# Toward the Scientific Ranking of Conservation Status

*Note: These three essays were originally published as posts to the FWGNA Blog in December 2011, January 2012, and March 2012. They can be cited either by their internet addresses, as given below, or as this personal communication from myself, RTD, dated 19Mar12.*

## Part I

http://fwgna.blogspot.com/2011/12/toward-scientific-ranking-of.html

Last month I got an email from a colleague in the South Carolina Department of Natural Resources, asking for my help updating the state wildlife conservation plan. I told him I'd be willing to pitch in with the 2011-12 effort, just as I helped in 2004-05 [1]. But I continue to harbor deep misgivings about the entire process.

In Part I of the series that follows, I debride a nasty sore in the left butt cheek of American environmental science - the unscientific (possibly pseudoscientific) method by which we prioritize our biota for conservation purposes. And in Part II of this series, to follow next month, I will begin the process of suturing that wound back up.

Like all other states with which I am familiar, South Carolina's wildlife plan relies upon a subjective system of conservation status ranks, as follows:

S1 - Critically imperiled state-wide because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation.
S2 - Imperiled state-wide because of rarity or factor(s) making it vulnerable.
S3 - Rare or uncommon in state.
S4 - Apparently secure in state.
S5 - Demonstrably secure in state.

The spreadsheet my DNR colleague sent me for my input [2] had a column for species number (N=32 freshwater snails in South Carolina), scientific name, common name, legal status, conservation status rank (as above), and an (astonishing!) 19 additional data columns, more about which later. My colleague asked me to complete this massive 32x24 matrix by January 15, indicating as he did that the results would (ultimately) be forwarded onward to the nonprofit organization, NatureServe.

The origin and evolution of the conservation ranking system in general currency around the United States is shrouded in mystery. According to documents available from the NatureServe website [3], the notion of a state "natural heritage inventory" arose from collaboration between the nonprofit Nature Conservancy and my very own South Carolina back in 1974, with the first (A-B-C) system of conservation status ranking appearing in 1978. The current five-tier system was developed in 1982. In 1994 a group of state natural heritage program directors formed a related but independent nonprofit organization called the "Association for Biodiversity Information" to catalog the rising flood of inventory and status ranking data, which (in some complex fashion) led The Nature Conservancy to spin off "NatureServe" in 2001.

The 1982 system featured ranking at three scales: Global (G-ranks), National (N-ranks), and Sub-national (S-ranks), based on eight "factors" scored by anonymous participants. The number of factors taken into consideration has increased over the years, as has the number of participants, as has the elaboration of the technique by which the body of anonymous opinion is reputedly converted into a system of conservation status ranks.

For example, the 19 columns on the right side of the matrix my DNR colleague sent me last month included:

- Knowledge of the species population status - "High" if we know the status throughout the species range, "Medium" if we know the status in select areas, "Low" if we know little to none.
- State Threats - "A" if very threatened, "B" if moderately threatened, "C" if not very threatened, "U" if unthreatened.
- Feasibility Measure - How likely is it that conservation activities can make a difference for this species (High, medium, low).

Any reader curious regarding the actual analytical technique by which standard international ignorance units (SIIUs), state threat quotients (STQs), feasibility metrics (FMs), and 16 similarly baffling variables counted and scored for each species are converted into the critical-imperilment-demonstrable-security scale on the global conservation status gauge is invited to peruse the voluminous documentation available from the NatureServe website [4].

This is obviously not science. Conservation status ranks, as they have been propagated throughout the entire natural resources community for 30 years, are not testable, verifiable or falsifiable. The entire system is, at its very foundation, anonymous, unaccountable, subjective opinion.

Are conservation status ranks merely unscientific, or are they pseudoscientific? Pseudoscience is “a claim, belief, or practice which is presented as scientific, but which does not adhere to a valid scientific method [5].” Thus the difference between harmless non-science and execrable pseudoscience is in its presentation.

To the extent that the conservation status ranks arising from this system are presented honestly, as an opinion poll of mysterious parameter, I think they can be excused as (at worst) innocent claptrap. Is there any better solution to the genuine challenge of prioritizing species for conservation? Are we not doing the best that we can in a difficult situation? This is America - take a vote. Fine.

But if there is any effort or intent to present conservation status ranks as scientific, then we as a community will be guilty of promulgating pseudoscience. The elaborate machinations of NatureServe, which have developed over the years into a byzantine system of coding and computation, look suspiciously like dressing a pig in a ball gown, especially when standing behind a velvet rope, looking towards the sty.

