Selecting Islands and Shoals for Conservation Based on Biological and Aesthetic Criteria

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ABSTRACT / Consideration of biological quality has long been an important component of rating areas for conservation. Often these same areas are highly valued by people for aesthetic reasons, creating demands for housing and recreation that may conflict with protection plans for these habitats. Most methods of selecting land for conservation purposes use biological factors alone. For some land areas, analysis of aesthetic qualities is also important in describing the scenic value of undisturbed land. A method for prioritizing small islands and shoals based on both biological and visual quality factors is presented here. The study included 169 undeveloped islands and shoals $\leq$0.8 ha in the Thousand Islands Region of the St. Lawrence River, New York. Criteria such as critical habitat for uncommon plant and animal species were considered together with visual quality and incorporated into a rating system that ranked the islands and shoals according to their priority for conservation management and protection from development. Biological factors were determined based on previous research and a field survey. Visual quality was determined by visual diagnostic criteria developed from public responses to photographs of a sample of islands. Variables such as elevation, soil depth, and type of plant community can be used to classify islands into different categories of visual quality but are unsuccessful in classifying islands into categories of overall biological quality.

Competing demands for housing, recreation, and natural areas, as well as concern about shrinking plant and animal habitats have stimulated research into the best techniques of selecting natural areas for protection. Many methods of selecting these natural areas have been employed (Tans 1974, Margules and Usher 1981, NYSDEC 1986, 1987b, Smith and Theberge 1986, Cable and others 1989, Hellyer 1989, Duever and Noss 1990). Some rating systems have focused on target species rather than land areas (Millsap and others 1990). Rating systems are usually applied to tracts of continental land that are already known to have rare plant or animal species or other unusual features, thus making them candidates for protection. Few methods have been developed for small tracts of land or areas where limited data are available.

Critical elements commonly included in rating systems include species or community rarity, community representativeness, species diversity, area, vulnerability to human impact, human use value and availability (Tans 1974, Margules and Usher 1981, Anselin and others 1989). Margules and Usher (1984) assert that ecological fragility, threat, species, and habitat are the most important criteria for small sites. Tans (1974) states that biological and physical characteristics, availability, and vulnerability are the most important factors when considering preservation by acquisition. In general, biological aspects are the most commonly considered factors.

Methods exist for assessing visual quality as one aspect of aesthetic value (Smardon and others 1986). The federal government provides for evaluation of landscape aesthetics through the National Environmental Policy Act of 1969 (NEPA). Federal agencies, including the US Forest Service, the Bureau of Land Management, the Soil Conservation Service and the US Army Corps of Engineers now have strategies for protection of visual resources. Various court cases have considered aesthetic issues and given legal impetus to the protection of public views (Smardon 1987, Smardon and others 1988). Smardon and others (1984, 1988) and Shannon and others (1990) have developed methods for assessing scenic access to the St. Lawrence River from public roads and riverside access points and assessing visual impacts for island and coastal environments.

While methods have been developed for the evaluation of landscapes of potential scenic value, these

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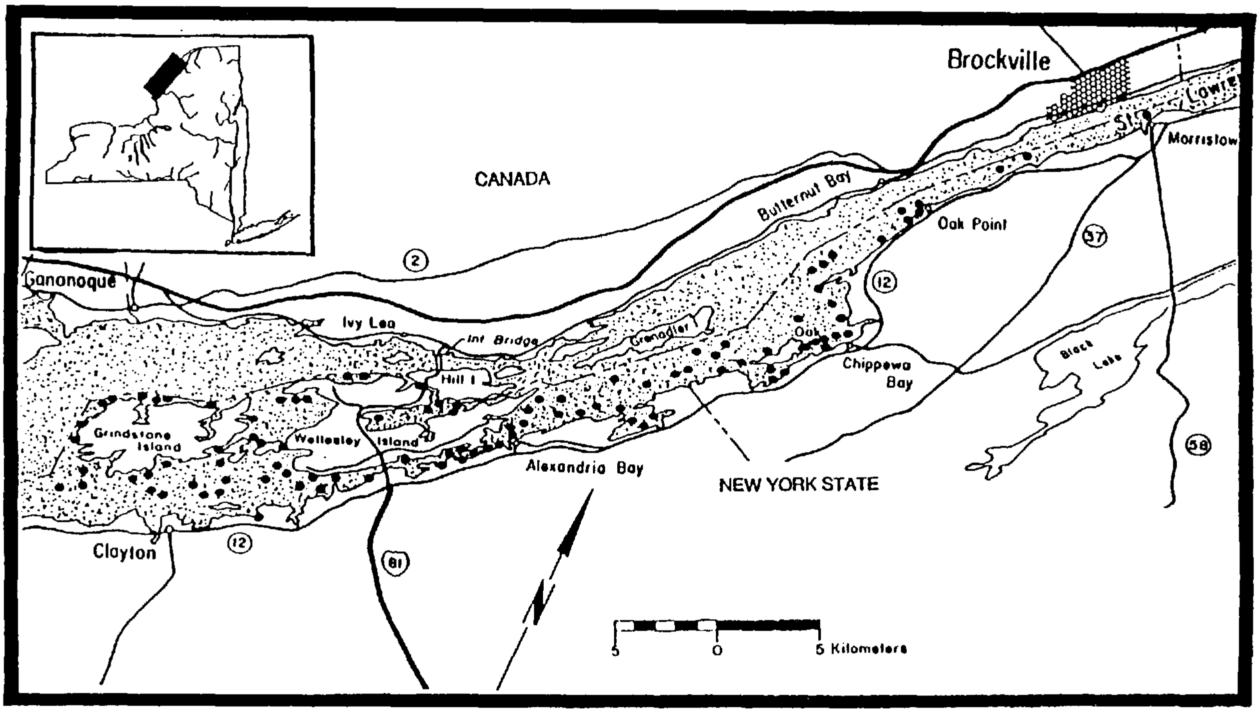

