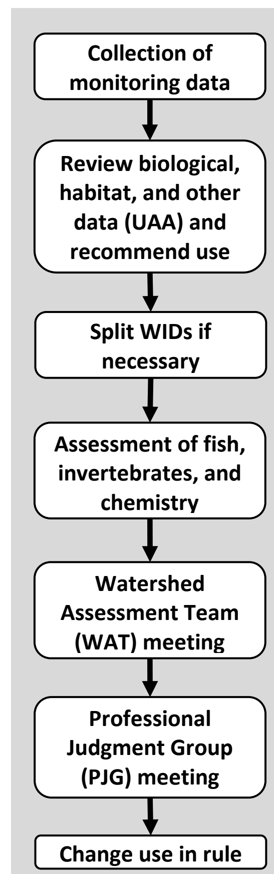
Acronyms

2Ae	Exceptional Use Cold Water Habitat
2Ag	General Use Cold Water Habitat
2Bde	Exceptional Use Warm Water Habitat (also protected for drinking water)
2Bdg	General Use Warm Water Habitat (also protected for drinking water)
2Bdm	Modified Use Warm Water Habitat (also protected for drinking water)
2Be	Exceptional Use Warm Water Habitat
2Bg	General Use Warm Water Habitat
2Bm	Modified Use Warm Water Habitat
ALU	Aquatic Life Use
ANOVA	Analysis of Variance
AUID	Assessment Unit ID
AWC	Altered Watercourse
BCG	Biological Condition Gradient
CALM	Consolidated Assessment and Listing Methodology
CFR	Code of Federal Regulations
CWA	Clean Water Act
MDNR	Minnesota Department of Natural Resources
DRG	Digital Raster Graphic
IBI	Index of Biological Integrity or Index of Biotic Integrity
GIS	Geographic Information System
GNIS	Geographic Names Information System
HUC	Hydrologic Unit Code
HUC8	8-digit Hydrologic Unit Code
Minn. Stat.	Minnesota Statute
MLE	Multiple Lines of Evidence
MPCA	Minnesota Pollution Control Agency
MSHA	Minnesota (or MPCA) Stream Habitat Assessment
NHD	National Hydrography Dataset
NWI	National Wetlands Inventory
PWI	Public Waters Inventory
QHEI	Qualitative Habitat Evaluation Index
TALU	Tiered Aquatic Life Uses
TMDL	Total Maximum Daily Load
UAA	Use Attainability Analysis
EPA	United State Environmental Protection Agency
USGS	United States Geologic Survey
WID	Waterbody ID

1. Executive summary

This document was developed to guide the process for changing or confirming aquatic life use (ALU) designations to ensure that the designation of ALUs for Minnesota streams and rivers are done in an appropriate and consistent manner. This includes both the designation of Tiered Aquatic Life Uses or TALUs and the review of thermal regime designations (i.e., cold water versus cool/warm water habitat) for the protection of aquatic life. This document does not cover the process for reviewing non-aquatic life uses (e.g., recreation, domestic consumption), development of site specific standards, or natural background reviews. The first step in assessing a water body is determining the correct use as defined by the Clean Water Act (CWA) and Minnesota Rule. If the wrong use is applied to a water body, the steps that follow may not be valid and can lead to errors in the assessment and management of that water body. In general, a multiple line of evidence approach is used which requires biological, chemical, physical, habitat, channel status, and other forms of evidence to understand the attainability of a use such that the appropriate use can be applied. The objective is to ensure that the existing use (i.e., those uses actually attained in the surface water on or after November 28, 1975 [Minn. R. 7050.0255, subp. 15]) is designated. This approach seeks to bring in all available current and historical information from a Waterbody ID (WID) or Assessment Unit (AUID) in order to build supporting evidence for the attainability of a beneficial use. In addition to describing the process for designating uses, this document also provides guidance for developing recommendations for splitting or merging WIDs.

Figure 1. Steps for assessing aquatic life uses in Minnesota.



2. Introduction

The Minnesota Pollution Control Agency (MPCA) is responsible for implementing the CWA in Minnesota. As such, the MPCA works to achieve the objective of the CWA which is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (U.S. Code title 33, section 1251 (a)). In addition to this objective, the CWA provides an interim goal for the Nations waters:

> ***"wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water" (U.S. Code title 33, section 1251 [a] [2])***

This sets a minimum goal for all waters that is often referred to as "fishable-swimmable". As a result, the MPCA protects most waters of the state (Minn. Stat. § 115.01, subd. 22) to at least this level. Some waters can be protected to a lower level, but this requires a Use Attainability Assessment (UAA) to determine if a lower use is appropriate. This assessment requires both a review of existing use (40 CFR § 131.3(e)) and a determination of whether or not a lower use is allowable because it cannot be feasibly attained (40 CFR § 131.10(g); see Table 1). This process is described in more detail in Section 3.

The use of biological indicators and the TALU framework in Minnesota require methods to accurately and consistently determine the attainability of ALUs. Prior to the assessment of aquatic life, an accurate determination of a water body's designated use must occur, otherwise subsequent management actions (e.g., stressor identification, Total Maximum Daily Load [TMDL], and permitting) may be invalid or less effective. Sufficient biological data drives the decision to confirm or change an aquatic life use with additional data (e.g., habitat, chemistry, land cover, anthropogenic activity) providing further information on the attainability of that use. Once the ALU is confirmed and designated, then the assessment of that water body can proceed by comparing biological and chemical measures against the appropriate criteria. The major steps in this process are outlined in Figure 1. In practice, much of the work to redesignate or confirm a beneficial use will take place during a UAA. However, the recommended uses that are proposed from the UAA process will undergo internal MPCA reviews and external public reviews (e.g. Professional Judgment Group Meetings) to bring additional evidence and expertise that informs the attainability of the use. Finally, the proposed use will undergo a formal rulemaking to establish the beneficial use in 7050.0470. This review process will ensure that the proposed use is appropriate.

3. Determination of tiered aquatic life uses for streams and rivers

A TALU-based monitoring program is designed and conducted to meet three principal objectives in the following order:

- Determine if use designations presently assigned to a given water body are appropriate and attainable.
- Determine the extent to which use designations assigned in the state Water Quality Standards are either attained or not attained.
- Determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices (i.e. effectiveness monitoring).

The review of the ALU designation determines the existing use of an assessment reach (see Table 1; 40 CFR § 131.3(e)). This states that the existing use is the beneficial use that was attained on or after November 28, 1975, so data outside of MPCA's 10-year assessment window is relevant to the determination of use. Biological data is central to use designation although several other forms of evidence are also required in determining aquatic life use for a water body. See MPCA (2014b, c) for descriptions of the Indices of Biological Integrity (IBI) and MPCA (2014a) for a description of the biological criteria. These other lines of evidence are especially important for waters where the General Use is not attained as it must then be determined if the General Use can and should be attained to be compliant with state and federal rules. The steps for determining a water body's beneficial use are detailed in Figure 3.

Although the final ALU recommendation is at the Waterbody ID or WID scale (i.e., a river or stream reach that is often delineated by major tributaries to the water course) and may include information from adjacent and nearby reaches, the review of the use is initially performed at the biological monitoring station level. The extent of the reach to which the beneficial use is applied is then determined by an assessment of the homogeneity uniformity of the reach. This involves an examination of channel condition throughout the WID and if there are any major geologic features, legacy anthropogenic impacts, tributaries, etc. present that could influence the attainability of the beneficial use. In cases where the WID is relatively homogenous and if the UAA of all monitoring stations within the reach results in the same recommended use, then the entire WID can be designated one use (Figure 2; Scenario 1). In cases where the monitoring stations indicate different uses are appropriate and/or the reach is not homogeneous, then a splitting of the reach can be recommended (Figure 2; Scenario 2). Similarly, if the WID is very long then a WID split may be recommended even if the entire reach is the same use. Splitting long WIDs is more likely to occur when the reach crosses through multiple aggregated 12-digit HUC watersheds. It should also be noted that the appropriate reach length is affected by the size of the river with longer reaches more appropriate on larger rivers. The determination of biological attainment for each WID is largely performed independently although the biological attainability of a reach may be informed by adjacent reaches.

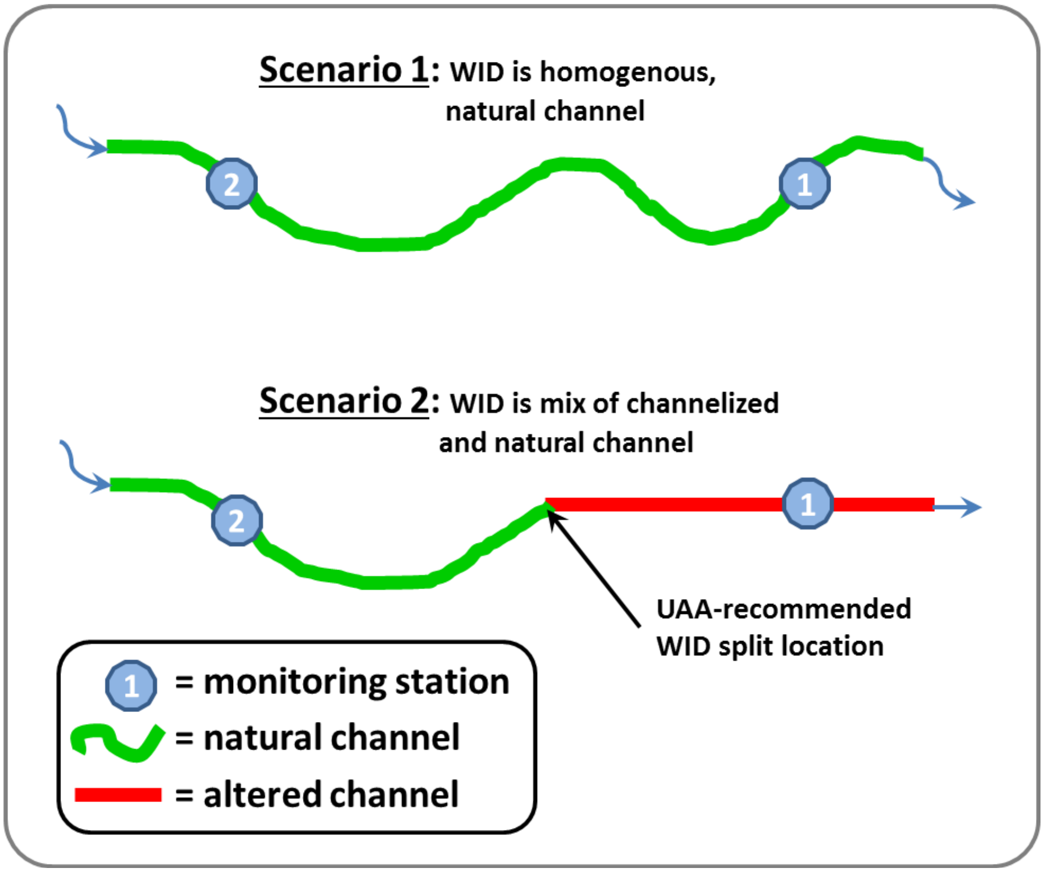
Table 1: Clean Water Act rules relevant to designation of aquatic life uses.

40 CFR § 131.3(e) Existing uses are those uses actually attained in the water body on or after November 28, 1975, whether or not they are included in the Water Quality Standards.

40 CFR § 131.10(g) States may remove a designated use which is not an existing use, as defined in Section 131.3, or establish sub-categories of a use if the State can demonstrate that attaining the designated use is not feasible because:

1) Naturally occurring pollutant concentrations prevent the attainment of the use; or
2) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met; or
3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place; or
4) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use; or
5) Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses;
6) Controls more stringent than those required by sections 301(b) and 306 of the Act would result in substantial and widespread economic and social impact.

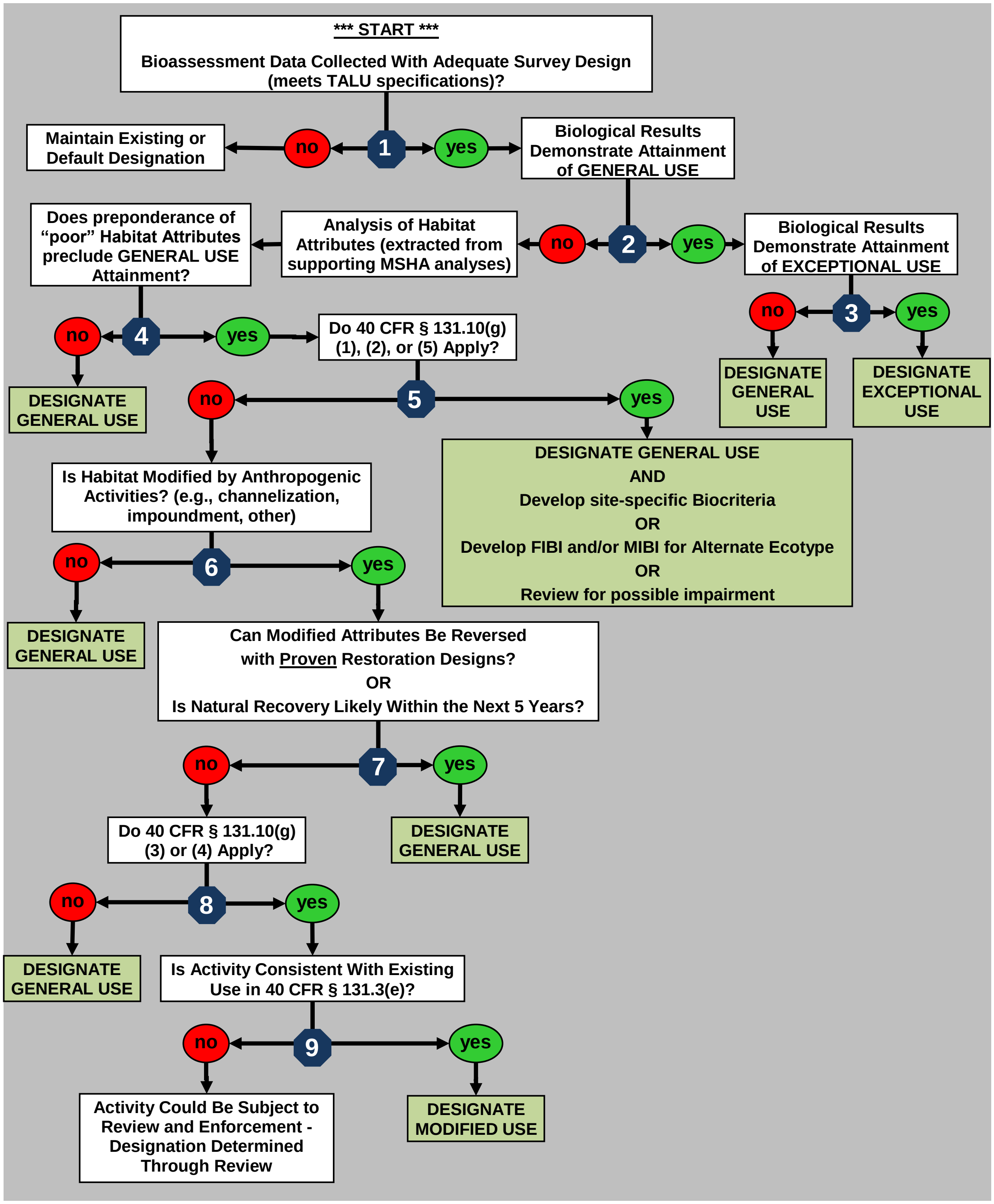
Figure 2. Examples of stream reaches (WIDs) with homogenous channel conditions and mixed channel conditions. The mixed channel reach would require a split to create two new homogenous reaches.



3.1 Use designation process

Prior to the adoption of the TALU framework, Minnesota largely used a one-size-fits-all approach to designate ALUs. A TALU framework changes this by introducing multiple tiers that better reflect the attainability of the use and which can be used to guide more effective management of the beneficial use. The introduction of additional tiers requires a detailed review of uses during the assessment of each 8-digit HUC (HUC8) watershed. In addition, changes to uses will need to be incorporated into the rule-making process (most likely on an annual basis). The process for performing TALU framework UAAs is described below with an overview of the process in Figure 3. The subsection numbers in Section 3.1 correspond to the step numbers in Figure 3. All of the appropriate steps in this process need to be followed and addressed before a change to a beneficial use is recommended.

Figure 3. Process for using biological assessments to make use designation decisions within a TALU framework in Minnesota.



3.1.1 Data review

The first step in the use review is to compile the relevant biological, chemical, and habitat data from the WID. This differs from the data that is used for assessments as it can be older than 10 years. In fact, older data can be helpful when collecting evidence to determine the existing use for a water body. This data will need to include at least one reportable/assessable visit from either fish or macroinvertebrates, although it is preferable that data from both assemblages are present. It is preferable that habitat data (i.e., Minnesota Stream Habitat Assessment [MSHA]) collected at the same time as the biological sampling visit is used. However, habitat data collected on a different day (e.g., during the sampling of the other assemblage) or from a different year may be used. In fact multiple measurements of habitat can be useful in gauging habitat conditions at different flows. If the biological and habitat data were collected at different times, then this should be considered during the review process. These considerations could include whether samples were collected during periods of very different flows or if something meaningfully changed between habitat measurements (e.g., ditch clean out, flooding, etc.). It is also useful to review available chemical data to review how chemical stressors might be impacting the biological communities.

Once the relevant biological, habitat, and chemistry data has been compiled for the assessment reach (i.e., WID) it is useful to look at channel condition of the entire reach. To do this, review the WID in a Geographic Information System (GIS) application with the Altered Watercourse (AWC) layer. During this process, it may also be useful to review LiDAR elevation data, historical and current aerial imagery, and drainage records if they are available. If discrepancies between the AWC layer and other information is identified it should be brought to the attention of the AWC manager for resolution. In most cases these issues will be resolved before this step through a comparison of the AWC layer and channel condition determinations during the biological sampling visit. The locations of the sample stations, the channel type(s) throughout the reach, and the length of the reach should be noted. The biological monitoring channel condition classification should be examined and compared to the AWC layer. Once a preliminary review of the locations of the biological stations and how they relate to the channel types in the whole WID is performed, proceed to Step 2 (Section 0).

3.1.2 Is the General Use attained?

Following a determination of sufficient monitoring data, an assessment of biological attainment of the General Use (i.e., Class 2Bg, 2Bdg, or 2Ag) is performed at each monitoring station using the biological data. This process is only needed for the nine stream classes for which Modified Uses are developed (i.e., **Fish:** Southern streams, Southern headwaters, Northern streams, Northern headwaters, Low gradient streams; **Macroinvertebrates:** Low gradient northern forest streams, High gradient southern streams, Low gradient southern forest streams, Low gradient prairie streams). For the remaining nine classes, the use review is limited to a review of the Exceptional Use (see Section 0). In cases where one biological assemblage is from a class that has a Modified Use and the other does not, the full use review can proceed for the assemblage with the Modified Use. The other assemblage would be limited to the Exceptional Use Review. The result may be that the WID will need to be split in order to accommodate multiple uses associated with different sections of the reach.

Each biological assemblage is initially assessed independently at the station level. This primarily involves a review of the IBI scores in relation to the relevant biological criteria although other lines of evidence may also be important. These data can include Biological Condition Gradient (BCG) scores, biological metric scores and raw biological data. If **both** biological assemblages have met General Use biocriteria on or after November 28, 1975, then at a minimum a recommendation of General Use can be made for the station. These data do not need to co-occur temporally as only a demonstration that both assemblages can meet the General Use is needed (see Figure 4). In cases where multiple biological visits are present, this data will need to be examined together to determine the existing use. This includes scrutinizing the temporal relationships of the visits and the proximity of the IBI scores to the biocriteria.

