

Section 4: Lichen Indicator

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Introduction

Lichens are very responsive to environmental stressors in forests, including changes in forest structure, air quality, and climate. Each lichen species on a plot is an indicator of how lichen communities respond to ecological conditions. Individual lichen species occur erratically and even common species are often absent from plots with suitable habitat. The combined response of all species is a better indicator of ecological conditions than responses of any one or a few lichen species.

FIA is interested in developing ecological gradients; the main gradients of interest are for air pollution and climate. Plot values for these gradients are assigned based on lichen species data. Lichen data are evaluated to assess spatial patterns and trends in ecological conditions of the plots. For details on how gradients are developed and analysis of lichen data see Will-Wolf (in press).

The lichen indicator field procedures (USDA Forest Service 2007) require the production crew to collect samples from as many lichen species on a plot as possible in the allowed sample time and assign an abundance class to each species. The allowed sample time is variable; the instructions (found in section 10.1.4 of the phase 3 (P3) field guide; USDA Forest Service 2007) are: “Sampling continues for a maximum of two hours or until 10 minutes elapse with no additional species recorded. At least 45 minutes in the Northwest, North Central, South and West Coast including Alaska, and 30 minutes in the Intermountain West, must be spent searching the plot, even if few lichens are present.” The production crew sends all collected samples to a regional lichen identification specialist to identify lichen species.

Lichen indicator quality analysis (QA) data and the structure of the management quality objective (MQO) are different from the standard FIA model of blind checks by a QA crew. A regional lichen QA specialist is considered an expert standard and provides measurements of variables. The lichen QA specialist visits the field plot and follows the same protocols as the production crew. A lichen QA specialist can be either a lichen identification specialist trained in FIA field protocols or a production crew member certified for lichens QA. Crew members that regularly achieve very high QA scores are candidates for certified lichen QA specialists.

The sampling protocol for the lichen indicator has been stable since 1994 and QA data have been collected since 1999.

As already stated, another difference from the standard FIA QA model is that lichen indicator data are from a timed sample rather than a complete inventory, and lichen species identification does not occur in the field. These differences have implications for how the MQO standards for the lichen variables are stated and evaluated.

Lichen data collected in the field can be divided into two sets. The first set contains three variables. Two of the variables, collection number and abundance score, are written on the packets containing the samples that are sent to the lichen specialist for species identification. The third variable, number of species, is determined after the lichen identification specialist identifies the species contained in the field samples. The second set of variables consists of all the remaining variables, which we will refer to as field-entered variables.

The collection number and abundance score (sections 10.3.8 and 10.3.9 in the lichen chapter of the P3 field guide; USDA Forest Service 2007) are recorded only on field sample packets. Collection numbers are unique to each field collection, so independent remeasurement of collection number is neither possible nor appropriate. The only logical MQO compliance factor is whether or not collection numbers were recorded. Currently there is no provision for entering into the database whether or not collection numbers were provided, so it would be difficult now to evaluate the MQO compliance rate and it is not considered further here.

What is important are the species of the lichen and the abundance score of each species. Since the species are not identified by the crew, the MQO is based on compliance rate for number of species found, stated as a minimum standard for 'successful performance of sample procurement procedure' (item 8 in section 10.2 in the lichen chapter of the P3 field guide; USDA Forest Service 2007). As will be explained in greater detail in the next section, what is of interest for MQO compliance is the number of lichen species found by the production crew in relation to the number of lichen species found by the lichen QA specialist, rather than the names of the species found. The current MQO compliance rate for abundance score only applies when the same species are tallied by both the production crew and lichen QA specialist, and the relevant comparison is between the final abundance score for each identified species as calculated by the lichen identification specialist, not the scores recorded in the field. Preliminary studies by lichen identification specialists have been conducted on how to evaluate the repeatability of abundance score. Further work is needed to determine the best MQO compliance rate that can be measured, given the way the lichen data are collected.

