

Northeast Regional Floristic Quality Assessment Final Report

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Coefficients of conservatism for the vascular flora of New York and New England: inter-state comparisons and expert opinion bias

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Abstract

The Floristic Quality Index is a widely used method for ecological condition assessments in the United States. The foundation of the index is the conservatism concept, which estimates a species' ecological sensitivity or propensity to occur in areas least-altered by humans. Plant species are assigned coefficients of conservatism (CoC) where ruderal and exotic species receive the lowest scores, competitors and matrix species intermediate scores, and remnant-dependent species the highest scores. The method has spread to over half of the United States, but New York and New England still lack CoC coverage. With funding from the Environmental Protection Agency and using nine of the region's most experienced botanists, an effort was undertaken to select CoC for the complete vascular flora of each New England state and New York State. Frequency distributions and rank correlations of CoC varied widely among states, except that each flora contained a large proportion of exotic species. Few taxa were scored with low confidence, although CoC at the extreme ends of the scale tended to be scored with higher confidence than more intermediate CoC. Differences in mean CoC and other summary measures for two botanists working independently on the same state indicate estimator bias in the ranking process, and calls for additional expert opinions, more careful instruction and calibration of botanists, or the use of panel discussions and objective scoring methods.

Introduction

Human activities cause measurable and often predictable shifts in patterns of vegetation (Hobbs 1997, Tilman 1999, U.S. EPA 2002), and floristic quality indices have emerged as a means of quantifying those patterns. Floristic quality assessment (Swink and Wilhelm 1994, Taft et al. 1997) is a widely used method for ecological condition assessments in the United States. This species-weighted approach can help to evaluate restoration and mitigation success, prioritize sites of conservation interest, and identify high quality natural areas (Herman et al. 1997, Taft et al. 2006). It can help to define the least-altered conditions needed for restoration projects (Allison 2002, Bowles and Jones 2006, Cretini et al. 2011, Jog et al. 2006, Poling et al. 2003), and provides an alternative to relying on high species richness or presence of rare species to value areas for protection. Floristic quality assessment is not intended as a stand-alone indicator but rather should be used in conjunction with other ecological metrics (e.g., Hargiss et al. 2008, Mack 2007).

The foundation of floristic quality assessment is the conservatism concept (Wilhelm 1977). Conservatism is an estimate of a species' ecological sensitivity or propensity to occur in least-altered conditions. The concept is loosely allied with the competition-stress-disturbance model of plant ecology (Grime 1974), and therefore derives from colonization and survival strategies and adaptation to post-disturbance successional stages (Bowles and Jones 2006, Taft et al. 1997). Species with high conservatism values are sensitive to anthropogenic stress and therefore restricted to minimally altered natural areas ("remnant-dependent"), whereas species with lower values are more likely to persist in or readily invade degraded areas (Spyreas and Matthews 2006). Botanists assign coefficients of conservatism (CoC) where ruderal and exotic species receive the lowest scores (integers 0 to 3), competitors and matrix species intermediate scores (4 to 6), and remnant-dependent species the highest scores (7 to 10) (Andreas and Lichvar 1995). For an area of interest, average conservatism of the complete or representative species assemblage is used as an estimate of the area's floristic quality (Bried and Edinger 2009, Cohen et al. 2004, Ervin et al. 2006, Lopez and Fennessy 2002, Matthews 2003, Miller and Wardrop 2006, Nichols et al. 2006).

Plant species are assigned CoC relative to other species in the local flora (Taft et al. 1997, Wilhelm and Ladd 1988). Stratifying the assignment by ecologically meaningful units (ecoregion, habitat type, etc.) may reduce estimator bias and improve accuracy (Bourdagh's et al. 2006, Cohen et al. 2004, Milburn et al. 2007), but traditionally the CoC have been assigned at the scale of an entire state. State-based rankings at least recognize that, due to varying ecological tolerance across the species' range, score validity declines as distance from the origin of assignment increases (Bourdagh's et al. 2006, Herman et al. 2006, Rothrock and Homoya 2005). Originally developed in the late 1970s to help assess prairies and open, undeveloped lands in the Lower Lake Michigan region (Wilhelm 1977, Swink and Wilhelm 1979), the coverage has spread to over half of the United States (Medley and Scozzafava 2009). With the recent development of full or partial CoC lists for Delaware, New Jersey, and Pennsylvania, the idea has caught on in the Mid-Atlantic and Northeast. There remains, however, a lack of CoC coverage across New York and New England; recent floristic quality estimates of a rare New York wetland type relied on New Jersey and Pennsylvania coefficients (Bried and Edinger 2009).

