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THE CAROLINA HERP ATLAS: AN ONLINE, CITIZEN-SCIENCE APPROACH TO DOCUMENT AMPHIBIAN AND REPTILE OCCURRENCES

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***Abstract*.—Despite effectiveness in other scientific disciplines, citizen scientists have generally been underutilized in herpetological research and conservation. In this paper, we detail the project design, preliminary results, and data obtained from an online, citizen-science based herpetological atlas, known as the Carolina Herp Atlas (CHA). The CHA contains several features that ensure quality of submitted data, while allowing registered users to keep a personal database, and to employ a variety of data visualization tools such as species distribution maps, charts, tables, photos, and other information on North and South Carolina's amphibians and reptiles. From 1 March 2007 to 22 September 2009, the CHA totaled 698 registered users and received 15,626 amphibian and reptile occurrence records. Specifically, distribution data for 32 frogs, 51 salamanders, 38 snakes, 12 lizards, 16 turtles, and the American Alligator (*Alligator mississippiensis*) were obtained, with most commonly reported group being snakes (5,349 records). Additionally, several records of amphibians and reptiles considered priority species by North and South Carolina were contributed to the CHA. By gathering data from a large number of citizen scientists across large spatial scales, the CHA represents an important step in allowing the public to become involved in documenting occurrences of herpetofauna.**

Key Words.—atlas; citizen-science; conservation; herpetofauna; North Carolina; South Carolina

INTRODUCTION

Amphibians and reptiles are generally experiencing population declines (e.g., Garber and Burger 1995; Houlahan et al. 2000; Reading et al. 2010) and are currently considered among the most threatened animal groups worldwide (Gibbons et al. 2000; Stuart et al. 2004). Numerous well-known anthropogenic factors including habitat destruction and fragmentation, invasive species, environmental pollution, and pesticides threaten amphibian and reptile populations (e.g., Klemens 2000; Semlitsch 2003; Mullin and Seigel 2009). Unfortunately, the ability to document the response of amphibians and reptiles to anthropogenic threats is often limited by the lack of basic knowledge regarding their population status and distribution. In the Southeastern United States, amphibian and reptile diversity is high, and these taxa represent a significant component of Southeastern ecosystems (Gibbons et al. 1997). Despite their importance in these ecosystems, few large-scale monitoring projects for amphibians and reptiles exist in this region.

Citizen-science, defined as the participation of the general public in scientific research (Trumbull et al. 2000), can significantly advance environmental monitoring and conservation issues while improving scientific literacy in the general public (e.g., Evans et al. 2005). Citizen-science based monitoring programs have been developed to obtain data on a wide variety of organisms, e.g., butterflies (Prysby and Oberhauser 2004), crabs (Delany et al. 2008), trees (Galloway et al. 2006), and ecosystems, such as isolated wetlands (Oscarson and Calhoun 2007). Perhaps the most well known citizen-science based programs are those focusing on birds, such as eBird (Sullivan et al. 2009), the United States Breeding Bird Survey (Sauer et al., 1997), and the Christmas Bird Count (LeBaron 2009). Bird watchers have a long history of aiding scientists in studying birds (Barrow 1998), and leading bird conservation organizations (i.e., Cornell Lab of Ornithology, United States Geological Survey, National Audubon Society, etc.) have been effective in integrating data collected by citizen scientists to study a variety of aspects of avian ecology, population dynamics, behavior, and distribution over large geographic regions (Bhattacharjee 2005). The general model for most large scale citizen-science programs involves participants following specific protocols provided by scientists and submitting data to a central location where they are made accessible to researchers. With large numbers of participants, data can be collected across large geographic regions and often over long time periods, and can ultimately address a wide variety of scientific questions (e.g., Dhondt et al. 2002).

Despite the success of citizen-science based contributions to ornithology, the use of citizen scientists in herpetological conservation has been limited. Most species of amphibians and reptiles are cryptic and remain widely unnoticed. Additionally, some reptiles (e.g., snakes) are feared and/or despised by the general public making their appeal for public involvement in monitoring quite low. However, monitoring efforts such as the North American Amphibian Monitoring Program (NAAMP; Weir and Mossman 2005) have shown that citizen scientists are willing to contribute to frog monitoring over large areas. Amphibian and reptile atlases have also been extremely successful. Some examples include Wisconsin (Casper 1996), New York (Gibbs et al. 2007), and Georgia (Jenson et al. 2008), and serve as the basis for a more comprehensive understanding of the status and distribution of species. However, most previous herpetological atlas projects have relied on a relatively few dedicated observers and scientists who provide records (mostly by mailing in voucher specimens, recordings, or photos) to the atlas coordinator. Currently, frog monitoring programs and atlases represent the primary method in which the public can become involved in monitoring and documenting herpetofauna. However, an increasing number of amateur naturalists, who spend considerable amounts of time in the field searching for and photographing amphibians and reptiles, can provide data useful in documenting the status and distribution of populations.