Figure 1. Island and shoal study sites within the Thousand Islands Region of the St. Lawrence River.

methods have rarely been systematically used together with biological criteria in rating land areas for conservation purposes. A notable exception is Steinitz (1990), who recently used both environmental and visual factors in his study of Acadia National Park.

Conflicts may arise when aesthetics and biological quality are not positively correlated. Hull and Harvey (1989) show that dense understory vegetation (a habitat structural characteristic that may be important to some wildlife) is less favored than an open understory by potential visitors to urban parks. However, high tree density, which may be important to certain birds and arboreal mammals was favored. Thus, important biological resources may not be highly valued aesthetically and high visual quality may not be an indicator of habitat quality. The key to solving such dilemmas may be to maximize aesthetics and biological quality when possible, while protecting scarce or unique resources of either dimension when they are identified.

The objective of this study was to develop a method of selecting small islands and shoals for conservation based on both biological and visual quality criteria. The process described here will at least ensure that both biological and visual qualities for the land area under consideration are identified. In addition, a rating system is developed to assist in making choices between competing areas.

Study Area

The Thousand Islands Region of the St. Lawrence River has long been of biological, recreational and economic importance as well as forming part of the US–Canadian border. The popularity of the Thousand Islands Region for recreation has led to a demand for shoreline development on islands and shoals. This study was prompted by concern about resource values of small islands and shoals that may be lost due to recreational development. Small islands were chosen because little was known about their habitat values and because development on them is highly visible. In addition, most of the large islands are at least partially developed, thus precluding their qualification as pristine landscapes.

The study sites include undeveloped islands and shoals less than or equal to 0.8 ha lying within US waters of the St. Lawrence River including Jefferson County and the St. Lawrence County towns of Hammond and Morristown, New York (Figure 1). The study area covers a length of approximately 77 km of the St. Lawrence River. The Thousand Islands Region is situated near the source of the St. Lawrence River and includes about 1800 islands and shoals ranging from a few square meters to many hectares in size.

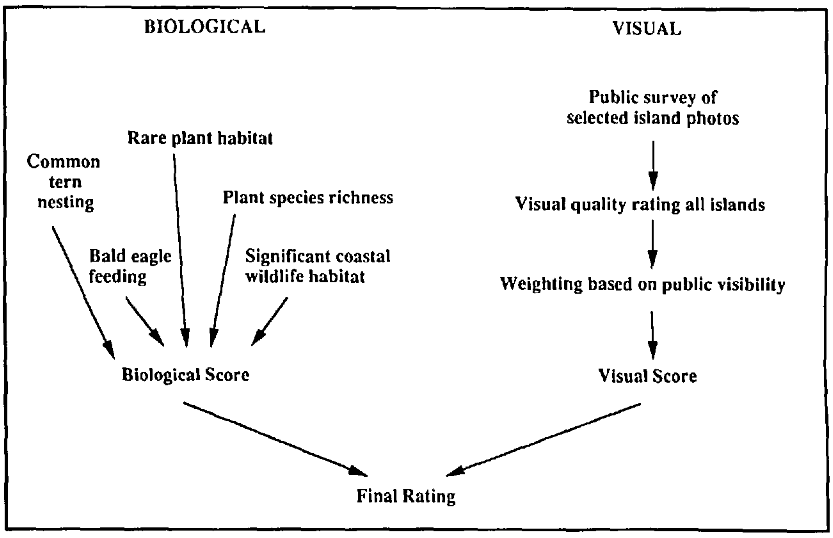

Figure 2. Flow diagram of island rating process.

