

2023

Citizen Science: Role of iNaturalist in Biodiversity Documentation and Education in Arkansas

K. Baker

University of Arkansas - Fort Smith, Fort Smith, AR

L. Barnes

University of Arkansas - Fort Smith, Fort Smith, AR

S. Rana

Haas Hall Academy, Fayetteville, AR

J. Jackson

University of Arkansas - Fort Smith, Fort Smith, AR

R. Kannan

University of Arkansas - Fort Smith, Fort Smith, AR
Follow this and additional works at: <https://scholarworks.uark.edu/jaas>



Part of the [Earth Sciences Commons](#), [Education Commons](#), [Engineering Commons](#), [Environmental Sciences Commons](#), [Life Sciences Commons](#), [Medicine and Health Sciences Commons](#), and the [Social and Behavioral Sciences Commons](#)

Recommended Citation

Baker, K.; Barnes, L.; Rana, S.; Jackson, J.; and Kannan, R. (2023) "Citizen Science: Role of iNaturalist in Biodiversity Documentation and Education in Arkansas," *Journal of the Arkansas Academy of Science*: Vol. 77, Article 20.

<https://doi.org/10.54119/jaas.2023.77119>

Available at: <https://scholarworks.uark.edu/jaas/vol77/iss1/20>

This article is available for use under the Creative Commons license: Attribution-NoDerivatives 4.0 International (CC BY-ND 4.0). Users are able to read, download, copy, print, distribute, search, link to the full texts of these articles, or use them for any other lawful purpose, without asking prior permission from the publisher or the author.

This Article is brought to you for free and open access by ScholarWorks@UARK. It has been accepted for inclusion in Journal of the Arkansas Academy of Science by an authorized editor of ScholarWorks@UARK. For more information, please contact scholar@uark.edu, uarepos@uark.edu.

Citizen Science: Role of iNaturalist in Biodiversity Documentation and Education in Arkansas

K. Baker¹, L. Barnes¹, S. Rana², J. Jackson¹, and R. Kannan^{1,3}

¹*College of Arts and Sciences, University of Arkansas - Fort Smith, Fort Smith, AR 72913*

²*Haas Hall Academy, Fayetteville, AR 72703*

³Correspondence: ragupathy.kannan@uafs.edu

Running title: Citizen Science: iNaturalist's Role in Biodiversity Documentation and Education

Abstract

iNaturalist is a global online digital platform for documenting and fostering interest in biodiversity, with Research Grade (RG) entries being vetted and scientifically valid observations. Here we present a review of the role of approximately 16,000 Arkansans using the iNaturalist tool for recording 445,000 verifiable observations comprising 10,800 species, with 40 percent RG, and one third of observations still pending confirmation. Overall, plants lead in RG observations followed by invertebrates and birds. Within these groups, reptiles lead in proportion of RG observations, followed by birds and amphibians. Less charismatic or infrequently encountered organisms are less represented. Arkansas ranks about average in per capita number of RG observations relative to other states. We urge further usage of this tool to increase biota awareness and research within the state of Arkansas.

Introduction

Engaging students and local people in science activities and mobilizing the public to gather and record scientific data opens science to the public (Bhattacharjee 2005, Aristeidou *et al.* 2021). With the digital revolution of the last decade, such citizen science ventures have played a significant role in researching and documenting biodiversity and in enhancing biota awareness of its participants (Bonney *et al.* 2016, Stevenson *et al.* 2021).

iNaturalist (www.iNaturalist.org) is a leading example. This powerful tool for engaging and educating people concerning the natural diversity of the world they live in was initially a joint initiative by the California Academy of Sciences and the National Geographic Society, but it is now an independent non-profit organization. The stated vision of iNaturalist is a world where everyone can understand and help sustain biodiversity through the practice of observing wild

organisms and sharing information about them. Its mission is to build a global network of 100 million naturalists by 2030 to connect people to nature and advance biodiversity science and conservation (iNaturalist 2023).

iNaturalist is not only a global online fellowship of citizens sharing biodiversity information. It is also a crowd-sourced species identification system that records and monitors occurrences of organisms. Through its web-based platform, easy-to-use mobile application, built-in artificial intelligence image recognition, and human vetting process, citizens help generate research quality data for scientists focused on understanding and conserving the world's biota. Such data are valuable for studying the distribution of organisms over large spatio-temporal scales (Bonney *et al.* 2009), especially in the wake of global disruptions caused by anthropogenic climate change (Kannan and James 2009, Stephenson and Stengel 2020, Callaghan *et al.* 2022).