In light of this gap, and the growing interest in using floristic quality assessment across the region, an effort was undertaken to assign CoC to the complete vascular flora of New York and New England. This paper documents the project method and explores major patterns in the aggregate CoC data, testing for differences in central tendency, variation, and distributional shapes among states and between botanists. It follows closely a presentation delivered at the 2011 Northeast Natural History Conference in Albany, New York.

Methods

At its March 2007 meeting, the New England Biological Assessment of Wetlands Workgroup (NEBAWWG) designated the development of a regional Floristic Quality Assessment as a priority project. This group, composed of state, federal, and academic wetland managers and scientists, has been testing wetland assessment techniques in the Northeast since its inception in 1998. The New England Interstate Water Pollution Control Commission (NEIWPC), which has supported the Workgroup by coordinating meetings and workshops on wetland assessment and seeking additional funds for specialized regional projects, took charge of planning, implementation, and oversight. Although the project was facilitated by wetland-focused organizations and funded by the Environmental Protection Agency's wetlands division, the final product is applicable to any non-crop, non-horticultural plant communities of New York and New England.

A technical advisory committee of state, federal, and academic participants was formed to assist with the project. The committee released a request for qualifications seeking botanists to assign CoC to upland, wetland, and coastal vascular plant species of the New England states and New York State. Proposals were reviewed and scored by the committee based on technical merit, performance capability, budget, and timeline. Following this review, NEIWPC partnered with nine of the region's most experienced botanists, including Don Schall (Connecticut), Matt Arsenault and Sue Gawler (Maine), Ted Elliman (Massachusetts), Dan Sperduto (New Hampshire), Dave Werier and Steve Young (New York), Rick Enser (Rhode Island), and Art Gilman (Vermont). Each botanist was responsible for their state of expertise.

An introductory meeting was held to provide background on floristic quality assessment concepts, set forth instructions and timelines, and distribute preliminary lists of vascular plant species for each state. Preliminary lists were extracted from the PLANTS database (<http://plants.usda.gov/java/>) and later refined by the botanists using best available sources, such as the New York Flora Atlas (Weldy and Werier 2011). Botanists were asked to assign CoC according to the basic criteria in Table 1 and to think about the statewide "average behavior" or ecological tolerance of each species. For purposes of floristic quality assessment, ecological tolerance is considered against disturbances and stressors occurring outside of the environmental variation to which the species is evolutionarily adapted. A species that needs periodic or annual disturbance (e.g., fire) may still be highly conservative (see Taft et al. 1997 for a detailed exposition of these concepts). Botanists were asked to select CoC using primarily their field experience and literature knowledge and without consulting other botanists. For each CoC, they assigned a personal confidence rating from 1 (low) to 5 (high).

A follow-up meeting provided botanists the opportunity to discuss any concerns about the protocol and specific species, and share their CoC lists. Botanists then had the opportunity to refine their scores and reconcile any major differences of opinion (for states with two assigners) before submitting final lists.