Definitions of islands, shoals, and littoral zones are adapted from the New York State Department of Environmental Conservation (NYSDEC 1978) as follows. An island is defined as any offshore landmass, surrounded by water, whose maximum elevation is above mean high water and usually supports trees or shrubs. A shoal is defined as any offshore shallow area with a water depth of less than 6 m. The littoral zone is the area of water surrounding islands and shoals that is less than 6 m deep. The term *island* in this paper refers to both island and shoal study sites, unless otherwise noted.

Methods

General Description

The study islands were identified from tax records and maps showing all land bordering or within the St. Lawrence River (Figure 1). Developed islands were eliminated from further analysis. Island size and assessed value for each island were obtained from the tax records. Study islands were visited June–August 1989. In general, islands were excluded from the field survey if they had permanent docks, habitable buildings, or were underwater.

Variables measured or estimated for each island included the following: (1) island elevation above water was estimated within 0.5 m using a meter stick, (2) percent soil cover was estimated from plan view sketches made in the field of each island showing soil and vegetative cover, (3) the maximum soil depth on the island was determined with a soil probe and centimeter ruler from three measurements taken at randomly selected vegetated points, (4) the plant communities were classified using Reschke's (1990) descriptions of the ecological communities of New York State, (5) the height of the highest tree was estimated by comparing the height of a person standing at the base of the tree with the overall height of the tree, and (6) human disturbance was scored on a scale of 1–5 based on the presence of foreign objects or vegetative disturbance (1 = no visible disturbance; 2 = debris, duck blind, campfire ring, small sign; 3 = clearing of vegetation, large sign, large amount of debris; 4 = deteriorated building, retaining wall, floating dock; 5 = habitable building, permanent dock).

A system of ranking the islands for conservation was developed, based on both biological and visual scores (Figure 2, Table 1). Biological scores were assigned according to whether or not the island provides critical (irreplaceable) habitat for uncommon species listed by the New York Natural Heritage Program (NYNHP 1989) and the NYSDEC (1987a). The visual score represents a visual quality score for each island weighted by public visibility of the island from public visual access points (highway views or views from popular boating routes). Scores in both categories ranged from 1 to 10. The maximum of the biological and the visual scores becomes the final rating for an individual island. This assures a high ranking for any island important in either one of these categories.

Biological Analysis

Nomenclature follows Burt and Grossenheider (1976), Conant (1975), Peterson (1980) and Mitchell (1986). A literature search, interviews with professionals working in the area, and the field survey identified five variables that were determined to be impor-

Table 1. Method used to derive a final score for each island

Category	Factors (a–e)	Factor score[a]	Weighting (W)	Category score (range: 1–10)	Final score (range: 1–10)
Biological (B)	(a) Common tern nesting	10	1		
	(b) Bald eagle feeding	10	1		
	(c) Rare plant habitat	7	1	B = max(a − e)	
	(d) Significant coastal wildlife habitat	6	1		max (B,V)
	(e) Plant species richness	5	1		
Visual (V)	Visual quality rating (Q)	5	1, 1.5, or 2	V = Q × W	

[a] The maximum score assigned to any island is shown. An island is rated as follows: 1. Assign scores for all biological factors (a–e). 2. Biological score equals the maximum score among factors a–e. 3. Assign visual quality rating using visual diagnostic criteria. 4. Determine weighting based on visibility. 5. Visual score equals the visual quality rating times the visibility weighting. 6. Final score is the maximum score of the biological and visual scores.

tant in maintaining current levels of biodiversity in the region. Thus, the biological score of each island represents the maximum score obtained on any of these five variables: plant species richness; presence of a rare plant; or whether the site is a common tern *(Sterna hirundo)* nesting site, a bald eagle *(Haliaeetus leucocephalus)* winter use area, or falls within significant coastal fish and wildlife habitat areas, as designated by the NYSDEC (1986). The scores in each category potentially ranged from 0 to 10 (10 = irreplaceable habitat, 0 = no habitat provided or no information available). Sites providing no identifiable value in a given category were rated 0 for that category.

Plant species richness was determined using a plotless method. Approximately 1 h was spent per island surveying the vegetation in an attempt to identify all species present. More time was spent on larger islands and less on smaller islands. The plant species richness variable was rated as follows: islands with 0–9 species rated 1, 10–19 species rated 2, and so on up to the maximum species richness of 40–50, which rated 5. The only rare plant identified in the field survey is not restricted to island habitats (House 1924), therefore, 7 was assigned to islands where this plant was present.

