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Dr. A.R. Dobell
CIT Peer Review Chair
Professor of Public Policy
University of Victoria
Victoria, BC

January 14, 2004

Re. Peer Review CIT – Ecosystem Spatial Analysis

Dear Dr. Dobell,

In accordance with your request for an independent peer review of the Coast Information Team Ecosystem Spatial Analysis (CIT-ESA), I hereby submit an assessment of the material with which I was provided. I was assisted in this review by Dr. Scott Harrison, who also meets the criteria set forth in the CIT policies for reviewers. Dr. Harrison has recently joined my research group at the University of Alberta, and brings complementary expertise to the review.

We have organized our review by the major sections of the report, and provide general and specific remarks on the content of each, as well as on overall report format. We take the opportunity here to comment on the general review process.

The CIT–ESA represents an extensive synthesis of information on a broad range of topics. The intent of the peer review process, as specified in the instruction to reviewers, is to ensure that the best available information was utilized, that the approaches employed were appropriate and scientifically rigorous, and that the related conclusions are sound. It follows that a comprehensive review of the CIT-ESA warrants consideration by scientists with a broad range of disciplinary expertise. It was a challenge to do justice to all aspects of the report, given the breadth of material included, and I hope that other reviewers of this document have additional expertise, particularly in the areas of freshwater and marine science. An alternative approach might have employed review teams.

Should there be any questions regarding this review, I hope that you or members of the project team will contact me directly. I wish you success in completing the process of peer review and revisions, and look forward to the final CIT product.

Sincerely,

Dr. Fiona K.A. Schmiegelow
Associate Professor

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Review of Coast Information Team Ecosystem Spatial Analysis

An Ecosystem Spatial Analysis for Haida Gwaii, Central Coast and North Coast British Columbia (Draft, 22 September 2003)

Submitted By: Dr. Fiona Schmiegelow, Associate Professor
and
Dr. Scott Harrison, Research Associate

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Submitted To: Dr. Rod Dobell, CIT Peer Review Chair and Professor
University of Victoria, Victoria, British Columbia

18 January 2004

Overview: In accordance with the conditions set out in CIT policies on peer review, we submit the following comments for consideration during the review process. Our remarks are restricted to the scientific content of the document, and we have focused on promoting 1) the use of the best available information; 2) the use of analytical approaches that are appropriate and scientifically rigorous, and 3) the presentation of sound conclusions that are supported by data. Our expertise lies in the areas of ecology and conservation science, particularly of terrestrial systems.

The CIT-ESA represents the most comprehensive and ambitious conservation assessment undertaken to date in Canada. It encompasses a large and diverse area of British Columbia, and addresses terrestrial, freshwater, and marine components of the planning area. The work represents a tremendous investment in the assembly of existing data and contributes novel work in the area of coarse-scale classification of freshwater ecosystems. There is generally good documentation of data and data assembly. The report presents a systematic approach to analysis that is based on clearly articulated goals and objectives. Many of the objectives are quantitative, resulting in a relatively transparent process. The application of automated computer tools (SITES, MARXAN) provides flexibility in the analysis of options and results in a planning process that is repeatable. The ESA Project Team is diverse, and the report has benefited from input from a range of specialists.

We applaud the CIT-ESA for its overall approach to addressing biodiversity conservation requirements through a three-pronged approach that aims to represent ecosystem types, protect special elements, and conserve focal species. These are laudable goals consistent with generally accepted conservation principles; however, we feel that parts of the document imply greater certainty of outcome than is warranted in a strict scientific sense. We hasten to point out that such implied certainty is likely present in all components of a planning strategy, including components such as economic forecasts and timber supply analyses, but we were not asked to review these components.

While we ardently support the use of data from well-designed, hypothesis-driven research to aid in land-use planning, we do not support inferences that an assertion is "scientific" without appropriate data to substantiate the claim. We also believe that planning processes are improved markedly when participants openly acknowledge the uncertainty inherent in policy decisions.

For example, the stated purpose of the ESA is "to identify priority areas for biodiversity conservation and, ultimately, to serve four well-accepted goals of conservation: 1) represent ecosystems across their natural range of variation; 2) maintain viable populations of native species; 3) sustain ecological and evolutionary processes within an acceptable range of variability; and 4) build a conservation network that is resilient to environmental change." (page 6). However, given the current limits of scientific knowledge, how one might achieve goals 3) and 4) is unknown without empirical study of these questions.

Many scientific undertakings are exercises in inference, and the strength and reliability of the inference rests on 1) the robustness of the assumptions underlying the overall approach; 2) the quality of the data used in analyses; 3) the analytical procedures employed, and 4) the appropriate interpretation of results. A corollary of this is that it is imperative that assertions that rest on theoretical principles are clearly distinguished from assertions that have been empirically substantiated in a general sense, and from assertions that have been verified locally. Additionally, the resultant assumptions and uncertainties should be articulated clearly in the interpretation of results. We use this underlying philosophy as a basis for reviewing the components of the ESA.

The ESA is a lengthy document with considerable repetition of components among sections. Cross-referencing was challenging. We offer the following review comments for each section of the document:

ACKNOWLEDGMENTS

"The team and its advisors represent an unprecedented collective of some of the premier researchers and practitioners in the fields of conservation biology, ecology, zoology, Geographical Information Systems (GIS), and land use planning in North America."

