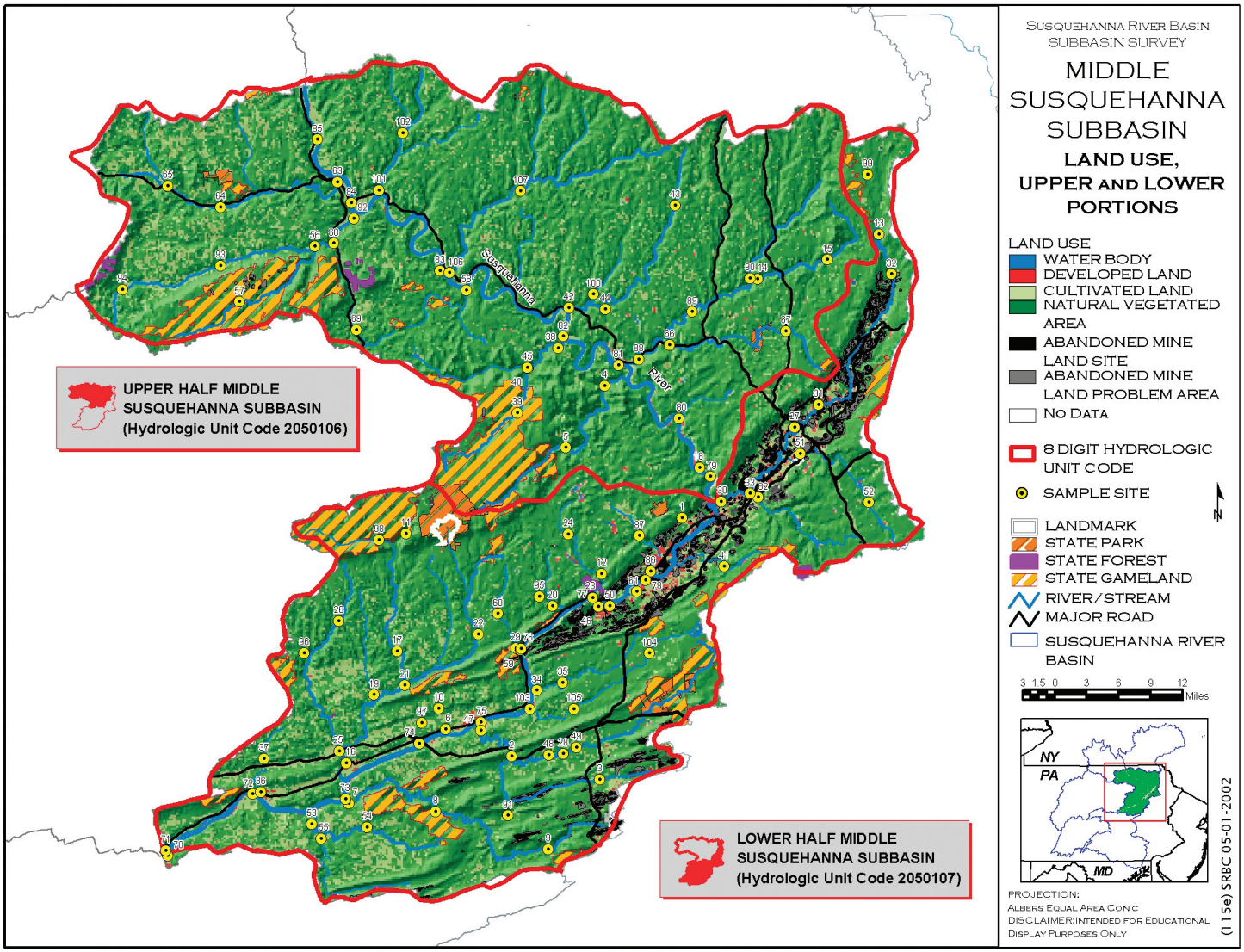

Figure 3. *Land Use in the Middle Susquehanna Subbasin*

Methods Used in the Subbasin Survey

DATA COLLECTION

During the summer of 2001, SRBC visited 106 sites throughout the Middle Susquehanna Subbasin and took water quality samples at all sites. Appendix A contains a list with the sample site number, the station name (designated by stream mile), a description of the sampling location, the ecoregion, and the drainage size category. Macroinvertebrate samples were taken at all but three sites due to excessive low flow (HNL 0.1), no riffle habitat (SUSQ 125.0A/B), or deep iron precipitates (NPT 0.1). Habitat was rated at all sites where a macroinvertebrate sample was collected and at NPT 0.1.