The field-entered lichen variables can be divided into two subsets. The first subset is the variables that identify the plot, i.e., P3 hex number, FIA plot number, state and county, and document the plot visit, i.e., date, etc. (variables 10.3.1 through 10.3.15 in the Lichen chapter of the P3 field guide; USDA Forest Service 2007). Except for variable 10.3.13, these variables are not of interest for this study. Variable 10.3.13 indicates whether the plot was searched for lichens and whether, if searched, any lichens were found. The values of this variable in the FIA database must completely match lichen lab data records (100 percent MQO compliance). Any mismatches are 100 percent resolved before lichen lab data can be successfully entered into the database. The incidence of such errors has been rare and has not been formally assessed.

The second subset (variables 10.3.16 through 10.3.24 in the Lichen chapter of the P3 field guide; USDA Forest Service 2007) are secondary variables that are intended for use by a lichen data analyst to understand any anomalies in the lichen species and abundance variables. On most QA plots, the lichen QA specialist has not collected these data electronically and the variables will not be analyzed in this study.

Summarizing, the only QA analysis that will be done in this study will be of the variable number of species. The number of species is determined after species identification of the field samples by a lichen identification specialist.

MQO for Number of Lichen Species

Studies of repeatability and reliability for the lichen indicator (McCune et al. 1997; and regional gradient models such as Jovan and McCune 2005, 2006; Geiser and Neitlich 2006) support establishment of the minimum QA standard. If the number of species the production crew finds is at least 65 percent of the number of species found by a lichen QA specialist, then repeat samples on the same plot reliably result in plot scores on gradients of interest that fall within the same 10 percent of the full range (length) of the original gradient. As long as the minimum QA standard of 65 percent is met, deviations of plot scores for repeat samples that are on average greater than 10 percent can be considered evidence of change in the relevant ecological condition. Deviations that are on average less than 10 percent are considered to be due to plot-level sampling error. If production crew samples on average achieve much higher than the minimum QA standard of 65 percent, it is likely that deviations due to sampling error might be smaller, thus smaller changes in response to gradients of interest might be detected.

Based on these studies, 65 percent of the number of species a QA lichen specialist finds is the minimum tolerance for lichen indicator lab data; the percentage, computed as $100 * [(\text{Number of species production crew}) / (\text{Number of species QA specialist})]$, is the QA score for a plot. Tolerance is expressed as a minimum QA score of 65 percent rather than a range because any higher percentage improves the reliability of the data; QA scores can be (and are, see Figs. 4.5-4.7) above 100 percent. The MQO compliance rate for the lichen indicator is that the minimum tolerance be achieved for 90 percent of the plots sampled for QA.

Methods

To evaluate each region's performance, FIA established a goal of at least 10 QA plots per year in each region where lichen data are being collected. QA sampling intensity for lichens has varied by years and by regions. We analyzed QA data for PNW, IW, and NE FIA regions. There was only one QA plot for SRS, so this region is not included in the analysis of lichen indicator QA data. The number of QA plots by year and by region is given in Table 4.1. The total number of production plots by year and by region is also in Table 4.1. The datum for each plot consists of a QA score, where:

$$\text{QA score} = 100 * (\text{Number of Species production crew}) / (\text{Number of Species QA specialist})$$

Table 4.1—Number of lichen QA and production plots by year and region.

Year	IW		NE		PNW	
	QA	Production	QA	Production	QA	Production
1999	3	219	4	159	4	112
2000	3	45	9	257	10	165
2001	10	141	10	213	9	165
2002			11	226		
2003	12	185	10	234	12	165
2004	9	149	5	87		
2005	10	158	2	28		