And when we scientists make use of conservation status ranks, we give the appearance of endorsing the process that brought them, turning nonscience into pseudoscience by the very act. Surely we wouldn't reproduce conservation status ranks in our peer-reviewed journals, would we? **Surely, surely we scientists wouldn't gin up some "crisis" on the basis of such a system, in a self-serving ploy to attract funding for our own research programs, would we?** To do so would be to commit pseudoscience of a high and aggravated nature.

I absolutely understand why natural resource agencies personnel rely on conservation status ranks for their state wildlife action plans. The state of South Carolina cannot launch inventories of every bug, slug, and butterfly within its vastly triangular borders every five years to meet the data requirements of each fresh wave of federal regulation [6].

But as scientists, we must be very clear that the current system of conservation status ranking, as implemented by NatureServe, cannot be endorsed.

The FWGNA project has now developed a large database with objective estimates of the abundance of all 57 species of freshwater snails inhabiting the Atlantic drainages of the southeast. In the next installment of this series, I will propose a new method to rank these 57 species into five categories of abundance for conservation purposes. But while this approach is designed to mimic the existing system of status ranking currently in favor throughout American conservation biology, it has a theoretical basis and will be rigorously objective.

## Notes

[1] I reviewed the 2005 South Carolina wildlife plan together with the plans of nine other southeastern states in my essay, "Freshwater Gastropods in State Conservation Strategies - The South." [26May06]

[2] The header indicated that this particular data matrix has been developed in collaboration with North Carolina and Georgia. I was peripherally involved in the Virginia process back in 2004, and it wasn't quite as elaborate.

[3] See the brief history of the organization on its "Tenth Anniversary" page: http://www.natureserve.org/aboutUs/anniversary/anniversary.jsp

[4] NatureServe Conservation Status Assessments: Methodology for Assigning Ranks: http://www.natureserve.org/publications/ConsStatusAssess_RankMethodology.jsp

[5] This is from Wikipedia, which is the first hit one gets, if one googles it.

[6] I'm surrendering to reality here. In fact, the FWGNA has surveyed most of five states for less than $20k in total grant support. I suppose the entire country could be done for $200k. Land snails and bivalves for similar figures? Each order of insects? We're probably talking several million dollars to inventory the biota of the entire country. I suppose that's too much to ask.

**Part II**

http://fwgna.blogspot.com/2012/01/toward-scientific-ranking-of.html

Since the birth of their discipline, community ecologists have been interested in a phenomenon generally called "the distribution of commonness and rarity." If one surveys bird abundance on a set of Pacific Islands, for example, certain patterns (e.g., all bird species equally common) do not seem to occur. Rather, what one typically finds is that a few species seem to be very common, and many species seem to be very rare. Such observations led to the development of several prominent theoretical models to explain the distribution of commonness and rarity, each based on slightly different assumptions about the processes that might be ordering biological communities. The best review of this literature I know is the 1975 work of Robert May [1].

The model that ultimately rose to prominence was the lognormal. In my book I gathered data from ten communities of freshwater mollusks (three of gastropods, five of unionid mussels, and two of pisidiid bivalves) and confirmed lognormal distributions for five of them, including the gastropod communities of Oneida Lake, NY, and Lake Esrom, Denmark [2].

A lognormal distribution of commonness and rarity is hypothesized to reflect "minimal structure" in biological communities [3]. If (for example) species #1 takes a random portion of the total resource, then species #2 takes a random portion of the remainder, then species #3 takes a random portion of the remainder, and so forth, a lognormal distribution of abundance will result.

Although (as far as I am aware) the lognormal model has not been extended beyond community ecology, it seems plausible to me that such "minimal structure" might generalize to evolutionary time, and find application to the regional (or even continental) distributions of related organisms no longer competing, or indeed even interacting, in any way.

For example, across the southern Atlantic drainages the FWGNA project has recorded 593 populations of *Helisoma anceps* and 192 populations of *Helisoma trivolvis*. But because *H. trivolvis* is adapted to lentic environments and *H. anceps* to lotic, they rarely occur together. The same relationship exists between *Gyraulus parvus* and *Menetus dilatatus*, and between *Amnicola limosa* and *Somatogyrus virginicus*, and in several other pairs and groups. This sort of "minimal structure," integrated over the evolutionary history of the freshwater Gastropoda, might plausibly lead to a lognormal distribution of commonness and rarity at a scale much larger than the single biological community.