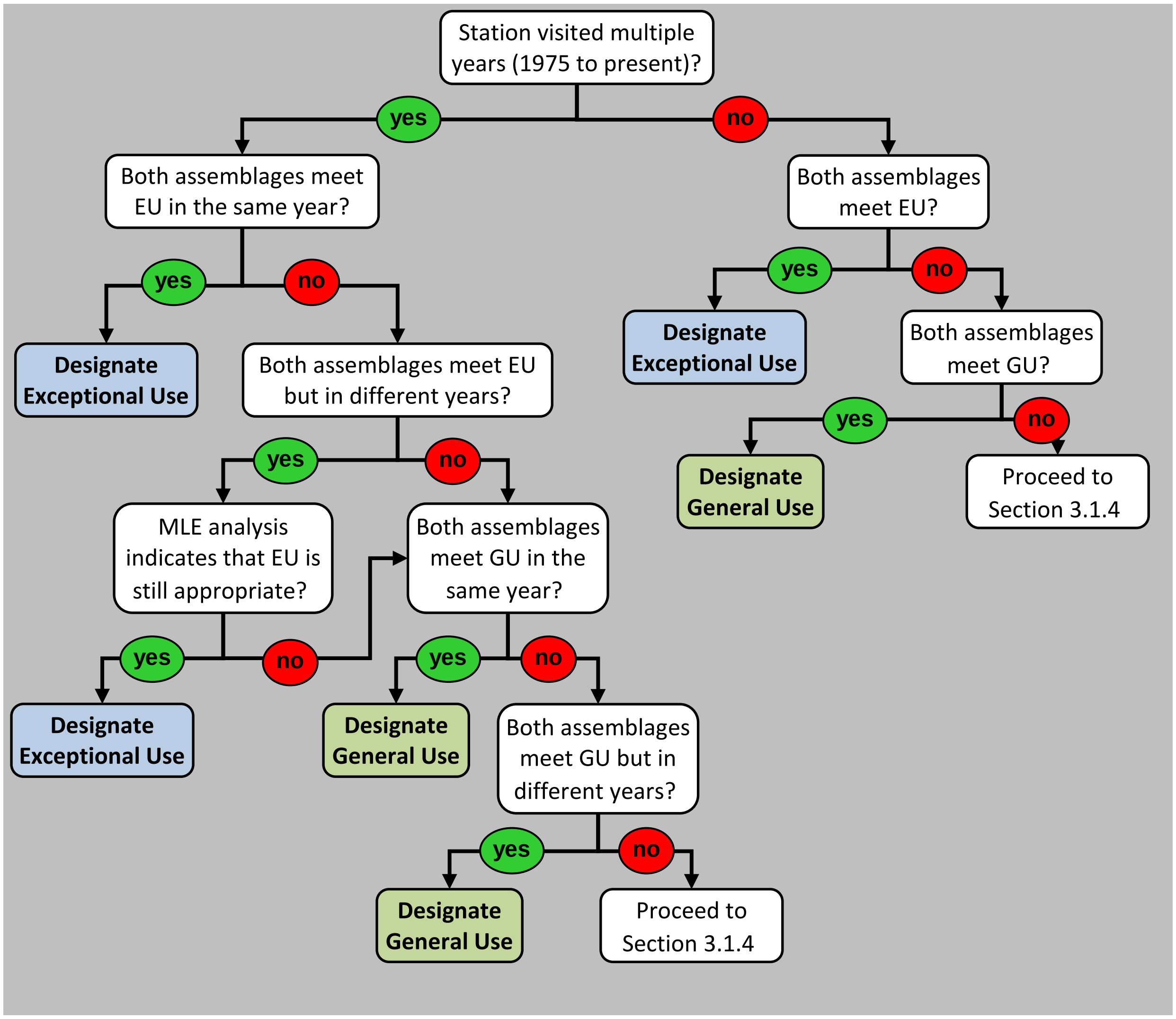


Figure 4. Process for making biological attainability decisions for single and multiple year sampling efforts.

For example, a single visit well above the biocriterion is probably sufficient to recommend General Use or higher unless there is evidence that the sample is atypical. If the biological data consists of several visits just above and/or below the biocriteria, then additional information should be considered. This can include a more detailed review of the biological data (e.g., metric by metric, species composition, BCG, etc.) to determine if the community is consistent with the General Use narrative (i.e., community structure and function largely maintained).

In cases where one assemblage does not meet the General Use while the other does, the review can proceed to the habitat assessment step (see Section 3.1.4). In other words, a Modified Use can be assigned based on the biological condition and habitat limitation of a single assemblage. Furthermore, when data is only available from a single assemblage, the review can still proceed to the habitat assessment step. In the case where the single assemblage strongly indicates a Modified Use is appropriate, the use designation is not likely to be altered by the collection of data for the other assemblage. However, if the only biological assemblage sampled meets or nearly meets the General Use biocriterion then the WID should be reviewed to determine channel condition (see Section 3.1.6). If the channel is anthropogenically modified then additional review should take place and a recommendation to collect data from the other assemblage may be warranted before the full use review can take place. In some cases the habitat data may be used without the biological data to determine if a Modified Use should be recommended.

Although a reach may be recommended for a Modified Use based on only one assemblage (i.e., one assemblage is limited by poor habitat while the other is not), the assemblages may inform each other in the review process. For example if one assemblage meets the Exceptional Use while the other nearly meets the General Use and/or is not strongly limited by habitat, it would most likely retain the General Use. In addition, the biological data from nearby sites can be reviewed whether they are within the same WID or not as long as the stations are located on similar reaches. Attainment of the biocriteria at nearby, similar stations may indicate that the General Use is attainable. To support the use decision, chemistry data, flow conditions, precipitation, and land use can also be considered.

If following the data review, there is still uncertainty regarding the attainment of the General Use, the station or WID can proceed to the next step of the UAA process (i.e., assessment of habitat condition; see Section 3.1.4). In many cases, the subsequent habitat review and other steps will help to resolve the use, but in others, additional data may need to be collected.

If the biological assemblages meet at least the General Use biological criteria or through a Multiple Lines of Evidence (MLE) approach it appears that the General Use criteria can be met, proceed to Section 0. If one or both assemblages do not meet the General Use biological criteria, proceed to Section 3.1.4.

3.1.3 Is the Exceptional Use attained?

If the General Use is attained at the station level, then the reach is further assessed to determine if it attains the Exceptional Use (i.e., Class 2Ae, 2Bde, or 2Be). As with the General Use, this primarily involves a review of the IBI scores in relation to the relevant biological criteria with other lines of evidence also considered (e.g., BCG scores, biological metric scores and raw biological data) when appropriate. If **both** biological assemblages meet the Exceptional Use biocriteria then the recommendation at the station level is Exceptional Use. This process is similar to that described for General Use assessment (see Section 0). Following this assessment, there are three scenarios:

1. A single station or multiple stations all meet the Exceptional Use biocriteria. In this case, all or part of the WID may be recommended for an Exceptional Use. To determine the extent of the reach to which the use can be extrapolated see Section 0.
2. There are multiple stations on the WID and not all stations meet the Exceptional Use biocriteria. In this case, some of the reach may be designated as Exceptional and some as General Use. See Section 3.2.2 for the process of reviewing the use designation in a WID with mixed biological results.
3. A single station or multiple stations all meet the General Use biocriteria, but not the Exceptional Use biocriteria. In this case, all or part of the WID should be recommended for a General Use. To determine the extent of the reach to which the use can be extrapolated see Section 0.

If there is a single station that attains the Exceptional Use for both assemblages, this station should be analyzed with consideration given to nearby stations and similar stations in the HUC8 watershed. For example, a single station that attains the Exceptional Use on a stream that otherwise only supports the General Use might not be designated Exceptional. However, if it is apparent that the stream reach that this single station is part of is different from adjacent reaches (e.g., different geology, gradient) it may still be designated Exceptional Use. In addition, if the single station that attains the Exceptional Use is in a watershed with little anthropogenic activity, that may also be used as evidence to support an Exceptional Use designation. If the biological data indicates that the Exceptional Use is nearly attained, additional monitoring may also be recommended for one or more stations to determine if the Exceptional Use is appropriate. In addition, most WIDs that nearly attain the Exceptional Use should be considered for protection strategies in the Watershed Restoration and Protection Strategy report.

3.1.4 Habitat assessment

As part of Minnesota's TALU framework, it is necessary to perform a review of the habitat when IBI scores are below the General Use biological criteria (Midwest Biodiversity Institute 2012). This is performed to determine if poor habitat is limiting attainment of aquatic life use goals in the station reach. If the habitat is deemed to be limiting the attainment of the biological criteria, then the reach could be considered for a Modified Use if other criteria are met.

When the General Use biocriteria are not met by one or both biological assemblages, a detailed analysis of the habitat is required (Figure 5). This analysis is driven by data collected for the MSHA tool (MPCA 2014d; www.pca.state.mn.us/publications/wq-bsm3-02.pdf), although other lines of evidence can also be part of this analysis. An overview of this process is provided here, but for a detailed description of this process see Appendix A: Habitat assessment tools. An analysis of the relationships between biological condition and habitat was performed which resulted in a suite of weighted habitat attributes that positively or negatively influence the ability of a stream to attain the applicable biocriteria (Midwest Biodiversity Institute 2015). The habitat attributes are specific to fish and invertebrate assemblages and to the nine different stream IBI classes with Modified Uses. Using these models, the number of poor or good habitat attributes as well as the probability of attainment given the scores for these attributes is calculated for each biological monitoring visit. Each biological assemblage (i.e., fish and macroinvertebrates) is reviewed separately to determine if habitat is limiting. This is done because these assemblages are sensitive to different habitat characteristics and separate models were developed to reflect these differences.

Figure 5. Habitat analysis conceptual diagram.

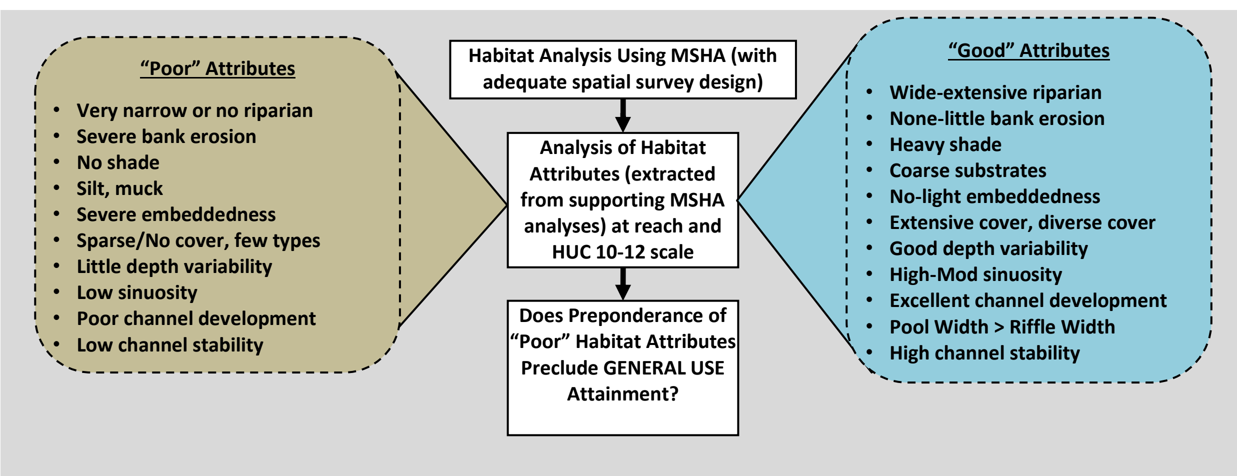


Figure 6. Probability of meeting the General Use biocriterion for fish against the number of good or poor habitat attributes in Northern headwaters (fit is a logistic regression).

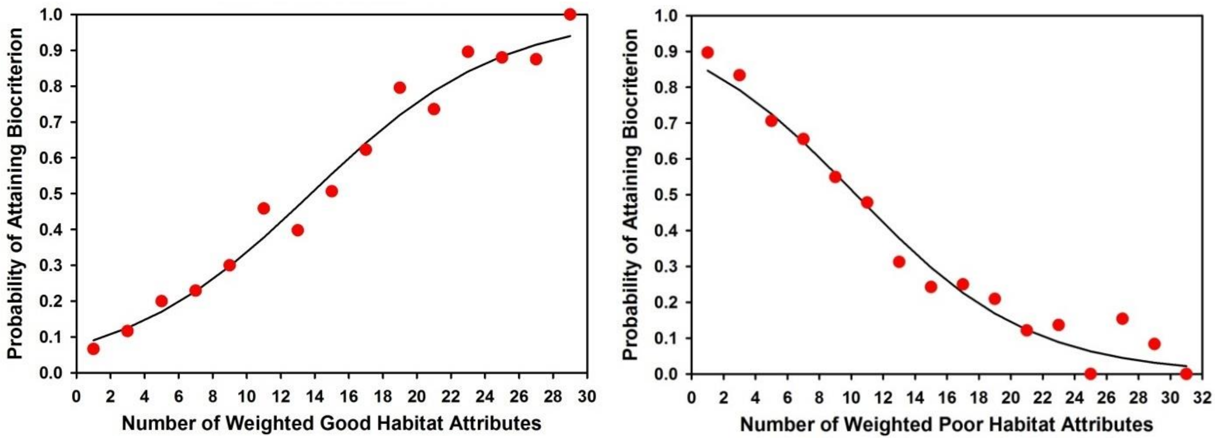


Table 1. Decision matrix for determining habitat limitation based on probabilities of attaining the General Use. This assessment only occurs when the GU is not attained.

		MSHA		
	Attainment probability	**<25%**	**25-50%**	**>50%**
Habitat tool metrics	<25%	Yes	Probable	Possible
	25-50%	Probable	Possible	Unlikely
	>50%	Possible	Unlikely	No

The process for assessing habitat condition consists of a review of the outputs from logistic regression models (Figure 6; see Appendix A: Habitat assessment tools and Appendix C: Logistic regression plots) which are based on the four habitat measures (i.e., good, poor, ratio of poor to good, and MSHA). For a station that does not attain the General Use, the results of logistic regression models are used to interpolate the probability of attaining the biocriteria based on the habitat attributes at the biological sampling station. The three habitat tool outputs are considered jointly and the MSHA output is considered separately (Table 1). For example, if any one of the habitat tool metric models and the MSHA model predict a less than 25% probability of attaining the General Use criterion, the biological assemblage in the reach is considered to be limited by habitat. When probabilities are between 25 and 50% and/or the results are mixed between the metrics, additional information will need to be considered. This information includes biological performance (i.e., proximity of IBI score to biocriterion, BCG tier), performance of the other assemblage, chemical data, and the stream's physical characteristics (i.e., recovery status, atypical features). For example, a stream reach with habitat that falls into this gray area may not be recommended for a Modified Use if the biological assemblage is close to meeting the biocriterion and there are obvious chemical stressors. Biological metric data can also be informative. For example, a small number or proportion of clinger invertebrate taxa may confirm poor habitat. In Ohio, it was determined that sensitive species are also a good measure of habitat limitation (Midwest Biodiversity Institute 2015). Another consideration can be the flows at the time of sampling. Biological data is reviewed before this review to flag or remove samples that were collected during periods outside of normal flow conditions. However, through a review of the habitat it may be determined that the flows were such that the MSHA did not effectively characterize the habitat.

If it is determined that neither biological assemblage is limited by habitat conditions, then the General Use would be recommended for the reach. If one or both biological assemblages indicate that habitat is limiting, then the reach requires further review (proceed to Section 3.1.6).

3.1.5 Are limited or poor habitat conditions the result of natural conditions?

If the habitat is limiting the biological communities, then the reach can be reviewed to determine if 40 CFR § 131.10(g)(1), (2), or (5) applies (see Table 1). This is a review to determine if the poor biological performance is a result of natural factors such as natural pollutants, flow condition, or other conditions. If 40 CFR § 131.10(g) (1), (2), or (5) applies, then the reach may be eligible for site-specific biocriteria or may require the development of a new IBI for the ecotype (Figure 3). In all cases, the reach should be recommended for a General Use or left as a default General Use and then reviewed by the appropriate group/panel (e.g., assessability, natural background, site-specific standard, etc.). In some cases, the reach may be recommended for a Consolidated Assessment and Listing Methodology (CALM) category 4D (i.e., impaired or threatened but does not require a TMDL because impairment is solely a result of natural sources) or 4E (i.e., impaired or threatened but existing data strongly suggests that a TMDL is not required because impairment is solely a result of natural sources; a final determination of Category 4D will be made in the next assessment cycle pending confirmation from additional information).

Natural pollutants: "*Naturally occurring pollutant concentrations prevent the attainment of the use* (40 CFR § 131.10(g)(1))": At this stage in the UAA review it has already been determined that the habitat is a limiting factor for the biology. As a result, naturally occurring pollutants are not likely to be an issue or they are a separate issue contributing to nonattainment. In practice, unless the naturally occurring pollutants are obvious, this factor may not be identified until the Stressor ID process. If there is evidence that the impairment is resulting from a natural pollutant then a site specific criterion will need to be considered. For example, in Minnesota there are streams that are influenced by wetlands which can naturally lower dissolved oxygen levels in the streams. These reaches would need to be referred to the Natural Background Review Team.

Natural low flow: "*Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met"* (40 CFR § 131.10(g)(2)): Notes and photos from the biomonitoring visits should be reviewed to determine if low flow conditions were present during biological sampling. If so it should to be determined if these flows were the result of normal conditions for this stream, drought conditions, or human alterations to the flow regime. If, for example, it is a small watershed or a more arid part of the state, it can be recommended that the default General Use be maintained. These streams may not be assessed until an IBI could be developed for this type of ephemeral or intermittent stream. If it is determined that the low flows are the result of atypical precipitation patterns then a default General Use would likely be recommended since the biological data collected during this period would likely be determined to be not assessable. If the low flows are the result of human alterations to the watershed (e.g., high percent of impervious surfaces) then it should be recommended for a General Use and this information should be noted for the assessment and stressor ID teams. In highly altered watersheds (e.g., watersheds with agriculture and/or urban land uses), reaches will often not be eligible for this consideration since the hydrology is often greatly modified by drainage. In the future, the incorporation of tools such as synthetic flows and reference flows might aid with the determination that a reach is naturally flow-limited or not. These reaches may need to be referred to the Natural Background Review Team.

Natural physical conditions: "*Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses* (40 CFR § 131.10(g)(5))." Natural physical conditions that result in nonattainment will likely need to be resolved by site-specific biocriteria or the development of IBIs for a new ecotype. If the physical issues are more common or widespread, then a new IBI model may be appropriate for that class of streams. The reach should be flagged so that it can be used in future work to develop this IBI. For example, some reaches are transitional between a stream and a wetland (i.e., defined channel but very low gradient) which may make the current IBIs unsuitable for assessment. In the case of unique features (e.g., natural impoundments) a recommendation of General Use or default General Use can be made, but a site-specific standard may need to be developed. These reaches may need to be referred to the Natural Background Review Team. If none of these three scenarios apply to the reach then a recommendation of General Use or default General Use is made. As a result of this review it may be determined that the poor habitat is the result of human activities and a recommendation of General Use is needed. For example, natural channel streams with unrestricted livestock access can often have poor habitat condition. Altered flow regimes, such as those found in watersheds with large amounts of impervious surfaces or tile drainage can also have poor habitat.

3.1.6 Origin of habitat modifications

In reaches where one or both biological assemblages do not attain the General Use and the habitat is determined to be limiting, it is then necessary to determine the origin of the habitat condition. In Minnesota, the most common form of habitat modification is channelization. Another possible form of channel modification in Minnesota streams is bank armoring such as riprap and concrete. Other modifications such as impoundments are also a possibility, but the MPCA's current biological sampling program typically avoids impounded reaches. If it is determined that habitat limitation is the result of a human-made impoundment, then this should be noted, but at this time the use should not be reviewed since the applicability of Minnesota's current biological tools have not been tested in impounded reaches. In some cases, a WID will have a mix of altered and natural reaches, but the full review of the WID takes place after aquatic life uses are reviewed for all stations within a WID (see Section 3.2). However, it is often useful to review all of the data from the WID and from adjacent WIDs to help inform the monitoring reach level decision.

Determination of channelization should be based on several lines of evidence (e.g., AWC layer, aerial imagery, LiDAR, site visit records, site photos, and county records). For example, the channelization review should not be based solely on the AWC layer and requires at least a review of LiDAR and aerial imagery to determine the status of the channel. This is especially true of waters that are recommended for a Modified Use. This review determines if the habitat is modified. There are a number of lines of evidence than can be used to determine if a stream is altered (see Appendix A in Altered Watercourse Determination Methodology [Krumrie et al. 2013]). These can include:

- Watercourse does not exist on prior aerial photography
- Watercourse feature flows parallel to road or other artificial structure (e.g. levee)
- Watercourse's sinuosity is significantly decreased from connected watercourses
- Watercourse cuts across old oxbows and meanders
- Watercourse feature flows across or starts inside dried-up wetland, pond, or lake
- Uniform-colored halo of pixels on imagery is thin, of constant width and parallel to watercourse
- Watercourse does not follow Digital Raster Graphics (DRG) stream lines
- Watercourse crosses DRG contours unnaturally

- DRG elevation contours straight, close and parallel to watercourse
- LiDAR imagery shows watercourse as straight and narrow or otherwise unnatural shape
- Associated MPCA Bio Site shows stream as altered
- Associated DRG stream or Geographic Names Information System (GNIS) feature labeled County or Judicial Ditch
- Associated Minnesota Department of Natural Resources (MDNR) 24k Stream feature's type is "Artificial" or nearby type is "Superseded Natural Channel"
- Associated GNIS of the United States Geologic Survey (USGS) indicates an artificial channel (FEATURE_CL = canal)
- Associated National Wetlands Inventory (NWI) feature's Special Modifier (SPEC_MOD) field is any type but blank or b (Beaver)
- Associated Public Waters Inventory (PWI) designates the stream as Public Ditch/Altered Natural Watercourse (PWI_Flag = 2)
- Watercourse connected or adjacent to artificial water body (e.g. sewage treatment pond)

In most cases, this determination will be obvious; however, channelized streams that have naturally recovered or that have been restored, may pose a challenge. In these cases, it will be important to determine if the habitat is limiting and to establish that at some point the channel was modified in order for the reach to be eligible for a Modified Use. If these requirements are met, then it can be assumed that the legacy impacts of the channel modification are continuing to impact biological condition.

In addition to establishing that the reach is altered, the legality of that alteration should be determined. Since most alterations to stream channels are the result of drainage construction and maintenance, this review will commonly consist of a review of drainage records. However, in most cases these records are difficult to obtain and this review may be limited until electronic versions of these records are available.

If the evidence does not indicate that the reach has been legally altered, then proceed to Section 3.1.5. If the reach is legally altered then proceed to Section 3.1.7.

3.1.7 Can a physically altered stream be restored?

Following determination of non-attaining biology that is limited by anthropogenically altered habitat is a review of the restoration potential (Figure 3). This step determines if the habitat in the reach can be restored using proven designs or if the reach is likely to recover naturally in the next five years. At this time, the restorability of an altered reach may be limited to relatively short sections (<1 mile) where the natural channel meanders and some connectively to a floodplain can be restored. As channel restoration technology improves, it will become feasible to restore larger sections and complexes of altered channels. Over time this will alter the threshold for this decision step. In regards to the natural recovery within five years, this step is in place for waters that are impacted by temporary modifications to the channel due to activities such as construction.

