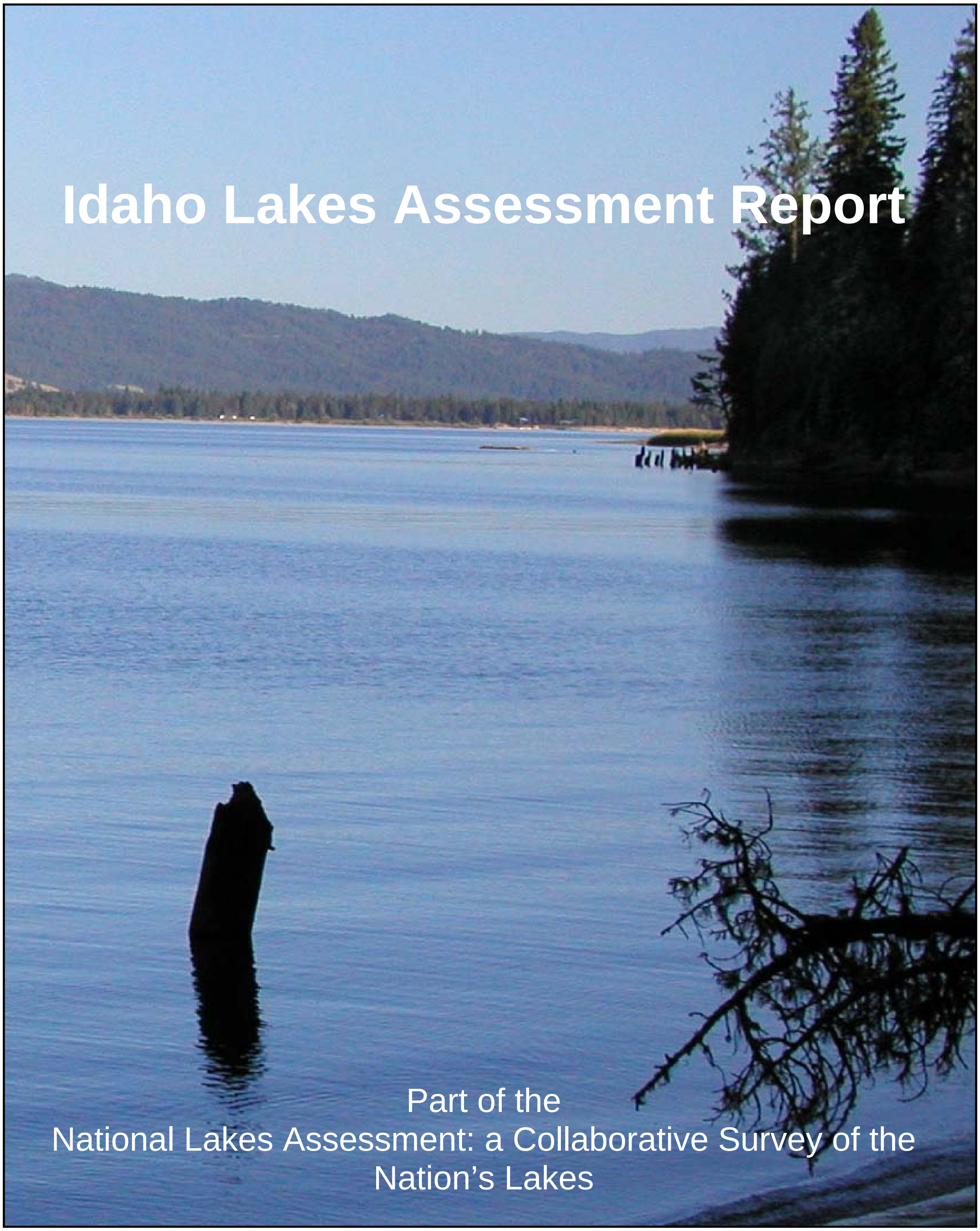
Idaho Lakes Assessment Report



Part of the
National Lakes Assessment: a Collaborative Survey of the Nation's Lakes

Idaho Department of Environmental Quality
December 2010

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Prepared by
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December 2010

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Summary

The Clean Water Act directs the U.S. Environmental Protection Agency (EPA) and States to develop programs that evaluate, restore, and maintain the chemical, physical, and biological integrity of the Nation's waters (33 U.S.C. §§ 1251-1387). Questions have long been asked of EPA regarding the condition of the waters in the U.S. and if that condition is improving or not. EPA has historically relied upon the various states to help answer that question. However, the states’ methodologies have been varied and difficult to compile. Therefore, EPA has begun the major effort of designing, funding, and implementing a national reconnaissance effort to determine the overall condition of the nation’s waters.

The National Lakes Assessment (NLA) Survey is a collaborative effort among EPA, states, tribes, the USGS, and other partners to evaluate the overall condition of the nation’s lakes and reservoirs. The NLA is one in a series of national studies that are funded by EPA with the purpose of helping to inform Congress of the condition of the nation’s waters. The NLA addresses two key questions: 1) to what degree are the Nation’s lakes in good, fair, or poor condition and 2) what is the relative importance of the different stressors evaluated in the NLA? This report will focus on the overall estimated condition of lakes and reservoirs within the State of Idaho as monitored during the NLA in 2007. Data and analysis provided in this report describe the chemical, biological, and physical condition of the State’s resources.

One aspect of this study is the use of probability-based survey designs similar to the type of survey designs used in election polling. In these probabilistic surveys, monitoring sites are chosen according to a random sampling design, in which each site has a known probability of being selected for sampling, and as a group the sites statistically represent the population of waters in the region. This probability-based design applies the statistical rigor of sample surveys to the science of environmental assessment (Diaz-Ramos et al. 1996). Of the 437 lakes in Idaho, 198 were determined to be outside of the target population parameters while 239 were target lakes. In Idaho there are estimated to be 239 lakes 10 hectares or larger that meet the target criteria. This corresponds to approximately 172,504 hectares of open water. Of the total number of lakes in Idaho, twenty-nine lakes were monitored. Nineteen of these lakes were part of the national survey and an additional 10 lakes were added so that an assessment of Idaho’s lakes with strong confidence intervals could be accomplished.

For the purposes of the NLA, two separate methods for determining reference condition were used; one to evaluate biological data and a separate method for evaluating chemical data. Ten chemical and physical measures of geography, geology, and morphology were used to evaluate reference potential. These parameters were total nitrogen, total phosphorus, chloride, sulfate, turbidity, dissolved oxygen in the euphotic zone, acid neutralizing capacity, shoreline disturbance by agriculture, shoreline disturbance by non–agriculture, and the intensity and extent of shoreline disturbance. If the screening value for any one of these parameters was exceeded at a site, it was dropped from consideration as a reference site. The national values for reference condition were used throughout because the total number of sites monitored in Idaho is too small to partition some sites out as reference and still have enough sites left to determine overall condition of lakes in the state.

The monitoring at each site was done in accordance with the methods outlined in the field operations manual (EPA 2007). At an index site, depth-integrated water samples were collected to be analyzed for chemical parameters, algal toxins, chlorophyll-a and phytoplankton. Also, *in situ* temperature, pH, conductivity and dissolved oxygen were recorded, using a multi-parameter probe. The depth of the station was recorded as well as a measurement of the Secchi disk transparency (Secchi depth). A Wisconsin net was used for plankton sample collection and a sediment core sample was collected for analysis of the diatom community. Once all the parameters were collected at the index site, the crew moved to collecting biological and physical parameters along the shore line. The shoreline was divided into 10 roughly equal intervals and 10 sampling stations were located at the shoreline. At each of these stations, physical habitat parameters along the shore, within the littoral zone, and in the riparian zone were evaluated. A benthic macroinvertebrate sample was collected within the littoral zone at each transect and all 10 of these were composited to create a single benthic macroinvertebrate sample for the lake. At the last transect sampled, a fecal indicator (Enterococci) sample was collected.

Condition ratings were developed for the chemical, physical, and biological data collected. These condition ratings classified a lake as being in good, fair, or poor condition for each parameter based upon its comparison to reference conditions for the ecoregion or nutrient region the lake resides in. Condition ratings are used as a way to analyze the overall status of the state's lakes. Lakes with parameter values greater than the 25th percentile of the reference lake distribution were considered to be in good condition, lakes with less than the 25th percentile of the reference lake distribution but greater than the 5th percentile were considered fair, and lakes with values less than the 5th percentile of the reference lake condition were considered to be in poor condition (EPA 2010).

To determine an overall condition rating for a site, the scores for each of the categorical indices were summed. The resulting dataset was then evaluated to determine the 25th and 75th percentiles. These percentile values were then used as the thresholds between the good/fair classifications and the fair/poor classifications.

The trophic state index is a way to evaluate the productivity of the water and was initially proposed by Carlsson (Carlsson 1977). The trophic state index was introduced as a simpler tool to describe the overall trophic state of a lake that incorporated the diverse aspects of trophic state found in more complex multi-parameter indices but had the simplicity of a single parameter index (Carlsson 1977). Carlsson's trophic state index focused primarily on the use of Secchi disk transparency as a surrogate for algal biomass. Carlsson's paper shows the inversely proportional relationship between Secchi disk transparency and chlorophyll-a. The majority (70.9%) of lakes and reservoirs in Idaho are oligotrophic. This means that the majority of lakes have low primary productivity with low algal production and clear water.

As reported here, lakes in the Xeric West ecoregion (one of Idaho's two ecoregions) tend to have higher values for total phosphorus, total nitrogen, and chlorophyll-a, and lower mean Secchi depths. There do not appear to be any significant differences in the distributions among the three scales analyzed here (state, regional, and national). In most cases, at least half the values in the distribution are greater than the recommended nutrient criteria.

Estimates for the various chemical parameters show that the majority of Idaho's lakes fall in the good and fair categories. Condition ratings base on chlorophyll-a indicated the highest number of lakes being in poor condition with 40% of the lakes in Idaho or approximately 64 lakes (Table 9) being rated as poor. Idaho scores generally are poorer than national scores for all the chemical parameters reported here. Nationally, less than 20% of lakes 10 hectares or greater have a poor condition rating for chemical parameters while in Idaho 20% to 40% of lakes 10 hectares or greater have poor chemical condition ratings. However, chemical condition ratings in Idaho are better than ratings for EPA Region 10 (Idaho has a smaller percentage in the poor classification) for all parameters except turbidity.

Generally, for shoreline disturbance, the majority of lakes on all three scales are in the fair condition. For littoral cover and complexity, the majority of lakes on all three scales are in good condition. For the riparian vegetation cover and complexity measure, national and regional lakes are mostly in good condition while Idaho lakes are in fair condition. For the littoral-riparian cover and complexity, again, most national and regional lakes are in good condition while Idaho lakes are more evenly spread out across all three classifications, the highest percentage being in poor condition. For three of the four physical habitat metrics, Idaho lakes have lower percentages in the good classification when compared to the regional and national scores. However, the percentage of Idaho lakes being classified in poor condition is relatively close to the national and regional scores.

Condition estimates for each parameter in each category were evaluated, scored, and combined as described in section 3.e. The results of these evaluations are shown in Figure 11 and Figure 12. Most Idaho lakes were classified good for chemistry and biology, and fair for physical habitat and overall condition. Nationally, most lakes were classified good for chemistry, and fair for biology, physical habitat, and overall condition. Regional results showed the same percentages of lakes being classified good and poor for chemistry and most lakes classified as fair for biology, physical habitat, and overall condition.

Idaho had 32% of lakes (51 lakes) classified as being in overall poor condition. Regionally, 28% of lakes were classified in overall poor condition and 19% nationally were in overall poor condition. The highest percentage (47%) of lakes in Idaho was classified as fair (75 lakes) while only 21% were classified as good (34 lakes).

The recommendation at this time would be to include the basic measures of chemistry (phosphorus, nitrogen, and chlorophyll-a), physical habitat measures (riparian and littoral community parameters measured at 10 transects around the lake, and Secchi depth measures) and biological measures (benthic macroinvertebrates and plankton). Other measures that should be collected at the index site, although not reported on here, include temperature, pH, conductivity, and dissolved oxygen profiles. Based on the recommendation in the Ambient Water Quality Criteria (EPA 1986) for freshwater, Escherichia Coli is a more appropriate indicator for pathogen pollution than Enterococci. Therefore, Escherichia Coli samples should be collected and analyzed in accordance with Idaho rule (IDAPA 58.01.02.251) to determine suitability for recreational uses.

Other recommendations made in this report are that lakes should be classified by size, maximum depth, retention time and ecoregion. Lake reference condition should be evaluated consistent with procedures developed for stream and river reference condition and include measures of land use, ecoregions, density of roads, mines, dams, point source discharges, and population within the watershed, and grazing activity at the site. It is also recommended that these measures be incorporated into a lake reference condition evaluation procedure to remain consistent with other water body assessment methodologies Also, to remain consistent with the goal of the ambient monitoring strategy a lake may be sampled only once per year.

Acknowledgements

Thanks go to Ana Gabica and Chris Hansen who diligently collected samples throughout the summer of 2007, to Jason Pappani the fearless coordinator who organized the collection effort, to Shannon Hubler of Oregon DEQ for help in analyzing data and supplying software to help in the analysis of data, to Lil Herger and Dave Peck for corralling and supplying all the data, and to Tony Olsen for all his help in understanding how to make the probabilistic design strategy work. Thanks also to Lisa Hansen for her editing expertise and to Michael McIntyre, Nicole Deinarowicz, Jason Pappani, and Don Essig for content review.

Ana Gabica

Chris Hansen

Jason Pappani

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1 Introduction

From Priest Lake in the north to Bear Lake in the south, Idaho is home to beautiful and productive lakes and reservoirs. These lakes and reservoirs support a wide variety of uses from fantastic trout and bass fisheries to power production to storing water to support the agricultural industry through drought years. However, increased human influence on Idaho's waterways has prompted significant interest in preserving or restoring water quality in the state's lakes and reservoirs. To truly understand the effects of this human influence on Idaho's waters data must be collected to adequately characterize these waters. In cooperation with the U.S. Environmental Protection Agency (EPA) and their goal to report on the condition of the nation's aquatic resources, Idaho DEQ participated in the National Lakes Assessment to help further our knowledge of these spectacular waters.

1.a Study Purpose

The National Lakes Assessment (NLA) Survey is a collaborative effort among EPA, states, tribes, the U.S. Geological Survey (USGS), and other partners to evaluate the overall condition of the nation's lakes and reservoirs. The NLA is one in a series of national studies that are funded by EPA with the purpose of helping to inform Congress of the condition of the nation's waters. The NLA addresses two key questions: 1) to what degree are the nation's lakes in good, fair, or poor condition and 2) what is the relative importance of the different stressors evaluated in the NLA?

This report will focus on the overall estimated condition of lakes and reservoirs within the State of Idaho as monitored during the NLA in 2007. Data and analysis provided in this report describe the biological, physical, and chemical condition of lakes and reservoirs in Idaho. For simplification, the rest of this report will use *lakes* to refer to both natural lakes and man-made reservoirs except when specifically identified as man-made or natural (section 4.d).

1.b Background

The Clean Water Act directs EPA and the states to develop programs that evaluate, restore, and maintain the chemical, physical, and biological integrity of the nation's waters (33 U.S.C. §§ 1251-1387). State agencies are conducting biological assessments in the Northwest to provide the information necessary to develop biological criteria. Biological criteria can complement existing physical and chemical water quality criteria and provide a better understanding of and more protection for the nation's aquatic resources.

The NLA Survey is designed as part of a larger overall effort to monitor and assess the overall condition of the nation's waters. Questions have long been asked of EPA regarding the condition of the waters of the U.S. and if that condition is improving or not. EPA has historically relied upon the various states to help answer that question. However, the states' methodologies have been varied and difficult to compile. Therefore, EPA has begun the major effort of designing, funding, and implementing a national reconnaissance effort to determine the overall condition of the nation's waters. The analysis procedures used in this study were taken from the national effort and do not necessarily reflect the current ambient monitoring protocols or procedures of the State of Idaho. Recommendations regarding accepting protocols for use in Idaho's ambient monitoring program are given in section 5.