Analysis

We graphed frequency distributions and cumulative percent distributions for the CoC and confidence ranks. Additionally, we compiled statistics of central tendency (mean, median), dispersion (standard deviation, interquartile range), and shape (skewness, kurtosis) for the CoC distributions of each state. Spearman's rank correlation was used to evaluate associations of CoC assigned to taxa commonly scored in all states. This was done for all taxa ($n = 440$, exotics included) and for taxa ranked with confidence of 4 ($n = 216$); no taxa commonly scored by all botanists received a confidence rank of 5. To assess initial estimator bias, a Monte Carlo test was used to compare means, standard deviations, skewness, and kurtosis ($n =$ number of native taxa) between the two botanists for Maine and New York. This analysis was performed on the independent initial scorings by each botanist and not after they discussed their results. Conservatism coefficients were shuffled between botanists and within rows (i.e., within taxa) 1,000 times using Resampling Stats v4.0 (written by S. Blank, ©2010, Resampling Stats Inc., Arlington, VA). The difference between statistics was recomputed over randomizations, with significance approximated by how many pseudo-differences equaled or exceeded the original. We repeated the test using all native taxa and only the native taxa ranked with full confidence (score = 5) by both botanists, under an expectation that estimator bias would decrease with increasing confidence.

Results

A cumulative total of 4,511 vascular plant taxa (1,437 non-native with ~1.5% considered introduced to some states but not others) were scored during this project and are available online at <http://www.neiwpcc.org/wetlands/nebawwg.asp>. The total number of taxa scored by each state ranged from 1,556 to 2,611. Distributions of conservatism rankings varied among states but each had a mode CoC = 0 (Fig. 1), indicating many exotic species. Based on the graphs (Fig. 1) and summary statistics (Table 2), the Connecticut, Massachusetts, and Vermont distributions appeared flatter (less peaked) and less skewed than the New Hampshire and Rhode Island distributions. Differences revealed by the distributional shapes were more dramatic than revealed by the central tendency and variation measures (Table 2). Few taxa were scored with low confidence (Fig. 2), although CoC at the extreme ends of the scale tended to be scored with higher confidence than more intermediate CoC. Rank correlations among all pair combinations of states and botanists ranged from 0.41 to 0.70 using total taxa and from 0.37 to 0.74 using only the confidently ranked taxa (Table 3).

The aggregate CoC also differed between botanists, depending on the statistic under consideration. Kurtosis distinctions were clear in each of four comparisons, whereas means and skewness differed in two comparisons (Table 4). The two botanists for New York differed by each metric using all taxa but only in terms of distributional shape for the confidently ranked taxa. Contrary to expectations, there was evidence of clear ($P < 0.001$) or marginal ($0.01 < P <$

0.05) overall differences between the Maine botanists using confidently ranked taxa, but not according to means or skewness of all taxa. For both Maine and New York, the proportion of species receiving the same score increased and the difference between botanists decreased when using only the confidently ranked taxa instead of all taxa (Fig. 3, Fig. 4). Also for both states, a zero difference was found more frequently at the extremes of the conservatism scale (1-2 and 9-10) than at intermediate levels.

Discussion

Distributions of CoC for the New England states and New York State evoked the irregular distributions for Michigan (Herman et al. 1997) more than the gradual step patterns documented elsewhere (Bowers and Boutin 2008, Herman et al. 2006, Milburn et al. 2007). Several previous CoC lists (Herman et al. 1997, Oldham et al. 1995, Rothrock and Homoya 2005) contained high percentages of species perceived as having high degrees of fidelity to a narrow range of synecological parameters (i.e., CoC = 9 or 10); in contrast, relatively few species were perceived that way for New York and New England. This suggests increasing degradation of natural areas throughout the region, or simply reflects inherent biases in botanist' experience or CoC interpretation (discussed further below).

The wide variation in CoC frequency distributions among states underscores the need to update any prior New York and New England assessments that used CoC from neighbor states (i.e., Bried and Edinger 2009). Clear distinction in distributional shapes also suggests that a floristic quality assessment in one state will have a different meaning from the assessment in another state. Consequently, caution is suggested when comparing floristic quality estimates from different states. This was additionally supported by the variable rank correlations of CoC among states. Our findings further imply that state lists should not be combined into composite CoC for the region. These recommendations make intuitive ecological sense. For example, species may be at their edge of range in one state but centered or widespread in another (Bourdaghs et al. 2006), leading to divergent thinking on CoC. Edge-of-range species for a given state could receive a higher CoC even though the species is not actually conservative at the scale of its entire range; the converse scenario may also be true. This may explain the weaker rank correlations among states located farther apart in the region. Because of this ambiguity, we recommend that botanists designate CoC based primarily on ecological tolerance (or sensitivity) and propensity to occur in human-disturbed habitats (or least-altered conditions) rather than on geographic or habitat ranges.

