An Ecological Assessment of Perennial, Wadeable Streams in the Red River Basin - North Dakota

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Table of Contents

List of Figures

List of Tables

Executive Summary

The perennial waters in the Red River basin in North Dakota are valuable public resources. In order to assess the current ecological condition of these water bodies in a statistically valid manner, a random, or probability, study design was employed (similar to the Western Pilot Environmental Monitoring and Assessment Program (EMAP-West). According to our estimates, a total of 4855.97 km of perennial lotic waters exist in the Red River basin in North Dakota. Of these, we were able to assess 2065.58 km (43%) with our sampling efforts.

The Red River basin in North Dakota includes two level III ecoregions, the Lake Agassiz Plain (48) and the Northern Glaciated Plains (46) ecoregions. Biological indicators of water quality used for this assessment include fish and macroinvertebrates. Macroinvertebrates were sampled in both ecoregions while fish sampling took place in the Lake Agassiz Plain ecoregion only. Ecological condition is estimated as a proportion of the perennial stream length considered to be in least disturbed, moderately disturbed or most disturbed condition. According to our estimates, 47% of perennial waters were considered to be in most disturbed condition while 30% were in least disturbed condition with regards to the macroinvertebrate indicator. Fish indicators reveal that 39% of streams were considered to be in least disturbed condition while 37% were considered most disturbed.

Chemical and physical stressors reveal that specific conductance is the greatest chemical stressor with 41% of streams in most disturbed condition. The greatest physical stressor is riparian disturbance where 75% of streams assessed are considered to be in most disturbed condition.

These results provide initial estimates of aquatic life use support to be used for State water quality and biological monitoring and assessment efforts. It is important to note that as additional data are added to these results, the thresholds, percentiles, etc. used in this report will be continually refined.

Introduction

The North Dakota Department of Health (NDDoH) has long recognized the natural, economic and recreational value of the many rivers and streams within the Red River basin. The protection, maintenance and restoration of water quality and the beneficial uses of these waterbodies has long been a top priority. This led to the development of the Red River Bioassessment Project with the intent of providing an ecological assessment of perennial rivers in the Red River basin in North Dakota. An ecological assessment includes the condition of the biota in the study area as well as the relative importance of human-caused stressors (Peterson et. al 2007).

The perennial, wadeable rivers and streams of the Red River basin in North Dakota are the primary focus of this bioassessment project. This project differs from past efforts by incorporating random site selection and a more intense physical habitat investigation. This will provide an integrated (physical, chemical and biological) assessment of the perennial, wadeable streams within the region.

Several variables within the Red River basin have led to potentially significant water quality impairments. Major impacts to surface water quality arise from non-point source (NPS) pollutants from agricultural practices as well as urban development. Primary pollutants are nutrients and sediment originating from agricultural lands. Cropland erosion on unprotected fields, especially during the winter, entrains sediment in the snowpack, which runs off during the spring melt. Rainfall or heavy snow events early in the spring can cause cropland erosion, ultimately transporting sediment to surface waters within the watershed which can have a significant effect on aquatic life such as fish and macroinvertebrates.

The Red River basin in North Dakota crosses two level III ecoregions (Figure 1), the Northern Glaciated Plains (46) and the Lake Agassiz Plain (48) (Omernik and Gallant 1988). The Lake Agassiz Plain ecoregion of North Dakota occupies the nearly flat basin of ancient Lake Agassiz. Relief of 50 to 100 feet is found along margins of the ecoregion but otherwise is generally absent. Streams originating from within the ecoregion are mostly intermittent and drain watersheds ranging up to a few hundred square miles. Perennial streams in this region generally originate in adjacent ecoregions. Average annual precipitation is from 20 to 22 inches, approximately half of which occurs during the growing season, April-September (Omernik and Gallant 1988).

Soils were formed from lacustrine sediments and sand/gravel beach deposits. Poor drainage occurs in areas of silt loam and clay, and poor to excessive drainage in areas of sandy loam. Stream water quality in this region is impacted by dryland farming practices. Runoff from fertilizer, pesticides and other farmland chemicals alter water chemistry in many areas. This process is generally accelerated where man-made surface and sub-surface drainage assists in areas of naturally poor soil drainage (Omernik and Gallant 1988).

The Northern Glaciated Plains ecoregion of North Dakota is characterized by glacially formed topography and low to moderate annual precipitation. A relatively short growing season promotes a land use emphasis on dry-farming and livestock production which in turn have the greatest large scale affect on water quality in the Northern Glaciated Plains. Trampling of stream banks and streambeds is particularly severe in this region because livestock tend to travel in dry water courses. Washing of manure from feedlots and stockyards into streams also has a dramatic effect on water chemistry. Rain events tend to be intense and of short duration. These rain events wash eroded cropland soil into streams which increases turbidity and sedimentation. Fertilizers and herbicides applied to cropland are also carried to streams through runoff (Omernik and Gallant 1988). The landscape is made up of glacial lake plains and nearly level to rolling glacial till plains that are punctuated by kettle holes, kames and moraines. Elevations range from 1000 to 1800 feet above sea level. The major watershed of focus in this ecoregion is the Sheyenne River which is a tributary to the Red River.

Aquatic life is a beneficial use assigned to all North Dakota rivers and streams through State water quality standards (NDDoH 2010). While an assessment of aquatic life use can be conducted indirectly (e.g., dissolved oxygen), direct measures of the biological community are more accurate. Aquatic life use, or biological integrity, is defined by Karr and Dudley (1981) as the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of natural habitats of the region. Human disturbance of streams and landscape alters key attributes of aquatic ecosystems (i.e., water quality, habitat, hydrologic regime) resulting in decreased biotic integrity.

In order to develop biological indicators capable of assessing biotic integrity, the NDDoH has developed two calibrated multi-metric indices of biotic integrity (IBI) based on aquatic macroinvertebrates, one for the Northern Glaciated Plains ecoregion (Larsen 2010) and one for the Lake Agassiz Plain ecoregion (Larsen 2011a). In addition to the macroinvertebrate IBI for the Lake Agassiz Plain ecoregion, a multi-metric IBI for fish has also been developed (Larsen 2011b).

Once an IBI has been developed, it becomes a valuable assessment tool. A multi-metric IBI assumes that multiple measures of the biological community or metrics (e.g., species richness, composition, tolerance, trophic structure, habit) have been evaluated and will respond well to increased pollution or habitat alterations. Metric development reduces the number of biological community attributes that need evaluation to only those that are sensitive to human disturbance or impairment.

The primary goals of the Red River Bioassessment Project are to: 1) assess, using the biological, physical and chemical data, the current biological condition of perennial, wadeable rivers and streams of the Red River basin in North Dakota; 2) assess the current status of aquatic life use attainment of the perennial, wadeable streams of the Red River basin in North Dakota; and 3) investigate potential stressors to impaired aquatic life use within the Red River basin in North Dakota. A secondary objective of the project, and one that was necessary in order to complete the assessment described in this report, was to develop and refine multi-metric IBIs for fish and macroinvertebrate communities in both the Northern Glaciated Plains (macroinvertebrates) and Lake Agassiz Plain (fish and macroinvertebrates) ecoregions.

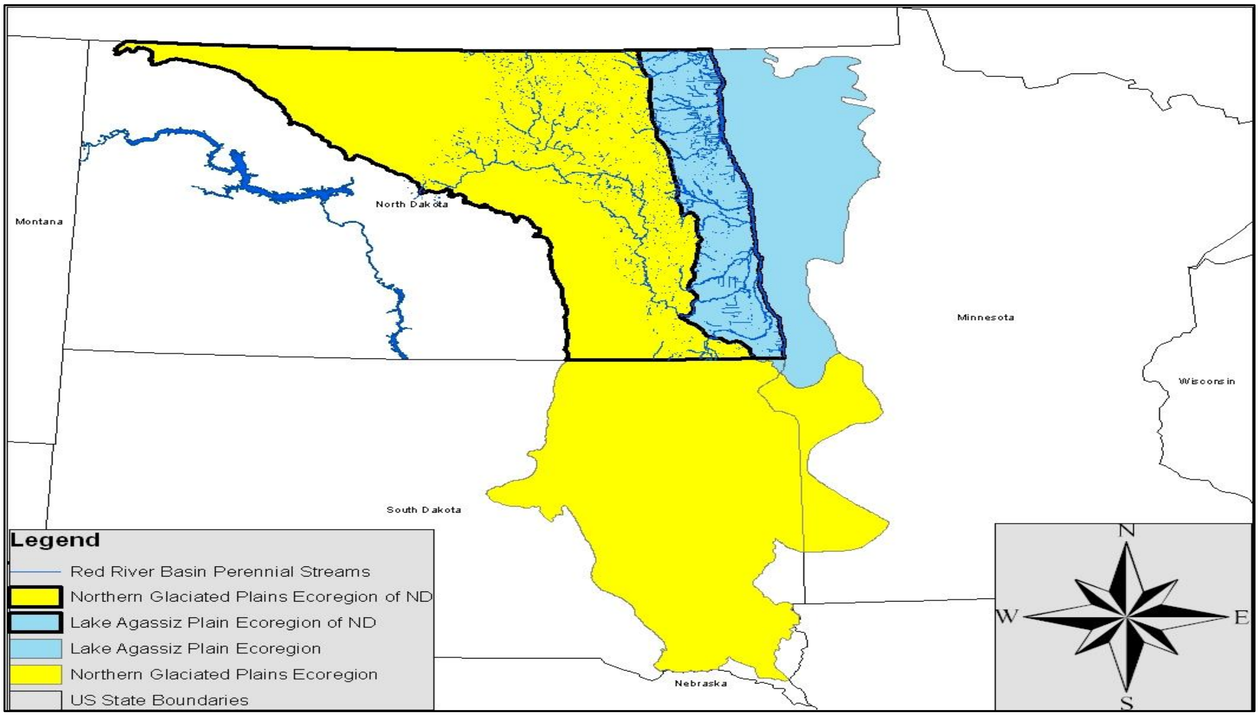

Figure 1. The Lake Agassiz Plain and the Northern Glaciated Plains Ecoregions and Their Extent in Minnesota and South Dakota. The Primary Focus of this Ecological Assessment is the Perennial Lotic Waters of the Red River Basin in North Dakota.

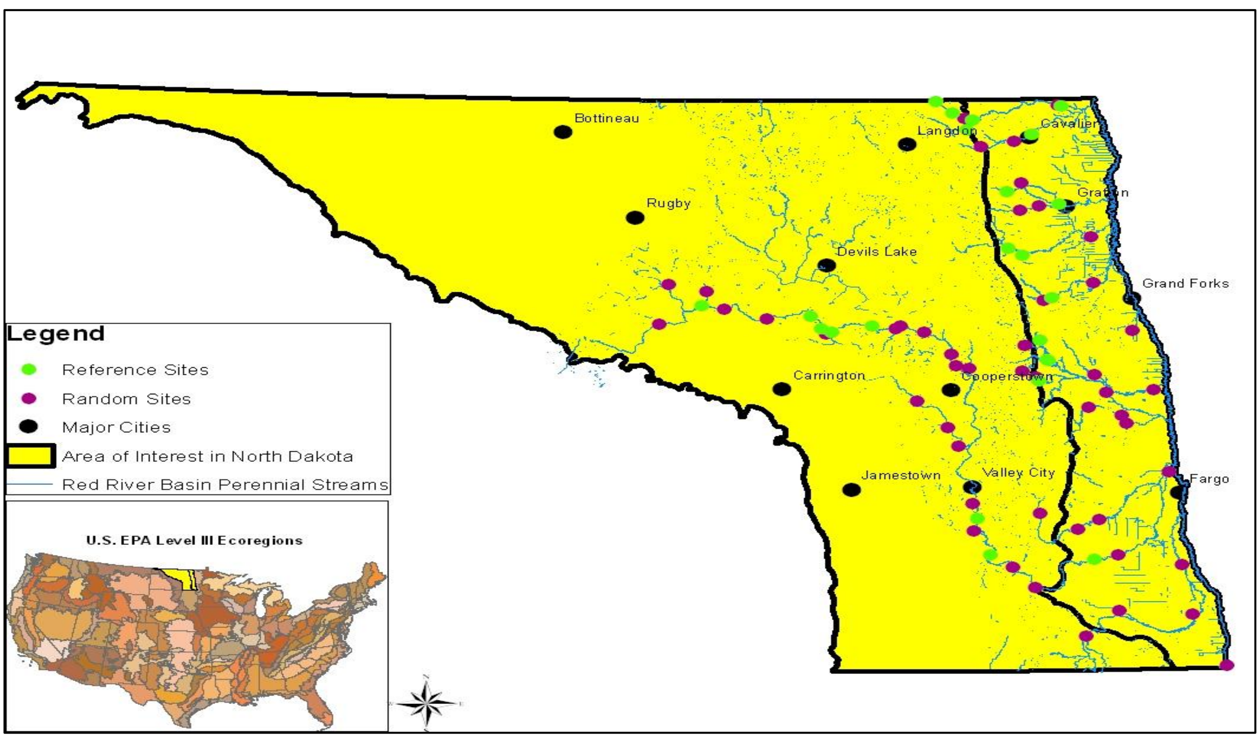

Figure 2. Sampling Locations for the Red River Bioassessment Project in North Dakota. Purple circles indicate random sites and green circles indicate reference sites.