It is inappropriate to include such a statement in the acknowledgments. Such commendations should be reserved for a preface by an external body (e.g., the CIT Management Team), if they feel such comments are warranted.

EXECUTIVE SUMMARY

This is an unusually long executive summary (~20 pages). What purpose is it expected to serve? If it is to be the most widely read documentation for the ESA, the executive summary must accurately reflect the analyses and interpretation, including assumptions and uncertainty. Thus, many comments on latter sections also apply here.

Background

"Protection of special elements: concentrations of ecological communities; rare or at-risk ecological communities; rare physical habitats; concentrations of species; locations of at-risk

species; locations of highly valued species or their critical habitats; locations of major genetic variants."

This paragraph places qualitative importance on "rareness" and then repeats the inference that rareness is important. There are few quantifiable points in the paragraph. For example, what is a "concentration of ecological communities"? How are "highly-valued species" defined? How can "genetic variants" be distinguished without data on the genetic structure of the whole population, which is inferred but undefined?

"Conservation of critical habitats of focal species, whose needs help planners address issues of habitat area, configuration, and quality. These are species that (a) need large areas or several well connected areas, or (b) are sensitive to human disturbance, and (c) for which sound habitat-suitability models are available or can be constructed."

The phrase "critical habitats" is empty because organisms do not use areas superfluously; hence, all used habitats are "critical". "Critical" is being used as a synonym for "rare" to invoke the sentiment that protection is required. The term "critical habitat" now has legal implications under the Federal Species at Risk Act and should be avoided.

Issues of habitat configuration and quality are not explicitly addressed by the analyses, and generic conservation goals are used as a proxy for satisfying area requirements.

There are no data that demonstrate that any of the species listed in this report "need several well-connected areas". The requirement for well-connected areas is the premise of metapopulation theory, but this premise remains largely untested other than some evidence for picas and checker-spot butterflies. While the notion that connectivity is important seems intuitive and logical, one should not define focal species by characteristics that remain untested. The term "focal species" has a diverse and contentious history. Given the focal species approach employed here is to address to the goal of "maintaining viable populations of native species", further elaboration is required.

What is a "sound" habitat-suitability model"? HSI models are tautological and their value is for the development of multiple, competing hypotheses. Using rudimentary HSI models to delineate areas for protection is inappropriate and misleading.

"Information obtained from this approach can be used with a computerized site-selection algorithm to create a conservation solution or "portfolio" of landscapes and seascapes, which when taken together and managed appropriately, would ensure the long-term survival of the region's biodiversity. Our team used the best available information for this assessment but recognizes that new and more comprehensive data will continually become available. Therefore, the ESA should be regarded as an initial step in an iterative assessment process."

The CIT cannot "ensure" anything; appropriate use of data and treatment of uncertainty can help to maximize probabilities of desired outcomes. Recognition of the ESA as "an initial step in an iterative assessment process" is appropriate, but in the absence of a strategy to achieve this, the results are likely to be interpreted as static.

1.0 INTRODUCTION

The introductory paragraphs of this section (p.27-28) contain many broad statements regarding the role and process of regional conservation planning. As this section establishes the expectation level for readers, it is important that bounds are clearly established. In addition, loose use of terminology should be avoided. We recognize that greater detail is provided in subsequent sections, but the report should highlight here several aspects which are not addressed. For example:

"This study is unique in that it integrates analysis of the biological values of terrestrial, freshwater, and marine ecosystems across this vast region."

The integration has not yet taken place, nor are methods for how it will be accomplished described. There is later reference to use of CIT QUEST for integrating ecological, cultural, and economic values.

"Species are not forgotten as the spatial and temporal scale of conservation broadens; indeed, species are often the best indicators of the status of ecosystems and are essential in answering questions about how the configuration of habitats across the landscape affects ecological integrity, which includes considerations of population viability."

Neither the configuration of habitats nor population viability is directly addressed by the analytical methods employed in this report. Ecological integrity is not clearly defined in the context of this study; many definitions abound.

"As described by Margules and Pressey (2000), systematic conservation planning…"

Steps 5) and 6) are not addressed here.

"Finally, regional conservation planning is precautionary. Although reserve selection algorithms, based on mathematical models that emphasize efficiency, attempt to capture the most biodiversity in the least area, the minimal area is properly interpreted as the area sufficient and essential to meet the stated conservation goals and objectives. "Sufficient" implies that the action can be fully expected to attain the stated goals; "essential" implies that, without the action, the goal or objective will not be attained. Superfluous actions, such as protecting more land than necessary to assure viability of species and ecosystems, are avoided."

"Nevertheless, the precautionary principle, which is becoming well accepted in many fields (Peterman 1990, Shrader-Frechette and McCoy 1993, Taylor and Gerrodette 1993, Noss et al. 1997), suggests that, in cases of uncertainty, it is better to risk protecting too much than too little. This precaution can be implemented in conservation planning by setting ambitious goals, while using the best available science to reduce uncertainty over time. Moreover, conservation measures can be implemented sequentially, starting with the sites of highest irreplaceability and vulnerability, then progressing to those where conservation values are lower or less certain."

This paragraph (split here for clarity) highlights a key difficulty for reports such as the ESA because the ideas in these two sections of the same paragraph are at odds with each other. The first section strives to make the report simultaneously politically and scientifically credible. The report reassures all sides that "Superfluous actions, such as protecting more land than necessary to assure viability of species and ecosystems, are avoided."