Results and Discussion

Table 4.2 presents a summary evaluation of QA scores for the combined data from the three regions and for each region individually across all years. Figure 4.1 presents the frequency distribution of the QA scores for all the regions. Figures 4.2-4.4 present the frequency distributions of QA scores for each region separately. These frequency distributions facilitate evaluating how close each region is to achieving threshold of 65 percent QA scores. While the left three bars contain plots that did not meet the threshold, the relative proportion of plots in these three bars indicates the degree of work needed to bring the QA scores up to the 65 percent threshold. For instance, if all the plots that are below the threshold are in the 55-64.9 percent group, less improvement is needed to meet the 65 percent threshold than if all are in the 0-44.9 percent group. Figures 4.5-4.7 present scatter plots of QA scores by year for each region separately, to facilitate evaluation of differences between years and whether they relate to sample size in a year. Figures 4.8-4.10 present scatter plots of QA scores for all years for each region separately, by number of species for QA specialist. This facilitates evaluation of differences between plots with few species versus many species. Note that Table 4.2 contains the compliance rate for each region, i.e., the percentage of the plots that are to the right of the vertical line in Figures 4.5-4.10.

We are not currently meeting our MQO of 90 percent of QA plots meeting minimum tolerance (Table 4.2) in any region. Frequency diagrams in Figs. 4.1-4.4 indicate that overall we are trending in the right direction, and the IW and PNW regions are close. If we could boost crew achievement to move all QA scores below 65 percent up one category, it appears we would meet the MQO for QA in those two regions. A large proportion of QA scores in those two regions are well above minimum tolerance, which is an excellent outcome.

Table 4.2—The percentage of QA scores which met the minimum tolerance that the number of species found by the production crew is at least 65 percent of the number of species the lichen QA specialist found.

Area	% MQO compliant	No. of QA scores
Combined	65	133
IW	74	47
NE	51	51
PNW	74	35

Scatter plots of QA score by year (Figs. 4.5-4.7) show there were peak performance years in each region, but they show no evidence that performance differs markedly in years with few versus many QA scores. Relatively few QA scores in 1999 and 2000 are a consequence of difficulty with logistics of QA sampling in those early years.

Scatter plots of QA score by number of species found by the QA specialist (Figs. 4.8-4.10) do not suggest any strong differences in proportion that met tolerance for very species-rich versus very sparse plots, suggesting training for how to search for lichens is equivalent for these very different kinds of plots.

We have not evaluated QA scores by individual or by years of crew experience. It appears from qualitative examination of certification scores and QA scores over the years that some individuals do perform better than others. It also appears from qualitative examination of QA scores over the years that many individuals perform better in their second and later years. Retention of well performing crew members for multiple years would likely boost QA scores in general. Some preselection of crew members for collection of lichens based on expressed interest and/or other criteria to be developed might also be considered; this might also boost QA scores in general.

Figure 4.1—Frequency distribution of the QA scores for all regions. QA score = $100 * (\text{Number of Species production crew}) / (\text{Number of Species QA specialist})$.

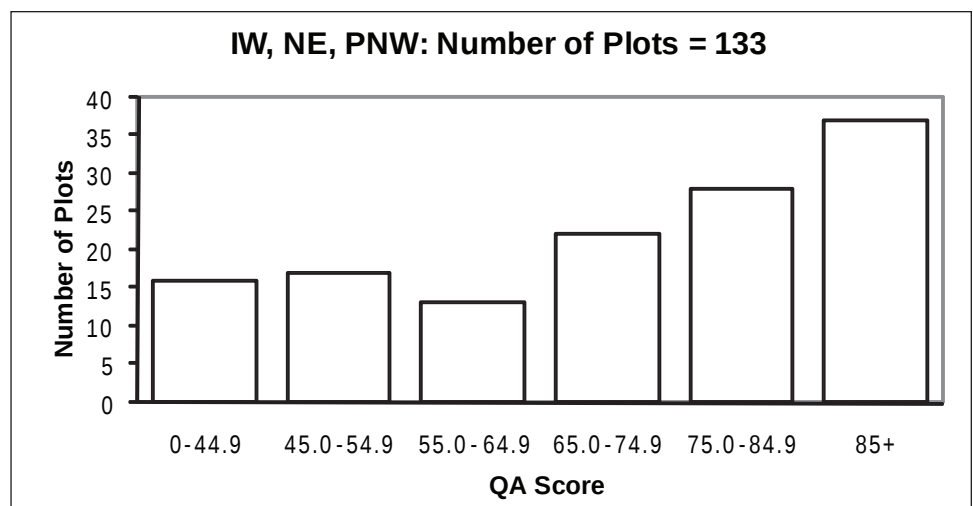


Figure 4.2—Frequency distribution of the QA scores for Interior West region. See Figure 4.1 caption for definition of QA score.

