Wetlands of Conservation Importance: An Analysis By The Upper Susquehanna Coalition

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A) Executive Summary:

The Upper Susquehanna Coalition (USC) has identified wetland areas of conservation importance within the Upper Susquehanna River Basin. USC staff scientists, along with researchers at SUNY-ESF published a full scientific report of the identification process in the Journal Wetlands. The document includes detailed verification efforts for techniques by USC identification of high quality wetland areas (Hunter et al. 2012). The current document presents an executive summary of the key information generated for the maps USC has provided to US Fish and Wildlife Service for planning purposes. These files include sensitive information, including the locations of wetlands that may support rare species occurrences. *Due to the sensitivity of these data, they are intended for internal* USFWS *use only; direct contact should be made with The Upper Susquehanna Coalition to discuss other uses for these data prior to their use.*

Our approach has two main components: 1) identify uncommon wetland types with high conservation value using geo-statistical modeling, and verification procedures and 2) rank areas according to abiotic criteria known to impact wetland quality and functioning (e.g., wetland size, distance to roads, type). Using validation measures, our approach outperforms existing methods for detection of areas suitable for mitigation, and does so for our entire focal area (>16,000 km^2). This approach identifies biologically rare communities (fens, bogs) providing the opportunity to protect wetlands with a high potential to support rare species.

In the following sections, we describe the general methods utilized for the modeling procedure, and an example priority ranking system for targeting restoration and protection of large landscapes containing rare communities with high capacity to support biodiversity. Using the procedures described below to develop this this database, we conclude the wetland areas identified to be high quality areas for wetland protection, where impacts should be minimized. Additional tools at USC's disposal allow for the identification of areas with great potential for restoring high quality wetlands.

Using statistical modeling, we identified areas likely to contain wetlands and rare wetland community types. We combined the information from validated wetland models with known wetland occurrences from National Wetlands Inventory (NWI) to create a comprehensive database of potential banks, hereafter "patches". Using this database of wetlands, we ranked patches to remotely identify priority wetland areas.

B) Model Development

We used GIS layers in the program MaxEnt (maximum-entropy modeling) to systematically identify wetland areas for conservation. We used five background environmental variables: elevation, slope, aspect, surface geology, and soil type, all scaled to 10 m^2. The program MaxEnt was chosen due to its superior prediction capabilities compared to other approaches (Elith et al. 2006). For modeling, we created a database of poorly drained areas that included randomly selected locations within examples of each of the four main wetland types present (emergent, deciduous forested, evergreen forested, and scrub-shrub). Occurrence records to model bogs were taken from acidic designations in existing National Wetlands Inventory data. Data from the New York Natural Heritage Program on the occurrence of fen locations (n=9) (NYNHP 2011) were combined with occurrence data (n=26) from previous site visitation to produce a rich fen occurrence layer for modeling.

Model output produced goodness-of-fit statistics, and we validated the model using the correct classification rate for extant wetlands. This type of remote statistical model validation is common in the peer reviewed scientific literature, and allows for more robust "Verification" than would be feasible based on field visitation alone. Model validation measures indicated that MaxEnt generally outperformed a model based on hydric soils (Hunter et al., 2012 Furthermore simple aerial photo interpretation, site visitation, and NWI comparison show that the procedure works well and identifies high priority wetlands.

Figure 1: MaxEnt identifies rare communities, a previously unknown

D) Potential Mitigation Site Ranking Procedure

For the purpose of prioritizing potential mitigation areas, we combined the model output with NWI wetland occurrences to produce a comprehensive coverage of wetland resources (patches). This approach effectively augmented NWI databases with: wetland occurrences omitted by NWI, fen and bog designations as appropriate. This approach advantageously allowed for potential high priority wetland areas to be systematically compared and ranked in terms of landscape viability using simple parameters with strong ecological underpinnings. Below we provide an overview of our default patch ranking, which favors protection of large areas with a diversity of wetland habitats (emergent, forested, scrub-shrub) and rare communities (fens and bogs).

