A Decision-Support Model of Land Suitability Analysis for the Ohio Lake Erie Balanced Growth Program

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I. PREFACE

The Ohio Lake Erie Balanced Growth Program invites individual communities and stakeholders in the Ohio Lake Erie Basin to connect with their neighbors within common watersheds and plan collaboratively for the future land use of the basin. It is the hope of the State of Ohio that a voluntary, incentive-based invitation to communities to reach out to their neighbors on planning issues without acquiescence of their zoning power may produce more holistic thinking about land use within multi-jurisdictional watersheds. A watershed mindset, in turn, may eventually lead to land-use decision-making that will ultimately mitigate the impact of human activity on the streams and rivers of the watershed. The potential for better water quality in the watersheds that drain to Lake Erie fuels the hope for better water quality in Lake Erie itself.

However, a watershed approach to land-use planning is unprecedented in the Ohio Lake Erie Basin and is a big and uncertain step for many communities comfortable with internalizing land-use and zoning decisions at the local municipal level. Ohio State statutes sanction this approach to local planning through home rule provisions. The goal of EcoCity Cleveland and the Ohio Lake Erie Commission is reach out a hand to communities to help them take the first, inquisitive step with the Lake Erie Balanced Growth Program. A GIS-based toolbox of data, instructions, and maps assembled with the full oversight of pilot watershed partnerships from the Ohio Lake Erie Basin serves as that helping hand. Rather than tell communities what to do, EcoCity Cleveland and the Ohio Lake Erie Commission encourage local governments and stakeholders in the basin to feel more comfortable about a watershed framework for land-use planning and be open to honest discussion with their neighbors about how they can help Lake Erie.

II. CONCEPTUAL FRAMEWORK

In their report, “Linking Land Use and Lake Erie: A Planning Framework for Achieving Balanced Growth in the Ohio Lake Erie Watershed,” the Ohio Lake Erie Balanced Growth Task Force proposes that the best way to mitigate the negative impact of land use on Lake Erie’s water quality is to mitigate the negative impact of land use on the health of the watersheds that drain to Lake Erie. To accomplish mitigation of watershed health degradation due to land-use impacts, the Commission calls for the creation of a planning framework that includes “a new focus on land-use and development planning in the major river tributaries of Lake Erie.” The new focus is on linking land-use planning to watershed health. The Commission suggests that the best way to develop this link is through the creation of Watershed Planning Partnerships among a watershed’s stakeholders and the designation of Priority Conservation Areas (PCAs) and Priority Development Areas (PDAs) within watersheds. The priority areas are intended to spatially organize the land uses in each watershed to minimize the impact of stormwater runoff pollution on both watershed health and, ultimately, Lake Erie’s water quality.

ROLE OF ECOCITY CLEVELAND

However, it is a significant request of individual stakeholders to generate the methodology and data to conduct an analysis of an entire watershed that will help Watershed Planning Partnerships determine Priority Conservation Areas and Priority Development Areas. Therefore, EcoCity Cleveland solicited financial support from the Joyce Foundation in Chicago to support the implementation of the Ohio Lake Erie Balanced Growth Program. In particular, EcoCity Cleveland proposed to develop a Geographic Information Systems (GIS) decision-support program to help watershed stakeholders designate Priority Conservation Areas and Priority Development Areas. Essentially, the GIS decision-support program will offer the stakeholders maps that they can use to help their Watershed Planning Partnerships designate Priority Areas. But what kinds of data will be represented on the GIS maps prepared by EcoCity Cleveland? What kind of analysis will EcoCity Cleveland conduct to produce these maps? What is the theoretical basis for the analysis chosen by EcoCity Cleveland? These questions demand a probe into what it means to rate one area of a watershed over another for a particular land use. Put another way, there must be an investigation of how land suitability is measured and how land suitability varies spatially across a watershed.

LAND SUITABILITY THEORY

Every portion of the Earth's landscape is characterized by a different set of features that render it more suitable for certain uses than others. Since all the Earth's surface is divided into drainage areas, or watersheds, the concept of land suitability applies to watersheds as well. That is, different areas of a watershed are characterized by a different set of features that render it more suitable for certain uses and less suitable for others. The concept of land suitability for particular uses is successfully developed by the late Ian McHarg, former professor of urban design and landscape architecture at the University of Pennsylvania. Ian McHarg's seminal text (1969), *Design with Nature*, suggests that each place on the land is a sum of natural processes and these processes constitute social values. If said values (i.e. protecting water quality while fostering economic growth) are accepted, then inferences may be drawn regarding the utilization of places to ensure optimum use and enhancement of social values. Though nearly 40 years old, McHarg's conceptual development of land suitability remains exceptionally pertinent today (Steiner 2000).

The concept of land suitability may also be presented in a more concrete way through McHarg's discussion of using the land for open space versus development. McHarg notes that, unlike the scenario of land scarcity painted by opponents of urban sprawl (scattered, low-density development of land), there is actually an abundance of land. The problem is one of diverting development to an area capable of absorbing it, and deflecting it from an area where despoliation would result. This idea, known as physiographic determinism, emphasizes that development should respond to the operation of natural processes (McHarg, 1969). These processes will vary from region to region. The application of the concept in the study area is circumstantial, but the concept is general in its applicability. That is, the concept of land suitability may be applied consistently across multiple watersheds, although the exact analysis may vary between watersheds. To examine land suitability in another way, consider urban development within the framework of open space. Rather than propose a blanket standard of open space, it is important to find discrete aspects of natural processes that carry their own values and prohibitions; it is from these that open space should be selected, it is these that provide the pattern, not only of metropolitan open space, but also the positive pattern of development (McHarg, 1969).

To inform the positive pattern of development of which McHarg writes, such as that created with the designation of Priority Conservation Areas and Priority Development Areas, it is necessary to conduct a land suitability analysis.

LAND SUITABILITY ANALYSIS

Land – ground or soil of a specified situation, nature, or quality

Suitability – adapted to a use or purpose; satisfying propriety

Analysis – separation of the whole into its component parts

Based on the above term definitions, a land suitability analysis is the separation of the nature or quality of land into its component parts based on the land's ability to serve a particular use or purpose. High land suitability means the land has relatively high numbers of the component parts it needs to serve a particular use or purpose, while low land suitability analysis means the land has relatively low numbers of the component parts it needs to serve a particular use or purpose.

McHarg (1969) characterizes land suitability analysis as both rational and explicit. A land suitability analysis is rational because evidence is derived, in main, from exact sciences (from the academic literature and from the existing knowledge base). A land suitability analysis is explicit because the entire methodology and data used in the analysis is made available to the public. This allows the public to then use their own value system to decide the final locations of Priority Areas. The main technical problem associated with land suitability analysis is ensuring the parity of factors. The results of the analysis will be qualified if the factors are of disproportionate weights.

It is important to note that a land suitability analysis ultimately results in a map that suggest a pattern of future land use, but a proposed land-use map is not a plan. A proposed land-use map is an expression of physical, social, and economic goals. It is the combination of these goals and the public and private powers to realize them that justifies the term "plan." A plan includes a question of demand, a resolution of demand relative to supply, and the incorporation of the capacity of the society or institution to realize its objectives (public participation). The land suitability analysis and the maps that show its results do not possess these characteristics. The analysis and maps are tools that can help stakeholders develop new land-use plans for their watersheds, but are not plans themselves.

POST-MCHARG APPLICATION OF SUITABILITY ANALYSIS

Since the release of *Design with Nature* in 1969, many planners have applied the principal of land suitability analysis in practice to help guide comprehensive land-use plans across communities and regions (Hopkins 1977; Steiner et. al. 2000; Barten & Carnst 2004). Several forms of suitability analysis have been applied, but many have been implemented with serious shortcomings. Lewis Hopkins, a protégé of McHarg, published a comparative analysis of land suitability methodologies in 1977 to critically compare different approaches on both their merits and faults. The results of his analysis guide the selection of a land suitability methodology for the Ohio Lake Erie Balanced Growth Program.

The table below summarizes all of the methods Hopkins compared, but a more detailed discussion will focus on the three more popular approaches to suitability analysis.

TABLE 1. Comparative analysis of land suitability methodologies

METHOD	HANDLES INTERDEPENDENCE OF FACTORS	EXPLICIT IDENTIFICATION OF REGIONS	EXPLICIT DETERMINATION OF RATINGS	ADDITIONAL COMMENTS	EXAMPLE
Gestalt	Yes	No	No		Hills (1961)
Mathematical					
Ordinal	No	Yes	Yes	Invalid Math	McHarg (1969)
Linear	No	Yes	Yes		Ward (1971)
Nonlinear	Yes	Yes	Yes	Required relationships usually unknown	Voelker (1976)
Region Identification					
Factor Combo	Yes	Yes	No	Many judgements	Wallace-McHarg (1964)
Cluster Analysis	Yes	Yes	No		Rice (1974)
Logical Combo					
Rules of Combo	Yes	Yes	Yes		Kiefer (1965)
Hierarchical Combo	Yes	Yes	Yes		Murray (1971)

(Hopkins, 1977)

The most common applications of land suitability analysis have been the ordinal combination method, the linear combination method, and rules of combination method. Some may raise question marks about rules of combination, but in fact this was the application of choice for most of McHarg's land suitability work.

To facilitate understanding of the differences between these three approaches (more detailed discussion is offered by Hopkins), it is necessary to put forth a simple hypothetical problem facing a regional planner. She must determine how to assess the suitability of her community for a future town hall. She has mapped the values for two land suitability factors in her community that will help her determine where the town hall should be sited: soil type and depth to bedrock. There are three soil types in here community (A, B, C) and bedrock depth ranging from zero to ten feet below the earth's surface.

Ordinal Combination

The ordinal combination approach requires the user to rank each land suitability factor based on the factor's values and the interpretation of those values for suitability for the land use in question. The planner wishing to site the town hall may rank the soil types as (B, C, A), with B soils classified as high suitability for development, C soils classified as moderate suitability for development, and A soils classified as low suitability for development. The planner may also determine that areas where bedrock is more than seven feet below the surface have high suitability for development, areas bedrock between three and seven feet below the surface have moderate suitability for development and areas where bedrock is less than three feet below the surface have low suitability for development.

SOIL MAP

A
B
C

BEDROCK DEPTH MAP

>7ft	3-7ft	<3ft

To create a suitability map, the planner would overlay the soils map on the bedrock depth map to produce a new map with nine possible combinations of soils and bedrock depth. The overlay is achieved mathematically by ranking each factor's values according to suitability and adding the ranked values. The highest rank would be given the highest score, so for three factor values, the highest rank would score 3, the middle rank would score as 2, and the lowest rank would score as 1. The sums of these rank scores would be the suitability values which are then reproduced in a land suitability map. Since our example includes two factors with three suitability values each, there are nine possible combinations of land suitability factors and therefore nine suitability values.

A soils plus bedrock >7 feet below = 1+3 = 4
A soils plus bedrock 3-7 feet below = 1+2 = 3
A soils plus bedrock <3 feet below = 1+1 = 2

B soils plus bedrock >7 feet below = 3+3 = 6
B soils plus bedrock 3-7 feet below = 3+2 = 5
B soils plus bedrock <3 feet below = 3+1 = 4

C soils plus bedrock >7 feet below = 2+3 = 5
C soils plus bedrock 3-7 feet below = 2+2 = 4
C soils plus bedrock <3 feet below = 2+1 = 3

LAND SUITABILITY VALUES MAP

4	3	2
6	5	4
5	4	3

Hopkins (1977) identifies many problems with the ordinal combination method, which render this land suitability method undesirable for land-use planners and decision makers. The addition of numbers on an ordinal measurement scale (numbers that represent a ranking or ordering) is mathematically invalid in the sense that the user assumes certain mathematical properties that do not hold:

1) The numbers must be assumed to be on an interval scale, not an ordinal scale, for arithmetic operations to be valid. The key difference between the ordinal scale and the interval scale is that the distances (intervals) between various ranks are equal in an interval scale and unknown in an ordinal scale (i.e. how much better is first-place over second-place? Second-place over third-place?)

2) The numbers assigned to the types of each factor must be assumed to be numbers in the same interval system (the units used to measure intervals of suitability must be the same). However, soil suitability is not measured in the same units as depth to bedrock. If slopes were included, they would also be in different units.

3) Because they operation of overlaying maps in the ordinal combination method is equivalent to addition, there is an inherent assumption that the ratings of each factor are independent. However, soil type may depend on depth to bedrock (or even slope). In that case the factors are interdependent and suitability values of those factors cannot be added.

For the above reasons, the ordinal combination method is not a good method for generating land suitability maps, despite its wide application among practicing planners.

Linear Combination

The most common response of planners to the obvious problems posed by the ordinal combination method has been to play what Hopkins calls "the weighting game." In other words, to put all ratings of each factor on the same interval scale, the types within each factor are rated on separate interval scales. Then a multiplier (a weight that reflects the importance of a particular factor) is assigned for each factor. The ratings for each factor are then multiplied by the weight and the sum of those products equals the suitability rating. The end effect of the linear combination method is to use an interval scale and equate the interval scales for each factor through weighted multipliers (the first two invalid assumptions made in the ordinal combination method). However, the linear combination method does not address the third assumption (interdependence of factors) and is therefore not considered the best method for land suitability assessment.

To apply linear combination to our example, supposed our land-use planner used an interval rating system to rate soil compositions using national engineering standards where 10 was the best for development and 0 was the worst. Suppose further that she assessed depth to bedrock based in feet and assigned a value of 10 to the greatest depths in our study area and a value of 0 to the shallowest depths. These methods of rating factors are no longer ordinal (ordering from best to worst), but rather interval in that the difference between two scores actually has meaning. These methods also put both factors on the same interval scale so they can be added together with mathematical validity.

The next step for the planner would be to determine how important each factor is in assessing overall suitability. The planner may decide that depth to bedrock is twice as important as soil type, so the overall suitability score would be the sum of the soil factor score and two times the depth to bedrock factor score, divided by the sum of the weights (one plus two), or three.

However, it is very likely that depth to bedrock and soil type are not independent of each other. The linear combination method assumes the factors are independent for the method to be valid and that is not the case in this example, nor many other examples in the natural world. Even in the non-natural world there are many land suitability factors which are not independent of each other. A good example is sewer lines and proximity to existing development. Both factors influence each other and to treat them as independent would be incorrect.