Extent of Resource

The data used to select random, or probability, sampling sites for the Red River Bioassessment Project in North Dakota are based on the perennial stream network located in EPA's River Reach File, known as RF3. According to the RF3 data file, the total length of perennial stream in the Red River basin in North Dakota is estimated to be 4855.97 km. A majority (2633.95 km or 54%) of this was found to be non-target (non-wadeable, non-perennial or non-target in some other fashion such as a wetland, reservoir, etc). A summary of target and non-target stream length is provided in Figure 3.

The remaining "target stream length" (2222.02 km or 46%) represents the portion of the Red River basin in North Dakota that meets our criteria (perennial, wadeable streams) for inclusion in this assessment. A small portion of stream length (100.21 km or 5%) was not accessible due to landowner denial. Another small portion (56.23 km or 2%) of the target stream length was not accessible due to physical barriers (inaccessible locations) that prevented sampling. The remaining 2065.58 km (43% of the original RF3 perennial data frame and 93% of the targeted stream length) comprise the assessed length of stream for this ecological assessment. Results of this assessment cannot be applied, or inferred, to the remainder (non-target) of the perennial streams that did not meet our criteria and could not be assessed for condition at this time.

The Lake Agassiz Plain ecoregion of North Dakota has an estimated 2815.58 km of perennial stream. Of this, 1101.23 km (39%) were assessed for condition while 1557.90 km (55%) were determined to be non-target. The remaining 156.45 km (6%) were either inaccessible due to a physical barrier or sampling personnel were denied landowner permission.

The Northern Glaciated Plains ecoregion of North Dakota has an estimated 2040.39 km of perennial stream in the Red River basin. Of this, 964.35 km, (47%) were assessed for ecological condition while 1076.05 km (53%) were evaluated as being non-target. In this ecoregion there were no physical barriers that prevented sampling crews from accessing sites nor were there any landowner denials.

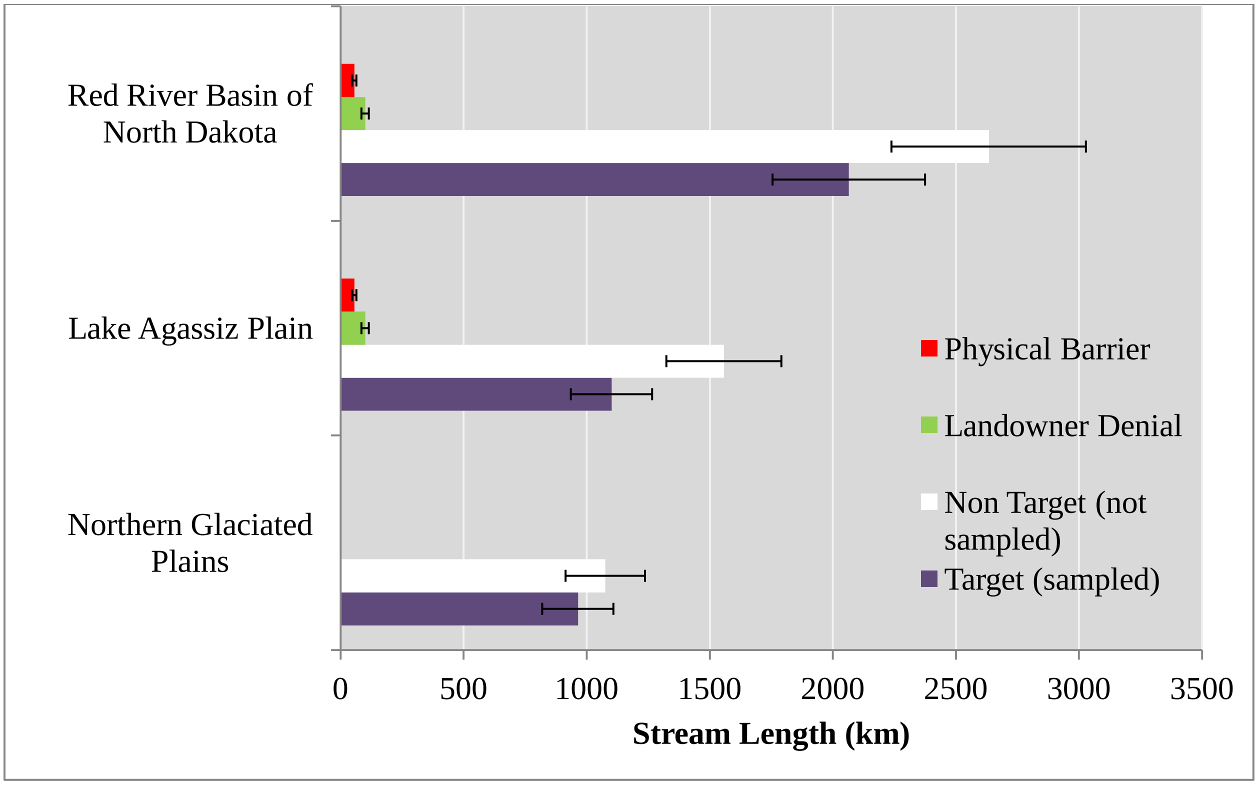

Figure 3. Stream Length Estimates for the Red River Basin in North Dakota Including Target and Non-Target Estimates.

Methods

<u>Sample Site Selection</u>

In order to assess the overall biological condition of the wadeable, perennial rivers and streams in the Red River basin in North Dakota with known precision and accuracy, a probabilistic sampling design was employed for this study. The probabilistic sampling design involved the selection of 25 randomly selected sites within each ecoregion, for a total sample size of 50. Site selection was conducted by the US EPA's Office of Research and Development (Corvallis, OR) laboratory using a Generalized Random Tessellation Stratified (GRTS) survey design for a linear resource. The GRTS design includes reverse hierarchical ordering of the selected sites. This design results in sites chosen at random based on the distribution of all perennial waters within the Red River basin. For a more complete explanation of the site selection process, refer to the Quality Assurance Project Plan (QAPP) for the Red River Bioassessment Project (NDDoH 2007).

Each sampling site was identified by a latitude and longitude coordinate depicting the midpoint of the sample reach (i.e., middle transect). Once the sampling site was located, the length of the sampling reach was determined by multiplying the average wetted width of the stream times 40 with a minimum of 150 meters and a maximum of 500 meters stream sampling reach (Peck et al.

2005). Once the reach length was determined, 11 evenly spaced transects were marked with orange survey flags throughout the reach. For example, if the sampling reach was 150 meters then each transect is spaced 15 meters apart. For a more complete description of any of the methods employed during this project, refer to the Quality Assurance Project Plan (QAPP) for the Red River Bioassessment Project (NDDoH 2007).

Within each ecoregion a total of 25 randomly selected sites were sampled for macroinvertebrates, water chemistry and physical habitat. In the Lake Agassiz Plain (48) ecoregion, fish were also sampled as an additional biological indicator of water quality. Results were analyzed using Analyze-It 2012 software.

Water Quality

In-situ field measurements for dissolved oxygen (DO), temperature, specific conductance and pH were taken at the middle transect of each sampling reach using an YSI handheld meter. A water quality sample was also collected during each visit and analyzed for major cations/anions, trace metals, nutrients (total nitrogen, total and dissolved phosphorus, nitrate-nitrite, and ammonia), and total suspended solids. Water quality samples were collected as a single grab sample taken in the deepest area of the middle transect at 60% of the total stream depth.

Physical Habitat

Physical habitat measurements were also taken with each site visit. Cross-sectional measurements were taken at each of the 11 transects within the sampling reach. Physical habitat measurements include bank measurements (i.e., wetted and bankfull width, etc) and channel measurements (i.e., water depth, substrate type, etc) (Table 15). A visual habitat assessment based on the Rapid Bioassessment Protocol (RBP) described by Barbour et al (1999) was also completed for each site (Table 12).

Benthic Macroinvertebrates

Benthic macroinvertebrate samples were collected using two methods. Stream sites located in the Lake Agassiz Plain ecoregion were sampled using the proportional sampling method described by Barbour et al. (1999). With this method, 20 individual D-frame jab samples are collected among each of the dominant habitat types present within the sample reach. The 20 samples are apportioned based on the proportion of each habitat type. For example, if riffle habitat, woody debris, rooted macrophytes, and pools represented 50, 20, 20 and 10 percent of all habitats each, then 10, 4, 4, and 2 jab samples would be collected within each habitat type, respectively. The 20 individual jab samples are then composited into one sample and submitted to the laboratory for processing.

In the Northern Glaciated Plains ecoregion, macroinvertebrate samples were collected using the transect method employed by the Environmental Monitoring and Assessment Program Western

Pilot study (EMAP – West) (Peck et al. 2005). With this method, benthic macroinvertebrate D-frame jab samples are collected at each of the 11 transects located within the sample reach. Beginning at the furthest most downstream transect and working upstream, a jab sample is collected from either the right, center or left side of the transect based on a random sample. Once the sample position is determined for the first transect, sampling at each of the remaining transects proceeds in order following the left side, center and right side sequence until each transect has been sampled. The 11 jab samples are then composited into one sample and submitted to the laboratory for processing. Laboratory analysis of macroinvertebrate samples was conducted on a 500 count subsample. These subsamples were obtained by spreading the sample evenly over a gridded pan and picking 500 individual organisms from randomly selected grids. Final organism identification was done to the lowest taxonomic level possible (genus/species preferred). Laboratory analysis was conducted by Dr. Andre Delorme and his staff at the Valley City State University Macroinvertebrate Laboratory.

<u>Fish</u>

As mentioned previously, fish samples were only collected at sites located in the Lake Agassiz Plain ecoregion. At each site the entire reach was sampled using a long-line electrofishing unit. Beginning at the downstream end of the reach and proceeding in an upstream direction, an effort was made to include all available habitat types in order to collect a representative sample of the entire reach. Enumeration included separating the individuals collected into species, measuring the largest and smallest of each species, and taking a batch weight of each species to account for total biomass.