Because this is such a massive effort the waters have been categorized and broken into various groups. Those categories include lakes and reservoirs, rivers and streams, wetlands, and estuaries and coastal waters. Each year, waters in one of these categories are monitored and assessed.

2 Methods

2.a Probability Design

One aspect of this study is the use of probability-based survey designs similar to the type of survey designs used in election polling. In these probabilistic surveys, monitoring sites are chosen according to a random sampling design, in which each site has a known probability of being selected for sampling, and as a group the sites statistically represent the population of waters in the region. This probability-based design applies the statistical rigor of sample surveys to the science of environmental assessment (Diaz-Ramos et al. 1996). Throughout this report, sites chosen by the probability design process are referred to as random sites since they are selected at random and will statistically represent the population as a whole. This report's References section contains bibliographic information for several additional sources of information about probability-based design (Olsen et al. 1999; Stevens, D. L., Jr. 1997; Stevens, D. L., Jr. and Urquhart 2000).

The sample frame is the representation (maps) considered to represent the target population (lakes). The target population is defined as lakes with a surface area greater than 4 hectares (ha), depth greater than 0.3 meters, and open water more than 1 hectare. In this case sites were selected from the 1:100,000 scale National Hydrography Dataset (NHD) and evaluated to determine if they fell within the target population. If a site selected from the sample frame (the NHD) did not meet the target criteria it was eliminated from the sample draw as a non-target site. If a site selected from the sample frame met the criteria it was considered part of the target population. Some lakes that were target sites still were not sampled due to inaccessibility or landowner denial of access rights. These lakes are still considered part of the target population and are labeled Target – Not Sampled.

Figure 1 illustrates how the sample frame, target population, and inference population are related. Within the target population, 33% of the lakes were deemed inaccessible leaving only 67% of the target population that we can make inferences about regarding their overall condition. This target sampled population is the inferred population and the results from this study apply to that population of lakes within Idaho. During analysis of the overall condition estimates it was determined that one lake representative of the size class between 4 and 10 hectares was influencing to an overwhelming degree the overall condition estimates for the entire dataset. It was decided to exclude all lakes in this size class from the results reported in the main body of this report so that a more consistent reporting of lake and reservoir condition could be made. Appendix A of this report details the condition ratings determined when including lakes in this 4 to 10 hectare size class.

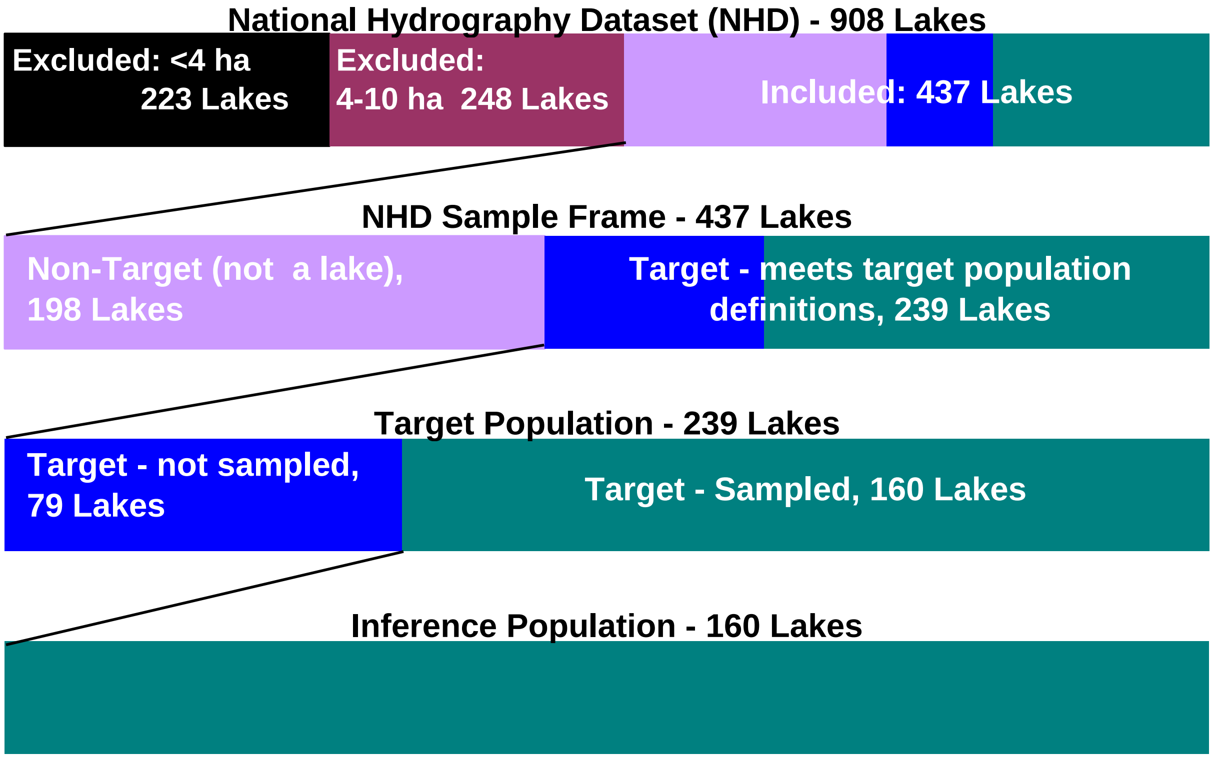

Figure 1. Sample frame, target population, and inference population sizes for lakes in Idaho. Adapted from the National Lakes Report (EPA 2009a)

2.b Reference Condition

When assessing biological, chemical, and physical condition of water bodies it is important to determine what the ideal condition of that water body should be. This is called reference condition. There are some water bodies that have not been impacted by human influence. These water bodies are identified as reference condition water bodies. Often, however, there are no water bodies that are completely free from human influence. In this case, those water bodies that have the least amount of human interference are identified and used as the standard by which other water bodies will be assessed.

For the purposes of the NLA, two separate methods for determining reference condition were used, one for evaluating biological data and a separate method for evaluating chemical data. Ten chemical and physical measures of geography, geology, and morphology were used to evaluate a site for its reference potential. These parameters were total nitrogen, total phosphorus, chloride, sulfate, turbidity, dissolved oxygen in the euphotic zone, acid neutralizing capacity, measures of shoreline disturbance including disturbance due to agriculture, disturbance by non-agricultural activities, intensity of disturbance, and extent of disturbance. If the screening value for any one of these parameters was exceeded at a site, it was dropped from consideration as a reference site. This screening of potential reference sites was done at a national scale and values from this national effort were used in the state report. The national values were used throughout because the total number of sites monitored in Idaho is too small to partition some sites out as reference and still have enough sites left to determine overall condition of lakes in the state.

As explained above, reference condition for biological data relied on measures of total phosphorus and total nitrogen. Since using those parameters to determine reference condition for chemical data would produce a circularity of reasoning that assessors try to avoid, other parameters were used to determine reference condition for nutrients. These parameters were chloride, sulfate, and the measures of shoreline disturbance including disturbance due to agriculture, disturbance by non-agricultural activities, intensity of disturbance, and extent of disturbance. Other measures included were in-field assessment of agricultural, residential, and industrial land use. Similar to the determination of biological reference condition, if any one of the selection screening criteria was exceeded in a lake, it was dropped from consideration as a reference lake. In the Western Forested Mountains ecoregion (which makes up approximately half of Idaho), chloride was not used to select reference lakes due to ocean/tidal influence, which is found at many Oregon and Washington sites. Again, these reference site conditions were developed on a national scale and the Western Forested Mountains ecoregion includes many sites in Oregon and Washington.

2.c Field Sampling Methods

The monitoring at each lake was done in accordance with the methods outlined in the field operations manual (EPA 2007). At each monitored lake the deepest point in the lake, up to 50 meters in depth, was selected as the index site. If the lake was deeper than 50 meters at the deepest point, the deepest point was located and then the site was gradually moved to a point close to the deepest point but at a depth of 50 meters, which was established as the index site. If the monitoring location was a man-made reservoir, the index site was established near the center of the reservoir, holding to the same 50-meter depth requirement.

As shown in Figure 2, depth-integrated water samples were collected at the index site and analyzed for chemical parameters, algal toxins, chlorophyll-a, and phytoplankton. Also, in situ parameters such as temperature, pH, conductivity, and dissolved oxygen were measured using a multi-parameter probe. The depth of the index site was recorded as well as a transparency measurement using a Secchi disk. A Wisconsin net was used to make two vertical tow samples for plankton sample collection. Lastly, a sediment corer was lowered to the bottom and a sample collected for analysis of the sediment diatom community. For more in-depth descriptions of the various methods mentioned here please refer to the field operations manual (EPA 2007).

Once all the parameters were collected at the index site, the field crew moved on to collecting biological and physical parameters along the shoreline. The shoreline was divided into 10 roughly equal intervals to establish 10 sampling stations. At these stations physical habitat parameters were evaluated along the shore, within the littoral zone, and in the riparian zone. A benthic macroinvertebrate sample was collected within the littoral zone at each transect and all 10 such samples were composited to create a single benthic macroinvertebrate sample for the lake. At the last transect sampled, a fecal indicator (Enterococci) sample was collected. Figure 2 shows how stations and zones are laid out at a monitored lake, including where each of the samples and parameters are collected or recorded.

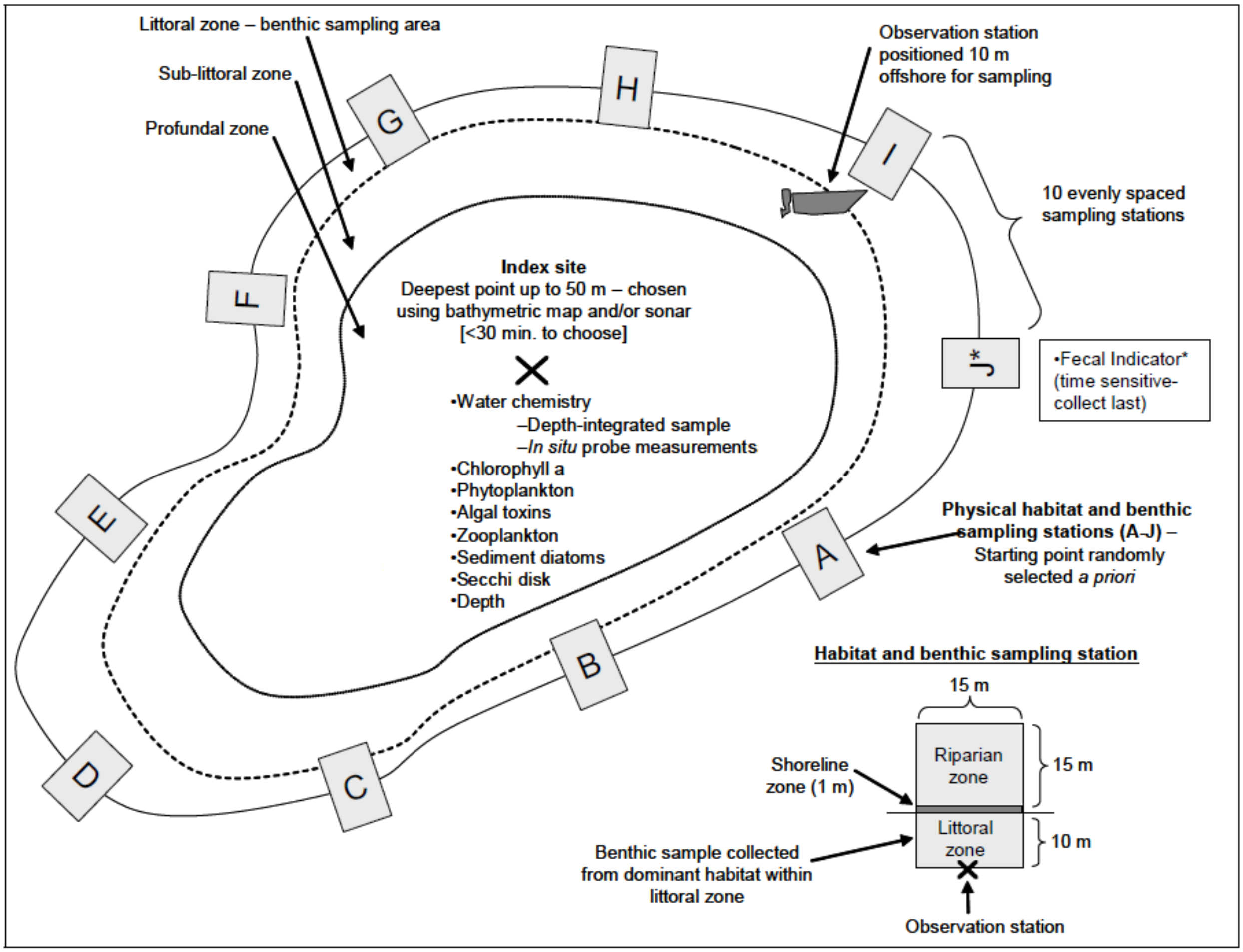

Figure 2. Locations and activities at monitoring points around the lake (EPA 2007).

2.d Laboratory Methods

The laboratory methods used to analyze the various collected samples are outlined in EPA's Survey of the Nation's Lakes Quality Assurance Project Plan (EPA 2009b). Chemical samples were shipped on ice to Dynamac Corporation in Corvallis, Oregon and analyzed for the parameters listed in Table 1.

Table 1. Chemical parameters sampled for in NLA.

Analyte	Analyte	Analyte
pH	Ortho-phosphate	Chloride (Cl)
Sulfate (SO_4)	Total Suspended Solids (TSS)	Nitrate (NO_3)
Total Organic Carbon (TOC)	Silica (SiO_2)	Calcium (Ca)
Ammonia (NH_3)	Potassium (K)	Magnesium (Mg)
Nitrate-Nitrite ($NO_3 - NO_2$)	True Color	Sodium (Na)

Biological samples were collected and preserved using Lugol's solution for the phytoplankton sample and 95% ethanol for the benthic macroinvertebrate and zooplankton samples. These samples were then shipped to the appropriate laboratory, where they were identified and counted. Sediment diatoms were enumerated to no more than 600 valves per sample. Phytoplankton samples were enumerated to 300 natural algal units. Each zooplankton sample was split into two subsamples, one for microcrustaceans and one for rotifers. These samples were enumerated to a minimum of 200 individuals but not more than 400 individuals per sample.

3 Data Analysis

3.a Chemical

Chemical data was provided by EPA to individual state programs in a series of ASCII files. The data was parsed according to aggregated Level II ecoregion so the data distribution for each ecoregion could be analyzed. The distributions for the two ecoregions found in Idaho were then compared at national, regional, and state levels to the recommended nutrient criteria (EPA 2000a; 2000b). Results from this analysis are explained further in section 4.b. The box plots showing the distributions of these datasets (Figure 6; page 16) were created using Sigmaplot (Systat Software 2008).

Thresholds for determining condition ratings of good, fair, and poor were developed at the national scale for 9 ecoregions due to the relatively few number of reference lakes sampled at the state scale. Chemical data was then analyzed using scripts written for the R statistical software application (R Development Core Team 2009) to evaluate the overall condition for chemical data at three scales: national, regional, and state.

3.b Biological

Biological communities sampled for this project include phytoplankton, zooplankton, cyanobacteria, sediment diatoms, and macroinvertebrates. Currently the data has been returned for phytoplankton, zooplankton, cyanobacteria and sediment diatoms. There is no data available as yet for the benthic macroinvertebrates.

Plankton are microscopic organisms found in lakes that are primary sources of energy in most lake ecosystems. Phytoplankton are plants while zooplankton are free-floating aquatic animals. Both of these planktonic organisms are very sensitive to changes in the water quality and the lake ecosystems. Environmental disturbances to the lake ecosystem can be determined by analyzing changes in the species composition and the abundance and size distribution of these two communities. Data regarding these two communities were analyzed and information on their various life stages, histories, and feeding habits was compiled to assess the overall health of the planktonic community.

