4.0 DISCUSSION

Similar to other reports that characterize the environment at a landscape-level (H. John Heinz III Center for Science, Economics and the Environment 2002, Schweiger et al. 2002), the individual sub-layers and main layers selected for TEAP reflect important attributes relating to ecosystem condition, and by extension, ecosystem function. TEAP characterizes ecological conditions in terms of three different aspects of ecosystems using existing data coupled with ecological theory, while recognizing that there are judgements involved in such an enterprise. Given the complexity of ecosystems, these judgements include determining which measures to concentrate on and which to exclude, and communicating the uncertainties and limitations of the data and TEAP analysis.

The TEAP is a relatively simple model that uses stratified data that are combined to give a total or composite picture of the state of Texas at the ecoregion level. Since complicated modeling and analysis tools are less likely to be used in regulatory processes, beneficial properties of GIS assessment tools such as TEAP include 1) simplicity (expert modeling abilities are not needed), 2) use of available data (rather than experimentation), 3) analytical (numerical simulation is not needed), 4) approximation (need matches level of effort), 5) measurable change, and 6) expandability (use in more sophisticated models) (Leibowitz et al. 2000). TEAP assesses and prioritizes locations when information is limited. Due to the scale at which the TEAP was performed it has limitations in utility with regard to regulatory decisions or processes requiring more detail. TEAP is a screening tool that can assist in overall conservation efforts (including project planning, mitigation, preservation, or restoration activities) and to identify areas where more detailed, site-specific data are needed. TEAP results should be used in conjunction with agency-specific information to support decisions. (Schweiger et al. 2002). TEAP should enable managers to consider specific decisions within an ecoregion context.

4.1 Data Limitations

Several limitations of the data and analysis should be noted. No individual sub-layers were removed *a posteriori* from this iteration of the protocol. The limitations and other issues concerning specific sub-layers or their use in the protocol or their application to regulatory processes are discussed, so that they can be modified or excluded in the next iteration of TEAP. It was also felt that by removing individual sub-layers, the composite may only have a few relatively non-ecological sub-layers to account for the majority of a main layer. Multivariate evaluation of the results may yield a clearer picture of the relative contribution of each sub-layer to each of the three main layers and the composite.

The scoring methods per layer and per ecoregion result in an issue at ecoregion boundaries. Two adjacent cells with the same land cover type and the same stressors can score differently in different ecoregions. For example, two cells both have a PAR of 0.123, but cell A could get a score of 75 while cell B could receive a score of 50 because of the differences in their respective ecoregions. The two cells could also have a composite score that is different, even though they are basically the same. The reverse is also true; sites with the same composite score could end up in a different category for similar reasons. Adjacent cells A and B both have a composite score of 225, but cell A is in the top 1% cell (colored red) in its ecoregion, but cell B scores in the top 10% cell (colored green) in an adjacent ecoregion.

Each sub-layer within the diversity layer represents different, but somewhat overlapping, attributes of diversity, that when combined, gives a broader picture of diversity in each ecoregion. It can be true that there is a dichotomy between contiguous area and appropriate land cover. These are reasons why the TEAP (and CrEAM) is a stratified approach (i.e., equally-weighted sub-layers feed into layers which are then combined into a composite).

Kuchler (1964) data was used in the diversity and sustainability layers. The comparison between the PNV (Kuchler 1964) and 1992 NLCD is the most common method of describing the original spatial distribution of land cover and current conditions (Geneletti 2003). In addition, maintaining vegetation in proportion to its former, pre-settlement abundance is a goal of biodiversity conservation (Geneletti 2003).

The TXBCD is an observational data set that does not specifically consider communities. It is not comprehensive or synoptic like the GIS coverages. This is the reason that the TXBCD (or any other individual sub-layer, for that matter) was not used to exclusively represent rarity, but was combined with vegetation rarity (using NLCD), and is included as a separate sub-layer of equal weight in the rarity main layer. Other studies use measures of rarity, and highlight its relevance, especially for biodiversity conservation. However, there is no consensus on the attributes to include for its evaluation (Geneletti 2003).

Actual habitat information is better than somewhat arbitrary buffers around species observation points. However, this type of data does not exist statewide, although gap analysis data may be available in the future to address this concern. Other databases or scientific studies may exist, but did not meet the general guideline of TEAP to use pre-existing data that was available statewide. The reason for not using localized study data is to avoid the bias that results because some species are better studied than others. For example, a great deal is known about the organisms that inhabit the Edwards Aquifer and recharge zone of the Edwards Plateau ecoregion (Figure 19). However, biota in other portions of this ecoregion may not be as well studied or have systematic data available. EPA Region 5 found a similar situation in its analysis where one state had a much more active monitoring and data collection program than other states. EPA Region 5 addressed this by using multiple measures or sub-layers to characterize rarity.

The TEAP sub-layers do not explicitly account for supporting habitat for species (versus the actual observation point), although the contiguous size of undeveloped land (Figure B2) describes polygons of adjacent undeveloped land cover types. While it is correct that any land cover patch is generally influenced in some way by its adjacent neighboring patches, the TEAP is not able to explicitly incorporate adjacency effects as would be possible in a dynamic simulation model. The TEAP is a static model which characterizes the landscape through a mono-temporal multi-criteria evaluation approach. Detailed spatial and temporal dynamics between landscape patches cannot be modeled in this class of static models. Given the goals and objectives of TERS, it is unlikely that a dynamic model would provide a better solution than the type of model used.