Although the contemporary Northeast has a high proportion of exotic species in its flora, floristic quality assessment usually is applied to local plant assemblages that tend to have proportionately few exotic species. Exotic species rarely have substantial effect on the floristic quality estimate, especially in species-rich communities, which helps explain why these indices often yield the same conclusions when calculated with and without exotic species (Bourdaghs et al. 2006, Cohen et al. 2004, DeBerry 2006, Taft et al. 1997). Nevertheless, it seems prudent to include exotic species in attempts to assess the floristic quality or "naturalness" of an area, and sometimes just one exotic species can have disastrous effects on ecosystem pattern and function (Ervin et al. 2006, Francis et al. 2000).

Studies of floristic conservatism have cautioned that disparity in botanist opinions may ultimately affect interpretations of floristic quality (Bourdagh et al. 2006, Cohen et al. 2004, Landi and Chiarucci 2010). Although differences of opinion may exist at the species level, floristic quality assessment is based on relative aggregate conservatism. We found mixed evidence for aggregate differences between two botanists working in Maine and New York. Similar to our findings, Landi and Chiarucci (2010) reported significant variation among independently assigned CoC, along with weaker agreement between botanists for species with intermediate scores. However, expert-derived versus data-generated CoC were similar in a study of prairie pothole complexes in North Dakota (Mushet et al. 2002). While the CoC are established based on subjective expert opinion, application of the CoC for individual site evaluations is carried out objectively (Andreas et al. 2004, Herman et al. 1997). Despite the subjectivity in assigning CoC, floristic quality assessment has repeatedly shown an inverse correlation across a gradient of increasing habitat degradation (Cohen et al. 2004, Ervin et al. 2006, Lopez and Fennessy 2002, Miller and Wardrop 2006).

Similar efforts in other parts of the country have placed more species at ruderal or conservative ends of the CoC scale than at intermediate levels (Cohen et al. 2004, Herman et al. 2006). In the current study, there was tendency to assign extreme rankings (1-2 and 9-10) with greater confidence, suggesting that the most tolerant and sensitive species are easier to assess and have relatively stable ecological behavior (Rothrock and Homoya 2005). However, the low percentage of CoC = 1 in this project may reflect uncertainty about the scoring concepts rather than a perception that native species occur infrequently outside of intact natural areas. The alternating step pattern for Rhode Island clearly suggests a preference for assigning certain ranks over others, which is not surprising given that two or three ranks may have the same definition (Table 1). Emphasis on *categories* along the scale rather than integer values may be a prudent approach for applying index calculations (see, for example, Taft et al. 2006).

The confusion over scoring criteria and the inherent bias of expert opinion call for clear instruction and careful calibration of the mental process, such as found in the Colorado project (Rocchio 2007). Panel discussions (e.g., Andreas et al. 2004, Mushet et al. 2002, Taft et al. 1997) may help to mitigate the potential for “conceptual drift” of fully independent CoC assignment, but sometimes dominant personalities can override the discussion. Objective methods or data-derived CoC should therefore be considered. Mushet et al. (2002) divided a large sample of prairie pothole wetlands into five habitat quality categories and selected CoC based on species occurrence and exclusivity to each category. Kutcher (2011) presented a similar idea but incorporated a more rigorous analysis of species’ fidelity and specificity. Rocchio (2007) used species occurrence rates along a human disturbance gradient to measure the accuracy of expert-derived CoC. Subjectivity bias may be tempered during index calculations by combining expert-derived CoC with relative frequency, dominance, or other quantitative species information (e.g., Tu et al. 2009).