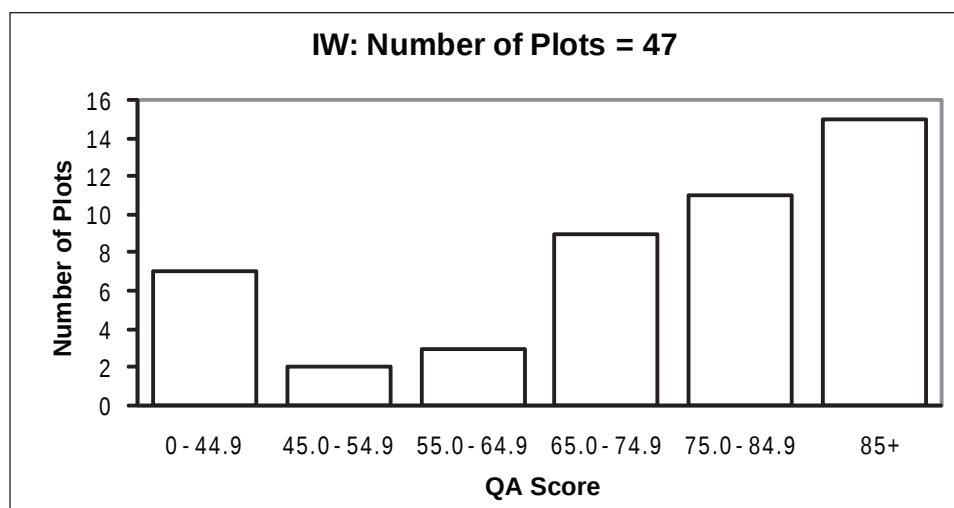


Figure 4.3—Frequency distribution of the QA scores for Northeast region. See Figure 4.1 caption for definition of QA score.

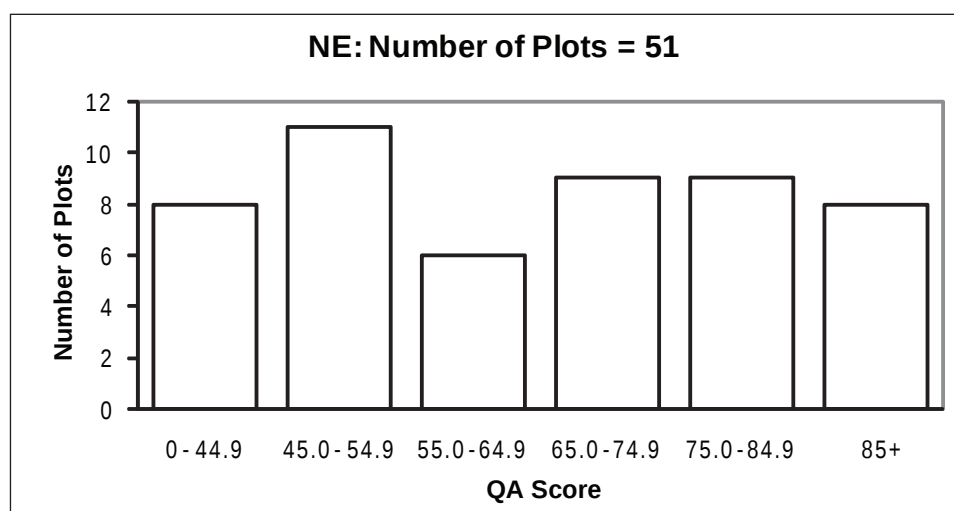


Figure 4.4—Frequency distribution of the QA scores for PNW. See Figure 4.1 caption for definition of QA score.