Based on the success of ornithological citizen-science projects and the general lack of knowledge of many amphibian and reptile species' distributions in the Southeastern United States, the Davidson College Herpetology Laboratory developed the Carolina Herp Atlas (CHA; www.carolinaherpatlas.org) in 2007. The CHA differs from previous herpetological atlases because it is an online database. Thus, the CHA uses the internet to gather, archive, and distribute information in real-time to a large audience. Additionally, the CHA provides citizen scientists with a simple way to maintain and manage a personal database of the amphibians and reptiles they observe. Our objectives were to describe the project design and specific data visualization tools of the CHA, to provide results from the first 31 months of data collection, and discuss the data resulting from the CHA.

Materials and Methods

For this study, we used data submitted to the CHA by citizen scientists from North and South Carolina from the initial launch on 1 March 2007 to 22 September 2009. The CHA includes features that ensure quality of data, allows registered users to keep a personal database, and permits non-registered public and registered users with data visualization tools such as species distribution maps, charts, tables, photos, and other information on North and South Carolina's herpetofauna. All those wishing to submit data to the CHA are required to register. Once registered the users obtain an account, which allows for personal database management. Users can add amphibian and reptile observations to the CHA via the "My Herps" section, which they access by providing their username and password. To ease submission of observations and prevent errors by users, the CHA data entry platform includes drop-down menus for state, county, genus and species. Common names appear as the user scrolls through scientific names. Links to species identification web pages (www.herpsofNC.org), are located next to the common name of each species to help users correctly identify species. The date field is automated (based on current day), but can be changed so that historic data can be entered. Time of day can also be entered for each observation using a drop down menu. Users manually enter a locality description for each observation; we provide instructions and examples to users on the qualities of a good locality description. To allow for verification of identification, we provide a method for users to download digital photographs for each record. Multiple images can be downloaded for a single record, helping to ensure that key identifying characteristics are available for review when verifying data (see below). Downloading digital photos of specimens is optional; however, we highly recommend that users download photos for verification purposes. Records without accompanying digital photos are given a lower status code than records with digital photos (see below). Finally, a section for comments is available.

A feature of CHA data submission is the Geolocator, which helps users pinpoint the precise location of their observation (Fig. 1). After clicking on the Geolocator, the user is brought to a map/aerial image of the Carolinas. The user can manually navigate to their observation or can use the "Find Address" or "Locate Me" features. The "Locate Me" feature centers the map on the user's personal computer IP address. Once the location of the observation is identified, the user has the option to automatically add the precise location of their observation. Accuracy of the mapping tool varies depending on imagery available, but generally is accurate to within 5 m. The Geolocator is powered by Microsoft Virtual Earth. All data are submitted to the CHA in Universal Transverse Mercator projection (datum NAD83). The Geolocator also provides a way to cross check the accuracy of locality submissions; CHA database administrators can compare county designation provided by the user with county designation provided to the Geolocator.

After submission of an observation, the user can add additional records from the same location without re-entering locality data. Each previously submitted observation by the user is available to view, including a map displaying the locations of the records (Fig. 2). Some information can be updated by the user (i.e., a photo can be downloaded). More than one record can be

FIGURE 1. The Geolocator provides the contributor with the ability to easily georeference an observation using an online mapping program. The contributor simply double clicks the precise locality (indicated as red dot) and geographic coordinates (Universal Transverse Mercator) appear on the map. Image of the Geolocator (captured from Microsoft Virtual Earth) is a screen capture from www.carolinaherpatlas.org.

selected and viewed on the map at once allowing the user to see all records for a given species or county.

The CHA contains several data visualization tools. The "Data and Maps" and "Photos" section of the CHA allows all registered users and the non-registered public to view data submitted. County-level distribution maps, which are updated in real-time (Fig. 3), are one important feature of the "Data and Maps" section; these maps can be searched by common name, scientific name, or county, and are linked to species identification web pages to help users and non-registered visitors to the site learn about the natural history of each species. Users and non-registered visitors can also view total number of records submitted to the CHA for each species via the tabular data feature. Tabular data can be sorted by group (i.e., frogs, salamanders), genus, species, common name, and count (e.g., number of records). Charts are also available, which the user can sort data by group and display the most commonly recorded species in each group. The "Photos" section allows the user to view all digital images submitted to the CHA. Images can be filtered by group, genus, and species.

Proper species identification is crucial in studies that rely on citizen scientists to collect data. After data are submitted, we review each record within one week of submission and edit each record to insure the accuracy of data entered into the CHA. Upon review, we assign each record a status code that reflects the overall accuracy of the record. Observations that do not contain a photo voucher receive a lower status code (e.g., status code of 6) than those records that do contain a photo (e.g., status code of 10). For potentially erroneous data (i.e., outside of species known range, extremely rare species), we contact the user to assure the record was entered correctly. If the user cannot confirm species identity through a photo voucher, their record is removed from the database.