From the Atlantic drainages of the four southeastern states, the FWGNA Project has recorded the 57 species of freshwater gastropods ranked down the left margin of Table 1 [4] by the total number of lines in our database [5]. The most common species across the region was (somewhat surprisingly) *Campeloma decisum* with 1,188 records, followed by *Physa acuta* with 1,082 records, and so forth, down to four species (*Gyraulus deflectus, Valvata tricarinata, Fontigens bottimeri* and *Marstonia gaddisorum*) with one record each.

Because data of this sort are typically found to contain many singleton values, the convention in community ecology has been to use base-2 log transformation. Thus log2 abundances for all 57 species are given in Table 1 and plotted in Figure 1, to the left above [Note 6, click for larger].

A lognormal hypothesis does indeed fit the distribution of commonness and rarity of the 57 freshwater gastropod species of southern Atlantic drainages (Shapiro-Wilk W=0.962, p<0.065). The mean of the distribution shown in Figure 1 is 4.83 (= 28.4 records), with a standard deviation of 2.96 (= 7.8 records).

In recent years a widespread practice has developed wherein species are prioritized for conservation purposes into a system of five "status ranks" [See the previous post in this series – Note 7 below]. Convention would dictate that special consideration should be given to the rarest 5% of the species, 1.64 standard deviations (or more) below the log mean abundance. Shall we assign such especially-rare species to "Rank-5"? Then Rank-4 species might be those with log abundance less than 1.64 standard deviations below the mean but greater than 1 standard deviation, and Rank-3 species might be those between 1 standard deviation below the mean and the mean itself. Let us assign Rank-2 to species with log abundances greater than the mean but less than 1 standard deviation above, and Rank-1 to all species with log abundances greater than 1 standard deviation above the mean.

Figure 1 shows that the 57 freshwater gastropod species of southern Atlantic drainages include just the 4 singletons at Rank-5, an additional 7 species at Rank-4, 17 at Rank-3, 17 at Rank-2, and 12 species at Rank-1. The conservation ranks of all 57 species are given in the far right column of Table 1.

The implications of adopting such a system to guide conservation decisions more generally, in other groups of organisms elsewhere, would bear considerable discussion. Perhaps we will devote a third essay to this question in some future month. For now I will close with this.

It will be obvious to any of my readership with a general appreciation of the North American freshwater gastropod fauna that two of the four species here designated as "Rank-5" are narrowly endemic and genuinely rare (the two hydrobiids) and that two of the four species (*Gyraulus deflectus* and *Valvata tricarinata*) would have become much more common had our survey been extended further north. Clearly, the ranks we have assigned in the present exercise are dependent on the region surveyed. Thus we propose to call this set of 57 "FWGSA" ranks – Freshwater Gastropods of the Southern Atlantic drainages [8].

And more generally, the stability of any ranking system based on abundance data will be a function of the area surveyed – the smaller the area, the more unstable the classification. So although the regulatory apparatus for conservation purposes (and grant funding!) is largely administered by the states, we have resisted the temptation of calculating state-level abundance ranks here. Rather, we anticipate expanding our area of coverage, ultimately to include the entire continent, at which point we will publish FWG**N**A ranks, perhaps characterized by some stability.

But in any case, the system described above is rigorous, objective, and theoretically-based. In short, it is a scientific method to assign conservation status ranks, heaven help us.

Notes

[1] Although I dabbled in community ecology early in my career, I admit I have not kept up with the literature. There is probably something more current than this:
May, R. M. (1975) Patterns of species abundance and diversity. Pp. 81 – 120 *in* Ecology and Evolution of Communities (M. Cody and J. Diamond, eds). Cambridge, MA: Belknap Press.

[2] Pp 421 – 428 in Dillon, R. T., Jr. (2000) The Ecology of Freshwater Molluscs. Cambridge University Press.
http://ebooks.cambridge.org/ebook.jsf?bid=CBO9780511542008

[3] Sugihara, G. (1980) Minimal community structure: An explanation of species abundance patterns. Am. Nat. 116: 770-787.

[4] Table 1. The 57 species of pulmonate gastropods inhabiting the southern Atlantic drainages of the United States, ranked by their abundances in the FWGNA database 1/2012. [pdf]

[5] Each line in the FWGNA database records the collection of a single species at a discrete site. We have screened any date-duplicates from the databases we have obtained from secondary sources, including museums and state natural resource agencies, as well as any nearly-neighboring collections, such as those taken upstream and downstream of single bridges.

