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BIOTA QUALITY: A RIPARIAN HABITAT MODEL

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ABSTRACT

This paper presents a model for defining and measuring biota quality for the purpose of assessing the impacts of resource development plans on biota quality. The model uses the habitat approach and concentrates on the riparian system. The means to measure the parts of a riparian system, weight the importance of the various parts, and produce an overall index of biota quality are presented.

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INTRODUCTION

The Principles and Standards (WRC 1973) requires that alternative management plans be evaluated in terms of achievement of goals which have been defined as specific outputs or desired effects. With Principles and Standards requirements in mind it is evident that goals within the Environmental Quality objective must be defined and evaluated as completely as those within the National Economic Development (NED) objective. Evaluating the quality of biological resources (biota quality) is an extremely important part of overall environmental quality evaluations. Methods for evaluating these resources are many, the approaches are varied and few, if any, are easily employed by a planner for evaluating the impacts of alternative resource management plans. This paper presents a method that is easily employed and produces useful results.

The model described here for assessing biota quality impacts can be used in the development of indices that reflect how well alternative water and related land resource development plans achieve environmental quality goals. A detailed discussion of the methodology for developing quantitative measures and generating environmental indices is found in Arthur, et.al., 1976.

BACKGROUND

Habitat has become a password and the vehicle through which the biological impacts of contemporary resource development projects are assessed. In general, it can be said that if we can do a good job in estimating the beneficial and adverse effects of a project on the relevant habitats, through their components, we can be spared the task of guessing how each "critter" will fare.

The habitat approach, as described by USFS Biologist, Jack Ward Thomas, (Pacific NW Forest and Range Experiment Station), is the result of realizing that land management or resource agencies do not manage wildlife, they manage habitat. They alter habitat with every decision. They understand it, relate to it and can be held accountable for it. Realization that habitat is the foundation for all wildlife management has triggered the new emphasis on habitat evaluations. To reinforce this I would like to quote a portion of the abstract from Thomas, 1979:

> Riparian zones are the most critical wildlife habitats in most managed agricultural lands. More wildlife species depend entirely on or spend disproportionately more time in this habitat than any other. The zone is also disproportionately important for grazing, recreation, timber production, fisheries production, road location and water quality and quantity. The importance to wildlife is examined and guidance given for management.

Much work has been done by both State and Federal agencies in the areas of habitat management and in establishing criteria for habitat definition and valuation. In addition to Thomas, the U.S. Fish and Wildlife Service's Project Impact Evaluation (PIE) team (Schamberger, 1978) has advanced methods of developing value indices for habitats so that impact evaluation can be approached quantitatively. One Subcommittee composed of State and Federal agency personnel in Oregon and Washington (Subcommittee, 1979) has published a report that includes descriptions of optimum riparian habitat conditions and a procedure for evaluatating habitat conditions. The work on habitat definition and valuation has not produced a model for relating biota quality to overall natural resource quality and, ultimately, environmental quality. Figure 1 shows the structure such a model must have before changes in lower level goals such as biota quality can be expressed as changes in environmental quality. It is, of course, important that the model be realistic and that the information it produces is useful to biologists and other wildlife experts.

MODEL FORMULATION

The habitat approach, then, along with the impact evaluative capability requirement, will guide the model formulation process. This process of model formulation parallels a research project applying a procedure for evaluating the overall environmental and economic benefits and costs of nonpoint pollution control plans in the Columbia Plateau area of N.E. Oregon.[1/] Recognizing the agricultural activities in the area (extensive wheat farming on hills with pasture or hay in the bottoms) and the objectives of nonpoint control plans (control of erosion and reduction of sediment and chemicals delivered to streams) leads us directly to the systems that we must model and evaluate. The riparian habitat in the study areas is the most productive habitat type and the one that is of prime concern with respect to nonpoint pollution abatement activities and their impacts. (We

[1/] Study still in process. For information contact the author.