3.1.8 Do hydrological modifications or human-caused pollution preclude attainment of aquatic life uses?

Following determination of non-attaining biology that is limited by anthropogenically altered habitat is a review of the restoration potential (Figure 3). This includes review of compliance with 40 CFR § 131.10(g)(3) or (4). In this case, the modified condition of the channel needs to be considered as well as the possibility that irreversible human pollution limits attainment. These causes include 1) channelized for drainage, 2) modifications resulting from dams, diversions, and other hydrologic modifications, and 3) human-caused pollution that cannot be remedied or cannot be remedied without causing more environmental damage.

3.1.8.1 Hydrologic modifications

Channelized for drainage: Streams with modified habitat are most commonly drainage ways designed to move water quickly off the land to improve agriculture, to reduce flooding, or to make areas suitable for development. Under current technologies, the ability to construct multiuse drainage ways (i.e., channels that provide drainage and protect aquatic life) has not been fully demonstrated – especially on a large scale. As a result, most maintained drainage ways are not presently restorable without a huge investment with uncertain results. However, in some cases short reaches (e.g., <0.25 miles) that are part of a largely unmodified stream system may be considered restorable using current technologies (e.g., remeandering, 2-stage ditches). Road crossings are a common cause of short, channelized reaches that may be difficult to restore. These reaches tend to be short and not characteristic of the WID, and are usually avoided for biological sampling. In addition, because they are short and not characteristic of the WID a split would not be appropriate to redesignate these atypical reaches. In cases where biological data were collected from a short reach impacted by a road crossing, the reach could be designated General Use or a decision may be made to not assess those data and to retain the default General Use. Furthermore, resampling in the natural stretch of the reach could be considered. If it is likely that the reach can be restored or that it will recover on its own, then the reach would be designated General Use. If based on a review of these considerations it is determined that the modifications cannot be feasibly reversed, then proceed to Section 3.1.9.

Dams and diversions: If the habitat in the reach is impacted by dams or diversions then it could be eligible for a Modified Use. To identify the influence of dams or diversions within a reach, the AWC layer, aerial photos, site visit notes and photos, and the MDNR Dam GIS layer can be used. If it is determined that the reach is directly impacted by an impoundment a Modified Use may be appropriate. [Note: Reaches with fish communities that are impacted by dams which create fish barriers may be considered for CALM category 4C] However, at this time biological data from impounded reaches is not assessable because the IBIs have not been tested in reaches of this type. For dams, it may be worthwhile to inquire with the MDNR to determine if restoration is feasible. If based on a review of these considerations it is determined that the modifications cannot be feasibly reversed, then proceed to Section 3.1.9.

3.1.8.2 Human-caused pollution that cannot be remedied

If the cause of the impairment is the result of anthropogenic pollution that cannot be remedied or the act of remediation would cause more environmental damage, then the reach could be eligible for a lower use. This will not be common in Minnesota streams, but could include legacy impacts from acid mine drainage or heavy metal pollution. Generally, such a finding will require an Environmental Review. Human-caused pollution that cannot be remedied does not include agricultural pollution. If based on a review of these considerations it is determined that the modifications cannot be feasibly reversed, then proceed to Section 3.1.9.

3.1.9 Existing use review

Following a determination that the reach cannot be restored, available information should be used to determine if the modifications occurred on or after November 28, 1975. This review will most likely be performed using historical aerial imagery. Presently, there are limited digital versions of these photos available, so this review may not be possible at this time. However, the USGS Historical Topographic

Map Explorer does include many maps that can help to narrow down the modification date (http://historicalmaps.arcgis.com/usgs/). Other records such as ditch liens can also be used to determine the date of ditching; however, this information is largely available in hard copy from the county in which the ditch is located. If it is determined that the activity is not consistent with existing use, the activity would need to be reviewed and the appropriate use would need to be determined. For example, a stream reach that was channelized after November 28, 1975, would not be eligible for a Modified Use and in most cases would be designated General Use.

If a review indicates that the channel was ditched before November 28, 1975, then the reach can be recommended for a Modified Use designation. If **both** biological assemblages meet the Modified Use biocriteria then the recommendation at the station level could be Modified Use. This process is similar to that described for General Use assessment (see Section 3.2).

3.2 Review of Aquatic Life Use for a WID

Following determination of the recommended use for each monitoring station within a WID, the full reach needs to be reviewed to determine the ALU for the WID and if splitting the WID is required. Although the focus is on the WID, it is also useful to make final use decisions using adjacent and nearby data to inform the decision. This WID-level process needs to take all of the steps in Figure 3 into consideration. This review is done to create WIDs that are homogeneous with a single TALU so that assessments in these stream segments are reflective of the entire reach. The existing WID framework is largely adequate for tiered uses. In this framework WID boundaries are primarily based on major tributaries, changes in use classification, or significant morphological features such as lakes and dams. It is also possible that WID merges could be recommended to improve management of these resources. The TALU framework will require some adjustment to the WID framework with most of these changes resulting from recommended use class changes within existing WIDs. However, reach characteristics (e.g., mid-reach lakes, changes in channel condition, major tributaries, etc.), landscape patterns (e.g., major changes in land use), or potential sources of legacy impacts (e.g., dams) can also be used to recommend a WID split. For reaches where sufficient biological data is not available, (this can include data from November 28, 1975, to the present) the use typically cannot be confirmed. As a result, these reaches will need to be delineated and left as default General Use waters. Most of the WID adjustments will be done during the first 10-years of the intensive watershed monitoring (IWM) cycle with some ongoing maintenance in subsequent cycles. Following the initial IWM cycle, additional use designation work will stem from data collected on previously unmonitored reaches, improvements in biological condition, and some corrections, as more data is available.

Following the use review process at each monitoring station, the reviewer(s) should already be familiar with the WID. This step largely brings together the ALU information from the available stations and any other pertinent information at the WID level or from adjacent WIDs. As with the station-level reviews, many forms of data are necessary to determine the appropriate ALU and the location of any WID splits (e.g., altered watercourse data, aerial imagery, site visit notes, etc.). This review should not result in many small (e.g., <0.25 miles) reaches with different uses. Instead, the purpose of this review is to characterize and recommend the overall use for larger reaches. Below are descriptions of the possible options for recommending an ALU in a WID.

3.2.1 All stations within a WID have the same recommended use

If use recommendations for all of the stations within a WID are the same use, then that ALU would be applied to the full reach. However, if the site or sites are not adequate to provide an assessment of the entire WID, then the WID-level review would need to consider if there are unmonitored reaches that differ from the monitored reaches. The most common cases for this situation are as follows:

- **All stations are Modified Use:** In a WID with one or more stations that are recommended for Modified Use, there may also be unmonitored, meandering reaches within the WID. If the natural reach is relatively long (e.g., >0.5 miles) then it should be designated a default General Use and a WID split would be needed. Therefore, it is only possible to include very short natural channel reaches that are associated with channelized reaches in a Modified Use WID. This review should also consider how far the Modified Use is extrapolated. Even in WIDs that are entirely altered, the Modified Use is typically only extrapolated approximately five miles from the biology station(s). This five-mile guideline could be extended for reaches where there are a series of biological stations which all indicate similar uses.
- **All stations are General Use:** In a WID with one or more stations that are recommended for a General Use, there can be reaches that are channelized within the WID. In this situation, the channelized reach could be retained within the WID as a General Use until there is data to recommend a different use for the channelized portion. However, if the channelized reach is very long or distant from the biomonitoring station (>5 miles), the unmonitored channelized portion should be designated a default General Use and a WID split would be required. In some cases where a resolution of the use is needed for an unmonitored reach, biological and habitat data (i.e., MSHA) should be collected to ascertain the appropriate use. In cases, where all or most of the channel is natural, but much of the reach is unmonitored, a General Use can be maintained. However, it should be noted in the UAA transparency form that the conformation of the use is based on limited information.
- **All stations are Exceptional Use:** The results of this review would be similar to the case when all of the stations are General Use. However, it is also possible that in a reach with only Exceptional Use stations that has natural channels, part of this reach could be considered General Use and a split could be recommended. This could occur on large reaches or reaches where landuse changes, a major tributary enters, channel condition changes, or some other landscape change occurs between the monitored and unmonitored reaches. In this case the unmonitored reach would be designated a default General Use and a WID spilt would be required. Typically, the Exceptional Use is only extrapolated approximately five miles from the biology station(s) although the five-mile guideline could be extended for reaches where there are a series of biological stations which all indicate Exceptional Use.

3.2.2 Different use recommendations for monitoring reaches within a WID

If there are different use recommendations among the stations within a WID, a review is needed to determine if the WID should be split and the location of such splits. As with the case where all stations have the same recommended use, a review of unmonitored reaches is also needed to determine if splits are needed for default General Use reaches. In some cases, it may be determined that although recommended uses differ at the station level, the WID should be given a single use and not be split. Most commonly, this would result from one Modified Use station among one or more General Use stations in a channelized WID. In this situation, the performance of the General Use station(s) may indicate that the General Use should also be attainable at the Modified Use station and therefore the entire reach designated General Use.

3.2.3 Splitting long WIDs

In all WIDs, the length of the WID should be considered. In many cases, especially on smaller streams, long reaches should be considered for a possible split unless the reach is homogenous and sufficient monitoring data is available throughout the reach. In most cases, if a large reach needs to be split, this will be determined in the steps above. However, in cases where this does not occur, it is worth reviewing the WID to determine if the reach is an appropriate assessment unit. A reason for splitting a long reach that is not the result of the designation of TALUs may include splitting a WID that crosses multiple aggregated 12-digit HUCs.

3.3 Summary of TALU use review process

The process of reviewing uses is intended to determine the appropriate and attainable use for Minnesota streams and rivers. It is important that these uses are properly reviewed and designated; otherwise the management activities that follow could be less efficient or erroneous. It is important that all of the steps are followed although the order of those steps may vary depending on the reach. Following a use recommendation, these waters will undergo an aquatic life use assessment and possibly stressor identification steps. These steps will include the incorporation of additional data and internal and external meetings. During this work, if evidence indicates that the initial use designation is incorrect, then the use can be reviewed further and changed if it is supported. Following the initial assessment of these reaches, a formal use designation process will occur. This formal rulemaking will incorporate these uses into Minn. R. 7050.0470 before any impairments on these reaches are added to the impaired waters list. Before the rule changes are adopted, the new designations are considered "recommended uses".

4. Cold and warm/cool water reviews

To change a use designation from cold water (Class 2A) to cool or warm water (Class 2B) or vice versa, a comprehensive review of biological, chemical, and physical measures as well as other data are used to determine the natural and existing use of a waterbody. These designations may be triggered for different reasons. Most commonly, cold water reviews are triggered when new biological data are collected from a stream by the MPCA. New fish, macroinvertebrate, and temperature data are screened using the processes described in Figures 8 and 9 to determine if a thorough review is necessary. Reviews of cold waters (Class 2A) to determine if they should be reviewed in detail for a possible cool/warm water (Class 2B or 2Bd) designation, only screens the fish (Figure 8). If this screening indicates a review of the designated use is needed, then the macroinvertebrates will be used as supporting information in that review. Reviews of warm/cool waters (Class 2B, 2Bd) to determine if they should be reviewed in detail for a possible cold water designation, screens both fish and macroinvertebrates (Figures 8 and 9). Both assemblages are screened in this case because either the fish or macroinvertebrates may be used alone to support the designation of a water to Class 2A. For example, some streams lack the habitat to support a population of salmonids, but temperatures and habitat are sufficient to support a cold water macroinvertebrate assemblage. In addition to routine screening of data performed by the MPCA, cold water reviews can also be triggered by changes to the MDNR trout waters list (Minn. R. 6264.0050) or by requests by stakeholders (Minn. R. 7050.0405) to review a designated use.

Figure 7. Relationship between summer (June-September) average water temperature (°C), percent of time during the summer with temperatures within the growth range for brook trout, and the percent of salmonids in streams.

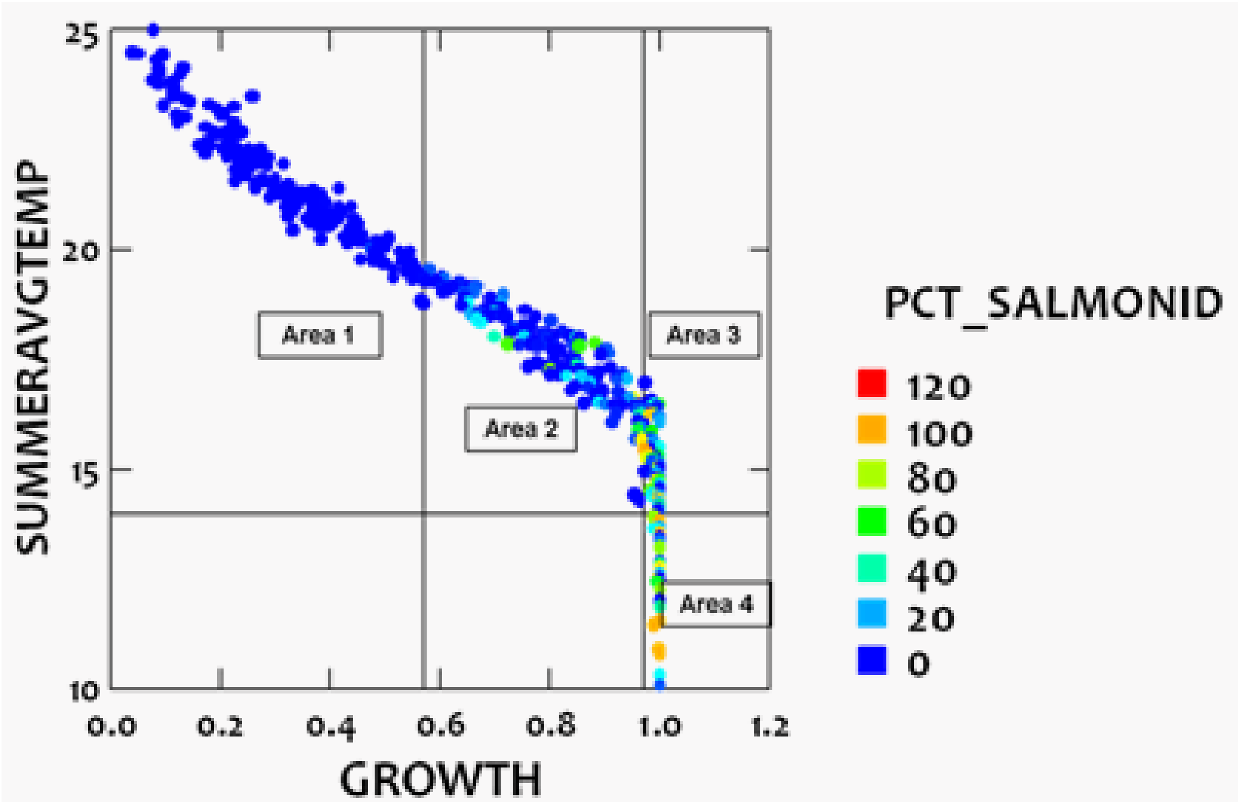


Figure 8. Flowchart of screening criteria for cold water fish assemblages. Cold water fish taxa are listed in Appendix D.

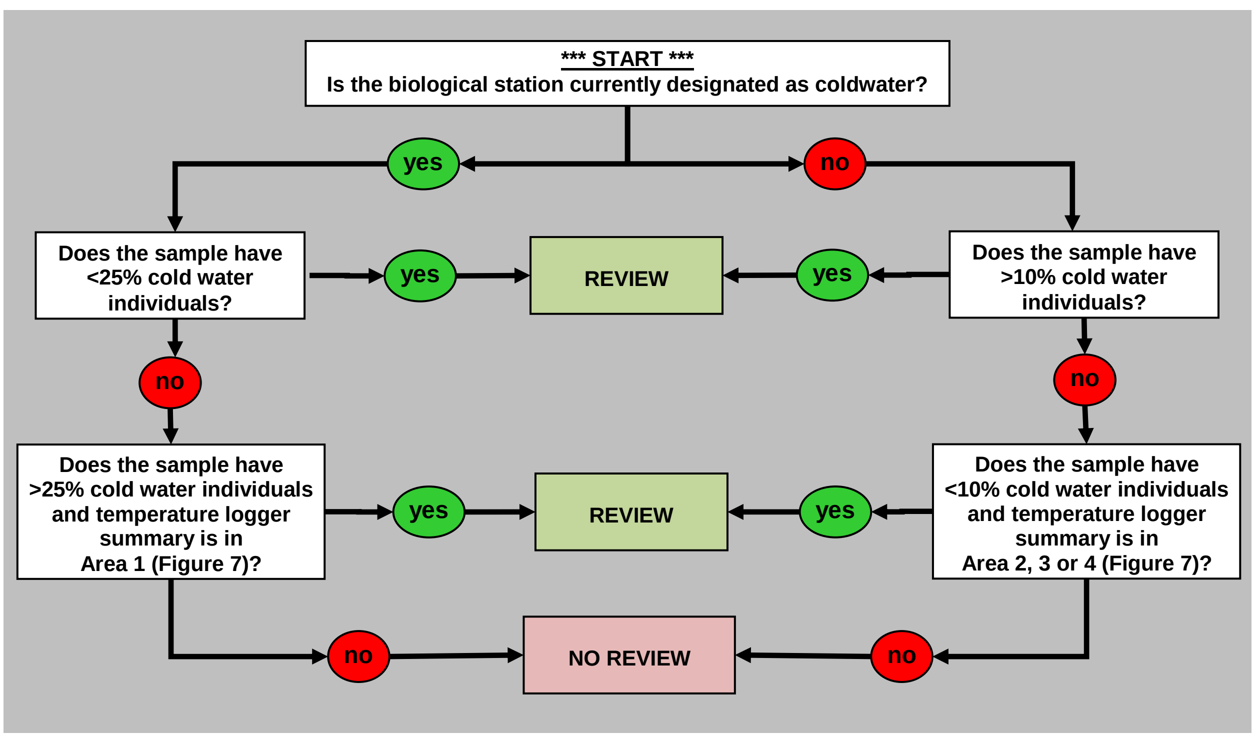
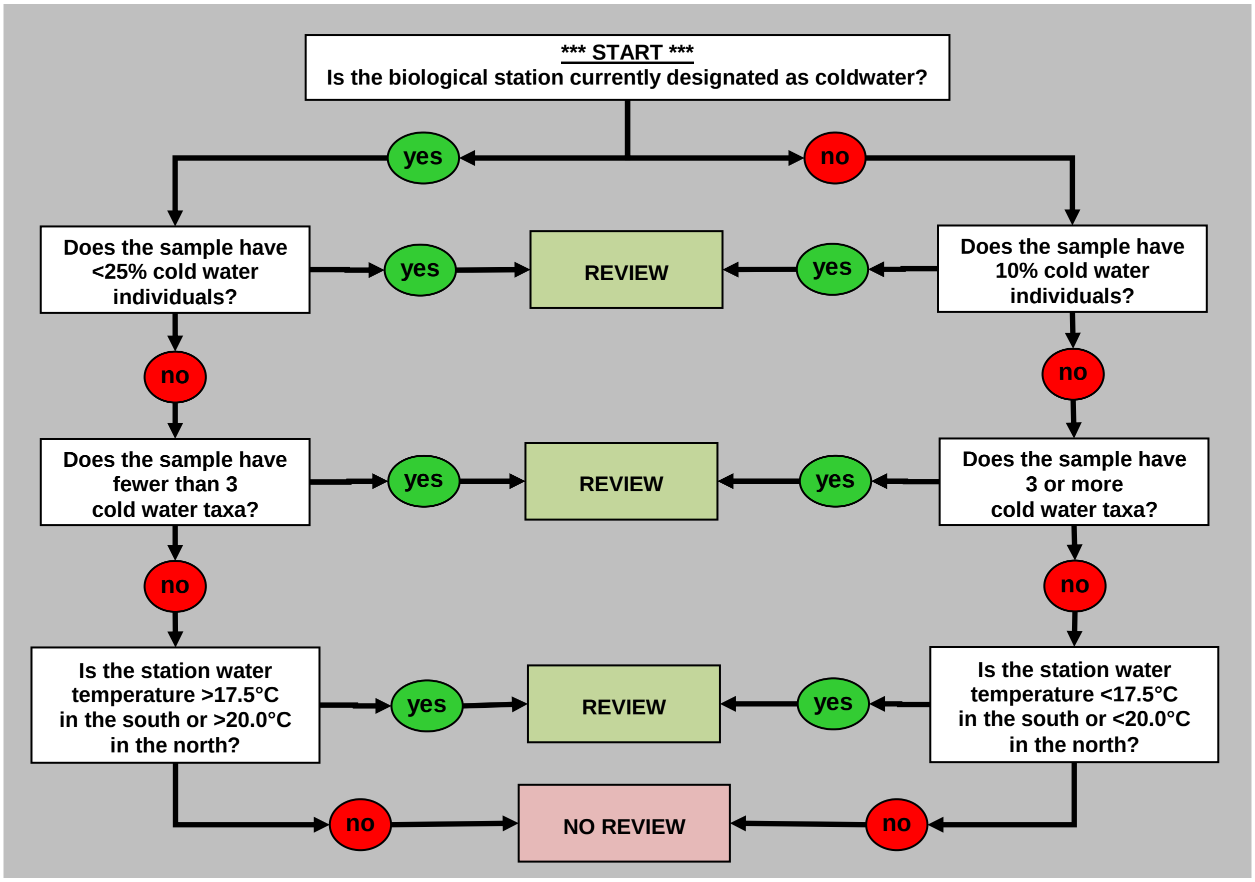


Figure 9. Flowchart of screening criteria for cold water macroinvertebrate assemblages. Cold water macroinvertebrate taxa are listed in Appendix E.