[6] Figure 1. Log2 abundances of the 57 freshwater gastropod species inhabiting the southern Atlantic drainages of the United States, divided into five categories ("FWGSA Ranks") as described in text. [pdf]

[7] Toward the Scientific Ranking of Conservation Status – Part 1. [12Dec11]

[8] A paper including the text of both my December and January essays, together with Table 1 and Figure 1, was initially made available as a pdf separate on 9Jan12. That paper was updated on 19Mar12 here [pdf].

## Part III

http://fwgna.blogspot.com/2012/03/toward-scientific-ranking-of.html

Thank you all for your comments on my posts of December and January, regarding my new method for assigning conservation status ranks [1]. Almost all of you addressed your emails to me personally, rather than posting comments to the blog. But I do think some of the points you raised are of sufficiently general interest to warrant sharing.

Many of you commented regarding the obvious sampling biases in the relative abundances of the freshwater gastropods listed on Table 1 in my January post [2]. Here's a cute example:

> Maybe "commonness" is actually "commonly seen in the field without a microscope-ness." Large things (elephants, Oprah, etc.) tend to be noticed more than tiny things (hydrobiids, lawyer's souls, etc.)

Yes, I agree that the conservation ranks I suggested back in January do indeed reflect sampling biases against small-bodied species, and against species that are difficult to identify, and against species unusual or cryptic in their habitat.

My biological intuition suggests to me, for example, that the most common freshwater gastropod species in southern Atlantic drainages may actually be either *Physa acuta* or *Ferrissia fragilis*. The *Physa* abundances in Table 1 are certainly biased downward by taxonomic difficulties – several species (all common) cannot be distinguished as juveniles, and hence no *Physa* of any species can sometimes be tallied in samples where physids most certainly do occur. The abundance of the large-bodied *Campeloma decisum* was probably biased upward in the casually-collected samples we obtained from museums, and the small-bodied *Ferrissia fragilis* biased downward in the quantitative (or semi-quantitative) macrobenthic data we obtained from natural resource agencies. Limpets are rarely recovered from kick-samples.

But such routine sampling biases, irritating though they may be, are nevertheless random with respect to the object for which these data were tabulated. There is no reason to suspect that species warranting conservation concern are different in their body size, habitat choice, or taxonomic nuisance than more common species.

Much worse, from the standpoint of our purposes here, must be conservation-biased oversampling, the sampling error in favor of rare species generated as a consequence of the misbegotten system under which we currently labor. For today we first identify our putatively endangered species by pseudoscience, and then secondarily fund directed surveys to hunt that anointed subset specifically.

In the early 1980s, for example, Hugh Porter was funded by a North Carolina Wildlife Resources Commission grant to survey Lake Waccamaw [3]. When I visited the NC Museum of Natural Sciences in 2005, there were so many lots of the (apparently endemic) Lake Waccamaw Floridobia (catalogued as "*Cincinnatia* sp."), differing only by transect number, that I simply closed the drawers and moved on [4]. The (just 4) records of Waccamaw Floridobia shown in January Table 1 result from my own (arbitrary, but admittedly subjective) culling efforts.

Footnote #5 of my January post bears further attention in this regard. To compile my Table 1, I footnoted “We have screened any date-duplicates from the databases we have obtained from secondary sources, including museums and state natural resource agencies, as well as any nearly-neighboring collections, such as those taken upstream and downstream of single bridges.” This exercise was much more complex than my footnote made it sound, but was rendered necessary by overly-intensive sampling, often brought on by narrowly-directed surveys like Porter’s.

The situation regarding the endemic hydrobiid fauna of Georgia is similar. Fred Thompson has surveyed this fauna exhaustively, lodging in the Florida Museum of Natural History (for example) 49 records of *Notogillia sathon* and 29 records of *Spilochlamys turgida* from five small counties in central Georgia [5]. Our colleague Charles Watson was also awarded a USFWS grant to survey this same fauna in 1995 [6], lodging 5 records of *Notogillia* and 4 records of *Spilochlamys* in the NCSM . These records I have boiled down to the 22 and 15 shown in Table 1, respectively, almost certainly every accessible spot where every *Notogillia* and *Spilochlamys* currently in existence can be sampled.