Prior to launching the CHA, we recruited participants by contacting several local and state wildlife managers, birding clubs, schools, and others potentially interested

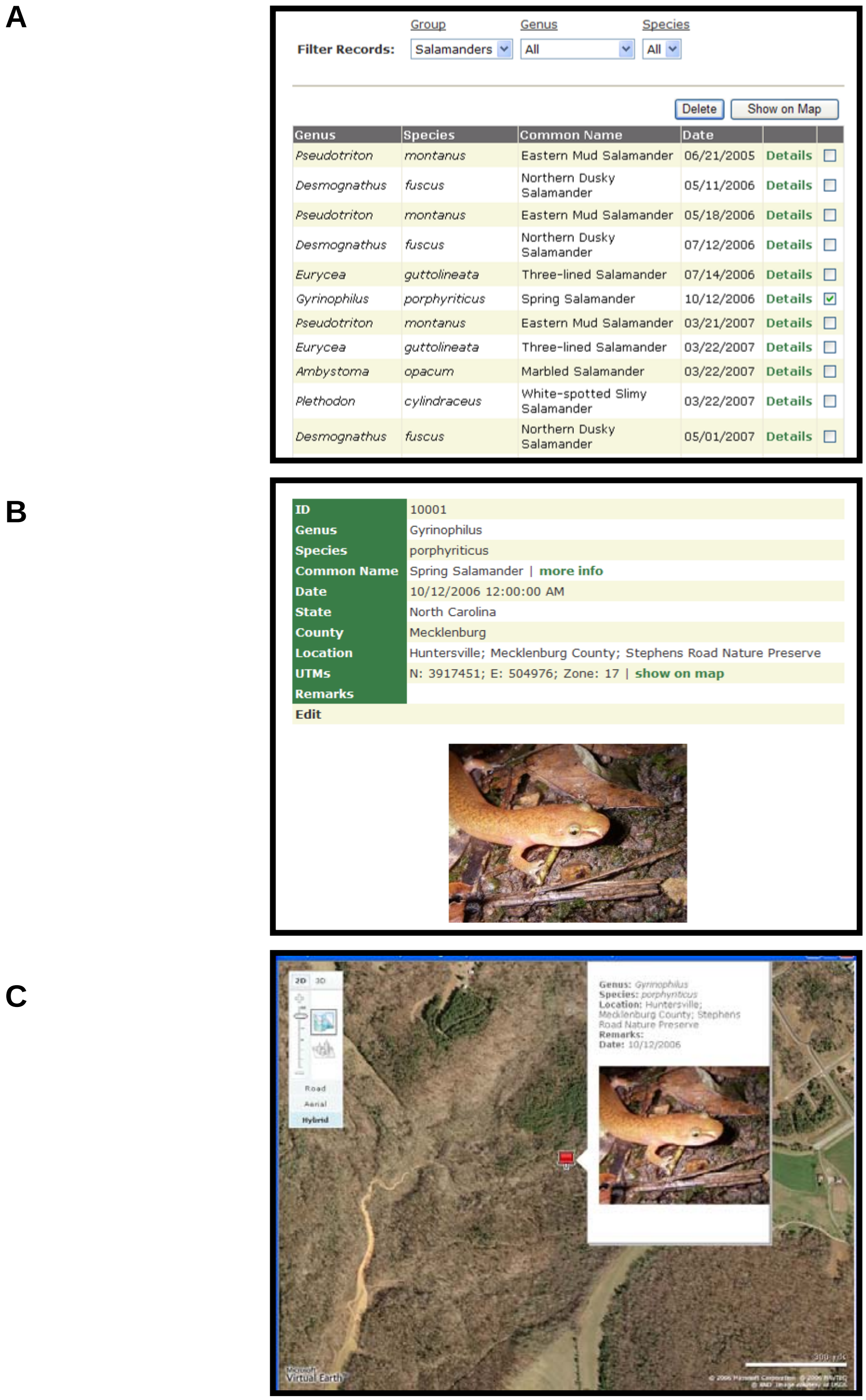

FIGURE 2. The "My Herps" section of the Carolina Herp Atlas allows users to maintain a personal database (A) of their reptile and amphibian observations. Each previously submitted observation is available for the user to view (B), including a map location of the record (C). Images are screen captures from www.carolinaherpatlas.org. (*Gyrinophilus porphyriticus* photographed by Steven J. Price).