Regardless of the reason for initiating a cold water review, a detailed consideration of available relevant data is needed to determine the appropriate designated use. Biological data are the primary source of information used to demonstrate if a cold water use is an existing use. Reviews of fish and macroinvertebrate data focus on the presence or absence and the proportion of cold water species (e.g., trout, sculpin, the amphipod Gammarus, and the small minnow mayfly Baetis tricaudatus). These reviews include assessments of contemporary and historical data. Of particular importance for use designation is the demonstration that these waters currently support or have supported sustained trout reproduction or that they have good year-to-year carryover of salmonids (e.g., stocked trout survive over the winter). Some streams that do not support trout due to barriers, stream size constraints, or poor fish habitat can also be designated Class 2A based on the presence of a cold water macroinvertebrate community and appropriate thermal indicators. Temperature data are also important in cold water reviews. Temperature logger data (i.e., measurements recorded continuously every 15-30 minutes during the summer index period) are especially useful as they provide a more comprehensive estimate of summer conditions and can be used to estimate the percent of the time temperatures are suitable for supporting and maintaining cold water biota. Other physical and chemical characteristics (e.g., habitat, flow, dissolved oxygen, presence of beaver dams, migration barriers) of the waterbody are also used as part of the review to determine the existing use. In all cases, the use review is held to determine whether or not a designated use is an existing use. This holds that uses attained in a surface water on or after November 28, 1975 must be protected (see Minn. R. 7050.0255, subp. 15). Data collected as part of MDNR trout stocking and management efforts is often important for establishing existing uses as there may often be data available from the 1960s-80s which helps to establish the condition of the habitat around the existing use date. Cold water reviews are also done with consultation from MDNR staff in order to compile all available information, consider MDNR's management goals for the water, and to align class 2A waters with MDNR's trout waters list when feasible.

The outcomes of the cold water review process include: 1) no change to the designated use, 2) change the designated use for the entire reach, or 3) change the designated use for part of the reach. In cases where the evidence is insufficient to support a use class change, no change to the designated use change is proposed. A recommendation to collect additional data may also occur in order to determine the appropriate use designation. In general, it will be the MPCA's responsibility to build the case for a use designation change. The outcome of most cold waters reviews is to retain the current aquatic life use designation.

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Appendix A: Habitat assessment tools

The implementation of Tiered Aquatic Life Uses (TALU) requires the development of several tools that make the management of the TALU framework feasible. One of these tools is a means to systematically and consistently measure the impacts of habitat on biological measures. This capability is necessary to support Use Attainability Analyses (UAAs) for Modified Use in the TALU framework. As part of routine biological monitoring, a qualitative habitat assessment called the Minnesota Stream Habitat Assessment or MSHA is performed (MPCA 2014d). This provides a measurement of the habitat condition as it relates to the biological assemblages. To further refine this information, an analysis was performed to determine which individual metrics are most strongly related to good or poor biological performance (Midwest Biodiversity Institute 2015). Building upon this work, this document describes how the habitat tool output is used to determine if habitat condition is limiting attainment of biological goals. Five fish and four macroinvertebrate classes are anticipated to have a Modified Use so the analyses in this document are limited to these nine classes.

Introduction

Some activities in Minnesota have resulted in legacy impacts to streams that currently have difficulty meeting Minnesota's aquatic life General Use goals. These activities include stream channelization that was performed under Minnesota Drainage Law (Minn. Stat. ch. 103E). The relationships between aquatic life and reduced habitat condition have been well documented (Gorman and Karr 1978, Griswold et al. 1978, Schoof 1980, Karr and Dudley 1981, Karr et al. 1986, Schlosser 1987). The biological limitation and reduced function of these waters is imposed by poor habitat is caused by ditch maintenance activities (e.g., excavation, cleaning, snagging, repair of banks; Doyle and Bernhardt 2011, Yoder and Rankin 1995) The biological limitation of these streams is imposed by insufficient habitat to support aquatic life that meets Minnesota's General Use goals. Despite these limitations, when these watersheds are managed appropriately (i.e., maintaining buffers, etc.) these systems should still be expected to meet some goal below General Use, and not be written off as waters that are incapable of supporting aquatic life or providing beneficial uses other than drainage. In fact, biological data collected by the MPCA demonstrates that some of these channelized waterways currently meet General Use goals for aquatic life. Under a TALU framework they will be held to a reasonable goal that accounts for the loss of habitat and is reflective of the biological potential of a properly managed channelized stream.

In accordance with the CWA, to determine when a Modified Use applies, a UAA will be performed to determine if the system cannot meet the General Use and that habitat is limiting this use. In cases where the habitat is deemed to be limiting, an evaluation is then required to determine if the habitat condition is the result of legal activities and that it cannot be restored (Midwest Biodiversity Institute 2012). If these criteria are met, the stream could be eligible for a Modified Use.

Minnesota Stream Habitat Assessment

As part of routine biological monitoring, field biologists perform a habitat assessment in the stream reach using the MSHA (MPCA 2014d). The MSHA is a qualitative measure of habitat condition modeled after Ohio's Qualitative Habitat Evaluation Index (QHEI; Ohio EPA 2006). The MSHA measures four classes of habitat metrics: 1) Land Use, 2) Riparian Zone, 3) Instream Zone, and 4) Channel Morphology.

The result of this assessment is a score from 0-100 with 0 indicating very poor habitat and 100 indicating excellent habitat. Details on the protocol for performing the MSHA can be found here: http://www.pca.state.mn.us/index.php/view-document.html?gid=6088.

Habitat tool

To improve the predictive ability of the habitat measures collected during biological visits, analyses were performed to identify specific habitat metrics that are associated with biological scores (i.e., indices of biotic integrity [IBIs]). The details of this work can be found in Midwest Biodiversity Institute (2015). These analyses identified the habitat metrics associated with good or poor IBI scores using an Analysis of Variance (ANOVA) and a Tukey's Multiple Comparison test when significant differences were identified by the ANOVA. The result is a weighted score for those metrics identified as important (see Appendix B). Metric attributes that were highly significant ($p<0.001$) were given a score of 2 points. Metric attributes with a significance of $p>0.001$, but less than $p<0.05$ were given a score of 1 point. Those less significant $p>0.05$, but strongly trending or where a lack of significant was due to small samples size were give a weighting of 0.5 points. Metric attributes with no relationship did not receive a score. The individual metric attribute scores are provided in Appendix B. Using these weighted scoring criteria, a count of the good and poor habitat attributes can be tallied for each stream reach.

Predicting biological potential using habitat measures

To determine the probability of attaining biological criteria, predictive models were developed using logistic regression. Logistic regression models (Equation 1) were fit to binned data for the count of good attributes, the count of poor attributes, the ratio of good to poor attributes, and the raw MSHA score. This analysis was performed in the program R ver. 3.0.2 (R Development Core Team 2013) using a generalized linear model ("glm" function using the binomial family and the link function "logit"; R Development Core Team 2013). The equation for the logistic curve can be written as:

Equation 1

$$P = \frac{e^{b_0+b_1X}}{1+e^{b_0+b_1X}}$$

The resulting logistic regression models for all five fish and four macroinvertebrate classes were significant ($p < 0.05$) for the four habitat measures tested (Tables 2-5; see Appendix C: Logistic regression plots). Using these models, a probability of meeting the fish or macroinvertebrate biological criteria can be assigned to a station using the MSHA data collected during the biological visit (Table 6). For example, the model predicts that a stream in the Southern stream (2) class with a single good attribute has a 12% probability of meeting the biological criteria for fish.

Table 2: Logistic regression model equations for good habitat attributes.

Assemblage	Class name	#	b_0	b_1	P value
Fish	Southern streams	2	-2.2495464	0.1222406	<0.0001
Fish	Southern headwaters	3	-2.1678254	0.1777816	<0.0001
Fish	Northern streams	5	-1.5771966	0.1757848	<0.0001
Fish	Northern headwaters	6	-2.244949	0.1779056	<0.0001
Fish	Low gradient	7	-3.0092939	0.4130413	<0.0001
Macroinvertebrates	Low gradient northern forest streams	4	-0.6347702	0.2872918	<0.0001

Assemblage	Class name	#	b_0	b_1	P value
Assemblage	Class name	#	b_0	b_1	P value
Macroinvertebrates	High gradient southern streams	5	-2.5834945	0.2779666	<0.0001
Macroinvertebrates	Low gradient southern forest streams	6	-2.9452517	0.3335281	<0.0001
Macroinvertebrates	Low gradient prairie streams	7	-3.772387	0.241916	<0.0001

Table 3: Logistic regression model equations for poor habitat attributes.

Assemblage	Class name	#	b_0	b_1	P value
Fish	Southern streams	2	0.3337835	-0.1641361	<0.0001
Fish	Southern headwaters	3	0.280476	-0.3067154	<0.0001
Fish	Northern streams	5	2.6819851	-0.2252628	<0.0001
Fish	Northern headwaters	6	2.082724	-0.2221071	<0.0001
Fish	Low gradient	7	1.8450675	-0.4164151	<0.0001
Macroinvertebrates	Low gradient northern forest streams	4	2.2536808	-0.2947712	<0.0001
Macroinvertebrates	High gradient southern streams	5	1.0973409	-0.2847617	<0.0001
Macroinvertebrates	Low gradient southern forest streams	6	0.8683169	-0.3114529	<0.0001
Macroinvertebrates	Low gradient prairie streams	7	1.0115956	-0.2701097	<0.0001

Table 4: Logistic regression model equations for the ratio of good to poor habitat attributes.

Assemblage	Class name	#	b_0	b_1	P value
Fish	Southern streams	2	-1.121281	-1.52768	<0.0001
Fish	Southern headwaters	3	-1.336723	-1.525376	<0.0001
Fish	Northern streams	5	0.3284526	-2.672028	<0.0001
Fish	Northern headwaters	6	-0.293191	-2.457475	<0.0001
Fish	Low gradient	7	-0.663735	-3.31253	<0.0001
Macroinvertebrates	Low gradient northern forest streams	4	0.8464985	-1.797965	<0.0001
Macroinvertebrates	High gradient southern streams	5	-0.741928	-2.312095	<0.0001
Macroinvertebrates	Low gradient southern forest streams	6	-1.043355	-2.241845	<0.0001
Macroinvertebrates	Low gradient prairie streams	7	-1.434873	-2.90616	<0.0001

Table 5: Logistic regression model equations for MSHA scores.

Assemblage	Class name	#	b_0	b_1	P value
Fish	Southern streams	2	-3.06590312	0.04268932	<0.0001
Fish	Southern headwaters	3	-2.95544088	0.04369541	<0.0001
Fish	Northern streams	5	-4.01841976	0.07078414	<0.0001
Fish	Northern headwaters	6	-4.11069995	0.06632642	<0.0001
Fish	Low gradient	7	-5.5288878	0.1010003	<0.0001
Macroinvertebrates	Low gradient northern forest streams	4	-3.12900681	0.06144438	<0.0001
Macroinvertebrates	High gradient southern streams	5	-3.59438404	0.04905375	<0.0001
Macroinvertebrates	Low gradient southern forest streams	6	-3.33722999	0.05473118	<0.0001
Macroinvertebrates	Low gradient prairie streams	7	-4.69133958	0.06545275	<0.0001

Table 6: Habitat assessment criteria based on logistic regression models. <25% and <50% equate to model predictions where there is a <25% or 50% probability of attaining the General Use biological criterion when the habitat metric threshold provided in the table is exceeded. Abbreviations: P/G = ratio of poor +1 attributes to good +1 attributes.

Assemblage	Class	Class #	Habitat metric	<25%	<50%
Fish	Southern streams	2	Good	≤9.0	≤18.0
Fish	Southern streams	2	Poor	≥8.5	≥2
Fish	Southern streams	2	P/G	≥0.97	≥0.19
Fish	Southern streams	2	MSHA	≤46.0	≤71.8
Fish	Southern headwaters	3	Good	≤6.0	≤12.0
Fish	Southern headwaters	3	Poor	≥4.5	≥1.0
Fish	Southern headwaters	3	P/G	≥0.70	≥0.14
Fish	Southern headwaters	3	MSHA	≤42.4	≤67.6
Fish	Northern streams	5	Good	≤2.5	≤9.0
Fish	Northern streams	5	Poor	≥17.0	≥12.0
Fish	Northern streams	5	P/G	≥3.42	≥1.33
Fish	Northern streams	5	MSHA	≤41.2	≤56.7
Fish	Northern headwaters	6	Good	≤6.0	≤12.5
Fish	Northern headwaters	6	Poor	≥14.5	≥9.5
Fish	Northern headwaters	6	P/G	≥2.13	≥0.76
Fish	Northern headwaters	6	MSHA	≤45.4	≤61.9
Fish	Low gradient streams	7	Good	≤4.5	≤7.0
Fish	Low gradient streams	7	Poor	≥7.5	≥4.5
Fish	Low gradient streams	7	P/G	≥1.36	≥0.63
Fish	Low gradient streams	7	MSHA	≤43.8	≤54.7
Macroinvertebrates	Low gradient northern forest streams	4	Good	-	≤2
Macroinvertebrates	Low gradient northern forest streams	4	Poor	≥11.5	≥8.0
Macroinvertebrates	Low gradient northern forest streams	4	P/G	≥12.08	≥2.96
Macroinvertebrates	Low gradient northern forest streams	4	MSHA	≤33.0	≤50.9
Macroinvertebrates	High gradient southern streams	5	Good	≤5.0	≤9.0
Macroinvertebrates	High gradient southern streams	5	Poor	≥8.0	≥4.0
Macroinvertebrates	High gradient southern streams	5	P/G	≥1.43	≥0.48
Macroinvertebrates	High gradient southern streams	5	MSHA	≤50.8	≤73.2
Macroinvertebrates	Low gradient southern forest streams	6	Good	≤5.5	≤8.5
Macroinvertebrates	Low gradient southern forest streams	6	Poor	≥6.5	≥3.0
Macroinvertebrates	Low gradient southern forest streams	6	P/G	≥1.06	≥0.35
Macroinvertebrates	Low gradient southern forest streams	6	MSHA	≤40.9	≤60.9
Macroinvertebrates	Low gradient prairie streams	7	Good	≤11.0	≤15.5
Macroinvertebrates	Low gradient prairie streams	7	Poor	≥8.0	≥4.0
Macroinvertebrates	Low gradient prairie streams	7	P/G	≥0.77	≥0.33
Macroinvertebrates	Low gradient prairie streams	7	MSHA	≤54.8	≤71.6

Appendix B: Habitat tool submetric scores

Habitat tool scores for fish indices of biotic integrity (see MPCA [2014d] for descriptions of the metrics)

Metric	Attribute	Southern streams	Southern headwaters	Northern streams	Northern headwaters	Low gradient
Substrate	Boulder-pool		0.5	2	0.5	
Substrate	Cobble-pool	1	0.5	2	1	
Substrate	Gravel-pool			1	1	
Substrate	Sand-pool			-2		
Substrate	Clay-pool		-0.5	-1		
Substrate	Bedrock-pool					
Substrate	Silt-pool	-1		-2	-1	
Substrate	Muck-pool					
Substrate	Detritus-pool		-0.5	-2	-1	
Substrate	Boulder-riffle		0.5	2	1	
Substrate	Cobble-riffle	1	1	2		
Substrate	Gravel-riffle		1	-2	-1	
Substrate	Sand-riffle	-1	1	-2	-1	
Substrate	Clay-riffle					
Substrate	Bedrock-riffle					
Substrate	Silt-riffle	-0.5	-1		-1	
Substrate	Muck-riffle					
Substrate	Detritus-riffle					
Substrate	Boulder-run	0.5		2	2	
Substrate	Cobble-run	2	2	2	2	
Substrate	Gravel-run	2	1	-2	2	
Substrate	Sand-run	-1	1	-2	-2	
Substrate	Clay-run	-1	-1	-2	-2	
Substrate	Bedrock-run					
Substrate	Silt-run	-2	-1	-2	-2	
Substrate	Muck-run					
Substrate	Detritus-run		-2		-2	
Substrate	Boulder-glide					
Substrate	Cobble-glide					
Substrate	Gravel-glide					
Substrate	Sand-glide					
Substrate	Clay-glide					
Substrate	Bedrock-glide					
Substrate	Silt-glide					
Substrate	Muck-glide					
Substrate	Detritus-glide					
Embeddedness	No coarse	-1	-1	-2	-2	-0.5
Embeddedness	Severe	-1	-0.5	-2	-1	-1
Embeddedness	Moderate				-2	
Embeddedness	Light	1	1	1	2	1
Embeddedness	None			2	2	0.5

Metric	Attribute	Southern streams	Southern headwaters	Northern streams	Northern headwaters	Low gradient
# Substrate types	>4	0.5	0.5		2	1
# Substrate types	<4	-0.5	-0.5		-2	-1
Cover types	Undercut banks					
Cover types	Overhanging vegetation					-0.5
Cover types	Deep pools	0.5	1			
Cover types	Logs and woody debris	1				
Cover types	Boulders				1	0.5
Cover types	Rootwads	1	1			
Cover types	Macrophytes					-0.5
Cover score	1	-1	-2	-0.5	-2	-2
Cover score	2	-1	-1	-0.5	-2	-2
Cover score	3	-0.5			-1	-1
Cover score	4		1		-1	
Cover score	5	0.5	1			1
Cover score	6	1	0.5		2	2
Cover score	7	1	2		1	
Cover amount	Choking vegetation		-0.5			
Cover amount	Absent	-2	-1	-1	-1	
Cover amount	Sparse	-0.5		-0.5		
Cover amount	Moderate	2	1	1	1	0.5
Cover amount	Extensive				1	
Pool/riffle width	Pw>rw	2	2		1	1
Pool/riffle width	Pw=rw	2				
Pool/riffle width	Pw<rw					
Pool/riffle width	No riffle	-2	-2		-1	-1
Pool/riffle width	No pool					
Pool/riffle width	Impounded					
Sinuosity	Excellent	1	1	2	2	2
Sinuosity	Good	2	2	2	2	1
Sinuosity	Fair	1	1	2	1	
Sinuosity	Poor	-2	-2	-2	-2	-2
Channel development	Excellent	2	0.5	2	2	0.5
Channel development	Good	2	2	1	1	2
Channel development	Fair	-1		-1	-1	
Channel development	Poor	-2	-2	-2	-2	-2
Channel stability	High			2	2	0.5
Channel stability	Moderate-high					
Channel stability	Moderate			-1	-2	
Channel stability	Low	-0.5		-2	-1	-0.5
Depth variability	4x var	2	2	2	2	2
Depth variability	2-4x var					
Depth variability	<2x var	-2	-2	-2	-2	-2

Metric	Attribute	Southern streams	Southern headwaters	Northern streams	Northern headwaters	Low gradient
Current velocity	Torrential					
Current velocity	Fast	1		0.5	0.5	0.5
Current velocity	Moderate					
Current velocity	Slow	-1				
Current velocity	Eddies	1	0.5	0.5	0.5	
Current velocity	Interstitial				1	
Current velocity	Intermittent					
Current score	-2					
Current score	-1					-0.5
Current score	0					-0.5
Current score	1	-2	-1	-1	-0.5	-1
Current score	2	-1		-1		
Current score	3	2	1	1		
Current score	4	2	1	1	0.5	
Riparian width	Extensive	0.5	0.5	1	2	2
Riparian width	Wide			1	2	2
Riparian width	Moderate				-2	-1
Riparian width	Narrow			-1	-2	-2
Riparian width	V. Narrow		-0.5	-1	-2	-2
Riparian width	None	-0.5	-0.5	-1	-2	-2
Erosion	Severe		-0.5			
Erosion	Heavy		-0.5			
Erosion	Moderate					
Erosion	Little					
Erosion	None	-0.5	-0.5	0.5		
Shading	None	-2	-0.5	-1	-0.5	-0.5
Shading	Light	-2			-0.5	
Shading	Moderate	2		1	0.5	
Shading	Substantial	1	0.5	1	1	
Shading	Heavy			1		0.5
Land use	Natural	1		2	2	2
Land use	Old field			1		1
Land use	Pasture			0.5		
Land use	No till				0.5	
Land use	Park			1		
Land use	Urban					
Land use	Row crop	-1		-2	-2	-2

