Comparison of Two Objective Protocols used to Determine the Status of North Carolina Aquatic Species

Todd Ewing, *North Carolina Wildlife Resources Commission, Division of Inland Fisheries, 1721 Mail Service Center, Raleigh, NC 27699-1721*

Abstract: A primary responsibility of wildlife resources agencies is to determine a species' conservation status. Two widely utilized protocols for status determination are those of the International Union for the Conservation of Nature (IUCN) and NatureServe. This study compares the risk categorization for 58 species of aquatic wildlife extant in North Carolina. The IUCN and NatureServe protocols produced threat rankings that were correlated with each other but very different in terms of how they classified risk. The NatureServe protocol most often placed a species as being in a higher threat category than did the IUCN protocol. Differences mainly appeared to be due to how the protocols treat species with restricted geographic range. Resource managers should be aware of the relative performances and reasons for discrepancies of these two protocols when determining conservation status for a species.

Key words: Conservation status, IUCN, NatureServe

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 66:64–68

A primary responsibility of wildlife resource agencies is the determination of a species' conservation status. Wildlife agencies need to accurately determine a species' conservation status both for legal reasons, such as establishing protected species lists, and practical reasons, such as deciding which species to dedicate limited resources. Ideally, a species' status should reflect that species' probability of extinction or extirpation. The probability of extinction of a species can be estimated by procedures such as population viability analysis (PVA; Bessinger and McCullough 2002, Morris and Doak 2002). However, PVAs are data-intensive, needing population estimates for multiple years and for multiple populations and often requiring estimates of various demographic perimeters (Morris and Doak 2002). These data are not readily available for most species and require dedicated funding and extended periods of time to collect. Therefore, alternative, less-intensive protocols have been developed to determine a species' conservation status that can be used in lieu of a PVA.

Alternative protocols can be subjective (i.e., expert opinion) or objective (i.e., ranking criteria). The North Carolina Wildlife Resources Commission (NCWRC) currently utilizes expert opinion to determine a species' status in North Carolina. A scientific council of expert biologists is assigned for each taxonomic group for which the NCWRC has management authority (mammals, amphibians and reptiles, birds, mollusks, aquatic crustaceans, and fish). The council is responsible for reviewing existing data for each species within the taxonomic group and a designation for each species is determined by consensus. However, subjective evaluations of extinction risk can lead to determinations that are biased towards overestimating extinction risk (McCarthy et al. 2004). Such overestimates of a species' risks may result in wasting limited resources on a species that are not actually imperiled. Additionally, if a species' designated status as determined by subjective means differs from those of more objective protocols, political and public confidence in the status determinations can be undermined.

Many objective protocols for determining conservation status have been developed (e.g., Sparrowe and Wight 1975, Menhinick 1987, Millsap et al. 1990, Townsend et al. 2007), but the two most widely used and accepted are those of the International Union for the Conservation of Nature (IUCN; Mace and Lande 1991, Mace et al. 2008, IUCN 2011), and NatureServe (Master 1991, Master et al. 2009). The IUCN protocol is rule-based, where a species is assigned to one of five threat categories (Table 1) based on meeting the threshold of at least one of five criteria (Mace et al. 2008). These five criteria are: 1) declining population (past, present and/or projected), 2) geographic range size, and fragmentation, decline or fluctuations, 3) small population size and fragmentation, decline, or fluctuations, 4) very small population or very restricted distribution, and 5) quantitative analysis of extinction risk such as a PVA (IUCN 2011). The NatureServe system is a points-based

Table 1. IUCN and NatureServe categories and their rankings. NatureServe categories can also include intermediate rankings (i.e., G1G2) to represent uncertainty in a species' status. Ranks for intermediate categories are the median of the two included ranks.

IUCN categories	NatureServe categories	Rank	Priority
CR – critically endangered	G1 – critically imperiled	1	High
EN – endangered	G2 – imperiled	2	High
VU – vulnerable	G3 – vulnerable	3	High
NT – near threatened	G4 – apparently secure	4	Low
LC – least concern	G5 – secure	5	Low

system where one of five threat categories (Table 1) is determined for a species by assessing multiple factors and determining a final score based on the scores from each factor (Master et al. 2009). The factors considered by NatureServe are broadly grouped into rarity, trends, and threats. In calculating the final conservation score, the three factors are weighted such that rarity factors are given a weighting of 50%, trends are weighted 30%, and threats are weighted 20% (Master et al. 2009). The NatureServe protocol can be used to determine a species status a state or regional level (S-scores) or at a global level (G-scores; Master et al. 2009). One unique aspect of the NatureServe protocol is that it allows for uncertainty in assigning a species to a threat category; thus, a species can be placed in two or more threat categories (e.g., G1G2; Master et al. 2009).