Several years of research into the breeding biology of common terns in the Thousand Islands Region resulted in identification of all islands hosting common tern colonies and a ranking based on habitat quality (Smith 1987). This ranking was translated into a rating of 10, 9, and 8, respectively, for these sites. Available information regarding bald eagle winter feeding areas and structural characteristics of the habitat (presence of trees over 7 m in height) were used to identify islands important as roosting or feeding areas for bald eagles. Those areas where open water is available all winter rated 10 (J. L. Herter, personal communication). Winter feeding areas that are not used all winter or only in mild winters rated 9. Islands and shoals represent critical habitats for the common tern and bald eagle and population declines or extirpation from the region may result if all such sites were rendered uninhabitable (Smith 1987).

Significant coastal wildlife habitat areas as identified by NYSDEC (1986) were used to determine important areas for nesting/feeding or resting for other wildlife (excluding fish). These areas had been rated for significance by the NYSDEC. All areas were given a rating of 5 except Goose Bay and Cranberry Creek, which rated 6 because of their importance to many animal species. These significant coastal wildlife areas are usually associated with wetlands, have shallow water depth, aquatic vegetation communities, and are important primarily as feeding areas for diving ducks during migration and as nesting sites for marsh-dependent species. Islands found within these areas did not justify the highest ratings because, while islands and shoals are found within these areas, their functional values are not dependent upon the islands. However, intermediate scores were justified because human disturbance of the islands was judged to have a potentially negative influence upon nearby marsh areas due to discharge of pollutants into the water, disruption of breeding sites from waves and noise created by boat traffic, and changes in the island shoreline vegetation due to development.

Visual Analysis

The visual analysis began with slides taken in the field of all the study islands and shoals. Posters displaying 14 photographs of small islands and shoals representing a range of visual qualities (from large to small islands) were placed in two places frequented by visitors to the Thousand Islands Region: the Wellesley Island Nature Center and the offices of the nonprofit organization, Save the River.

Table 2. Island and shoal visual diagnostic criteria

Rating[a]	Landform (A)	Vegetation (B)	Color (C)	Cultural features (D)
Distinctive (5)	High vertical relief or prominent rock formations. Dramatic topography. Shoreline edges clear.	A variety of vegetative types in interesting forms, textures, and patterns. Structural variety, conveying spatial depth. May have triangular shape.	Rich color combinations, contrast, variety, or vivid color (orange lichen on rocks, conifers and deciduous trees)	No built structures or built structures of unique architectural or historical significance.
Average (3)	Rock or topographic features interesting but not exceptional. Shoreline edge hidden or unclear.	Vegetation of limited structure or diversity. Some variation in form, texture, or pattern present but not dominant.	Variation in color present but not dominant feature.	Built structures barely visible or blend well with landform and vegetation.
Minimal (1)	Low relief, geomorphology unapparent, homogeneous, small size (shoal)	Vegetation lacking, sparse or homogeneous in form, texture or pattern. Lacks spatial depth.	Homogeneous colors	Built structure which seriously degrades scenic quality.

[a] Rating procedure: (1) rate each island or shoal in each category A–D, (2) Select the highest rating in category A–C, (3) assign the lowest rating of step (2) and category D = final visual quality score. For example: an island/shoal with a rating of 3, 3, 5 in categories A–C, respectively, and 3 in category D would receive a final visual quality score of 3. An island/shoal with a rating of 3, 3, 3 in category A–C, respectively, and a 5 in category D would also receive a final visual quality score of 3.

Survey forms and instructions were included to obtain information regarding the viewers' visual preferences. The sampling was not random, and the majority of those responding were expected to be visitors. The viewers were asked to rate each island on a scale of 1–10 (1 = lowest scenic quality, 10 = highest scenic quality). Comments on visual qualities were also solicited for each island. Mean visual ratings were calculated for each of the islands on the poster and the comments reviewed.

Visual diagnostic criteria were derived from the above comments and mean ratings. These criteria included four factors: landform, vegetation, color, and cultural features (Table 2). An island or shoal could be scored as distinctive (5), average (3), or minimal (1) in each factor. Those islands and shoals displaying prominent rock formations and a variety of vegetation types or color combinations and lacking built structures scored highest. Although none of these small islands and shoals had buildings of unique architectural or historical significance, this cultural feature descriptor was added to make the rating scheme more generally applicable to other islands in the region. The highest score in any factor A–C (landform, vegetation and color) was assigned as the composite score for those factors. This score was compared with the cultural features score and the lowest score between the two was assigned as the visual quality score for the island or shoal. Thus, cultural features can only lower the visual quality score of an island. These diagnostic criteria are an adaptation of similar methods used by the USDI Bureau of Land Management (1980), the USDA Soil Conservation Service (1978) and the USDA Forest Service (1974) (Smardon and others 1986).

The visual diagnostic criteria above were applied to all the islands by showing slides of each island to two trained observers who independently scored each one. The mean score of the two observers was used as the visual quality score for each island.