Meanwhile, January Table 1 showed just 16 records of *Fontigens nickliniana*, an ecologically-similar hydrobiid common in every hardwater spring in western Virginia (ranging all the way to Michigan, if you can believe it, Note 7) and hence attracting no interest from funding agencies or conservationists.

*Io fluvialis* must (literally) be the poster-child for conservation-biased oversampling (witness crawling at left on the FMCS logo above). The snails are as spectacular on the hoof as any freshwater gastropod worldwide, but populations are currently restricted to the Clinch, Powell, Holston and Nolichucky Rivers in western Virginia and East Tennessee. The raw database I received in 2005 from Brian Watson, my colleague at the Virginia Fish & Game, included 128 (mostly historical) records of *Io* from Virginia alone, to which 54 records were added from directed surveys. I culled these records as best I could, but reference to the map at left below suggests that the 42 records ultimately remaining in our database continue to represent a gross over-estimate of the abundance of *Io* relative to the other 37 freshwater gastropods inhabiting East Tennessee River drainages.

The FWGNA survey we released in August found *Pleurocera clavaeformis* to be the most common freshwater gastropod in East Tennessee drainages, represented by 289 records as against our 42 records of *Io*. But my simple search of the Global Biodiversity Information Facility this morning returned 456 "occurrences" of *Io fluvialis* in the museums of the world, and just 204 occurrences of *Pleurocera* ("*Elimia*" or "*Goniobasis*") *clavaeformis* [7].

So here's my bottom line for the month of March. Not only is the method I proposed back in January scientific, it will be more effective in ranking species for conservation priority than the current system as developed by NatureServe. What is needed, now more than ever, is a continental survey of our freshwater gastropod fauna, conducted in a manner that is objective with respect to conservation status. Welcome to the FWGNA project… 14 years old, and still toddling forward.

Notes

[1] Toward the Scientific Ranking of Conservation Status:
Part I - [12Dec11]
Part II – [9Jan12]

[2] Table 1 - The 57 species of freshwater gastropods inhabiting the southern Atlantic drainages of the United States, ranked by their abundances in the FWGNA database 1/2012. See following...

[3] For references to Hugh Porter's research see my post:
Crisis at Lake Waccamaw [16July10]

[4] My search of the online database at the NC Museum of Natural Sciences this morning only returned nine records of "*Cincinnatia* sp." from Lake Waccamaw. That's just a small fraction of their actual holdings, if my 2005 notes are correct.

[5] The Florida Museum of Natural History online database can be accessed here:
http://www.flmnh.ufl.edu/malacology/collections.htm

[6] Watson, C. (2000) Results of a survey for selected species of Hydrobiidae (Gastropoda) in Georgia and Florida. In Freshwater Mollusk Symposia Proceedings, Part II, eds. Tankersley, Warmolts, Watters, Armitage, Johnson & Butler, pp. 233 - 244. Columbus: Ohio Biological Survey.

[7] Hershler, R., Holsinger, J. & Hubricht, L. (1990) A revision of the North American freshwater snail genus Fontigens (Prosobranchia: Hydrobiidae). Smithsonian Contributions to Zoology, 509, 1-49.