Keith et al. (2004) concluded that both the IUCN and NatureServe protocols could be useful for forecasting extinction. However, several studies on different taxa groups have found that these two systems can give widely differing results. O'Grady et al. (2004) found a weak positive rank correlation between the IUCN and NatureServe protocols for 55 taxa, mostly birds and mammals. Differences were apparent in all threat categories but were most evident in the intermediate categories. Similarly, Mehlman et al. (2004), examining the status of 710 North American bird species with the IUCN and NatureServe protocols, found that the IUCN and NatureServe protocols showed differences in all categories but especially in the intermediate categories. In a recent study of 409 North American mammal species, Goodenough (2012) noted positive but weak relationship between the IUCN and NatureServe protocols, and that differences were apparent at all levels of classification.

Recently, both fish and mollusk scientific councils appointed by the NCWRC expressed the need for development of a more quantitative and objective process for determining species status in North Carolina (Harris et al. 2011, Savidge et al. 2011). The NCWRC is evaluating the merits of utilizing a more objective process for determining the status of aquatic species for which it has management authority: aquatic mollusks, fish, and aquatic crustaceans. As an initial step in this process, a comparison of existing protocols is needed. If existing protocols produce similar results, then there is can be a high level of confidence that both protocols accurately reflect a species' conservation status. It is readily apparent that the IUCN and NatureServe classification protocols produce only moderately concordant status determinations for mammals, birds, reptiles, and amphibians. However, there has been little comparison of these two systems for classifying fish and mollusks and none for crayfish. The purpose of this study is to compare how the IUCN and NatureServe protocols classify the extinction risk of fishes, mussels, and crayfish species found in freshwater habitats of North Carolina and evaluate the relative threat ranking of the two protocols for these taxa groups.

Methods

Risk categories for 58 aquatic species (27 freshwater mussels, 17 crayfish, and 14 fish) were obtained from IUCN (www.iucnredlist.org) and NatureServe (www.naturserve.org) on 12 March 2012. Only 58 species were used because the IUCN has produced rankings for relatively few of the aquatic species native to North Carolina. These 58 species represent the majority of which the IUCN has ranked. Data were ranked so that 1 = most threatened and 5 = least threatened (Table 1). Some species classified by NatureServe had dual scores (e.g., G1G2; definitions for NatureServe G-scores and IUCN classifications are given in Table 1), indicating uncertainty in the true status of the species, which were assigned the median rank of the coded values (e.g., G1G2 = 1.5). Species assigned a classification of CR, EN, or VU by IUCN were considered to be a species in most need of conservation actions and given a categorical description of "high priority" and species classified as NT and LC were considered "low priority." Similarly, species classified as G1, G2, or G3 by NatureServe were considered "high priority," and those assigned a G4 or G5 rank by NatureServe were considered "low priority" (Table 1). For this study, G3G4 species were considered "low priority." NatureServe S-scores were not utilized in this study because the IUCN does not publish evaluations of species for the state level.

To calculate a measure of correspondence between the two systems, correlations between the risk categories assigned by IUCN and NatureServe were calculated using Spearman's rank correlation analysis corrected for ties (r_s) on the entire dataset and also for three subsets of the data (fish, mussels, and crayfish) individually. To compare how each system classified a species in terms of high or low priority, the Cramer correlation coefficient for dichotomous, nominal-scale data (Φ_2) was used. To determine if the two protocols rank species differently, the median rank for each protocol was calculated and compared for each taxa group separately and all taxa combined using univariate, multi-response permutation procedures (MRPP) for paired data (Mielke and Berry 2001). The MRPP were performed using the Blossom statistical package (Cade and Richards 2005) utilizing ordinary Euclidian distance. All other statistical tests were made using GB-Stat version 9.0. A $P < 0.05$ was used to determine statistical significance.

Absolute mismatches in the risk status were calculated and defined as the difference between the rank statuses as determined by the IUCN versus the NatureServe protocol. A relative mismatch was noted when one protocol determines a species is high priority and the other protocol determines a species is low priority. Species with absolute of mismatches of two or more were examined to determine what factors lead to the discrepancy in categorization.