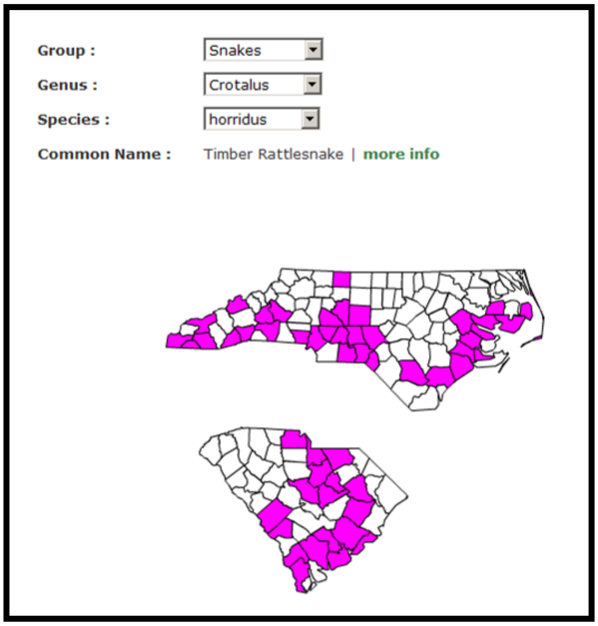

FIGURE 3. County-level distribution maps are available for each species to registered users and unregistered visitors. Maps can be searched by common name, scientific name, or county and are linked to species identification web pages to help users confirm their identification and learn more about the natural history of each species. (Pictured map is a screen capture from www.carolinaherpatlas.org).

in wildlife monitoring and herpetology. We also advertised the CHA in numerous wildlife-related publications and magazines in North and South Carolina (i.e., North Carolina Herpetological Society Newsletter, Wildlife in North Carolina). After launching the CHA, we advertised at regional scientific meetings including Southeastern Partners in Reptile and Amphibian Conservation and Association of Southeastern Biologists.

RESULTS

The CHA was officially launched on 1 March 2007. Prior to the launch, the Davidson College Herpetology Lab imported 3,963 amphibian and reptile records, primarily from Mecklenburg, Iredell, and Cabarrus counties in the western Piedmont of North Carolina, into the CHA database. From 1 March 2007 through 22 September 2009, the CHA totaled 698 registered users and received 11,663 reptile and amphibian records from North and South Carolina. The number of registered users peaked during the first few months of operation; however, we consistently received 20–25 new users during warmer months (March-October) in 2008 and 2009 (Fig. 4). The numbers of submitted observations were also generally higher during warmer months (March-October), and peaked during September and October 2008 (Fig. 5). The number of records submitted per individual was quite variable (range 1–4,452), although 74 individuals submitted 10 or more records to the CHA database. Additionally, the CHA received 2,618 voucher photographs; thus 22% of records have a photo voucher. Of the 168 species known to occur in North and South Carolina, 147 have at least one record

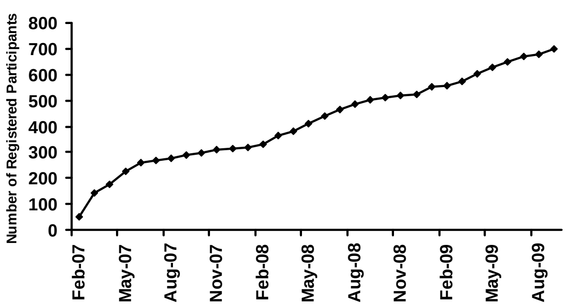

FIGURE 4. Cumulative number of users registered for the Carolina Herp Atlas from 1 March 2007 to 22 September 2009.

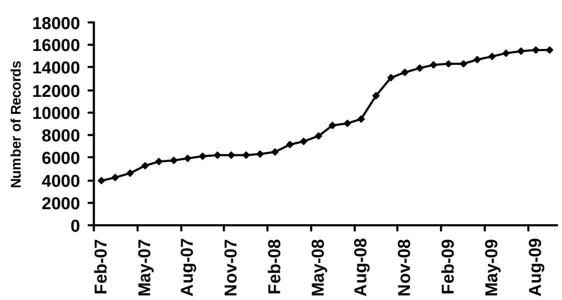

FIGURE 5. Cumulative number of amphibian and reptile observations submitted to the Carolina Herp Atlas from 1 March 2007 to 22 September 2009.