Unlike EPA Region 5, Texas does not contain any natural lakes (other than isolated playa basins). Therefore, the open water land cover types (i.e., reservoirs) had to be excluded from sustainability sub-layers such as regularity of ecosystem boundary. It is a long and tedious manual process in GIS to “mask out” these areas so that only the shoreline was used. Including the entire area of these reservoirs (rather than just the shoreline) could tend to skew the area included in the one percentile fraction of the total area in an ecoregion.

The watershed obstruction sub-layer calculates dams per stream miles within each HUC whereas the water quality sub-layer uses actual stream segments. These two sub-layers should be more consistent in the next iteration because both could use stream segments (vs HUCs). However, a significant amount of technical assistance would be required to modify the calculations for these two layers for the next iteration of TEAP.

The road density sub-layer did not intentionally include or exclude water bodies. Cells that had zero roads scored 100, therefore cells that are all water are scored 100 (predominately found in the coastal areas).

In the urban/agriculture disturbance sub-layer (Figure B19), a 600 m buffer around urban and agricultural areas may tend to mask the presence of riparian and greenbelt areas. Though highly susceptible to development pressures, these areas may be among the most important to maintain and protect, especially for adequate water quality necessary to sustain aquatic species and to reduce downstream pollutant transport. TEAP is not intended to discourage use or designation of buffer zones around riparian, urban, or recreation areas. TEAP should point out places for conservation and enhancement (especially in terms of potentially restoring landscape connectivity) in areas that are currently not sustainable without intensive human management.

Given the available data and timeline, the EPA Region 5 model was at a scale (300 m^2) that allowed them to pick out a single or a few pixels of important ecological areas in or near cities (e.g., within the top 25% of all sites in the midwest.). This iteration of TEAP did not use such a fine scale resolution because of data quality and computer calculation time.

4.2 Accuracy Assessment

The accuracy assessment was performed by The Conservancy, an independent entitynoy involved with the calculations of the TEAP main and composite layers. The portfolio sites used in the accuracy assessment were derived independently from the TEAP using The Conservancy's process. Both TEAP and The Conservancy's processes use GIS information at some level; however, The Conservancy's process also includes field investigations whereas TEAP does not. As explained in the results section, the match between The Conservancy's portfolio sites and highly scored TEAP composite locations is good; however, there is less of a match at lower TEAP scores. This may be due to the fact that The Conservancy's process is designed to identify the highest quality or rare ecological communities for protection rather than identifying lower quality sites for restoration or mitigation process opportunities. It is difficult to determine the degree or "goodness" of the match between TEAP and The Conservancy without further field investigations. The decision to proceed with field investigations depends on the priority of such investigations for the TERS member agencies and the usefulness of these lower scored TEAP composite locations to agency programs (e.g., agencies looking for restoration opportunities).

Further analysis using multivariate statistics is needed to further verify the results of TEAP. Future actions such as the application of landscape metrics to study the pattern found at a finer resolution are also recommended to understand the spatial landscape patterns (McGarigal and Marks 1994, Riitters et al. 1995, Hargis et al. 1998, Roy and Tomar 2000, Herzog et al. 2001, Lee et al. 2001, Ochoa-Gaona 2001, Lausch and Herzog 2002).

4.3 Conservation

TEAP uses generally accepted ecological theory as the basis for its analysis. However, an aspect that affects potential conservation and protection of ecologically important locations in Texas regards the protection of large contiguous tracts of land versus protection of small high-value remnants that are possibly unsustainable areas without intense human management. The argument of protecting Several Small or Single Large areas/reserves (SLOSS) has been discussed considerably in the scientific literature (see Ovaskainen 2003). In the end, questions related to the spatial configuration of reserves and how the surrounding matrix was managed became more important as conservation goals.

Conservation is not the primary mission of many regulatory agencies. For these agencies, the TEAP may be useful in meeting NEPA requirements and in making project planning level analyses and decisions.

It seems obvious that planners should avoid negatively impacting ecologically important areas, especially in areas where there are few ecologically important areas remaining. On the other hand, the most threatened and rarest species and communities are often found in areas that TEAP would identify as less important. The key is to strike a balance between protecting and enhancing highly ecologically important areas versus protecting and enhancing vulnerable species/communities in less ecologically important areas.

Eventually, the decision should be determined by several factors. Ovaskainen (2003) suggested that the SLOSS decision should promote 1) maximizing the number of species that will eventually survive, 2) maximizing the number of currently occurring species, 3) lengthening species time to extinction, and 4) maximizing metapopulation capacity. Similarly, Noss and

Csuti (1994) proposed that 1) critical ecological processes must be maintained, 2) goals and objectives must come from an ecological understanding of the system, 3) external threats must be minimized and external benefits maximized, 4) evolutionary processes should be conserved, and 5) management must be adaptive and minimally intrusive. Harris et al. (1996) and Noss (1996) suggest a connectivity approach to protect landscapes from further fragmentation and to restore connectivity to culturally fragmented landscapes, where possible. Linking such areas may enhance landscape connectivity (e.g., organism dispersal, optimal foraging areas) and reduce the effects of fragmentation (Beier and Noss 1998, Hoctor et al. 2000, Swenson and Franklin 2000).

The ecologically important areas identified through TEAP do not represent areas that, if left undisturbed, would capture all of the remaining biodiversity in the state, nor does it give license to destroy areas that have lower TEAP scores of ecological importance. The use of TEAP would be the first step in avoidance of impacts, not the last. TEAP identifies the top 1% ecologically important areas in each ecoregion and provides information to aid streamlining agency decisions used to protect the biodiversity of Texas. When communicating with decision-makers concerning the results of TEAP, protecting (or avoiding) every square inch of an area falling in the 1% category does not necessarily protect biodiversity *per se*. It can, however, help protect places that make a significant contribution to the biodiversity of Texas.