❖ Standard 11: Design ecoregional portfolios/biodiversity visions to best meet goals for all conservation targets/ biodiversity elements, using the principles of efficiency, representation, irreplaceability, and functionality.

Case Study: **Priority Sites and Spatial Variability for the Carolinian Marine Ecoregional Assessment**

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Purpose and region of analysis

The purpose of the Carolinian Ecoregional Assessment is to bring an enhanced focus to marine conservation and management in the region (DeBlieu, 2005). To achieve this purpose, three products were developed: a spatial database of the region's biodiversity and the factors that affect it, a decision-support framework to evaluate conservation and management alternatives, and a set of conservation areas that represent the region's biodiversity. The assessment involved many partners in academia, state and federal agencies, and other nongovernmental organizations, as well as staff from all TNC state chapters in the region and TNC's Marine Initiative. All the tools, data, and results used in the assessment are available in a distributable CD-ROM to inform and support partner conservation and management efforts.

Regional ecosystem-based management is gaining support around the world as an approach for integrated planning and conservation of nearshore marine environments and resources. While there are many elements to effective ecosystem management, one of the essential requirements is the need is to efficiently consider multiple species and their habitats as well as the socioeconomic factors in the region. The Carolinian Assessment provides a foundation for partner coalitions or individual agencies to develop an ecosystem management framework. This integrated information supports a greater understanding of the biological diversity of the ecoregion and provides a clearer picture of the condition of their natural areas, as well as the challenges to their continued survival.

The Carolinian Ecoregion extends from the mouth of the Chesapeake Bay in Virginia south to Cape Canaveral in Florida. It includes the temperate bays, estuaries, and coastal marshes of five states and the waters, deep reefs, and sand plains of the continental shelf. Its eastward or seaward boundary is the shelf edge at the 200-meter isobath; its western boundary is the zone along the coastal plain where salt-tolerant plants and ecological communities are replaced on the landscape by fresh-water-dependent species. The ecoregion is characterized by a broad, shallow shelf platform, extensive sandy barrier islands and beaches, many productive estuaries, vast coastal marshes, and major piedmont and coastal plain rivers that terminate at the coastal margin.

Criteria/Methods

The primary purpose of this assessment is to provide an ecoregional context in which to make good decisions for lasting conservation and effective natural resource management. One major element of the assessment is to identify a single, efficient, yet comprehensive network of priority conservation areas that, if effectively conserved, can best sustain the biological diversity of the region. The objective of the selection process is to ensure that conservation goals for the representation and distribution for all targets are met as efficiently as possible, with total cost factors and total area minimized. This network – the conservation portfolio – becomes the framework for more detailed planning and conservation efforts within and around these areas.

Thirty-six individual targets (species, ecosystem, and coarse filter surrogates) were mapped across the study area and representation goals were established for each. Additionally, eleven different factors which track anthropomorphic effects were compiled into a suitability index which enables us to build into our site selection process an aspect which will favor capturing representation goals in areas which are more suitable for conservation (i.e. having greater ecological integrity). The Marxan automated site selection algorithm was then employed to enable a dynamic decision support system (DSS). In this system representation criteria are established and explicitly stated. Then a statistical sampling method known as simulated annealing is employed to sample through millions of possible collections of priority sites and select configurations which are "better" than other alternatives based on the established criteria. The Marxan tool is design to provide near optimal solutions to complex problems. It is not designed to sample every possible priority site configuration, but rather to sample many and retain a solution which is better than many others, but may not be the single best alternative. This is generally regarded as a minor issue since priority sites resulting from automated algorithms should always be reviewed and adapted based on many real world considerations which are not factored into automated site selection.

In addition to selecting a near optimal set of priority sites the Marxan tool also offers users the opportunity to create what the algorithm refers to as a summed runs solution. The summed runs solution is the result of tracking results for many independent solutions for priority site configuration. In the case of the Carolinian Ecoregion,50 independent runs were conducted resulting in 50 near-optimal sets of priority sites. The summed runs solution adds together the result of each of the fifty independent runs to determine how often each area is selected as a priority site. This information enables us to explore the spatial variability which is available for efficient conservation priority setting. There is more than one good alternative for how we would choose to meet our representation criteria. The summed runs solution offers us one way to investigate these alternatives. This is particularly valuable as it allows us to know which areas have significance for conservation representation and because the most optimal priority site configurations based on model input will rarely be a perfect match with the most optimal alternative in real world scenarios.

Products/Outcomes

The Marxan DSS was developed by establishing a single set of contiguous analysis units that cover the study area. These units were 1,500 hectare hexagons and the analysis included 11,903 hexagon analysis units. These units were populated with information on the distribution of the thirty six targets and the 11 conservation suitability factors. After determining representation criteria for targets, we then ran Marxan to construct suitable sets of priority conservation sites and employed the summed runs option to track the results of each run. Marxan produced both a "best" solution and a summed runs solution as output, both of which were used to guide the development of a conservation portfolio. The "best" solution is the set of planning units that best meets the conservation goals for all targets at the minimum cost. The best solution for this assessment resulted in a set of 78 sites that included 2,603 planning units for a total area of slightly more than 3.9 million hectares – or 21.8 percent of the ecoregion. In truth, there is no single best solution since it is mathematically impossible to obtain a truly optimal output and since certain outputs may be statistically indistinguishable from others. The best solution met the conservation goals for all 36 targets and exceeded goals for many.