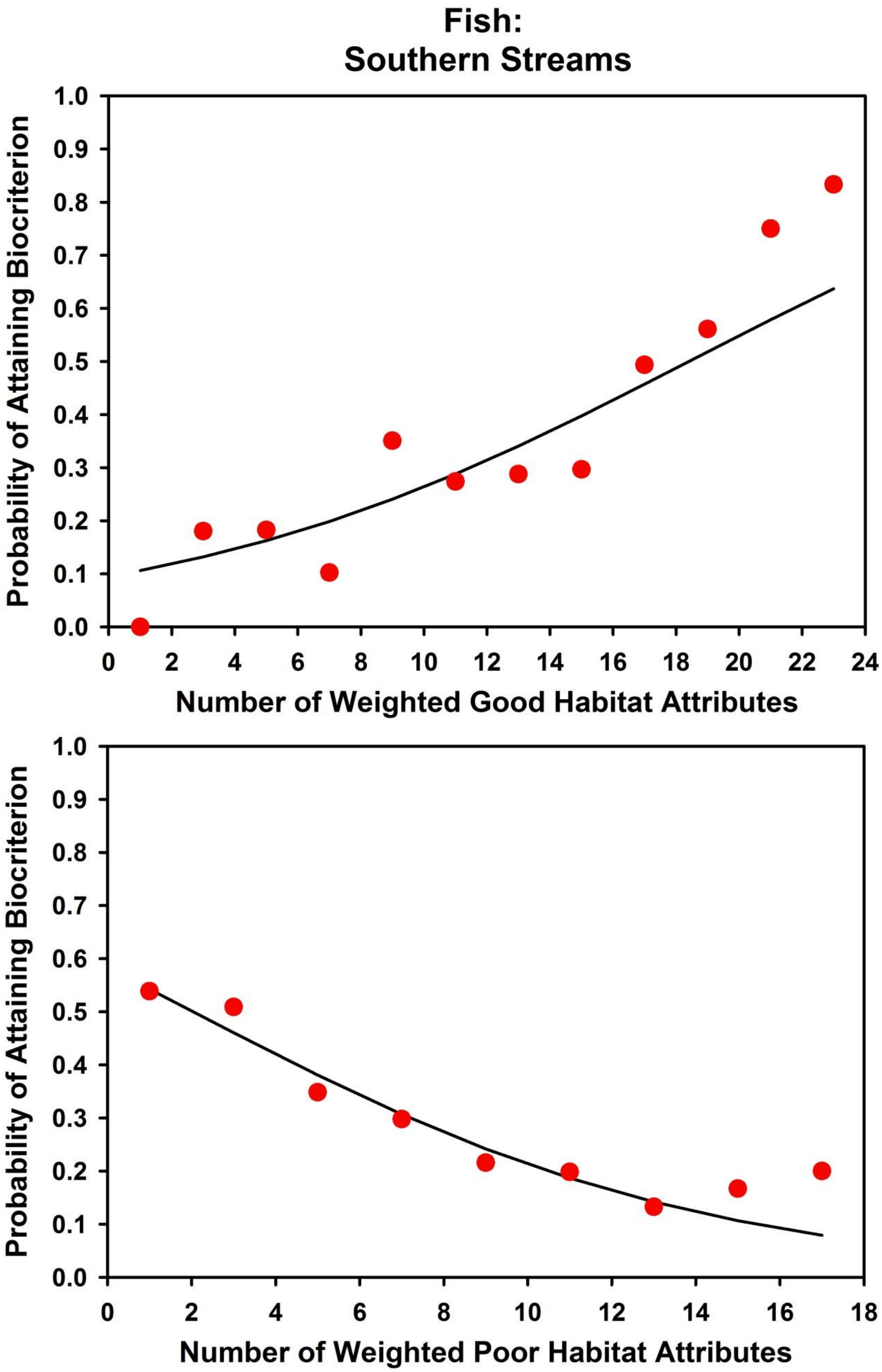
Habitat tool scores for macroinvertebrate indices of biotic integrity (see MPCA [2014d] for descriptions of the metrics)

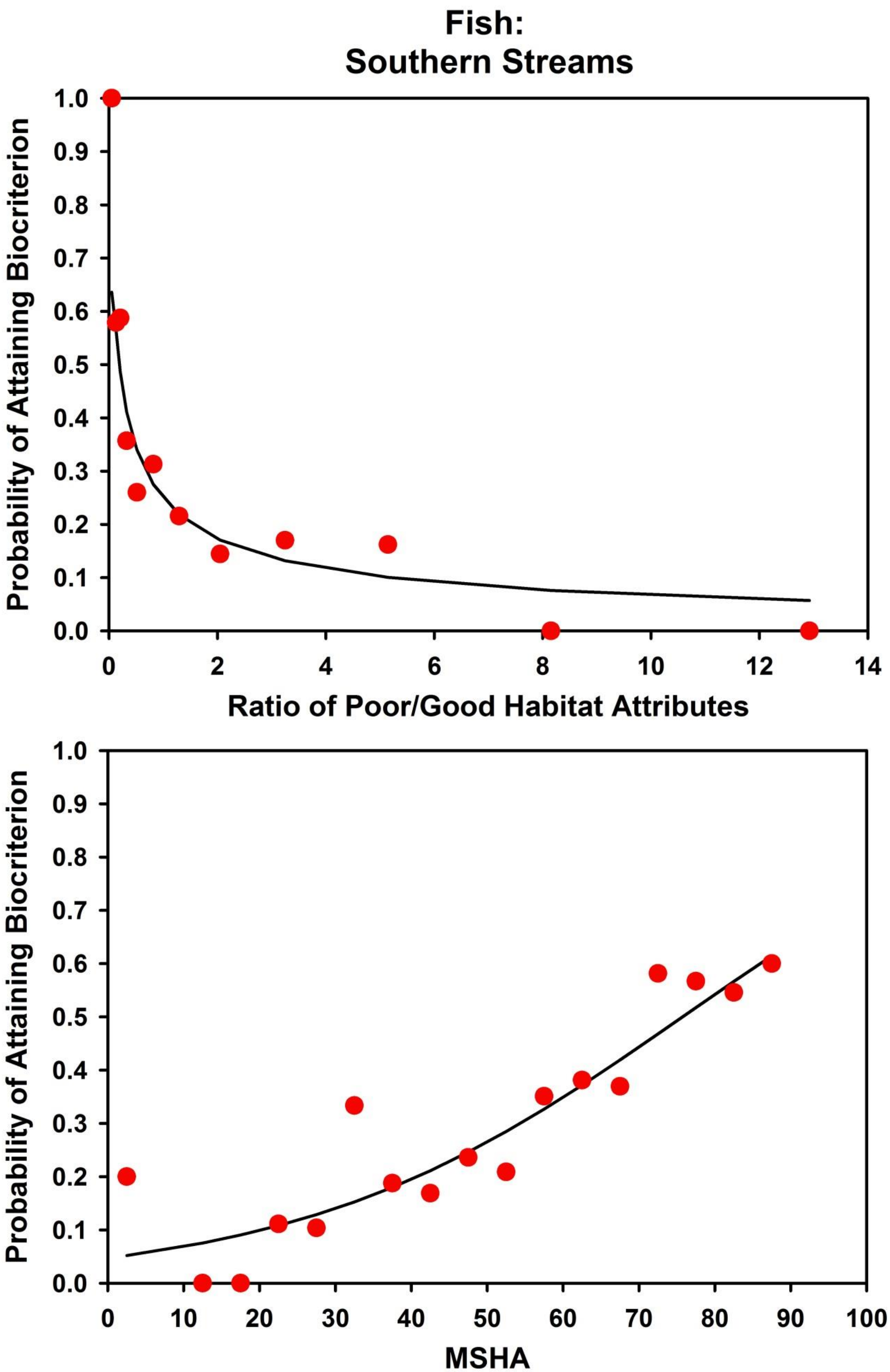
Metric	Attribute	Northern streams glide-pool	Southern streams riffle-run	Southern streams glide-pool	Prairie streams glide-pool
Substrate	Boulder-pool	0.5			
Substrate	Cobble-pool	0.5	2		
Substrate	Gravel-pool	0.5			
Substrate	Sand-pool				
Substrate	Clay-pool		-1		
Substrate	Bedrock-pool				
Substrate	Silt-pool	-0.5	-2		
Substrate	Muck-pool				
Substrate	Detritus-pool	-0.5			
Substrate	Boulder-riffle		0.5		
Substrate	Cobble-riffle				
Substrate	Gravel-riffle		-0.5		
Substrate	Sand-riffle		-0.5		
Substrate	Clay-riffle				
Substrate	Bedrock-riffle				
Substrate	Silt-riffle				
Substrate	Muck-riffle				
Substrate	Detritus-riffle				
Substrate	Boulder-run		1		0.5
Substrate	Cobble-run		1	0.5	0.5
Substrate	Gravel-run	2	-1	1	1
Substrate	Sand-run	-1	-1	1	1
Substrate	Clay-run		-1		-0.5
Substrate	Bedrock-run				
Substrate	Silt-run	-2	-1	-1	-1
Substrate	Muck-run				
Substrate	Detritus-run	-2		-1	-0.5
Substrate	Boulder-glide				
Substrate	Cobble-glide				
Substrate	Gravel-glide				
Substrate	Sand-glide				
Substrate	Clay-glide				
Substrate	Bedrock-glide				
Substrate	Silt-glide				
Substrate	Muck-glide				
Substrate	Detritus-glide				
Embeddedness	No coarse	-2			-2
Embeddedness	Severe	-0.5			
Embeddedness	Moderate				1
Embeddedness	Light	1			1
Embeddedness	None	1	1		

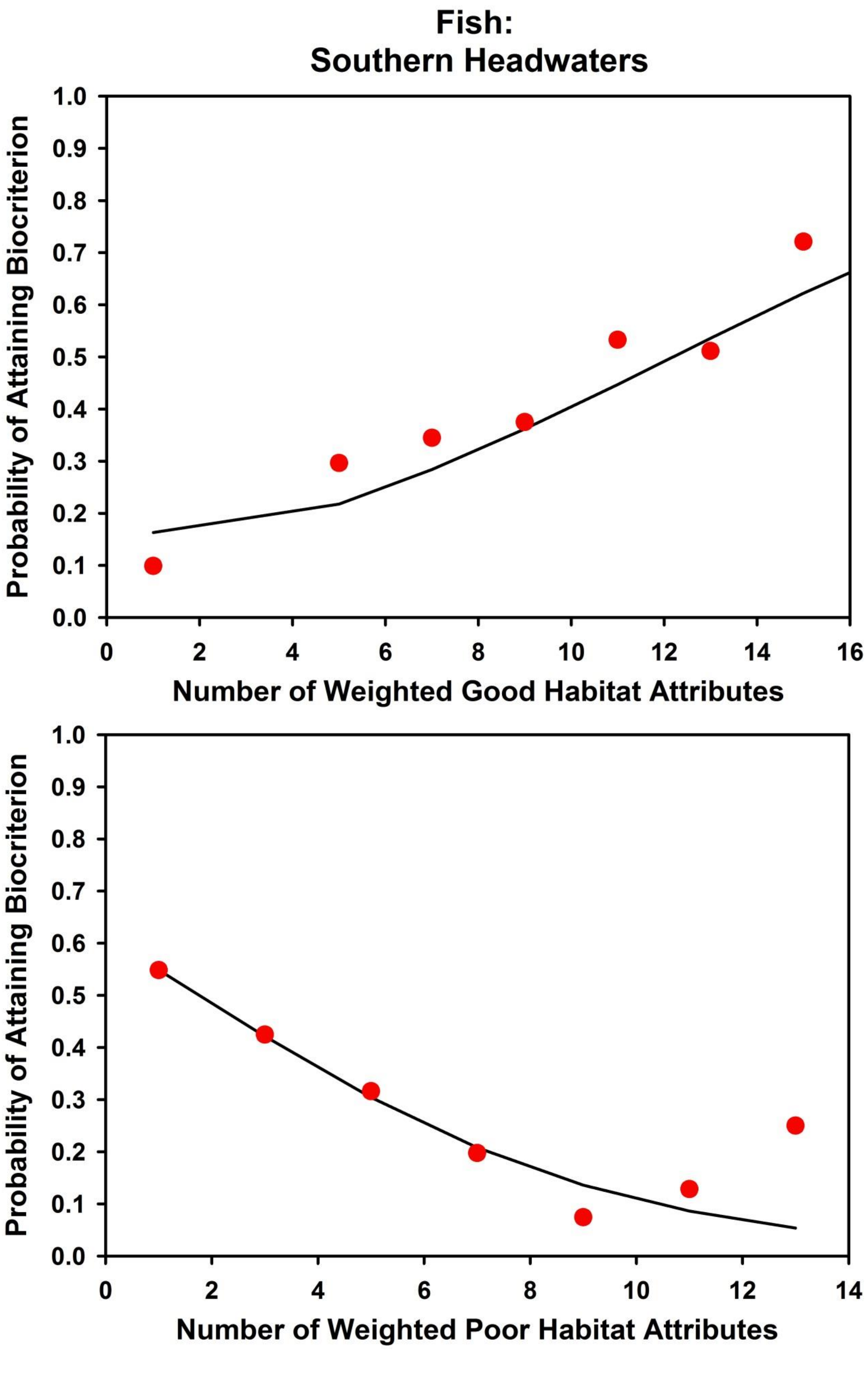
Metric	Attribute	Northern streams glide-pool	Southern streams riffle-run	Southern streams glide-pool	Prairie streams glide-pool
# Substrate types	>4	1			2
# Substrate types	<4	-1			-2
Cover types	Undercut banks				
Cover types	Overhanging vegetation				
Cover types	Deep pools				1
Cover types	Logs and woody debris			0.5	1
Cover types	Boulders				1
Cover types	Rootwads				1
Cover types	Macrophytes				-1
Cover score	1				-1
Cover score	2				-1
Cover score	3		-1	-1	-2
Cover score	4				-1
Cover score	5				
Cover score	6	0.5	1	1	2
Cover score	7	0.5	0.5	1	2
Cover amount	Choking vegetation				
Cover amount	Absent				
Cover amount	Sparse				
Cover amount	Moderate				
Cover amount	Extensive				
Sinuosity	Excellent			-1	1
Sinuosity	Good			1	1
Sinuosity	Fair				
Sinuosity	Poor			-1	-1
Pool/riffle width	Pw>rw			-1	1
Pool/riffle width	Pw=rw			1	1
Pool/riffle width	Pw<rw				
Pool/riffle width	No riffle			-1	-1
Pool/riffle width	No pool				
Pool/riffle width	Impounded				
Channel development	Excellent				
Channel development	Good				
Channel development	Fair	1	2	2	1
Channel development	Poor	1	2	1	2
Channel stability	High			1	-1
Channel stability	Moderate-high	-1	-2	-2	-2
Channel stability	Moderate	1	1	0.5	2
Channel stability	Low	1	1	1	2
Depth variability	4x var			1	
Depth variability	2-4x var	-1	-1	-2	-2
Depth variability	<2x var				

Metric	Attribute	Northern streams glide-pool	Southern streams riffle-run	Southern streams glide-pool	Prairie streams glide-pool
Current velocity	Torrential			1	
Current velocity	Fast				
Current velocity	Moderate				
Current velocity	Slow	1	2	2	2
Current velocity	Eddies	0.5	1	1	
Current velocity	Interstitial	-1	-2	-2	-2
Current velocity	Intermittent				
Current score	-2	1			2
Current score	-1				
Current score	0	-1			-2
Current score	1	1		1	
Current score	2				
Current score	3				
Current score	4	-2	-1	-2	-2
Riparian width	Extensive	-2	-1	-2	-2
Riparian width	Wide	-2	-1	-2	-2
Riparian width	Moderate	-2	-1	-2	-2
Riparian width	Narrow				
Riparian width	Very narrow	2	1	2	2
Riparian width	None	1	1	2	1
Erosion	Severe		1	0.5	2
Erosion	Heavy			1	1
Erosion	Moderate				
Erosion	Little	-0.5	-1	-1	-1
Erosion	None	-0.5	-0.5	-1	-2
Shading	None	-0.5	-0.5	-0.5	-0.5
Shading	Light				
Shading	Moderate				
Shading	Substantial	2			
Shading	Heavy				
Land use	Natural				
Land use	Old field		-2	-2	-0.5
Land use	Pasture		-2	-1	-0.5
Land use	No till		1	1	
Land use	Park		1	1	0.5
Land use	Urban		1	1	0.5
Land use	Row crop		2	2	2

Appendix C: Logistic regression plots




Fish:
Southern Streams
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
Ratio of Poor/Good Habitat Attributes
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
MSHA


Fish:
Southern Headwaters
Probability of Attaining Biocriterion
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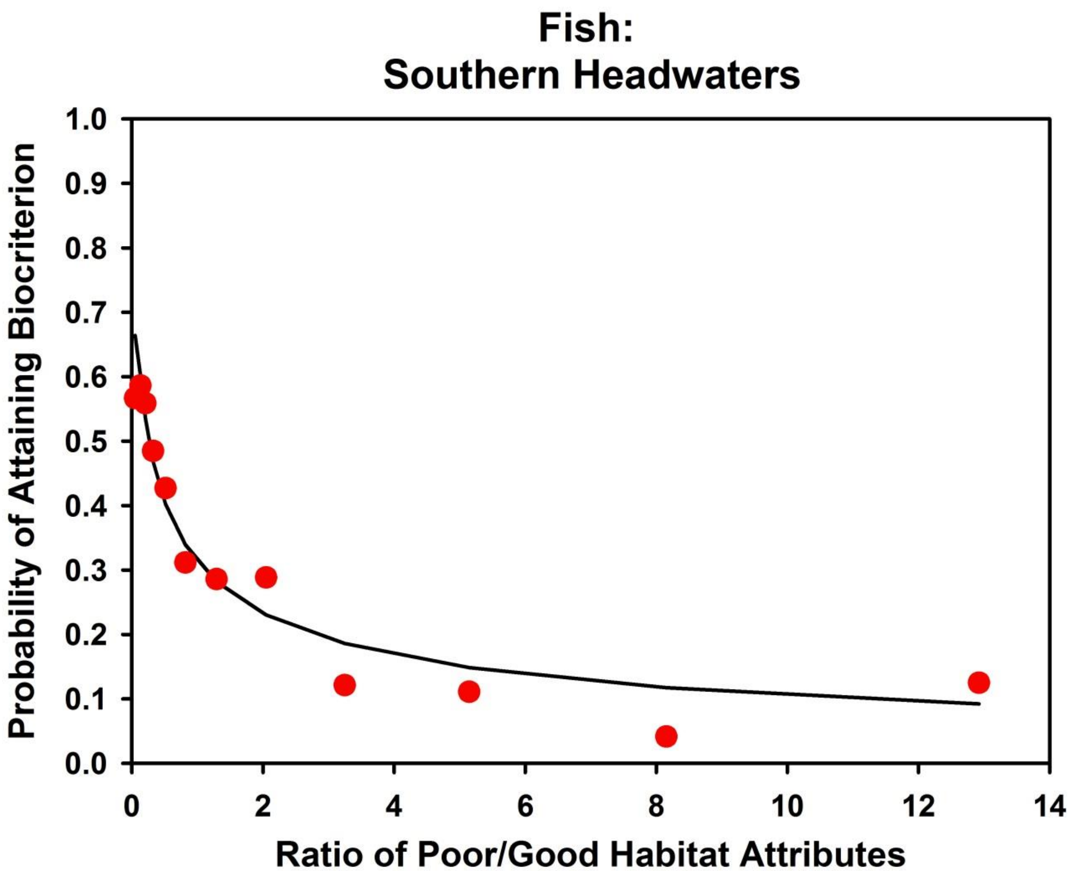
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
16
Number of Weighted Good Habitat Attributes
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
Number of Weighted Poor Habitat Attributes


Fish:
Southern Headwaters
Probability of Attaining Biocriterion
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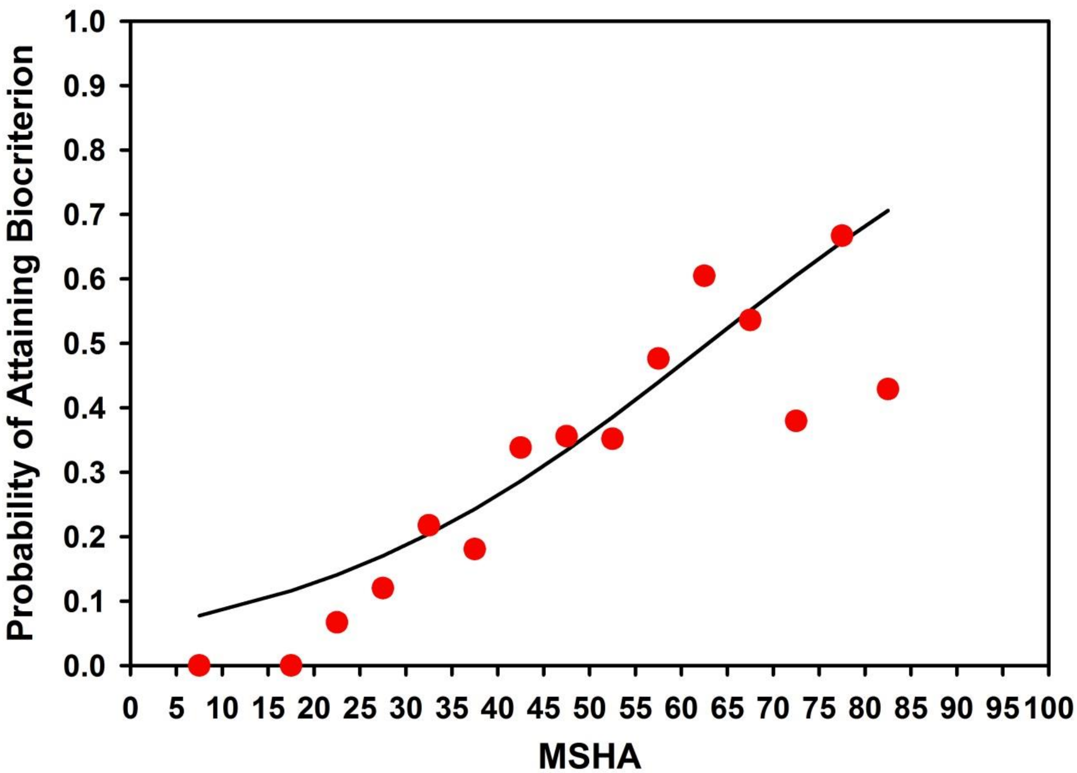
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
Ratio of Poor/Good Habitat Attributes