Setting Expectations for Impairment

In addition to the randomly selected sites, a set of 10 “reference” or “least disturbed” sites were also selected and sampled in each ecoregion (Figure 2). While data from these “reference sites” were used in the development of the macroinvertebrate and fish IBIs, these sites were also used to develop the chemical and physical stressor scoring thresholds used in this report. These targeted “reference” sites were selected using ArcView 3.2A and the Analytical Tool Interface for Landscape Assessments (ATtILA). In general, targeted reference sites were evaluated and selected based on a set of landuse factors or metrics found within a circular 2 km buffer of the site on the river or stream. Sites that were considered “least disturbed” with respect to these landuse metrics (e.g., riparian buffer distance, road density, agricultural practices) were selected as candidate “reference” sites. Final reference site selection was made following a site visit where final site screening was conducted. In general, reference sites had a well established riparian zone, low road density and overall low amount of human activity.

In order to assess biological condition or aquatic life use support of rivers and streams, we need to be able to compare what we are measuring to some estimate of good, or fully supporting, biological condition of the river or stream. This is also referred to as the river or stream’s "biological potential." Setting reasonable expectations for a biological indicator, like an IBI, is one of the greatest challenges to an assessment of this type. Is it appropriate to take a historical perspective, and try to compare current conditions to some estimate of pre-Columbian conditions, or to pre-industrial conditions, or to some other point in history? Or, is it acceptable to assume that some level of human disturbance is a given, and simply use the best of today's conditions as the measuring stick? The answers to all these questions relate to the concept of "reference condition" (Bailey et al. 2004, Stoddard et al. 2006).

Due to the difficulty of estimating historical conditions for most biological indicators, the Department has adopted the "least-disturbed" condition as the operational definition of reference condition. "Least-disturbed condition" is found in conjunction with the best available physical, chemical and biological habitat conditions for a given area or region (e.g., ecoregion) given the current state of the landscape. "Reference" or "least-disturbed" condition is described by evaluating data collected at sites selected based on a set of explicit criteria defining what is "best" or "least-disturbed" by human activities. These criteria vary from ecoregion to ecoregion in the state and are developed iteratively with the goal of identifying a set of sites which are influenced the least by human activities. The Department's procedure for selecting reference sites is described in Appendix A.

Once a set of "reference sites" are selected for a given ecoregion in the state, they are sampled using the methods described earlier. The range of conditions (e.g., habitat variables, chemical concentrations, or IBI scores) found at these "reference sites" describes a distribution of values, and extremes of this distribution are used to set thresholds in order to separate sites that are in relatively good condition from those that are clearly not. One common approach, and the one used by the Department, is to examine the range or statistical distribution of IBI scores for a set of reference sites within an ecoregion, and to use the 5th or 10th percentile of this distribution to separate the most disturbed (i.e., poor biological condition) sites from moderately disturbed (i.e., fair biological condition) sites. Similarly, the 25th or 50th percentile of the distribution is used to distinguish between moderately disturbed sites and those in "least-disturbed" condition. Details on how these thresholds were set for each multi-metric IBI developed by the Department are available in each of the reports referenced earlier, while the IBI scoring thresholds for each biological condition class and use support category are provided in Tables 1, 2, and 3.

To determine the biological condition or aquatic life use support of streams, threshold values are required to determine what constitutes good biological condition scores (i.e., fully supporting aquatic life use) or poor biological condition scores (i.e., not supporting aquatic life use) in a multi-metric index.

The assessment approach used for this report is outlined in Barbour et al. (1999). First, the appropriate percentile of the reference site IBI scores was determined. Based on the reference site macroinvertebrate IBI scores for sites in the Lake Agassiz Plain ecoregion (Table 5), the 50th percentile of reference site IBI scores is 71. This value is equivalent to the dividing line between good and fair biological condition. (Note: This threshold could be set lower if there is more confidence that the reference sites truly represent non-impacted conditions.) Since there is usually some doubt about the certainty of the reference site population, using values above the 25^{th} percentile was selected as a conservative approach.

Biological condition scores were then translated into aquatic life use attainment categories by assigning the good biological condition class as fully supporting aquatic life use and the poor biological condition class as not supporting aquatic life use (Table 1-3).

Table 1. Scoring Thresholds by Biological Condition Class and Aquatic Life Use Support Category for the Lake Agassiz Plain Ecoregion Macroinvertebrate IBI.

IBI Score	Biological Condition Class	Aquatic Life Use Support
100-72	Least Disturbed	Fully Supporting
71-60	Moderately Disturbed	Fully Supporting, but Threatened
59-0	Most Disturbed	Not Supporting

Table 2. Scoring Thresholds by Biological Condition Class and Aquatic Life Use Support Category for the Northern Glaciated Plain Ecoregion Macroinvertebrate IBI.

IBI Score	Biological Condition Class	Aquatic Life Use Support
100-71	Least Disturbed	Fully Supporting
70-59	Moderately Disturbed	Fully Supporting, but Threatened
58-0	Most Disturbed	Not Supporting

Table 3. Scoring Thresholds by Biological Condition Class and Aquatic Life Use Support Category for the Lake Agassiz Plain Ecoregion Fish IBI.

IBI Score	Biological Condition Class	Aquatic Life Use Support
100-63	Least Disturbed	Fully Supporting
62-47	Moderately Disturbed	Fully Supporting, but Threatened
46-0	Most Disturbed	Not Supporting

Ecological Condition

<u>Macroinvertebrate Assessment</u>

With regards to the macroinvertebrate indicator, 828.43 km (30%) of the 2815.58 perennial stream kilometers were assessed in the Lake Agassiz Plain. Final metrics include: Diptera Taxa, Hilsenhoff Biotic Index, Percent EPT, Scraper Taxa, Shannon Wiener Index, Sprawler Taxa and Total Taxa. This final index includes two richness metrics, two composition metrics, one tolerance, one trophic and one habit metric. Table 4 illustrates final macroinvertebrate metrics for the Lake Agassiz Plain ecoregion while Table 5 provides thresholds used to determine condition class estimates. Final condition class estimates are illustrated in Figure 4.

According to our estimates, 2040.39 perennial stream kilometers are present in the Northern Glaciated Plains ecoregion. Of these perennial waters, we assessed 964.35 km, (47%), using the macroinvertebrate indicator. Final metrics for the Northern Glaciated Plains ecoregion include: Percent EPT, Percent Non-Insect, Percent Univoltine, Tolerant Taxa, Hilsenhoff Biotic Index and Swimmer Taxa. This final index includes three composition metrics, two tolerances and one habit metric. Table 6 illustrates final macroinvertebrate metrics for the Northern Glaciated Plain ecoregion and Table 7 summarizes threshold values used to determine condition class estimates. Final condition class estimates are illustrated in Figure 5.

Overall condition class estimates for the entire Red River Basin in North Dakota are represented in Figure 6. Of the estimated 4855.97 perennial stream kilometers, 1792.78 km (37%) were assessed for this project. Overall, 543.46 km (30%) were assessed as in the least disturbed condition, 410.66 km (23%) were assessed as moderately disturbed and 838.66 km (47%) were assessed as most disturbed with regards to the macroinvertebrate indicator.

Table 4. Minimum and Maximum Values Used to Standardize Macroinvertebrate Metrics in the Lake Agassiz Plain Ecoregion.

Final Metric	Category	Response to Perturbation	Minimum Value	Maximum Value
Diptera Taxa	Richness	Decrease	3	8
Hilsenhoff Biotic Index	Tolerance	Increase	4.34	7.09
Percent EPT	Composition	Decrease	0.86	68.03
Scraper Taxa	Trophic	Decrease	0	8
Shannon Wiener Index	Composition	Decrease	1.27	2.82
Sprawler Taxa	Habit	Decrease	1	5
Total Taxa	Richness	Decrease	14	35

Table 5. Threshold Values Used to Determine Condition Class in the Lake Agassiz Plain Ecoregion with Regards to the Macroinvertebrate Indicator.

	Least Disturbed	Moderately Disturbed	Most Disturbed
Percentile	50th	NA	5th
IBI Score	> 71	≤ 71 and ≥ 60	< 60

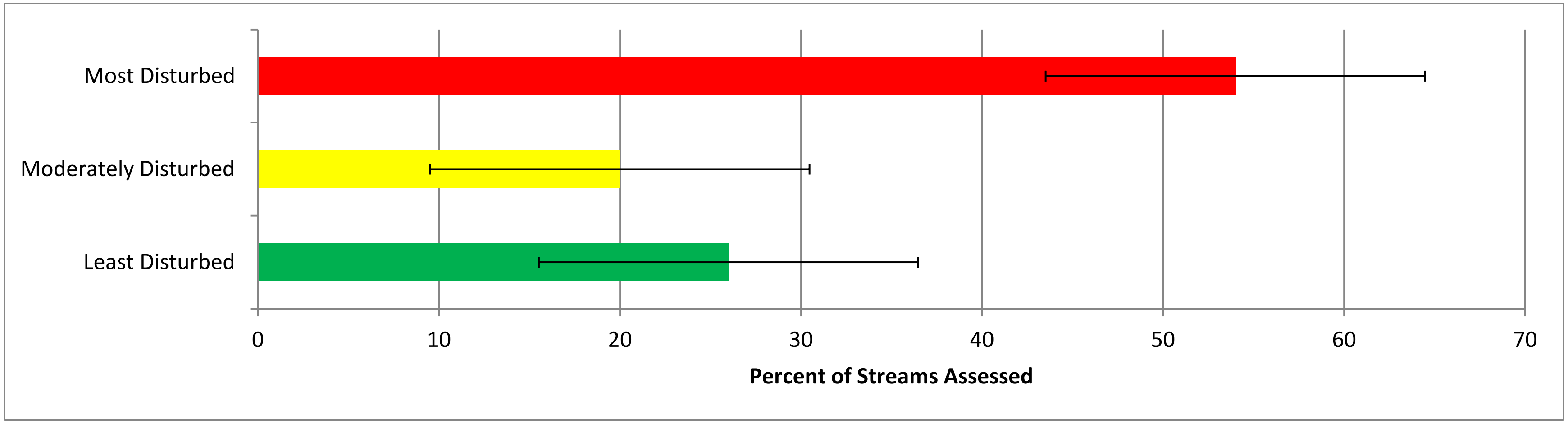

Figure 4. Condition Class Estimates for the Lake Agassiz Plain Ecoregion of the Red River Basin with Regard to the Macroinvertebrate Indicator.

Table 6. Minimum and Maximum Values Used to Standardize Macroinvertebrate Metrics in the Northern Glaciated Plains Ecoregion.

Final Metric	Category	Response to Perturbation	Minimum Value	Maximum Value
Percent EPT	Composition	Decrease	2.37	75.59
Percent Non-Insect	Composition	Increase	0.97	78.23
Percent Univoltine	Life Cycle/Composition	Decrease	3.48	76.69
Tolerant Taxa	Tolerance	Increase	1	12
Hilsenhoff Biotic Index	Tolerance	Increase	4.52	7.31
Swimmer Taxa	Habit	Increase	0	8

Table 7. Threshold Values Used to Determine Condition Class in the Northern Glaciated Plains Ecoregion with Regard to the Macroinvertebrate Indicator.