This statement says that this plan uses science to protect everything and does so using the minimal amount of area. The trap here is equating a novel technological approach, SITES, to science. There are few data in science that provide direction on how to "assure [the] viability of species and ecosystems". There are ways of using natural-history data to develop viability analyses that can be incorporated into the planning process; however such analyses were not done for this project.

The second section of the paragraph on Page 28 (*"Nevertheless, the precautionary principle,...)* invokes the precautionary principle to suggest that "it is better to risk protecting too much than too little". This view is in direct contrast to the first approach. The precautionary approach is appropriate if one is interested in true sustainability of ecosystems (i.e., perpetual maintenance of ecological processes and ecological resilience) because there is real scientific uncertainty about ecological systems and the response of these systems to perturbation.

Acknowledging uncertainty and taking measures to reduce it over time is a key element of an adaptive planning and management process. While mention of the need for this occurs throughout the report, no specifics are provided as to how it will be accomplished.

Vulnerability is not addressed. If vulnerability is to be incorporated as a criteria for assigning conservation priorities to planning units, critical evaluation of the appropriateness of the conventional irreplaceability/vulnerability matrix should occur.

2.0 CONSERVATION TARGETS

2.1.1 Special Elements

The limitations of occurrence data are well described, and we concur that including known occurrences as a post hoc filter rather than an objective function is appropriate.

"Although surveys are not comprehensive for most of Canada, to neglect areas known to be rich in biodiversity or other ecological values simply because survey data across the region in question are incomplete would be foolhardy. A precautionary approach would protect known hotspots."

It is not clear that diversity *per se* was emphasized in subsequent stages; rather the inclusion of the occurrences of rare species was the primary consideration.

2.1.3 Focal Species

"Focal species analysis complements the special elements and representation tracks by addressing questions concerning the size and configuration of reserves and other habitats necessary to maintain viable populations. The focal species approach can be distinguished from the species component of the special elements track, in that habitat suitability and population viability are modeled and extrapolated beyond currently known occurrences and, usually, beyond the present time."

Many of the complementary features of focal species analysis identified here are not addressed by the ESA. It is not clear that the best use of available data was made relative to these questions; in particular, the application of static HS models.

"Static habitat suitability models, such as those employed in this study, can be either conceptual models, based on existing literature and expert opinion about species-habitat relationships, or empirical models, e.g., resource-selection functions built by associating occurrence data with potential predictor variables through multiple logistic regression or other statistical techniques (Manly et al. 1993, Boyce and McDonald 1999, Carroll et al. 2001)."

Insufficient detail is provided in the model descriptions to determine which approach(es) were employed. The latter class is considerably more robust and quantitative measures of model performance can be generated.

"Dynamic population models useful in conservation planning include the several kinds of spatially explicit population viability analyses (PVAs) (Beissinger and McCullough 2002). These models are typically more time-consuming and difficult to construct than static models, and require more information on the demographic characteristics of each focal species."

Akçakaya and Sjögren-Gulve (2000) recognize 3 model structures for conducting PVAs. Occupancy models do not require demographic data.

"Hence, our focal species models do not explicitly consider population viability. We recommend that dynamic population models for selected species be developed in the future."

The appropriate qualifiers are identified here but are not carried consistently through the report. As a result, the strength of conclusions is overstated. Population viability is the most important aspect of a conservation plan for focal species. We support the need for further work in this area.

2.2.1.2 Results and Discussion (Terrestrial Targets – Special Elements)

"The special elements analysis highlights the scarcity of occurrence data on much of the BC coast. The majority of element occurrence data is on Haida Gwaii/QCI reflecting an uneven distribution of surveying effort. There is also a concern that many of the occurrence points are near roads, possibly reflecting a surveying bias. Instead of using the fine filter data as an input to the SITES runs, a post hoc analysis was conducted by overlaying the fine filter data on the SITES outputs to determine how well the analysis captured the fine filter element occurrences. Although there are concerns regarding biased survey data we still need to protect the locations of special elements where we have location data."

The results of the post hoc analysis described are not reported in Section 6.0.

Considerable emphasis is placed on "rare" species occurrences, the perception of which can be strongly influenced by survey biases. Thus the final statement should be further qualified.

2.2.1.3 Recommendations (Terrestrial Targets – Special Elements)

"For future iterations of this plan and other planning efforts in the region, given the state of our limited knowledge on target viability and population dynamics, we recommend establishing initial conservation goals for special elements, then refining these goals as much as possible with target-by-target information (Comer 2001).

Initial conservation goals were set for terrestrial targets based on their geographic scale, distribution and spatial pattern. Initial conservation goals are an attempt to represent the "natural" or historic range of distribution for the target. For example, if 50% of the known, natural range of the target falls within the ecoprovince, the goal for the ecoprovince should reflect roughly 50% of a range wide goal. The target's distribution, relative to the ecoprovince is used to establish numeric differentials in goal setting – i.e. higher with endemic, to lower with peripheral (Comer 2001, TNC 2000, Rumsey et al. 2003). Table 2.3 outlines the matrix used in setting initial conservation goals."

What is the process for refining initial goals? The rationale for specific numbers is in Table 2.3 is not provided, thus they appear arbitrary.