Probability of Attaining Biocriterion
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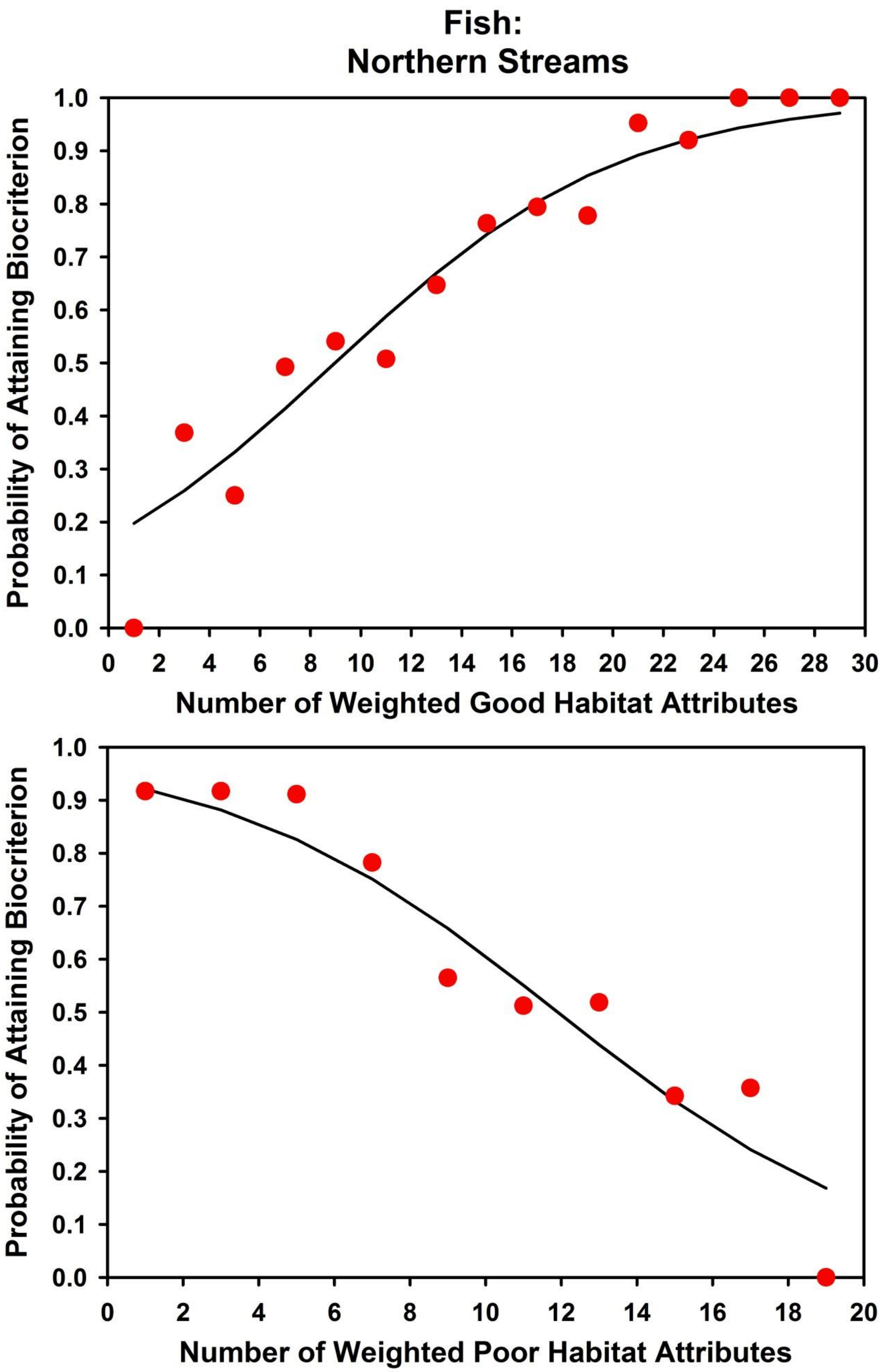
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
MSHA


Fish:
Northern Streams
Probability of Attaining Biocriterion
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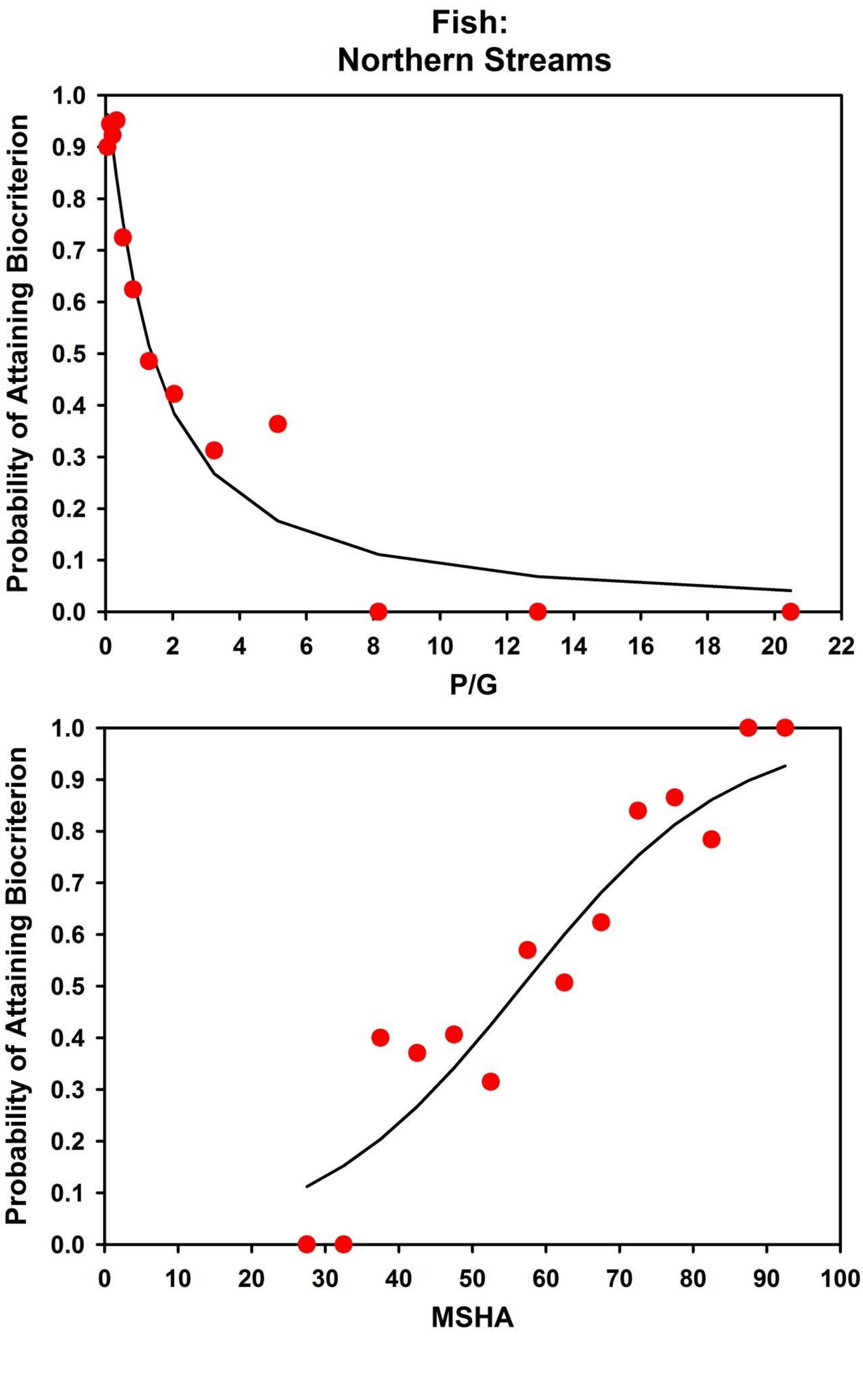
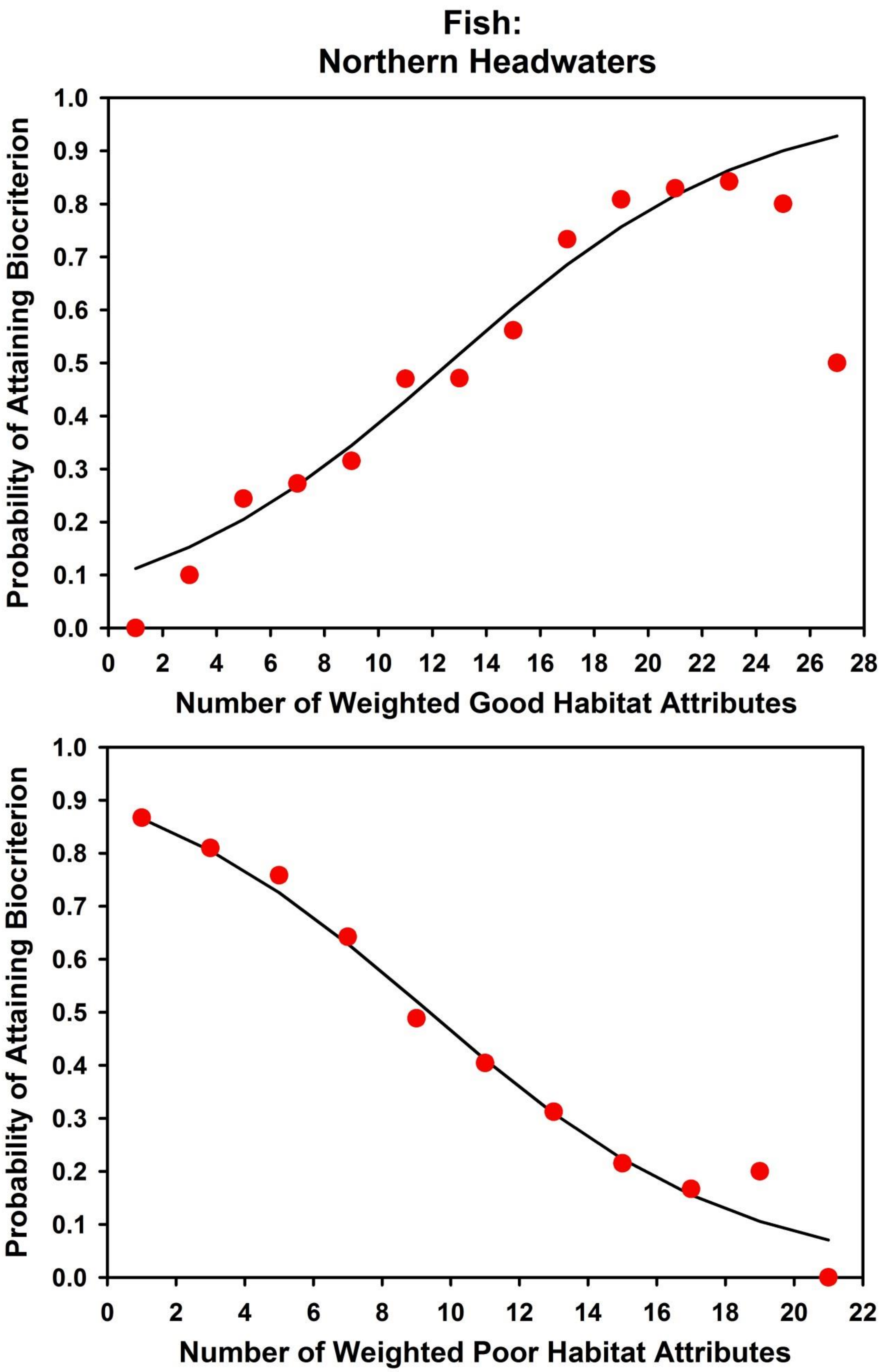
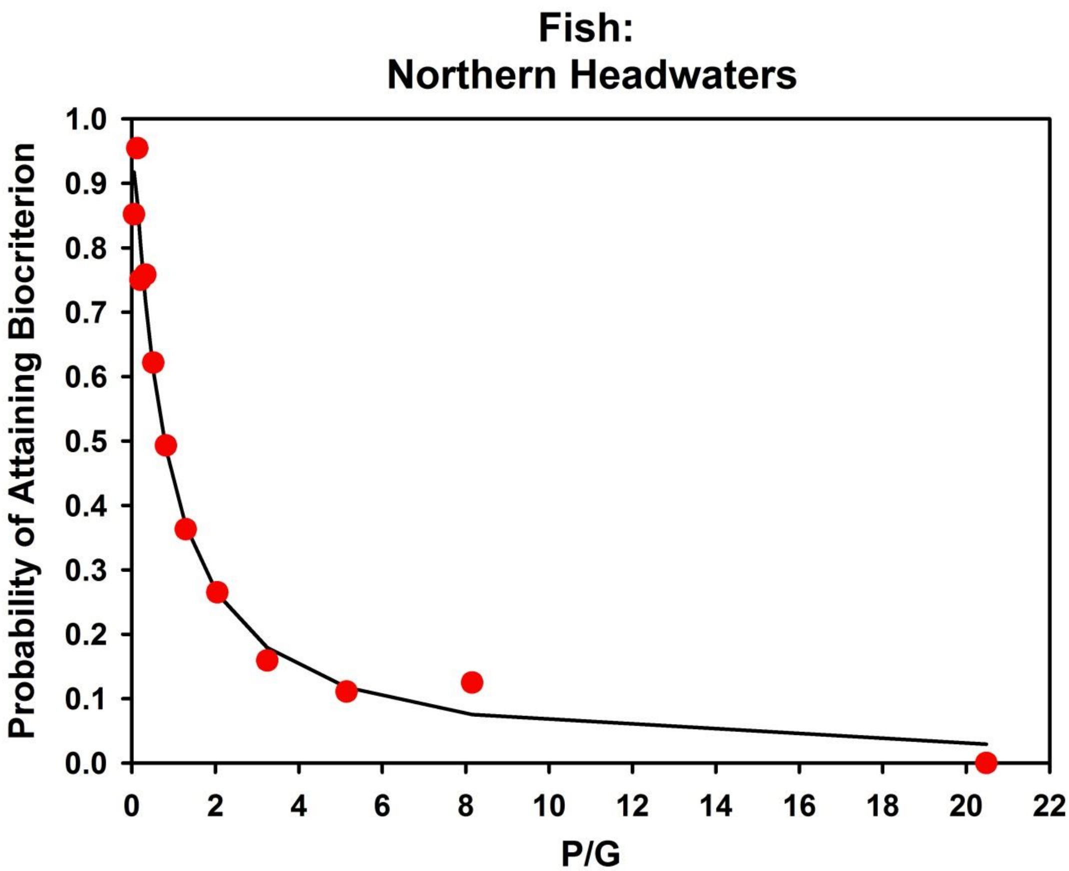
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Number of Weighted Good Habitat Attributes
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 2 4 6 8 10 12 14 16 18 20
Number of Weighted Poor Habitat Attributes


Fish:
Northern Streams
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
16
18
20
22
P/G
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
MSHA


Fish:
Northern Headwaters
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28
Number of Weighted Good Habitat Attributes
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0 2 4 6 8 10 12 14 16 18 20 22
Number of Weighted Poor Habitat Attributes


Fish:
Northern Headwaters
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
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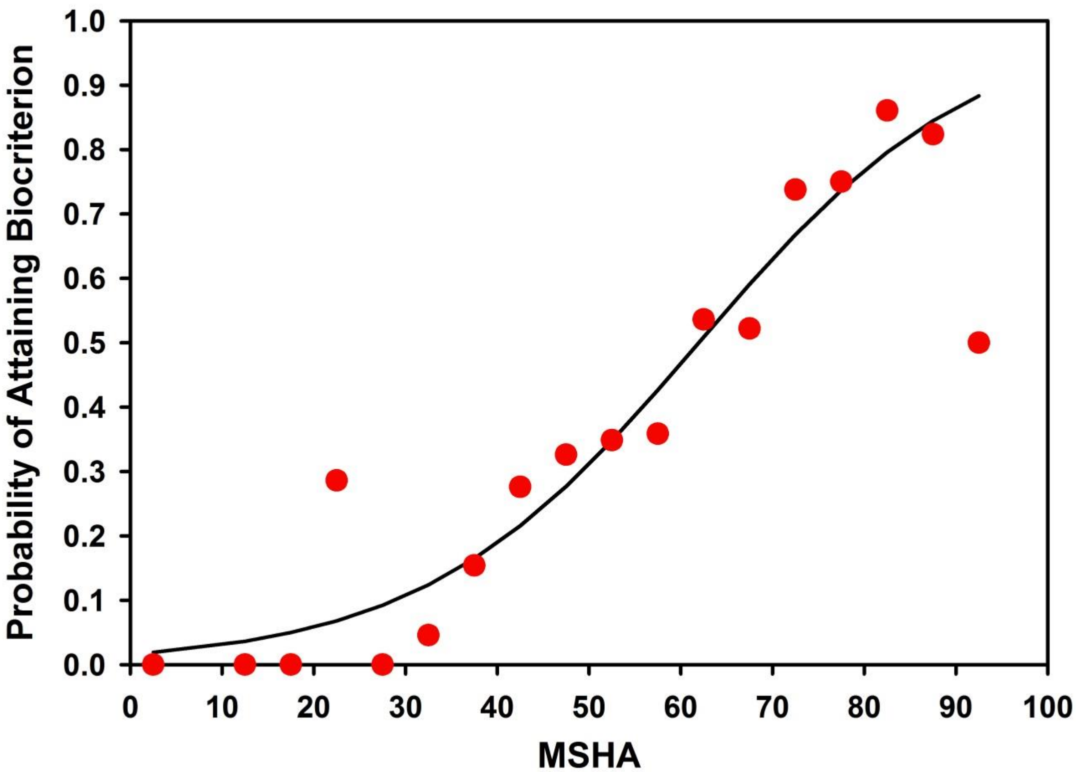
12
14
16
18
20
22
P/G


Probability of Attaining Biocriterion
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0.5
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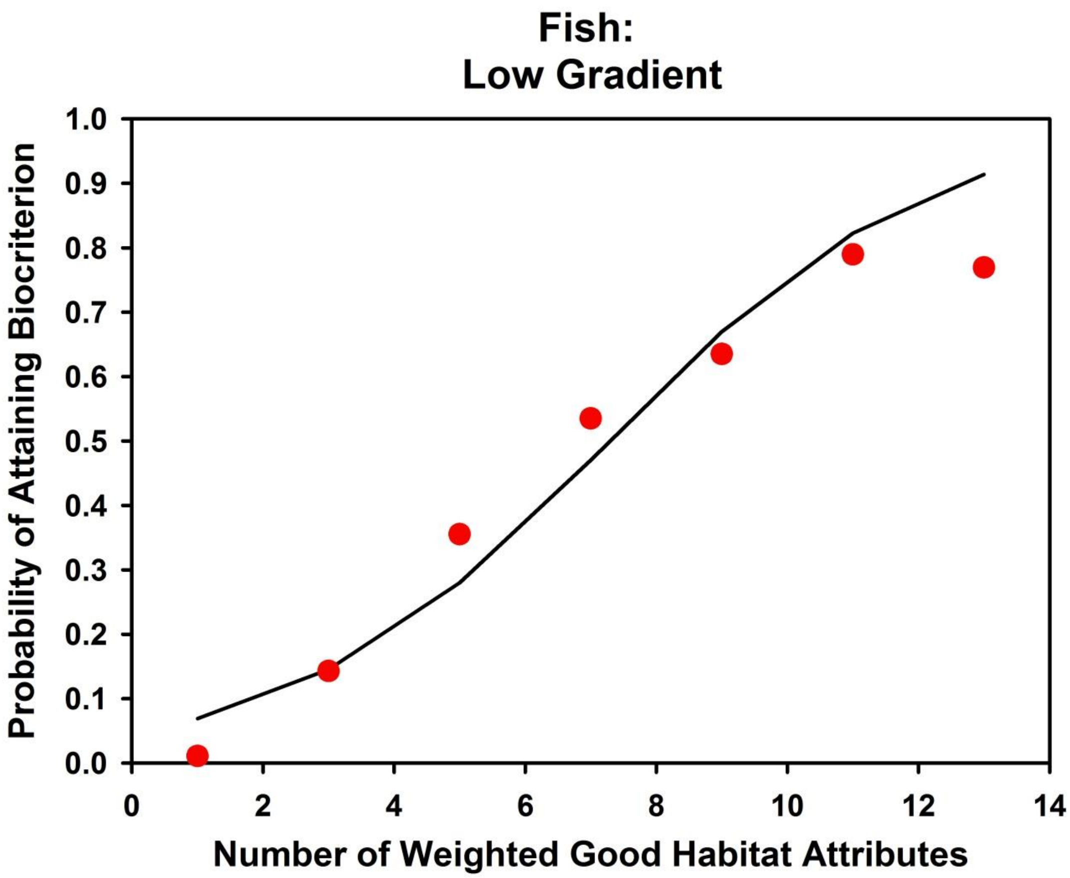
40
50
60
70
80
90
100
MSHA