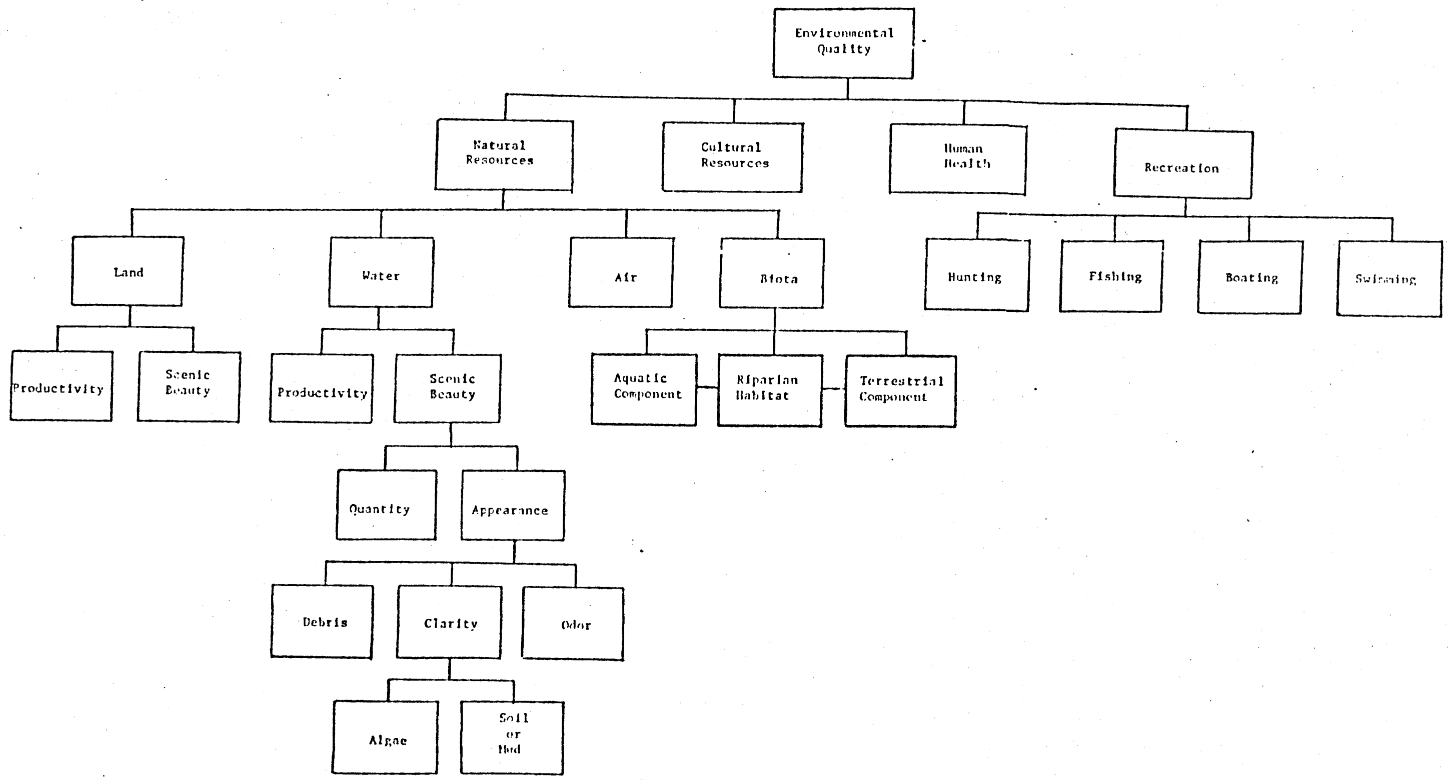

Figure 1, Structure for Evaluating Environmental Quality Goals.

choose to define riparian in this case to be both the streams and wet areas and adjacent vegetative communities influenced by the aquatic portion). In the cropland and pasture areas there is little, high quality habitat besides the riparian type. Some fenceline-hedgerow areas exist but these areas are not extensive and are not likely to be effected at all by conservation practices directed at abating nonpoint pollution problems. Given, then, the predominance of the riparian habitat type in the area, the disproportionately high value it has over the other types and that the goals and likely impacts of nonpoint pollution control plans relate directly to riparian areas and the wildlife they support (fish and recreators), biota quality will be modeled as riparian habitat.

It should be noted here that while a specific application of the methodology may use a few or a single habitat type, as many types as necessary may be modeled as long as an index can be developed for each and the relative values of the various indices can be weighted.

The Riparian Habitat Subcommittee (Subcommittee, 1979) has provided a good, usable procedure for modeling riparian habitat. While the committee did not have the objective of developing an index of riparian habitat for impact evaluative work, the evaluation parameters and the numbers given to them in describing "optimum" conditions make the model attractive for such an application.

The evaluation parameters listed below are those that will be used in the model. The first three relate to aquatic or fish-type habitat in the riparian zone, and are evaluated from that perspective, and the second three relate to the wildlife or terrestrial type.

1. Stream surface shaded	- SH	4. Grass-forb cover	- GR
2. Stream bank stability	- ST	5. Shrub cover	- SB
3. Streambed sedimentation	- SE	6. Tree cover	- TR

With the above parameters, the habitat model can be presented using the following shorthand:

Riparian Habitat = f(Aquatic Parameters, Terrestrial Parameters)

or

$$RH = f(AP,TP)$$

where

$$AP = f(SH,ST,SE)$$

and

$$TP = f(GR,SB,TR)$$

Aquatic Parameter (AP) Component

The aquatic portion of the riparian habitat index will be derived using the following arithmetic:

$$AP = SH^a \times ST^b \times SE^c$$

where SH, ST and SE are parameter index values between 0 and 10 and a, b and c are values between 0.0 and 1.0, and sum to 1.0. The a, b and c values are used to weight the importance of each parameter in determining AP.