2.2.1.3.2 Data Gaps

"The fine filter analysis was lacking in invertebrate data. No sources for location data were found. Coastal temperate rainforests are known to have very high invertebrate biodiversity (Scudder 1996). However, targeting old-growth forests in the focal ecosystems analysis, supplemented by focal-species modeling, will presumably capture the majority of rare and endangered invertebrates. There are also a number of rare and endangered lichens that were not included in the fine filter database. Although these are outlined in "The Lichens of British Columbia" by Goward (1999), we were not able to obtain or create digital files for these locations."

The assumption regarding invertebrates is large. Elsewhere in the document there are assertions that such approaches are unlikely to capture rare occurrences hence the need for a special elements analysis. Why would this differ for invertebrates? Will the lichen location data be available in the future?

2.2.2 Representation

Approximation of the historic amounts of ecosystem types, as a basis for evaluating representation, is a strength of the ESA. Using BEC information and site productivity is appropriate for estimating the abundance of each ecosystem type, but it was unclear if and how this was used to inform seral stage goals. For example, page 51 refers to young intact forest goals; however, if all impacted areas are considered old growth prior to impact and a low level of natural disturbance is assumed (p.48), how would the historic abundance of younger seral stages be estimated?

2.2.3– 2.2.8 Focal Species Models (Terrestrial)

The focal species models are a key element of the ESA. The intermediate level of detail provided in the report is insufficient for a thorough evaluation of their merits; however, we note that previous reviews were undertaken. In the spirit of transparency, we recommend that these reviews, and the response of authors, be made available. We also note that all focal species selected are presumed to require old growth forest to satisfy some aspect of their life history requirements. A related assumption is that the needs of species associated with other ecosystem types will be addressed by the representation and special element analyses.

The generic nature of many of the models, **and their implicit circularity**, limits their utility for detailed conservation planning. For example, the Marbled Murrelet model yields a binary output of (potentially) suitable/non-suitable habitat. While many of the limitations of this model are identified within the report (p.55-56), Map 7 appears definitive, in that the key indicates "MAMU Habitat". Page 56 asserts that *"There is no way of verifying that the maps produced by the model match the actual distribution of murrelet breeding activity in British Columbia."* We disagree; maps should be treated as hypotheses, which can be evaluated using empirical data. A large amount of research has taken place on Marbled Murrelets in the study region; some of the information is used as a qualitative check by the authors within the ESA. Quantitative evaluations should also be conducted.

Sensitivity analyses on parameters included in models should be conducted for all focal species, in order to evaluate their influence on the solutions generated by SITES.

Appendix 1.0.1.3.1 (referred to on p.58) is missing.

2.2.8.1 Background and Rationale (Focal Species: Black Bear)

"Black bears were chosen as focal species outside of occupied grizzly bear habitat for the CIT ESA because they also can be considered keystone, indicator and umbrella species (see grizzly bear model). In addition, the Kermode genotype is extremely rare, more appropriated examined as a focal species than a special element in the ESA. Black bears were not modeled inside occupied grizzly bear habitat because of their high overlap in habitat requirements."

The justification provided for grizzly bears should not be transposed uncritically onto black bears. How were targets for black bears evaluated if they were not modeled over the entire study area?

3.0 SETTING GOALS

3.1 Background

"Establishing goals is among the most difficult - and most important – scientific questions in conservation planning (e.g., How much protected area is enough? How many discrete populations and in what spatial distribution are needed for long-term viability?). As some have pointed out (e.g. Noss 1996, Soule & Sanjayan 1998), questions such as these cannot be answered satisfactorily by theory, but require an empirical approach, target-by-target, and a commitment to monitoring and continual re-evaluation over the long-term."

This is the essence of the exercise, and the authors identify the important considerations and a robust approach. Nevertheless, most of the elements identified are not explicitly addressed in this report. A similar statement in the Executive Summary (p.18) implies much greater specificity than the analyses warrant: *"Goals for conservation targets specify the number and spatial distribution of occurrences."* In particular, there are no criteria in the objective functions specified in SITES, the post hoc analyses referred at various points, or in the interpretation of the results that suggest that the spatial distribution of targets was considered in the evaluation of options and scenarios.

"Although we were not able to rigorously analyze population viability of our focal species in this study, we have considered the conditions that contribute to viability in a general way."

This is a recurrent theme, but nowhere are the surrogates used to evaluate viability clearly and concisely summarized. Readers can infer that representation and area targets served as surrogates. Only under Section 5.4.3 is it explicitly stated that *"Condition was used as a surrogate measure for target viability."*

3.1.1 How much is enough: Level of landscape protection (Representation Analysis)

The interpretation of Cumming et al. (1996) is not strictly correct. They evaluated the ability of landscape units of varying spatial extent to achieve representation.

"Importantly, site selection algorithms, by themselves, do not address the more difficult and real-world questions concerning the area needed to maintain viable populations of species and the persistence of biodiversity."

This point needs to be re-iterated throughout all sections of the report, particularly relative to results and conclusions.

"Many studies have proposed minimum targets for biodiversity conservation, either generally or for specific regions. In some cases these figures are based on estimates by experts of the area necessary to maintain viable populations, ecosystem services, or the persistence of biodiversity generally; in other cases they are based on the empirical results of studies employing site-selection algorithms and/or population viability analyses (Table X)."