Fish:
Low Gradient
Probability of Attaining Biocriterion
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0.8
0.7
0.6
0.5
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0.2
0.1
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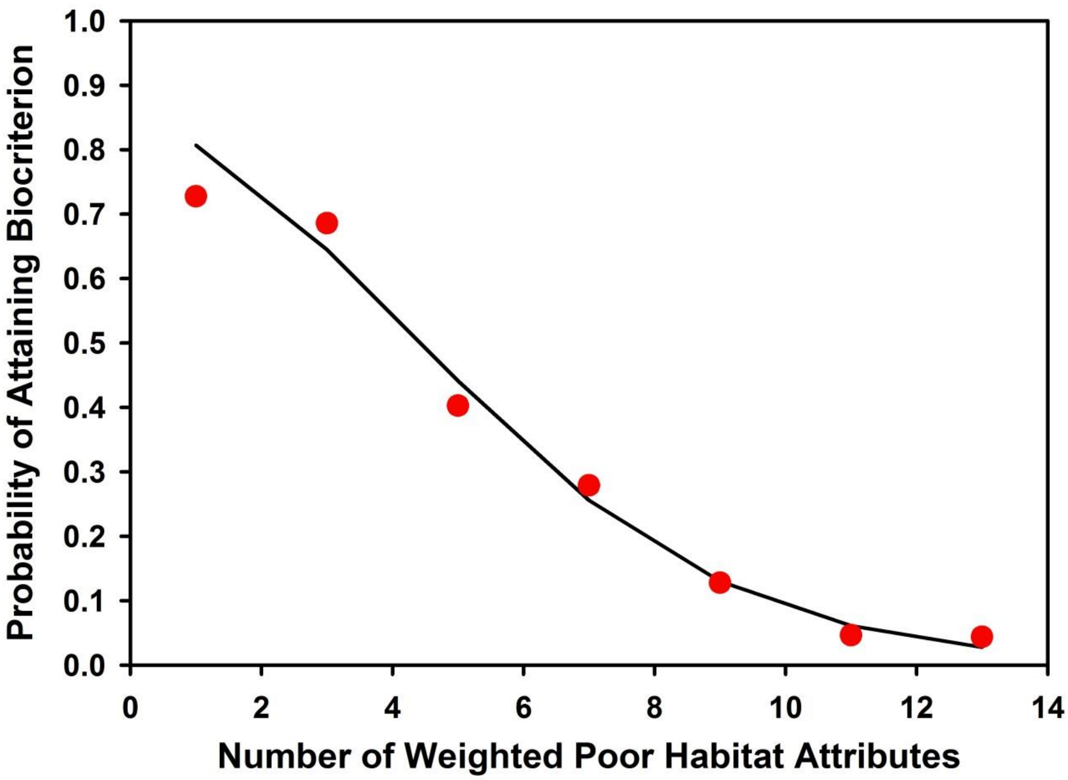
2
4
6
8
10
12
14
Number of Weighted Good Habitat Attributes


Probability of Attaining Biocriterion
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0.7
0.6
0.5
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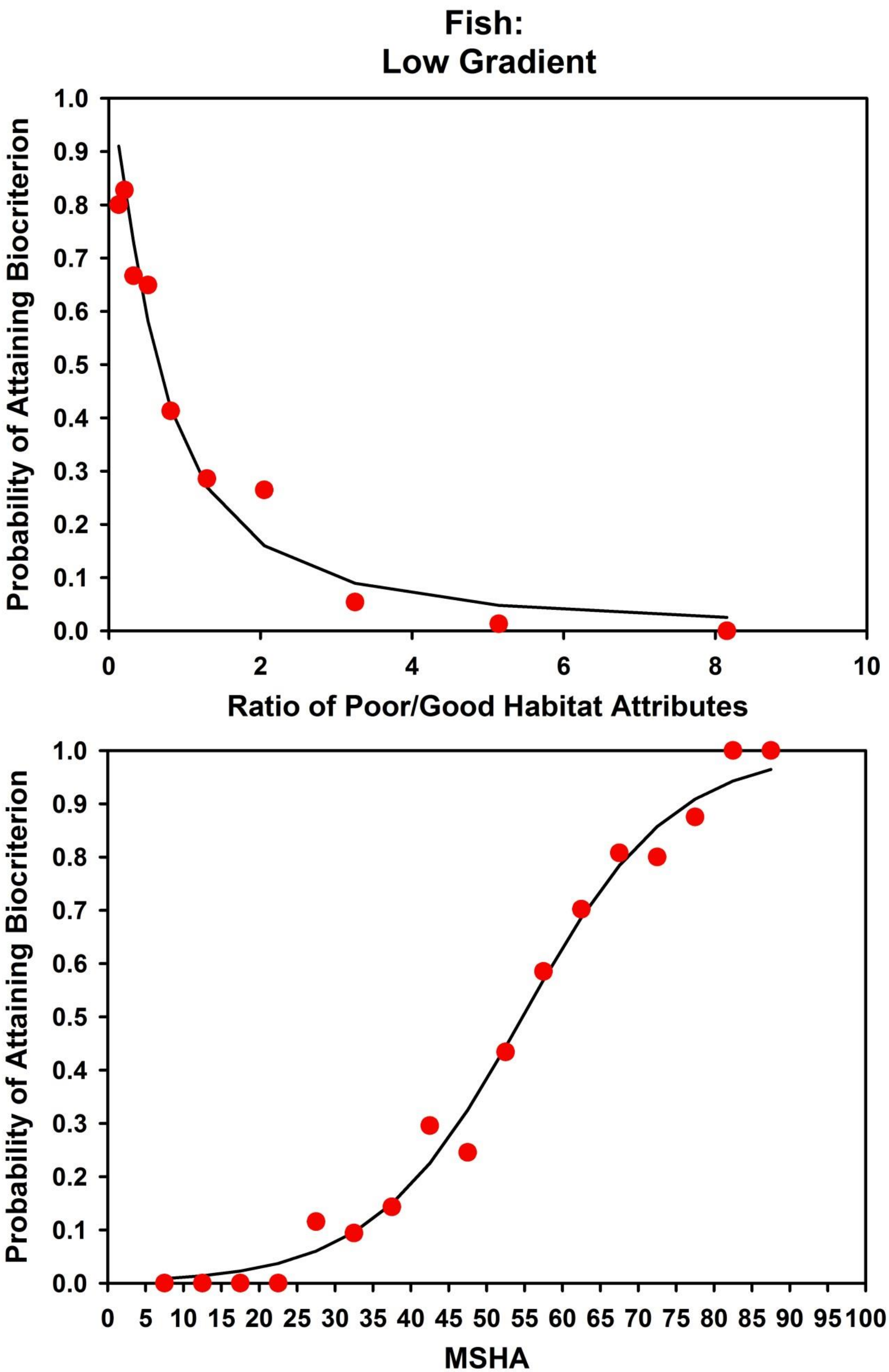
4
6
8
10
12
14
Number of Weighted Poor Habitat Attributes


Fish:
Low Gradient
Probability of Attaining Biocriterion
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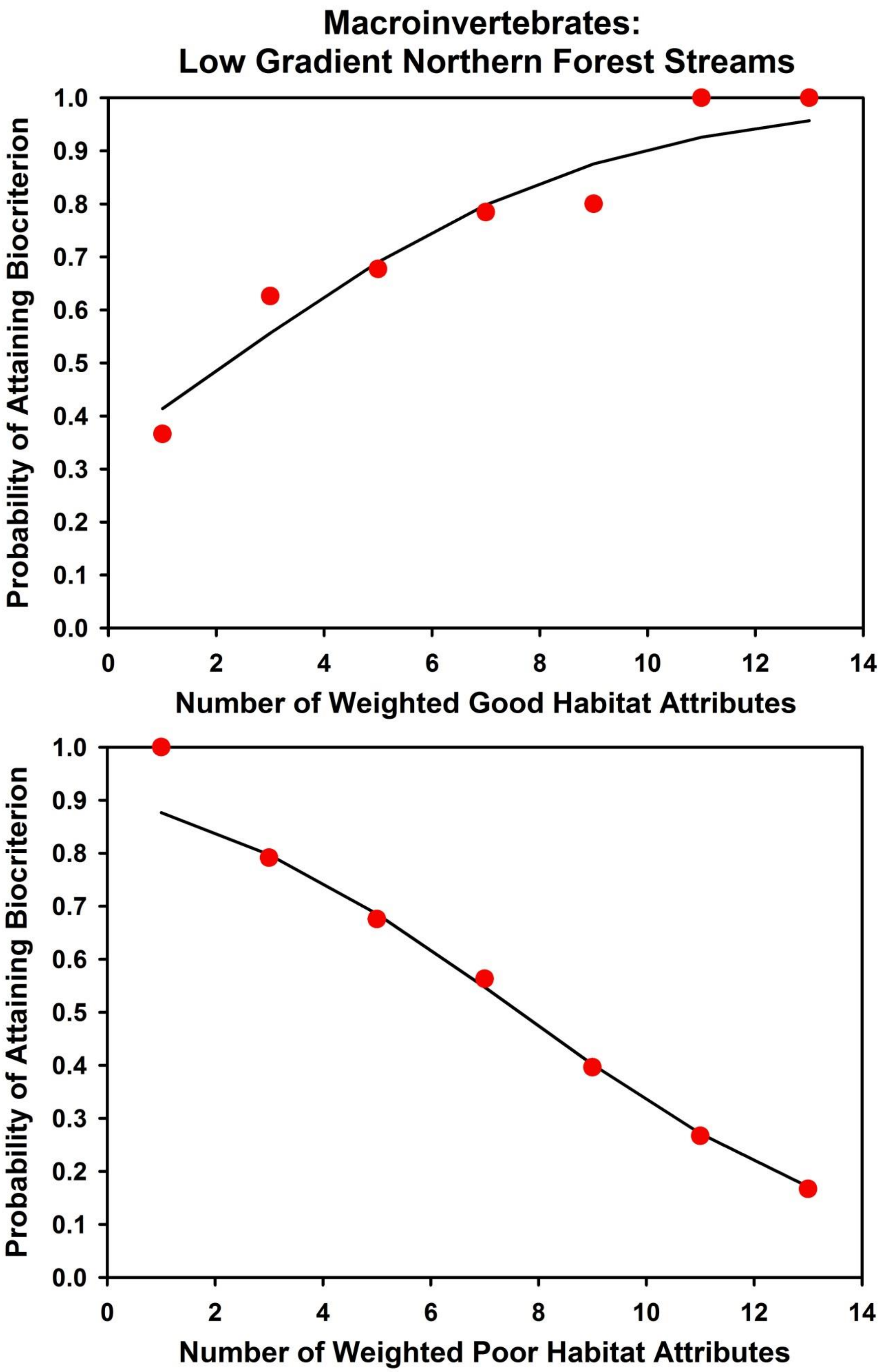
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
Ratio of Poor/Good Habitat Attributes
Probability of Attaining Biocriterion
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
MSHA


Macroinvertebrates:
Low Gradient Northern Forest Streams
Probability of Attaining Biocriterion
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0.8
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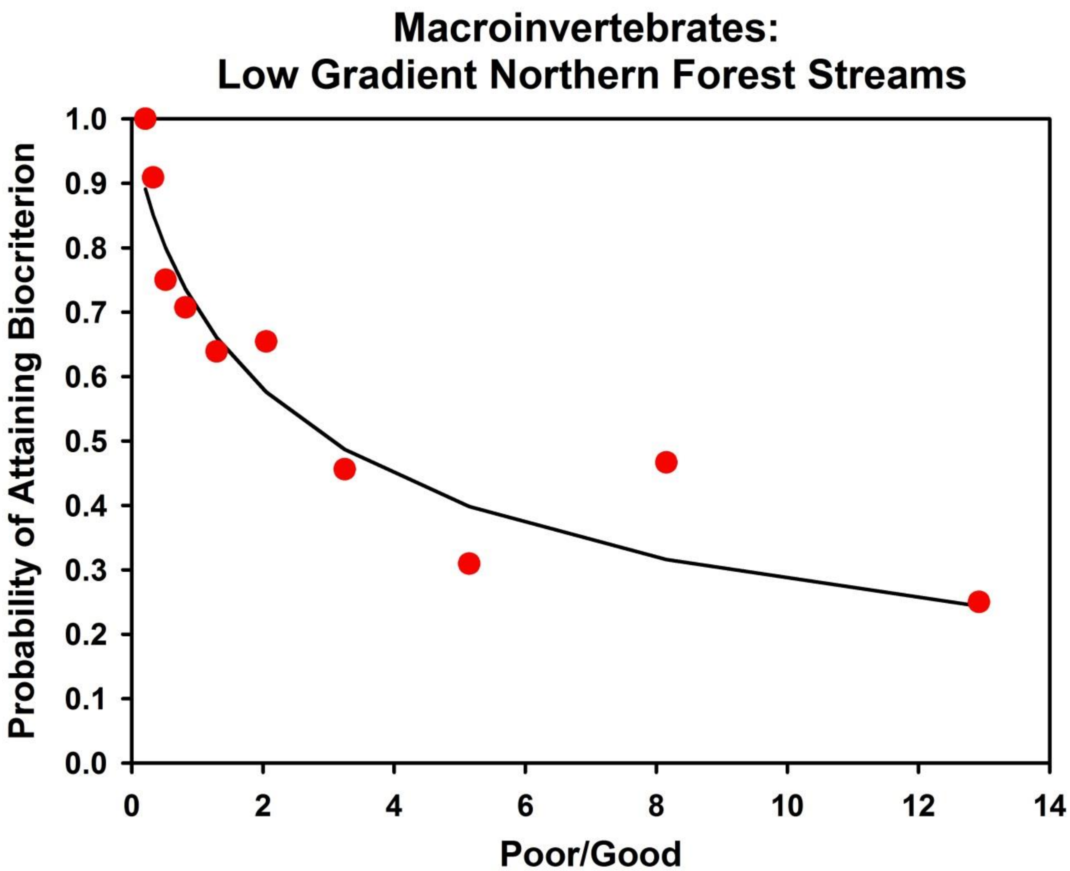
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
Number of Weighted Good Habitat Attributes
Probability of Attaining Biocriterion
Number of Weighted Poor Habitat Attributes



Macroinvertebrates:
Low Gradient Northern Forest Streams
Probability of Attaining Biocriterion
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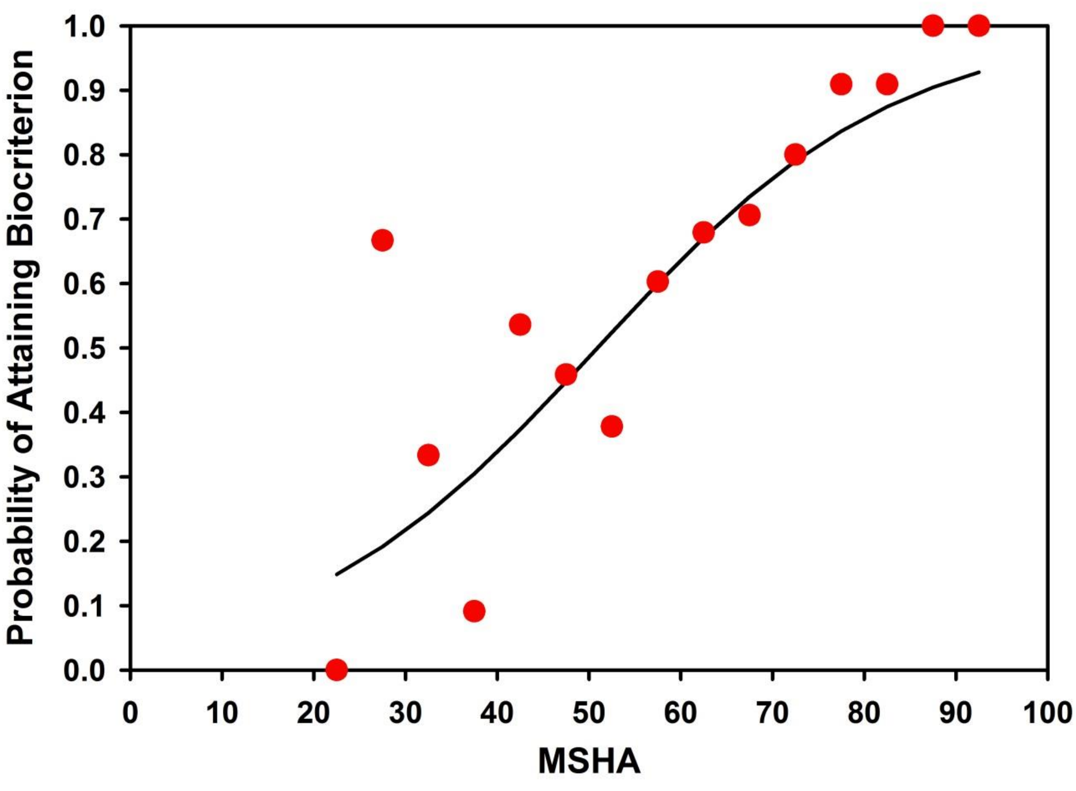
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
Poor/Good



Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
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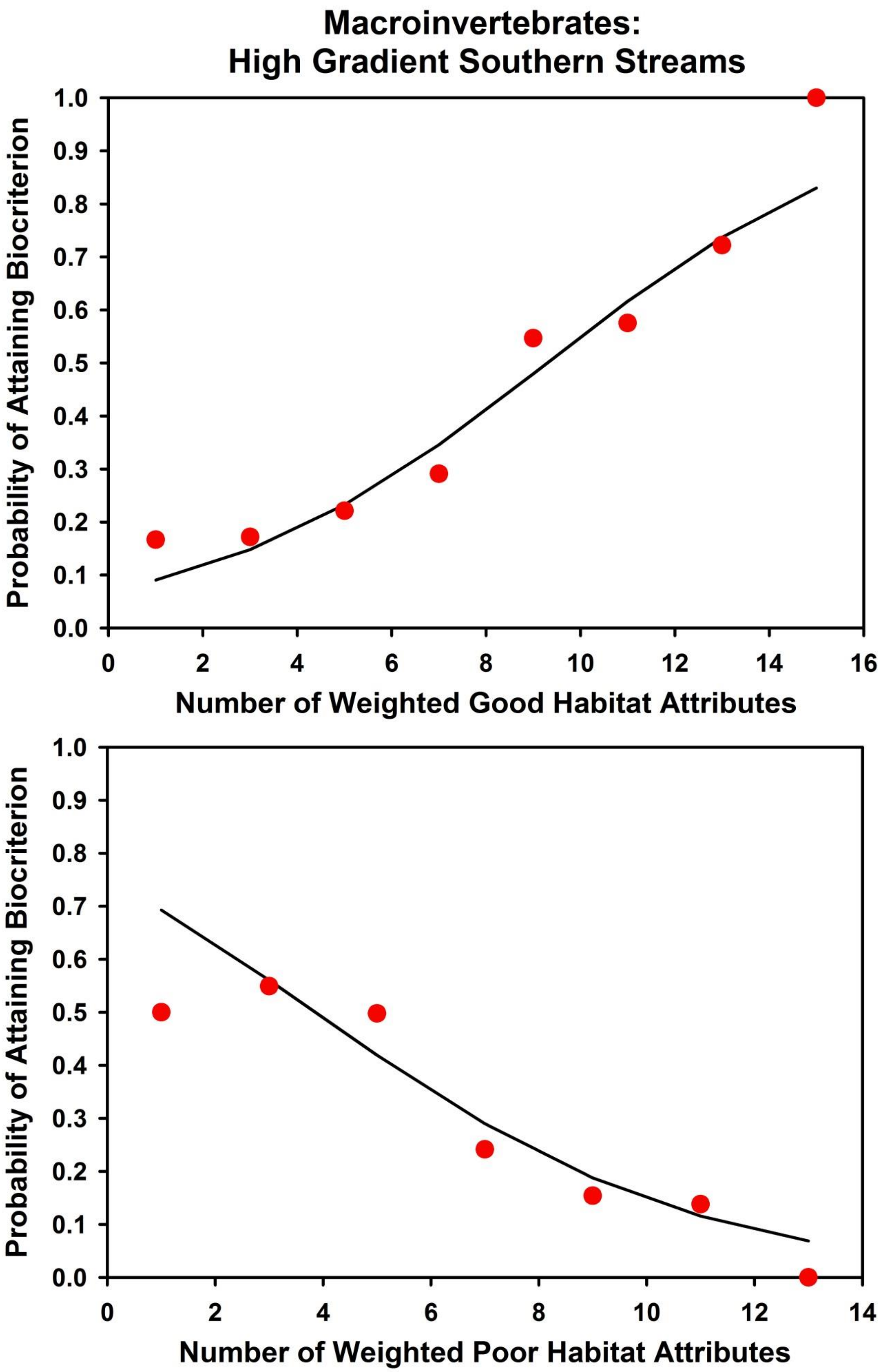
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
MSHA