	Least Disturbed	Moderately Disturbed	Most Disturbed
Percentile	25th	NA	5th
IBI Score	> 70	≤ 70 and ≥ 59	< 59

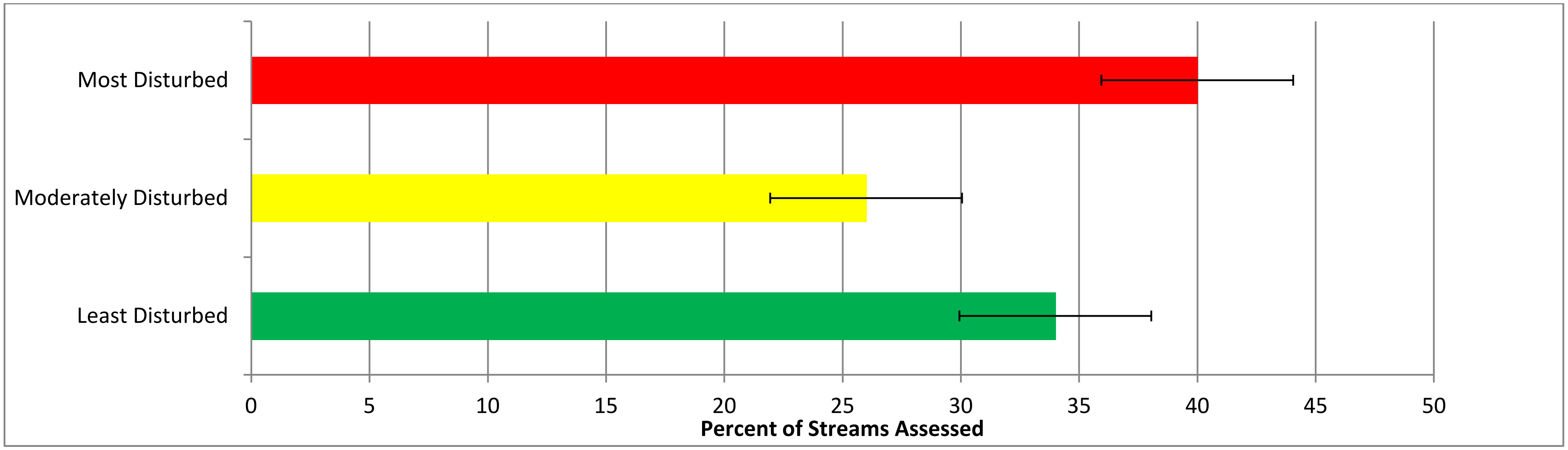

Figure 5. Condition Class Estimates for the Northern Glaciated Plains Ecoregion of the Red River Basin with Regard to the Macroinvertebrate Indicator.

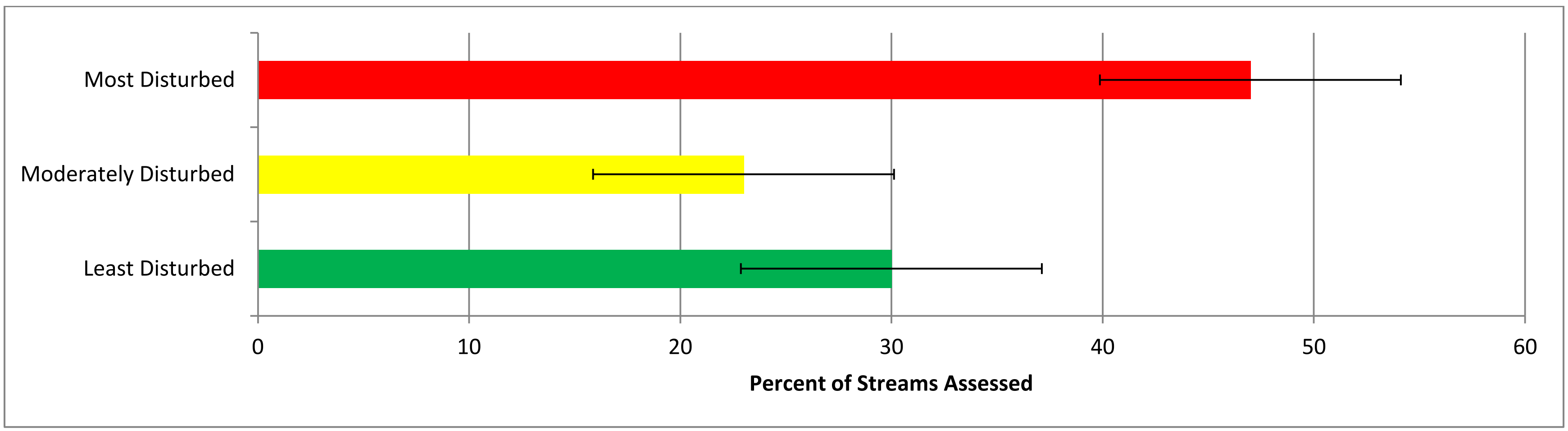

Figure 6. Condition Class Estimates for all Perennial Waters of the Red River Basin in North Dakota with Regard to the Macroinvertebrate Indicator.

Fish Assessment

Fish were sampled in the Lake Agassiz Plain only. Previous biological monitoring efforts achieved poor results with the fish indicator in the Northern Glaciated Plains ecoregion due to depauperate fish communities throughout the region. Therefore, the fish assessment was not included in the Northern Glaciated Plains. Final metrics used in the fish index include: fish per minute, percent lithophilic taxa, percent lithophilic individuals, percent insectivorous cyprinids, percent dominant taxon, percent tolerant taxa and total taxa. This final index includes one abundance metric, two reproductive, one trophic, one composition, one tolerance and one richness metric. Table 8 shows the final fish metrics used in the Lake Agassiz Plain ecoregion. Final condition class estimates are provided in Figure 7 while threshold values used to determine condition class estimates are provided in Table 9. Of the 2815.58 perennial stream kilometers present in the Lake Agassiz Plain ecoregion, 755.73km (27%), were assessed using the fish indicator. Of these, 297.63 km (39%) were assessed as least disturbed while 178.41km (24%) were moderately disturbed and 279.69 km (37%) were considered to be in most disturbed condition.

Table 8. Minimum and Maximum Values Used to Standardize Fish Metrics in the Lake Agassiz Plain Ecoregion.
* Denotes Metric is Drainage Area Dependent. Use Results of Linear Regression to Determine Maximum Value Where DA = drainage area in mi^2.

Final Metric	Category	Response to Perturbation	Maximum	Minimum
Fish per Minute	Abundance	Decrease	16.4	0.15
Percent Lithophilic Taxa	Reproductive	Decrease	63.33	0
Percent Lithophilic Individuals	Reproductive	Decrease	81.27	0
Percent Insectivorous Cyprinids	Trophic	Decrease	88.61	0
Percent Dominant Taxa	Composition	Increase	95.23	24.71
Percent Tolerant Taxa	Tolerance	Increase	100	24.27
Total Taxa*	Richness	Decrease	y = 0.0243(DA) + 6.987	2

Table 9. Threshold Values Used to Determine Condition Class in the Lake Agassiz Plain Ecoregion with Regard to the Fish Indicator.

	Least Disturbed	Moderately Disturbed	Most Disturbed
Percentile	25th	NA	10th
IBI Score	> 62	≤ 62 and ≥ 47	< 47

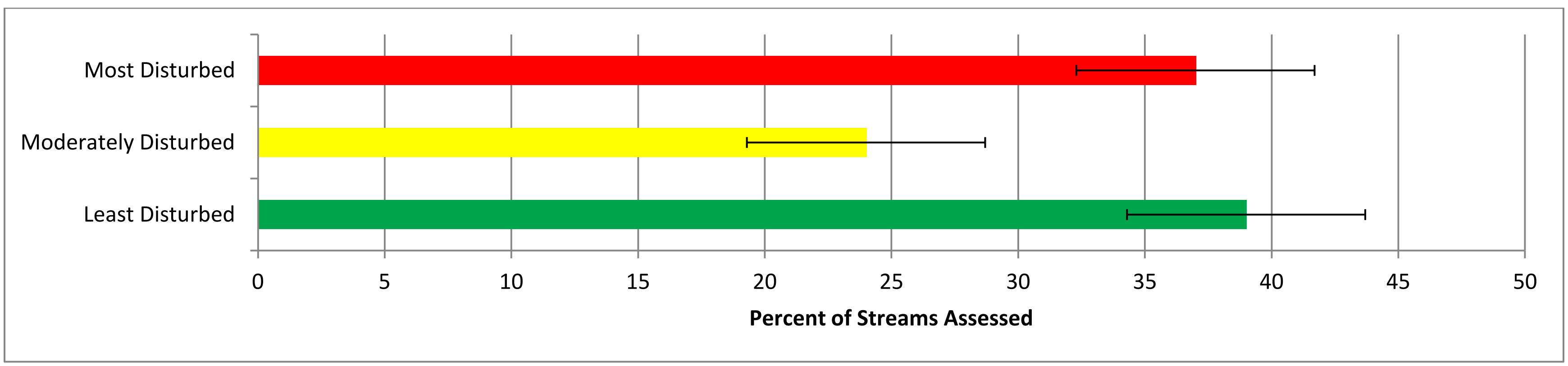

Figure 7. Condition Class Estimates for the Lake Agassiz Plain Ecoregion of North Dakota with Regard to the Fish Indicator.

Stressor Condition

Chemical Stressors

Previous studies have shown that three chemical stressors are of particular importance in the region (Johnson et al. 2009), total nitrogen, total phosphorus and specific conductance. Based on the statistical distribution of reference site data, thresholds were drawn using the 75th percentile and above as most disturbed and the 25th percentile and below as least disturbed. Values falling between are considered moderately disturbed.

In the Lake Agassiz Plain ecoregion sampling took place throughout the summer, from June through September. Chemical stressors from both macroinvertebrate and fish sampling periods were combined. Of the 2815.58 km of perennial streams in the ecoregion, 1584.17 km (56%) were assessed for chemical stressors. Threshold values are presented in Table 10 and results are presented in Figure 8.

In the Northern Glaciated Plains ecoregion sampling took place from August through September. Of the 2040.39 km of perennial streams and rivers present in the ecoregion, 964.35 km (47%) were assessed using chemical stressors. Table 11 summarizes threshold values and results are presented in Figure 9.

It is estimated that 4855.97 km of perennial streams and rivers are present in the entire basin. Of these, 2548.52 (52%) were assessed for chemical stressors in the Lake Agassiz Plain and Northern Glaciated Plains. Results from both ecoregions are combined and presented in Figure 10 for a complete assessment of the Red River basin as a whole.

Table 10. Threshold Values Used to Determine Condition Class for Three Chemical Stressors in the Lake Agassiz Plain Ecoregion.

Chemical Stressor	Most Disturbed	Moderately Disturbed	Least Disturbed
Total Nitrogen	>1230 µg/L	1230 - 883 µg/L	<883 µg/L
Total Phosphorus	>261 µg/L	261 - 148 µg/L	<148 µg/L
Specific Conductance	>1432 µmho/cm	1432 - 911 µmho/cm	<911 µmho/cm

Table 11. Threshold Values Used to Determine Condition Class for Three Chemical Stressors in the Northern Glaciated Plains Ecoregion.