The sites were sampled once in this Year-1 sampling round in order to provide a point-in-time look at stream characteristics throughout the whole subbasin. Samples were collected using a slightly modified version of the U.S. Environmental Protection Agency's (USEPA's) *Rapid Bioassessment Protocols for Use in Streams and Rivers* (RBP III) (Plafkin and others, 1989). Sampling was performed during the summer, when base flow was sustained primarily by ground water.

Water Quality

A portion of the water sample was separated for laboratory analysis, and the rest of the sample was used for field analysis. A list of the field and laboratory parameters and their units is found in Table 1. Measurements of flow, water temperature, dissolved oxygen, pH, conductivity, alkalinity, and acidity were taken in the field. Flow was measured using standard United States Geological Survey (USGS) methodology. Temperature was measured with a field thermometer in degrees Celsius. A Cole-Parmer Model 5996 meter was used to measure pH. Dissolved

Field Parameters	
Flow, instantaneous cfs[a]	Conductivity, µmhos/cm[c]
Temperature, °C	Alkalinity, mg/l
pH	Acidity, mg/l
Dissolved Oxygen, mg/l[b]	
Laboratory Analysis	
Specific Conductance, µmhos/cm	Total Sodium, mg/l
pH	Total Potassium, mg/l
Alkalinity, mg/l	Chloride, mg/l
Total Suspended Solids, mg/l	Sulfate - IC, mg/l
Total Nitrogen, mg/l	Total Fluoride, mg/l
Total Ammonia - N, mg/l	Total Copper, µgrams/l[d]
Nitrite - N, mg/l	Total Iron, µgrams/l
Nitrate - N, mg/l	Total Lead, µgrams/l
Total Phosphorus, mg/l	Total Manganese, µgrams/l
Total Organic Carbon, mg/l	Total Nickel, µgrams/l
Total Hardness, mg/l	Total Zinc, µgrams/l
Total Calcium, mg/l	Total Aluminum, µgrams/l
Total Magnesium, mg/l	Total Orthophosphate, mg/l

[a] cfs = cubic feet per second
[b] mg/l = milligram per liter
[c] µmhos/cm = micromhos per centimeter
[d] µgrams/l = micrograms per liter

Table 1. *Water Quality Parameters Sampled in the Middle Susquehanna Subbasin.*

oxygen was measured with a YSI 55 meter, and conductivity was measured with a Cole-Parmer Model 1481 meter. Alkalinity was determined by titration of a known volume of sample water to pH 4.5 with 0.02N H_2SO_4. Acidity was determined by titration of a known volume of sample water to pH 8.3 with 0.02N NaOH.

One 500-ml bottle and two 250-ml bottles of water were collected for laboratory analyses. One of the 250-ml bottles was acidified with nitric acid for metal analysis. The other 250-ml bottle was acidified with sulfuric acid for nutrient analysis. Samples were iced and shipped to the Pa. Department of Environmental Protection, Bureau of Laboratories in Harrisburg, Pennsylvania.

Macroinvertebrates

Benthic macroinvertebrates (organisms that live on the stream bottom, including aquatic insects, crayfish, clams, snails, and worms) were collected using a modified version of RBP III (Plafkin and others, 1989). Two kick screen samples were obtained at each station by disturbing the substrate of representative riffle/run areas and collecting dislodged material with a one-meter-square 600-micron mesh screen. Each sample was preserved in 95 percent denatured ethyl alcohol and returned to SRBC's lab, where the sample was sorted into a subsample of at least 100 organisms. Organisms in the subsample were identified to genus, except for midges and aquatic worms, which were identified to family.

Habitat

Habitat conditions were evaluated using a modified version of RBP III (Plafkin and others, 1989; Barbour and others, 1999). Physical stream characteristics relating to substrate, pool and riffle composition, shape of the channel, conditions of the banks, and the riparian zone were rated on a scale of 0-20, with 20 being optimal. Other observations were noted about weather, substrate material composition, surrounding land use, and any other relevant features in the watershed.