There is clearly enormous variation in how such numbers have been generated. While the results of goal-driven site selection procedures may be empirical, they are entirely dependent on the choice of goal. For example, a study may ask the question: how much of the total area of system A would be required to achieve representation of ecosystem type or elements B at level C? Assuming complete classification of an area, C can never be less than A. Empirical results derived in this manner do not meet the scientific standard addressed by population viability analyses.

Table X is presumably Table 3.1.

"Generally, most experts have reported that some degree of protection for at least 40-60% of the terrestrial lands and fresh waters would be required to sufficiently protect biodiversity, *assuming that the very "best" and representative areas are selected."*

These are loose terms, and the definitions of these terms will strongly influence the outcome of related analyses. What type of protection, over what spatial extent, based on what criteria?

3.1.2 How much is enough: Individual conservation area size (Representation Analysis)

"The required size of individual conservation areas can be considered relative to the natural disturbance regime. Pickett and Thompson (1978) defined a "minimum dynamic area" as the smallest area that contains patches unaffected by the largest expected disturbances. This large size is required to allow recolonization from undisturbed patches within the reserve. Shugart and West (1981) estimated that in order to maintain a landscape's dynamic ecological processes in equilibrium, a reserve ought to be 50-100 times larger than a typical large disturbance. However, calculations at this scale are unrealistic to conservation planners and agency decision makers. Moreover, the assumption that a landscape should be in equilibrium with a disturbance regime is questionable, especially in ecosystems characterized by large, catastrophic disturbances (Baker 1989)."

Why are calculations at this scale considered unreasonable? In coastal systems, where it is earlier acknowledged that natural disturbances are typically infrequent and small, a minimum dynamic area might be quite small. Regardless, the concept does not assume that a landscape should be in equilibrium with a disturbance regime; rather, it suggests that the maintenance of "patches" of different habitat types should be within the range of variation that has historically existed as a result of the natural disturbance regime. The assumption is that these conditions have fostered persistence.

"These studies do not, however, include measurements of differences in human activities surrounding protected areas…formally protected status may not be required across the entire landscape, if management there is environmentally sensitive and emphasizes the maintenance of native biodiversity and ecological processes... protected or conservation areas serve as insurance that the most sensitive components of biodiversity receive sufficient security, whereas management of the surrounding matrix determines whether or not ecological processes remain viable across the region and long-term conservation goals are met."

These are important concepts that are not revisited elsewhere in the report. The assumption throughout is that areas outside those identified in various solution sets contribute nothing to conservation goals.

3.1.3 Goals for Focal Species

The recognition of uncertainty here is appropriate and should be extended to all focal species analyses.

3.1.4 Conclusions

The qualifiers that appear in the first two paragraphs of this section, related to estimating the needs for persistence and factors contributing to variation in protection goals, should be added to the sister section in the Executive Summary.

"In this study, we did not have the time or funding… Nevertheless, we are able to use the results of other studies, such as those reviewed above, to qualitatively evaluate the ability of alternate designs to sustain populations of focal species over time."

We do not believe that this assertion is supported by the methods employed.

"For coastal regions of BC, the grizzly bear has been identified as a key focal species, and represents an umbrella species with the most impressive spatial requirements. For grizzly bears, recent research provides several relevant insights (see discussion above for citations)…"

The paragraph that flows from these opening statements is based on extrapolation from general principles, many of which are untested. Four recommendations follow, which should be clearly identified as conjectures with a high degree of uncertainty. It is not clear how these are translated into quantitative conservation goals within this study – another post hoc analysis? Further, it is not justified to present these within the concluding section, given they were not discussed in Section 3.1.3 (Goals for Focal Species).

Table 3.1 - The percentage estimates are missing, and a column indicating the method of estimation should also be added.

3.2 CIT-ESA Terrestrial/Freshwater Goal Setting

What is the justification for applying percentage goals uniformly across all ecosystem and focal species targets? Section 3.4 (Goals for Offshore Marine) describes an approach to setting variable goals based on qualitative rankings.

3.3 Goals for the Marine Nearshore Environment

"There was no mechanism for us to consistently assess viability for fine and coarse filter marine targets. Since we couldn't rely on the marine data sets to provide information about the relative viability of individual occurrences, we set conservative (low) goals that would help drive the algorithm to assemble an efficient portfolio around the sites most important to multiple targets. We therefore attempted to answer the question 'where do we start?' in conserving places for nearshore biodiversity, as opposed to 'how much (area) is enough?'. We based the goals on importance of the targets, co-occurrence of habitat types and species, least cost (or the most suitable places), and our confidence in individual data sets."

This represents a radically different philosophy and approach than was employed for terrestrial and freshwater components of the ESA. There needs to be a discussion somewhere as to why this occurred, and what are the implications for integration of the resultant analyses, and interpretation of results.

3.3.1 Representation (Coarse Filter) Goals

"Goals for individual shoreline ecosystem targets were 10% and 20% (Table 3.2)… coarse filter intertidal vegetation and habitat targets were run at goals of 15% and 30%, respectively (Table 3.3)."

There is considerable variation in goals among the major environments considered by the ESA (terrestrial/freshwater: 30-70% in 10% increments; marine nearshore: 10-30%, depending on target; marine offshore: 5-50% - Section 3.4). It would be prudent to run all analyses across the same range of goals, and to devote a portion of Section 6.4 (Integrated Spatial Analysis) to interpreting the results appropriately.