A preliminary list of CoC is now available for the vascular plants known from each New England state and New York State (<http://www.neiwpcc.org/wetlands/nebawwg.asp>). We say “preliminary” in part because this project used only one or two botanists per state whereas similar efforts have used a core team of 4–10 botanists to cover a single state (Bernthal 2003, Herman et al. 1997, Milburn et al. 2007). We encourage further discussion and refinement of the

lists over time using additional expert opinions or objective scoring methods. Furthermore, the NEIWPC will be working with NEBAWWG to evaluate this tool for monitoring and assessment of wetland condition in the Northeast. Potential topics of discussion and future research include: (1) Which metric shows the strongest relationship to anthropogenic disturbance (mean CoC, mean CoC weighted by species richness, etc) and how does this metric perform relative to other biological condition indicators? (2) How does the sampling approach (e.g., habitat stratification, area sampled, time of sampling) affect floristic quality estimates? (3) Does the method perform similarly among different community types? These questions have been explored in other regions (Bourdagh et al. 2006, Cohen et al. 2004, Ervin et al. 2006, Johnston et al. 2009, Matthews et al. 2005, Miller and Wardrop 2006, Nichols et al. 2006, Taft et al. 2006) and should be addressed for the Northeast. In the meantime, the Northeast has the basic ingredient to facilitate floristic quality assessment, a potentially valuable tool for restoration monitoring, site prioritization efforts, and identification of high quality natural areas.

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Table 1. Guiding definitions for coefficients of conservatism (CoC) assigned to the vascular flora of New York and New England.

CoC	Criteria
0	Non-native with wide range of ecological tolerances. Often these are opportunistic of intact undisturbed habitats.
1 to 2	Native invasive or widespread native that is not typical of (or only marginally typical of) a particular plant community; tolerant of anthropogenic disturbance.
3 to 5	Native with an intermediate range of ecological tolerances and may typify a stable native community, but may also persist under some anthropogenic disturbance.
6 to 8	Native with a narrow range of ecological tolerances and typically associated with a stable community.
9 to 10	Native with a narrow range of ecological tolerances, high fidelity to particular habitat conditions, and sensitive to anthropogenic disturbance.

Table 2. Summary statistics for the distributions in Fig. 1, excluding non-native species (SD = standard deviation, IQR = interquartile range).

State	Mean	Median	SD	IQR	Skewness	Kurtosis
CT	6.60	7	2.36	4	-0.323	-0.940
MA	5.45	5	2.38	4	0.143	-0.956
NH	4.85	5	2.01	3	0.340	-0.787
RI	5.17	5	2.09	4	0.500	-0.741
VT	6.09	6	2.21	4	-0.186	-0.951

Table 3. Spearman's rank correlations of conservatism coefficients using the commonly scored total taxa, including exotics, among the seven states and nine botanists ('NY1' and 'NY2' denote New York botanists one and two, likewise for Maine). Values in parentheses are the rank correlations for the confidently ranked taxa (rank of 4, no taxa commonly scored by all nine botanists received a confidence rank of 5).

	NH	CT	MA	RI	VT	NY1	NY2	ME1	ME2
NH	1.00								
CT	0.49 (0.48)	1.00							
MA	0.63 (0.67)	0.64 (0.66)	1.00						
RI	0.54 (0.53)	0.56 (0.59)	0.61 (0.61)	1.00					
VT	0.58 (0.60)	0.49 (0.45)	0.58 (0.60)	0.44 (0.42)	1.00				
NY1	0.54 (0.51)	0.59 (0.61)	0.64 (0.70)	0.57 (0.57)	0.65 (0.58)	1.00			
NY2	0.59 (0.58)	0.59 (0.61)	0.70 (0.74)	0.57 (0.56)	0.70 (0.68)	0.85 (0.85)	1.00		
ME1	0.65 (0.68)	0.41 (0.37)	0.58 (0.61)	0.52 (0.50)	0.54 (0.61)	0.44 (0.46)	0.50 (0.54)	1.00	
ME2	0.64 (0.63)	0.52 (0.54)	0.61 (0.68)	0.59 (0.65)	0.50 (0.58)	0.53 (0.55)	0.56 (0.60)	0.59 (0.60)	1.00

Table 4. Summary statistics and Monte Carlo based significance for the patterns in Figs. 3 and 4
 ('Conf = 5' includes the subset of species ranked with full confidence by both botanists).