A subset of phytoplankton called cyanobacteria is a natural part of all freshwater ecosystems and is known to produce biochemical and bioactive toxins. Eutrophication of lakes often creates conditions that encourage these bacteria to grow and create cyanobacterial blooms. When this happens, a layer of odorous scum may form on the surface of the water. In some instances this algal bloom may cause an allergic reaction or, somewhat less likely, a severe sickness in humans and animals that come into contact with the water. The most common toxin found in lakes with a cyanobacterial problem is microcystin. This toxin affects the liver, is known to be a tumor promoter, and may be a human carcinogen. Three indicators including microcystin, cyanophyta density and chlorophyll-a concentrations were used to evaluate the potential for impact to recreational uses on lakes. Diatoms are a group of algae that typically account for at least 20% of the primary production on earth. Diatoms are unique among algae as their cell walls are composed of silica which remains intact even after the animal dies. Over time, a buildup of silica shells in the bottom sediments of lakes and reservoirs occurs and this buildup can help biologists determine lake conditions at various time periods in the lake's history. Because the water quality conditions under which different diatom species thrive can show a great deal of variety, sediment diatoms are a useful indicator of changes in the lake's water quality. Diatoms from sediment cores were enumerated and identified from the top of the core to assess the health of the lake diatom community. In addition, diatoms from sediment cores were enumerated and identified at the bottom of the sediment core to evaluate the overall change in conditions for each natural lake.

3.c Physical

Aquatic communities such as macroinvertebrates and fish rely on a healthy physical environment. The physical habitat of the lake includes the bottom substrate of the lake, both biological and non-biological features of the lake in the littoral zone (the area near shore), and vegetation and structure along the shoreline (the riparian zone). By evaluating not only the biological communities present in lakes, but the physical environment as well, we can arrive at a better understanding of the overall health of the system and where it may be heading. For the NLA, ten stations were evenly spaced around the lakeshore beginning with a random placement of the first station. At each station, physical habitat was evaluated and these evaluations were used to help determine the overall impact of human influences on the lake and shoreline (Figure 2).

At each of the ten stations, the field crew did an assessment of the riparian zone, the littoral zone, and the substrate within the littoral zone. These assessment measures encompassed characteristics such as lake depth, water surface, bank morphology, substrate size, fish concealment, aquatic macrophytes (plants), riparian vegetative structure, and human activities. From this dataset, metrics were calculated and evaluated by the national research team.

Four measures of lake condition were developed using the data collected during the NLA to describe the overall health of the lake ecosystem. These measures are 1) extent and intensity of human land use activities (Shoreline Human Disturbance Index - RDIS), 2) structure and cover in three layers of riparian vegetation (Riparian Vegetation Cover Complexity Index - RVegQ), 3) biotic cover complexity including large woody snags, brush, overhanging vegetation, aquatic macrophytes, boulders, and rock ledges (Littoral Cover and Complexity Index - LitCvrQ); and 4) a combination of 2 and 3 to integrate the complexity of the land-water interface found in lakes (Littoral-Riparian Cover and Complexity Index - LitRipCvQ). These metrics were calculated differently for different ecoregions of the nation depending upon the reference lake condition used for each ecoregion.

Physical characteristic data was parsed by ecoregion and by lake origin to determine if there were any significant differences in the data based on these classifications. Box plots were created using Sigmaplot (Systat Software 2008). Data was also evaluated on national, regional, and state scales; however, there did not appear to be any significant differences at these scales and those results are not included here. Condition ratings for the different metrics were evaluated and R scripts provided by EPA were used to determine the overall estimates of condition for physical habitat. More information on the development and selection of these metrics may be found in the following section.

3.d Metric and Index Development and Selection

To evaluate the planktonic community, a model that looks at the loss of taxa was developed. This observed/expected (O/E) model compares the taxa that were actually identified at that lake (observed) to the overall taxa that one would expect to find based upon reference condition (expected). The application of this O/E index depends heavily on the development of models that predict how taxonomic composition varies with natural environmental settings due to the high degree of variance that can occur within natural environmental conditions. By comparing the observed taxa to the expected taxa, a ratio of the taxa lost is generated. Typical values for this model are between 0 and 1 and are interpreted as percentages. Each tenth of a point different from 1 represents a 10% change in the taxonomic community. For phytoplankton and zooplankton, three regionally-specific O/E models were developed to predict the extent of taxa loss.

Sediment diatom metrics were developed by looking at measures of taxonomic composition and relative abundance of the different taxa within the sediment core. Metrics used in the index were derived from counts of the sediment diatoms present and traits of each individual taxon. Morphological and growth form traits were obtained from literature or best professional judgment. In some cases specific species that were characteristic of reference condition lakes or impaired lakes were used to determine either high or low total phosphorus or total nitrogen conditions. More detailed information on the metrics used and the selection process for those metrics may be found in the NLA Technical Appendix (EPA 2010).

The metrics were then categorized and evaluated based upon their performance. Those metrics that showed the best ability to recognize a difference in the community between reference and impacted sites and had the lowest correlation to other metrics and categories were selected for inclusion in the Lake Diatom Condition Index. Lake Diatom Condition (LDC) was calculated to evaluate the overall condition of the diatom community within the lake. The LDC was calculated using the following steps to produce a multi-metric index ranging from 0 to 100. Five metric categories were identified during the development process of the index. Individual metrics within each of these five categories were averaged to produce five values, one for each category. These five values were then evenly weighted by multiplying by 20 and summed to produce a single overall index value to be used in classifying the overall diatom assemblage. Finally, the LDC was calculated as the deviation between the observed LDC and the expected LDC value for a specific lake (EPA 2010).

3.e Condition Ratings

Condition ratings were developed for the chemical, physical, and biological data collected. These condition ratings classified a lake as being in good, fair, or poor condition for each parameter based upon comparison to reference conditions for the ecoregion or nutrient region the lake resides in. Condition ratings are used as a way to analyze the overall status of the state's lakes. For each parameter, lakes with values greater than the 25th percentile of the reference lake distribution were considered to be in good condition, those with values less than the 25th percentile of the reference lake distribution but greater than the 5th percentile were considered fair, and those with values less than the 5th percentile of the reference lake condition were considered to be in poor condition (EPA 2010). Figure 3 illustrates the theoretical distributions of the entire sample population with that for the reference population.

The values that determine the good, fair and poor condition ratings for chemical parameters in the Xeric West and Western Forested Mountains ecoregions are called threshold values and were developed using the 5th and 25th percentiles of reference population (below 5th, poor; 5th - 25th, fair; above 25th, good). These threshold values are described further in section 4.b and in Table 6.

The threshold values for the physical habitat metrics were calculated on a lake-specific basis for lakes in the Western Forested Mountains and the Xeric West. These calculated values used elevation, latitude, and the aggregate ecoregion to help determine the reference condition for each of these lakes.

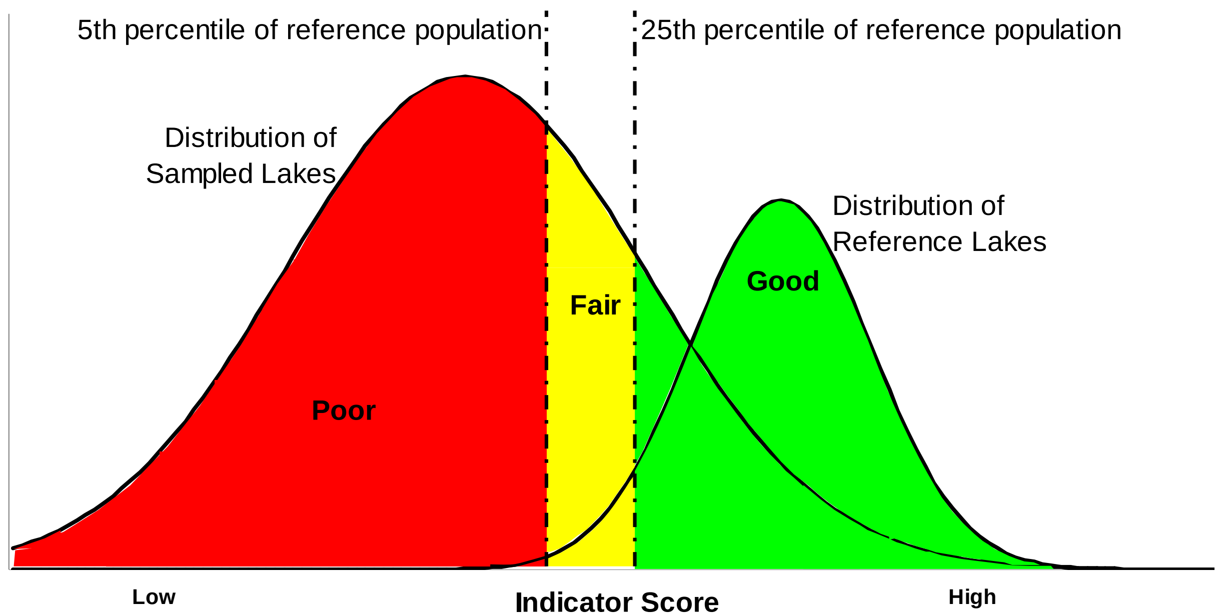

Figure 3. The relationship between distributions for sample population compared with reference condition. Adapted from the National Lakes Report (EPA 2009a)

Distributions of the O/E values for reference lakes around the nation were analyzed and used to evaluate the condition of the assessed lakes. The 25th percentile threshold value was less than 20% taxa loss for good conditions, while the 5th percentile threshold value was at 40%. Thus, lakes with 20-40% taxa loss were considered in fair condition and lakes with taxa loss greater than 40% were considered in poor condition.

Distributions of the LDC were analyzed using the R scripts provided by EPA. Condition ratings were assigned based on the 5th and 25th percentiles of the reference condition distribution. Comma-separated-value files that had the condition ratings for all of the chemical, physical, and biological parameters outlined in this section were provided by EPA to the individual state programs. These files were used in determining the national, regional, and state extent of the condition ratings using the R scripts provided by EPA.

Condition ratings for each of the various parameters were evaluated and given a score; a condition rating of good (least disturbed) scored a 1, fair (intermediate disturbance) scored a 2, and poor (most disturbed) scored a 3. These scores where then averaged together for the four chemical parameters (total phosphorus, total nitrogen, chlorophyll-a, and turbidity), the four physical habitat parameters (shoreline disturbance, riparian vegetation, littoral cover and complexity, and the littoral-riparian cover and complexity index) and the two biological parameters (LDC and O/E), creating a score for each of these three categories (chemical, physical, and biological). The average score in each category was then multiplied by four to give a final categorical score. Averaging the scores in each category normalized for any missing data within the category.

Once a score for each of these three categories was established, a categorical index score was created using the good, fair, and poor categories. Good condition ratings scored between 4 and 5 overall. This range was chosen for a good condition rating because it allows for a site to have one fair condition rating but no poor condition ratings. For example, a site may score 1 for TP, for TN, and for chlorophyll-a and a 2 for turbidity and still be considered in good condition; however, a site cannot score 1 for TP, for TN, and for turbidity and 3 for chlorophyll-a and still be considered in good condition. The range for fair conditions was determined by looking at site scores where a site may score poor for two parameters, but not three. Table 2 provides additional examples of how categorical condition ratings are translated from combinations of scores.

Table 2. Examples of score combinations and corresponding categorical condition ratings.

Categorical Condition Rating	Sum of Scores	Examples
Good	4-5	[1,1,1,1] or [1,1,1,2]
Fair	6-9	[1,1,2,2]; [2,2,2,2]; [3,3,2,1]
Poor	10-12	[3,3,3,1]; [3,3,2,2]; [3,3,3,3]

To determine an overall condition rating for a site, the scores for each of the categorical indices were summed. The resulting dataset was then evaluated. In some instances, a site may be missing scores from one or two indices (typically, biological parameters were missing). The dataset was divided into three groups, one in which all three categories were scored, another in which only two categories were scored, and a last one with only one categorical index score. Those that had scores for all three indices were then evaluated to determine the 25th and 75th percentiles. These percentile values were then used as the thresholds between the good/fair classifications and the fair/poor classifications. The same was done for those that had scores for only two indices. There were 7 sites that had only chemical data. These sites were classified using the thresholds given in Table 3.

Table 3. Overall condition ratings.

Overall Condition Rating	1 index score	2 index scores sum	3 index scores sum
Good	4-5	8-10	12-16
Fair	6-9	11-17	17-25
Poor	10-12	18-24	26-36

4 Results

4.a Population Extent

In Idaho there are estimated to be 239 lakes 10 hectares or larger that meet the target criteria. This corresponds to approximately 91,655 hectares of open water. Of the total number of lakes in Idaho, 29 lakes were sampled. Nineteen of these lakes were part of the national survey and an additional 10 lakes were added so that an assessment of Idaho's lakes with strong confidence intervals could be accomplished. Figure 5 (page 14) illustrates the locations of the sampled and non-target lakes in Idaho.

Table 4 provides a statistical breakdown of sites found to be non-target, target sites that couldn't be sampled and sampled sites. Of the total lake sites selected, six were eliminated from the final set of sites based on site evaluation findings. These sites could not be sampled due to site-specific issues related to physical access and safety of access. These six target not-sampled sites correspond statistically to approximately 33% of the overall number of lakes and 0.4% of the overall surface area. Therefore, this report is an analysis of about 66.8% of the total target lakes and about 99% of the total surface area for most metrics. Initially, it may appear that there is a large discrepancy between the number of inaccessible lakes and the overall surface area represented by these inaccessible lakes. In Idaho, a large number of small lakes are located in wilderness, roadless, or mountainous areas that proved to be inaccessible for this type of study. Although there may a large number of these lakes, they tend to be smaller so although they make up a large percentage of the number of lakes, their overall contribution to total surface area is relatively small. This is especially poignant when viewed in light of the surface area of the three largest lakes/reservoirs in Idaho: Lake Pend Oreille, Bear Lake, and American Falls Reservoir. These three alone have a combined surface area of 65,579.2 hectares (72% of the total surface area in the target population).

Table 4. Statistical breakdown of Idaho's probabilistic lake sampling effort.

Number Evaluated/ Monitored	Type	Target/ Non-Target	Total Area (Hectares)	Represents		
				# Lakes	% Area	% Lakes
5	Lake Shallow	Non-Target	411.9	24		
1	Lake Special Purpose	Non-Target	208.4	4		
1	Lake Vegetated	Non-Target	80.1	4		
15	Not Lake	Non-Target	938.5	155		
6	Target Inaccessible	Target	122	79	1.47%	33.19%
29	Target Sampled	Target	30,335	160	98.53%	66.81%

Figure 4 details the breakdown of the inferred population based upon lake size. Roughly 67% of lakes in Idaho are less than 10 hectares in size while only 2.75% of them are 500 to 5,000 hectares and 0.4% are greater than 5,000 hectares. Overall, Idaho has a greater percentage of lakes in the smaller size class (less than 10 hectares) than the nation, 67% compared to 47%. Only one lake less than 10 hectares was in the target sampled group. This led to a large weighting factor being applied to data from this one lake. While analyzing the data regarding condition estimates it was noted that condition estimates tended to correlate closely with the condition rating for this one lake. Therefore, a decision was made to run the analysis again without the less than 10 hectares size class for condition estimates at national, regional, and state scales. The data distributions shown in box plots in sections 4.b, 4.c, and 4.d include analysis of all 30 target sampled lakes (all size classes) while the tables and barplots showing condition ratings for chemical, biological, physical and overall condition in section 4.f are limited to only those size classes 10 hectares and greater.

The national population size (128,035 lakes) used in the original calculations included lakes in the 4-10 hectare size class. After correcting this population size to disregard this lake size class in both the target and non-target populations, there are 60,299 lakes in the national population, 2,033 lakes in the regional population, and 437 lakes in Idaho that are 10 hectares or greater in size. Of these 437 lakes in Idaho, 198 were determined to be non-target while 239 were target lakes.