DATA ANALYSIS

Seven reference categories were created for data analysis. The 15 sites on the main stem of the Susquehanna River were grouped into the same reference category in order to compare them to each other and observe how the water quality changes downstream. All the other sites in the Middle Susquehanna Subbasin were divided into reference categories based on ecoregions (Omernick, 1987) and drainage size. The three ecoregions were Ecoregion 60 (Northern Appalachian Plateau and Uplands), Ecoregion 62 (North Central Appalachians), and Ecoregion 67 (Central Appalachian Ridges and Valleys) (Figure 2). All the sites within each ecoregion were divided into small drainage areas (<50 square miles) and medium drainage areas (>50 square miles).

Taxonomic Richness: the total number of taxa in the sample. Number decreases with increasing stress.

Percent Contribution of Dominant Taxa: the percentage of the taxon with the largest number of individuals out of the total number of macroinvertebrates in the sample. Percentage increases with increasing stress.

EPT Index: the total number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa present in a sample. Number decreases with increasing stress.

Ratio of EPT to Chironomidae: the total number of individuals in the orders Ephemeroptera, Plecoptera, and Trichoptera divided by the number of Chironomidae (midges) in a sample. Ratio decreases with increasing stress.

Shannon-Wiener Diversity Index: a measure of the taxonomic diversity of the community. Index value decreases with increasing stress.

Hilsenhoff Biotic Index: a measure of organic pollution tolerance. Index value increases with increasing stress.

Water quality was assessed by examining 32 water quality parameters, including nutrients, major ions, and metals. For each parameter, all the sites were ranked from lowest value to highest value within each reference category. A percentage of the highest value (representing the worst water quality) was taken for all parameters except dissolved oxygen (the lowest value represented the worst water quality). All the percentages for each parameter were averaged for a Water Quality Index (WQI) score (McMorran and Bollinger, 1990), with the lowest percentages representing better water quality. The difference between WQI values was divided into thirds creating "higher" quality, "middle" quality, and "lower" quality designations. Only 22 out of the 32 parameters were analyzed because temperature, pH (field and lab), alkalinity (field and lab), acidity, calcium, magnesium, potassium, and fluoride could not be ranked for use in the WQI.

Benthic macroinvertebrate samples were analyzed using six metrics: Taxonomic Richness; Percent Contribution of Dominant Taxa; EPT (Ephemeroptera, Plecoptera, Trichoptera) Index; Ratio of EPT to Chironomidae; Shannon-Wiener Diversity Index; and Hilsenhoff Biotic Index.

Reference sites were determined for each reference category, primarily based on the results of the macroinvertebrate metrics and secondarily based on habitat and WQI scores, to represent the best combination of conditions. The metric scores were compared to the reference scores and a biological condition category was assigned based on RBP III methods (Plafkin and others, 1989; Barbour and others, 1999).

The same reference sites were used in the analysis for the habitat scores. The ratings for each habitat condition were totaled and a percentage of the reference site was calculated. The percentages were used to assign a habitat condition category to each site (Plafkin and Barbour and others, 1999).

