# 2.0 Principles Used to Score Indicators and Structure the Models

## 2.1 Introduction

Many models in ecology and especially hydrodynamics are mechanistic. That is, rates are first estimated or measured for individual processes that comprise (for example) a river channel function, and then mathematical formulas (e.g., hydraulic or thermodynamic equations) are prescribed to combine variables that determine those processes into an actual rate for a function, e.g., grams of phosphorus retained per square meter per year. However, generally applicable measurements of the processes and the variables that determine them simply do not exist for the types of wetlands occurring in much of the study area. Attempts have been made to build such models on whatever regional data do exist but due to the lack of data involving direct measures of wetland function from a broad array of wetlands, WESPAK-SE uses a different approach to model the various things that wetlands do naturally. Rather than being deterministic, that approach is at times speculative but logic-based and heuristic. Such approaches are well-regarded as an interim or alternative solution when knowledge of system behaviour is scant (e.g., Haas 1991, Starfield et al. 1994, Doyle 2006).

## 2.2 Indicators

For most WESPAK-SE models, physical or biological *processes* that influence a given function were first identified and then *indicators* of those processes were chosen and grouped accordingly. (The term *indicators* is comparable to the term *metrics* used by some other methods). The indicators then were phrased as questions in the data forms. None of WESPAK-SE’s field-level indicators require *measurement*; they all are based on visual estimates. While the *precision* of measurements is typically greater than for visual estimates, their *accuracy* in predicting functions may or may not be. That is because it is often difficult to obtain sufficient measurements of an indicator, in the span of time typically available to wetland regulators or consultants, to create a full representation of any particular indicator of wetland function, let alone all the indicators that would be needed to assess a common suite of functions.

WESPAK-SE’s indicators were mainly drawn from inferences based on scientific literature and the author’s experience throughout North America (e.g., Adamus 1993, Adamus et al. 1987, Adamus et al. 1992). Indicators used by other methods for rapidly assessing functions of wetlands in North America were also considered. To qualify as an indicator, a variable not only had to be correlated with or determining of the named process or function, but it also had to be rapidly observable during a single visit to a typical wetland during the growing season, or information on the indicator’s condition had to be obtainable from aerial imagery, existing spatial data, and/or landowner interview.

When developing models of any kind, the factors that contribute to the output can be categorized in three ways: (1) unknown influencers, (2) known influencers that are difficult to measure within a reasonable span of time, and (3) influencers that can be estimated visually during a single visit and/or from existing spatial data. WESPAK-SE provides an incomplete estimate of wetland functions because it incorporates only #3. Also, some of the indicator variables it uses may be *correlates* of wetland functions rather than actual influencers. For example, changes in water levels are correlated with changes in nutrient cycling, but it is the difficult-to-measure changes in sediment oxygen and pH that induce the changes in nutrient cycling, not the water level changes themselves (which happen to correlate loosely with those changes in oxygen and pH). These types of limitations apply to all rapid assessment methods.

For regulatory and management applications (e.g., wetland functional enhancement), it’s often helpful to understand to which of four categories an indicator belongs:

1. *Onsite modifiable*. These indicators are features that may be either natural or human-associated and are relatively practical to manage. Examples are water depth, flood frequency and duration, amount of large woody debris, and presence of invasive species. More important than the simple presence of these are their rates of formation and resupply, but those factors often are more difficult to control.

2. *Onsite intrinsic*. These are natural features that occur within the wetland and are not easily changed or managed. Examples are soil type and groundwater inflow rates. They are poor candidates for manipulation when the goal is to enhance a particular wetland function.

3. *Offsite modifiable.* These are human or natural features whose ability to be manipulated in order to benefit a particular wetland function depends largely on property boundaries, water rights, local regulations, and cooperation among landowners. Examples are watershed land use, stream flow in wetland tributaries, lake levels, and wetland buffer zone conditions.