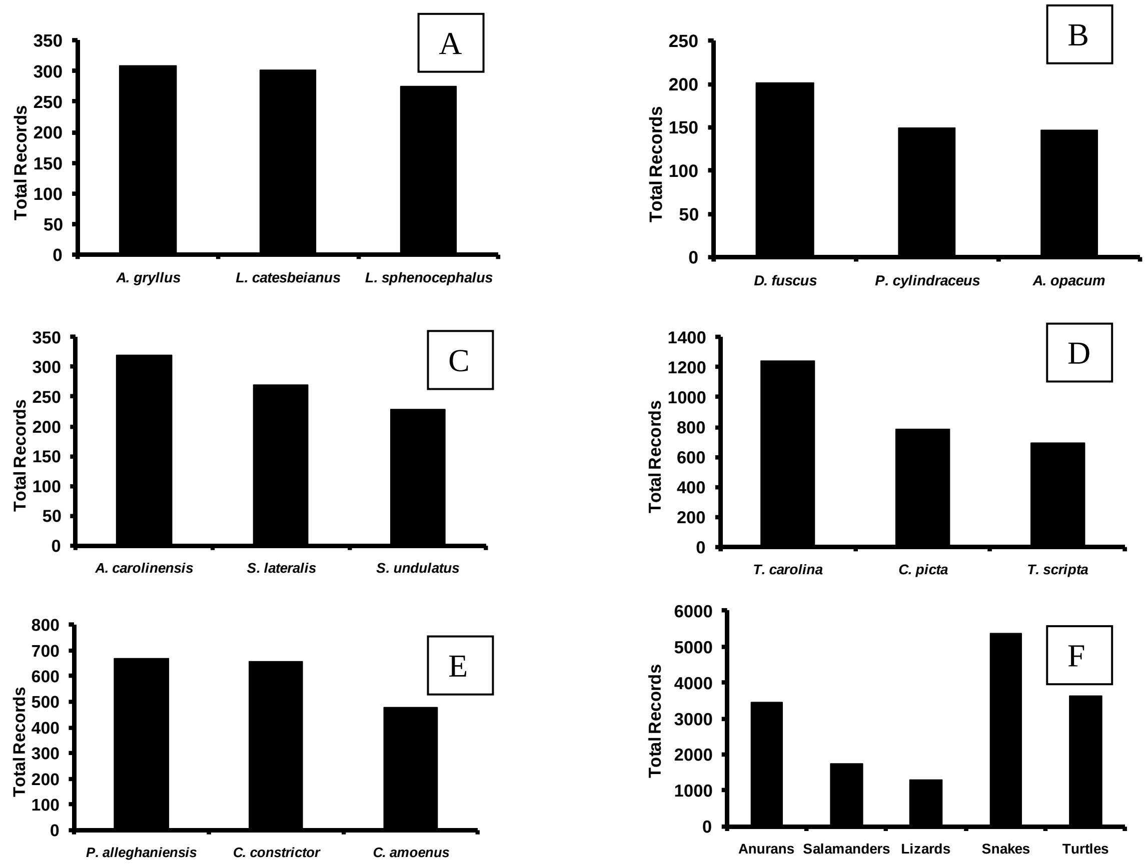

FIGURE 6. The most commonly reported frog (A), salamander (B), lizard (C), turtle (D), and snake (E) species to the Carolina Herp Atlas. From 1 March 2007 until 22 September 2009, snakes were the most commonly reported group, whereas lizards had the fewest reports (F).

in the CHA.

The CHA collected species-level distribution data for 32 frogs, 51 salamanders, 38 snakes, 12 lizards, 16 turtles, and the American Alligator (*Alligator mississippiensis*) in North and South Carolina. The most commonly reported group was snakes with 5,349 records (Fig. 6). The most commonly reported species was *Terrapene carolina* (Eastern Box Turtle; 1,239 records), followed by *Chrysemys picta* (Painted Turtle; 789 records), *Trachemys scripta* (Slider; 691 records), *Pantherophis alleganiensis* (Rat Snake; 668 records), *Coluber constrictor* (Racer; 657 records), *Carphophis amoenus* (Eastern Worm Snake; 479 records), *Agkistrodon contortrix* (Copperhead; 373 records), *Nerodia fasciata* (Banded Watersnake; 333 records), *Anolis carolinensis* (Green Anole; 324 records) and *Acris gryllus* (Southern Cricket Frog; 314 records; Fig. 6A-E displays the most commonly reported species in each group). Records of several amphibians and reptiles considered special concern, threatened, or endangered by the states of North and South Carolina have also been submitted to the CHA (Table 1).

DISCUSSION

The CHA provides an example of how citizens can contribute to herpetological research and conservation by providing distributional data across large spatial scales. The collection of 11,663 amphibian and reptile observations by 698 registered users in North and South Carolina during 31 months of operation suggests that the CHA has the potential to surpass many other herpetological atlas projects in number of observations and individual contributors. For example, the highly successful Georgia Herp Atlas (Jenson et al. 2008) collected 7,452 records (of which 6,632 were accepted) by 492 volunteers during its five years of operation. There may be several reasons for the large number of observations and users of the CHA. We suspect that the interactive features, such as "My Herps" and data visualization tools (e.g., real-time maps, tables, and charts), reward and encourage users to provide data to the CHA. Sullivan et al. (2009) found that participants

TABLE 1. Records of amphibian and reptile species submitted to the Carolina Herp Atlas from 1 March 2007 to 22 September 2009 that are listed as endangered (E), threatened (T), or of special concern (SC, R) by North or South Carolina. The Total Records column lists only the records for the state(s) where the species is listed.