These visual quality scores were then weighted based on the island's visibility from available public vantage points. To assess visibility, viewsheds from public roads and public access points as documented by Smardon and others (1984) were used to determine which islands and shoals are visible from these viewing points. Popular tour boat routes and the shipping channel were mapped on acetate overlays of navigation charts. Islands falling within 1000 m of the public access points, tour boat lines, or the shipping channel were considered visible. Large numbers of public viewers have visual access to the islands through the first means (cars, buses, and tour boats), whereas a more limited public views islands from the shipping channel (owners of personal boats and their visitors or persons renting boats and commercial barge or ship captains and employees). Therefore, the visual quality scores of islands visible from public access points, Rt. 12, and tour boat lines were doubled, giving a maximum possible visual quality score of 10. Visual quality scores of islands visible from the main shipping channel were multiplied by 1.5. The visual quality scores of all other islands and shoals were not changed.

Canonical Discriminant Analysis

Canonical discriminant analysis was used to determine whether visual and biological quality ratings could be predicted from eight measured (or estimated) variables obtained from tax records or the field survey. Discriminant analysis is used to assess how groups differ based on some set of variables and whether these variables can be used to differentiate these groups. Measured variables for 151 undeveloped islands (excluding underwater shoals), including land area, assessed value, maximum elevation above water level, percent soil cover, maximum soil depth, height of the highest tree, and human disturbance were used. The vegetative community type for each island was assigned a numerical score roughly corresponding to vegetative structure, with low scores assigned to the shoreline outcrop and wetland communities, intermediate scores to communities with <50% tree cover and the highest values to communities with >50% tree cover (range = 1–11). Some of the data were transformed to reduce the substantial positive skewing observed in the variables (Tabachnick and Fidell 1989). Square roots were taken of soil depth; natural logarithms were taken of elevation above water level, maximum tree height, human impact, area, and assessed value. The islands and shoals were grouped by visual quality scores and biological cumulative scores (sum of the scores in the five biological categories, reduced to five classes) (both ranges: 1–5). The biological cumulative scores were used instead of the final biological scores because they provided a better spread of the islands into groups, especially in the high range of scores. The biological cumulative scores (range = 1–28) were reduced to five classes in order to compare the results with the visual analysis. The class reduction was made, beginning with the lowest scores and moving to the highest scores, by assigning approximately the same number of islands to each class. An original biological cumulative score of 1 equals 1 (N = 28 islands), scores of 2–3 equal 2 (N = 33), scores of 4–9 equal 3 (N = 32), scores of 10–11 equal 4 (N = 32) and scores of 12–28 equal 5 (N = 26).

Results

Within the study area, a total of 372 islands and shoals under 0.8 ha (both developed and undeveloped) were identified from the tax records and field survey. Of these, over half (55%) are developed. Although the undeveloped islands represent approximately 45% (N = 169) of the number of islands <0.8 ha, they comprise only 19% of the area. The assessed value of the undeveloped islands was only 6% of the total value of all the islands in this size class.

Biological Analysis

A detailed description of the biological communities found on these islands is given in Knutson (1990). A total of 37 species of birds, mammals, and reptiles was identified on or near the islands and shoals during the field survey. A total of 236 vascular plant species from 63 families was identified on the study islands. One member of the flora, small skullcap (*Scutellaria parvula* Michx. var. *parvula*), has a rarity listing of S1 G4 (S1 = 5 or fewer occurrences in the state, G4 = apparently secure globally) (NYNHP 1989).

Eleven different plant communities adapted from Reschke (1990) were identified. The shoreline outcrop and underwater shoal communities are by far the most prevalent communities, representing 56% of the islands in the study. The heath barren communities are also common and are found on the larger islands.

Islands important biologically were characterized by examining mean values on measured variables and counting the number of islands that are important for more than one reason. The largest number of islands were included in the bald eagle feeding areas (N = 50), while only nine islands were important as common tern nesting areas. Small skullcap was found on the larger islands, representing a variety of plant communities, with higher species richness. Only one of these islands also hosted common terns and four were within bald eagle feeding areas. Common terns were found on shoals with low assessed values, lower species richness, and minimal elevation. Few islands were rated as important in more than one category of biological importance.

Visual Analysis

A total of 192 public responses were received from the two posters. Of these, 95 respondents included comments. The majority of the respondents were visitors and most viewed the poster at the Wellesley Island Nature Center.

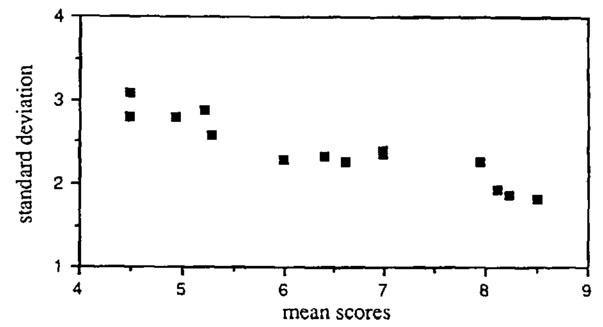

Figure 3. Plot of the mean visual quality scores for each poster island and the standard deviation of those scores.