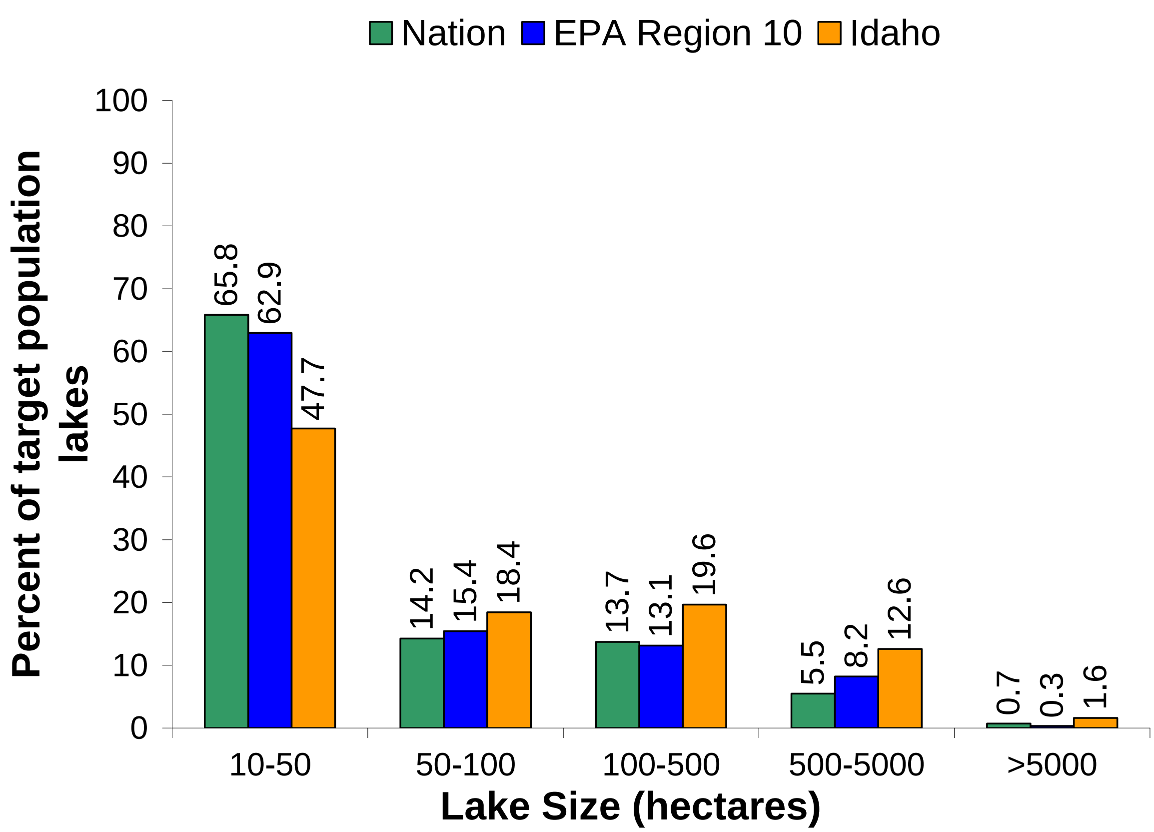

Figure 4. Percentage of target population lakes in various size classes.

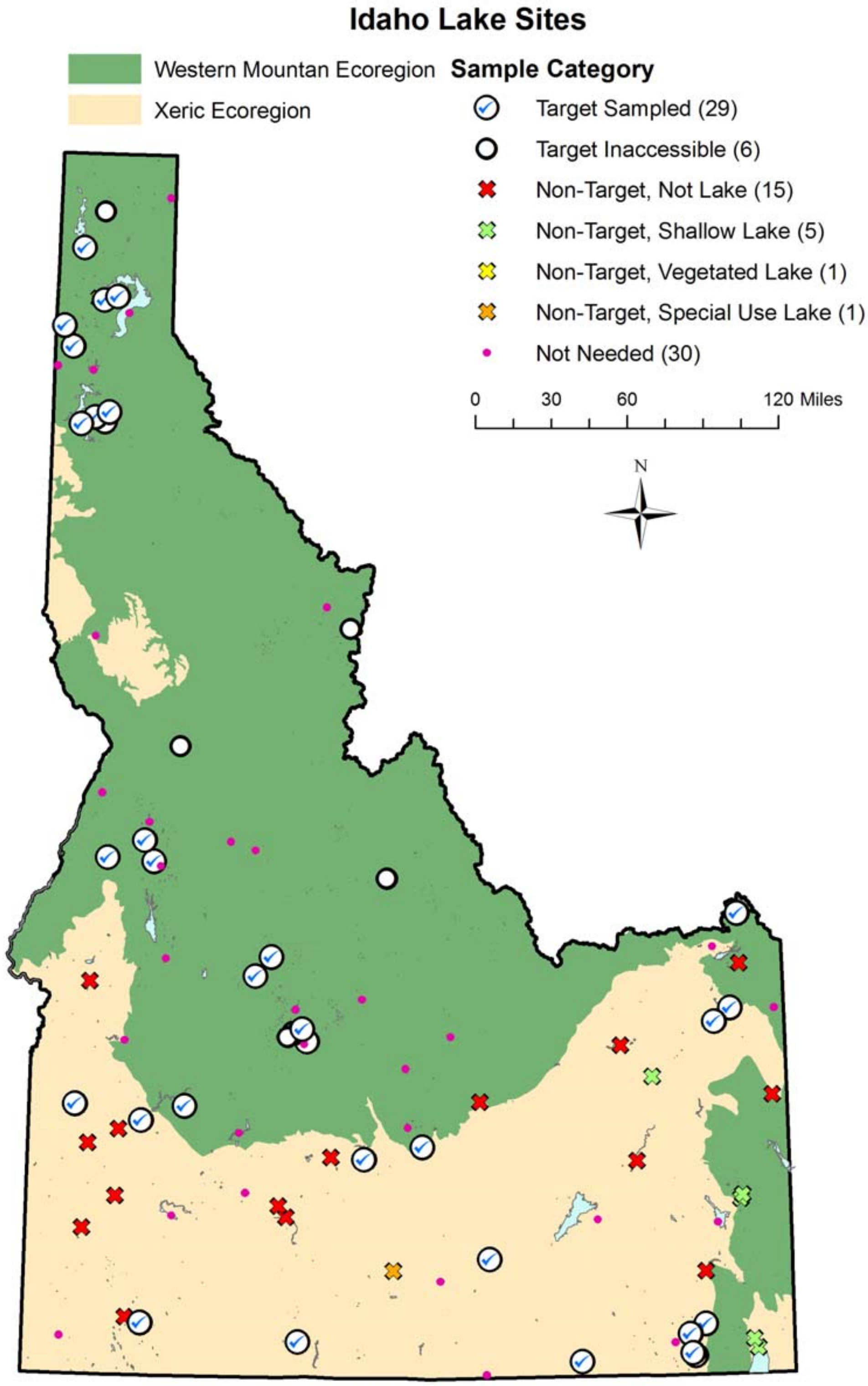

Figure 5. NHD (National Hydrography Dataset) lakes in Idaho identified as target or non-target.

4.b Chemical

In 2000, EPA published a series of water quality recommendations for nutrients in various aggregated ecoregions (EPA 2000a; 2000b). There are 14 ecoregions in the U.S., two of which are partially in Idaho: the Western Forested Mountains (ecoregion II) and the Xeric West (ecoregion III). The study that produced these recommendations used the data available to EPA through the EPA STORET database and from EPA's Region 10 office from 1990 to 1998. The recommended criteria values were set as the 25th percentile of the entire data set. The recommended nutrient criteria for these two ecoregions are listed in Table 5.

Table 5. Recommended nutrient criteria for lakes and reservoirs.

	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Chlorophyll-a (µg/L)	Secchi Depth (m)
Western Forested Mountains (II)	8.8	100	1.9	4.5
Xeric West (III)	17.0	400	3.4	2.7

The threshold values for determining chemical condition in the NLA were evaluated in a similar manner but used only the results from this monitoring effort. The cutoff between good and fair condition was set at the 75th percentile value for the reference lake population and the cutoff between fair and poor condition was set at the 95th percentile of the reference lake population (EPA 2010). The recommended nutrient thresholds for Idaho's two ecoregions are listed in Table 6.

Table 6. Threshold values for chemical condition ratings.

Ecoregion	Condition Rating	Total Phosphorus (µg/L)	Total Nitrogen (µg/L)	Chlorophyll-a (µg/L)	Turbidity (NTU)
Western Forested Mountains (II)	Good/Fair	15	278	1.81	1.44
	Fair/Poor	19	380	2.74	5.47
Xeric West (III)	Good/Fair	48	514	7.79	3.69
	Fair/Poor	130	2286	29.5	24.9

As can be identified by a comparison of the two tables, in a couple of cases (chlorophyll-a in the Western Forested Mountains and total nitrogen in the Xeric West), the 75th percentile for the reference lake population in 2007 roughly approximates the 25th percentile for all lakes from the 1990-1998 data set. However, in the case of total phosphorus and total nitrogen in the Western Forested Mountains and chlorophyll-a in the Xeric West, the 75th percentile for reference lakes is nearly double the 25th percentile for the 1990-1998 dataset. For total phosphorus in the Xeric West, the 75th percentile value is nearly three times greater than the 25th percentile value from the 1990-1998 dataset.

The technical appendix for the NLA (EPA 2010) did not evaluate mean Secchi depth but instead used turbidity as the measure of water clarity.

The box plots shown in Figure 6 compile the data for total phosphorus, total nitrogen, chlorophyll–a, and mean Secchi depth from all lakes in the target population. The data was evaluated at the national, regional, and state scales to evaluate what, if any, differences may occur. As shown, lakes in the Xeric West tend to have higher values for total phosphorus, total nitrogen, and chlorophyll–a, and lower mean Secchi depths. There do not appear to be any significant differences in the distributions among the three scales analyzed here. In most cases, values in at least half of each distribution are greater than the corresponding recommended nutrient criterion (shown as a red line).

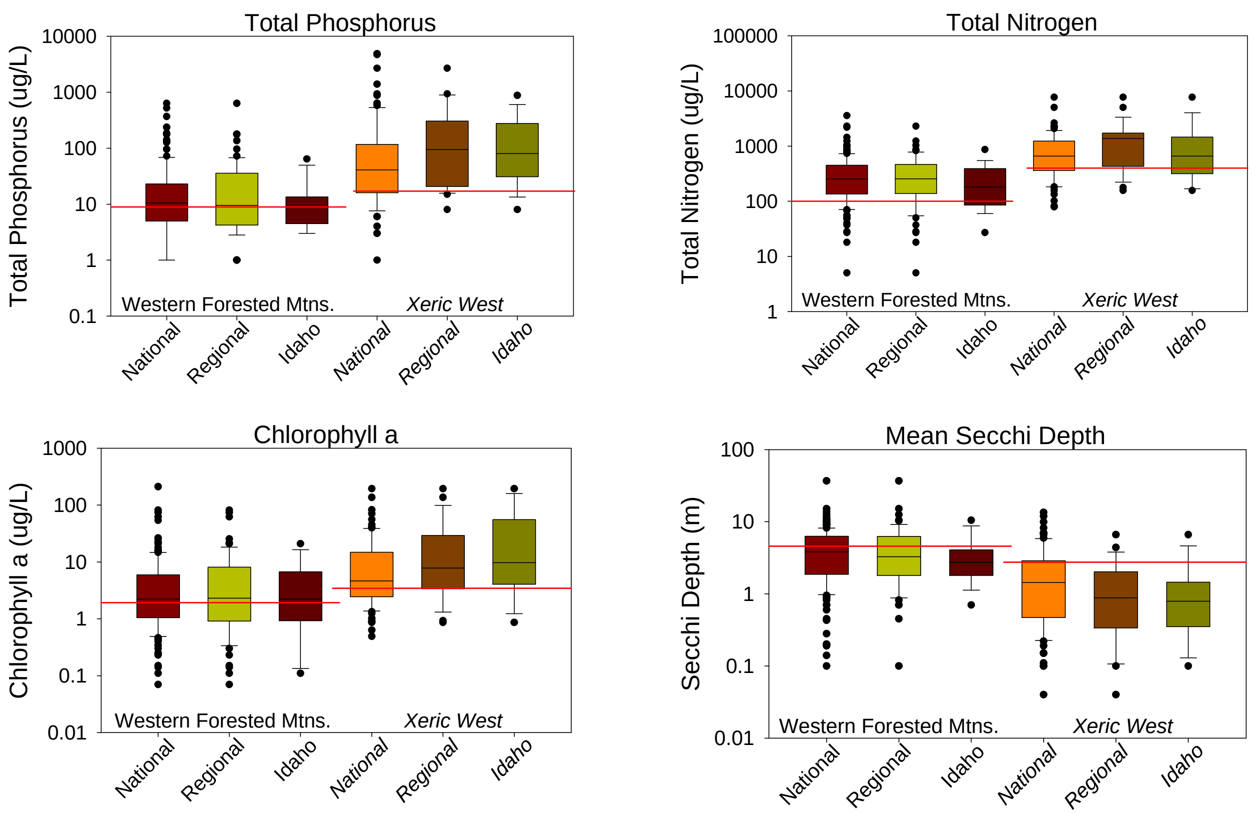

Figure 6. Box plots showing distribution of chemical parameters at national, regional, and state scales. The red lines in each graph correspond to the corresponding recommended nutrient criterion.

For total phosphorus in the Xeric West, the 25th percentile value for Idaho is 32.25 µg/L, approximately one and a half (1.5) times the recommended nutrient criterion. This indicates that in more than 75% of lakes in the Xeric West ecoregion of Idaho, total phosphorus would be considered to exceed this criterion. The same is true for chlorophyll-a in the Xeric West, total nitrogen in the Western Forested Mountains, and mean Secchi depth for both ecoregions. In Idaho, 50% of the values in the various distributions exceed the recommended criterion for chlorophyll-a and total phosphorus in the Western Forested Mountains and for total nitrogen in the Xeric West.

4.c Biological

Distributions of the plankton O/E index show that lakes in the Western Forested Mountain ecoregion tend to have less taxa loss as compared to lakes in the Xeric West ecoregion at all three scales (Figure 7). The distribution for Idaho lakes in the Western Forested Mountains is slightly narrower than for the regional or state scales, with a median value of 1.125. This value suggests that 50 % of the lakes show more slightly more taxa than expected for a single sample and that these lakes typically have a healthy plankton community. For the Xeric West target lake population, the median value of the plankton O/E index is 0.63. This value suggests that 50% of the lakes in this population have 40% or more taxa loss and that the plankton communities in these lakes are likely significantly different than in the reference condition.

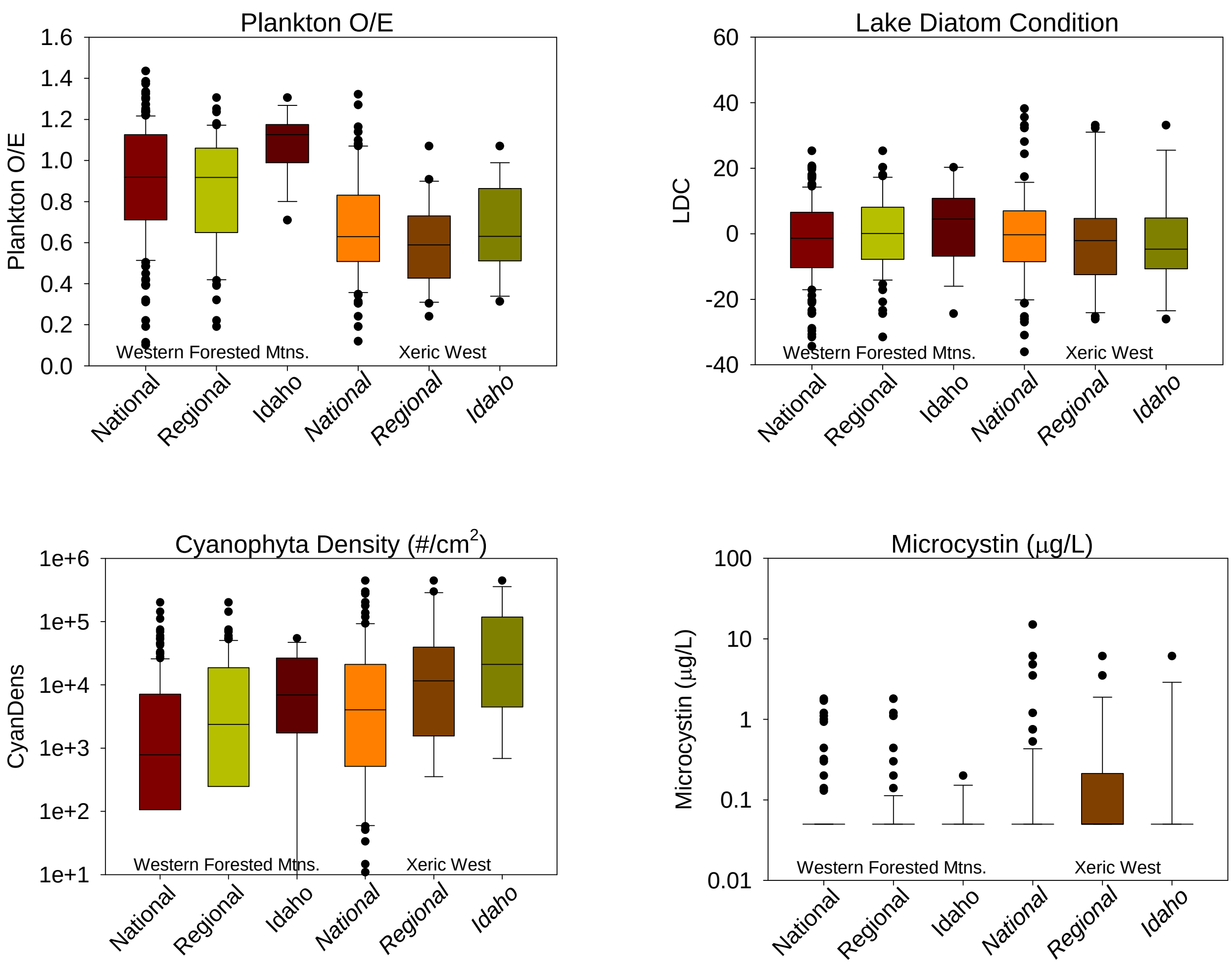

Figure 7. Box plots showing distribution of biological parameters at national, regional, and state scales.