Results

Rank correlation between the two systems for all taxa indicated moderate correspondence (r_s = 0.74, df = 58, P < 0.0001; Figure 1). Rank correlations for crayfish (r_s = 0.57, df = 15, P = 0.017), fish (r_s = 0.66, df = 12, P = 0.011) and mussels (r_s = 0.79, df = 25, P < 0.0001) were also moderately concordant. There was also a positive correlation between the two protocols in classifying a species as high or low priority (Φ_2 = 0.42, χ^2 = 10.11, df = 1, P = 0.0015; Table 2).

Thirty-nine of 58 species had absolute mismatches. Seven of these absolute mismatches were by only half of a rank and could be attributed to the fact that NatureServe allows for uncertainty in the ranking. Seventeen of the absolute mismatches were from 1 to 1.5 ranks and 15 of the absolute mismatches were from two ranks or more. Of these 39 absolute mismatches, the NatureServe protocol ranked 37 in a higher risk category than IUCN. The NatureServe protocol also classified species as high priority more often than did IUCN. In terms of relative mismatches, NatureServe classified 36 of 58 species as high priority whereas only 20 out of 58 were classified as high priority by IUCN (Table 2). The median rank assigned by NatureServe was significantly lower (more threatened) than that assigned by IUCN for all taxa combined (P < 0.001), crayfish (P < 0.001), fish (P = 0.012), and mussels (P < 0.001; Figure 2).

Discussion

There was a correlation between how IUCN and NatureServe protocols rank taxa, which indicated that the two systems produced somewhat similar results for freshwater species in North Carolina. The rank correlations reported here were similar to that reported by O'Grady et al. (2004) for 55 species of mostly mammals and birds (r_s = 0.69), but greater than that reported by Goodenough (2012) for 409 species of North American mammals (r_s = 0.50). Despite this correlation, the two protocols often produced risk rankings that were very different from each other. Over half of the species were mismatched by at least one full rank. In addition, there was considerable difference between the protocols on whether a species was classified as high or low priority. Only about half of the species classified as high risk by NatureServe were similarly classified as high risk by IUCN. The results of the present study were similar to those found by previous studies of various taxa (Mehlman et al. 2004, O'Grady et al. 2004, and Goodenough 2012). Assessments using IUCN and NatureServe protocols can produce correlated but very different results, and this is consistent across a wide variety of taxa.

Table 2. Contingency table comparing numbers of species categorized as high priority or low priority by the IUCN and NatureServe protocols. See Table 1 for which categories are considered high and low priority.

	NatureServe priority	
	High	Low
IUCN Priority		
High	18	2
Low	18	20

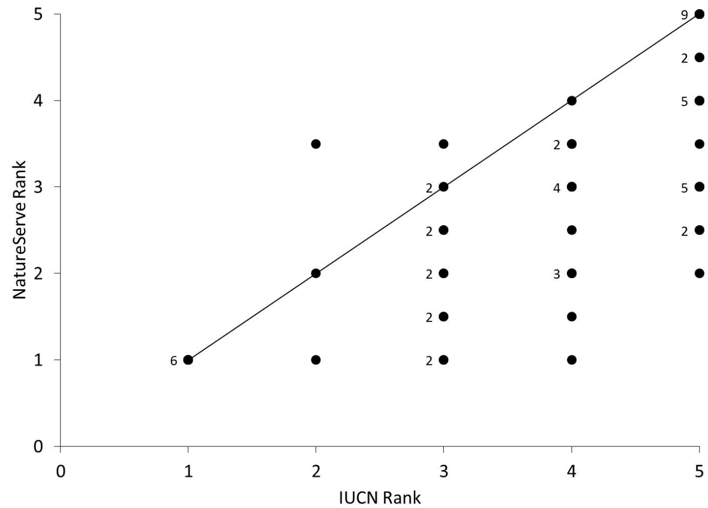

Figure 1. Relationships among the assessments of the 58 aquatic taxa using the NatureServe and IUCN protocols. Numbers beside the points refer to the number of data points lying on top of each other. Line represents a 1-to-1 relationship.