Rules of Combination Method

The rules of combination method was the most common approach applied by McHarg and avoids the pitfalls of the ordinal combination method and the linear combination method. The rule assigns suitabilities to sets of combination types rather than to single combinations. The rule is expressed in terms of verbal logic rather than in terms of numbers and arithmetic. Rules of combination method does not violate any laws of mathematics and it is easily understandable because the rules are stated in plain language and not mathematical expressions.

For our example, the planner may determine that each factor has high, moderate, and low ratings as was proposed in the discussion on the ordinal combination method. However, rather than adding rankings together, the planner decides to established rules for combining different rankings for each factor to determine levels of suitability. The set of rules may be as follows:

Rate a parcel HIGH land suitability for development if the parcel rates HIGH on either soil type or depth to bedrock.

Rate a parcel MODERATE land suitability for development if it rates MODERATE or HIGH on either soil type or depth to bedrock.

Rate a parcel LOW land suitability for development if it does not rate MODERATE or HIGH on either soil type or depth to bedrock.

These rules, when applied to the simple map diagram outlined in the discussion on ordinal combination method, produce the following map. Both are provided below for comparison.

SOIL MAP

A
B
C

BEDROCK DEPTH MAP

>7ft	3-7ft	<3ft

SOIL SUITABILITY MAP

LOW
HIGH
MODERATE

BEDROCK DEPTH SUITABILITY MAP

HIGH	MOD	LOW

LAND SUITABILITY MAP (ORDINAL)

4	3	2
6	5	4
5	4	3

LAND SUITABILITY MAP (RULES)

H	M	L
H	H	H
H	M	M

The land suitability map based on rules of combination has only three ratings: H (high), M (moderate), or L (low suitability). A comparison with the land suitability map based on ordinal combination reveals that LOW suitability corresponds to a score of two; MODERATE suitability corresponds to a score of three or four; and HIGH suitability corresponds to a score of four, five, or six. The simple example shown here suggests there is not much difference in the outcome when comparing the two methods, but what is important is that one method clearly requires invalid assumptions about the data while the other does not.

LAND SUITABILITY AS A DECISION-SUPPORT METHODOLOGY FOR THE OHIO LAKE ERIE BALANCED GROWTH PROGRAM

The choice for the rules of combination method may seem clear after considering Hopkins' analysis and showcasing the pitfalls of other widely practiced approaches. However, further discussion is warranted given the intent of the Ohio Lake Erie Balanced Growth Program and the nature of local planning practice in Ohio.

Ohio's long-time status as a home rule state presents difficulties for multi-jurisdictional land-use planning in Ohio. According to state statutes, municipalities (cities and villages) are authorized under Home Rule Powers to make their own land-use planning and zoning decisions. Townships of certain size are also authorized under Limited Home Rule Powers to make land-use planning and zoning decisions. Cities, villages, and townships are not required or even encouraged to discuss decisions with one another; hence, they generally do not. The principal objective of the Ohio Lake Erie Balanced Growth Program is to encourage local governments to address land-use issues together, rather than individually, on a watershed basis. However, because of home rule, the State of Ohio cannot mandate cooperation among local governments, even through a program like the Ohio Lake Erie Balanced Growth Program. However, the State of Ohio can use the program to encourage cooperation among communities that share a common interest; in its case, a watershed. Therefore, the Ohio Lake Erie Balanced Growth Program is voluntary and incentive-based; the program coaxes, rather than prods, communities to work together.

The choice of land suitability methodology, then, is important so that local governments are not dictated by the suitability analysis to follow a certain course of action, but rather are provided the data, tools, and encouragement to work together to plot their own course. It is very important that local governments participating in the Ohio Lake Erie Balanced Growth Program do not feel coerced or threatened to accept solutions generated by a land suitability analysis. Therefore, rules of combination may be an acceptable method of suitability analysis for the program, but some clarification of the role of land suitability analysis is necessary so participants understand that they are not losing any decision-making or zoning power when they delineate priority conservation and priority development areas. To achieve the necessary clarification, it is important to emphasize the difference between "suitability" and "priority."

"Suitability" and "priority" have very different meanings. The word "suitable" has already been defined in the initial discussion of land suitability analysis: "adapted to a use or purpose; satisfying propriety; proper; able; qualified." The word "priority" means "superiority in rank, position, or privilege; a preferential rating; something given or meriting attention before competing alternatives"). "Suitability" implies what ought to be, while "priority" implies what is desired. "Suitability" suggests objectivity, while "priority" suggests subjectivity. Suitability is more scientific, while priority is more humanistic. Thus, a land suitability analysis may show which areas are proper for particular land uses based on an objective analysis of land characteristics and processes, while a land priority analysis may show which areas are desired for particular land uses based on the preferences and values of stakeholders.

The Ohio Lake Erie Balanced Growth Program wants communities that share common watersheds to collaborate in the selection of priority conservation areas and priority development areas. Based on the definition of priority, discussed in the previous paragraph, it is reasonable that these areas will reflect the preferences and values of stakeholders from the different communities in a common watershed. However, the program is focused on achieving "balanced growth" and there are clear objectives of protecting Lake Erie's water quality and simultaneously fostering a positive environment for growth. Therefore, priority conservation and development areas must be informed by scientifically-valid analysis that upholds water quality protection as a key objective for priority conservation areas and positive economic growth for priority development areas. Hence, it is imperative that suitability analyses be conducted for watersheds and the results of these analyses be provided to stakeholders to inform, not dictate, their final selection of priority conservation areas and priority development areas.

The need for two separate analyses, both suitability and priority, is further supported by reviewing earlier discussion of McHarg's work. *Design with Nature* focused on the axiom that each place on the land is a sum of natural processes and these processes constitute social values. Indeed, McHarg's sentiment implies that researchers fully understand social values and are able to make clear connections between those values and the natural processes they can objectively measure and map. However, that implication is invalid; researchers cannot readily divine the values cherished by a community's stakeholders. Rather it is the stakeholders themselves who must realize their personal values. Therefore, both researchers and stakeholders have a valid role to play in the realization of priority conservation areas and priority development areas through the Ohio Lake Erie Balanced Growth Program. Researchers must produce an objective, scientifically-valid land suitability analysis for watersheds to reflect the program's objectives of water quality protection and economic development. Community stakeholders must produce a subjective, values-driven land priority analysis for their watershed to reflect their preferences for the location of priority conservation areas and priority development areas. The researchers' work should inform, but not dictate, the final product community stakeholders must produce.

The idea of the selection of priority areas as a concrete, two-step process, particularly when applying Geographic Information Systems (GIS) software, is further supported in the broader multi-criteria decision analysis literature. Malczewski (1999) discussed the limitations of using a GIS-based overlay analysis method to select the most suitable areas for specific land use. He states that any spatial decision-making must incorporate the right balance of objective, hard information (reported facts, quantitative estimates, and systematic opinion surveys) and subjective, soft information (opinions of decision-makers, based on intuition, ad hoc surveys, questionnaires, comments, and similar sources). However, Malczewski also admits GIS overlay functions do not provide enough analytical support when the selection of the most suitable areas involves conflicting preferences with respect to evaluation criteria.

Many applications of land suitability analysis actually make final priority designations using a straight one-step GIS overlay function. These approaches make two assumptions:

1) more information is better for conflict resolution

2) no disagreement among the competing parties over the validity of both data and decision models used within the framework of GIS.

However, Obermeyer and Pinto (1994) show that both assumptions are false.

1) the increasing availability and quality of geographic data will lead to increased (not decreased) conflict in the short run because a greater number of parties can use GIS capabilities to support their own objectives. Conflict will level off, but at a higher level than previously.

2) Interest conflict (disagreement over facts) and value conflict exist. While GIS may mitigate interest conflict, value conflict will remain irrespective of data and information; value conflict may actually increase because parties know more and more facts can aggravate value conflict.

While GIS systems can provide a tool for handling the disagreements over facts by providing more and better information (land suitability analysis), decision analysis techniques can help in diminishing disagreements over values among the parties to conflicting interests (land priority analysis). Thus, a GIS-based decision-support system for the Ohio Lake Erie Balanced Growth Program is appropriate for the type of objective land suitability analysis discussed here. However, it is not appropriate to apply the same model of GIS-based decision-support to a land priority analysis, since GIS software and objective data will not resolve the value conflicts that arise when stakeholders must collaborate to determine priority conservation areas and priority development areas.

In conclusion, the literature supports a rules-of-combination approach to land suitability analysis as the first phase toward delineation of priority conservation areas and priority development areas. The GIS-based decision support system developed by EcoCity Cleveland for the Ohio Lake Erie Balanced Growth Program provides an objective, data-supported medium for stakeholders to gain critical information about their watershed. However, a second phase (a land priority analysis) is also necessary for stakeholders to reconcile their preferences and desires for the spatial organization of land uses within a watershed. The final priority conservation areas and priority development areas mapped by watershed partnerships must reflect stakeholder values. Stakeholder values cannot be generated by an objective, scientifically-based land suitability analysis; the stakeholders themselves must have the final say.

A DECISION SUPPORT MODEL OF LAND SUITABILITY ANALYSIS FOR OHIO LAKE ERIE BALANCED GROWTH PROGRAM

Land suitability analysis is an assessment of an area to determine how proper or appropriate it is for a particular use of the land in a particular location. Like a resume, each location has a set of qualifications (also known as factors) that determine its suitability for a particular land use. Each land-use category merits its own land suitability analysis (i.e. a location is assessed using different factors dependant upon the proposed land use). Furthermore, the list of factors associated with each land-use category has largely been subjective in the application of land suitability analysis during the past four decades.

Ian McHarg justified separate land suitability analyses for different land-use categories in *Design with Nature* (1969). According to McHarg, each suitability analysis should leave little doubt where high and low suitability areas exist for a particular land-use category. However, he also advocated that there is no possibility of ranking the categories themselves. Communities may value one land use over another (determined through their priority analysis), but it is essential that the suitability analysis clearly shows where each land-use category has highest suitability independent of where other land-use categories may have highest suitability (each land-use category's suitability determined through a separate land suitability analysis). The ranking of importance of one land-use category over another is the domain of the stakeholders through their social values.

McHarg does offer some guidance on how to convert potential land-use conflicts, based on high suitability for multiple uses, to complementary land-use solutions. According to him, one of the most valuable innovations of the method is the conception of complementary land uses, the search for areas that can support more than one use. The recognition that certain areas are intrinsically suitable for several land uses can be seen as an opportunity to combine uses in a way that is socially desirable. In these situations, it may be helpful to consider more than one scenario and the potential impact of each on watershed health. A useful baseline for comparing the impacts of each scenario is the status quo (if a Watershed Planning Partnership opted not to change any part of the current land-use planning strategy within the watershed after considering the results of the land suitability analysis). If planning requires the posing of alternatives with the costs and benefits of each, it is necessary to be able to demonstrate the physical and financial consequences of the status quo extended into the future.

Categories of Land-Use Suitability

The Ohio Lake Erie Balanced Growth Program invites planning partnerships in watersheds to develop maps of priority conservation areas and priority development areas. Therefore, the GIS-based decision-support land suitability analysis should target conservation land use and development land use. At first glance, it appears the conservation-development land use dichotomy accounts for all possible land uses within a watershed (the intent of the Ohio Lake Erie Balanced Growth Program). However, upon closer examination, it is apparent that while development is equivalent to non-conservation (you cannot conserve land and use it for development at the same time), non-development is not equivalent to conservation (it is possible to not have development on a site, yet still use the site for something other than conservation). This scenario is realized with agriculture land use. Agriculture lands are not considered developed lands (indeed, many view agriculture lands as open space worthy of protection and an amenity to a community), but neither are they conservation lands. Whether agricultural lands are viewed positively or negatively, they merit their own consideration in a separate land suitability analysis because they are a distinct land use from conservation or development. Therefore, the GIS-based decision-support system should include three land suitability analysis models for three land-use categories: agriculture, conservation, and development. The agriculture and conservation land suitability analyses will hopefully inform priority conservation areas and the development land suitability analysis will hopefully inform priority development areas

Factors of Land Category Suitability

The factors (qualifications) considered when assessing a location's suitability for a particular land-use category should be selected by the proponents of, or experts on, that particular category of land uses. For example, development land suitability should be assessed through factors selected by the developers themselves and by experts on what factors developers seek to qualify a location as suitable for development. It is not appropriate (although commonly applied in much of land suitability analysis practice) for factors to be selected by opponents of a particular land use or experts on a competing land use. However, land-use categories should not be ranked against each other (implying one land-use category is more valuable than another) in the objective suitability analysis. Ian McHarg (1969) supported separate, equal treatment of land suitability for different land-use categories. Furthermore, the Ohio Lake Erie Balanced Growth Program supports economic development balanced with conservation of open space, whether for green or agriculture. Therefore, each land suitability analysis must be independent of the others. This independence applies to all aspects of the analysis, including the selection of factors used to rate a location's suitability for a particular land use. The upshot will be a GIS-based decision support model comprised of three independent suitability analyses for a regional watershed. The results of the three independent suitability analyses are then considered simultaneously by stakeholders as they prepare to discuss their personal values and then apply both the objective suitability analysis results and their personal values to a land priority analysis. The outcome of the land priority analysis will be maps of priority conservation areas and priority development areas for the regional watershed.

Previous suitability analyses violate the independence of suitability analyses for different land-use categories. One of the most egregious examples is the selection of development suitability factors by environmental advocates or agricultural preservationists. Such groups often view development land uses as inherently detrimental and secondary to conservation and agriculture land uses. In addition to the example of conservation or agriculture proponents selecting development suitability factors, another violation of this independence would be a land suitability analysis where suitability for one land-use category was determined (even in part) by lack of suitability for a competing land-use category. This has also been common in past applications of land suitability analysis, particularly where development suitability has been rated based lack of conservation suitability or agricultural suitability (all locations that are not considered highly suitable for conservation or agriculture are automatically considered highly suitable for development). The same violation of independence has been true for suitability analyses from the development perspective, where high suitability for conservation or agriculture has been assigned to locations that are rated as low suitability for development.

LAND SUITABILITY ANALYSIS FOR WATERSHEDS

The foundation and frame for a GIS-based decision support model has been constructed as three independent, objective suitability analyses (one each for agriculture, conservation, and development) comprised of factors selected by experts on each land-use category. However, the Ohio Lake Erie Balanced Growth Program is predicated on a watershed approach to land-use decision-making. The GIS-based decision support model must support the efforts of watershed stakeholders to collaboratively determine maps of priority conservation areas and priority development areas for their watersheds. Therefore, it is important to review land suitability analysis applications to watersheds in the literature. Previous applications of land suitability analysis to watershed planning and land-use decision-making efforts may provide support for a land suitability-based model to provide land priority decision-support to watershed partnerships in the Ohio Lake Erie Basin (and, eventually, watershed partnerships throughout the Great Lakes Basin).