Chemical Stressor	Most Disturbed	Moderately Disturbed	Least Disturbed
Total Nitrogen	>1047 µg/L	1047 - 581 µg/L	<581 µg/L
Total Phosphorus	>215 µg/L	215 - 115 µg/L	<115 µg/L
Specific Conductance	>1044 µmho/cm	1044 - 991 µmho/cm	<991 µmho/cm

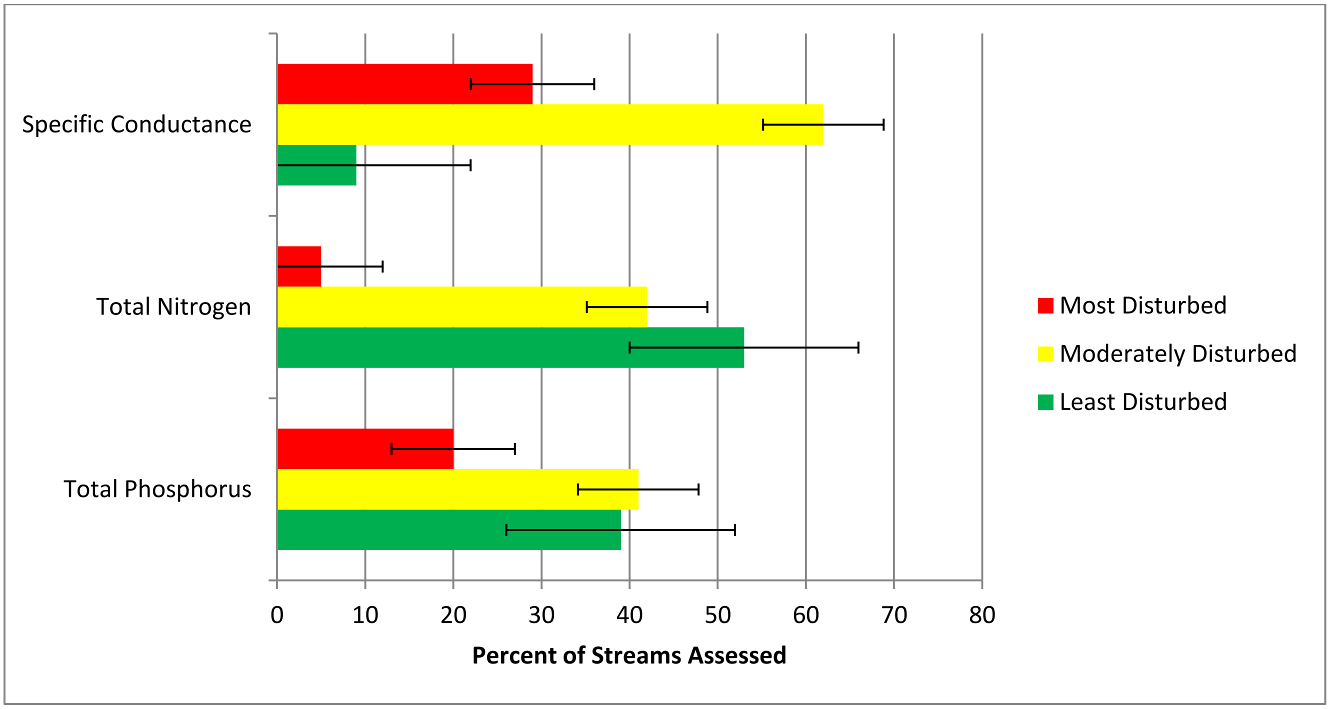

Figure 8. Stream Length in the Lake Agassiz Plain Ecoregion Considered to be Least Disturbed, Moderately Disturbed or Most Disturbed Based on Three Chemical Stressors.

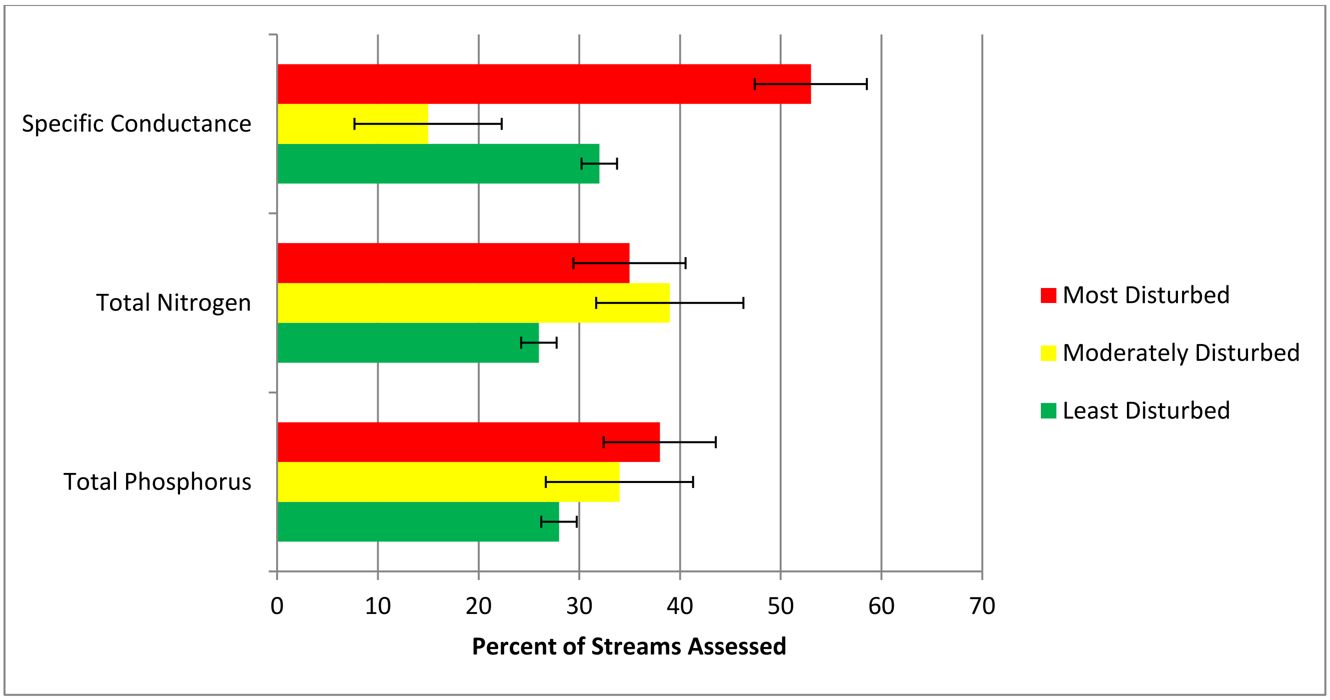

Figure 9. Stream Length in the Northern Glaciated Plains Ecoregion Considered to be Least Disturbed, Moderately Disturbed or Most Disturbed Based on Three Chemical Stressors.

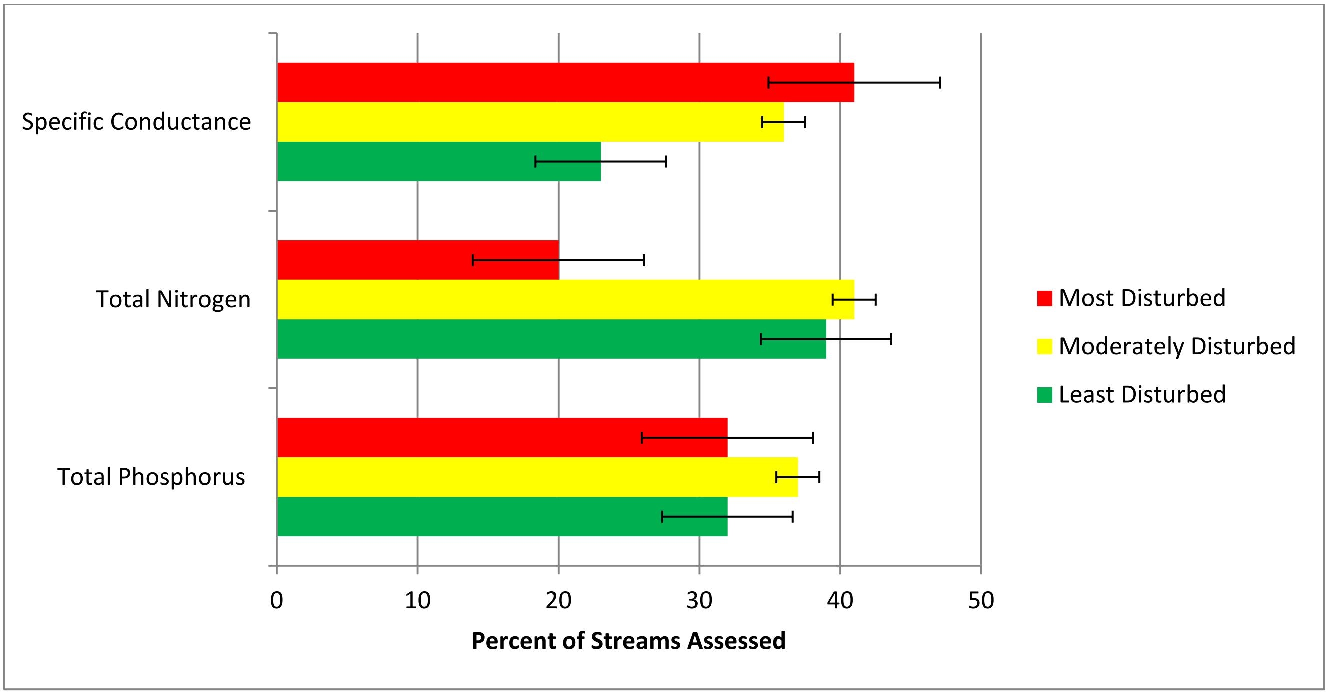

Figure 10. Stream Length in the Red River Basin Considered to be Least Disturbed, Moderately Disturbed or Most Disturbed Based on Three Chemical Stressors.

Based on the chemical stressor indicators, it is estimated that 682.23 km (27%) are least disturbed, 877.77 km (34%) are moderately disturbed and 936.99 km (37%) are most disturbed with regards to total phosphorus, while 919.59 km (36%) are least disturbed, 1035.42 km (41%) are moderately disturbed and 541.99 km (21%) are in most disturbed condition based on the total nitrogen stressor. (Note: A site representing 51.53 km (2%) of the total phosphorus and total nitrogen indicator is unaccounted for due to the water quality sample being discarded as a result of a field error.) According to the specific conductance indicator, 601.07 km (24%) are least disturbed, 1043.66 km (41%) are moderately disturbed and 903.79 km (35%) are in most disturbed condition (Figure 10).

Physical Habitat Stressors

The physical habitat assessment consisted of two components, the Rapid Bioassessment Protocol (RBP) visual assessment and a geomorphologic assessment comprised of physical measurements of the stream channel at each of 11 cross-sections throughout the sampling reach. Once IBI (dependent variable) scores were calculated, linear regressions were run in order to identify potential physical habitat stressors (independent variable) for each ecoregion. Table 12 provides a list of RBP parameters evaluated during the visual assessment. In the Lake Agassiz Plain ecoregion, strong correlations exist between biological integrity and available cover, sediment deposition, riparian vegetative zone width, channel alteration and vegetative protection (Figure 11).

Table 12. Rapid Bioassessment Protocol (RBP) Visual Habitat Assessment Parameters.

Available Cover	Channel Flow Status	Riparian Vegetative Zone Width
Bank Stability	Channel Sinuosity/Frequency of Riffles	Sediment Deposition
Bank Vegetative Protection	Embeddedness/Pool Variability	Substrate Type
Channel Alteration		

In the Northern Glaciated Plains ecoregion, linear regressions revealed strong correlations with riparian vegetative zone width, vegetative protection, pool variability, channel sinuosity and channel alteration (Figure 12).

Of the 13 physical habitat measurements taken as part of the geomorphologic assessment (Table 13), riparian disturbance, relative bed stability and available cover were shown to be the primary physical habitat stressors affecting ecological condition in the Red River basin in North Dakota. Of the 2815.58 km of perennial stream in the Lake Agassiz Plain, 755.73 km (27%) were assessed using these three physical habitat stressors.

Based on the physical stressor threshold values developed for the Lake Agassiz Plain ecoregion (Table 13), it is estimated that 328.27 km (43%) of stream in the Lake Agassiz Plain ecoregion are in the least disturbed condition, 237.47 km (31%) are moderately disturbed and 190 km (26%) are most disturbed with regard to the available cover stressor (Figure 13). It is also estimated that 268.1 km (36%) of streams are in least disturbed condition, 295.88 km (39%) are moderately disturbed and 191.76 km (25%) are most disturbed with regard to the relative bed stability stressor (Figure 13). The greatest percentage of streams in the Lake Agassiz Plain ecoregion was assessed as most disturbed for the riparian disturbance stressor. Riparian disturbance was estimated to be in the most disturbed condition for 483.7 km (64 %) of streams, while 220.52 km (29%) of streams were assessed as moderately disturbed and 51.52 km (7%) were assessed as least disturbed (Figure 13).