4.0 HUMAN IMPACTS

4.2 Methods

"These are sub-primary watersheds that are between 10,000 ha and 100,000 ha and 100,000 ha to 1,000,000 ha respectively, and defined using a standardized set of decision rules (see APPENDIX X for details). This allows assessment of impacts and other characteristics at multiple spatial scales."

Appendix X is missing.

"Using these criteria, we applied a scheme to assess ecological integrity, based on a modified Moore (1991) methodology. Human impacted area was calculated …."

Ecological integrity is not defined. The inference is that any area with human impacts that exceed the threshold for being considered ecologically intact (see below) have lost their ecological integrity.

"Watersheds with more than 2% of their area affected may still be ecologically intact, depending largely on both the cumulative impact of human alteration and the spatial location of human alterations. To identify such watersheds, we used two additional factors for assessing the overall level of impact, 1) proximity of impacts to rivers and streams and 2) road density. This allowed separation of moderately impacted areas from those with higher levels of human impacts (Table 4.2)."

No rationale is provided for the 2% area threshold, or for the 0.35 km/km^2 road density threshold (Table 4.2). Why define criteria for 6 classes, but then distill them to 3 (Table 4.2; Map 31)?

In addition we also sought to identify relatively intact watersheds a multiple spatial scales. Small intact watersheds may be sufficient for harboring viable occurrences of some non-vagile species (e.g. rare plant communities), but larger, contiguous intact areas and characteristics present only in larger river systems are necessary to conserve viable populations of vertebrate species.

The requirement for contiguous intact areas for conservation of viable populations is assumed.

Table 4.3 – The units for river system classification are missing.

5.0 SPATIAL ANALYSIS: METHODS

5.1 Background

"Our ecosystem spatial analysis is designed to serve four well-accepted goals of conservation (Noss & Cooperrider 1994): 1) represent ecosystems across their natural range of variation; 2) maintain viable populations of native species; 3) sustain ecological and evolutionary processes; and 4) build a conservation network that is resilient to environmental change. In pursuit of these goals we integrate three basic approaches to conservation planning: 1) protection of special elements, including imperiled species, natural communities, and genetic variants; 2) representation of a broad spectrum of environmental variation (e.g., vegetation, geoclimatic, and aquatic classes); and 3) protection of critical habitats of focal species (Lambeck 1997; Miller et al. 1998/99), whose needs help planners address issues of habitat area, configuration, and quality. Together, these three tracks constitute a comprehensive approach to conservation planning (Noss et al. 1999)."

The report may serve goal "*1) represent ecosystems"*; however, there is no indication that the other 3 points will be served by this plan. While the *"three basic approaches to conservation planning"* may *"constitute a comprehensive approach to conservation planning"*, it is misleading to suggest that this approach will achieve goals *2) viable populations, 3) ecological and evolutionary processes, or 4) environmental resilience*.

5.2.1 Steps of Spatial Analysis

"For the CIT ESA, the challenge is to take an analysis of special elements, ecosystem representation, and focal species, and create a spatially explicit assessment of where the region's biodiversity values are located and what condition they are in. <u>This information can then be used to create a conservation solution or "portfolio" of landscapes and seascapes that taken together, and managed appropriately, would ensure the long-term survival of the region's biodiversity</u>.:

See earlier comment for in "Background" section re. use of term "ensure".

" In order to perform this assessment, the three-track approach is applied to freshwater, terrestrial, and marine environments via the following key steps:"

Step 4 (*Set conservation goals to serve as benchmarks for identifying conservation priorities and as an initial hypothesis about the level of effort required to conserve biodiversity*) correctly identifies the goals as hypotheses, but this philosophy is not explicitly reflected in the remaining steps.

5. Integrate information for special elements, ecosystem representation, and focal species in each of freshwater, terrestrial and marine environments to create a spatially explicit assessment of conservation values for the study area

6. From that assessment, use goals and viability measures to develop options for creating a portfolio of conservation areas that will effectively conserve the region's biodiversity in the long term.

The following paragraph states that team "*recognizes that new and more comprehensive data will continually become available and that ultimately, the ESA must be regarded as being a first step in an iterative assessment process*." The process for achieving the iterative process [?] should be included as "key steps".

5.2.2 Automated Site Selection Algorithms

5.2.2.1 SITES

"SITES utilizes an algorithm called "simulated annealing with iterative improvement" as a heuristic method for efficiently selecting regionally representative sets of areas for biodiversity conservation (Pressey et al. 1996, Csuti et al. 1997, Possingham et al. 1999). It is not guaranteed to find an optimal solution, which is prohibitive in computer time for large, complex data sets such as ours.

Assertions of optimality relative to solutions appear elsewhere.

Rather, the algorithm attempts to minimize portfolio "cost" while maximizing attainment of conservation goals in a compact set of sites. This set of objectives constitutes the "Objective Cost function:"

Cost = Area + Species Penalty + Boundary Length

where Cost is the objective (to be minimized), Area is the number of hectares in all planning units selected for the portfolio, Species Penalty is a cost imposed for failing to meet target goals, and Boundary Length is a cost determined by the total boundary length of the portfolio."

SITES is a powerful analytical tool, but whether the output should be treated as robust rests on the confidence users have on the objective functions and data that drive site selection.