The stream surface shaded parameter (SH) has its greatest importance during the summer months and during the hours of 10 am to 4 pm. Shading from streamside vegetation is essential in preventing lethal water temperatures from occurring. If 80% of the stream surface is shaded, the shading parameter is at its optimum. The below schedule of index value to surface shade relationships illustrate that as shading increases past 90%, the index value decreases. Further explanation of the development of this index is presented in Subcommittee, 1979, page 3.

SH Index Value	% Surface Shaded
8	95-100
9	85-94
10	75-84
9	65-74
8	55-64
7	45-54
6	40-44
5	30-39
4	15-29
3	5-14
2	0-4

Streambank Stability (ST) is important in itself for protecting the aquatic environment. In a stable, non-eroding condition, banks provide cover and reduce exposure of water to solar radiation during part of the day. Where streambanks are not eroding, channel widths are narrower and stream depths greater than where banks are not stable (Subcommittee, 1979). The absence of sediment originating from eroding banks and the trapping of sediment before it moves into a stream from adjacent areas are also characteristics of stable streambanks. That streambanks should have 80% or greater of their lineal distance in a stable condition for habitat to be optimal is related in the below schedule. The habitat index minimum value of 1.5 indicate that there will always be some potential for fisheries productivity if water exists but it would be small if a high degree of streambank instability exists.

ST Index Value	% Streambank Stable
10	85-100
9	75-84
8	70-74
7	65-69
6	55-64
5	50-54
4	40-49
3	20-39
2	5-19
1.5	0-4

Streambed Sedimentation (SE) relates the amount of the stream substrate covered by inorganic sediment. Fine sediments clog the gravels which are important to insects, developing fish eggs and fry. The prevention of the percolation of oxygen rich water causes fish and insect mortalities. Sedimentation of pool areas effect rearing the hiding habitat (Subcommittee, 1979). The below schedule indicates that no more than 15% of the substrate can be covered with sediment without habitat conditions becoming less than optimal.

SE Index Value	% Streambed Sedimentation
10	0-15
9	16
8	17
7	18-19
6	20-22
5	23-26
4	27-29
3	30-34
2	35-49
1.5	50-100

Terrestrial Parameter (TP) Component

The terrestrial portion of the riparian habitat index model, is based on the general relationships between potential wildlife production and native riparian vegetation conditions (Subcommittee, 1979). The index will be derived in the same manner as the AP index:

$$TP = GR^x \times SB^y \times TR^z$$

Where GR, SB and TR parameter index values between 0 and 10 and x, y and z are values between 0.0 and 1.0 that sum to 1.0. As the a, b and c values indicate the relative importance of a parameter in the aquatic portion, the x, y and z weight the terrestrial parameters according to their importance.

The terrestrial parameters are all described in terms of site enhancement potential (SEP). This potential is an expert survey team estimate of the possible vegetative production for an area. Therefore, while we are concerned with the actual percentage cover provided by a vegetation type, the concept that is critical to the index is the site enhancement potential.

Grass-Forb Cover (GR) is simply the percentage of the riparian zone covered by such vegetation and how that compares to the SEP. Optimal conditions are achieved when a zone provides 80% of the SEP for such vegetative cover. The below schedule describes the index-site enhancement potential relationship.

(GR, SB, TR) Index Value	% of Site Enhancement Potential
10	80-100
9	75-79
8	65-74
7	55-64
6	45-54
5	35-44
4	25-34
3	15-24
2	5-14
1	1-4
0.1	0

Shrub Cover (SB) is the percentage of the riparian zone covered by shrubs and the relationship between that value on the SEP. Optimal conditions are related in the same site enhancement potential terms as GR, and the 80%

value. The SB index, therefore will be derived from a schedule of site enhancement potential percentages exactly the same as those listed for GR.

Tree Cover (TR) is the percentage of crown cover in the riparian zone and how that percentage compares with SEP. Optimal conditions are expressed exactly like those for grass-forb and shrub cover and the site enhancement potential-index value relationships are displayed in the above schedule.