Of the perennial 2040.39 km of perennial lotic waters in the Northern Glaciated Plains, 964.35 (47%) km were assessed during the physical habitat assessment. Based on the physical stressor threshold values developed for the Northern Glaciated Plains ecoregion (Table 14), it is estimated that 539.84 km (56%) of streams in the Northern Glaciated Plains ecoregion are in the least disturbed condition, 143.06 km (15%) are moderately disturbed and 281.45 km (29%) are most disturbed with regard to the available cover stressor (Figure 14). It is also estimated that 454.06 km (47%) of streams are in least disturbed condition, 78.22 km (8%) are moderately disturbed and 432.07 km (45%) are most disturbed with regard to the relative bed stability stressor (Figure 14). The greatest percentage of streams in the Northern Glaciated Plains ecoregion were assessed as most disturbed for the riparian disturbance stressor. Riparian disturbance was estimated to be in the most disturbed condition for 800.37 km (83%) of streams, while 112.46 km (12%) of streams were assessed as moderately disturbed and 51.52 km (5%) were assessed as least disturbed (Figure 14).

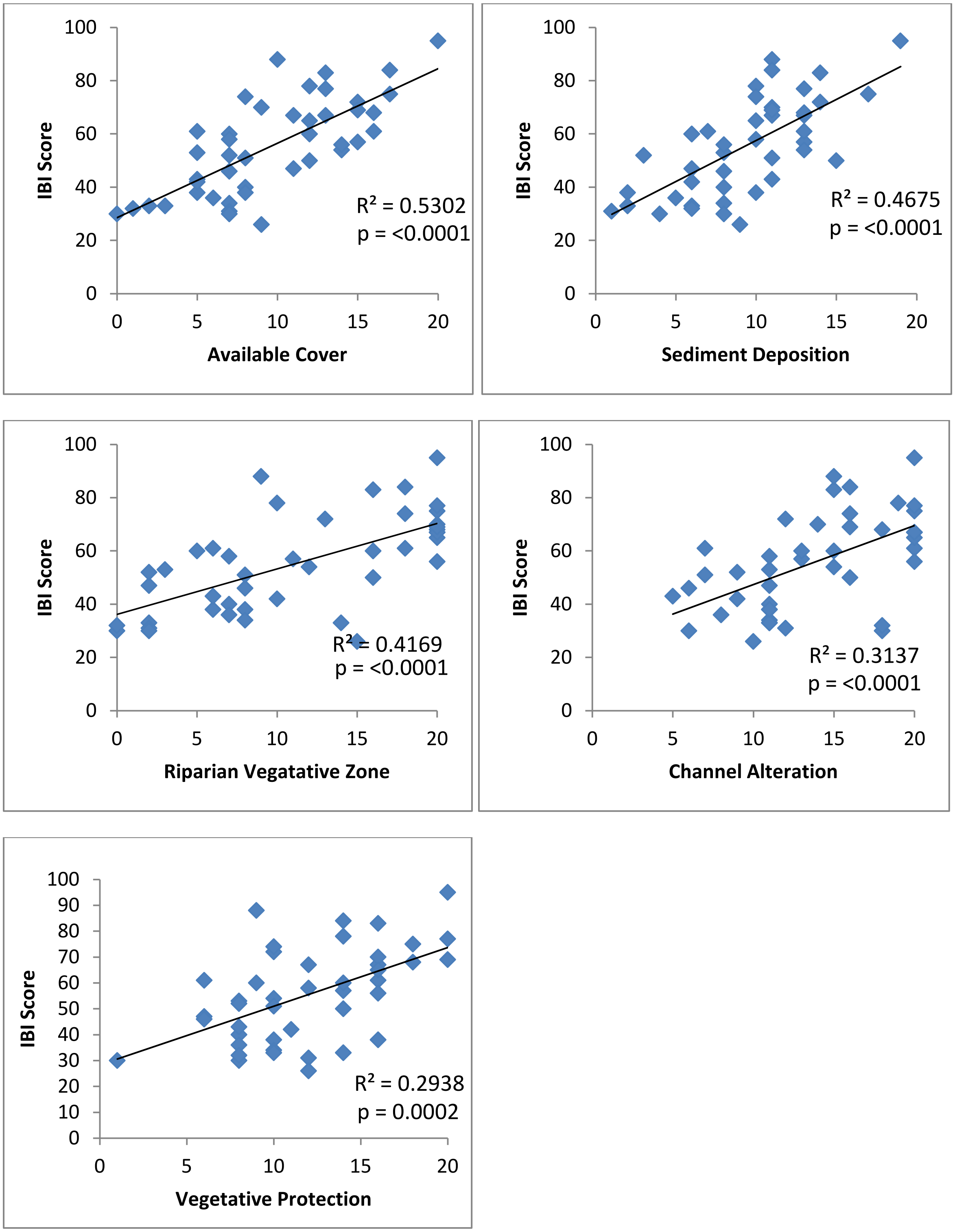

Figure 11. Linear Regressions of Macroinvertebrate IBI Scores and Rapid Bioassessment Protocol (RBP) Parameters in the Lake Agassiz Plain Ecoregion.

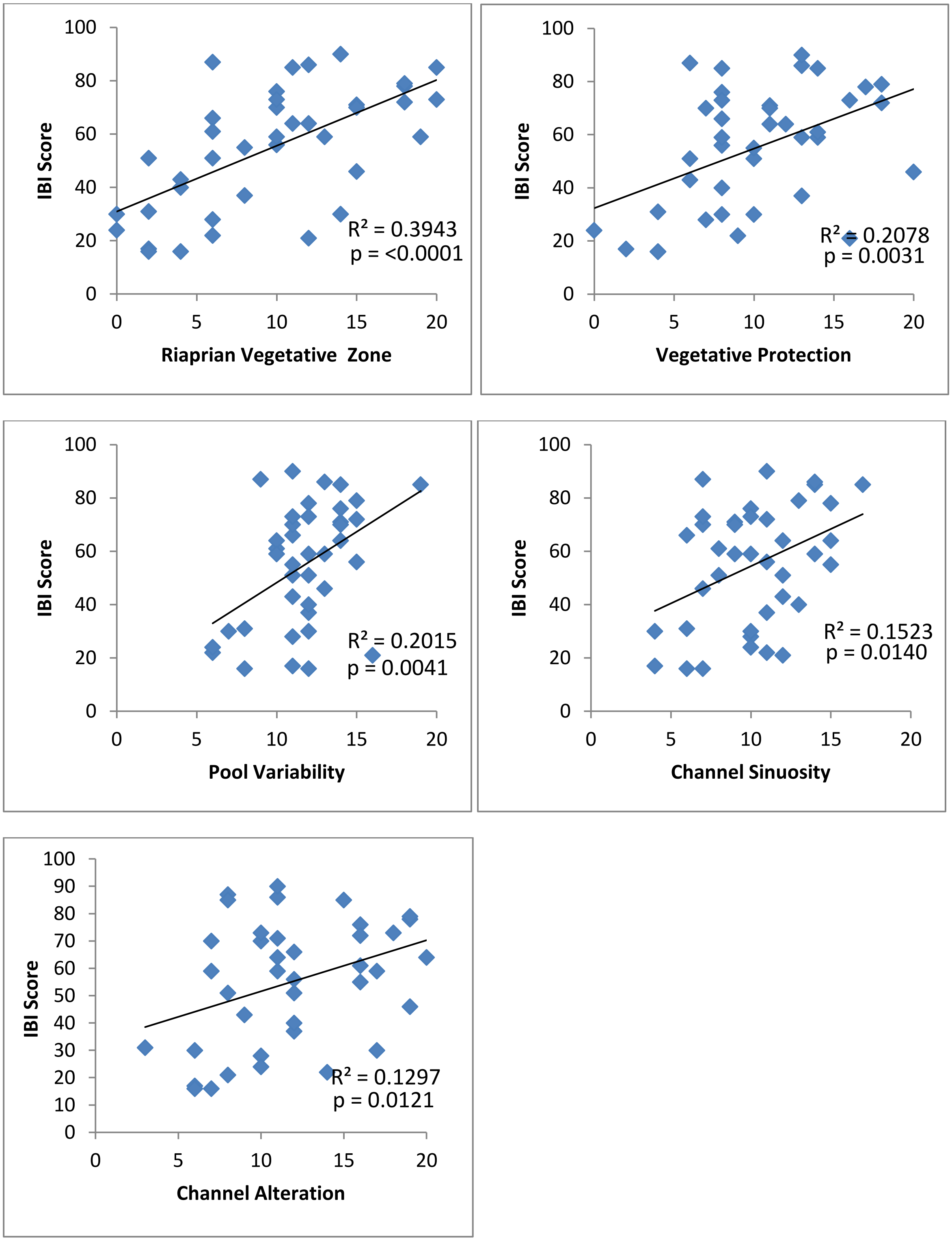

Figure 12. Linear Regressions of Macroinvertebrate IBI Scores and Rapid Bioassessment Protocol (RBP) Parameters in the Northern Glaciated Plains Ecoregion.

Table 13. Threshold Values Used to Determine Condition Class for Three Physical Stressors in the Lake Agassiz Plain Ecoregion.

Physical Stressor	Most Disturbed	Moderately Disturbed	Least Disturbed
Riparian Disturbance	5th Percentile or < 2.08	$\geq$ 2.08 and $\leq$ 2.45	25th Percentile or > 2.45
Relative Bed Stability	5th Percentile or <1.30	$\geq$ 1.30 and $\leq$ 2.53	50th Percentile or > 2.53
Available Cover	5th Percentile or < 1.26	$\geq$ 1.26 and $\leq$ 1.6	25th Percentile or > 1.6

Table 14. Threshold Values Used to Determine Condition Class for Three Physical Stressors in the Northern Glaciated Plains Ecoregion.

Physical Stressor	Most Disturbed	Moderately Disturbed	Least Disturbed
Riparian Disturbance	5th Percentile or < 1.98	$\geq$ 1.98 and $\leq$ 2.39	50th Percentile or > 2.39
Relative Bed Stability	10th Percentile or < 1.88	$\geq$ 1.88 and $\leq$ 2.15	50th Percentile or > 2.15
Available Cover	5th Percentile or < 1.31	$\geq$ 1.56 and $\leq$ 1.31	25th Percentile or > 1.56

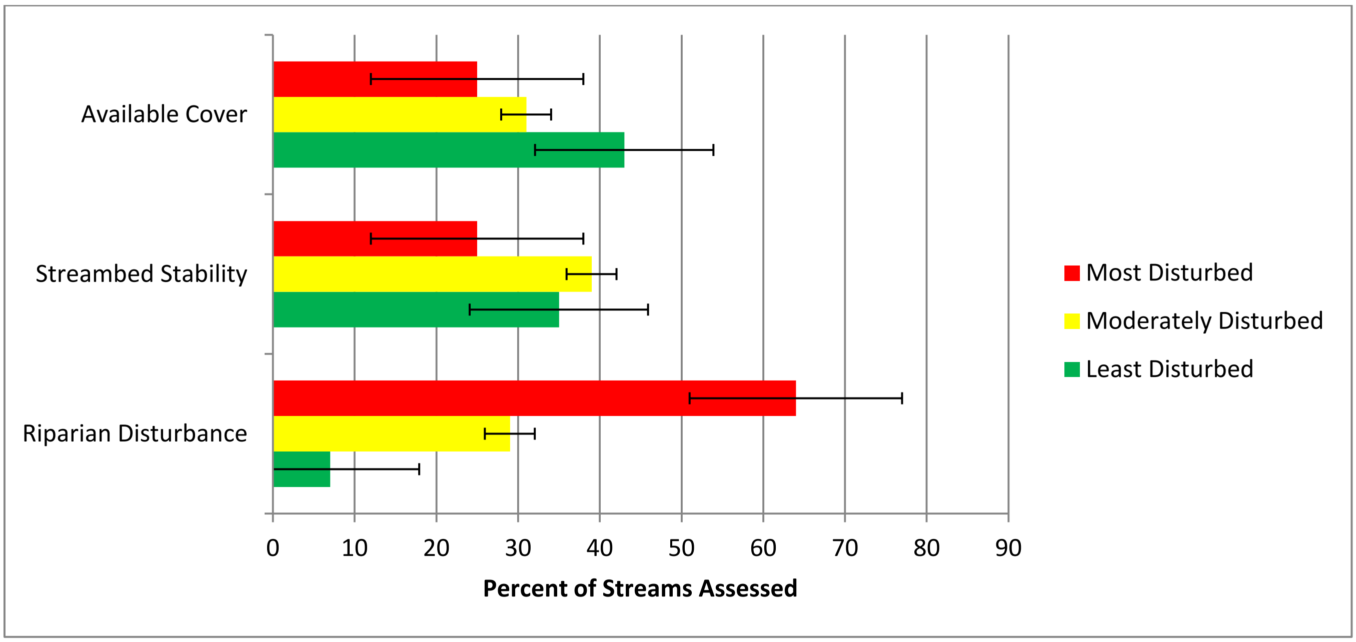

Figure 13. Stream Length in the Lake Agassiz Plain Ecoregion Considered to be Least Disturbed, Moderately Disturbed or Most Disturbed Based on Three Physical Stressors.