4. *Offsite intrinsic*. These are natural features such as a wetland’s topographic setting (catchment size, elevation) and regional climate that in most cases cannot be manipulated. Still, they must be included in a wetland assessment method because of their sometimes-pivotal influence on wetland functions.

## 2.3 Weighting and Scoring

Explicitly or implicitly, WESPAK-SE assigns relative weights or scores at seven junctures:

1. Scoring of the *conditions* of an indicator variable, as they contribute to that indicator’s prediction of a given wetland process, function, or other attribute.

2. Scoring of *indicators* (metrics) relative to each other, as they together may predict a given wetland process, function, or other attribute.

3. Scoring of wetland *processes*, as they together may predict a given wetland function or other attribute.

4. Combining scores for 14 wetland functions into function *group* scores (4 per wetland).

5. Combining wetland group scores into wetland *value scores* (1 per wetland).

6. Converting wetland value scores to value *categories*.

7. Modifying wetland categories in some cases by applying an *abundance factor.*

Each of these is now described.

### 2.3.1 Weighting of Indicator Conditions

As an example of #1, consider the following conditions of the indicator, Ponded Open Water Percentage as it is applied by WESPAK-SE to estimate the Waterbird Habitat function:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| A | B | C | D | E | F | G |
| F14 | % of Ponded Water That Is Open  | In ducks-eye aerial view, the percentage of the ponded water that is open (lacking emergent vegetation during most of the growing season, and unhidden by a forest or shrub canopy) is: |   |   |   | 0.00 |
| <1% or none, or largest pool occupies <0.01 hectares. Enter "1" and SKIP to F20 (Floating Algae & Duckweed). | 0 | 1 | 0 |   |
| 1-5% of the ponded water. Enter "1" and SKIP to F20. | 0 | 2 | 0 |   |
| 5-30% of the ponded water. | 0 | 4 | 0 |   |
| 30-70% of the ponded water. | 0 | 6 | 0 |   |
| 70-99% of the ponded water. | 0 | 4 | 0 |   |
| 100% of the ponded water.  | 0 | 3 | 0 |   |

Each row following the first one describes a possible *condition* of this indicator. You must select the one condition that best describes the wetland being assessed by entering a “1” next to that condition in column D). In column E, WESPAK-SE’s author previously assigned relative weights to each of these conditions as they relate to the function. You cannot alter those. In this case, the fourth condition (30-70%) was considered most supportive of that function, other factors being equal, and so had been given a weight of six. This does not necessarily mean it is 6 times more influential than the first condition which has a weight of 1, because this is not a deterministic model. However, available literature seemed to suggest that this intermediate condition is distinctly better than the second and fourth condition choices, and so it was assigned a weight of 6, separating it by 2 points from the next closest conditions, rather than a weight of 5, thus signifying that the relationship of these conditions to the function is believed to be slightly nonlinear rather than linear. When the same indicator is used to score a different function, the weight scheme might be reversed or otherwise differ.

In many instances, considerable scientific uncertainty surrounds the exact relationship between various indicator conditions and a function, and thus which weights should be assigned. However, keep in mind that Ponded Open Water is just one of 47 indicators used to assign a score to the Waterbird Habitat function. To some degree, the use of so many indicators will serve to buffer the uncertainty in our knowledge of exact relationships, and the additional time they add to performing the assessment is miniscule .

WESPAK-SE users will also notice that the weighting scale for some indicators ranges from 1 to 8 (especially if there are 8 condition choices) while for others it ranges only from 0 to 2, or some other range. This does not mean that the first indicator is secretly being weighted 4 times that of the second, because before the indicators are combined, their scores are “normalized” to a 0 to 1.00 scale. The Excel spreadsheet accomplishes that by multiplying the “1” signifying a user’s choice (in column D) by the pre-determined condition weight in column E, and placing the product in the last column, whereupon a formula (not visible here) in the green cell takes the maximum of the values pertaining to this indicator in that last column and divides it by the maximum weight in column E, the condition weight column. The formula in the green cell could just as easily have taken the only non-zero value in the last column and divided it by the maximum weight pre-assigned to the indicator conditions.