Because "*SITES attempts to minimize total portfolio cost by selecting the fewest planning units and smallest overall area needed to meet as many target goals as possible, and by selecting planning units that are clustered together rather than dispersed*.", one is minimizing the area that is selected. This seems to follow an economic approach to make the selection of areas politically palatable. However, this minimizing approach disregards the precautionary principle given the vast uncertainties of the ecological data (species distributions, movement patterns, survival rates, reproductive rates, dispersal rates). A precautionary approach would maximize areas and connections. The modellers using SITES may have built in "buffers" to run SITES in a precautionary way; however, this approach would be deceptive unless stated explicitly that buffers were added to all data for the model runs.

How is variability in habitat suitability or capability, as defined for focal species, incorporated into the SITES analysis?

"*Alternative scenarios were evaluated by varying the inputs to the Cost function. For example, the Boundary Length cost factor was increased or decreased depending on the assumed importance of a spatially compact portfolio of sites, and a range of goals were used. Varying the inputs to SITES in order to assess the outcome, in terms of units selected, allows portfolio design to be tailored to expert opinion, while quantifying the effects of such subjective decisions*."

This method could be also used to evaluate model uncertainty for focal species (i.e., it represents a type of sensitivity analysis).

In the ESA, many of the quantitative goals are based on expert opinion, but they are not treated as subjective.

5.2.2.2 MARXAN

Given the strengths of MARXAN identified here, why was it not used for all analyses?

5.2.3 Terrestrial and Freshwater Spatial Analysis

5.2.3.2 Planning Units

The choice of 500-ha planning units is not substantiated; for example, why not use 100- or 1000-ha units?

5.2.3.2.4 Boundary Length Modifiers

The implications of varying boundary length for spatial configuration of sites are apparently explored in many of the analyses, but no interpretation of results is provided.

5.2.3.2.6 Goal Settings

"We used five different goal levels: 30%, 40%, 50%, 60%, and 70%, as described in section 6.2."

"%" of what? This section is under **5.2.3 Terrestrial and Freshwater Spatial Analysis**, but section 6.2 describes **6.2 Marine Nearshore Spatial Analysis Results**.

The issue of "goal thresholds" is unclear for the terrestrial component. At every expression of %, the reader should be clear on the "% of what total" the report is referring. The sections of the report dealing with Marine Ecosystems are clear with respect to the "% of what" when percentages are used.

Clear and consistent definitions are required for the following terms: *representation goals*, *conservation goals*, *goal thresholds*, and *goal percentages*.

Three examples of confusing sentences:

"Goals for the site-selection algorithm were set varying from 30% to 70% representation in 10% increments based on historical abundance of ecosystem type."

"Goals for focal ecosystems were varied from 30% to 70% in 10% increments."

"We examined 6 reserve network sizes: 5%, 10%, 20%, 30%, 40%, and 50%."

5.2.4 Nearshore Marine Spatial Analysis

5.2.4.4 Spatial Analysis

This is an excellent description of the goal-setting, analytical process, reporting and interpretation of the MARXAN scenarios. A similar description should be provided for the other environments.

5.4 Options and Scenarios

5.4.2 Conservation Value

"A key concept in conservation planning is irreplaceability... defined in two ways: 1) the likelihood that a particular area is needed to achieve an explicit conservation goal; or 2) the extent to which the options for achieving an explicit conservation goal are narrowed if an area is not conserved. Given the constraints under which the site selection algorithms operate, we can expect that summed solutions will describe a range of important conservation criteria including rarity, richness, diversity and <u>complimentarity</u>. These <u>criteria are optimized</u> through the selection of a minimum set of planning units to meet goals for our conservation targets. For the CIT ESA, we have used these <u>summed solutions as a broad measure of irreplaceability</u>, which

for the purposes of this report, we more simply describe as "conservation value" (note: the CIT offshore analysis also uses the term "conservation utility" to describe this parameter). Conservation value however is not always a direct and absolute measure of true irreplaceability since areas with high conservation value may indeed be replaced by using larger areas of lower value sites.

Complimentarity should be Complementarity. Criteria are not optimized.

The introduction of novel terms such as "conservation value" and "conservation utility" is confusing. They are not "simpler" descriptions; rather, they represent something different. Why wasn't true irreplacebility, as defined, evaluated within the confines of the data available? At a minimum, the same novel term should be used for all analyses. Section 6.3.2 (Utility – Offshore Marine Spatial Analysis Results) provides a much better description.

Scores for both analysis and landscape units were then grouped into 5 classes based on the quintile scores of the summed solutions (see Table 5.1). A planning unit selected 180 or more times in SITES fell into the top 2 quintiles, or top 40%, of the solution and was scored as having high conservation value. Analysis units with scores in the middle quintile were scored as medium conservation value, and those in the 4th quintile were scored as low conservation value. Those units with a score in the lowest quintile were not ranked.

What is the rationale for the 5 classes, and why were quintile scores assigned to only 3 values (high, medium, low)? Why did the fifth quintile receive no rank?

Table 5.1 – The numeric ranges for summed solution scores are not comprehensive (i.e., >180 should be ≥180, etc.).

5.4.3 Condition

Condition was used as a surrogate measure for target viability in the CIT ESA and was evaluated using the human impacts information described in Section 4. Impacts were assessed for both hexagonal analysis units and for Landscapes/seascapes. The six impact classes described in Table 6.2 were simplified into the three broad condition classes--intact, modified and developed (see Table 5.2).