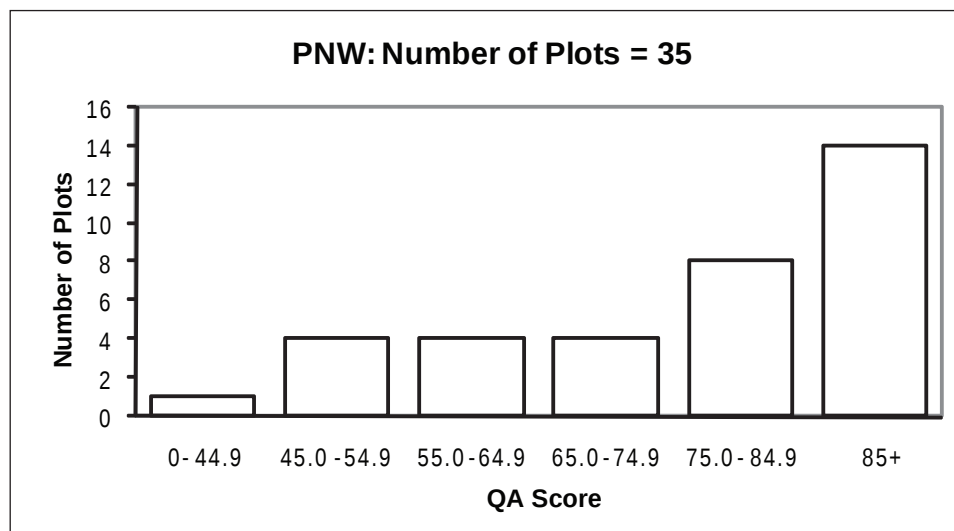


Figure 4.5—Scatter plots, by year, of the QA scores for IW. Points to the right of the vertical line QA Score = 65 achieve minimum tolerance. See Table 4.2 for overall compliance rate.

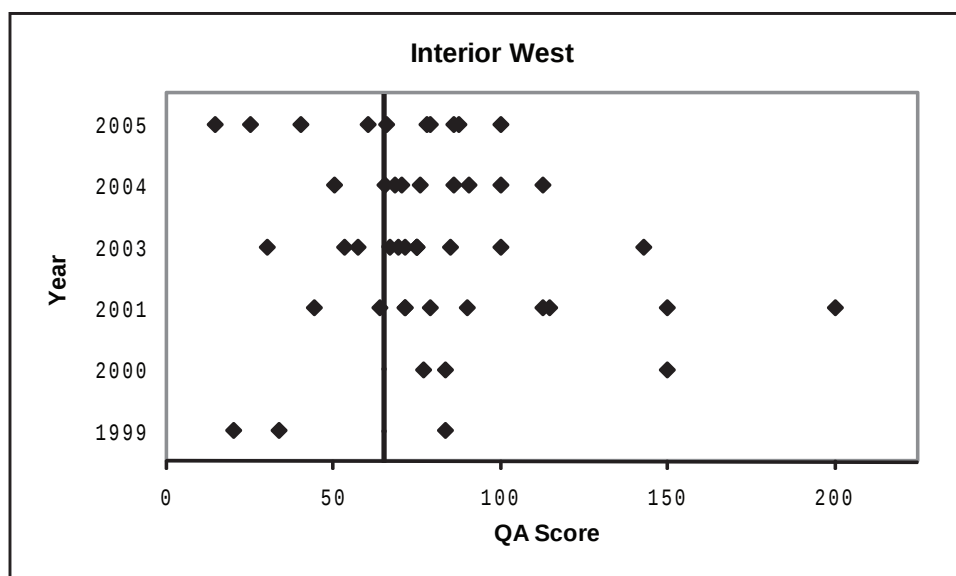


Figure 4.6—Scatter plots, by year, of the QA scores for NE. Points to the right of the vertical line QA Score = 65 achieve minimum tolerance. See Table 4.2 for overall compliance rate.