For the Red River basin in North Dakota as a whole, where 1720.08 km were assessed for physical habitat stressors, 868.11 km (50%) of streams are considered to be in least disturbed condition, 380.53 km (22%) are moderately disturbed and 471.45 km (27%) are most disturbed with regards to available cover. The relative bed stability analysis revealed 722.16 km (42%) of streams are in least disturbed condition, 374.1 km (22%) are moderately disturbed and 623.83 km (36%) are considered most disturbed. Riparian disturbance revealed 103.04 km (6%) of streams and rivers in least disturbed condition, 332.98 km (19%) as moderately disturbed and 1284.07 km (75%) assessed as most disturbed (Figure 15).

Table 15. Physical Habitat Parameters Including Bank and Channel Measurements.

Bank Measurements	Stream Channel Measurements
Bank Angle	Bar Width
Bankfull Height	Canopy
Bankfull Width	Embeddedness
Channel Type	Riparian Buffer Distance
Incised Height	Substrate Size
Undercut Bank	Water Depth
Wetted Width	

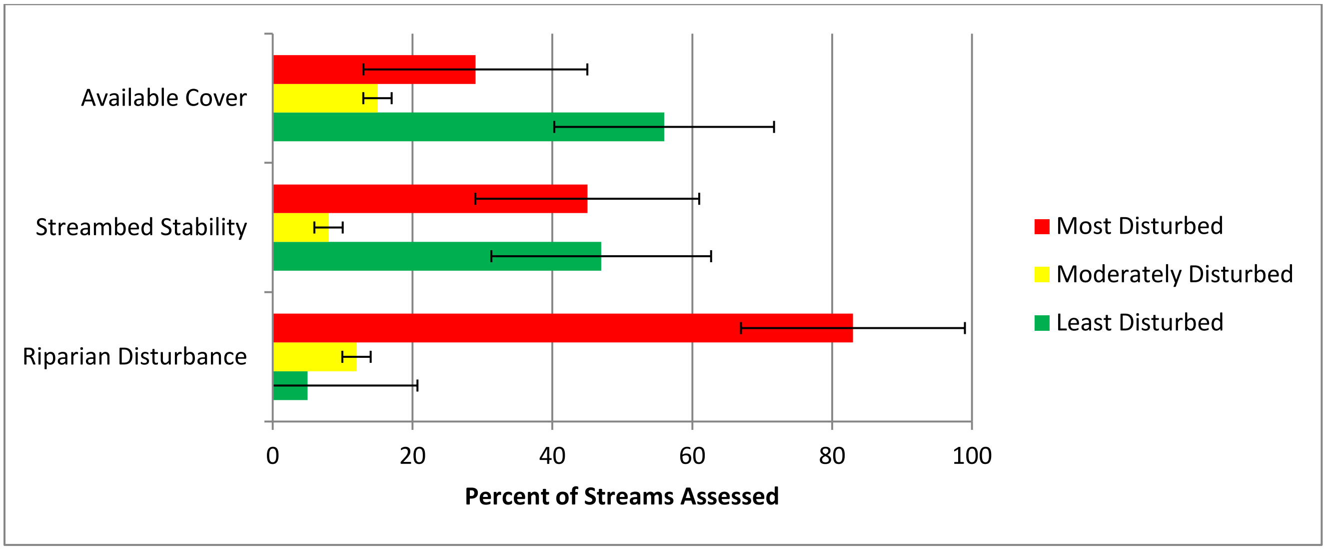

Figure 14. Stream Length in the Northern Glaciated Plains Ecoregion Considered Least Disturbed, Moderately Disturbed or Most Disturbed Based on Three Physical Stressors.

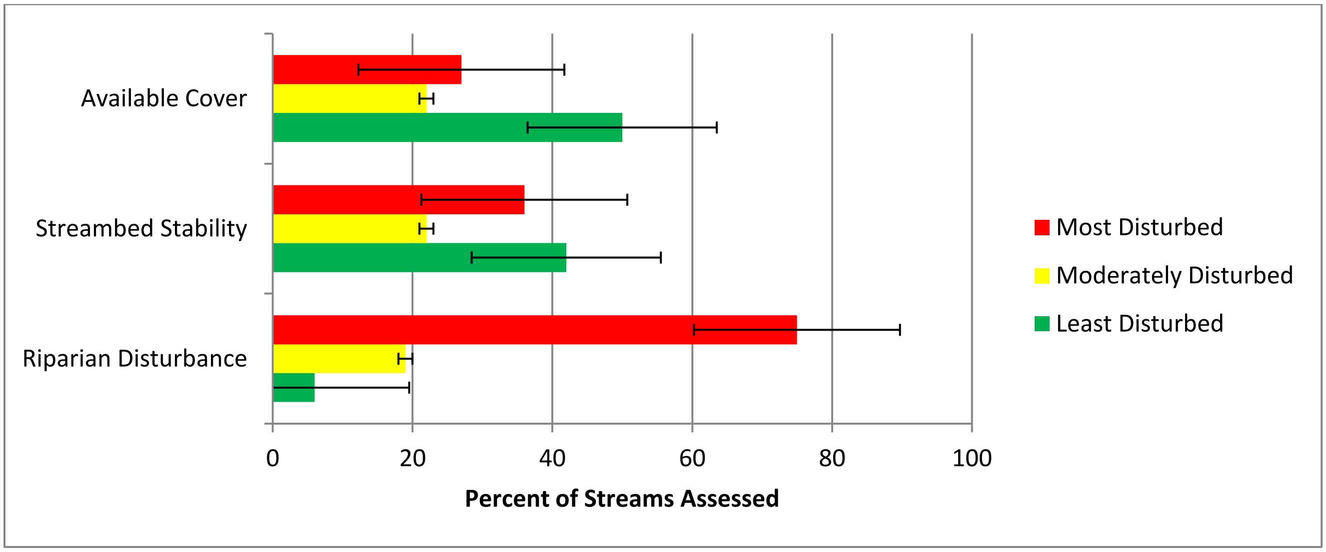

Figure 15. Stream Length in the Red River Basin in North Dakota Considered Least Disturbed, Moderately Disturbed and Most Disturbed Based on Three Physical Stressors.

Summary

The data used for this assessment and presented in this report were collected in 2005-2007. A total of 149 site visits took place which included 99 targeted reference and disturbed sites and 50 randomly selected sites (25 in the Lake Agassiz Plain ecoregion and 25 in the Northern Glaciated Plains ecoregion). Sampling efforts were conducted by North Dakota Department of Health (NDDoH) staff and United States Geological Survey (USGS) staff with the goal of providing unbiased estimates of ecological condition within the Red River basin in North Dakota. Targeted "reference" and "disturbed" site data were used to develop/refine indices of biotic integrity and to derive appropriate biological condition scoring threshold values which were then used to assess the random (probability) site data.

The chemical and physical habitat stressors used in this assessment were chosen based on their relevance in the EMAP Western Pilot project (Stoddard et. al 2005). When compared to results reported for the EMAP Western Pilot project, results reported for this study are comparable for most indicators and stressors (Table 16). It should be noted that there are subtle differences in how the biological indicators and stressors were calculated between this study and the EMAP Western Pilot project which may explain some of the differences between the two studies. It is also important to point out these indexes are in the early stages of development, at the state level, and refinement will be necessary in the future, but were successfully employed for this assessment.

The Red River basin in North Dakota contains an estimated 4855.07 km of perennial lotic waters. Of these, 2548.52 km (52%) were assessed for chemical stressors, 1720.08 km (35%) were assessed using physical habitat stressors, 1792.78 km (37%) were assessed using the macroinvertebrate indicator and 755.73 km (16%) were assessed using the fish indicator.

Biological indicators had a tendency to provide higher estimates of most disturbed condition. Based on the macroinvertebrate indicator, 543.46 km (30%) are least disturbed, 410.66 km (23%) are moderately disturbed and 838.66 km (47%) are considered to be in most disturbed condition (Figure 6). The fish indicator reveals that 297.63 km (39%) are least disturbed in the Lake Agassiz Plain ecoregion, 178.41km (24%) are moderately disturbed and 279.69 km (37%) are in most disturbed condition (Figure 7).

Throughout the Red River basin in North Dakota, 682.23 km (27%) are least disturbed, 877.77 km (34%) are moderately disturbed and 936.99 km (37%) are most disturbed with regard to the chemical stressor, total phosphorus. With regard to total nitrogen, 919.59 km (36%) are least disturbed, 1035.42 km (41%) are moderately disturbed and 541.99 km (21%) are in the most disturbed condition. According to the specific conductance indicator, 601.07 km (24%) are least disturbed, 1043.66 km (41%) are moderately disturbed and 903.79 km (35%) are in the most disturbed condition (Figure 10) in the Red River basin of North Dakota.

The physical habitat assessment revealed that 868.11 km (50%) of streams are in least disturbed condition, 380.53 km (22%) are moderately disturbed and 471.45 km (27%) are most disturbed with regard to available cover. The relative bed stability analysis revealed 722.16 km (42%) of streams are in least disturbed condition, 374.1 km (22%) are moderately disturbed and 623.83 km (36%) are considered most disturbed. Riparian disturbance revealed 103.04 km (6%) of streams and rivers are in least disturbed condition, 332.98 km (19%) are moderately disturbed and 1284.07 km (75%) are considered most disturbed (Figure 15).

Based on the Rapid Bioassessment Protocol (RBP) data, the greatest stressors to aquatic health in the Red River basin were assessed as riparian vegetative zone distance, vegetative protection and channel alteration. Each of these stressors has a strong correlation with IBI scores in both the Lake Agassiz Plain and Northern Glaciated Plains ecoregions. Continued data analysis will develop/refine physical habitat metrics based on these stressors.

Table 16. Most Disturbed Condition Class Estimates Based on Results from EMAP-West Wide, EMAP-West Plains Region and Red River basin in North Dakota.

Region	Fish	Macroinvertebrates	Riparian Disturbance	Relative Bed Stability	Available Cover	Total N	Total P	Conductivity
EMAP-West Wide	45%	27%	47%	26%	17%	15%	15%	6%
EMAP-West Plains Region	50%	42%	62%	40%	38%	38%	23%	27%
Red River Basin	37%	47%	75%	36%	27%	20%	32%	41%

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Appendix A

Targeted Site Selection

STANDARD OPERATING PROCEDURE
FOR THE SELECTION OF REFERENCE AND DISTURBED
SITES FOR BIOLOGICAL MONITORING IN NORTH DAKOTA

Summary

The North Dakota Department of Health (NDDH) utilizes reference (least impaired) and disturbed (most impaired) physical conditions to provide an estimate of natural and human induced variability in biological community structure and in stream habitat quality. Sites are also used to develop threshold values and compile Indices of Biological Integrity (IBI). When selecting reference or disturbed conditions the NDDH Surface Water Quality Management Program (SWQMP) must account for natural and climatic variability across the state of North Dakota. To account for environmental variability in North Dakota, the state's total land area was separated four regions by US Geological Survey Level III Ecoregions and each area was evaluated individually.