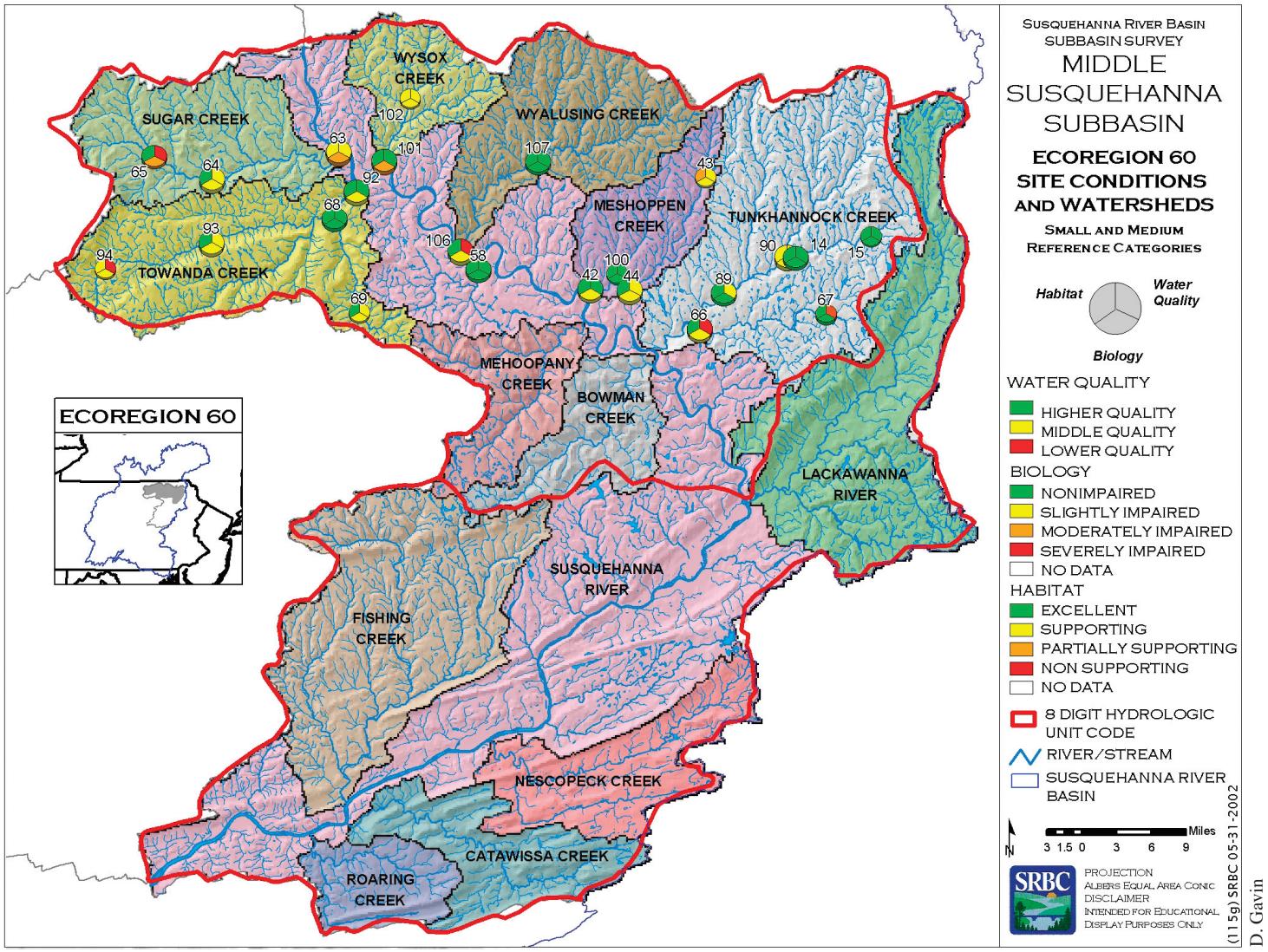

Figure 4. *Water Quality, Biological, and Habitat Categories in Ecoregion 60 (small and medium drainage) Sample Sites in the Middle Susquehanna Subbasin.*