The popularity of iNaturalist is due in part to its ease of use. Its mobile application enables users to upload photographs of organisms, and almost immediately, the image recognition system suggests a tentative identification. All photographs are geo-referenced to capture exact locations (obscured for sensitive species). A "Verifiable" observation is of a wild organism with documentary evidence (mostly photographs, but can also be audio, tracks, etc.) with date and locality information. Volunteer experts (those familiar with that taxonomic group) serving as "Identifiers" weigh in with their feedback from around the world. Observations are elevated to "Research Grade" (RG) if at least 2/3 of identifiers agree on the species. RG observations can be considered a scientific record of that species in that time and place. Unconfirmed or pending (but Verifiable) identifications are designated "Needs ID", and those that lack evidence, date, or exact location information (or of captive or cultivated organisms) are relegated to "Casual" status.

Citizen Science: iNaturalist's Role in Biodiversity Documentation and Education

RG observations can revert to Needs ID status if subsequent identifications by the network make it fall below the 2/3 threshold. Some observations at a coarser taxonomic level than species for some taxa for which photographs alone are insufficient (see Kays *et al.* 2022) may be designated RG if it is “as good as it can be,” and therefore, further refining of identification is deemed by the community to be unlikely.

Although the image recognition system of iNaturalist does make mistakes, it can be impressive. A photograph of a dismembered corpse of a rabbit (Figure 1A) was correctly identified as the Eastern Cottontail *Sylvilagus floridanus*. A Lichen-carrying Green Lacewing *Leucochrysa pavida* (Figure 1B) was also correctly identified. Both of these remarkable identifications were later confirmed and upgraded to RG level.



Figure 1A. (left) Dismembered corpse identified as an Eastern Cottontail. Figure 1B. (right) Lichen-carrying Green Lacewing. Both were correctly identified by the image recognition system of iNaturalist. Photos 1A and 1B by Ragupathy Kannan and Luke Barnes, respectively.

Here, we provide an overview of the role played by iNaturalist in the mostly photographic documentation of biodiversity of Arkansas (AR). We compare the number of RG observations in AR with other states to highlight the scope for further improving this database to educate our citizenry and document our Natural State's biota. We also highlight projects done by the state's educational and research institutions to promote biodiversity education and document biota of their campuses or taxonomic subjects of interest. Our goal in making this compilation is to make more scientists, schoolteachers, and college faculty aware of this resource, so that they can use this invaluable research and teaching tool to promote biodiversity studies and education in AR.

Methods

To survey the biodiversity reported from AR, we used the Explore and Filter features in iNaturalist to list all RG observations of wild organisms in AR. We then sorted those observations by their taxonomic group and listed the number of observers, identifiers, and species. We also graphically portrayed the proportion of all AR observations that are categorized as Casual, Needs ID, and RG for each major taxonomic group.

To gauge the level of usage of iNaturalist in AR relative to the other 49 states in the United States, we computed and ranked the per capita number of RG observations in each state.

Finally, to investigate the pedagogic and biota research efforts underway in our state we listed all iNaturalist “Projects” (specifically focused endeavors to document a particular region or focus on specified taxa) with at least 200 RG observations in AR and listed the number of RG observations and species recorded in each.

It should be noted that data in iNaturalist is in constant flux, with citizens constantly uploading data. Unless indicated otherwise, the data presented here represent a snapshot downloaded in March-April of 2023.

Results

I. Biodiversity documentation in Arkansas

A comprehensive list of the major taxa reported in iNaturalist from AR is given in Appendix I. These tables present the total number of observations with supporting evidence (mostly photographic but including audio and traces of organisms like tracks) that have been designated RG, i.e., verified by at least 2/3 of identifiers, and thus constituting a scientific record of that organism in that time and place. The number of species in each category is also provided. The classification used is up to the family level in most taxa presented. Due to space constraints, some taxa (Arthropoda, Non-Vascular plants, Invertebrates) are presented at a higher classification level.