Macroinvertebrates:
High Gradient Southern Streams
Probability of Attaining Biocriterion
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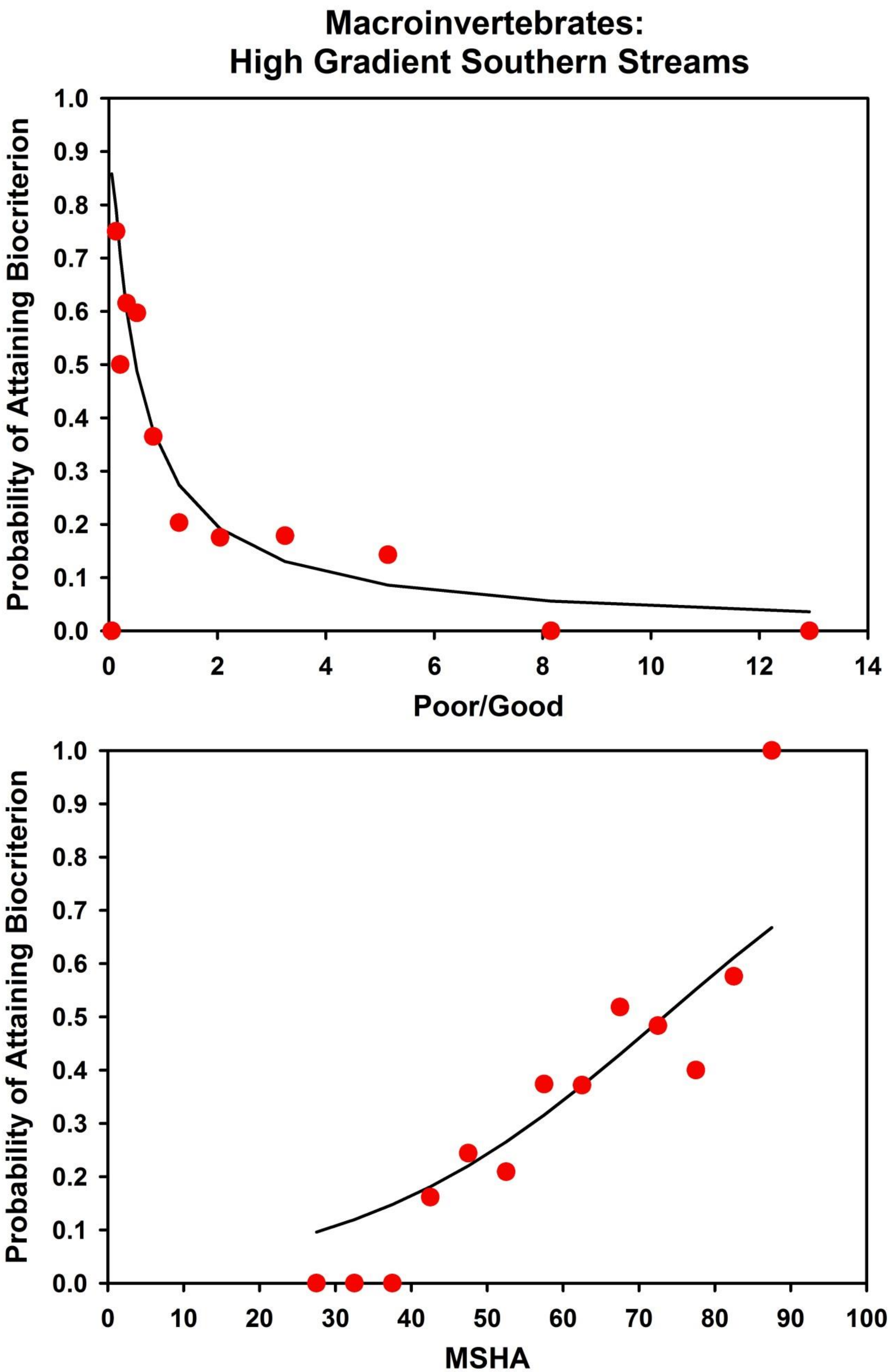
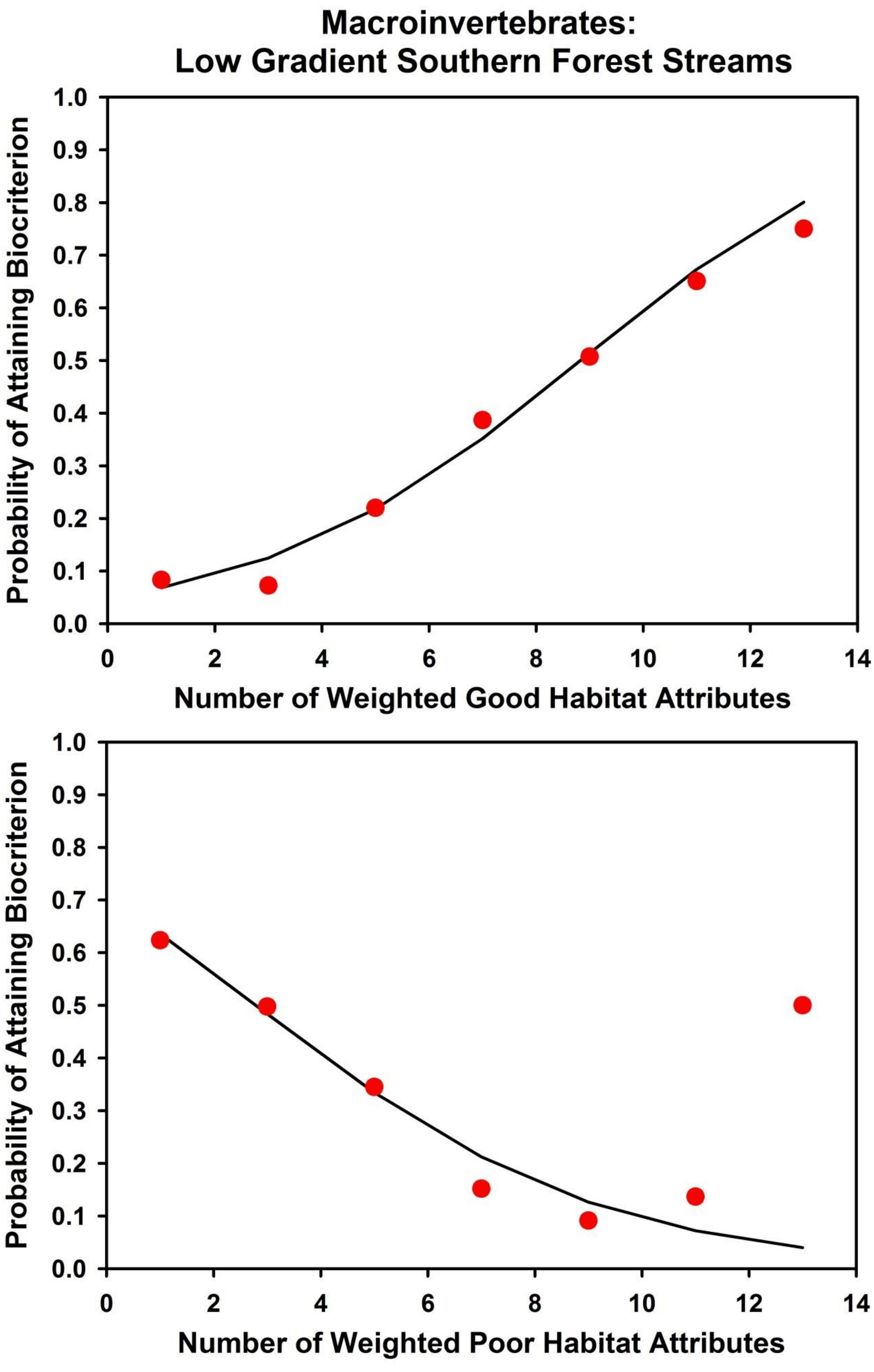
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
16
Number of Weighted Good Habitat Attributes
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
Number of Weighted Poor Habitat Attributes



Macroinvertebrates:
High Gradient Southern Streams
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
Poor/Good
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
MSHA


Macroinvertebrates:
Low Gradient Southern Forest Streams
Probability of Attaining Biocriterion
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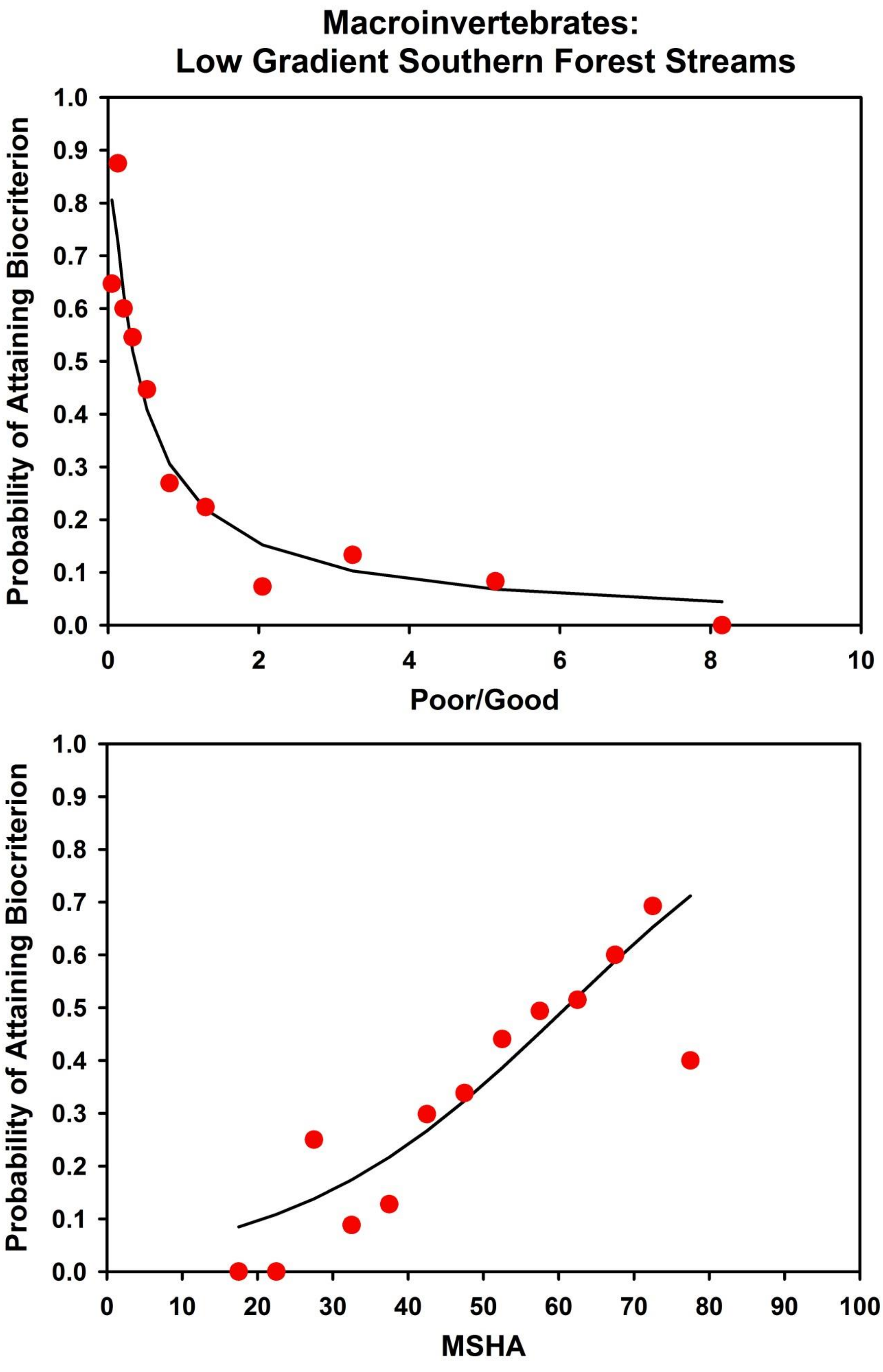
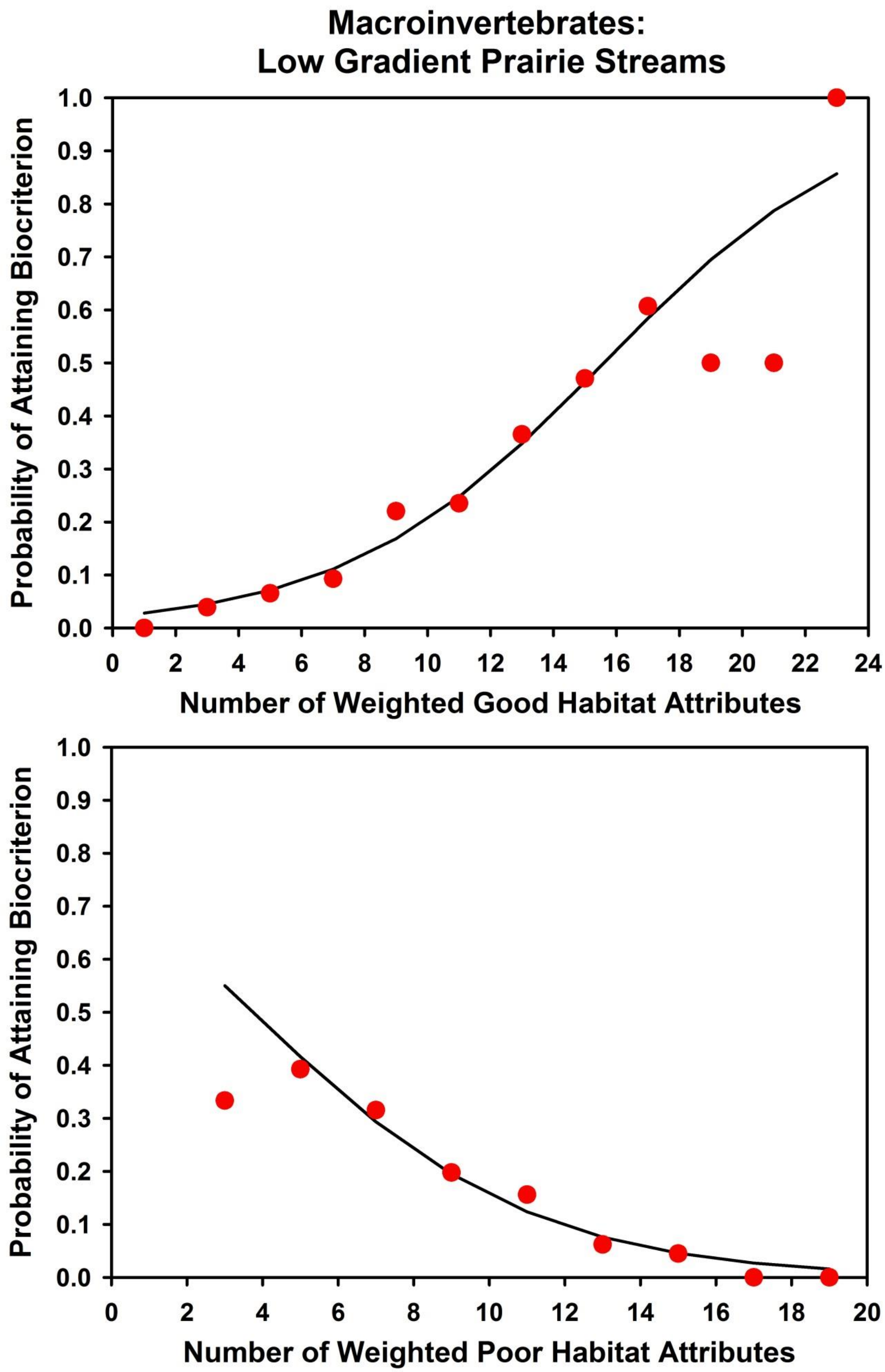
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
Number of Weighted Good Habitat Attributes
Probability of Attaining Biocriterion
Number of Weighted Poor Habitat Attributes


Macroinvertebrates:
Low Gradient Southern Forest Streams
Probability of Attaining Biocriterion
Poor/Good
Probability of Attaining Biocriterion
MSHA


Macroinvertebrates:
Low Gradient Prairie Streams
Probability of Attaining Biocriterion
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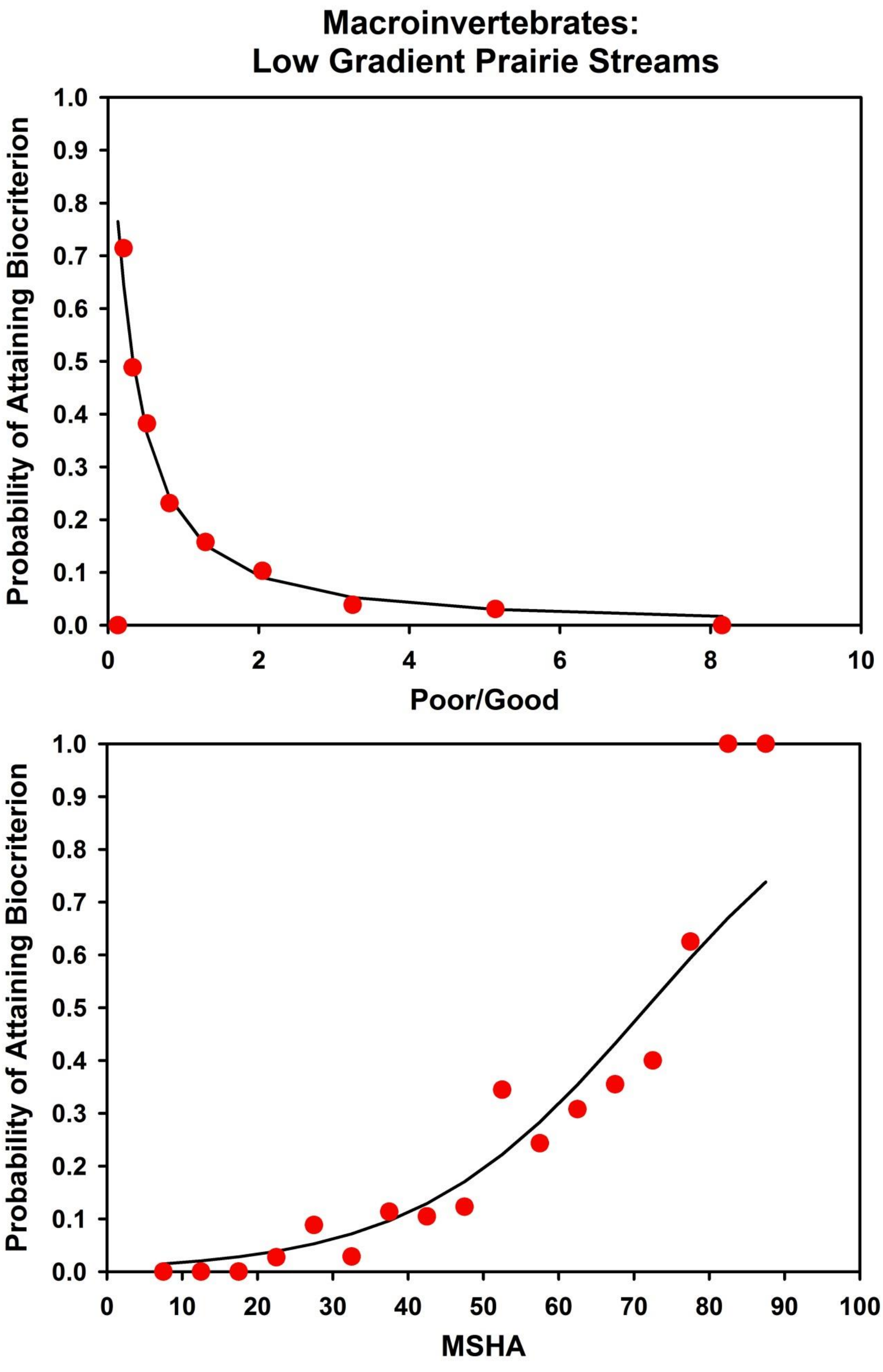
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Number of Weighted Good Habitat Attributes
Probability of Attaining Biocriterion
20
Number of Weighted Poor Habitat Attributes



Macroinvertebrates:
Low Gradient Prairie Streams
Probability of Attaining Biocriterion
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0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
Poor/Good
Probability of Attaining Biocriterion
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
50
60
70
80
90
100
MSHA

Appendix D: List of cold water fish taxa

Scientific Name	Common Name
Cottus	sculpins
Cottus cognatus	slimy sculpin
Cottus bairdii	mottled sculpin
Oncorhynchus gorbuscha	pink salmon
Oncorhynchus kisutch	coho salmon
Oncorhynchus tshawytscha	chinook salmon
Oncorhynchus mykiss	rainbow trout
Salmo salar	Atlantic salmon
Salmo trutta	brown trout
Salmonidae hybrid	tiger trout
Salvelinus hybrid	splake
Salvelinus namaycush	lake trout
Salvelinus fontinalis	brook trout

Appendix E: List of cold water macroinvertebrate taxa

Taxon	Taxon
Ameletus	*Goera*
Amphinemura	*Heleniella*
Apsectrotanypus	*Hesperophylax*
Aquarius	*Hesperophylax designatus*
Baetis tricaudatus	*Heterotrissocladius*
Boyeria grafiana	*Isoperla*
Brachycentrus	*Leuctra*
Brachycentrus americanus	*Limnephilus*
Brachycentrus occidentalis	*Lype*
Chelifera	*Lype diversa*
Chimarra aterrima	*Micrasema gelidum*
Clinocera	*Odontomesa*
Diamesa	*Oligostomis*
Diplectrona	*Pagastia*
Diplectrona modesta	*Parachaetocladius*
Diplocladius cultriger	*Paraleuctra*
Dolophilodes	*Parapsyche apicalis*
Doncricotopus bicaudatus	*Parapsyche sp.*
Epeorus	*Prodiamesa*
Epeorus vitreus	*Psilometriocnemus*
Ephemerella	*Psilotreta indecisa*
Ephemerella excrucians	*Rhithrogena*
Ephemerella invaria	*Rhyacophila*
Erioptera	*Rhyacophila angelita*
Eukiefferiella	*Rhyacophila fuscula*
Eurylophella bicolor	*Rhyacophila fuscula*
Eurylophella funeralis	*Rhyacophila invaria*
Gammarus	*Somatochlora minor*
Glossosoma	*Soyedina*
Glossosoma intermedium	*Trichoclinocera*
Glossosoma lividum	*Trissopelopia ogemawi*
Glossosoma nigrior	