A detailed discussion of land suitability analyses for watersheds is in STEP I under the METHODOLOGY section of this report.

CONCEPTUAL FRAMEWORK (DIAGRAM)

The relationships between the GIS-based decision support model of independent land suitability analyses and the ultimate goals of priority conservation maps and priority development maps are illustrated in Figure 1.

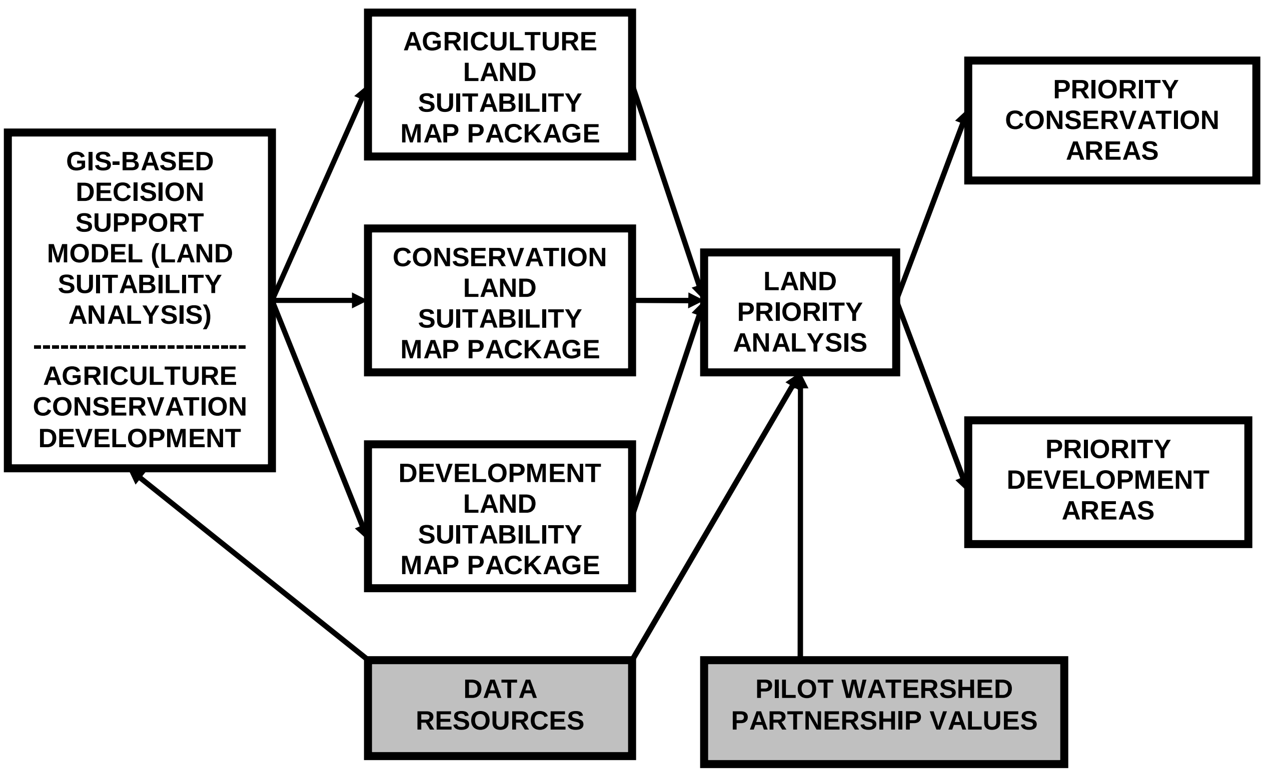


FIGURE 1. Relationships between GIS-based decision support model (land suitability analysis) and priority conservation and development areas for a watershed partnership

The role of EcoCity Cleveland is to develop a GIS-based decision support model, based on objective land suitability analyses for agriculture, conservation, and development land-use categories, and apply the model to produce packages of agriculture, conservation, and development land suitability maps for watershed partnerships in the Great Lakes region. While it is the expectation that these suitability maps will inform each watershed partnership's land priority analysis, EcoCity Cleveland and the Ohio Lake Erie Balanced Growth Program cannot dictate what watershed stakeholders will decide. Watershed partnership stakeholders will develop a land priority analysis to incorporate the suitability results of the model, additional data and studies they obtain or derive, and their social values. The final outcome of the land priority analysis is a map depicting priority conservation areas and priority development areas.

III. METHODOLOGY

PROPOSED TOOLBOX

The toolbox prepared by EcoCity Cleveland for the Ohio Lake Erie Balanced Growth Program includes a decision-support suitability methodology and map package applicable basin-wide. The toolbox was developed with support from state rules, policies, and precedents, technical advisory committees comprised of experts in agriculture, conservation, and development, representatives of three sub-watersheds chosen to be pilots within the Ohio Lake Erie Basin, and literature on suitability analysis for watersheds.

This toolbox may be helpful to both the pilot watershed planning partnerships and future (post-pilot) watershed planning partnerships as they prepare priority land-use maps (both conservation and development priority areas) for their local watershed plans:

FOUNDATIONS

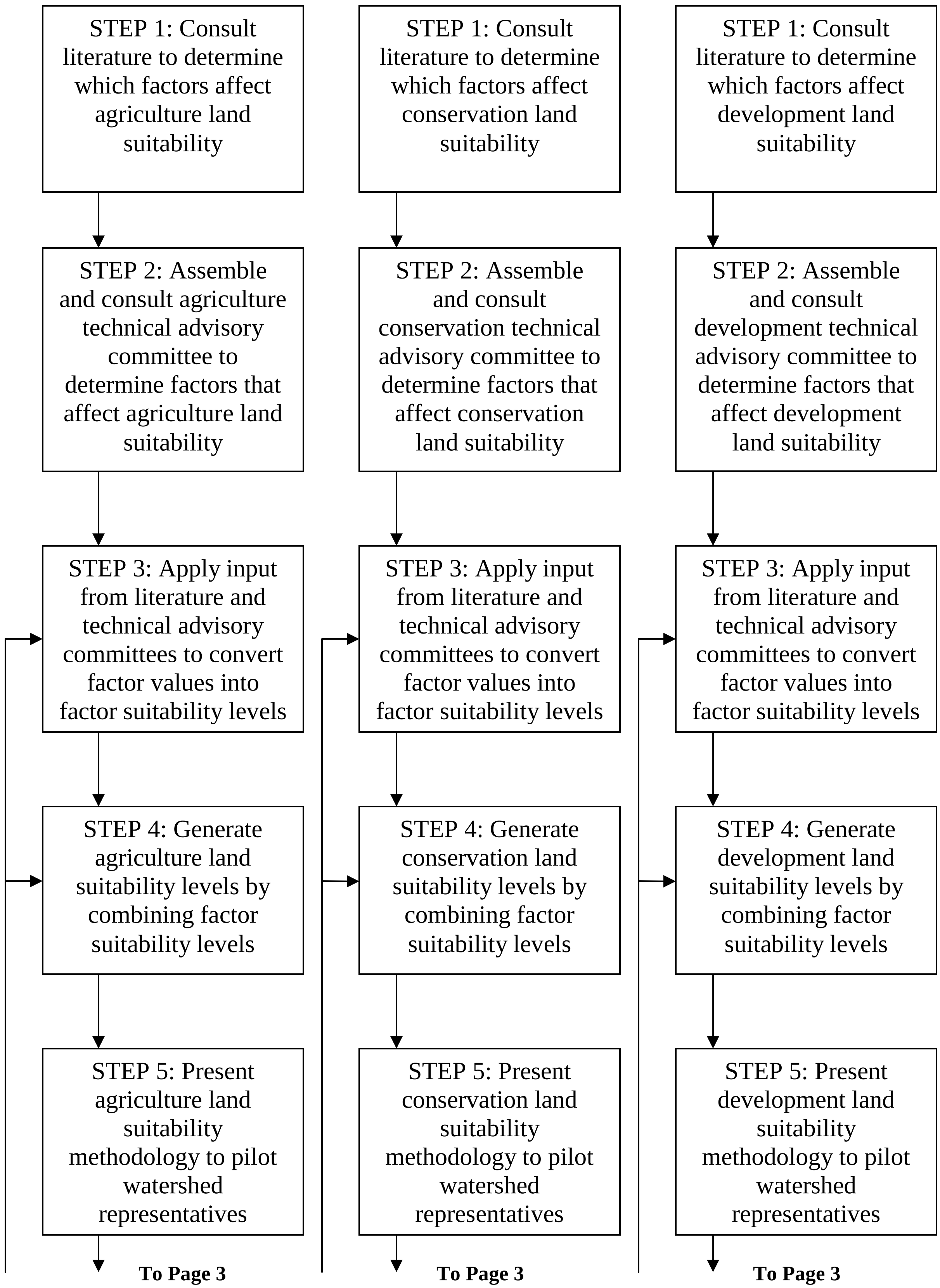
The Balanced Growth Component of the 2000 Lake Erie Protection and Restoration Plan suggests that collaborative, conscious decisions about land use among the communities that share a common tributary watershed in the Lake Erie Basin may improve long-term lake health.

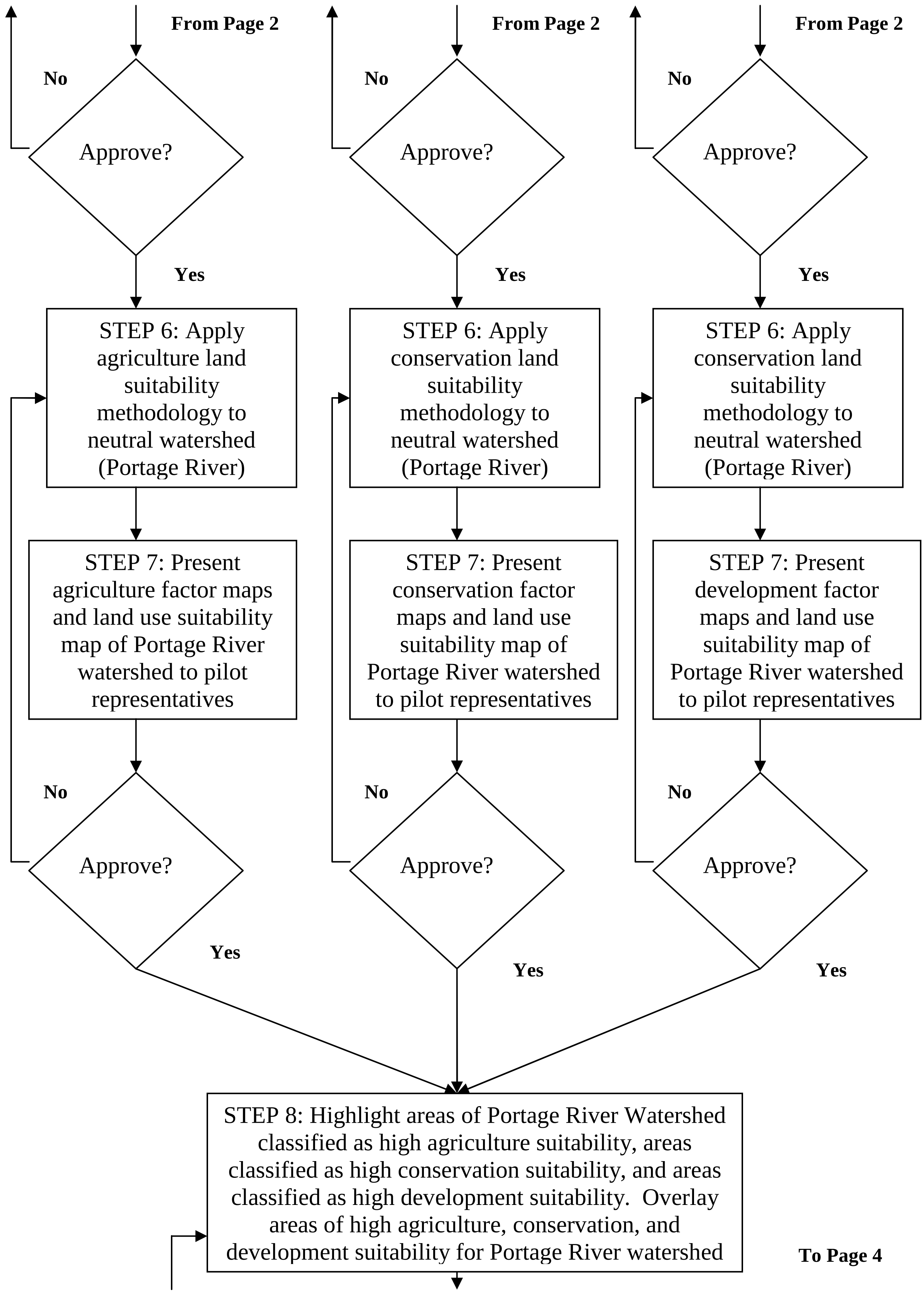
The Balanced Growth Component of the 2000 Lake Erie Protection and Restoration Plan also strongly encourages equal consideration of the merits of development and non-development (conservation) uses across the entire basin; some areas may be equally suitable for multiple land uses and watershed communities may have to craft solutions to allow for a balance of uses.

EcoCity Cleveland and the Ohio Lake Erie Commission offer assistance to pilot watershed representatives through development of a basin-wide methodology to assess the suitability of different areas within their respective tributary watersheds to support both development and non-development (conservation) land uses. The development of this methodology is only done with the input and guidance of the pilot watershed representatives, selected technical advisory committees, and existing literature about previous efforts to assess land suitability in watersheds.

ROAD MAP

The following diagram (Figure 2) illustrates the roadmap of steps taken by EcoCity Cleveland, the Ohio Lake Erie Commission, and representatives of three pilot watersheds (selected by the Ohio Lake Erie Commission from a wide range of watersheds within the Ohio Lake Erie Basin) to develop a decision-support toolbox to inform the decisions of stakeholders to delineate priority conservation and development areas within their respective watersheds. The roadmap leads from the selection of the three pilot watersheds to the final production of comprehensive land suitability maps for each pilot watershed. A sectioned discussion follows the roadmap diagram to elucidate the methods behind each step in the roadmap.