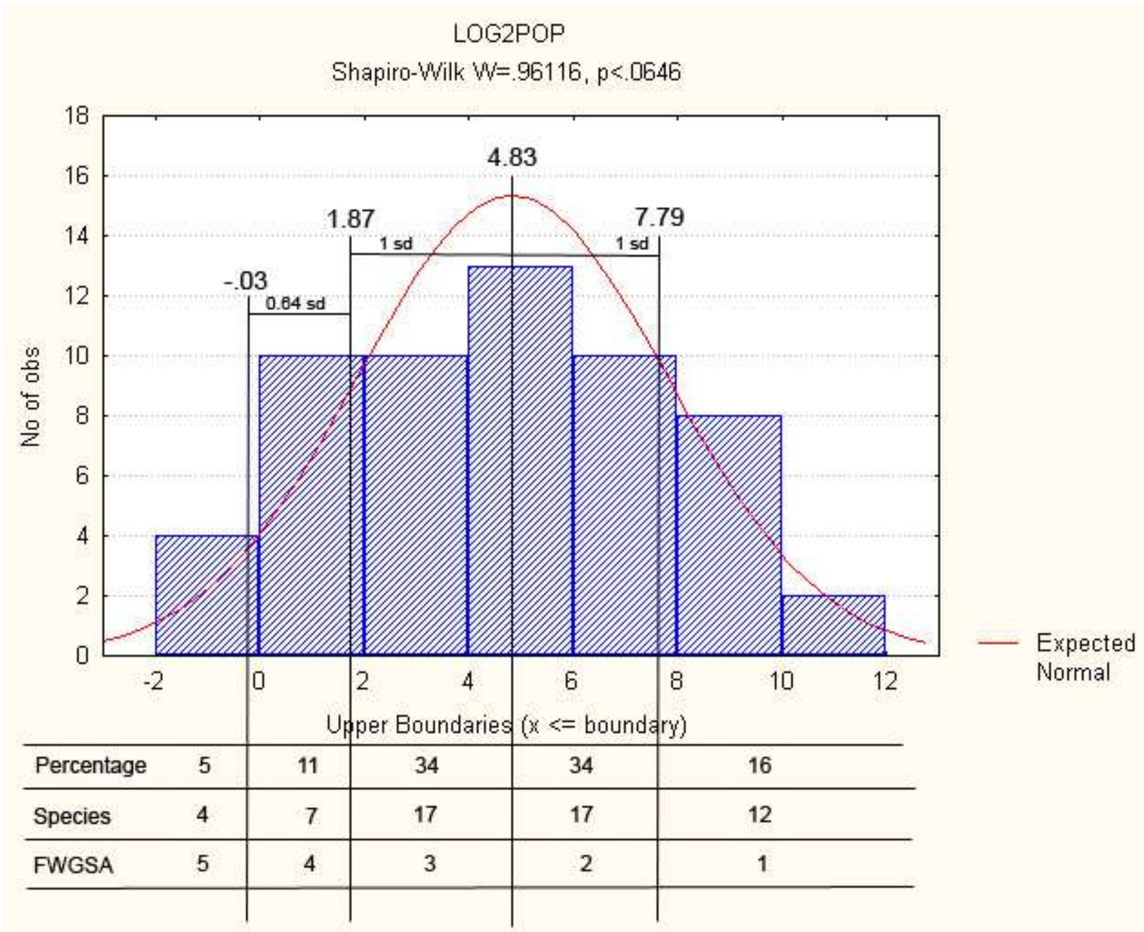
[8] For more about the GBIF see:Freshwater Gastropod Databases Go Global! [26May09]

Table 1. The 57 species of freshwater gastropods inhabiting the southern Atlantic drainages of the United States, ranked by their abundances in the FWGNA database 1/2012.