Taxon	Species	Total Records	NC Status	SC Status
Amphibia: Urodella	Mole Salamander (*Ambystoma talpoideum*)	5	SC	--
	Tiger Salamander (*Ambystoma tigrinum*)	27	T	R
	Green Salamander (*Aneides aeneus*)	13	T	R
	Eastern Hellbender (*Cryptobranchus allenganiensis*)	6	SC	R
	Dwarf Salamander (*Eurycea quadridigitata*)	9	SC	--
	Four-toed Salamander (*Hemidactylium scutatum*)	5	SC	--
	Webster's Salamander (*Plethodon websteri*)	23	--	E
	Wehrle's Salamander (*Plethodon wehrlei*)	2	T	--
	Southern ZigZag Salamander (*Plethodon ventralis*)	1	SC	--
Amphibia: Anura	Northern Cricket Frog (*Acris crepitans*)	234	--	R
	Pine Barren's Treefrog (*Hyla andersonii*)	4	--	T
	Bird-voiced Treefrog (*Hyla avivoca*)	2	--	R
	Mountain Chorus Frog (*Pseudacris brachyphona*)	12	SC	--
	Upland Chorus Frog (*Pseudacris feriarum*)	230	--	R
	Gopher Frog (*Lithobates capito*)	3	T	E
	Pickerel Frog (*Lithobates palustris*)	43	--	R
Crocodylia	American Alligator (*Alligator mississippiensis*)*	69	T	--
Chelonia	Spiny Softshell (*Apalone spinifera*)	27	SC	--
	Loggerhead Sea Turtle (*Caretta caretta*)*	13	T	T
	Spotted Turtle (*Clemmys guttata*)	40	--	T
	Bog Turtle (*Glyptemys muhlenbergii*)*	7	T	T
	Striped Mud Turtle (*Kinosternon baurii*)	43	--	R
	Diamond-backed Terrapin (*Malaclemys terrapin*)	9	SC	--
Reptilia: Squamata; Serpentes	Eastern Diamond-backed Rattlesnake (*Crotalus adamanteus*)	17	E	R
	Timber Rattlesnake (*Crotalus horridus*)	184	SC	R
	Southern Hog-nosed Snake (*Heterodon simus*)	26	SC	R
	Eastern Milksnake (*Lampropeltis triangulum*)	36	--	R
	Harlequin Coralsnake (*Micrurus fulvius*)	3	E	R
	Florida Green Watersnake (*Nerodia floridana*)	25	--	R
	Pinesnake (*Pituophis melanoleucus*)	27	SC	R
	Black Swampsnake (*Seminatrix pygaea*)	67	--	R
	Pygmy Rattlesnake (*Sistrurus miliarius*)	35	SC	--

*The United States Fish and Wildlife Service designate these species as threatened according to the Endangered Species Act of 1973.

in the monumentally successful eBird project (i.e., 500,000 users and 21 million bird records) grew extensively when upgrades designed to increase user-reward were launched in fall 2005. Furthermore, the CHA effectively uses the internet for data submission and species identification, thus making submission of data less time consuming than previous atlas projects requiring mailing of forms and voucher photographs.

Although our results are preliminary, they provide some interesting information regarding observations provided by users. Snakes were the most commonly reported group, outnumbering turtles by approximately 1,700 records. This differed from Jenson et al. (2008), who found that frogs were the most commonly reported group in Georgia. For the most part, snakes are notoriously difficult to study because of their cryptic habits (Dorcas and Willson 2009); however, most people, whether they fear or are attracted to snakes, do pay attention to them and are interested in learning snake identification, especially if the species is venomous. We found that people who observed snakes often took photographs, which they used to identify the snake by searching the internet. The internet search would often lead them to the CHA website, where they submitted their observation. Five of the top 10 most reported species were snakes and included three common species, *Pantherophis alleganiensis*, *Coluber constrictor* and *Carphophis amoenus*. Of particular note, users submitted a surprisingly large number of observations for *Crotalus horridus* (Timber or Canebrake Rattlesnake; 184 records, 62 of the 184 included photo vouchers), a species listed as Special Concern in both South and North Carolina and considered imperiled throughout much of its range (Brown 1993). Although it is well known that *C. horridus* populations occur in the mountainous and coastal regions of the Carolinas, many observations submitted to the CHA were from the Piedmont region of both states, where *C. horridus* is considered rare (Palmer and Braswell 1995, Stroupe and Dorcas 2001). The Piedmont region is rapidly becoming urbanized (Griffith et al. 2003), thus the *C. horridus* records received by the CHA may represent significant contributions to our knowledge of the current status and distribution of the species, which may aid in the management and conservation of this species.

The most commonly reported species was the Eastern Box Turtle, *T. carolina* (1,239 records). The large number of submissions for *T. carolina* is encouraging from a conservation perspective, because throughout their range, Eastern Box Turtles are currently threatened by habitat loss, habitat fragmentation, and commercial trade (Dodd et al. 1989, Dodd 2001, Bowen et al. 2004). However, few baseline data exist on the status and distribution of the species. Our results have shown that citizen-science based efforts such as the CHA can provide data on the distribution of potentially declining species such as the Eastern Box Turtle.