The results from Marxan were peer-reviewed and modified in workshops with scientists, managers, and conservation practitioners to develop a portfolio of Conservation Areas that met the conservation planning objectives. Here the "best" solution was used as a starting point and the summed runs solution was used to demonstrate where high quality alternative were available. Having the ability to represent good alternatives was a major asset in refining the output for the automated site selection tool. Experts recommended few major changes to the Marxan results and primarily identified changes to aggregate selected planning units into more biologically meaningful sites. By comparing the summed solution to the final set of priority sites, it was also clear that the final portfolio incorporated planning units that were selected in most Marxan runs. For instance, 204 planning units were selected in at least 90 percent of the Marxan runs, and all but three of these units are included in the final portfolio. Two hundred forty-seven units were chosen in at least 80 percent of the Marxan runs, and all but eight were included in the final portfolio.

The end result was a conservation portfolio that included a total of 41 Conservation Areas and encompassed 21 percent of the ecoregion. The planning team then worked with additional TNC staff to assess the targets, threats, and opportunities at the 41 Conservation Areas. From this process, ten Action Areas were recommended where TNC should first explore opportunities for further contributions to marine conservation. The Conservation and Action Area boundaries are rough approximations for specific areas. It is assumed that more ecologically meaningful boundaries will be identified through site-specific planning and conservation efforts. The identification of these Conservation and Action Areas makes no presumption about the best strategies for conservation at individual sites. Before identifying conservation strategies, TNC will work with our partners to better understand the present and likely future threats to marine diversity, as well as the biological, socioeconomic, and political circumstances at each site.

Three primary products were developed through this assessment:

- a spatial database of the region's biodiversity and the factors that affect it;
- a decision-support framework to evaluate conservation and management alternatives; and
- a set of priority conservation areas that represent the region's biodiversity.

Tools

The primary tool for priority site selection was Marxan (Ball 2000, Possingham 2000). Marxan was used provide decision support and to develop potential sets of conservation areas that met objectives. The Marxan tool is available for distribution through the University of Queensland's Ecology Centre. It is widely in use for regional marine conservation planning and examples of its application are available through the Ecology Centre <http://www.ecology.uq.edu.au/index.html?page=27710>.

In addition to the Marxan tool, a geodatabase was constructed to manage geospatial information associated with the Carolinian Ecoregional Assessment.

Both the Carolinian marine geodatabase and the decision support system (developed as Marxan input files) are available for distribution through the Conservancy's Global Marine Initiative.

Strengths and weaknesses

There are several recognized advantages to the site selection approach employed in the Carolinian Assessment. The most important is likely to be a shift from largely expert driven processes which we could not duplicate and which depended on subjective decision to a science driven process where the assumptions are stated explicitly and the process can be repeated independently to arrive at similar conclusion. Another major advantage to this approach is that it is an adaptable approach where revisions or alternatives can be incorporated into the existing scenario and the site selection can be rerun based on revisions. Similarly the process enables planning teams to adapt the process by changing representation values, suitability rankings, or by adding new information into the existing scenario. This enables us to refine the process over time with lower added investment. We are also able to employ this decision support approach in stakeholder forums where we can exclude certain areas or reach agreement on including certain areas and then rerun the site selection process to insure that representation criteria are met. The summed runs solution offers us important utility in recognizing that our representation goals can lead to alternative priority sites. There is not one single answer on where we can do important conservation work, but rather a range of possible alternatives. By developing a summed runs solution we are able to represent the alternatives and explore their utility toward meeting our objectives.

One clear weakness to the employing Marxan as an automated approach to site selection is its interpretability. The Marxan process is intensely analytical and many people find it difficult to understand and operate. Additionally, employing the Marxan tool in the manner used here requires a significant investment in the development, integration, and interpretation of geospatial information. This process requires a high level of capacity of information management and spatial analysis.

New weaknesses are introduced when assumption are made in the process of establishing the decision support system. For example, a benthic complexity model was developed for use in the Carolinian Assessment. But this model has not yet been validated, making the assumption that the model is accurate, one of the weaknesses of the plan. Similarly scaled values are applied to the various factors employed in the suitability index. This scaling has not yet been validated and represents another assumption in need of further research. In general, we counter for these weaknesses by using the Carolinian Assessment as only one stage in our conservation planning process. After identifying an area as a potential priority site, we then investigate that area more closely through a conservation area planning approach where we can conduct a more detailed analysis before establishing management plans.

Suggestions for others considering similar analysis

We recommend the application of the Marxan site selection algorithm for marine regional planning exercises where spatial priorities are being established. The regional planning approach employed in the Carolinian Marine Ecoregional Assessment is a robust and adaptable process which enables us to balance information and values for a variety of sectors and create a comprehensive vision for meeting representation criteria. The general process where representation criteria are explicitly stated is a clear step forward from subjective decision driven processes.

We also recommend that the summed runs solution option be employed when creating Marxan scenarios. This approach enables us to represent spatial variability and allows us more flexibility in developing compromise scenarios. Without the recognition of spatial variability a set of priority conservation sites can be difficult to accept, particularly for stakeholders influenced by management decisions. By representing alternatives, we are better able to engage partners and communities in supporting the implementation of representative conservation plans.

References

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