STEP 1: Consult literature to determine which factors affect agriculture land suitability
STEP 2: Assemble and consult agriculture technical advisory committee to determine factors that affect agriculture land suitability
STEP 3: Apply input from literature and technical advisory committees to convert factor values into factor suitability levels
STEP 4: Generate agriculture land suitability levels by combining factor suitability levels
STEP 5: Present agriculture land suitability methodology to pilot watershed representatives
To Page 3
STEP 1: Consult literature to determine which factors affect conservation land suitability
STEP 2: Assemble and consult conservation technical advisory committee to determine factors that affect conservation land suitability
STEP 3: Apply input from literature and technical advisory committees to convert factor values into factor suitability levels
STEP 4: Generate conservation land suitability levels by combining factor suitability levels
STEP 5: Present conservation land suitability methodology to pilot watershed representatives
To Page 3
STEP 1: Consult literature to determine which factors affect development land suitability
STEP 2: Assemble and consult development technical advisory committee to determine factors that affect development land suitability
STEP 3: Apply input from literature and technical advisory committees to convert factor values into factor suitability levels
STEP 4: Generate development land suitability levels by combining factor suitability levels
STEP 5: Present development land suitability methodology to pilot watershed representatives
To Page 3


From Page 2
No
Approve?
Yes
STEP 6: Apply agriculture land suitability methodology to neutral watershed (Portage River)
STEP 7: Present agriculture factor maps and land use suitability map of Portage River watershed to pilot representatives
No
Approve?
Yes
From Page 2
No
Approve?
Yes
STEP 6: Apply conservation land suitability methodology to neutral watershed (Portage River)
STEP 7: Present conservation factor maps and land use suitability map of Portage River watershed to pilot representatives
No
Approve?
Yes
From Page 2
No
Approve?
Yes
STEP 6: Apply conservation land suitability methodology to neutral watershed (Portage River)
STEP 7: Present development factor maps and land use suitability map of Portage River watershed to pilot representatives
No
Approve?
Yes
STEP 8: Highlight areas of Portage River Watershed classified as high agriculture suitability, areas classified as high conservation suitability, and areas classified as high development suitability. Overlay areas of high agriculture, conservation, and development suitability for Portage River watershed
To Page 4

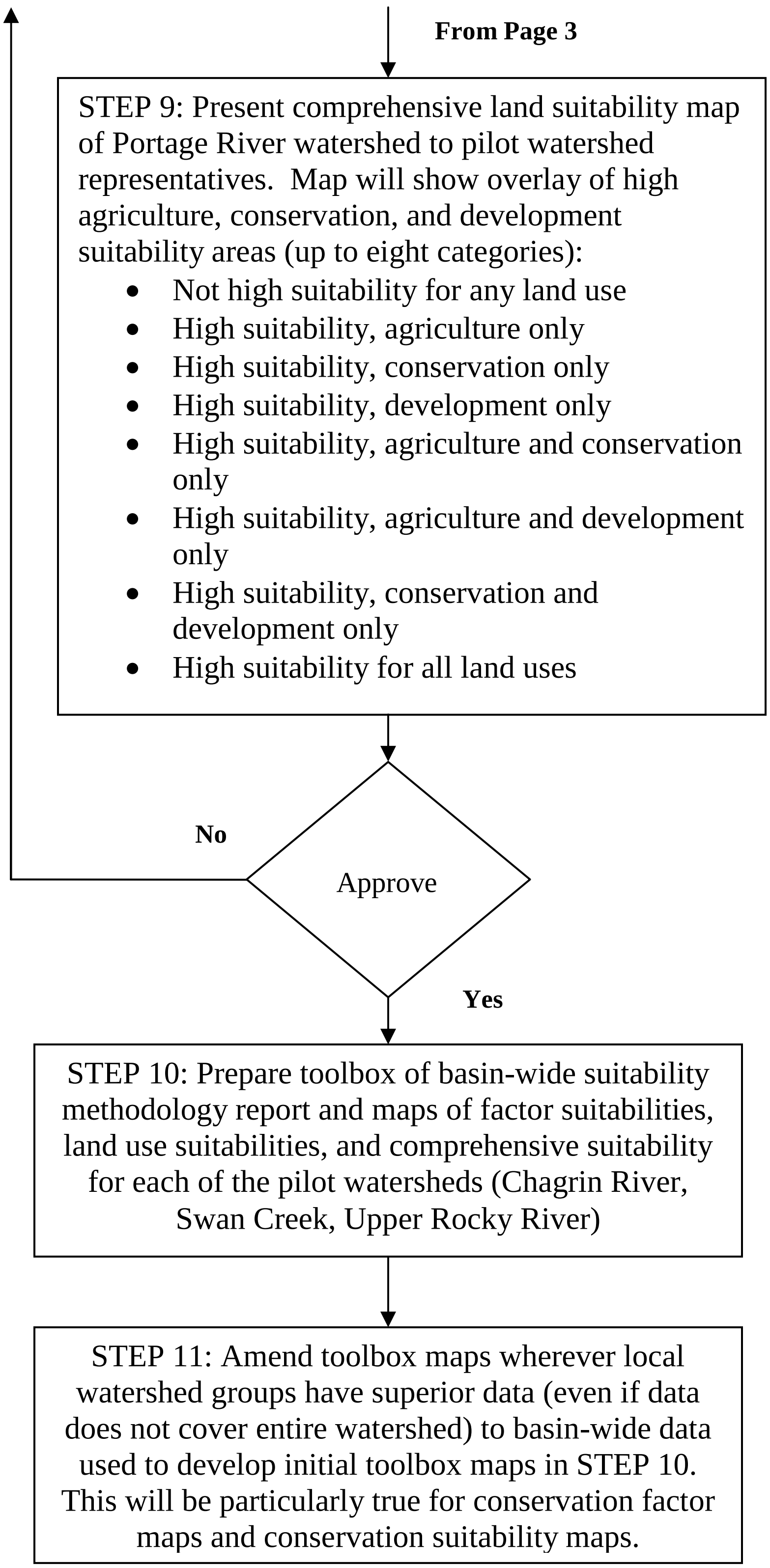
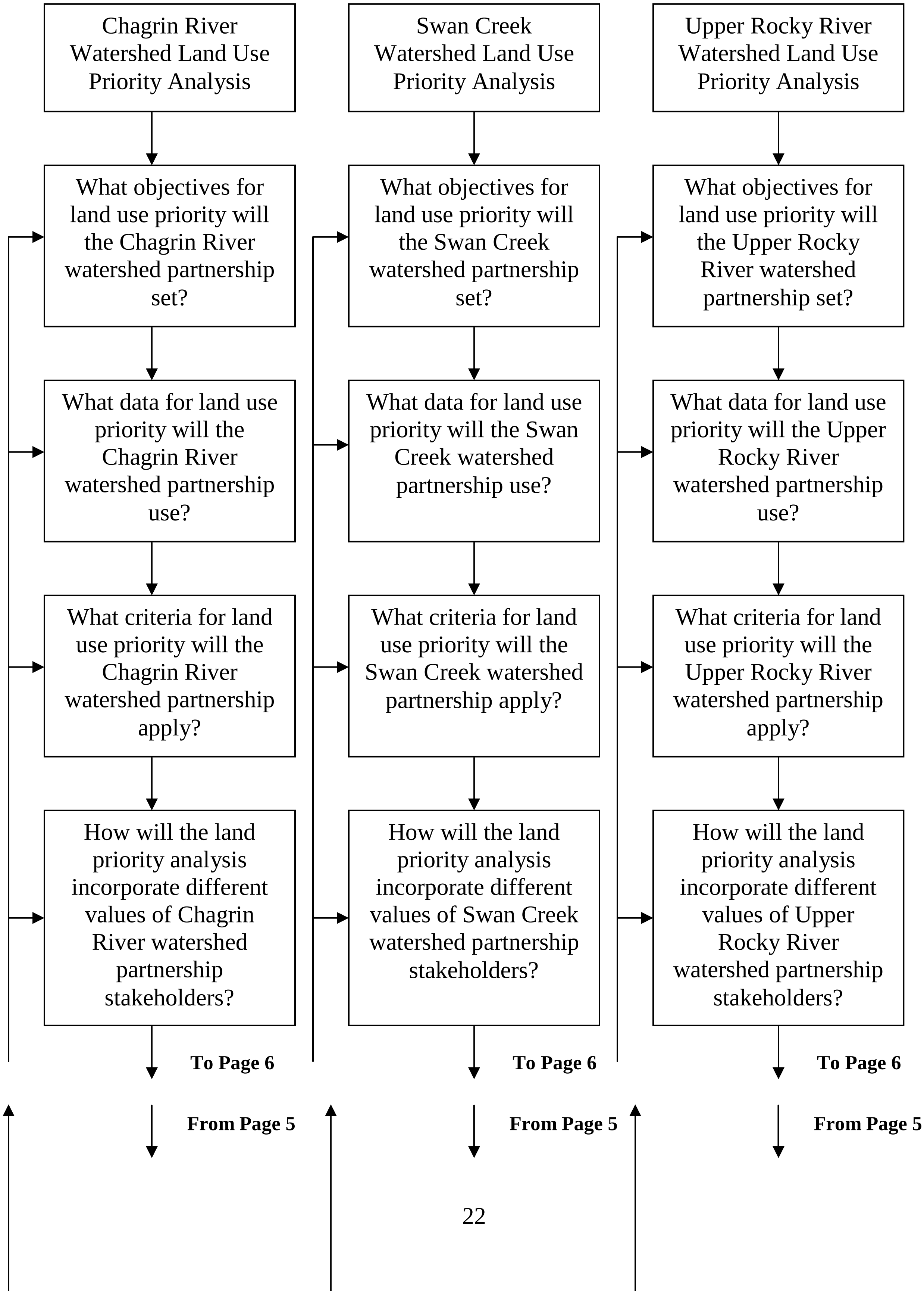


FIGURE 2. Road map of steps necessary to facilitate toolbox development between EcoCity Cleveland and pilot watershed representatives (PHASE I)

The local watershed planning partnership, possibly utilizing the basin-wide land suitability toolbox developed in PHASE I, among other tools and data, will draft priority maps that highlight areas where watershed partnerships favor development uses versus conservation uses.



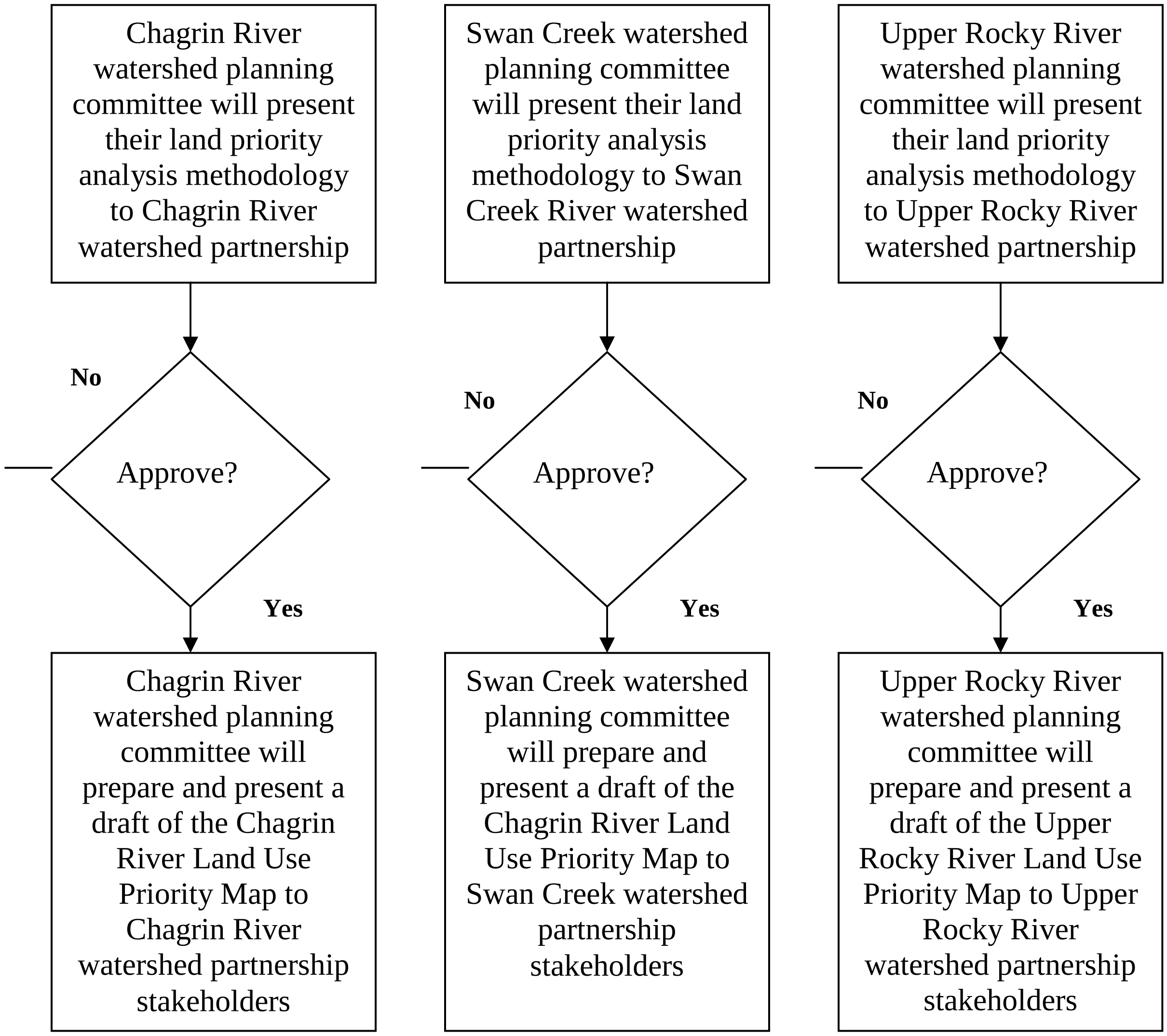


FIGURE 3. Road map to guide watershed planning partnership's development of land priority analysis to delineate priority conservation areas and priority development areas (PHASE II)

PHASE I, STEP 1: Consult literature to determine which factors affect land suitability

Agriculture

The current literature search has revealed a land suitability analysis for agriculture and a land suitability analysis for groundwater-protective conservation (the watershed-protective conservation suitability analysis may be separated into two sub-analyses: groundwater protection and surface water protection). There has not been any land suitability analysis model found in the literature for surface water-protective conservation or development, as of yet.