Although the CHA has shown that citizen scientists can contribute important information on distribution and status of certain amphibians and reptiles in the Carolinas, some common species or groups were represented by relatively few records. Such a trend suggests that a certain degree of taxonomic bias is contained within the CHA dataset. Salamanders and lizards collectively represented about 20% of all records (Fig. 6). The low number of salamander records (11% of records) was likely a reflection of a combination of factors including their cryptic nature (e.g., usually underground), difficulty in species identification, and potentially fewer numbers of users in areas of highest species richness, particularly the Appalachian Mountains. Indeed, other citizen-science based monitoring projects, such as eBird, have found that datasets are most sparse in areas with lower human populations (Sullivan et al. 2009). Relatively few lizard submissions was likely a reflection of low species richness (15 species) and difficulty distinguishing among species such as *Plestiodon fasciatus* (Five-lined Skink), *P. inexpectatus* (Southeastern Five-lined Skink), and juvenile *P. laticeps* (Broadhead Skink), as well as the four species of glass lizards (genus *Ophisaurus*). In addition to reporting biases associated with species detectability, identification, and geographic distribution of users, additional problems were also likely associated with CHA data. Maintaining a consistent or increased level of interest is a challenge that all citizen science projects must deal with, although we continue to have new users register and new records submitted on a frequent basis. Most importantly, because the CHA appeals to users with a variety of skills in identifying amphibians and reptiles, the data collected likely contain misidentifications. If a photo voucher was not submitted, we could not be sure of species identity. Problems, such as those highlighted above, are important to keep in mind when using data collected by any citizen science program.

Despite the limitations associated with some of the CHA data, the CHA has the potential to aid wildlife managers and may help the general public become more knowledgeable about wildlife and science. Thus far, we have received requests for data from herpetologists and wildlife managers interested in assessing distribution patterns at local and over large geographic scales. These data would be difficult for researchers to obtain and nearly impossible to collect without the involvement of citizen scientists. The observations of special concern, threatened, and endangered species have also provided a better understanding of the distributions of these priority species (Table 1). Similar to other citizen-science programs (Sullivan et al. 2009), by contributing to the CHA, the general public can gain insight concerning scientific protocols and data collection. Education of the general public also occurs when the user has questions about identification or misidentifies a species and is questioned by Davidson College herpetologists. We have found this provides an excellent opportunity to teach about amphibian and reptile identification, distribution, and aspects of conservation and ecology. In addition to collecting useful data on distribution of amphibians and reptiles of the Carolinas, the CHA also represents an important step in allowing the public to become involved in herpetological conservation.

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LITERATURE CITED

Barrow, M.V. 1998. A Passion for Birds: American Ornithology after Audubon. Princeton University Press, Princeton, New Jersey, USA.

Bhattacharjee, Y. 2005. Citizen scientists supplement work of Cornell researchers. Science 308:1402–1403.

Bowen, K.D., P.L. Colbert, and F.J. Janzen. 2004. Survival and recruitment in a human-impacted population of Ornate Box Turtles, *Terrapene ornata*, with recommendations for conservation and management. Journal of Herpetology 38:562–568.

Brown, W.S. 1993. Biology, Status and Management of the Timber Rattlesnake (*Crotalus horridus*): A Guide for Conservation. SSAR Herpetological Circular 22: 1–84.

Casper, G.S. 1996. Geographic Distributions of the Amphibians and Reptiles of Wisconsin. Milwaukee Public Museum, Milwaukee, Wisconsin, USA.

Delany, D.G., C.D. Sperling, C.S. Adams, and B. Leung. 2008. Marine invasive species: validation of citizen science and implications for national monitoring networks. Biological Invasions 10:117–128.

Dhondt, A.A., T.L. Kast, and P.E. Allen. 2002. Geographic differences in seasonal clutch size variation in multi-brooded bird species. Ibis 144:646–651.

Dodd, Jr., C.K. 2001. North American Box Turtles: A Natural History. University of Oklahoma Press, Norman, Oklahoma, USA.

Dodd, Jr. C.K., K.M. Enge, and J.N. Stuart. 1989. Reptiles on highways in northcentral Alabama, USA. Journal of Herpetology 23:197–200.

Dorcas, M.E., and J.D. Willson. 2009. Innovative methods for studies of snake ecology and conservation. Pp. 5–37 *In* Snakes: Ecology and Conservation. Mullin, S.J., and R.A. Seigel (Eds.). Cornell University Press, Ithaca, New York, USA.

Evans, C., E. Abrams, R. Reitsma, K. Roux, L. Salmonsen, and P.P. Marra. 2005. The neighborhood nestwatch program: participant outcome of a citzen-science ecological research project. Conservation Biology 19:589–594.

Galloway, A.W.E., M.T. Tudor, and W.M. Vander Haegen. 2006. The reliability of citizen science: a case study of Oregon White Oak stand surveys. Wildlife Society Bulletin 34:1425–1429.