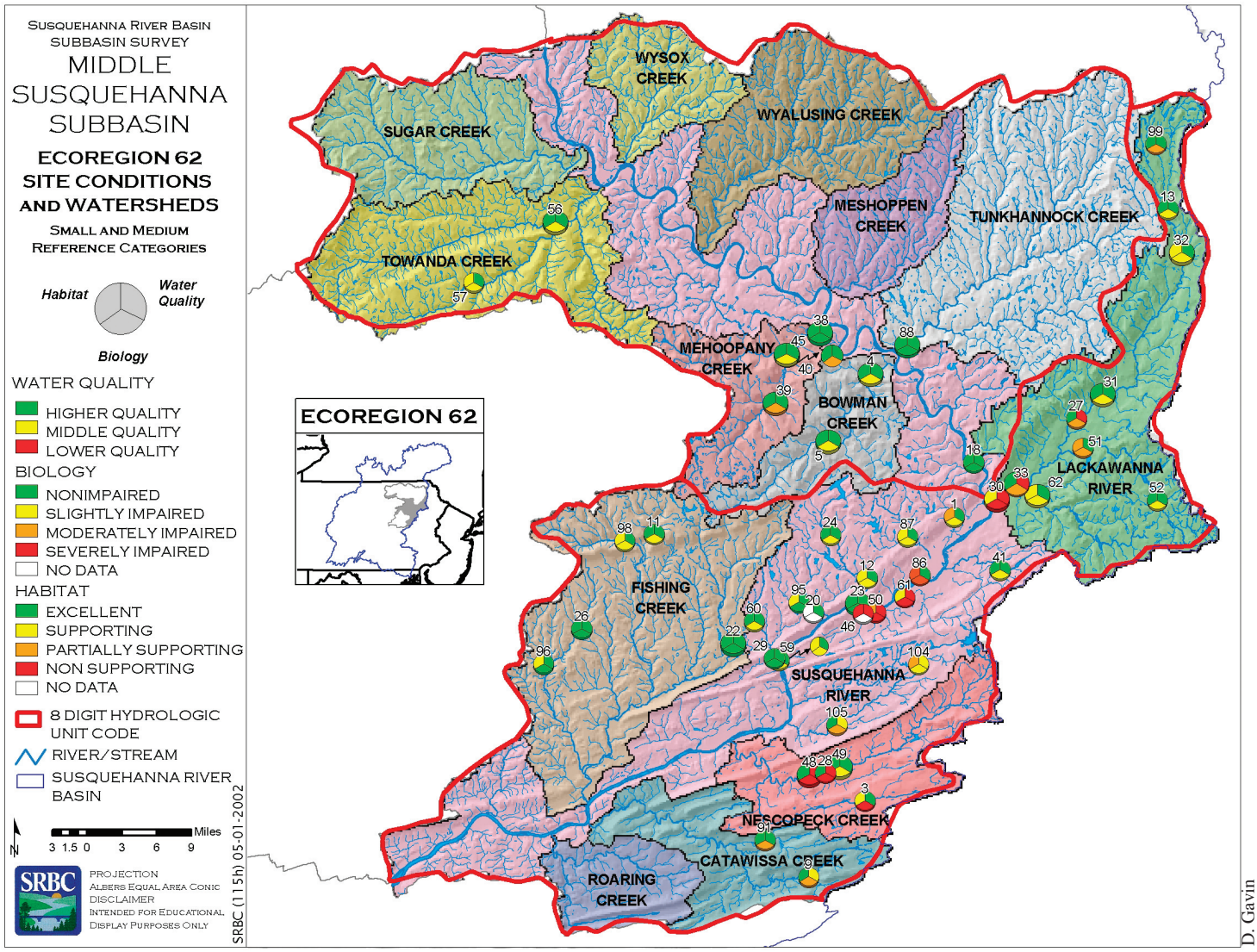

Figure 5. *Water Quality, Biological, and Habitat Categories in Ecoregion 62 (small and medium drainage) Sample Sites in the Middle Susquehanna Subbasin.*

Results/Discussion

The Middle Susquehanna Subbasin was divided into an "Upper Half" and a "Lower Half" based on USGS Hydrologic Unit Code (HUC) 8 (Seaber and others, 1987) in order to differentiate between the major land uses in the Middle Susquehanna Subbasin. Figure 3 shows that abandoned mine lands and urban development had a greater influence on the "Lower Half" of the subbasin. Table 2 lists sites that have extreme values in parameters that are characteristic of AMD or agriculture/wastewater treatment plants. Only values that exceeded limits based on values from Hem (1970), The Commonwealth of Pennsylvania (2002), Gagen and Sharpe (1987), and Baker and Schofield (1982) are listed. Most of the sites in Table 2 were located within the "Lower Half" of the Subbasin. Table 3 lists the same parameters that are characteristic of AMD or agriculture/wastewater treatment plants; however, it contains values for sites that have been designated as Exceptional Value (EV) and High Quality-Cold Water Fishes (HQ-CWF) for comparison to the values in Table 2.

Figures 4 - 7 show the larger watersheds in the subbasin and their relative locations. These figures also show the ratings for water quality, biological condition, and habitat condition relative to the corresponding reference category. Figure 8 (A, B, and C) shows a summary of the ratings for water quality, biological condition, and habitat condition in each reference category. Ecoregion 62 contained most of the severely impaired streams (Figure 8 B), and all of the streams rated nonsupporting in habitat (Figure 8 C). Figures 9 – 12 show the relationships of biological and habitat condition scores at sample sites in each reference category.