The Lake Diatom Condition (LDC) Index as described in Section 3.d shows relatively little difference in values across ecoregions or scales. The distribution shown in Figure 7 plots the residuals of the observed LDC and the expected LDC. Values near zero indicate little or no difference between what is observed and what is expected. Negative values in this distribution suggest that there has been some loss of integrity in the diatom community. The median LDC value for Idaho in the Western Forested Mountains was 4.5 and in the Xeric West was -4.7; suggesting that lakes in the Western Forested Mountains have a healthy diatom community while those in the Xeric West may be slightly less healthy when compared to reference condition.

4.d Physical

The metrics developed to evaluate the physical habitat surrounding the lakes were grouped according to ecoregion and to origin (man-made vs. natural). The resulting distributions were then plotted and compared to determine if there were any significant differences in the distributions. The metrics were also analyzed on the national, regional, and state scales similar to the evaluation of the chemical data. However, there were no significant differences in the distributions at these scales.

When reviewing the data for all four metrics it was noted that there are differences in the metric scores when comparing the Western Forested Mountains to the Xeric West as well as when comparing natural lakes to man-made reservoirs. However, this observation may be confounded due to the fact that the majority of reservoirs are located in the Xeric West ecoregion and the majority of natural lakes are in the Western Forested Mountains ecoregion. Figure 8 shows the distributions for the four physical habitat metrics for all sites located in the Western Forested Mountains and Xeric West ecoregions (including sites outside Idaho) broken down by ecoregion and origin.

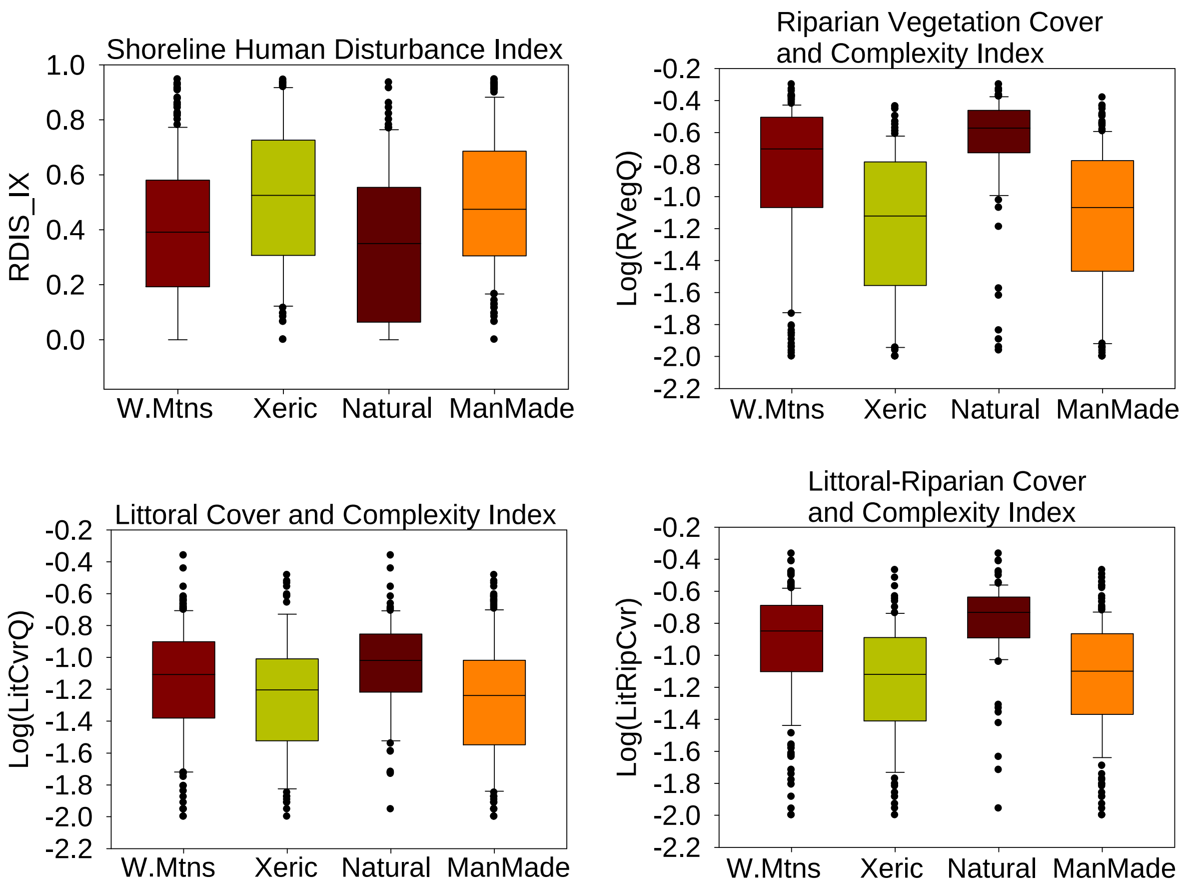

Figure 8. Box plots showing distributions of physical habitat parameters for all sites in the Xeric West and Western Forested Mountains ecoregions.

The largest difference in the distributions is between the distributions for natural and man-made conditions indicated by scores on the Riparian Vegetation Cover and Complexity and Littoral-Riparian Cover and Complexity Indices. There is nearly complete distinction between the 25th percentile for the natural distribution and the 75th percentile for the man-made distribution.

For the other two metrics (of the four metrics used to describe physical habitat), the distribution among natural lakes tends to have higher values for Littoral Cover and Complexity and lower values for Shoreline Human Disturbance. For the four physical habitat metrics, higher values for Shoreline Human Disturbance indicate a larger departure from reference condition while lower values for the other three metrics indicate lesser departures from reference condition. Therefore, in the case of natural vs. man-made distributions, the natural distribution tends toward values closer to reference condition than the man-made distributions. Comparing the Western Forested Mountains ecoregion to the Xeric West ecoregion, physical habitat shows a similar trend, with Western Forested Mountains distributions tending toward lower values for the Shoreline Human Disturbance Index and higher values for the other three metrics.

Reducing the datasets to evaluate only those sites in Idaho produced the box plots shown in Figure 9. Each distribution contains roughly the same number of samples. There were 15 lakes/reservoirs in the Western Forested Mountains, 14 in the Xeric West, 12 in the natural, and 17 in the man-made distributions. As with the national dataset, the Western Forested Mountains and natural distributions tend to have higher values for the three measures of vegetative cover and complexity. However, for the Shoreline Human Disturbance Index, there is little difference between the Western Forested Mountains and Xeric West distributions. The natural distribution for this metric trends the same as for the previously discussed metrics, with lower values for the natural distribution than for the man-made distribution.

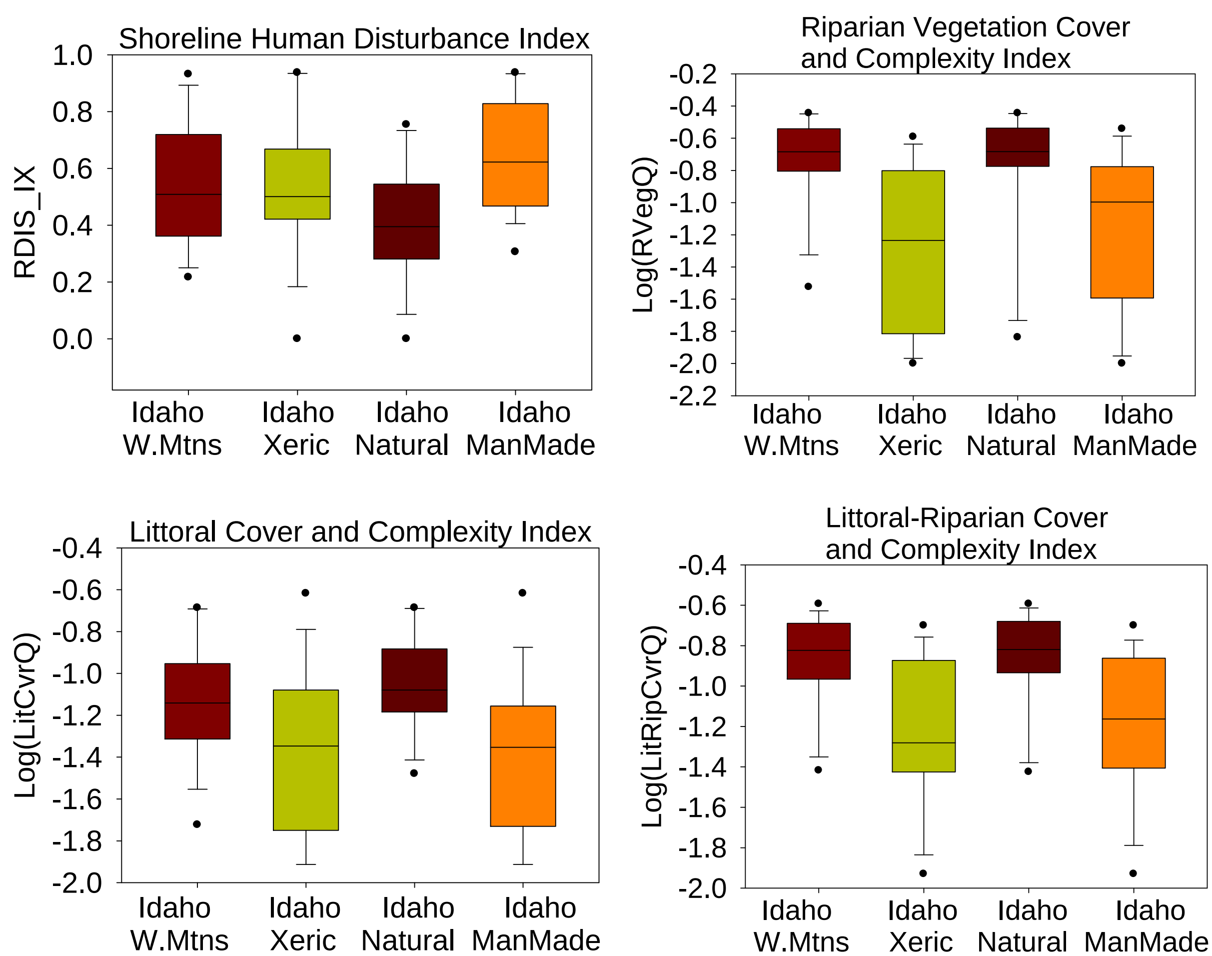

Figure 9. Box plots showing distributions of physical habitat metrics for Idaho sites.

4.e Recreation

The presence of toxic algae in a lake may be a sign of increased human influence, also called cultural eutrophication. Cyanobacteria exist in all freshwater systems, but when conditions are enhanced by the addition of nutrients (often from human or livestock sources) these cyanobacteria may increase to a point where a toxic algal bloom occurs. These blooms may cause severe illness in livestock, pets, or humans who ingest the water. A surrogate measure for determining if an algal bloom is possible is the density of cyanobacteria. The World Health Organization has posted guidelines (Chorus and Bartram 1999) for determining the risk of illness based on exposure to cyanobacteria at different densities (Table 7). For Idaho's lakes within the Western Forested Mountains, the median cell count value was 6,930 cells/L well below the low-risk threshold while the 75th percentile, at 23,424 cells/L, was slightly above the low-risk threshold, suggesting that roughly 75% of lakes in this ecoregion have a low risk of illness due to exposure to algal toxins. In Idaho's Xeric West lakes, the median value was 21,032 cells/L suggesting that roughly 50% of the lakes in this ecoregion have a low risk of illness based on exposure to algal toxins. Five lakes surveyed in Idaho showed microcystin in the water, corresponding to 35 lakes in the target population. Of the lakes in Idaho that showed a presence of microcystin, the highest recorded value was 6.1 µg/L while all other values were less than 1.0 µg/L, all below the 10.0 low-risk threshold for microcystin. Therefore, even though microcystin may be present in these lakes, there is still a low risk of illness based on exposure to algal toxins for these lakes.

Table 7. World Health Organization guidelines (risk thresholds) for illness due to exposure to cyanotoxins.

Indicator	Low Risk	Moderate Risk	High Risk
Cyanobacteria (#/mL)	< 20,000	20,000 - <100,000	≥ 100,000
Microcystin (µg/L)	<10	10- ≤ 20	> 20

There are two species of Enterococci that are commonly found in the intestines of humans and used for determining pollution due to human pathogens. Enterococci were detected at seven of the 29 lakes sampled (Table 8). Based on the adjusted weights from the probability design, this corresponds to roughly 43 of the 160 lakes in the target population that have Enterococci present. All seven of these lakes have Enterococci levels above the federally recommended standard (EPA 1986) for acceptable gastroenteritis rates for infrequently used full body contact recreation (151 cells / 100 mL)

Table 8. Entercocci detections.

Lake	Aggregate Ecoregion*	Lake Origin	Area Category**	Enterococci concentration (#/100 mL)
Shepherd Lake	WMT	Natural	"(20,50]"	185
Round Lake	WMT	Natural	"(10,20]"	301
Lower Twin Lake	WMT	Man-made	≥100	307
Blanchard Lake	WMT	Man-made	"(50,100]"	340
Chase Lake	WMT	Natural	"(50,100]"	519
Carey Lake	XER	Natural	"(50,100]"	581
Foster Reservoir	XER	Man-made	"(50,100]"	769

* MWT – Western Forested Mountains; XER – Xeric West

** (x,x] indicates the lower size limit included in the category and the upper size limit excluded in the category, e.g., (50,100] includes lakes of 50 ha but not 100 ha.

4.f Conclusions

4.f.1 Trophic state

The trophic state index is a way to evaluate the productivity of the water and was initially proposed by Carlsson (Carlsson 1977). The trophic state index was introduced as a simple tool to describe the overall trophic state of a lake that incorporated the diverse aspects of trophic state found in more complex multi-parameter indices but had the simplicity of a single-parameter index (Carlsson 1977). Carlsson's trophic state index focused primarily on the use of Secchi disk transparency (Secchi depth) as a surrogate for algal biomass. Carlsson's paper shows the inversely proportional relationship between Secchi disk transparency and chlorophyll-a.

The trophic states for lakes and reservoirs are shown in Figure 10 for the national, regional, and state scales. In Idaho, the majority (70.9%) of our lakes and reservoirs are oligotrophic. This means that the majority of lakes have low primary productivity with low algal production and clear water.