State	Species	Botanist comparison	Mean	SD	Skewness	Kurtosis
ME	All	1	5.26	2.24	0.083	-1.010
		2	5.28	1.97	0.010	-0.692
		<i>P</i> value	0.350	<0.001	0.366	<0.001
	Conf = 5	1	5.44	2.33	0.008	-1.088
		2	5.58	2.12	-0.089	-0.803
		<i>P</i> value	0.018	<0.001	0.064	<0.001
NY	All	1	6.19	2.32	-0.054	-1.113
		2	5.83	2.24	0.214	-0.774
		<i>P</i> value	<0.001	<0.001	<0.001	<0.001
	Conf = 5	1	5.67	2.51	0.227	-1.160
		2	5.57	2.57	0.466	-0.935
		<i>P</i> value	0.100	0.089	<0.001	<0.001

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Figure 4. Comparison of conservatism coefficients between botanists for Maine using all native taxa and only the confidently ranked native taxa (score = 5).

Figure 1

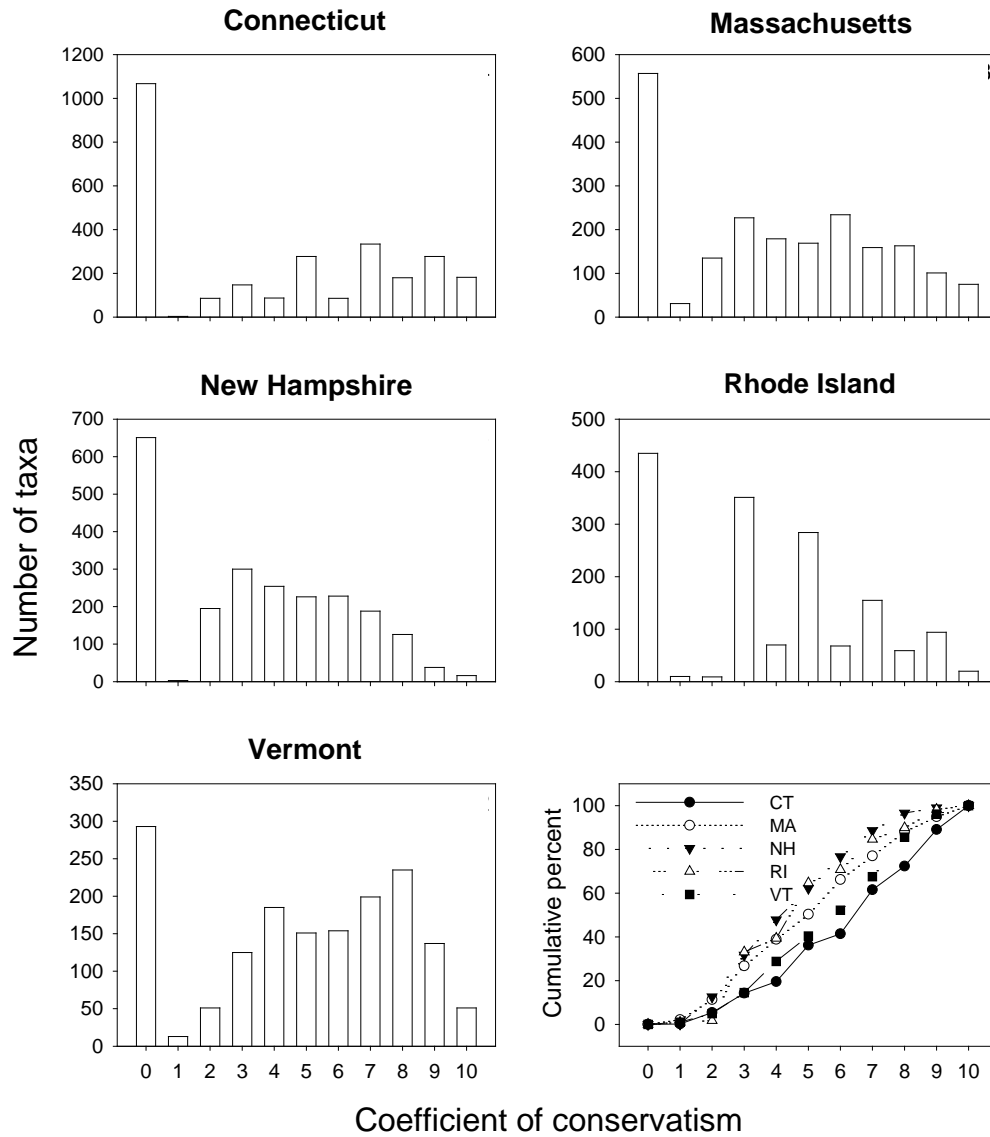


Figure 2

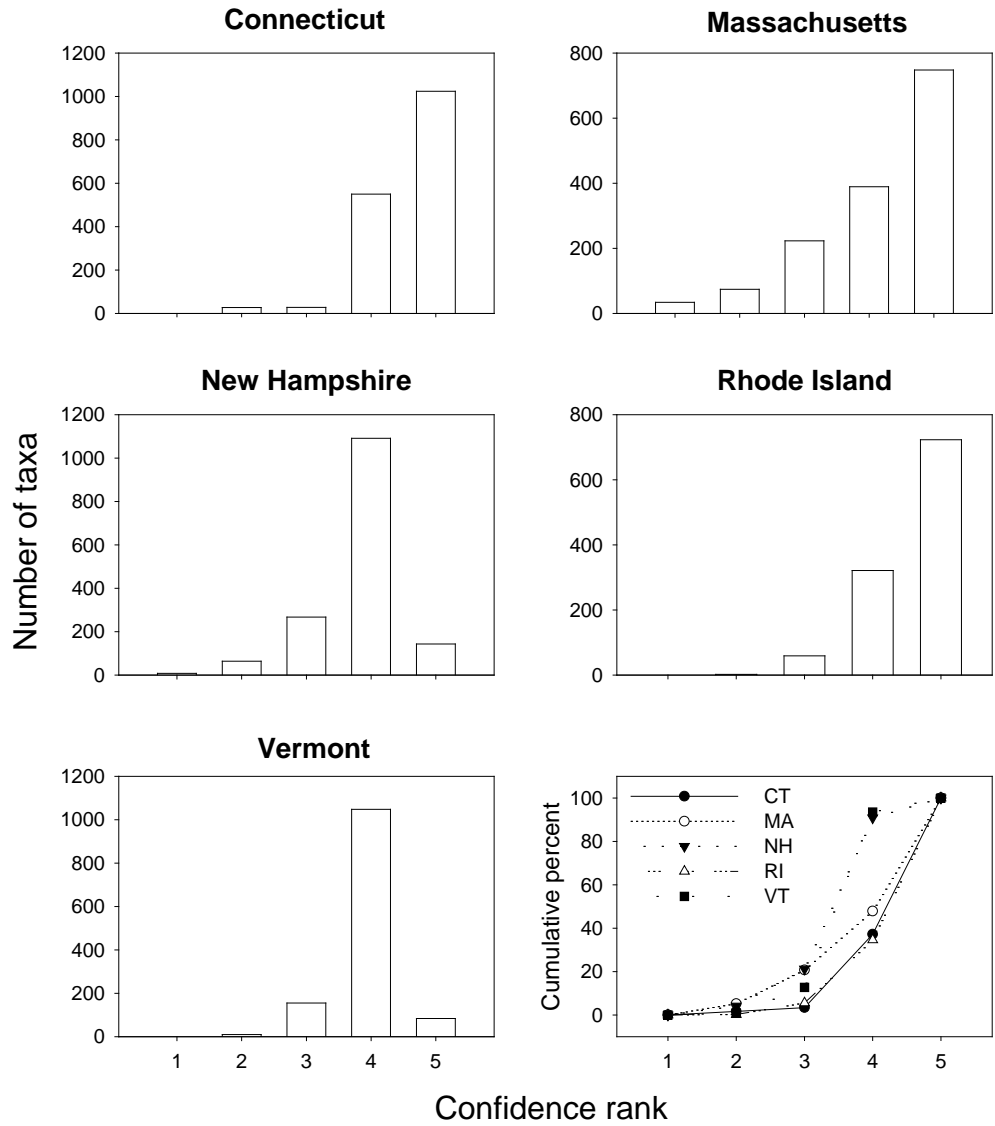


Figure 3

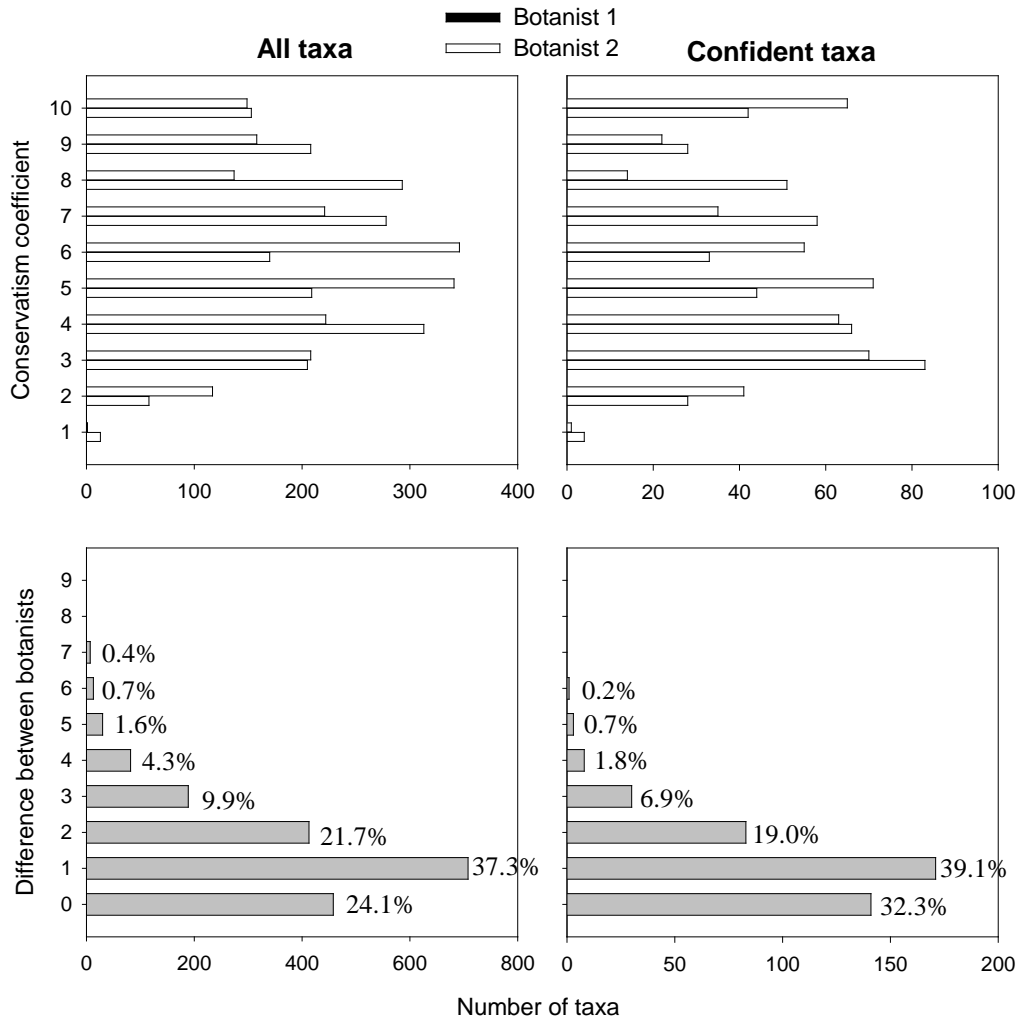


Figure 4