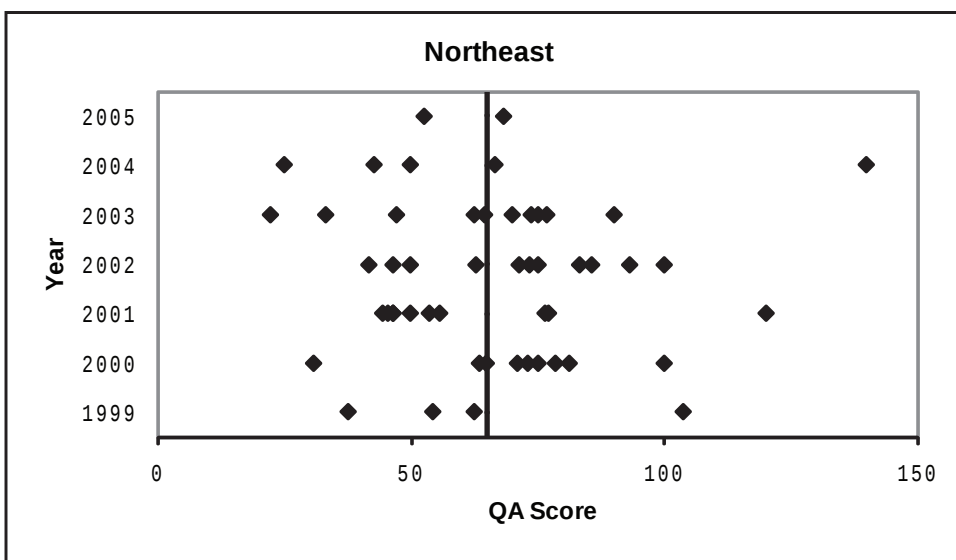


Figure 4.7—Scatter plots, by year, of the QA scores for PNW. Points to the right of the vertical line QA Score = 65 achieve minimum tolerance. See Table 4.2 for overall compliance rate.

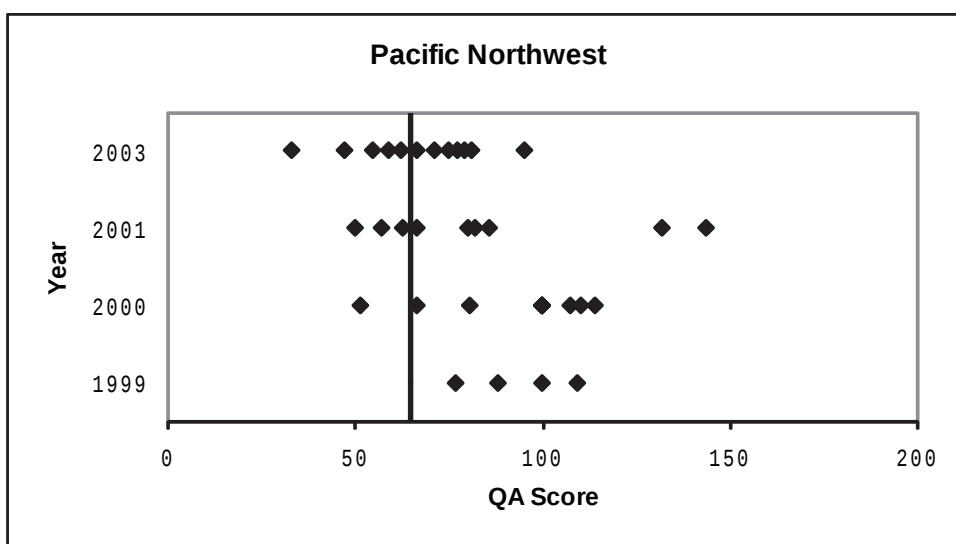


Figure 4.8—Scatter plots, by categories of the total number of species found by the QA specialist, of the QA scores for IW. Points to the right of the vertical line QA Score = 65 achieve minimum tolerance. See Table 4.2 for overall compliance rate.