The land suitability analysis for agriculture is entitled Land Evaluation and Site Assessment. It was developed by the United States Department of Agriculture in 1981 and the details of the methodology published in 1982. The Land Evaluation portion of this model actually holds the technical suitability analysis used to rate the suitability of an area for cropland, forestland, and rangeland. The Site Assessment portion contains an approach that communities may use to incorporate stakeholder values in the analysis. For the purposes of the Ohio Lake Erie Commission Balanced Growth Program, the Land Evaluation portion of the model could be implemented to assess the suitability of lands within the Lake Erie watershed for agriculture. Value decisions will be left to the Watershed Planning Partnerships once the findings have been presented, although EcoCity Cleveland will be available to these groups to offer technical and planning guidance.

The land suitability analysis for groundwater-protective conservation is entitled DRASTIC, an acronym that represents each of the landscape features combined in an index to identify the risk of groundwater pollution. Higher risk translates to higher suitability for groundwater-protective conservation. The model was developed by the United States Environmental Protection Agency in 1987. The landscape features represented in the acronym are as follows:

- D - depth to the water table
- R - recharge of the aquifer
- A - aquifer media
- S - soil media
- T - topography
- I - impact of the vadose zone (region of aeration above the water table)
- C - conductivity

Unless an existing model is found for surface water-protective conservation suitability and development suitability, EcoCity Cleveland will have to contrive its own methods to assess suitability for these land uses. These methods must be based on the existing academic literature and sufficiently documented so that each component of the method can be traced to its original source. There should be nothing covert about the analysis or data used by EcoCity Cleveland to assess the land suitability of the watersheds in the Lake Erie Basin.

The purpose of this memorandum is to share my proposal for assessing agricultural land suitability across the 35 counties that are at least partially within the Ohio Lake Erie Basin.

The basis for the agriculture land suitability methodology is the Land Evaluation and Site Assessment (LESA) Model, developed by the United States Department of Agriculture in 1983. An excellent update of their work is Land *evaluation and site assessment: A guidebook for rating agricultural \lands*, published in 1996 by J.R. Pease and R.E. Coughlin (full citation provided below). In Pease and Coughlin's text, referenced as “Guidebook”, the LESA Model is presented as two components: Land Evaluation (LE), which largely focuses on evaluation of soil quality for agricultural production, and Site Assessment (SA), which largely focuses on individual parcels and the characteristics of individual parcels that affect their suitability for agricultural use. Since the purpose of the Ohio Lake Erie Balanced Growth Program is to provide decision support for land-use policy across whole watersheds and not on a parcel-by-parcel basis, only the Land Evaluation part of the LESA Model should be used to assess agricultural land suitability.

Since the Land Evaluation part of the LESA Model is not dependent upon parcel characteristics to assess agricultural suitability, it can be applied across entire watersheds using the watershed as the unit of analysis. The Site Assessment part of the LESA Model depends upon individual parcel characteristics to assess agricultural suitability. It cannot be applied across entire watersheds using the watershed as the unit of analysis since the individual parcel is the unit of analysis. Therefore, I recommend that the Land Evaluation part of the LESA Model be used to assess agricultural suitability across the Lake Erie Basin, while use of the Site Assessment part of the LESA Model be deferred until watershed stakeholders are ready to assess valuations of priority for conservation (agricultural priority areas should be distinguished within the broader classification of priority conservation areas). Then Site Assessment may be applied on a parcel-by-parcel basis, according to the wishes of the local watershed planning partnership.

Land Evaluation incorporates four factors that may be used to assess agricultural land suitability based on soil quality: land capability, soil productivity, soil potential, and important farmland classification. The land capability classification system assigns soil mapping units to one of eight classes, ranked based on the number of limitations to agricultural productivity, and four subclasses to identify the main limitation (erosion, water, inherent soil properties, or climate). Soil productivity is a measure of the capacity of a soil to produce a specified plant or sequence of plants under a physically defined set of management practices. Soil potential is a measure of the relative quality of a soil, compared with other soils in the area, for a given crop. Important farmland classifications are assigned and/or approved by the United States Department of Agriculture: prime farmland, unique farmland, non-prime farmland of statewide importance, and non-prime farmland of local importance.

The Guidebook offers some considerations for users of the Land Evaluation approach when selecting which factor(s) will be used in assessing agricultural suitability: time, budget, data availability, and spatial area of interest. In their 1983 presentation and discussion of the LESA Model, the United States Department of Agriculture (supported by the Natural Resource Conservation Service) suggested using three of the four factors to evaluate land for agricultural suitability: land capability, soil potential, and important farmland classification. However, studies since this recommendation have shown that there is considerable redundancy when using all three factors to evaluate agricultural suitability (Ferguson & Khan 1992). In The Guidebook, Pease and Coughlin recommend using soil potential or both land capability and soil productivity for Land Evaluation. The Guidebook also suggests that spatial area of interest be considered as well: for statewide analyses Pease and Coughlin recommend land capability or important farmland classification; for countywide or municipal analyses they recommend soil potential and soil productivity. Another consideration is that soil potential and soil productivity are index values derived county-by-county for the crops and management conditions determined by a land evaluation committee for each county.

Based on the above considerations and the scope of the Balanced Growth Program, the important farmland classifications should be used as the Land Evaluation factor to determine agricultural land suitability across the Lake Erie Basin. The Ohio Lake Erie Commission wishes to provide decision-making support to watershed planning partnerships without burdening the partnerships by asking them to develop soil potential and soil productivity indices or by asking them to rank the various land capability classifications and subclassifications. Because the methodology for assessing agricultural land suitability should be consistent across all 35 counties within the Lake Erie Basin, the important farmland classifications are useful because they are based on established definitions and methodologies set by the United States Department of Agriculture.

This approach may seem too simplistic for someone who is used to implementing the full LESA Model across a county, but the purpose here is to make sure areas of high agricultural suitability are given equal consideration as areas of high conservation suitability and areas of high development suitability across a very large area (35 counties). It is important to keep things as simple as possible as long as there is support from experts. The United States Department of Agriculture has recommended important farmland classifications as a Land Evaluation factor and The Guidebook recommended it for assessing areas larger than single counties (state-level). Furthermore, the classifications are based on established standards and definitions by the United States Department of Agriculture (even they have to approve farmlands recommended as locally important) so there is no need for individual county or watershed committees to hash out their own soil potential or soil productivity indices, or land capability classification rankings.

Conservation

The literature review for the conservation land suitability analysis did not focus generally on all suitability analyses that happened to include conservation factors. Since the focus of the Ohio Lake Erie Balanced Growth Program is on protecting water quality through land-use decision-making, the literature review for conservation land suitability analysis focuses exclusively on watershed-based land suitability analyses. Table 2 is a matrix of the conservation suitability factors included in the key studies of land suitability analyses conducted within a watershed framework.

TABLE 2. Inclusion of various conservation suitability factors in published land suitability analyses

CONSERVATION SUITABILITY FACTOR	ASOTIN COUNTY (Beach et al. 1978)	UPPER GILA RIVER (Steiner et al. 2000)	US WATERSHEDS (Barten & Ernst 2004)
Proximity to Water	X	X	X
Lakes	X	X	X
Streams	X	X	X
Wetlands			X
Slope	X	X	X
Erodibility	X	X	
Site Drainage	X	X	
Flow Accumulation			X
Soil Texture	X	X	X
Land Cover			X
Microclimate	X	X	
Scenic Interest	X	X	
Topographic Interest	X	X	
Vegetation Interest	X	X	
Wildlife Interest	X	X	

Proximity to surface water and wetlands, slopes, and soils are the common conservation suitability factors across all three studies. Further review of the water quality and water resource protection literature provided support for the conservation suitability factors selected for the three land suitability analyses in Table 2, particularly proximity to surface water and wetlands.

From a stream management perspective, both the sources and processing of nutrients into streams affect biotic integrity. Nutrient delivery to streams and stream habitat quality are influenced by quality of riparian habitat (Doppelt et. al. 1993 and Johnson et. al. 1997) and land use (Richards et. al. 1996; Allan et. al. 1997; Wang et. al. 1997). As both riparian vegetation and aquatic habitat quality affect how nutrients are assimilated , protecting existing high quality riparian buffers, or otherwise restoring them, is an “obvious first step towards maintaining biotic integrity (Miltner & Rankin 1998, 156).”

Wang (2001) demonstrated that river biological integrity is strongly related to the habitat health. This linkage suggests that the goal of protecting water quality through land-use planning can and should be achieved through development of riverside corridors that can have many benefits: protecting water quality, enhancing biological diversity, and minimizing soil erosion. Steedman (1988) demonstrated a co-relationship between riparian zone quality and land use in terms of how each affected the fish communities and Index of Biotic Integrity values of Toronto area streams. Horner et. al. (1997) also found that the negative effects of urban land use were mitigated by riparian protection and other management interventions. However, in both studies the quality and extent of the riparian zones ceased to be effective above 45-60% impervious land cover. Johnson et. al. (1997) found that land use within the stream ecotone, defined as the 100-meter stream buffer on each bank, explained more variance in summer Total Phosphorous (TP) concentrations than whole catchment land use in the Saginaw Bay drainage of Michigan, U.S.A., suggesting processes acting within the stream ecotone are important determinants of Total Phosphorous in Streams.

Not only does adjacent land use influence nutrient export to the stream, but habitat quality within the stream may influence nutrient processing. Degraded stream channels with poorly developed riparian habitat exacerbate deleterious effects of residual nutrients via decreased riparian uptake, increased retention time due to siltation and wider channels, and by allowing full sunlight to reach the stream (Barling & Moore 1994). Conversely, high quality habitats with mature, intact riparian zones may ameliorate potential adverse impacts of nutrients by terrestrial assimilation (with export via leaf litter), by reducing sunlight and by reducing clay and silt loads to which nutrients are often absorbed (Klotz 1988).

A “protective proximity” of developable land to surface water bodies and wetlands is a matter of debate in the literature. According to Lewis (2001), United States wetland policy centers on a ‘no-net loss’ policy with no mention of adjacent lands. While there are state and provincial policies (e.g. Ontario, Massachusetts, and New Jersey) that explicitly address buffer zones, the width of regulated buffers are from 30-120 meters, far narrower than research suggests is necessary to protect wetland water quality. Houlahan and Findlay (2004) found that for many sediment and water nutrients, the effects of adjacent land uses are detected at proximities up to 4,000 meters (~2.5 miles) and perhaps beyond. Thus, small-scale solutions alone (e.g. narrow buffers around individual wetlands) will likely be ineffective. A better approach to sustain the quality of wetland water would be “a heterogeneous regional landscape containing significant proportions of natural forest and wetlands, as well as crop and pasturelands; regulating agricultural activities such as irrigation and fertilizer application; and maintaining comparatively large forested wetland buffers (Houlahan & Findlay 2004, 687).”

Riparian zone management has become one of the most visible and widely accepted applications of watershed management. A focus on protection of riparian corridors is well-grounded in current scientific knowledge of land-water interactions and the multiple mechanisms through which terrestrial ecosystems influence streams and rivers. Recommendations for riparian buffer widths commonly are of the order of 10-100 meters, and are based on a sound intuitive grasp of the processes that should be protected. Buffer widths may vary with stream size, stream order, and ecosystem type. Sensible as these recommendations may be, the scientific information arguing for or against a specified buffer width is limited (Osborne & Kovacic, 1993). Furthermore, the implicit message is that land use throughout the catchment can be ignored, or at least is of lesser importance, relative to riparian land use. This amounts to an assumption about scale and causality that is difficult to rationalize (Allan, et. al. 1997, 150-151).

Yoder et. al. (2000) address the importance of a catchment-wide approach to land use in watershed protection. The most meaningful results of our analysis are the upper thresholds at which attainment of Clean Water Act goals are mostly lost (e.g. 25% watershed in urban land use) and that beyond which it never occurs (>60% watershed in urban land use). Newly urbanizing watersheds should be developed with an emphasis on determining which attributes (e.g. riaparian zones, wetlands, flow regime) need to be maintained and preserved in order to protect and maintain instream habitat and biological quality. However, since quality degrades mostly during the first waves of urbanization in the watershed, it is "prudent to advocate policies that preserve existing riparian zones rather than responding with post-urbanization retrofits (Yoder et. al. 2000, 41)." These results suggest that management of local and riparian conditions will provide some benefits, but that regional landscape conditions may be of greater importance; hence, managers and planners must think in terms of catchments and river basins (Doppelt, et. al. 1993).

In conclusion, distance from a stream or river or wetland is not enough to determine level of conservation suitability. Consideration must be given to the land use within the catchment or sub-basin drained by the stream in question. The literature thus supports proximity to surface water bodies and wetlands as important conservation suitability factors, but also the factors that determine drainage patterns across the entire watershed: slopes, soils, and land uses.

Development

The three land suitability analyses developed for watersheds in Table 2 also offered development suitability factors. However, their development suitability factors were not derived from the developer's perspective, but rather from the conservation perspective. Since the land suitability framework developed for the Ohio Lake Erie Balanced Growth Program depends upon the independence of the agriculture, conservation, and development land suitability analyses, it would not be appropriate to use development suitability factors unless they were derived from the development literature.

Unfortunately, no literature prescribes which factors developers consider when they assess a region for future projects. Personal conversations with both national and state (Ohio) representatives from the National Homebuilders Association, for example, yielded interesting discussions about what developers consider when choosing a site, but also strong messages that if the financing works in their favor, developers will do projects just about anywhere. Therefore, the question of which factors to incorporate in a development land suitability analysis was deferred to the development suitability technical advisory committee assembled in STEP 2.

PHASE I, STEP 2: Assemble and consult technical advisory committee to determine factors that affect land suitability

After the conclusion of the literature review, the next step is to select technical advisory committees for each of the three land suitability analyses: agriculture, conservation, and development. The purpose of these committees is to establish input from experts in each arena of land use from around the State of Ohio. To ensure the independence and validity of the suitability factors chosen for the analysis and of factor values assigned to different suitability values (high, medium, low), EcoCity Cleveland wanted a group of experts who would approach suitability from their own perspective. Therefore, EcoCity Cleveland and the Ohio Lake Erie Commission targeted individuals around the State of Ohio with expertise on what factors made some areas more suitable for their particular land use than others:

Agriculture: soil scientists, organic farmers, soil conservation officers, farmland preservation officers

Conservation: water quality specialists, park planners, environmentalists, conservationists

Development: residential builders, commercial builders, industrial builders, real estate analysts, economic development coordinators

A "snowball technique" for soliciting committee participation was used: an initial list was derived through collaboration of EcoCity Cleveland and Ohio Lake Erie Commission. However, additional names were garnered through the initial list and other suggestions from pilot watershed representatives. Appendix I provides the names for the individuals invited to participate on the technical advisory committees; those individuals who declined the invitation are included so that the reader knows all those considered in the process.