| Species | VA | NC | SC | GA | Totals | log2(tot) | **FWGSA** |
|---|---|---|---|---|---|---|---|
| Campeloma decisum | 275 | 644 | 157 | 112 | 1188 | 10.21432 | **F1** |
| Physa acuta | 209 | 654 | 147 | 72 | 1082 | 10.07948 | **F1** |
| Ferrissia fragilis | 152 | 594 | 70 | 37 | 853 | 9.736402 | **F1** |
| Menetus dilatatus | 191 | 498 | 95 | 61 | 845 | 9.722808 | **F1** |
| Lymnaea columella | 118 | 368 | 113 | 58 | 657 | 9.35975 | **F1** |
| Helisoma anceps | 189 | 336 | 56 | 12 | 593 | 9.211888 | **F1** |
| Leptoxis carinata | 445 | 146 | | | 591 | 9.207014 | **F1** |
| Laevapex fuscus | 50 | 274 | 83 | 21 | 428 | 8.741467 | **F1** |
| Pleurocera proxima | 40 | 268 | 56 | 17 | 381 | 8.573647 | **F1** |
| Amnicola limosa | 31 | 142 | 28 | 61 | 262 | 8.033423 | **F1** |
| Pleurocera catenaria catenaria | 9 | 126 | 38 | 81 | 254 | 7.988685 | **F1** |
| Lyogyrus granum | 68 | 107 | 22 | 30 | 227 | 7.826548 | **F1** |
| Helisoma trivolvis | 30 | 91 | 40 | 31 | 192 | 7.584963 | **F2** |
| Lymnaea humilis | 92 | 54 | 1 | 1 | 148 | 7.209453 | **F2** |
| Pleurocera virginica | 84 | 35 | | | 119 | 6.894818 | **F2** |
| Gyraulus parvus | 37 | 33 | 24 | 20 | 114 | 6.83289 | **F2** |
| Somatogyrus virginicus | 7 | 49 | 17 | 33 | 106 | 6.72792 | **F2** |
| Physa pomilia | 51 | 17 | 16 | 9 | 93 | 6.539159 | **F2** |
| Physa carolinae | 21 | 34 | 15 | 18 | 88 | 6.459432 | **F2** |
| Pleurocera catenaria dislocata | 17 | 40 | 16 | 8 | 81 | 6.33985 | **F2** |
| Physa gyrina | 47 | 7 | | 1 | 55 | 5.78136 | **F2** |
| Planorbula armigera | 3 | 37 | | | 40 | 5.321928 | **F2** |
| Gillia altilis | 2 | 37 | 1 | | 40 | 5.321928 | **F2** |
| Ferrissia rivularis | 37 | | | | 37 | 5.209453 | **F2** |
| Littoridinops tenuipes | 6 | 18 | 7 | 4 | 35 | 5.129283 | **F2** |
| Lioplax subcarinata | 5 | 26 | 3 | | 34 | 5.087463 | **F2** |
| Promenetus exacuous | 5 | 19 | 5 | 2 | 31 | 4.954196 | **F2** |
| Lymnaea cubensis | | 6 | 17 | 6 | 29 | 4.857981 | **F2** |
| Bellamya japonica | 13 | 4 | 12 | | 29 | 4.857981 | **F2** |
| Viviparus intertextus | | 8 | 16 | 3 | 27 | 4.754888 | **F3** |
| Valvata bicarinata | | 4 | 1 | 18 | 23 | 4.523562 | **F3** |
| Notogillia sathon | | | | 22 | 22 | 4.459432 | **F3** |
| Pleurocera semicarinata | 21 | | | | 21 | 4.392317 | **F3** |
| Fontigens nickliniana | 16 | | | | 16 | 4 | **F3** |
| Spilochlamys turgida | | | | 15 | 15 | 3.906891 | **F3** |
| Viviparus georgianus | 2 | | 7 | 5 | 14 | 3.807355 | **F3** |
| Hebetancylus excentricus | 2 | 3 | 3 | 5 | 13 | 3.70044 | **F3** |
| Lyogyrus latus | | | | 12 | 12 | 3.584963 | **F3** |
| Marstonia halcyon | | | | 11 | 11 | 3.459432 | **F3** |
| Pomacea insularum | | | 3 | 5 | 8 | 3 | **F3** |
| Fontigens orolibas | 7 | | | | 7 | 2.807355 | **F3** |
| Viviparus subpurpureus | | | 5 | | 5 | 2.321928 | **F3** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Floridobia A | | | | 5 | 5 | 2.321928 | **F3** |
| Marstonia agarhecta | | | | 4 | 4 | 2 | **F3** |
| Floridobia waccamaw | | 4 | | | 4 | 2 | **F3** |
| Pleurocera floridensis timidus | | | | 4 | 4 | 2 | **F3** |
| Helisoma magnificum | | 3 | | | 3 | 1.584963 | **F4** |
| Helisoma eucosmium | | 3 | | | 3 | 1.584963 | **F4** |
| Bithynia tentaculata | 3 | | | | 3 | 1.584963 | **F4** |
| Biomphalaria obstructa | | | 1 | 1 | 2 | 1 | **F4** |
| Fontigens morrisoni | 2 | | | | 2 | 1 | **F4** |
| Pomacea paludosa | | | 2 | | 2 | 1 | **F4** |
| Floridobia floridana | | | | 2 | 2 | 1 | **F4** |
| Fontigens bottimeri | 1 | | | | 1 | 0 | **F5** |
| Gyraulus deflectus | 1 | | | | 1 | 0 | **F5** |
| Valvata tricarinata | 1 | | | | 1 | 0 | **F5** |
| Marstonia gaddisorum | | | | 1 | 1 | 0 | **F5** |
| **Totals** | **2290** | **4689** | **1077** | **808** | **8864** | | |

Figure 1. Log2 abundances of the 57 freshwater gastropod species inhabiting the southern Atlantic drainages of the United States, divided into five categories ("FWGSA Ranks") as described in text.




| | | | | | |
|---|---|---|---|---|---|
| Percentage | 5 | 11 | 34 | 34 | 16 |
| Species | 4 | 7 | 17 | 17 | 12 |
| FWGSA | 5 | 4 | 3 | 2 | 1 |