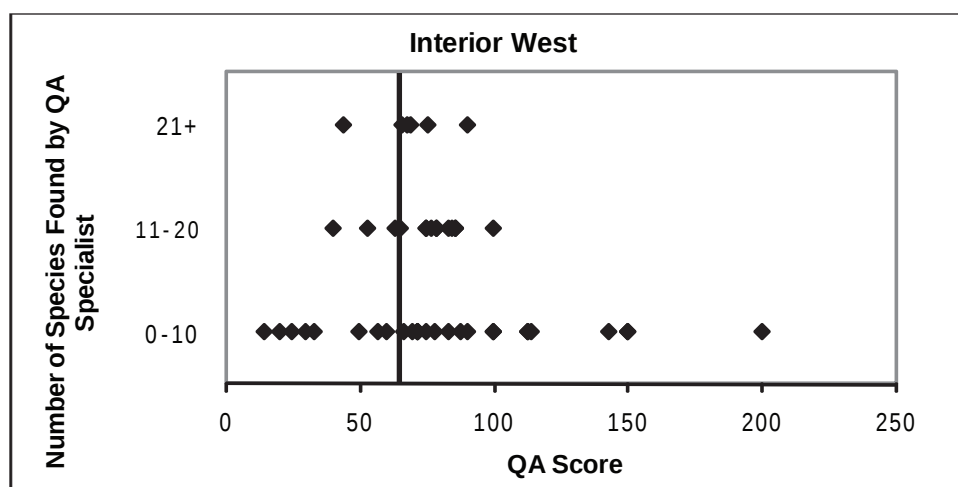


Figure 4.9—Scatter plots, by categories of the total number of species found by the QA specialist, of the QA scores for NE. Points to the right of the vertical line QA Score = 65 achieve minimum tolerance. See Table 4.2 for overall compliance rate.

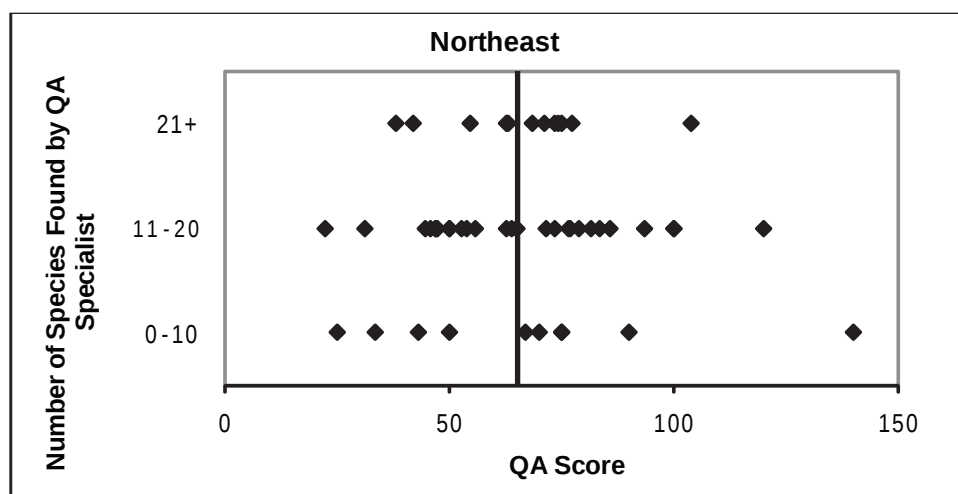


Figure 4.10—Scatter plots, by categories of the total number of species found by the QA specialist, of the QA scores for PNW. Points to the right of the vertical line QA Score = 65 achieve minimum tolerance. See Table 4.2 for overall compliance rate.