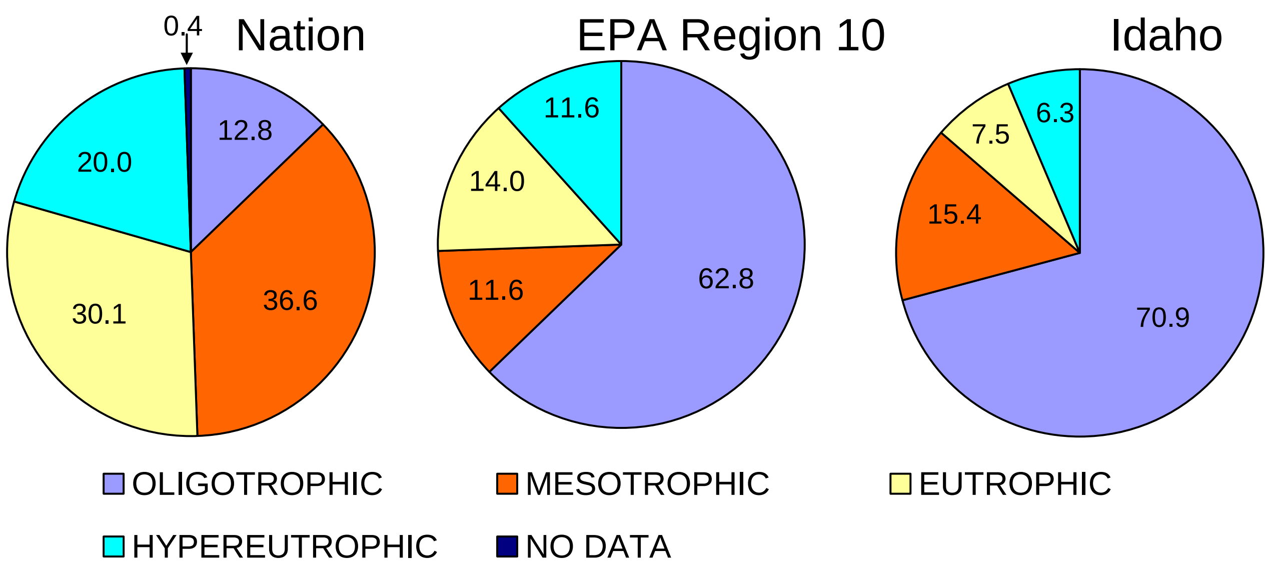

Figure 10. Trophic state distributions at the national, regional and state scales.

When evaluating the trophic state index for lakes and reservoirs, it is important not to equate the trophic state index to a water quality index (Carlsson 1977). A tendency to equate oligotrophic lakes with high quality waters arises often, but is not in keeping with the intention of the trophic state index. The natural progression of lake trophic status from oligotrophic through to eutrophic means that a eutrophic state is possible even in reference conditions and is even desirable in the aspects of increased bio-diversity and the ability of the eutrophic system to support more and varied forms of life. In some cases, oligotrophic lakes may have poor water quality due to increased concentrations of metals that are toxic to fish and other aquatic organisms in the lake. In other cases that arise in the Pacific Northwest, cultural oligotrophication may occur when a lake loses the marine sources of nutrient that were historically provided by anadromous fish, thereby decreasing the amount of nutrients available to support other life in the lake ecosystem (Stockner et al. 2000).

4.f.2 Overall Estimates of Condition

As discussed in Section 3.e, the distributions for each category and metric were analyzed to determine the reference condition threshold values. This in turn allowed each site to be given a condition rating—good, fair or poor—for each result evaluated. Once each site was given condition ratings for the available data, all sites were evaluated and overall estimates of condition were produced. Table 9, Table 10, and Table 11 detail the results for condition estimates in each category. These overall condition rating results are for lakes 10 hectares or greater in size at the national, regional, and state scale. Similar results were calculated for all lakes in the target population (includes the 4-10 hectare size class) and are shown in Appendix A. The results reported here apply to 29,070 target lakes at the national scale, 735 lakes at the regional scale and 160 lakes at the state scale.

Table 9. Estimates of chemical condition in target population greater than 10 hectares.

Parameter	Good	Fair	Poor
Total Phosphorus			
National	59.09%	25.19%	15.72%
EPA Region 10	47.38%	9.44%	43.18%
Idaho	60.21%	14.55%	25.24%
Total Nitrogen			
National	56.22%	26.68%	17.10%
EPA Region 10	41.83%	21.95%	36.22%
Idaho	53.71%	26.69%	19.60%
Chlorophyll-a			
National*	68.51%	15.58%	15.14%
EPA Region 10	44.87%	6.47%	48.66%
Idaho	36.47%	23.18%	40.35%
Turbidity			
National	73.15%	19.15%	7.70%
EPA Region 10	47.76%	35.74%	16.5%
Idaho	42.74%	34.67%	22.59%

* 0.76% had no data.

Estimates for the various chemical parameters show that the majority of Idaho's lakes fall in the good and fair categories. The poorest performer is the chlorophyll-a with 40% of the lakes in Idaho (approximately 64 lakes) being in poor condition for chlorophyll-a (Table 9). Idaho scores generally are poorer than national scores for all the chemical parameters reported here. Nationally, less than 20% of lakes 10 hectares or greater are in the poor category for chemical parameters while Idaho ranges from 20% to 40% poor condition ratings. However, Idaho scores are better than regional scores (smaller percentage in the poor classification) for all chemical parameters except turbidity.

Trends in chemical conditions show that nationally the majority of lakes are in good condition for all four chemical parameters. Idaho shows a majority of lakes in good condition for total phosphorus and total nitrogen, and relatively even distribution across all three condition classifications for chlorophyll-a and turbidity with the highest percentage in the poor category for chlorophyll-a and the highest percentage in the good category for turbidity. Regional results show an even distribution of results between the good and poor categories for total phosphorus and chlorophyll-a and even distributions for nitrogen and turbidity.

As shown in Table 10, estimates of condition for the plankton community show that Idaho is on par with the national condition with nearly 60% of lakes in good condition and less than 25% in poor condition. Regional results show that only 36% of lakes in Region 10 are in good condition and 38% have poor plankton condition. For the Lake Diatom Condition, estimates show that 62% of the state's lakes are in good condition relative to the sediment diatom community while 26% are in fair condition and 5% are in poor condition. Generally, Idaho lakes show good biological health based on these metrics with a majority of lakes in the good condition category for both plankton O/E and LDC. This is consistent with national results which also show a majority of lakes in good condition while regional results show a majority of lakes in good condition for LDC but are evenly distributed across all three classifications for plankton O/E.

Table 10. Estimates of biological condition in target population lakes greater than 10 hectares.

Parameter	Good	Fair	Poor	Not Assessed
Plankton O/E				
National	60.98%	17.53%	19.54%	1.95%
EPA Region 10	36.00%	23.07%	38.62%	2.31%
Idaho	57.39%	12.08%	24.46%	6.07%
Lake Diatom Condition				
National	43.84%	28.35%	24.99%	2.82%
EPA Region 10	67.18%	18.21%	6.92%	7.69%
Idaho	62.37%	26.42%	4.90%	6.31%

Physical habitat parameters are used to evaluate the effects of human disturbance on the riparian and littoral habitat. Four measures of habitat impact were evaluated: shoreline disturbance, riparian vegetation cover, littoral cover, and a metric that looks at the riparian and littoral boundary. Idaho lakes show only a small percentage of lakes in good condition regarding the shoreline disturbance metric (2%) while the majority of lakes are in fair condition (73%). Idaho lakes show the highest percentage of good condition in the littoral cover and complexity metric with 69% being estimated as good (Table 11).

Generally, for shoreline disturbance, the majority of lakes on all three scales (national, regional, and state) are in fair condition. For littoral cover and complexity, the majority of lakes on all three scales are in good condition. For the riparian vegetation cover and complexity measure, national and regional lakes are mostly in good condition while Idaho lakes are in fair condition. For the littoral-riparian cover and complexity, again, most national and regional lakes are in good condition while Idaho lakes are more evenly spread out across all three classifications, the highest percentage being in poor condition. For three of the four physical habitat metrics Idaho lakes have lower percentages in the good classification when compared to the regional and national scores. However, the percentage of lakes being classified in poor condition at the state scale is relatively close to the percentage at the national and regional scales.

Table 11. Estimates of physical habitat condition in target population greater than 10 hectares.

Parameter	Good	Fair	Poor	Not Assessed
Shoreline Human Disturbance				
National	29.40%	50.50%	18.99%	1.11%
EPA Region 10	21.67%	54.81%	23.19%	0.33%
Idaho	2.24%	72.63%	23.54%	1.60%
Riparian Vegetation Cover Complexity				
National	46.56%	16.13%	36.06%	1.25%
EPA Region 10	50.71%	13.61%	35.35%	0.33%
Idaho	25.37%	30.51%	42.53%	1.59%
Littoral Cover and Complexity				
National	57.03%	23.33%	18.48%	1.16%
EPA Region 10	73.83%	14.60%	11.24%	0.33%
Idaho	69.34%	13.61%	15.45%	1.60%
Littoral-Riparian Cover and Complexity				
National	44.41%	20.25%	34.04%	1.30%
EPA Region 10	53.94%	13.68%	32.05%	0.33%
Idaho	32.15%	23.73%	42.52%	1.60%

Condition estimates for each parameter in each category were evaluated, scored, and combined as described in Section 3.e. The results of these evaluations are shown in Figure 11 and Figure 12. Most Idaho lakes were classified good for chemistry and biology, and fair for physical habitat and overall condition. Nationally, most lakes were classified good for chemistry, and fair for biology, physical habitat, and overall condition. For chemical parameters, regional results showed the same percentages of lakes being classified good and poor, and fewer lakes in fair condition. For biology, physical habitat, and overall condition, most lakes regionally classified as fair.

Idaho had 32% of lakes (51 lakes) classified as being in overall poor condition. Regionally, 28% of lakes were classified in overall poor condition and 19% nationally were in overall poor condition. The highest percentage (47%) of lakes in Idaho was classified as fair (75 lakes) while only 21% were classified as good (34 lakes).

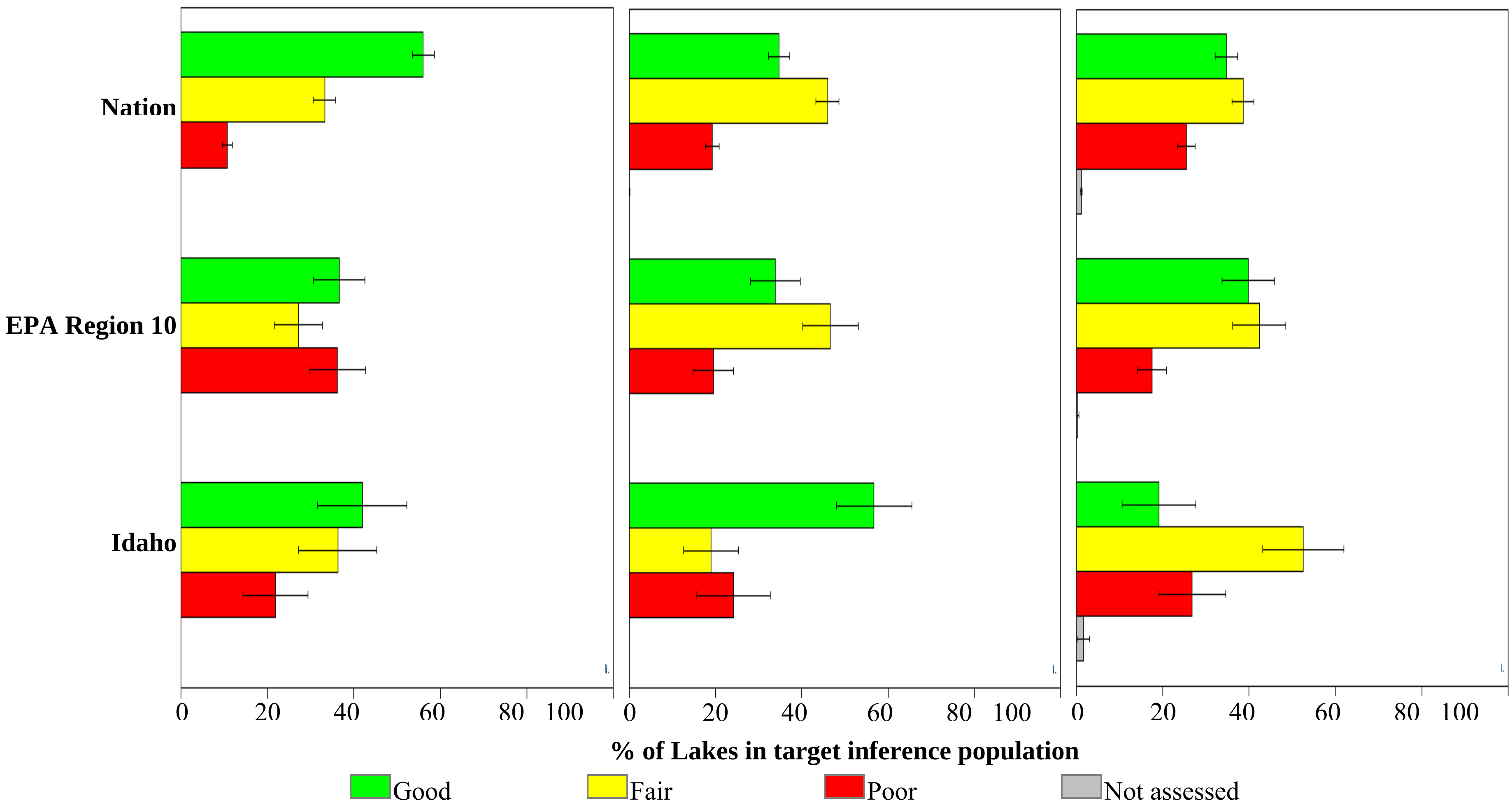

Figure 11. Overall condition rating for chemical (left), biological (center), and physical habitat (right) indices.

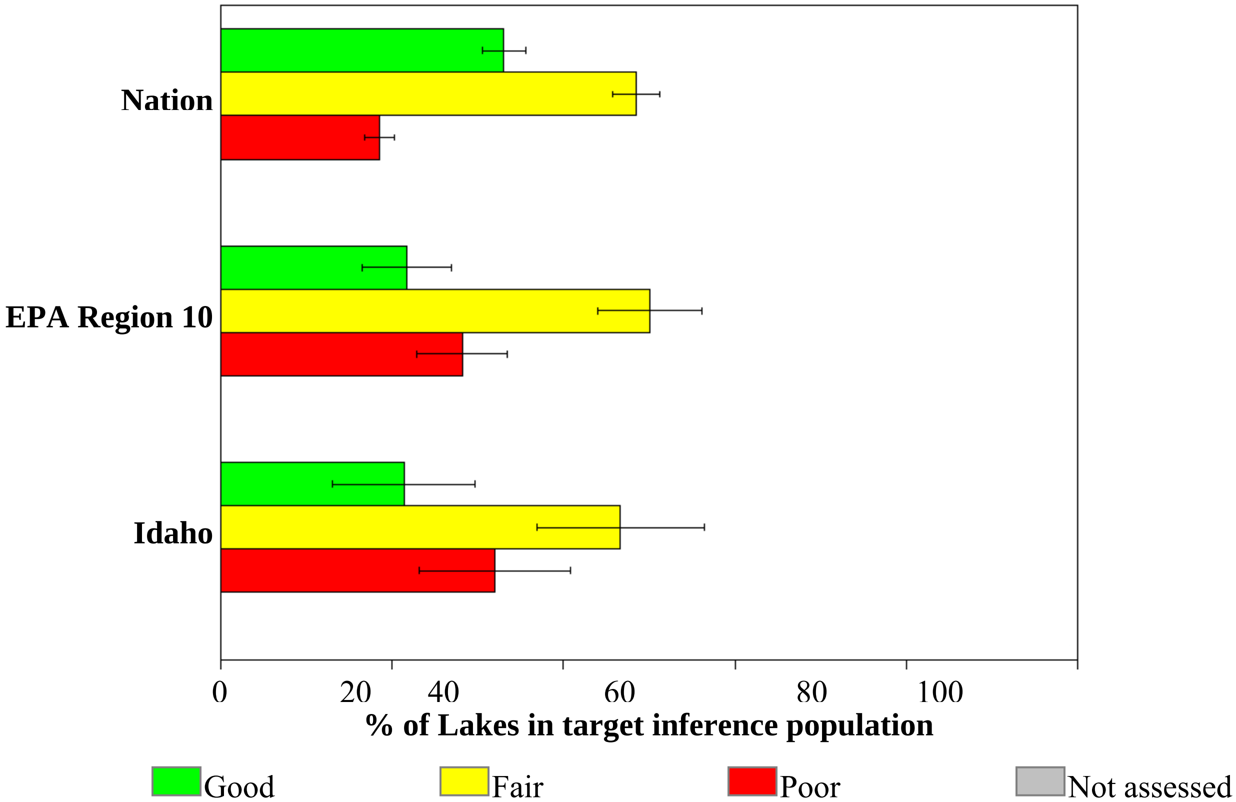

Figure 12. Overall condition ratings

5 Recommendations

This section outlines various considerations that should be evaluated to help provide a comprehensive and cost effective methodology for assessing Idaho's lakes. While the methods and protocols outlined in EPA's Survey of the Nation's Lakes Field Operations Manual (EPA 2007) and the National Lakes Assessment: A Collaborative Survey of the Nation's Lakes (EPA 2009a) are comprehensive, they were also developed to answer questions on a national scale with national resources to support them. Idaho's resources for ambient water quality monitoring are more limited, not just financially but in available personnel and technical support as well. This section will evaluate the methods and data analysis provided by EPA to determine which of the parameters and indices will provide Idaho with the most effective and efficient way to determine the overall condition of lakes and reservoirs in Idaho.