Possible scores for each island depicted on the poster ranged from 1 to 10, but actual mean scores for each island ranged from 4.5 for the lowest rated islands to 8.5 for the highest rated island. The islands depicted on the poster were grouped into three categories (distinctive, average, and minimal) based on their mean scores and comments from the public. Islands in the distinctive category share characteristics of high variety of rock and tree forms, balance, large size, and lack of signs of human use. The five islands in the average category had lower relief, a lower variety of rocks and trees and, in one case, a building was present. The five islands in the minimal category were all of small size and lacked trees.

Analysis of variance (ANOVA) using Fisher's protected least significant difference (PLSD) test was used as a guide in defining the above groups of islands. This analysis showed that mean scores of islands in the above groups (minimal, average, distinctive) differed significantly (experimentwise error rate <0.05, $F = 69.6$, $P < 0.001$) from other groups. Correlations of subgroup mean scores grouped either by poster site (Wellesley Island, Save the River, or ESF) or resident status (visitors, summer residents, year-round residents) were high (range: 0.87–0.99), indicating agreement between these subgroups of respondents on the overall ranking of the islands.

When the standard deviations of the mean visual scores for islands depicted on the poster are plotted against the means (Figure 3), we see that there is more general agreement between persons about high-quality views than about low-quality views. In general, islands with high visual contrast between rock and trees; variation of form, color, or texture; and clear shoreline edges evoked the most positive responses.

When all of the study islands were rated using the visual diagnostic criteria shown in Table 2, 13 islands rated 5 (distinctive), 12 rated 4, 27 rated 3 (average), and 117 rated 2 or 1 (minimal). Scores of the two observers had a correlation of 0.783, and the difference between the scores (paired t test) was not statistically significantly ($t = 1.626$, $P = 0.1062$). This indicates that the rating criteria developed were generally successful in achieving agreement between the scores of two independent observers.

Selection of the islands for conservation identified islands with final scores (the maximum of biological and/or visual scores) of 8 or above as first priority for protection from development. The 71 islands and shoals in need of first-priority protection represent nine community types and include 42 shoals and 29 islands. Of these, 58 were highly rated for biological reasons and 13 for visual reasons. No islands rated high on both biological and visual criteria. Detailed descriptions of selected islands, management recommendations, and laws protecting these resources can be found in Knutson and others (1990).

Canonical Discriminant Analysis

Canonical discriminant analysis (SAS PROC CANDISC) was used to separate the islands into visual quality groups using the measured variables. Two canonical variables were calculated from the linear discriminant function analysis, assuming equal variance–covariance matrices in the five groups. The five group centroids are significantly different (Wilks' lambda $P < 0.0001$). The first canonical variable represents 81.5% of the total variation, the second represents 11.7%, for a cumulative total of 93.2% of the total variation. The first canonical variable has high positive loadings on percentage soil cover (0.58), plant community (0.72), soil depth (0.67), elevation (0.64), and maximum tree height (0.58); the second canonical variable has high positive loadings on disturbance (0.44) and percentage soil cover (0.40). Thus, the first canonical variable corresponds to variables that could be termed "physical and vegetational structure" and the second corresponds to variables that could be termed "disturbance."

A classification matrix generated using SAS PROC DISCRIM (using a within-covariance matrix and proportional priors) shows that the linear discriminant function classifies the lowest and the highest visual quality scores well but has some trouble with intermediate scores, for an overall classification success rate of 81% (Table 3). This indicates that about 81% of the islands would have been classified correctly using the canonical variables derived from the measured variables. However, the success rate is optimistic because some level of success would be expected based on

Table 3. Classification error matrix for visual quality scores[a]

Classified from visual quality score	Islands classified into visual quality score					
	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total N
1	88	4	7	1	0	84
2	35	65	0	0	0	17
3	8	12	73	0	8	26
4	27	9	0	64	0	11
5	0	0	8	0	92	13
Number	85	18	26	8	14	151

[a] Overall correct classification rate: 81%.

Table 4. Classification error matrix for biological cumulative scores[a]

Classified from bio. cum. score	Islands classified into biological cumulative score					
	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Total N
1	93	0	0	4	4	28
2	12	61	18	3	6	33
3	31	3	50	9	6	32
4	63	6	6	25	0	32
5	39	8	12	8	35	26
Number	70	25	27	15	14	151

[a] Overall correct classification rate: 52%.

chance alone and because the discriminant function is calculated from data for the study islands. Application of the discriminant function to other islands may be less accurate.