PHASE I, STEP 3: Apply input from literature and technical advisory committees to convert factor values into factor suitability levels

Agriculture

Both the literature review and the input from the agriculture suitability technical advisory committee supported use of the United States Department of Agriculture's important farmland classification system from the National Soil Survey Handbook (United States Department of Agriculture 2005) for the agriculture suitability analysis. The single agriculture suitability factor is important farmland classification status. The possible values are:

- Prime farmland
- Prime farmland if drained
- Prime farmland if either protected from flooding/not frequently flooded during the growing season
- Prime farmland if either drained or protected from flooding/not frequently flooded during the growing season
- Farmland of unique importance
- Farmland of local importance
- Not prime farmland
- Water features

A consultation of the agriculture suitability technical advisory committee yielded the following breakdown of important farmland classification status values into high, moderate, and low agriculture suitability categories:

HIGH (Prime farmland; Prime farmland if drained)

MODERATE (Prime farmland if either protected from flooding/not frequently flooded during the growing season; Prime farmland if either drained or protected from flooding/not frequently flooded during the growing season; Farmland of unique importance; Farmland of local importance)

LOW (Not prime farmland; Water features)

Conservation

More potential conservation suitability factors means more discussion among the technical advisory committee members about which factors should apply to the Ohio Lake Erie Balanced Growth Program. Consensus was strong among the technical advisory committee members for proximity to surface water bodies and proximity to wetlands (including the wetland areas) as conservation suitability factors. However, there was no ready agreement about a precise relationship between suitability and distance from a stream or wetland. Furthermore, there was greater disparity about how to account for drainage patterns and land cover. An initial suggestion was to use imperviousness and size of sub-watersheds to determine how “pristine” they were; the literature had supported stronger protection policies for smaller, undeveloped watersheds rather than larger or more urban watersheds where degradation had already taken its toll. There was also significant concern among conservation technical advisory committee members about sources of data used to discern streams, wetlands, and land cover. Members agreed that sources of data should be made explicit to toolbox users.

Development

Recall that the literature review for development land suitability analysis did not provide a useful list of development suitability factors. Therefore, the development suitability technical advisory committee was surveyed to determine, by the frequency of their responses, which factors mattered most to the development community. So as to distinguish among different types of development projects, technical advisory committee members were queried about residential, commercial, and industrial development separately. The following tables (3, 4, and 5) list the factors (both primary and secondary) provided by the committee members and the frequency with which these factors were mentioned as important to the development community for residential, commercial, and industrial projects, respectively.

TABLE 3. Residential development suitability factors cited by development technical advisory committee members

Development Suitability Factor	Response Frequency (%)	Primary/Secondary Factor
public water availability	71	primary
public sewer availability	71	primary
pro-development attitude in community	64	primary
school quality	64	primary
land cost	50	primary
median household income in community	43	primary
land availability	43	primary
community growth characteristics	29	primary
proximity to highway	29	primary
proximity to highway interchange	29	primary
proximity to retail	29	primary
topography (aesthetics)	29	primary
trees (aesthetics)	29	primary
proximity to employment centers	21	primary
proximity to parks and recreational facilities	21	primary
water (aesthetics)	21	primary
community zoning patterns	14	primary
greenfield vs. infill location	14	primary
community taxes	14	primary
community education levels	7	primary
community racial diversity	7	primary
fiberoptics service	7	primary
quality of public services	7	primary
access to public transportation	7	primary
depth to bedrock	7	secondary
slope	7	secondary
soil type/stability	7	secondary

TABLE 4. Commercial development suitability factors cited by development technical advisory committee members

Development Suitability Factor	Response Frequency (%)	Primary/Secondary Factor
public water availability	64	primary
public sewer availability	64	primary
median household income in community	50	primary
community population density	50	primary
proximity to highway	50	primary
community growth characteristics	43	primary
land availability	43	primary
pro-development attitude of community	43	primary
proximity to highway interchange	43	primary
proximity to other commercial development	29	primary
proximity to a population center	29	primary
land cost	29	primary
community traffic density	21	primary
soil type/stability	21	secondary
community taxes	14	primary
proximity to employees	14	primary
depth to bedrock	14	secondary
slope	14	secondary
highway visibility	7	primary
community education levels	7	primary
access to public transportation	7	primary
fiber-optics service	7	primary
school quality	7	primary
well-known locale	7	primary

TABLE 5. Industrial development suitability factors cited by development technical advisory committee members

Development Suitability Factor	Response Frequency (%)	Primary/Secondary Factor
proximity to highway	64	primary
public sewer availability	57	primary
public water availability	57	primary
land availability	50	primary
proximity to highway interchange	50	primary
pro-development attitude of community	36	primary
proximity to employees (including CEO)	29	primary
land cost	29	primary
soil type/stability	29	secondary
median household income in community	21	primary
community taxes	21	primary
slope	21	secondary
community growth characteristics	14	primary
proximity to gas pipelines	14	primary
proximity to population center	14	primary
proximity to freight rail lines	14	primary
quality of public transportation	14	primary
depth to bedrock	14	secondary
existence of wetlands	14	secondary
existence of floodplains	14	secondary
community population density	7	primary
brownfield liability	7	primary
electric power service	7	primary
fiber-optics service	7	primary
school quality	7	primary
site cleanup costs	7	primary
unionization status of area workers	7	primary

The development technical advisory committee would not, however, determine which development suitability factors should be used in the Ohio Lake Erie Balanced Growth Program, nor would they relate factor values to development suitability levels. Therefore, the contents of Tables 3, 4, and 5 were presented to the pilot watershed representatives in STEP 5.

PHASE I, STEP 4: Generate land suitability levels by combining factor suitability levels

Agriculture

Only a single agriculture suitability factor defines the agriculture suitability analysis, so the agriculture land suitability levels match the important farmland classification suitability levels.

Conservation

The literature and technical advisory committees suggested several conservation suitability factors that had merit in a watershed land suitability analysis, but did not distinguish what combination of factor suitabilities would translate to various levels of overall conservation suitability. EcoCity Cleveland decided to present the findings from both the literature and the technical advisory committee to the pilot watershed representatives for discussion and determination in STEP 5.

Development

As discussed in STEP 3, EcoCity decided to present the results of the development technical advisory committee survey to the pilot watershed representatives in STEP 5 to determine the development suitability factors, the suitability levels for different factor values, and the overall development suitability levels for different combinations of factor values.

PHASE I, STEP 5: Present land suitability methodology to pilot watershed representatives

Over a period of several months' worth of meetings, telephone conversations, email exchanges, and personal interaction between January and June 2006, the pilot watershed representatives received and honed the findings on agriculture, conservation, and development suitability factors from both the literature and the technical advisory committees into a toolbox of suitability factors and suitability levels based on the values of those factors. The results of this interactive development period are outlined in the description of the GIS-decision support toolbox in SECTION IV (THE TOOLBOX: LAND SUITABILITY FOR THE PILOT WATERSHEDS).

PHASE I, STEP 6: Apply land suitability methodology to neutral watershed

This step was dropped from PHASE I because the pilot watershed representatives needed to initiate the land priority analysis development process as expeditiously as possible to begin PHASE II.

PHASE I, STEP 7: Present agriculture factor maps and land-use suitability map of Portage River watershed to pilot representatives

This step was dropped from PHASE I because the pilot watershed representatives needed to initiate the land priority analysis development process as expeditiously as possible to begin

PHASE II. Since the pilot watershed representatives did not review factor maps and a land-use suitability map of the Portage River watershed, they also did not approve or reject such maps.

PHASE I, STEP 8: Highlight areas of Portage River Watershed classified as high agriculture suitability, areas classified as high conservation suitability, and areas classified as high development suitability. Overlay areas of high agriculture, conservation, and development suitability for Portage River watershed

This step was dropped from PHASE I because the pilot watershed representatives needed to initiate the land priority analysis development process as expeditiously as possible to begin PHASE II.

PHASE I, STEP 9: Present comprehensive land suitability map of Portage River watershed to pilot watershed representatives. Map will show overlay of high agriculture, conservation, and development suitability areas (up to eight categories)

This step was dropped from PHASE I because the pilot watershed representatives needed to initiate the land priority analysis development process as expeditiously as possible to begin PHASE II.

PHASE I, STEP 10: Prepare toolbox of basin-wide suitability methodology report and maps of factor suitabilities, land-use suitabilities, and comprehensive suitability for each of the pilot watersheds (Chagrin River, Swan Creek, Upper Rocky River)

Once the pilot watershed representatives had approved the land suitability methodology from STEP 5, they urged EcoCity Cleveland and the Ohio Lake Erie Commission to move to STEP 10 and provide the GIS-based decision-support toolbox of maps to the pilot watershed representatives so the representatives could then shepherd the toolbox into PHASE II development of a local land priority analysis with their respective local watershed stakeholders.

PHASE I, STEP 11: Amend toolbox maps wherever local watershed groups have superior data (even if data does not cover entire watershed) to basin-wide data used to develop initial toolbox maps in STEP 10. This will be particularly true for conservation factor maps and conservation suitability maps.

Since the pilot watershed representatives were eager to move into PHASE II and development of a land priority analysis to map priority conservation areas and priority development areas, EcoCity Cleveland and the Ohio Lake Erie Commission delegated STEP 11 to the pilot watershed partnerships.

In terms of the anticipated relationship between and land suitability and land priority, the clearest indication we have is when there is high suitability for a particular land-use category and not high suitability for other land-use categories. For example, an area characterized by high suitability for conservation, but not high suitability for development and not high suitability for agriculture, provides stakeholders in a watershed planning partnership with strong evidence to support the area as priority for conservation (bearing in mind that the stakeholders have the prerogative to dismiss any or all of the land suitability analysis results if they so choose). But what about instances when a place does not have high suitability for any of the uses? Or, when a place has high suitability for more than one use? These scenarios merit separate discussion.

In areas of a watershed where there is not high suitability for conservation, nor high suitability for development, nor high suitability for agriculture, then there is no technical support for establishing a priority area. This does not mean that such places cannot be established as priority areas for any particular use. However, such priority designations are not supported by the data available (noting that watershed planning partnerships may have superior local data to the basin-wide data used for the toolbox land suitability analysis).

In areas of a watershed where there is high suitability for at least two of the uses[1]: conservation, development, and agriculture, the stakeholders in a watershed planning partnership must decide whether to favor one use over another, or develop creative strategy to incorporate both or all uses. For example, a particular area may have high suitability for conservation and high suitability for development. A land suitability analysis does not attempt to rate the value of conservation against the value of development; that value choice is left to the stakeholders within the watershed. Ian McHarg (1969) suggests that areas designated as high suitability for multiple land uses are excellent opportunities for creative development that can accommodate each use. On the other hand, the communities of a watershed may decide to make trade-offs by designating one area as priority for one of the uses for which it has high suitability and another area as priority for the other use for which it has high suitability. Local stakeholders always have the final word on what is priority for the watershed.

IV. THE TOOLBOX: LAND SUITABILITY FOR THE PILOT WATERSHEDS

This section lists the final factors selected for each of the three land category components of the land suitability analysis toolbox. The toolbox includes each factor's suitability criteria and each land category's suitability criteria. The toolbox also provides detailed instructions about how to make all the base maps, factor suitability maps, and land category suitability maps (final comprehensive suitability maps for each pilot watershed included in SECTION V). Detailed instructions are listed in the Appendices of the report, as referenced in the more general instructions of this section. The toolbox was created for the Ohio Lake Erie Basin by EcoCity Cleveland, the Ohio Lake Erie Commission, and the representatives of the three watersheds chosen as pilots for the Balanced Growth Program (Chagrin, Rocky River Upper West Branch, and Swan Creek).[2] For more information about the toolbox, GIS techniques, and access to Ohio data, contact Sandra Kosek-Sills at the Ohio Office of Coastal Management, 419-609-4121.

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[1] Please note that since all areas are considered to have high development suitability from the standpoint of developers, all areas labeled "high suitability" agriculture, conservation, or both will also be high suitability for development. Only areas that are not high suitability for agriculture or conservation will be highly suitable for development only.

[2] Please note that file pathnames are included in the event this report accompanies the actual GIS toolbox prepared by EcoCity Cleveland (home directories might change, but the pathways should remain the same). Please also note that updated Natural Resources Conservation Service (NRCS) Soil Data for Henry County (Swan Creek Watershed) and Portage County (Chagrin River Watershed) were not available during the grant period and therefore could not

STEP 1: Make political watershed maps using the instructions in the following file (see Appendix A):

C:\bgi_final_cd\land_suit\derived_maps\poliwatermap

AGRICULTURE LAND SUITABILITY FACTORS

Factor: Important Farmlands Classification Designation by Natural Resources Conservation Service, United States Department of Agriculture

Factor Suitability:

- HIGH: All Prime classifications
- MODERATE: Not Prime, but deemed noteworthy by select political jurisdictions (Unique or Locally Important)
- LOW: Not Prime (political jurisdictions either did not undergo the process to note Unique or Local Importance, or they did and these areas did not qualify)

Land Category Suitability: Equivalent to factor suitability

AGRICULTURE LAND SUITABILITY DELIVERABLES (compact disc)

- Raw soils data (Natural Resources Conservation Service)
  - Chagrin River (Cuyahoga, Geauga, Lake, NOT Portage, Counties)
  - Rocky River Upper West Branch (Medina County)
  - Swan Creek (Fulton, Lucas, NOT Henry, Counties)
- Soil Classification Maps (NOT Portage, Henry Counties)
- Important Farmland Classification Maps (NOT Portage, Henry Counties)
- Agriculture Suitability Maps (NOT Portage, Henry Counties)
- Instructions for mapping (use to incorporate Portage and Henry County data)
  - Download data (Appendix B: I): C:\bgi_final_cd\land_suit\raw_data\county_data\soil\downloadsteps
  - Reproject and rasterize data (Appendix B: II and III): C:\bgi_final_cd\land_suit\derived_maps\countydatamap
  - Make agriculture suitability map (Appendix B: IV): C:\bgi_final_cd\land_suit\derived_maps\makefarmmap

CONSERVATION LAND SUITABILITY FACTORS

Factor #1: Riparian Corridor, Stream Designation by United States Geological Survey digitized Topographic Maps at 1:24,000 scale

Factor Suitability (PROPOSED):

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be included in the results. However, the instructions provided in the toolbox enable representatives of those watersheds to include those areas in the suitability analysis once the data becomes available.