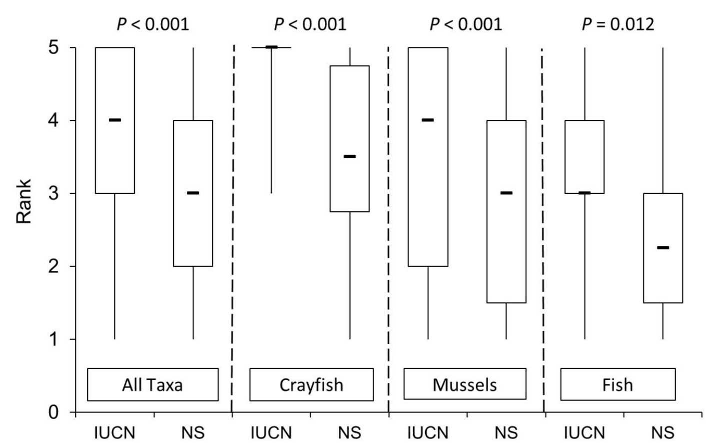

Figure 2. Box and whisker plot showing the distribution of ranks for all taxa combined, crayfish, mussels, and fish as determined by the IUCN and NatureServe (NS) protocols. The whiskers cover the 5% and 95% percentiles, the boxes cover the 25% and 75% and the dash represents the median. Significance values as determined by MRPP.

Goodenough (2012) noted that NatureServe tends to be more precautionary than IUCN in how it ranks a species' risk of extinction. The same was true for this study as well. NatureServe tended to rank species in higher risk categories as well as categorizing more species as high priority. Crayfish, mussels, and fish were all classified as more threatened with the NatureServe protocol than with IUCN. Crayfish had the greatest rank differences between protocols, with a median rank difference of 1.5 compared to 0.75 for fish and 1.0 for mussels. It appears that the differences are due mainly to how the NatureServe protocol weights geographic range. Ten of the 15 absolute mismatches of two or greater ranks in this study were in species with limited geographic distribution but stable populations. In the NatureServe protocol, extent of occurrence and area of occupancy, two measures of geographic range extent, are more highly weighted than population trend so they therefore have more influence on a species final score (Faber-Langendoen et al. 2009). In the IUCN protocol, for a species with limited geographic distribution to be considered at risk it must also be experiencing population decline or severe fluctuations or be severely fragmented (IUCN 2011). Other factors not inherent in the way protocols calculate extinction risk can lead to species having differing threat rankings. In this study, two of the IUCN assessments were more than 15 years old and may have used different data than the more current NatureServe assessments. Regan et al. (2005) found large variation in species' classifications as determined by different assessors, even when utilizing identical information, so it is to be expected that some differences exist even if the two systems were to have been more structurally similar.

Ideally, risk assessment protocols should lead to similar conclusions based on a predicted level of extinction probability. When two widely-accepted protocols, such as the ones examined in this study, differ on the status of a species it can lead to confusion among the public as well as policy makers and erode confidence in species listings and conservation actions based on these listings (O'Grady et al. 2004). While it would be ideal for resource managers to conduct a PVA on all species to determine their extinction risks, this approach is unrealistic given the data needs required for this technique and the limited resources available. Determining relative merits between these two protocols is difficult and beyond the scope of this study. However, De Grammont and Cuarón (2006) evaluated 25 different threatened species categorization systems and determined that the IUCN protocol had the most desirable characteristics for assessing extinction risk of species, followed by NatureServe. O'Grady et al. (2004) determined that IUCN rankings were more strongly correlated with a species' probability of extinction in 100 years than NatureServe rankings; however, neither protocol was strongly correlated to extinction risk. In contrast, Andelman et al. (2004) reviewed nine different protocols and determined that the NatureServe protocol was best for selecting at risk species by the U.S. Forest Service.

The preference of using one protocol over another may depend on how an agency chooses to characterize extinction risk. Geographic range as a measure of rarity was weighted in the NatureServe protocol such that species with a small geographic range were typically considered to have a high extinction risk, even if the species exhibited a stable or increasing population abundance trend. However, for a species with limited geographic range to be considered at risk by IUCN, it must also have experienced a population decline or severe fluctuations or been severely fragmented. This latter approach is recommended by Flather and Sieg (2007) who note that a species may qualify as rare but not be considered at risk of extinction. Flather and Sieg (2007) recommend incorporating knowledge of population dynamics and not just consider restricted range when determining the conservation need of a species. This approach is utilized in New Zealand for classifying risk categories of species (Townsend et al. 2007) where a species can be considered "at risk" due to just limited range but not be considered "threatened." Thus, choice of objective protocols for assessing extinction risk varies among resource agencies and biologists, and is likely dependent upon personal choice to some degree. Resource managers who utilize either of these protocols should be aware of the differences in how protocols rank extinction risk and chose the one that best suits their management goals. These characteristics of the IUCN and NatureServe protocols will be considered by the NCWRC as an objective protocol is being developed for determining the status of aquatic species in North Carolina.