Similar analysis using biological cumulative scores as the grouping variable were conducted. Again, the group centroids are different (Wilks' lambda $P < 0.0001$). The first canonical variable represents 62.6% of the variability, the second represents 22.1%, for a cumulative total of 84.7% of the variability. The first canonical variable has high positive loadings on percentage soil cover (0.81), plant community (0.71), soil depth (0.85), elevation (0.67), and maximum tree height (0.59) and may be interpreted as "physical and vegetation structure." The second canonical variable has a high positive loading on disturbance (0.82) and a somewhat lower loading on area (0.42). A classification matrix generated using SAS PROC DISCRIM (using a within-covariance matrix and proportional priors) shows that the linear discriminant function is not successful in classifying the groups, with an overall classification success rate of 52% (Table 4).

Discussion

Rating System

The structure of the rating system used to select the islands was driven by the following considerations. Rating systems generally assign ordinal numbers to different variables and then combine those variables into a final score. Problems encountered in the combination of these variables include interdependence among the factors and mathematical operations on nominal and ordinal numbers. Hopkins (1977) cautions against assigning integers to nominal or ordinal data and then combining those integers using mathematical operations such as addition and multiplication. Unless the relationships between the factors are known and can be expressed in mathematical form (which is rarely the case), the results of mathematical operations between the factors are unknown. Tans (1974) discusses the problem of mathematical operations and recommends multiplicative scoring without presenting a rationale for this conclusion. Anselin and others (1989) describe a method for overcoming invalid mathematical operations and assigning explicit weighting factors in a hierarchical process, but they do not address the problem of interdependence of factors. In practice, most rating systems use some combination of addition and multiplication of factors to achieve their final scores (Tans 1974, NYSDEC 1987b, Anselin and others 1989, Duever and Noss 1990).

To address these problems, Hopkins (1977) recommends an approach he calls "hierarchical rules of combination." Factors within subcategories of criteria are rated. Then, rules are developed for combining these factors to determine the subcategory score. For example, the highest rating among the factors may take precedence and provide the final rating for that subcategory. The subcategory rules are then determined, thus providing the overall final rating for each site. This system is used in this study. Each island is rated according to its maximum value in any category rather than a sum or average of the scores in each category. Thus, visual and biological scores are considered of equal importance, and islands important in either category are highly rated. This method identifies islands with positive traits in any category, rather than islands with a combination of positive features.

Biological Analysis

The low number of plant species found compared with other work (Beschel and others 1970, Cody 1975) can be attributed to several factors. These small islands and shoals together represent a small land area and provide only a limited number of habitats. Natural disturbance from wind, waves, and ice scour are major factors in retarding plant succession. These factors no doubt greatly reduce the number of species present in comparison with large islands of several hectares or with the mainland. There are undoubtedly more species of plants on these islands than were identified in this study. In particular, many grasses, sedges, mosses, lichen, and aquatic plants were not identified. More intensive surveys may reveal additional rare plants.

Very little specific information is available on the habitat values provided by the islands for reptiles, amphibians, birds, and mammals. More detailed studies of the ecology of the animal communities on these islands are needed to determine the presence of additional rare species or the roles the islands play in the overall life history of animals known to use them. Studies of the aquatic ecology of the littoral zone of the islands are also needed.

As expected, common tern nesting sites were restricted to the fewest plant community types, while the site requirements for small skullcap, bald eagle winter feeding areas, and significant coastal wildlife areas were more diverse. Small skullcap was found in open areas of the islands near the shoreline but may need some canopy cover, since it was found on larger islands more often than on the shoals. The bald eagle feeding areas and significant coastal wildlife areas are related to factors other than the physical features of the islands and so would not be expected to be restricted to any specific plant community type. This demonstrates that factors at many scales (site, community, and region) are important in determining biological importance. The community and regional landform influences what areas are important for migrating waterfowl and what areas of the river remain open in the winter.

Visual Analysis

A greater variation in the responses was found for the lowest rated islands than for the highest rated islands, indicating that people in general agree about high-quality views, but may disagree about lower-quality views (Figure 3). This is in contrast to Steinitz (1990) and Smardon and others (1984), who found greater disagreement about midrange visual quality views but general agreement about low- and high-quality views. The reason for the disparity may be that in this study, worst examples of developed small islands were not used, because the objective was to gain information about how people ranked undeveloped islands. Therefore, the lower end of the range of responses is absent.

The high correlation of mean scores between subgroups of the public agrees with Steinitz's (1990) findings and corroborates the findings of other studies (Smardon and others 1984), in which general agreement among subgroups of people as to what constitutes high-quality views was also found. Negative responses to developed landscapes found here have also been found in other studies (Smardon and others 1984, 1986, Shannon and others 1990, Steinitz 1990). More information about responses of different groups of people could be obtained by selecting specific groups a priori.