Ambient monitoring data such as DEQ collects on lakes and reservoirs is used to support development of water quality criteria, report on the condition of Idaho's waters, and identify impaired waters to be reported to EPA. Currently, much work has been done to improve the assessment process for flowing waters (rivers and streams) while less work has been done to build assessment methodologies for lakes and reservoirs. Assessing lakes and reservoirs is currently done on an *ad hoc* basis and is not consistent throughout the state. By establishing a monitoring and assessment methodology for lakes and reservoirs, more consistent assessments of these water bodies may be made. The recommendations found in this section outline some goals and suggestions that should be considered for developing that more robust monitoring methodology. These recommendations largely follow principles laid out in the Water Body Assessment Guidance – Second Edition (Grafe et al. 2002) and the Surface Water Ambient Monitoring Plan – First Edition (Grafe 2004). The recommendations are in four categories: classification of lakes, defining reference condition, frequency and timing of sampling, and selection of metrics and indices.

5.a Classifying Lakes

There is a wide variety of lake types in Idaho from small (less than 10 hectares) high-elevation ultra-oligotrophic lakes to large (greater than 22,000 hectares) low-elevation riverine reservoirs. The biological, physical, and chemical properties for these should not be expected to be the same. Therefore, it is necessary to differentiate between and classify the various lakes and reservoirs based upon some scheme. In light of these differences, the National Lakes Assessment used Level II aggregate ecoregion (Western Forested Mountains and Xeric West) to classify lakes and reservoirs. It is possible that Idaho could develop a more comprehensive classification scheme that would create a more robust reference condition approach. Suggested classification factors would be:

1. Lake/reservoir size and depth
2. Lake/reservoir morphology
3. Watershed characteristics including geology and land use
4. Elevation
5. Trophic state
6. Ecoregion

It is recommended that once a large enough sample size of monitored lakes is available, a cluster analysis of various environmental parameters (e.g., precipitation, drainage area, geology, depth, surface area, elevation, temperature) be performed to determine the best grouping of lakes. It is desirable to reduce the number of clusters in order to adequately delineate differences in lakes and reservoirs but still allow for the possibility of having enough lakes in reference condition within each cluster to adequately determine what reference or least-impacted conditions for that cluster would be. In lieu of that larger sample size, it is recommended that lakes be classified by size, maximum depth, retention time and ecoregion.

5.b Defining Reference Condition

Determining what the condition of a lake or reservoir should be is important in evaluating whether or not that lake is currently in good or poor condition and if the impacts to that lake are human-caused or not. DEQ's approach to determining the current lake condition should be to establish reference conditions for lakes based upon the classification scheme.

Idaho currently uses a methodology for determining reference or least-impacted condition for streams and rivers that uses measures of the intensity of human activity within the watershed. This includes measures of land use, ecoregions, density of roads, mines, dams, point source discharges, and population within the watershed, and grazing activity at the site. It is recommended that these measures be incorporated into a lake reference condition evaluation procedure to remain consistent with other water body assessment methodologies. Similar to the river reference condition, it is possible that reference sites may not be evenly distributed across the state due to heavier population influences in the lower elevations. If this is found to be true, then it is recommended that a cluster analysis similar to the national study be done to determine the most appropriate classification for reference condition.

The NLA did not use data on land use in the watershed for final reference site screening, since it was believed that sites in agricultural areas may be considered least-impacted based upon the parameters evaluated regardless of the overall human impact to the land around the lake. Instead, for the purposes of this national study, lakes were grouped into distinct regional categories based on nine environmental variables (elevation, precipitation, air temperature, longitude, latitude, calcium concentrations, area, depth, and shoreline development). Seven regional clusters were identified during this grouping process. To then identify reference sites, chemical and physical data from the sites were used to determine if a site was in reference condition. If a site exceeded any one of ten criteria values it was considered not to be a reference lake.

Setting reasonable expectations for metrics and indices will be a significant challenge due to the difficulty in estimating historical conditions for lakes and defining what reference condition for a reservoir should be. Due to the fact that reservoirs are in fact a human-caused water body type, there is truly no such thing as a natural reservoir. For the purposes of the NLA, the established guideline was that if the lake existed prior to European settlement, the lake was considered natural regardless of any later augmentation such as increased impoundment. Using that definition, 82% of Idaho's lakes would be considered natural and 18% man-made.

Whereas this report and EPA's NLA are focused on categorizing waters into good, fair, or poor condition, Idaho's ambient monitoring program focuses more on determining whether water bodies are fully supporting or not fully supporting their designated beneficial uses. This is a fundamental difference in determining threshold values and breakpoints for the various metrics and indices used. Upon further investigation, it may be shown that those in good and fair conditions are fully supporting their designated beneficial uses while those in poor condition do not support the uses; however, this is something that will need to be explored further during data analysis and determination of reference condition.

5.c Sampling Frequency and Timing

Another issue that will need to be addressed is the frequency and timing of lake sampling. With flowing waters, a single monitoring event likely captures a significant amount of the pertinent biological and physical parameters that affect aquatic life and recreation issues. This is not necessarily the case with lakes and reservoirs. Many lake managers recommend sampling at least four times per year to capture an overall view of the lake in the different seasons. However, the goals of the ambient monitoring strategy must be balanced with the limited resources available to perform sampling and analysis.

Sampling during the summer index period is recommended because monitoring during this time increases the chances of finding eutrophication problems that may arise. During the summer months, warmer water in the top stratified layer, together with abundant sunlight and nutrients, provide a rich environment for algal growth. With the limited resources available, such once per year sampling is likely to gather data during the time period that is most critical to the overall health of the lake. Although more frequent sampling is desirable to truly understand the cycling of life within any given lake, the purpose of an ambient monitoring program is to try to assess all waters within the state using limited resources. Therefore, it is consistent with the goal of the ambient monitoring strategy to sample a lake only once per year.

5.d Metric/Index Selection

In order to evaluate performance of the individual metrics and indices described in this report, the number of times a metric or index agreed with the overall assessment was evaluated. To prepare this evaluation, the metric score was rated according to the condition rating score laid out in Table 2. This rating was then compared to the overall assessment rating and the number of times the two agreed was divided by the total number of sites with data for that metric or index. The same formula was used for the individual index ratings. For the pairs of indices, the two individual index scores were added together and given condition ratings based on the two-indices thresholds (Table 3), which were compared to the overall assessment rating.

As shown in Table 12 the agreement percentage for individual metrics ranged from 43% to 57%. The individual indices had slightly better agreement (54 – 67%) and combinations of the indices (chemistry/biology, chemistry/physical habitat, biology/physical habitat) had agreements ranging from 73% to 78%.

Table 12. Condition rating agreement

Metric	Agreem't	Metric	Agree m't	Metric	Agreem't
Total Phosphorus	49.51%	Lake Diatom Condition	56.66%	Riparian Disturbance	52.00%
Total Nitrogen	52.92%	Observed/ Expected	50.15%	Riparian Vegetation	47.12%
Turbidity	42.90%			Littoral Cover	42.80%
Chlorophyll-a	43.01%			Littoral- Riparian Cover	49.33%
Index	**Agreem't**	**Index**	**Agreem't**	**Index**	**Agreem't**
Chem	53.40%	Bio	69.28%	PhysHab	56.82%
Chem/PhysHab	74.51%	Chem/Bio	78.21%	Bio/PhysHab	75.68%

In keeping with the methodology laid out in the water body assessment guidance (Grafe et al. 2002), those lakes with condition ratings of good and fair were considered to fully support the aquatic life beneficial uses while those with condition ratings of poor were considered to not fully support the aquatic life beneficial uses. When using the support status to determine agreement between indices and the overall assessment, individual indices agreed with the overall assessment in 77 – 86% of all sites. When combining indices, the chemistry and physical habitat indices agreed in 91% of sites, the chemistry and biological indices agreed 92% of the time, and the biology and physical habitat indices agreed 86% of the time (Table 13). This suggests that roughly 91% of all lakes can be adequately identified as supporting beneficial uses using the chemical and physical habitat indices. By adding the LDC to the chemical and physical habitat indices the percent agreement is raised only slightly to 92%.

Evaluating the individual metrics, indices, and combination of indices for only those lakes in Idaho (Table 13) shows that the best agreement between the overall condition and a combination approach is for the combination of chemistry and biology (97%). Biology combined with physical habitat agrees in 93% of the sites. However, due to the relative expense and difficulty in collecting both the sediment diatoms and the plankton, an evaluation of the chemical, physical habitat and one indicator of biology was done (Table 14) showing that there is slightly better agreement when using the plankton O/E index with chemistry and physical habitat (93.1%) over chemistry, physical habitat and lake diatoms (92.6%).

Table 13. Support status agreement national results

Index	Agreement	Index	Agreement	Index	Agreement
Chem	84.63%	Bio	86.20%	PhysHab	76.92%
Chem/PhysHab	90.66%	Chem/Bio	91.83%	Bio/PhysHab	86.33%
Chem/PhysHab/ LDC	92.04%	Chem/PhysHab/ O/E	86.05%		

Table 14. Support status agreement state results

Index	Agreement	Index	Agreement	Index	Agreement
Chem	83.33%	Bio	90.00%	PHab	75.86%
Chem/PhysHab	90.00%	Chem/Bio	96.67%	Bio/PhysHab	93.33%
Chem/PhysHab/ LDC	92.59%	Chem/PhysHab/ O/E	93.10%		

Although macroinvertebrate data were not available in time to be included in this report, macroinvertebrate community data will likely add valuable information to the overall assessment of lakes in this study. Macroinvertebrate indices are a staple in the evaluations of river and stream ecological health and so will likely also play a role in the evaluation of lake ecological health.

At this time, the recommendation is to include the basic measures of chemistry (phosphorus, nitrogen, and chlorophyll-a), physical habitat measures (riparian and littoral community parameters measured at 10 transects around the lake, Secchi depth measures), and biological measures (benthic macroinvertebrates and plankton). Other measures that should be collected at the index site although not reported on here include temperature, pH, conductivity, and dissolved oxygen profiles. Based on the recommendation in the Ambient Water Quality Criteria (EPA 1986) for freshwater, *E. coli* is a more appropriate indicator for pathogen pollution than Enterococci. Therefore, *E. coli* samples should be collected and analyzed in accordance with Idaho rule (IDAPA 58.01.02.251) to determine suitability for recreational uses.

5.e Summary of Recommendations

The following recommendations are made to improve and implement a robust lakes monitoring program in Idaho.

- Lakes should be classified by size, maximum depth, retention time, and ecoregion.

- Lake reference condition be evaluated consistent with procedures developed for stream and river reference condition and include measures of land use, ecoregions, density of roads, mines, dams, point source discharges, and population within the watershed, and grazing activity at the site.

- To remain consistent with the goal of the ambient monitoring strategy, it is recommended to sample a lake only once per year during the index period of July through early September depending upon lake stratification.

- The lakes monitoring program should include the basic measures of chemistry (phosphorus, nitrogen, and chlorophyll-a), physical habitat measures (riparian and littoral community parameters measured at 10 transects around the lake, Secchi depth measures), and biological measures (benthic macroinvertebrates and plankton).

- Other measures that should be collected at the index site include temperature, pH, conductivity, and dissolved oxygen profiles.

- *E. coli* samples should be collected and analyzed in accordance with Idaho rule (IDAPA 58.01.02.251) to determine suitability for recreational uses.

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Appendix A

Condition estimates for lakes greater than 4 hectares.

The original probability study design evaluated lakes 4 hectares or greater. As was discussed in Section 2.a, the results in the main body of this report evaluated only those lakes with a surface area of 10 hectares or greater. This appendix reports the results as they pertain to the entire target population (4 hectares and greater in size).

In Idaho, there are estimated to be 694 lakes that meet the target criteria of 4 hectares or greater. This corresponds to approximately 94,293 hectares of open water. Of the total number of lakes in Idaho, 30 lakes were sampled. Compared to the 239 lakes that were 10 hectares or larger, a vast majority of lakes in Idaho (454) are between 4 and 10 hectares in size.

Table 15. Statistical breakdown of Idaho's probabilistic lake sampling effort in target population greater than 4 hectares.

Number Evaluated/ Monitored	Lake Type	TNT	Total Area (Ha)	Represents		
				# Lakes	% Area	% Lakes
5	Lake Shallow	Non-Target	411.9	24		
1	Lake Special Purpose	Non-Target	208.4	4		
1	Lake Vegetated	Non-Target	80.1	4		
15	Not Lake	Non-Target	938.5	155		
7	Target Inaccessible	Target	116.9	309	2.69%	44.47%
30	Target Sampled	Target	30341	385	97.31%	55.53%

Of the sites evaluated, seven were eliminated from the final set of sample sites based on site evaluation findings. These sites could not be sampled due to site-specific issues related to physical access and safety of access. These seven target not-sampled sites correspond statistically to approximately 44% of the overall number of lakes and 0.6% of the overall surface area. Therefore, this report is an analysis of about 56% of the total target lakes and about 99% of the total surface area for most metrics. In Idaho, a large number of small lakes are located in wilderness, roadless, or mountainous areas that proved to be inaccessible for this type of study. Although there may a large number of these lakes, they tend to be smaller (4-10 hectares) so although they make up a large percentage of the number of lakes, their overall contribution to surface area is relatively small. This is especially poignant when viewed in light of the surface area of the three largest lakes/reservoirs in Idaho: Lake Pend Oreille, Bear Lake, and American Falls Reservoir. These three alone have a combined surface area of 65,579.2 hectares (72% of the total surface area in the target population). The breakdown of all lakes in the target population (including those that are 4 – 10 hectares) by size class is shown in Figure 13

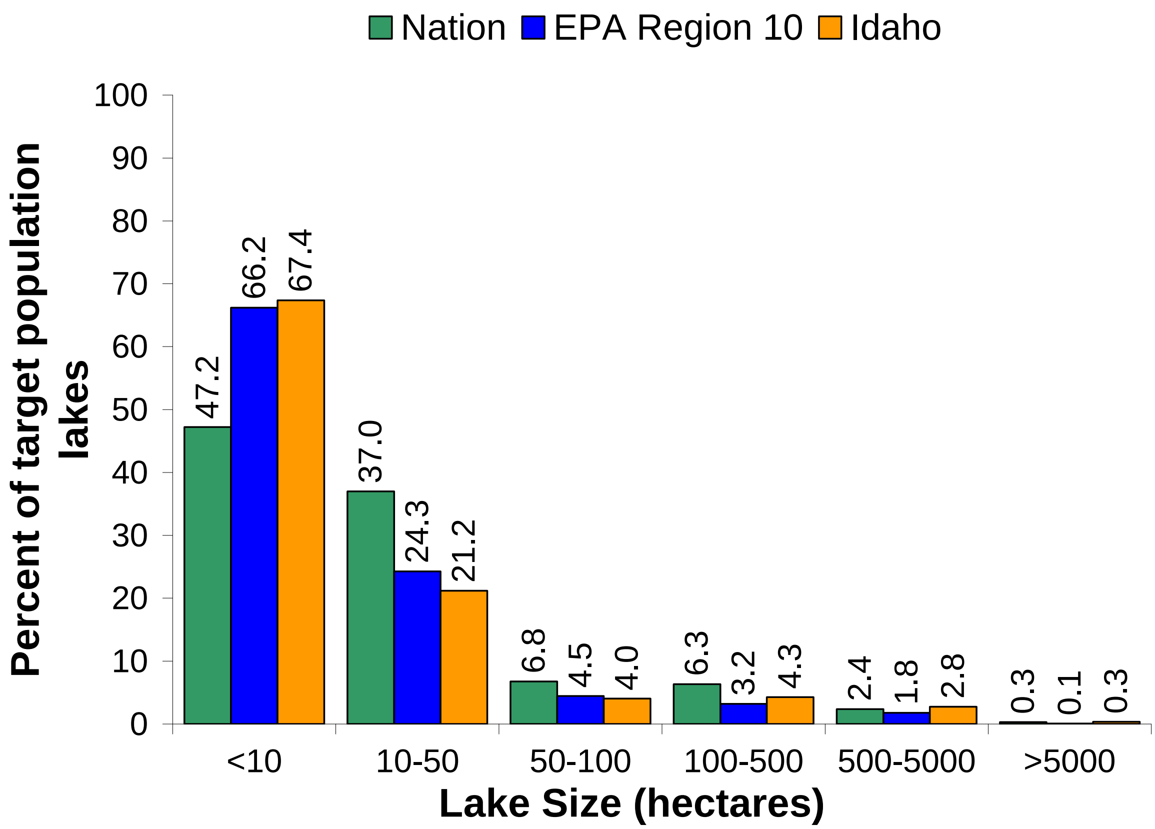

Figure 13. Percentage of all target population lakes in various size classes reported in condition estimates.