Garber, S.D, and J. Burger. 1995. A 20-year study documenting the relationship between turtle decline and human recreation. Ecological Applications 5:1151–1162.

Gibbons, J.W., V.J. Burke, J.E. Lovich, R.D. Semlitsch, T.D. Tuberville, J.R. Bodie, J.L. Green, P.H. Niewiarowski, H.H. Whiteman, D.E. Scott, J.H.K. Pechmann, C.R. Harrison, S.H. Bennett, J.D. Krenz, M.S. Mills, K.A. Buhlmann, J.R. Lee, R.A. Seigel, A.D. Tucker, T.M. Mills, T. Lamb, M.E. Dorcas, J.D. Congdon, M.H. Smith, D.H. Nelson, M.B. Dietsch, H.G. Hanlin, J.A. Ott, and D.J. Karapatakis. 1997. Perceptions of species abundance, distribution and diversity: lessons from four decades of sampling on a government-managed reserve. Environmental Management 21:259–268

Gibbons, J.W., D.E. Scott, T.J. Ryan, K.A. Buhlmann, T.D. Tuberville, B.S. Metts, J.L. Greene, T. Mills, Y. Leiden, S. Poppy, and C.T. Winne. 2000. The global decline of reptiles, déjà vu amphibians. BioScience 50:653–666.

Gibbs, J.P., A.R. Breisch, P.K. Ducey, G. Johnson, J.L. Behler, and R.C. Bothner. 2007. The Amphibians and Reptiles of New York State. Oxford University Press, New York, New York, USA.

Griffith, J.A., S.V. Stehman, and T.R. Loveland. 2003. Landscape trends in mid-Atlantic and southeastern United States ecoregions. Environmental Management 32:572–588.

Houlahan, J.E., C.S. Findlay, B.R.Schmidt, A.H Meyer, and S.L. Kuzmin. 2000. Quantitative evidence for global amphibian declines. Nature 404:752–755.

Jensen, J., C.D. Camp, J.W. Gibbons, and M. Elliot (Eds.). 2008. Amphibians and Reptiles of Georgia. University of Georgia Press, Athens, Georgia, USA.

Klemens, M.W. (Ed.). 2000. Turtle Conservation. Smithsonian Institution Press, Washington, D.C., USA.

LeBaron, G. 2009. The 109th Christmas Bird Count. American Birds 63:2–7.

Mullin, S.J., and R.A. Seigel (Eds.). 2009. Snakes: Ecology and Conservation. Cornell University Press, Ithaca, New York, USA.

Oscarson, D.B, and A.J.K. Calhoun. 2007. Developing vernal pool conservation plans at the local level using citizen-scientists. Wetlands 27:80–95.

Palmer, W.M., and A.L. Braswell. 1995. Reptiles of North Carolina. The University of North Carolina Press, Chapel Hill, North Carolina, USA.

Prysby, M.D., and K.S. Oberhauser. 2004. Temporal and geographical variation in Monarch densities: Citizen scientists document Monarch population patterns. Pp. 9–20 *In* The Monarch Butterfly: Biology and Conservation. Oberhauser, K., and M. Solensky (Eds.). Cornell University Press, Ithaca, New York, USA.

Reading, C.J., L.M. Luiselli, G.C. Akani, X. Bonnet, G. Amori, J.M. Ballouard, E. Filippi, G. Nanlleau, D. Pearson, and L. Rugiero. 2010. Are snake populations in widespread decline? Biology Letters 6:777-780.

Sauer, J.R., J.E. Hines, G. Gough, I. Thomas, and B.G. Peterjohn. 1997. The North American Breeding Bird Survey Results and Analysis. Version 96.4. Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Semlitsch, R.D. (Ed.). 2003. Amphibian Conservation. Smithsonian Institution Press, Washington, D.C., USA.

Stuart, S.N., J.S. Chanson, N.A. Cox, B.E.Young, A.S.L. Rodrigues, D.L. Fischman, and R.W. Waller. 2004. Status and trends of amphibian declines and extinctions worldwide. Science 306:1783–1786.

Stroupe, D.A., and M.E. Dorcas. 2001. The apparent persistence of *Crotalus horridus* in the western Piedmont of North Carolina. Herpetological Review 32:287–288.

Sullivan, B.L., C.L. Wood, M. J. Iliff, R. E. Bonney, D. Fink, and S. Kelling. 2009. eBird: A citizen-based bird observation network in the biological sciences. Biological Conservation 142:2282–2292.

Trumbull, D.J., R. Bonney, D. Bascom, and C. Cabral. 2000. Thinking scientifically during participation in a citizen-science project. Science Education 84:265–275.

Weir, L.A., and M.J. Mossman. 2005. North American Amphibian Monitoring Program (NAAMP). Pp. 307–313 *In* Amphibian Declines: The Conservation Status of United States Species. Lannoo, M. (Ed.). University of California Press, Berkeley, California, USA.

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