- HIGH: areas that meet ONE of the following conditions:
  - within 300 feet of a stream edge, stream drains area over 300 square miles
  - within 120 feet of a stream edge, stream drains area 20-300 square miles
  - within 75 feet of a stream edge, stream drains area 0.5-20 square miles
  - within 25 feet of a stream edge, stream drains area under 0.5 square miles
- LOW: areas that do not meet ANY of the above conditions

Factor Suitability (IMPLEMENTED)

- Due to the nature of the hydrologic layer available from the United States Geological Survey, the drainage area for each stream is not known. Since the rasterization of the hydrologic shapefile yields a cell network with a resolution of 100 feet, any cell that contains a “stream or shoreline” feature is considered to be “stream or shoreline.” Any cell within a 120-foot buffer of a “stream or shoreline” cell is categorized as HIGH suitability, while cells not within 120 feet are categorized as LOW suitability. The following classifications may constitute “stream or shoreline” in the United States Geological Survey Data (note there are also some features that are not classified, but are still included in the analysis)[3]:
  - Closure Line
  - Closure Line-Stream
  - Dam/Weir
  - Ditch/Canal
  - Intermittent
  - Intermittent-Closure Line-Stream
  - Intermittent Ditch/Canal
  - Intermittent Lake/Pond
  - Intermittent Manmade Shoreline
  - Intermittent Shoreline
  - Intermittent-Shoreline-Closure-Line
  - Intermittent Stream
  - Intermittent Stream-Ditch/Canal
  - Lake/Pond
  - Manmade Shoreline
  - Manmade Shoreline-Dam/Weir
  - Shoreline
  - Shoreline-Closure Line
  - Shoreline-Dam/Weir
  - Stream

- Instructions for mapping:
  - Download data (Appendix C: I): C:\bgi_final_cd\land_suit\raw_data\state_data\streams\downloadsteps
  - Reproject and rasterize data (Appendix C: IIA, III): C:\bgi_final_cd\land_suit\derived_maps\statedatamap

[3] The primary difficulty of this approach is with rivers wider than 100 feet (cells may be entirely within the river, but may not register as having a “stream and shoreline” feature.

    - Make suitability map (Appendix C: IV): C:\bgi_final_cd\land_suit\derived_maps\makestreammap

Factor #2: Floodplain, 100-year Federal Emergency Management Agency floodplain boundaries from Ohio Department of Natural Resources and floodplain soils designated by Natural Resources Conservation Service

Factor Suitability:

- HIGH: areas that meet ONE of the following conditions:
    - Within a 100-year floodplain designated by the Federal Emergency Management Agency
    - Classified as floodplain soils by the Natural Resources Conservation Service
- LOW: areas that do not meet ANY of the above conditions

- Instructions for mapping:
    - Download floodplain data (Appendix D: I): C:\bgi_final_cd\land_suit\raw_data\county_data\floodplain\downloadsteps
    - Download floodplain soils data (Appendix B: I): (see soils data download under agriculture suitability)
    - Reproject and rasterize data (Appendix B: II, III): C:\bgi_final_cd\land_suit\derived_maps\countydatamap
    - Make suitability map (Appendix D: II): C:\bgi_final_cd\land_suit\derived_maps\makefloodmap

Factor #3: Wetland, Ohio Wetland Inventory or National Wetland Inventory (not yet digitized) and types of hydric soils from Natural Resources Conservation Service

Factor Suitability:

- HIGH: areas that meet ONE of the following conditions:
    - Within the confluence of an Ohio Wetland Inventory-designated wetland AND hydric soils OR non-hydric soils with hydric inclusions
    - Within the confluence of a National Wetland Inventory-designated wetland AND hydric soils OR non-hydric soils with hydric inclusions,
    - Within 165 feet of a wetland (regardless of class)
- LOW: areas that do not meet ANY of the above conditions
- Instructions for mapping:
    - Download wetland data (Appendix E: I): C:\bgi_final_cd\land_suit\raw_data\county_data\wetland\downloadsteps
    - Download hydric soils data (Appendix B: I): (see soils data download under agriculture suitability)
    - Reproject and rasterize data (Appendix B: II, III): C:\bgi_final_cd\land_suit\derived_maps\countydatamap
    - Make suitability map (Appendix E: II): C:\bgi_final_cd\land_suit\derived_maps\makewetlndmap

Factor #4: Infiltrative Capacity, TR-55 Runoff Curve Numbers represent combinations of Natural Resource Conservation Survey hydrologic soil groups (A, B, C, D) and 2003 EPA Land Cover categories prepared by the University of Cincinnati (deciduous forest, evergreen forest, pasture, crop, open water, residential, commercial/industrial/transportation, bare/mines, urban/recreational grasses, herbaceous wetlands, woody wetlands)

Factor Suitability:

- HIGH: All areas where the combination of hydrologic soil group and land cover category generate a runoff curve number no greater than 79[4]
- LOW: All areas where the combination of hydrologic soil group and land cover category generate a runoff curve number greater than 79

[4] All forested areas, regardless of hydrologic soil group, are characterized by runoff curve numbers no greater than 79. Therefore, a critical curve number of 79 to distinguish areas of HIGH infiltrative capacity suitability versus LOW infiltrative capacity suitability ensures all forested areas are classified as HIGH (supported by representatives from each of the pilot watershed partnerships according to Chris Hartman of Rocky River Upper West Branch watershed, personal conversation 6.30.2006).

TABLE 6. Runoff curve numbers assigned to combinations of land cover and hydrologic soil group

LAND COVER	HYDROLOGIC SOIL GROUP	RUNOFF CURVE NUMBER	SUITABILITY
Deciduous Forest	A	36	HIGH
Deciduous Forest	B	60	HIGH
Deciduous Forest	C	73	HIGH
Deciduous Forest	D	79	HIGH
Evergreen Forest	A	36	HIGH
Evergreen Forest	B	60	HIGH
Evergreen Forest	C	73	HIGH
Evergreen Forest	D	79	HIGH
Pasture	A	46	HIGH
Pasture	B	65	HIGH
Pasture	C	76	HIGH
Pasture	*D*	*82*	*LOW*
Crop	A	64	HIGH
Crop	B	75	HIGH
Crop	*C*	*82*	*LOW*
Crop	*D*	*85*	*LOW*
Residential	A	65	HIGH
Residential	B	77	HIGH
Residential	*C*	*85*	*LOW*
Residential	*D*	*88*	*LOW*
Commercial/Industrial/Transportation	*A*	*85*	*LOW*
Commercial/Industrial/Transportation	*B*	*90*	*LOW*
Commercial/Industrial/Transportation	*C*	*92*	*LOW*
Commercial/Industrial/Transportation	*D*	*94*	*LOW*
Bare/Mines	A	77	HIGH
Bare/Mines	*B*	*86*	*LOW*
Bare/Mines	*C*	*91*	*LOW*
Bare/Mines	*D*	*94*	*LOW*
Urban/Recreational Grasses	A	50	HIGH
Urban/Recreational Grasses	B	68	HIGH
Urban/Recreational Grasses	C	79	HIGH
Urban/Recreational Grasses	*D*	*84*	*LOW*
Herbaceous Wetlands	all	na	HIGH
Woody Wetlands	all	na	HIGH
Open Water	all	na	HIGH

(USDA 1986)

Land Category Suitability:

- HIGH: If an area has a HIGH suitability rating for any of the conservation factors (Riparian Corridor OR Floodplain OR Wetland OR Infiltrative Capacity)
- LOW: If an area does NOT have a HIGH suitability rating for any of the conservation factors (Riparian Corridor OR Floodplain OR Wetland OR Infiltrative Capacity)

- Instructions for mapping:
    - Download land cover data (Appendix F: I): C:\bgi_final_cd\land_suit\raw_data\state_data\land_cover\downloadsteps
    - Download hydrologic soil data (Appendix B: I): (see soils data download under agriculture suitability)
    - Reproject and rasterize data (Appendix F: II; Appendix D: III for land cover data; Appendix B: II, III for hydrologic soil data) : C:\bgi_final_cd\land_suit\derived_maps\ (statedatamap for landcover data; countydatamap for hydrologic soil data)
    - Make infiltrative capacity suitability map (Appendix F: III): C:\bgi_final_cd\land_suit\derived_maps\makeinfcapmap

<u>CONSERVATION LAND SUITABILITY DELIVERABLES (compact disc)</u>

- Raw soils data (Natural Resources Conservation Service), including floodplain soils, hydric soils, non-hydric soils with hydric inclusions, and hydrological soil groups
    - Chagrin River (Cuyahoga, Geauga, Lake, NOT Portage, Counties)
    - Rocky River Upper West Branch (Medina County)
    - Swan Creek (Fulton, Lucas, NOT Henry, Counties)
- Stream Layer Maps (United States Geological Survey)
- Riparian Corridor Suitability Maps
- Floodplain Maps
- Floodplain Suitability Maps (NOT Portage, Henry Counties)
- Ohio Wetland Inventory Maps
- Wetland Suitability Maps (NOT Portage, Henry Counties)
- 2003 Land Cover Maps
- Infiltrative Capacity Suitability Maps (NOT Portage, Henry Counties)
- Instructions (see above for individual factor suitability instructions; incorporate Portage and Henry County data when available) for mapping conservation suitability map (Appendix G): C:\bgi_final_cd\land_suit\derived_maps\makeconsermap

<u>DEVELOPMENT LAND SUITABILITY FACTORS</u>

The consensus of the technical advisory committees for all categories of development is that all areas of a watershed are suitable; they do not want to label any area as less than high suitability since every site is developable if the finances are justified. Therefore, the entire political watershed is classified as HIGH development suitability.

<u>DEVELOPMENT LAND SUITABILITY DELIVERABLES (compact disc)</u>

- Sewer Facility Planning Area Maps
- Sewer Suitability Maps
- Highway and Highway Interchange Maps
- Fiber-optic Network Maps (currently unavailable, but possibly in future)

- Freight Rail Line Maps
- Gas Line Maps (currently unavailable, may be successfully retrieved by Ed Hammett)
- Electric Power Line Maps
- Instructions for Mapping: Download files are found in each raw development data folder in the toolbox, but since the consensus is that there should not be any areas of the watershed marked as less than high development suitability, then there are no additional mapping instructions

<u>COMPREHENSIVE LAND SUITABILITY MAP</u>

- Instructions for mapping comprehensive land suitability (Appendix H): C:\bgi_final_cd\land_suit\derived_maps\makesuitmap

V. RESULTS

Although the toolbox contains a plethora of maps (both raw data and derived) for the pilot watershed planning partnerships, only the final comprehensive suitability map for each pilot watershed is included in this report (see Figures 4, 5, and 6). It is important for the reader to understand that the pilot watershed partnerships plan to update these maps with their own local data. However, those updates are part of the transition from the land suitability analysis (PHASE I) to the land priority analysis (PHASE II). Use of their own data, where it is available, begins to impart a particular watershed partnership's values on the process and thus the results become increasingly reflective of local priorities versus objective suitabilities.

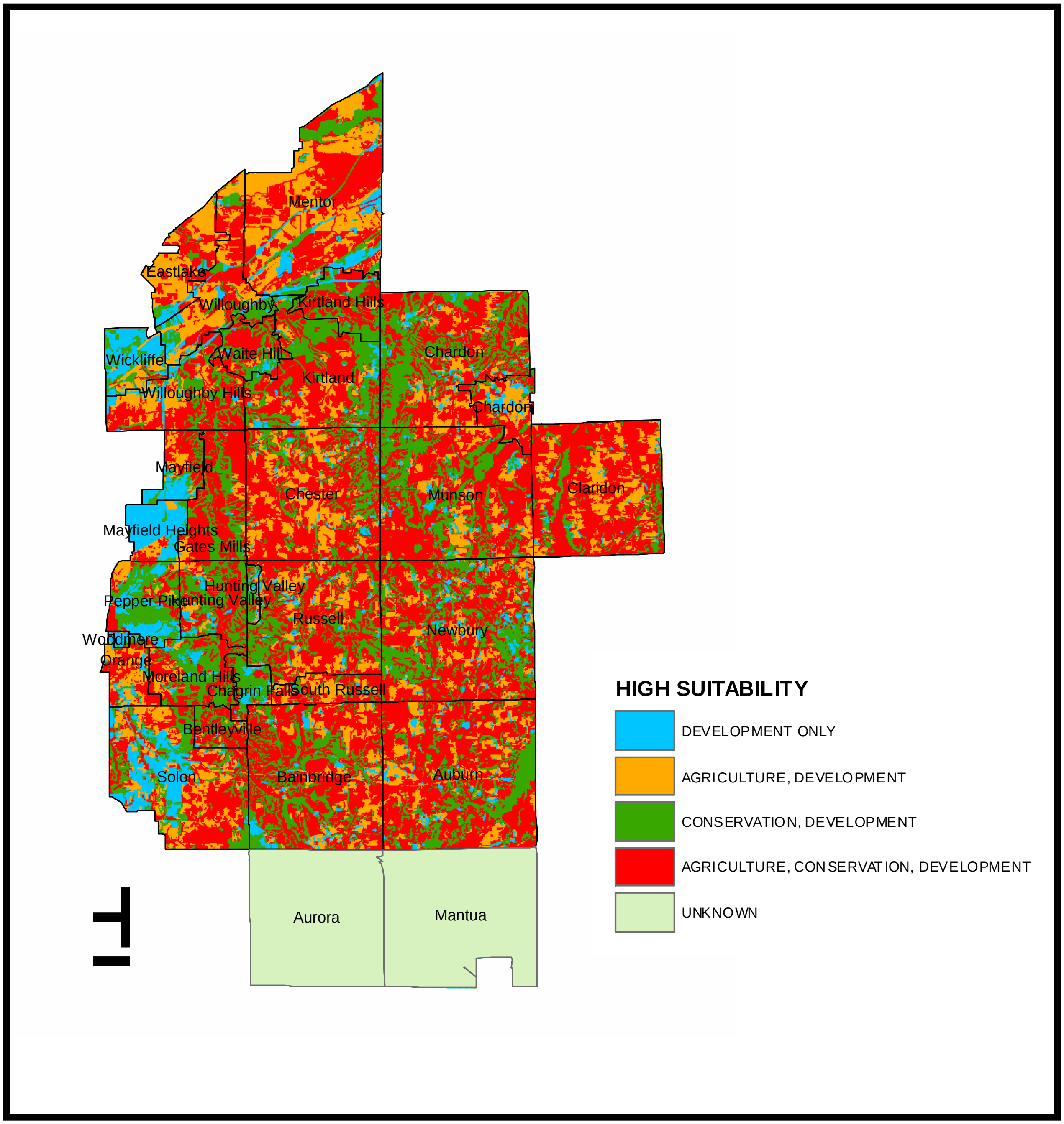

FIGURE 4. Comprehensive map of high agriculture, high conservation, and high development suitability in Chagrin River Watershed