As discussed in Section 3.e, the distributions for each category and metric were analyzed to determine the reference condition threshold values. This in turn allowed each site to be given a condition rating—good, fair or poor—for each result evaluated. Once each site was given condition ratings for the available data, all sites were evaluated and overall estimates of condition were produced. Table 16, Table 17 and Table 18 detail the results for condition estimates in each category. These overall condition rating results are for lakes that are 4 hectares or greater in size at the national, regional, and state scales. These results apply to 385 lakes at the state scale.

Table 16. Estimates of overall chemical condition for lakes in target population greater than 4 hectares.

Parameter		Good	Fair	Poor
Total Phosphorus				
	National	58.08%	23.74%	18.18%
	EPA Region 10	57.41%	4.08%	38.51%
	Idaho	84.35%	5.72%	9.93%
Total Nitrogen				
	National	53.76%	27.13%	19.11%
	EPA Region 10	41.25%	9.50%	49.25%
	Idaho	21.13%	10.50%	68.37%

Parameter	Good	Fair	Poor
Chlorophyll-a			
National	67.99%	17.01%	14.55%
EPA Region 10	53.00%	16.04%	30.96%
Idaho	75.00%	9.12%	15.88%
Turbidity			
National	77.53%	16.21%	6.26%
EPA Region 10	57.57%	15.46%	26.97%
Idaho	77.47%	13.65%	8.88%

Estimates for the various chemical parameters show that the majority of Idaho's lakes fall in the good and fair categories. When including the smallest lakes (those between 4 and 10 hectares) the national results show only small changes in the percentages between good, fair and poor condition assessments. There are somewhat larger changes in the regional results with an increased percentage of lakes in good condition for phosphorus, chlorophyll–a, and turbidity, while the percentage of good condition assessments for nitrogen remained the same. Regionally,, percentages of lakes with a poor condition rating increased for nitrogen and turbidity and decreased for phosphorus and chlorophyll-a.

In Idaho, there was a significant difference in the overall estimates of condition when evaluating all 30 sites. This was due to the relatively large weighting factor that was applied to a single lake monitored within the 4 – 10 hectare size class. When comparing the percentages of lakes in the good category, those rated good for total phosphorus, chlorophyll-a, and turbidity increased by 24 – 39% while those rated good for total nitrogen decreased by 33%. The percentage of lakes rated poor for total nitrogen increased by 49% and decreased by 14-25 % for the other chemical parameters. Trends in chemical conditions show that the majority of lakes are in good condition with the exception of nitrogen at the regional and state scales.

Table 17. Estimates of overall biological condition for lakes in target population greater than 4 hectares.

Parameter	Good	Fair	Poor	Not Assessed
Plankton O/E				
National	55.81%	21.25%	21.79%	1.15%
EPA Region 10	62.40%	9.98%	26.62%	1.00%
Idaho	83.24%	4.75%	9.62%	2.39%
Lake Diatom Condition				
National	48.36%	26.05%	22.79%	2.80%
EPA Region 10	66.14%	27.61%	2.96%	3.29%
Idaho	85.19%	10.40%	1.93%	2.48%

When evaluating the biological community, again, there is only a small change in the estimates of condition at the national scale (roughly 1.5 to 5 % change), while regionally the changes range from 1 to 26%. At the state scale, the change in condition estimates of the biological community are much more significant with smallest change being a 3% decrease in the estimates of poor biological condition for the Lake Diatom Condition Index and the largest change being a 26% increase in good condition estimate for the O/E Index and 23% in good condition for the Lake

Diatom Condition Index. This change in condition estimates tracks exactly with the weighted condition rating for the single lake monitored in the 4 – 10 hectare size class which was rated as good for plankton O/E Index and good for Lake Diatom Condition Index.

As shown in Table 17, Idaho estimates a higher percentage of lakes in the good condition for biological communities than either the regional or national estimates. The percentage of lakes estimated as not assessed is relatively consistent between the three scales. Lakes were considered not assessed for a biological parameter if no data was collected or the sample was not processed in accordance with the quality assurance project plan.

Physical habitat parameters are used to evaluate the effects of human disturbance on the riparian and littoral habitat. Four measures of habitat impact were evaluated including shoreline disturbance, riparian vegetation cover and complexity, littoral cover and complexity, and a metric that looks at the riparian and littoral boundary. Idaho lakes show only a small percentage of lakes in good condition regarding the shoreline disturbance metric (less than 1%) while the majority of lakes are in fair condition (89%). Idaho lakes show the highest percentage of good condition in the littoral cover and complexity metric with 88% being estimated as good (Table 18).

Table 18. Estimates of overall physical habitat condition for lakes in target population greater than 4 hectares.

Parameter	Good	Fair	Poor	Not Assessed
Shoreline Human Disturbance				
National	34.83%	47.63%	16.88%	0.66%
EPA Region 10	19.29%	50.71%	29.86%	0.14%
Idaho	0.88%	89.23%	9.26%	0.63%
Riparian Vegetation Cover Complexity				
National	45.51%	17.83%	35.94%	0.72%
EPA Region 10	35.18%	29.56%	35.12%	0.14%
Idaho	9.98%	72.66%	16.73%	0.63%
Littoral Cover and Complexity				
National	58.72%	20.45%	20.14%	0.69%
EPA Region 10	68.85%	26.14%	4.86%	0.15%
Idaho	87.93%	5.36%	6.08%	0.63%
Littoral-Riparian Cover and Complexity				
National	46.79%	20.09%	32.36%	0.76%
EPA Region 10	50.33%	15.83%	33.70%	0.14%
Idaho	73.30%	9.34%	16.73%	0.63%

General changes in the estimates of physical habitat condition again showed little change on the national scale (1-5%), more change at the regional level (2-16%) and the most change at the state scale (1-41%). The greatest change was a change of 42% in the estimate of lakes in fair condition for riparian vegetation cover and complexity and 41% in the estimate of lakes in good condition for the littoral-riparian cover and complexity index. The overall trend for physical habitat parameters shows that Idaho estimates significantly lower percentages of lakes in good condition for the shoreline human disturbance index and the riparian vegetation cover complexity indices and significantly higher percentages of lakes in good condition for the littoral cover and complexity and the joint littoral-riparian cover and complexity indices as compared to the national and regional scales. For the index of shoreline human disturbance, Idaho estimates the largest percentage of lakes to be in fair condition (89%) and a small percentage (9%) to be in poor condition.

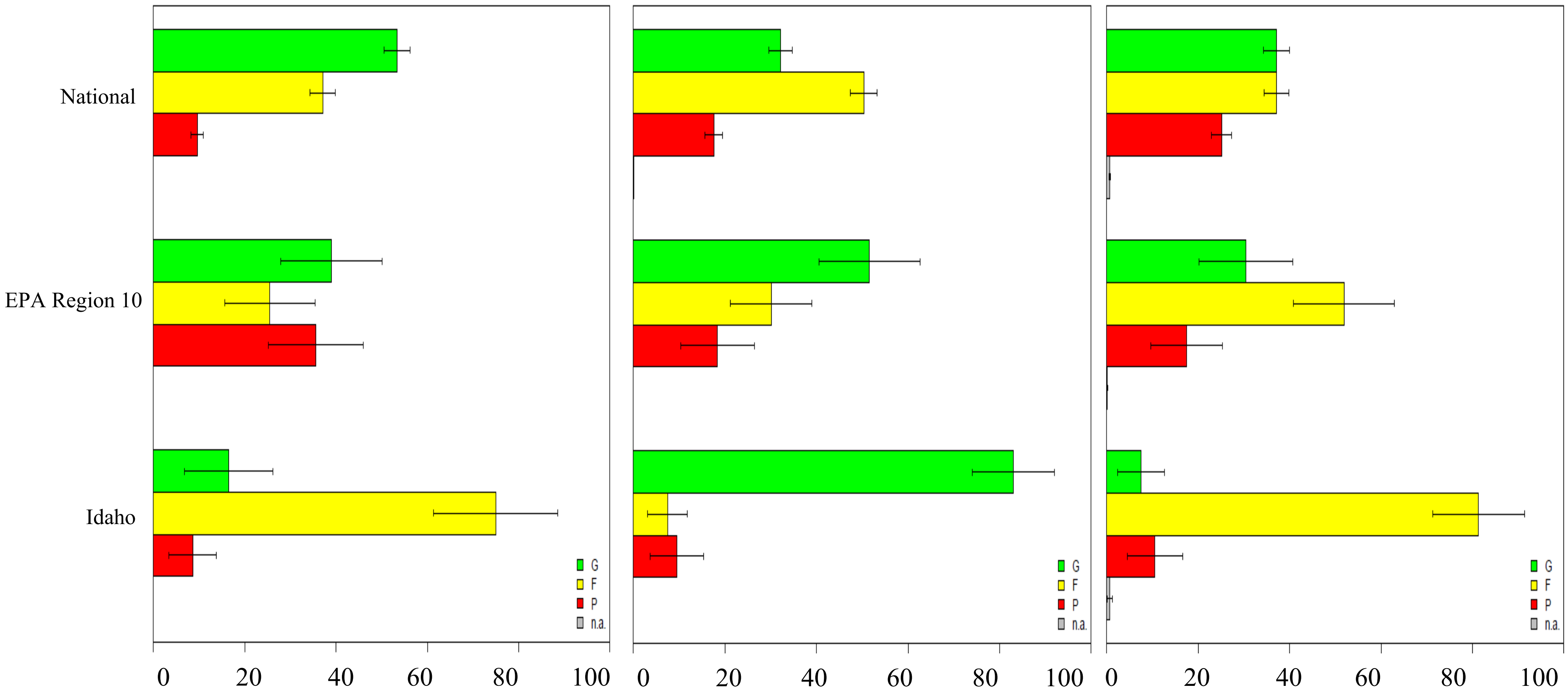

Figure 14. Overall condition rating for chemical (left) and biological (center) and physical habitat (right) indices for target population greater than 4 hectares.

Good Fair Poor Not assessed

Condition estimates for each parameter in each category were evaluated, scored and combined as described in Section 3.e. The results of these evaluations are shown in Figure 14 and Figure 15. Most Idaho lakes were classified good for chemistry and biology, and fair for physical habitat and overall condition. Nationally, most lakes were classified good for chemistry, and fair for biology, physical habitat, and overall condition. Regional results showed the same percentages of lakes being classified good and poor for chemistry and most lakes classified as fair for biology, physical habitat, and overall condition.

Idaho had 32% of lakes (51 lakes) classified as being in overall poor condition. Regionally, 28% of lakes were classified in overall poor condition and 19% nationally were in overall poor condition. The highest percentage (47%) of lakes in Idaho was classified as fair (75 lakes) while only 21% were classified as good (34 lakes).

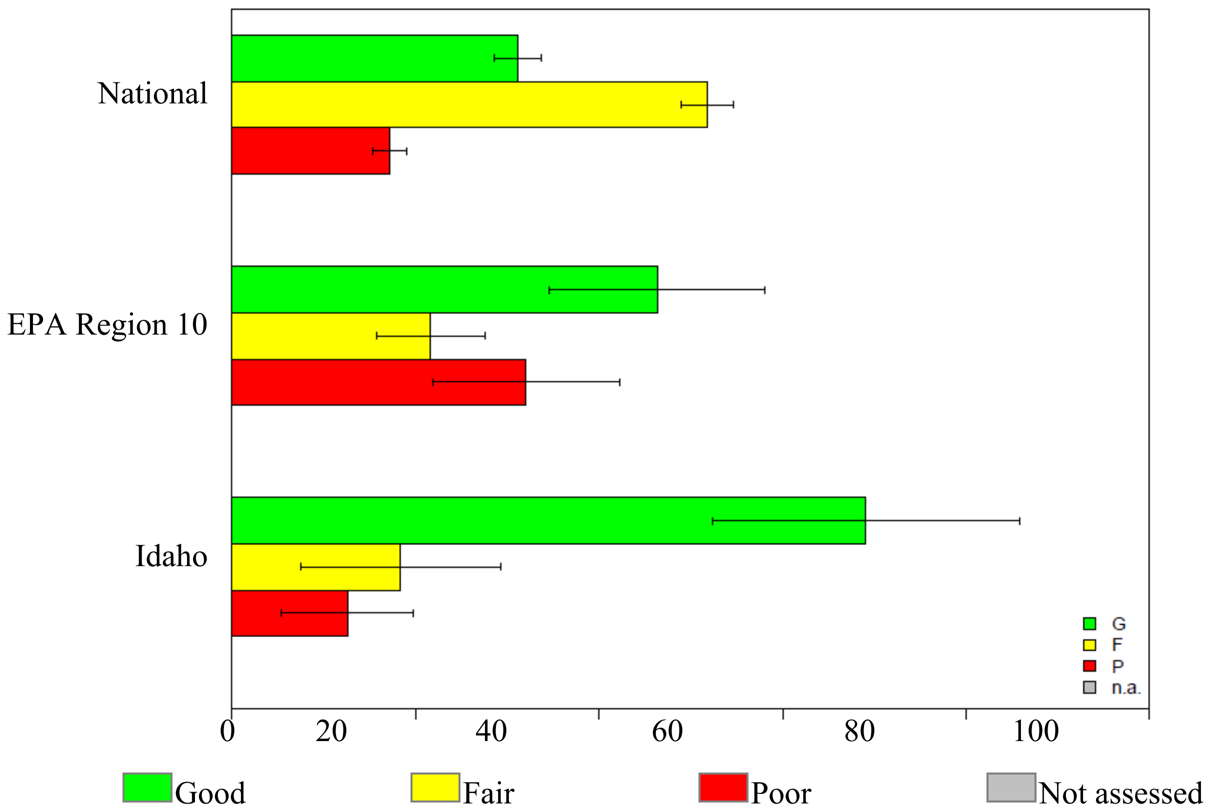

Figure 15. Overall condition ratings for target population greater than 4 hectares.