The first step in site selection involves a remote sensing component which utilizes an ESRI ArcView Geographic Information System (GIS), ArcView extensions and various GIS data layers. The Analytical Tool Interface for Landscape Assessments (ATtILA) extension allows users to calculate many common landscape metrics including: landscape characteristics, riparian characteristics, human stressors and physical characteristics. Grouped metrics are used to estimate anthropogenic stressors in a 1000 meter (m) circular buffer around distinct sampling points located on perennial flowing waters of the state. Ultimately a final site score is calculated based on the varying metric scores in the buffer. The most disturbed points are classified with the highest scores while the least disturbed points receive the lowest scores. The highest scoring disturbed sites and lowest scoring reference sites then move to the second evaluation step.

The second screening step is to evaluate each site individually by using additional GIS layers. Sites are plotted and examined for landscape attributes which may result in the site not being suitable for sample collection (e.g. water was too deep). Layers used in screening step two include but are not limited to: roads; aerial photos; public and private land ownership; township, range and section grids; county boundaries; and dam structures. The remaining viable sampling locations are then evaluated with another level of screening.

The third screening step involves site reconnaissance, also known as 'ground truthing'. During this step, SWQMP personnel visit sites to evaluate reference or disturbed site criteria. Evaluation of the stream is done using best professional judgment. Some important features to consider while 'ground truthing' are stream geomorphology, stream habitat alterations (e.g. dams, rip-rap), land use in or adjacent to the riparian zone, and other human influences at or near site locations.

Software and Data Layers/Sources

___ ArcView 3.X (ArcView version 3.2a or higher recommended)

Extensions:

___ ArcView 3.X Spatial Analyst Extension

___ Analytical Tool Interface for Landscape Assessments (ATtILA2004v1.0) Extension (EPA)

___ Buffer Theme Builder Extension

___ Display Points Lat/Long Extension

___ Divided line by adding points evenly Extension

___ Grid & Theme Projector version 2 Extension

___ XTools Extension (9/15/03)

Datasets and Layers:

___ Ecoregion GIS Layer (USGS)

___ National Agriculture Imagery Program (NAIP) 2005 Aerial Photography (NRCS) <u>or</u> Digital Orthophoto Quarter Quadrangles (DOQQ) (USGS)

___ National Elevation Dataset (NED) (USGS)

___ National Hydrography Dataset (NHD) (USGS)

___ National Land Cover Data (NLCD) (USGS)

___ North Dakota Public Land Ownership Layer

___ State and County Roads GIS Layer (North Dakota GIS Hub)

___ Township, Range and Section Grid

Procedures

Step 1: Remote Sensing

1. Create a new ArcView 3.X GIS project. Set the map coordinate system to *Universal Transverse Mercator* (UTM) zone 14N (North). Set map coordinate units to decimal degrees. Set map distance units to meters.

2. Select stream reaches in the NHD shapefile that fall inside the target watershed or study area. Create a new shapefile with the selected features. Perennial streams should be selected using the following F_CODEs in the NHD attribute table: 33400, 33600, 46003, 46006, and 55800.

3. Use the *Divide Line by Adding Points Evenly* extension to add points along the NHD shapefile features at intervals of 2000 meters.

4. Make sure the map coordinate system is set to UTM zone 14N. Next use the *Display Points Lat & Long Extension* to add Latitude and Longitude coordinates for each point to the shapefile's attribute table.

5. Use the *Buffer Theme Builder*'s "Create Buffer Theme" button to produce a shapefile of 1000 meter buffers around each potential sampling site in the point shapefile created in step 3.

6. Create a slope grid in percent from a statewide NED grid. Use the map calculator in spatial analyst and the function *[grid].slope (zFactor, percentRise)* to derive slopes where *zFactor* is the conversion factor if x, y, and z are in different units and *percentRise* equals true for percent slope and false for degree slope.

7. With the new Buffer Theme selected as the reporting unit, select and calculate the desired metrics in each of the four groups: landscape characteristics, riparian characteristics, human stressors and physical characteristics. Metric scores result from the evaluation of the NLCD grid, a roads layer, precipitation, and population density. Metrics should be chosen for their sensitivity. The most sensitive metrics will have the most variability in scores and will make site characteristic differentiation simpler.

8. Once the most sensitive metrics are chosen, use ATtILA to calculate an index score for each assessment unit. Scores are based on a summation of quantile rankings. The number of quantiles is user-defined.

9. Select the assessment units with the lowest and highest index scores, which are a measure of human disturbance. Lowest scores will be the least disturbed reference assessment units or "best available" sites in the study population and the highest scores will be the most disturbed sites.

Step 2: Digital Media Screening

10. Use aerial photography, GIS layers and best professional judgment to evaluate land uses within the selected assessment units. This screening step is mainly used to exclude best available sites with obvious landuse and waterbody characteristics that may disrupt or prohibit sample collection.

Characteristics of Concern

Reference Sites

- Animal feeding operations near the waterbody

- Heavily grazed or degraded riparian area

- Debris or trash in the water body riparian area

- Stream banks with large areas of mass wasting

Reference and Disturbed Sites

- Areas with significant human alteration (e.g. concrete channels)

- Dam structures creating deep pools

GIS Layers used:

- National Agriculture Imagery Program (NAIP) 2005 Aerial Photography (NRCS) or Digital Orthophoto Quarter Quadrangles (DOQQ) (USGS)

- Federal and State Highways, County Roads and Township Roads

- Designated Public Lands and Township, Range, and Sections Grids

- Dam Structures Point Features

Step 3: Landowner Verification and Site Visitation

11. Before a site visit is scheduled, it is advisable to research the identity of the person(s) or group(s) that own land adjacent to or around a potential monitoring location. The inquiry into the property ownership may prove more useful than waiting to contact local residents during an initial site visit and reduce the time expended to obtain permission to access the site. If the land is determined to be held publicly, an effort should be made to contact any and all renters (e.g., producers renting North Dakota State Land Department School Sections).

12. Once permission to access a site is obtained, a site visit should be scheduled. When first arriving at a site it is important to observe any property ownership signage or placards

declaring “No Trespassing” or that hazardous conditions are present. If permission to access has been granted, proceed to the site coordinates.

13. Upon reaching the site coordinates, begin to verify the Level 2 assessment screening of GIS layers and aerial photography. Characteristics of the site location that should be examined include but are not limited to; landuse(s) in and around the stream, stream geomorphology, water depth and obstructions to the flow of water. The site investigator should keep a log of notes pertaining to site characteristics and comment on any features present in aerial photos, county maps, or landowner atlases that could be used during future sampling visits.

    A useful tool for examining stream conditions is the Rapid Geomorphic Assessment (RGA) which was developed by the United States Department of Agriculture. The RGA method classifies stream channel stability and the habitat quality of riparian areas and may be used calculate a general stream and habitat score to classify potential Reference and Disturbed sampling locations. The RGA form and instructions for its completion can be found on the following pages.

RAPID GEOMORPHIC ASSESSMENT (RGA) FORM CHANNEL STABILITY & HABITAT RANKING SCHEME

Station Name: ____

Station Description: ____

Date: _________ Time: ______ Slope: _______% Pattern: meander/ straight/ braided

Crew: ______________________ Pictures (circle): u/s, d/s, x-sec, LB, RB

1. Primary bed material

Bedrock	Boulder/Cobble	Gravel	Sand	Silt/Clay
0	1	2	3	4

2. Bed/bank protection

Yes	No	(with)	1 bank	2 banks
0	1		2	3

3. Degree of incision (relative elev. of "normal" low water if floodplain/terrace is 100%)

0-10%	11-25%	26-50%	51-75%	76-100%
4	3	2	1	0

4. Degree of constriction (relative decrease in top-bank width from up to downstream)

0-10%	11-25%	26-50%	51-75%	76-100%
0	1	2	3	4

5. Streambank erosion (dominant process each bank)

	None	Fluvial	Mass Wasting (failures)
Inside or left	0	1	2
Outside or right	0	1	2

6. Streambank instability (percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	0	0.5	1	1.5	2
Outside or right	0	0.5	1	1.5	2

7. Established riparian vegetative cover (woody or stabilizing perennial grasses each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	2	1.5	1	0.5	0
Outside or right	2	1.5	1	0.5	0

8. Occurrence of bank accretion (percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	2	1.5	1	0.5	0
Outside or right	2	1.5	1	0.5	0

9. Sum of All Values ☐

<u>Instructions for Completion of a Rapid Geomorphic Assessment Form</u>

Define a representative reach 6-20 channel widths long.

1. Primary bed material

Bedrock — The parent material that underlies all other material. In some cases this becomes exposed at the surface. Bedrock can be identified as large slabs of rock, parts of which may be covered by other surficial material.

Boulder/Cobble — All rocks greater than 64 mm median diameter.

Gravel — All particles with a median diameter between 64.0 — 2.00 mm

Sand — All Particles with a median diameter between 2.00 — 0.063 mm

Silt-Clay — All fine particles with a median diameter of less than 0.063 mm

2. Bed/bank protection

Yes — Mark if the channel bed is artificially protected, such as rip rap or concrete.

No — Mark if the channel bed is not artificially protected and is composed of natural material.

Protection

1 Bank — Mark if one bank is artificially protected, such as with rip rap or concrete.

2 Banks — Mark if two banks are artificially protected.

3. Degree of incision (Relative elevation of “normal” low water; floodplain/terrace @ 100%)

Calculated by measuring water depth at deepest point across channel, divided by bank height from bank top to bank base (where slope breaks to become channel bed). This ratio is given as a percentage and the appropriate category marked.

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

Often found where obstructions or artificial protection are present within the channel. Taking the reach length into consideration, channel width at the upstream and downstream parts of the reach is measured and the relative difference calculated.

5. Stream bank erosion (Each bank)

The dominant form of bank erosion is marked separately for each bank, left and right, facing in a downstream direction.

If the reach is a meandering reach, the banks are viewed in terms of ‘Inside, Outside’ as opposed to ‘Left, Right’ (appropriate for questions *5-8).* Inside bank, being the inner bank of the meander, if the stream bends to the left as you face downstream, this would be the left bank. Outside bank, being the outer bank, on your right as you face downstream in a stream meandering left.

None	No erosion
Fluvial	Fluvial processes, such as undercutting of the bank toe, cause erosion.
Mass Wasting	Mass movement of large amounts of material from the bank is the method of bank erosion. Mass Wasting is characterized by high, steep banks with shear bank faces. Debris at the bank toe appears to have fallen from higher up in the bank face. Includes, rotational slip failures and block failures.

6. Stream bank instability (Percent of each bank failing)

If the bank exhibits mass wasting, mark percentage of bank with failures over the length of the reach. If more than 50% failures are marked, the dominant process is mass wasting (see question *5).*

7. Established riparian woody-vegetative cover (Each bank)

Riparian woody-vegetative cover represents most permanent vegetation that grows on the stream banks. Distinguished by its woody stem, this includes trees and bushes but does not include grasses. Grasses grow and die annually with the summer and thus do not provide any form of bank protection during winter months whilst permanent vegetation does.

8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)

The percentage of the reach length with fluvial deposition of material (often sand, also includes fines and gravels) is marked.

9. Sum of All Values

Sum all category values for question one through eight. Lower aggregate scores indicate more stable geomorphology and improved habitat. Higher scores indicate unstable geomorphology and decreased habitat.