This is first place where a surrogate for viability is clearly and explicitly identified.

The reference to Table 6.2 should be Table 4.2.

5.4.4 Alternative Options for Conservation

"To explore the interaction between conservation value and condition, analysis units and landscapes/seascapes were clustered into 3 conservation tiers based on the conservation value and condition matrix in Table 5.2."

Is there any precedent for criteria used to assign analysis units to "*conservation tiers*"? How is exploration of "*the interaction between conservation value and condition*" served by this classification? The array of attribute assignments to units makes it very difficult to track the implication of sequential, and quite possibly additive, assumptions for potential solutions. A matrix that describes the criteria for re-assignment of planning units from start to finish in the analysis and reporting would be extremely helpful.

5.4.6 Comparing Options and Scenarios

In order to compare between and within options and scenarios, potential solution sets from summed runs were evaluated against three goal thresholds, 30,50 and 70%. For each scenario, performance of conservation tiers (options) was assessed both in terms of effectiveness, as measured by the proportion of targets that met or exceeded the goal threshold, and efficiency, the proportion of the study area required to meet the threshold.

The description appears to apply only to terrestrial/freshwater analyses (with goal thresholds of 30, 50 and 70%).

If mandatory goal thresholds are defined by the targets, how can a solution be ineffective? Confusion over varying use of the term "goal threshold" is apparent here. "Efficiency" of solutions relative to minimum area is defined by the SITES/MARXAN algorithms; however, efficiency is here redefined relative to the conservation tiers described in Section 5.4.4. This does not aid in ease of interpretation, in the absence of an explicit rationale, and limits the range of options considered.

6.0 SPATIAL ANALYSIS: RESULTS AND DISCUSSION

6.1 Terrestrial/Freshwater Spatial Analysis Results

Table 6.1 and 6.2 need to have definitions for "solution" footnoted.

The reporting structure, emphasizing conservation tiers derived from summed scores, does not allow readers to evaluate the relative influence of targets on the solutions. For example, what proportion of total area in the solution is required to meet representation, focal species and special element goals? Reporting relative to the three prongs of the approach would be much more informative, given the relative quality of the data, and related assumptions and uncertainty. This is standard for similar undertakings. Table 6.3 (Marine Nearshore Analyses) provides a model for how this might be achieved.

6.2 Marine Nearshore Spatial Analysis Results

Much of the text is this section is repeated from Section 5.2.4.4.

6.3.2 Utility (Offshore Marine Spatial Analysis Results)

This is a very informative description of results and interpretation, and the related map (Map 34) clearly illustrates concentrations of conservation sites by applying a continuum from seldom chose to chosen frequently.

6.4 Integrated Spatial Analysis

Neither methods nor results are described. This is an important component of the planning exercise, and will be a novel contribution to the field.

7.0 INTEGRATING CIT ESA, EGSA, AND CSA SPATIAL ANALYSES

This integration is also a critical component of the planning process. Modification of the cost functions in SITES seems a reasonable, initial approach. We are not familiar with QUEST, but caution that such software can create a false sense of certainty and confidence in users. The outcomes of projections are only as reliable as the underlying data.

8.0 CONCLUSIONS

"In progress."

One of the three aspects of this report that we were to review was the "presentation of sound conclusions that are supported by data". Earlier sections reported conclusions relative to individual analyses, but the overall credibility of the ESA hinges on what is included in this section, relative to the appropriate interpretations of results to date. We hope that our review in helpful in formulating these. We also hope that this section, or an additional section, will provide a synthesis of recommendations for future work.

9.0 LITERATURE CITED

Many of the references cited in the text, particularly within tables, are missing from this section. Some citations are incomplete. Most of the references from the entire "Introduction" section are missing.

Citation format within the text is inconsistent. For example:

Schoonmaker, von Hagen and Wolf 1997 vs. Schoonmaker et al. 1997
Soule & Sanjayan 1998 vs. Soule and Sanjayan 1998
Carroll and colleagues (2003) vs. Carroll et al. 2003

Limited use is made of the primary literature; rather, there is heavy reliance on unpublished reports and so-called grey literature. As a result, interested readers will be challenged to find original sources. We recommend that an on-line Reference Library be created for the project. This would contain digital versions of all reports referenced by the ESA.

MAPS

Map 8 – missing

Maps 22-30 and 45-52 – are not numbered and legends are difficult to interpret

Map 32 – legend requires further explanation

Maps 33-36 – so called "no value" areas should still be keyed in legend and appear on maps; it is not clear what goal threshold these correspond to

Map 35 – includes 2 candidate protected areas listings (one is presumably options)

Map 36 – the spatial distribution of conservation values in the "unconstrained option" is very different than for constrained options; is this fully acknowledged in the text?

Maps 37b, 38b, 39b, 40b – why are no Tier 3 areas indicated, as per Maps 41-44?

APPENDICES

References to appendices were incomplete in the text, and a listing does not appear in the Table of Contents. Appendices were not provided for review.

GENERAL FORMAT

The entire report needs a thorough edit. Within the first few paragraphs of the **Introduction** there exist several hanging sentences, and both typographical (e.g., “settling conservation goals” vs. “setting …”) and grammatical (e.g., data “was” vs. “were”) errors.

Overall, the structure of the report is easy to follow, and section headings are clear.