Variation in the photographic quality of the photos used in the survey is a limitation of the visual analysis method employed. Several respondents to the public survey felt that the variation in the quality of the photographs in terms of correct exposure, clarity, distance from the subject, presence or absence of birds, and type of day the photo was taken biased the study in favor of those islands that had "postcard quality" as opposed to those that were taken under less than ideal circumstances. An additional bias is the direction from which the photograph was taken. The viewer position from which the photographs was taken was a normal position (from a small boat). Views of the islands from a tour boat will be from a superior position, giving a much different view of the islands. Ideally, public input would be obtained from volunteers in the field, or possibly, a videotape of the islands could be used.

Integration of Biological and Visual Qualities

The relationship between the biological and visual quality ratings is complex. In general, the islands ranking high in terms of visual quality did not rank high in terms of their biological qualities. The larger islands that rated high visually provide habitat for more common animals such as song sparrows *(Melospiza melodia)*, red-winged blackbirds *(Agelaius phoeniceus)*, eastern kingbirds *(Tyrannus tyrannus)*, northern watersnakes *(Natrix sipedon)*, and meadow voles *(Microtus pennsylvanicus)*. The common tern nests on shoals or low shrubland, neither of which rank high visually. No islands rated high visually are located within the bald eagle wintering areas.

The discriminant analysis showed that variables such as elevation, soil depth, and type of plant community can be used to classify islands into different categories of visual quality, but they are unsuccessful in classifying islands into categories of overall biological quality. In other words, discriminant functions using measured variables have higher predictive ability for visual quality than for overall biological quality. This seems reasonable, in that visual quality can be viewed as an aesthetic gestalt of an island's physical properties, some of which are represented by the measured variables. The visual diagnostic criteria derived from the public survey included landform, vegetation structure, and cultural features (a measure of disturbance), factors that are partially represented by the measured variables. The predictive ability of the measured variables is important because they could be used to estimate visual quality, if public comment could not be obtained due to time or other constraints.

The biological cumulative scores, on the other hand, represent the overall importance of islands and shoals for different species of birds and plants. These species all have unique habitat niches, which, not surprisingly, were not adequately characterized as a group by the measured variables. The presence or absence of uncommon plant and animal species is often due to factors other than those measured in this study, such as qualities of the soil and substrate, natural disturbance or competition, type of cover, contiguity to other habitats, presence of predators, or even availability of open water in winter. Much work on the links between habitat and species presence/absence has shown that species respond to both ecological conditions (habitat) and other members of the ecological community (niche) (O'Neil and Carey 1986). Even under the most detailed analysis, habitat variables cannot be expected to explain all or even most of the variation in species presence or absence.

The islands identified as top priority for protection appear to be a representative sample of small islands and shoals in the region. Seventy-one islands and shoals from nine different community types, spread spatially over most of the study area, are included. Over four times as many islands were highly rated for biological than for aesthetic reasons. This is because some of the biological criteria included areas of the river, not individual islands. None of the islands rated high on the basis of both biological and visual quality.

The rating system was not entirely successful because seven islands not selected by the rating system were identified in the field as being of outstanding beauty or having a combination of other positive features warranting their protection. These islands did not rate 8–10 on the rating scale. There were several reasons for this. Some islands that scored high visually are not located on regularly traveled boating routes, and thus received a lower total visual score. However, these may be some of the most picturesque islands in the entire survey. The rating system also did not identify islands with combinations of features such as a diversity of habitats, or islands that were large and still undeveloped, a unique feature in itself. It may be possible to amend the rating system to include these additional islands.

This study has documented a process of setting priorities for protection of limited natural resources based upon both biological and aesthetic criteria. The process is relatively simple and, therefore, practical for land use planning or natural resource agencies to accomplish. The techniques used could be applied to many small tracts of land or areas for which limited data are available. Existing information is used to the maximum extent possible, thus maximizing cost-effectiveness. Based on the results of this study, it may be possible to estimate island visual quality from measured physical and vegetation structural variables, if time or other constraints preclude a public survey.

Shoreline development on small islands and shoals in the Thousand Islands Region of the St. Lawrence River has reached a point where continued, unrestricted development may have a serious impact on the visual quality of the area as well as jeopardizing critical habitat for some species. A method of selecting small islands and shoals for conservation purposes based on both biological and visual quality has been presented that attempts to maximize protection of habitat for sensitive species while maintaining some islands and shoals in an undisturbed state for the enjoyment of human visitors to the area. It appears that some compromises will be required, since islands rating high for aesthetics did not rate high for biological qualities and vice versa. Conservation decisions will need to consider both the quality of a particular visual or biological resource and its scarcity within a larger context.

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