MODEL APPLICATION

The original shorthand for describing the riparian habitat index can now be put in a form for application.

$$RH = f(AP,TP)$$

Where RH is an index with a value between 0 and 10, representing the quality of the riparian habitat, (assumptions of site potential, etc. inherent in parameters) and AP and TP are index values between 0-10 as previously defined, and are related as:

$$RH = AP^{.5} \times TP^{.5}$$

This geometric average of the two index values relates that neither of the terrestrial nor the aquatic parameter set is seen to be more important in determining RH. While in most cases a simple arithmetic average would provide a meaningful overall index value, it would cease to be meaningful when the two indexes, AP and TP, deviate widely. The geometric mean will provide a more meaningful value when this occurs, as well as allowing the impacts to be related more realistically through the model. An example follows using the relationships as presented below:

$RH = AP^{.5} \times TP^{.5}$

$AP = SH^{a} \times ST^{b} \times SE^{c}$

$TP = GR^{x} \times SB^{y} \times TR^{z}$

The riparian zone within a proposed nonpoint pollution control project area was subjected to a field evaluation. The stream surface was estimated to have 50% of its surface shaded, 70% of its banks in a stable condition and overall, 25% of the stream substrate appeared to be effected by inorganic sediments. In this area, none of the three evaluation parameters were judged to be more important than the others, thus:

$AP = 7^{0.333} \times 8^{0.333} \times 5^{0.333}$

$AP = 6.53$

An evaluation of the vegetation conditions revealed a grass-forb cover of 40%, which was suggested to be 75% of potential, a shrub cover of 20%, which was 50% of potential and a crown cover of 10% which is 80% of potential. The grass-forb and shrub covers were judged to be little more important in this area than tree cover, thus:

$TP = 9^{0.4} \times 6^{0.4} \times 10^{0.2}$

$TP = 7.81$

The index value for the riparian habitat in its current state then is:

$RH = 6.53^{0.5} \times 7.81^{0.5}$

$RH = 7.14$

(In this case the arithmetic average is 7.17.)

The RH index provides a starting point for evaluating the effects of various practices proposed to control nonpoint pollution in the area.

A plan for the area involves both on and off the farm practices to abate nonpoint problems. The on-farm practices include minimizing tillage, managing crop residues, grazing limitations, streambank stabilization and land use conversions which are all aimed at reducing the sediment delivered to streams and holding the soil resources on the land. The off-farm practice was streambank stabilization using vegetation and rock rip-rap with the intent of decreasing the contribution of streambank erosion to downstream sedimentation problems.

Evaluating the on-farm practices, we could find that while the practices had great value in conserving the soil resource and reduced the total tons of soil delivered off of the land, the sediment that is eroded may be made up of a greater percentage of the fine soil particles that have the worst effect on stream substrata and water quality. Also, during high runoff events, it is possible that enough of the larger particles would be delivered and settled out that the current situation, which is quite good, would not be improved or appreciably changed.

The streambank stabilization can be felt in many ways within the riparian zone. The stabilization, whether it be vegetative or rock (preferably a combination of both), can be related directly through the (ST) parameter, and for the example, we will assume (ST) will increase to 90%. The stabilization could reduce both the contribution of sediment by the streambank and the sediment moving in from adjacent areas, so that (SE) is decreased by 5%. As the vegetative stabilization activity is designed, the grass-forb cover will increase to 85% of potential and shrub cover to 60% of potential.

The impacts of the practices can be now related through the model in terms of changes in the riparian habitat. (ST) changes from 8 to 10. (SE) changes from 5 to 6. (GR) changes from 9 to 10 and (SB) from 6 to 7.

$AP = 7^{0.333} \times 10^{0.333} \times 6^{0.333}$

AP = 7.48 (14% increase)

$TP = 10^{0.4} \times 7^{0.4} \times 10^{0.2}$

TP = 8.67 (11% increase)

The changes in the overall riparian habitat index associated with proposed practices is:

$RH = 7.48^{0.5}$

RH = 8.05

$\Delta RH = 8.05 - 7.14$

$\Delta RH = +0.91$

CONCLUSIONS

The above model is simple in concept and use. It has the ability to relate the effects of nonpoint abatement plans and provides useful information. While the index, itself, may be of little interest to a wildlife manager, the model is physically based and is not so complicated that the operations and individual parameter effects are obscured.

The model can be used to evaluate the net impact of a single plan, as presented in the example, but the real value in application of such a model is in comparing the effects of multiple alternatives. The exponential weighting allows one to express the importance of specific components of the habitat and emphasize the importance of the aquatic or terrestrial portions of the habitat.

Overall plans to control nonpoint pollution will likely include practices for forested lands as well as crop and pasture land. If forested lands exist in a study area, riparian habitat in these areas should be evaluated separately. With such obvious differences in the wildlife-terrestrial parameter values for agricultural lands as opposed to forested lands, it might be "naive" to start averaging. The canopy cover and site enhancement potentials would be very different and it is likely that the weighting that reflects the relative importance of evaluation parameters should be different with respect to the agricultural and forested lands.

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