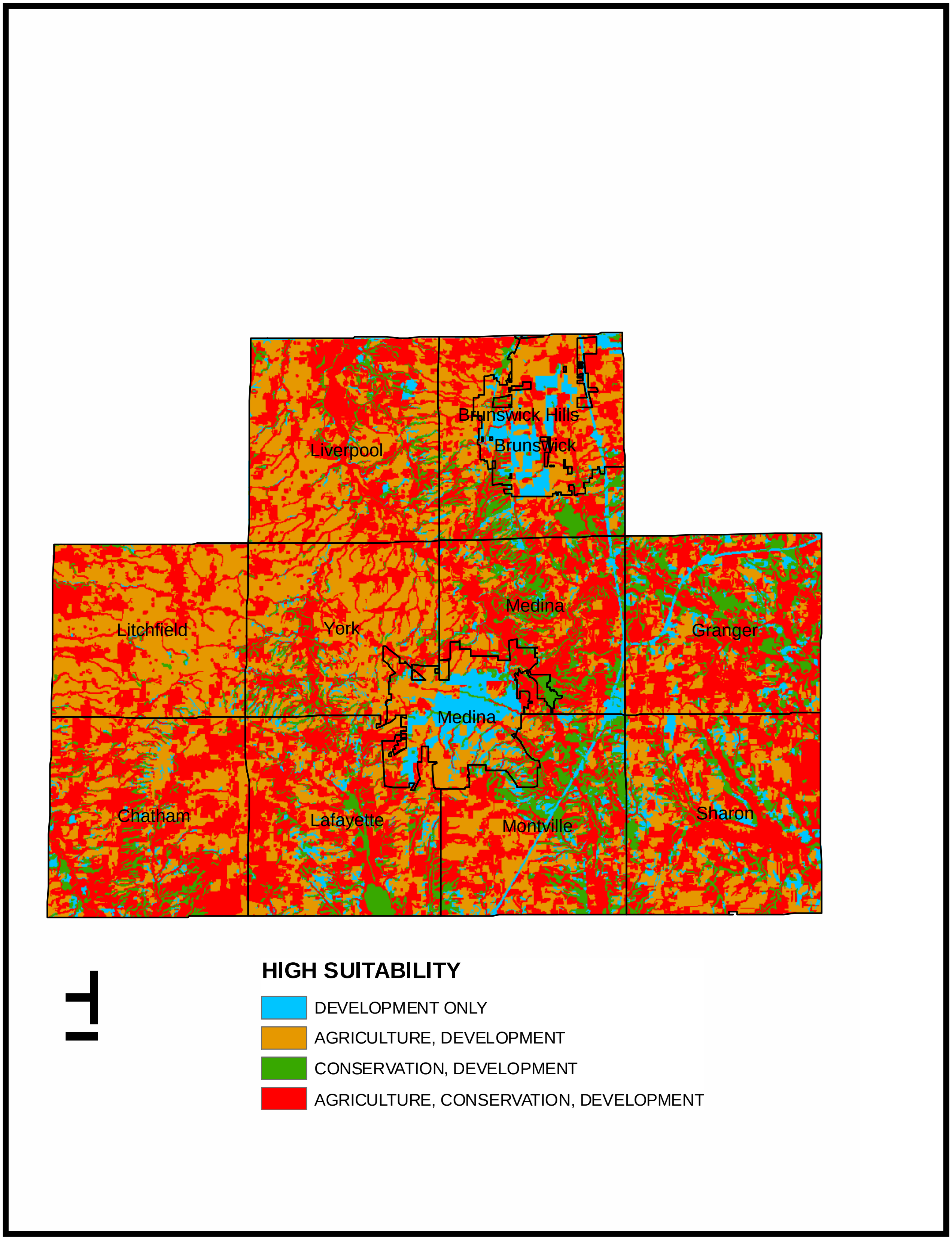

FIGURE 5. Comprehensive map of high agriculture, high conservation, and high development suitability in Upper Rocky River West Branch Watershed

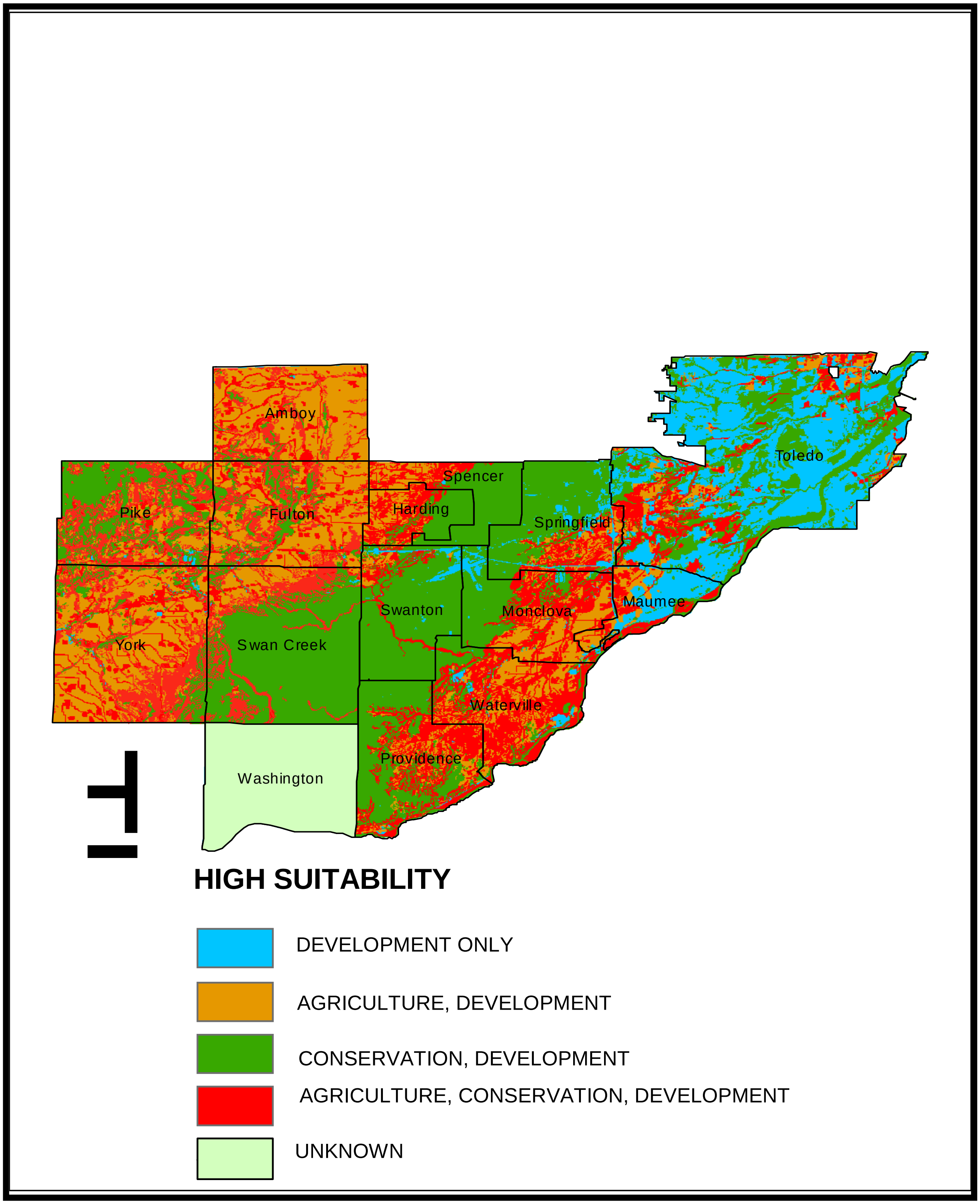

FIGURE 6. Comprehensive map of high agriculture, high conservation, and high development suitability in Swan Creek Watershed

VI. LESSONS LEARNED

What worked?

There were several positive outcomes from EcoCity Cleveland's GIS-based decision-support tool for the Ohio Lake Erie Balanced Growth Program. First, EcoCity Cleveland developed a new conceptual framework for a two-pronged approach to land-use decision-making: objective, data-based land suitability analysis and stakeholder value-based land priority analysis. Second, EcoCity Cleveland developed the land suitability analysis prong as three independent land category suitability analyses for agriculture, conservation, and development. Third, EcoCity Cleveland opened the development of the decision-support tool to the pilot watershed representatives so they could advise findings from both the literature and technical advisory committees. Finally, EcoCity Cleveland labored successfully to reassure the pilot watershed representatives that the primary goal was not to tell communities what to do, but rather foster a positive environment for watershed-based land-use decision-making discussions. The decision-support tool was successfully accepted by the pilot watershed representatives as a structured starting point for future multi-jurisdictional planning activity.

A shift of focus from developing a model to make decisions for the pilot watershed partnerships to a toolbox that will inform their decision-making process is very important. The Ohio Lake Erie Balanced Growth Program is designed to be a voluntary, incentive-based program. The most important objective for EcoCity Cleveland was not, as initially considered, for EcoCity Cleveland to develop a model that would tell watershed planning partnerships what to do. Rather, the most important objective for EcoCity Cleveland was to initiate the dialogue among stakeholders in the pilot watershed planning partnerships about watershed-wide land-use decision-making by providing a useful framework of data and maps. The data and maps, which comprise the toolbox, supports future decisions by giving watershed planning partnerships some common ground for planning discussion across political boundaries; previously this common ground was not provided by the State of Ohio. While respecting the right of every municipality in Ohio to continue making its own land-use and zoning decisions under the auspices of Home Rule, EcoCity Cleveland offers to each municipality an invitation to look at their watershed neighbors in more collaborative light. EcoCity Cleveland and the Ohio Lake Erie Balanced Growth Program encourage stakeholders in the same watershed to think more holistically about what the future of their larger neighborhood might be if they build a conversation with their new toolbox.

What did not work?

The GIS-based decision-support toolbox is not perfect; there are several areas where improvements will hopefully be made to provide a stronger foundation for the pilot watershed planning partnerships to eventually map priority conservation and development areas. First is the inclusion of additional data: neither Henry, nor Portage, County soils data updates were available when the toolbox was completed and presented in October 2006. Furthermore, pilot watershed planning partnerships had local data they wanted to include in addition to the basin-wide data available in the toolbox. Second, it would have been ideal to facilitate the land priority analysis among pilot watershed planning partnerships, but the contracts were signed between the Ohio

Lake Erie Commission and the pilot watershed planning partnerships in January 2006 and EcoCity Cleveland's project staffing period officially ended in July 2006. Nevertheless, it is expected that the Ohio Lake Erie Commission will continue to facilitate the land priority analysis development process as pilot watershed partnerships consider stakeholder values in light of the toolbox EcoCity provided. Finally, it would have been beneficial to spend more time analyzing the results of the land suitability analysis, but the same time crunch occurred between the pilot watershed start date (January 2006) and the project end date (July 2006). In particular, it would have been productive to run the suitability analysis with both basin-wide data and with local data to see if different data sources yield dramatically different maps. It would also have been useful to determine how many units of area in the watershed were classified by each combination of land category suitability. It may help watershed planning partnerships to know the distribution of land among the different land categories in terms of high suitability as they collaborate to develop maps of priority conservation and development areas.

What did preparation of a land suitability GIS-decision support toolbox teach EcoCity Cleveland?

EcoCity Cleveland provides a practical tool based on "hard science" and "objective data." However, to make this tool not only feasible but also acceptable to the local watershed planning partnerships, EcoCity Cleveland had to separate suitability (resolution of the "interest" conflict) from priority (resolution of the "value" conflict). It was more important for EcoCity Cleveland to lay a foundation for local partnership collaboration through a scientifically-valid, objective analysis than to attempt a more subjective, value-laden model dictating their priorities.

Ohio's tradition of home rule means no community had to participate in the pilot; it is voluntary and incentive-based; no mandates here. Therefore, it was necessary for EcoCity Cleveland to "invite" the local watershed planning partnerships to work on the decision support toolbox. Although a thorough review of the literature, input of technical advisory committees and a starting point were offered to the pilot watershed planning partnerships, they and the technical advisory committees steered toolbox development; this freedom gave the pilots a feeling of ownership in the process and helped build their confidence in the integrity of EcoCity Cleveland and the Balanced Growth Program. This confidence also enabled the pilot watershed planning representatives to drum up more support for the process among their local constituents.

It is critical to emphasize how much input from the pilot groups and our technical advisory committees was included. This was a clear, fishbowl of a project from Day One; everyone involved knew exactly what was happening and had the right at anytime to comment and even change direction as the decision support system evolved. As a consequence, it took longer than anticipated to develop the tool, but an open process rendered the decision support tool that much more defensible by its creators. Furthermore, by separating the suitability analysis (and calling it the decision support tool) and the priority analysis (reserved exclusively for the local watershed planning partnerships), the local partnerships did not feel as though the State of Ohio was trying to tell them what to do. They had the final say in where PCAs and PDAs would exist on a map of their watershed and that final say would be driven by their values and their priorities (not those of EcoCity Cleveland, nor those of the State).

Thus, the decision support tool developed by EcoCity Cleveland gets the ball rolling for the local watershed partnerships, but it does not offer a decision process to lead people through the analysis and allow them to reach consensus. To facilitate greater discussion among the members of a local watershed planning partnership and to reassure the stakeholders that the State was not trying to make decisions for them, the decision support system offers information and objective analysis for land-use suitability. It does not attempt to determine land-use priority. Priorities are based on values, which are best determined by local stakeholders.