Note also that the weight scale for some indicators begins at 0 while for others it begins at 1. Often, “0” was reserved for instances where, if the indicator was the only one being used, that condition of the indicator would suggest a nearly total absence of the function. Because each of the indicator scores is normalized, this difference (0 vs. 1) at the bottom end of the scales for different indicators is probably trivial.

### 2.3.2 Weighting and Scoring of Indicators of Wetland Functions

In most cases, WESPAK-SE does not assign weights so explicitly (i.e., as multipliers) to the various indicators of a function. More often, weights are implicit in the manner in which indicators are combined. For example, if a function model is:

Indicator A + (Average of: Indicator B, Indicator C, Indicator D)

This implies that Indicators B, C, and D individually are likely to have less weight than Indicator A because they are only contributing to an average rather than standing alone, and as such, a low score for one may compensate somewhat for a high score on another.

If one indicator is so important that occurrence of a particular condition of that indicator can solely determine whether a function even exists in a wetland, then conditional (“IF”) statements are used in WESPAK-SE models to show that. For example, if a wetland dries up annually, it is not on a floodplain, and it contains no inlets or outlets, the Fish Habitat function is automatically scored “0”. In this case, “access” (presence/absence of inlets or outlets) is a controlling indicator. If a few indicators are not individually so controlling but at least one is likely to be strongly limiting in some instances, WESPAK-SE takes the *maximum* among of the indicators, rather than the average. The latter is applied to situations where indicators are though to be compensatory, collinear, or redundant. WESPAK-SE uses averaging as the default operator unless situations can be identified where there is compelling evidence that an indicator is controlling or strongly limiting.

There also are instances where the condition of one indicator (such as wetland type) is used to determine the relevance of others for predicting a wetland function. For example, the effect of vegetation structure within a wetland on the wetland’s ability to slow the downslope movement of water in a watershed can be ignored if the wetland has no outlet channel. In the WESPAK-SE calculator spreadsheet, all such contingent relationships among indicators that we identified and incorporated into WESPAK-SE models are documented in the Rationale column.

### 2.3.3 Weighting and Scoring of Wetland Processes That Influence Functions

For many functions, dozens of hydrologic (e.g., evapotranspiration) and/or ecological (e.g., juvenile dispersal) processes contribute to its ultimate level of performance. Often, too little is know about the relative importance of these processes in determining a wetland function, and for some processes there are no known indicators that can be estimated visually. Nonetheless, used processes as an organizing framework for the many indicators it employed to score each function. For most functions, the processes are weighted like indicators and used as a "subscore" when computing the score for a function. For example, for the function Phosphorus Retention, the function model contains these processes:

[(3\*Adsorb + 2\*AVERAGE(Connec, Desorb) + AVERAGE(IntercepWet, IntercepDry)] /6

That means that Adsorption was given half (3/6) of the weight, the average of Connectivity and Desorption was given one-third (2/6) of the weight, and the average of Dry Interception and Wet Interception was given 1/6 of the weight. They are divided by 6 because that is the sum of their weights (3 + 2 + 1) and the resulting function score, for the sake of clear comparisons, must be normalized to the 0 to 1 scale used by all functions.

### 2.3.4 Normalizing of WESPAK-SE Function Scores

WESPAK-SE automatically normalizes (converts to a 0-to-1 scale) the raw scores from all surveyed wetlands in a study region. Normalizing answers the question, “How does this wetland compare with a large set of others in the study region?” In that sense, normalized scores are like percentiles. Normalizing also allows for straightforward comparison of any function score with any other function score from the same or a different wetland. The normalizing process, which was applied to the scores for each function, employed this widely-recognized formula:

 raw score of **“wetland x”** – **minimum** score from all wetlands in the same region

 **maximum** score of all wetlands in regoin - **minimum** score of all wetlands in region