Acknowledgments

This paper was improved by the suggestions and comments of Shannon Deaton, David Yow, Steve Sammons, and three anonymous reviewers.

Literature Cited

Andelman, S. J., C. Groves, and H. M. Regan. 2004. A review of protocols for selecting species at risk in the context of U.S. Forest Service viability assessments. Acta Oecologia 26:75–83.

Bessinger, S. R. and D. R. McCullough, editors. 2002. Population viability analysis. University of Chicago Press, Chicago, Illinois.

Cade, B. S. and J. D. Richards. 2005. User manual for Blossom statistical software. U.S. Geological Survey Open File Report 2005–1353.

de Grammont, P. C. and A. D. Cuarón. 2006. An evaluation of threatened species categorization systems used on the American continent. Conservation Biology 20:14–17.

Faber-Langendoen, D. L., et al. 2009. NatureServe conservation status assessment: methods for assigning ranks. NatureServe, Arlington, Virginia.

Flather, C. H. and C. H. Sieg. 2007. Species rarity: definition, causes, and classification. Pages 40–66 *in* M. G. Raphael and R. Molina, editors. Conservation of rare or little-known species: biological, social, and economic considerations. Island Press, Washington, D.C.

Goodenough, A. E. 2012. Differences in two species-at-risk classification schemes for North American mammals. Journal for Nature Conservation 20:117–124.

Harris, F., et al. 2011 Reevaluation of status listings for jeopardized freshwater fishes in North Carolina. Report to the Nongame Wildlife Advisory Committee of the North Carolina Wildlife Resources Commission.

International Union for the Conservation of Nature (IUCN). 2011. Guidelines for using the IUCN Red List categories and criteria Version 9.0.

Keith, A. K., et al. 2004. Protocols for listing threatened species can forecast extinction. Ecology Letters 7:1101–1108.

Mace, G. M. and R. Lande. 1991. Assessing extinction threats: toward a reevaluation of IUCN threatened species categories. Conservation Biology 5:148–157.

_____, et al. 2008. Quantification of extinction risk: IUCN's system for classifying threatened species. Conservation Biology 22:1424–1442.

Master, L. L. 1991. Assessing threats and setting priorities for conservation. Conservation Biology 5:559–563.

_____, et al. 2009. NatureServe conservation status assessments: Factors for assessing extinction risk. NatureServe, Arlington, Virginia.

McCarthy, M. A., et al. 2004. Comparing predictions of extinction risk using models and subjective judgment. Acta Oecologia 26:67–74.

Mehlman, D. W., K. V. Rosenberg, J. V. Wells, and B. Robertson. 2004. A comparison of North American avian conservation priority ranking systems. Biological Conservation 120:383–390.

Menhinick, E. F. 1987. A numerical method for ranking of endangered species and its application to North Carolina freshwater fishes. Journal of the Elisha Mitchell Scientific Society 102:54–86.

Mielke, P. W., Jr. and K. J. Berry. 2001. Permutation methods: a distance function approach. Springer-Verlag, New York, New York.

Millsap, B. A., J. A. Gore, D. E. Runde, and S. I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildlife Monographs 111:1–57.

Morris, W. F. and D. F. Doak. 2002. Quantitative Conservation Biology: Theory and Practice of Population Viability Analysis. Sinauer Associates, Sunderland, Massachusetts.

O'Grady, J. J., et al. 2004. Correlations among extinction risks assessed by different systems of threatened species categorization. Conservation Biology 18:1624–1635.

Regan, T. J., et al. 2005. The consistency of extinction risk classification protocols. Conservation Biology19:1969–1977.

Savidge, T., et al. 2011. 2011 reevaluation of status listings for jeopardized freshwater and terrestrial mollusks in North Carolina. Report to the Nongame Wildlife Advisory Committee of the North Carolina Wildlife Resources Commission.

Sparrowe, R. D. and H. M. Wight. 1975. Setting priorities for the endangered species program. Transactions of the North American Wildlife and Natural Resources Conference 40:142–156.

Townsend, A. J., P. J. de Lange, C. A. J. Duffy, C. M. Miskelly, J. Molloy, and D. A. Norton. 2007. New Zealand threat classification system manual. New Zealand Department of Conservation, Wellington.