Patches were ranked according to the following criteria: (log) patch area (*A*), predicted designation as significant natural community (*B)*, distance to nearest road (*R*), distance to nearest large remaining wetlands (*W* :NWI wetlands $\geq$ha). These criteria were chosen due to their documented influence on biodiversity and the functioning of ecological communities, particularly wetlands (MacArthur and Wilson 1963, Edinger et al. 2002, Kaushal et al. 2005, Karraker et al. 2008). Variables were divided by respective maximum values to produce indices on 0-1 scales for summation. *Fens and bogs received a *B* value of 1 (all other wetlands received 0). The following formula was used for patch ranking: $A+B+R+(1-W)/Max(A+B+R+(1-W))$.

**As modeling focused on hydrogeologic settings (unique soil conditions) fens and bogs in this scheme encompassed a variety of successional stages (from emergent to scrub shrub to forested), therefore not biasing towards a single type. Plant ecologists are increasingly expressing wetland communities in terms of source hydrology, and are less focused on the form of vegetation (forested vs. emergent) thus North American wetlands with mineral rich groundwater discharge are referred to as fens regardless of presence of a tree canopy cover (Bedford and Godwin 2003).*

E) Potential Mitigation Site Ranking Procedure Results

To test the efficacy of the patch based ranking, we calculated the average ranking for all patches, and for the ten New York Natural Heritage Program wetland occurrences falling within our focal region (NYNHP 2011). Average patch rank out of a 0 to 0.99 scale for all patches was 0.40 (± 0.14 SD), while average patch rank for heritage sites was 0.79 (± 0.13 SD), a dramatic difference (Figure 2). Nine of the ten NYNHP sites also ranked in the top 15% of sites, indicating this method possesses the ability to identify biologically important sites.

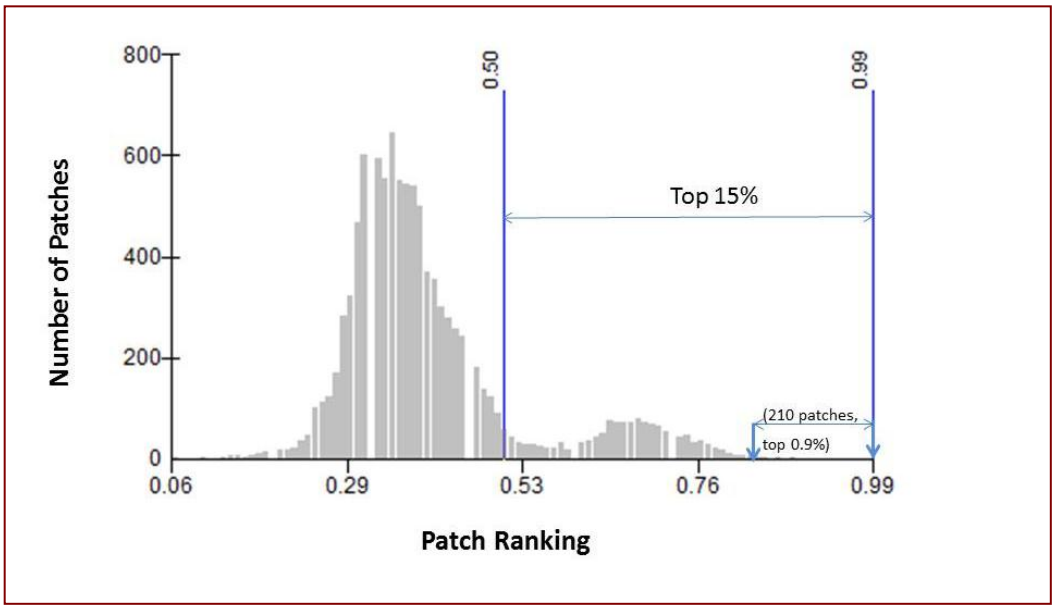

Figure 2: Histogram of patch ranks for the Upper Susquehanna River Basin (N=21,970) indicates the majority of wetlands in our focal area are small, common wetland types found near human impacts (roads are common entry points for invasive species). 85% of patches ranked lower than 0.50. Nine out of ten wetlands identified by the Natural Heritage Program as biologically significant ranked in the top 15% in our study.

A) Summary

We note that typical methods for identifying important conservation sites are far less comprehensive than those described here and commonly fail to provide a similar quantitative rigor. With the positive results of the validation measures for both our modeling procedure and the ranking system, we feel well justified in using this approach to identify priority focal areas for mitigation work.

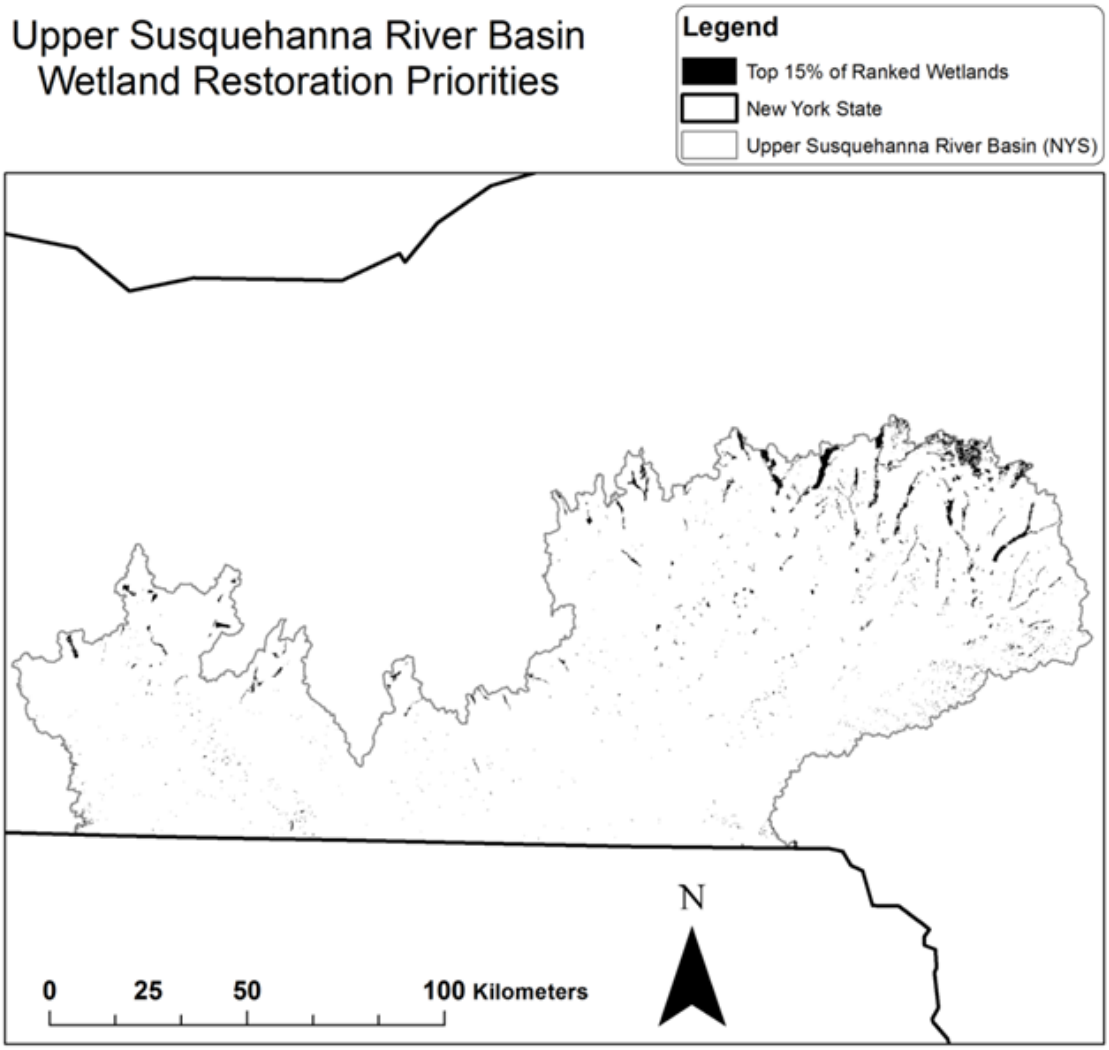

Figure 1: High Priority Wetland Areas

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