Globally, the iNaturalist database had 129,005,561 Verifiable observations as of 15 March 2023 from 419,139 species and 2,537,285 observers. From the United States, there were 60,890,216 observations from 91,858 species and 1,332,514 observers by the same date. Of these observations from the United States, 453,362 (0.74%) were from AR, comprising 10,776 (11.7%) species and 16,328 (1.22%) observers. The

average time for recorded observations to be confirmed by reviewers is around 90 hours.

Of the major taxonomic categories observed in AR, plants lead in the RG observations, comprising 47% of all RG observations from the state, followed by invertebrates (28%) and birds (9%). Plants also comprise the largest group in the Needs ID category, with 50% of all Needs ID observations in AR, followed by invertebrates (33%), and fungi (15%) (Figure 2).

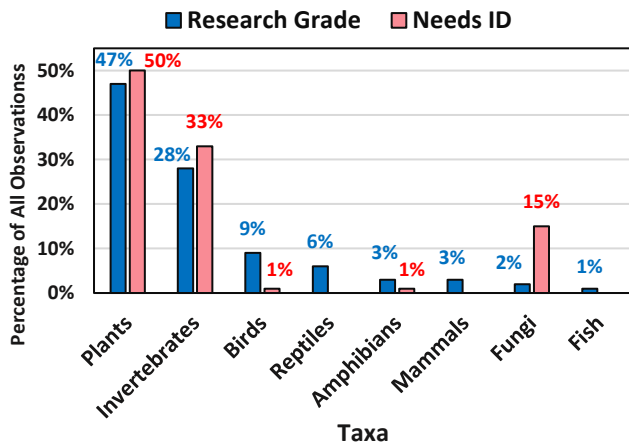


Figure 2. Percentage of Arkansas observations in iNaturalist by taxon and grade

Forty percent of all observations uploaded from AR have been elevated to RG (Figure 3). An additional 34% of AR observations are pending confirmation, in the Needs ID status, for a total of 74% of observations in the Verifiable grade. Some observations may be permanently in that Needs ID status because photographs alone may be insufficient to positively identify to the species level. Only 26% of all observations from AR are in the Casual status (Figure 3), meaning, those that are not supported by either the exact date or location or both, or are of captive or cultivated organisms.

Within each individual major taxa (Figure 3), observations of reptiles in AR were most often upgraded to RG status, with 95% of observations of that taxon reaching this highest classification. This is followed by birds (93%), amphibians (86%), fishes (84%), and mammals (81%). The more taxonomically challenging taxa (plants, fungi, and invertebrates) are less often upgraded to RG, due to the inherent difficulties in identifying them to finer levels, especially with just a photograph, and perhaps due to relative paucity in identifiers of those taxa.

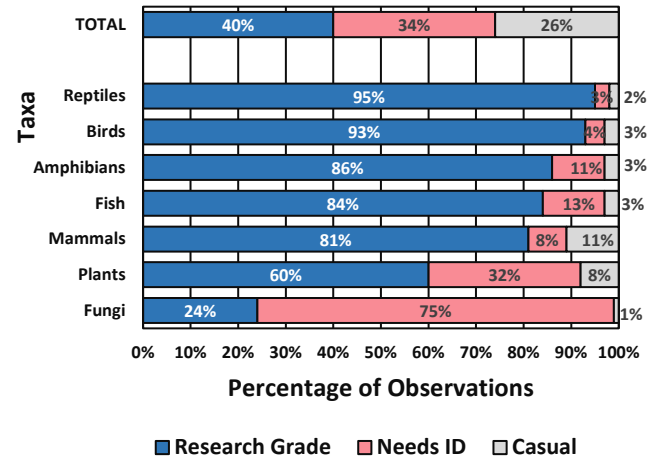


Figure 3. Distribution of quality grade within each taxonomic category in Arkansas.

An overview of the iNaturalist observations from AR indicates that animals often reported by citizens are mostly of a charismatic and conspicuous nature (e.g., Northern Cardinal *Cardinalis cardinalis*, Figure 14). Therefore, fauna that are cryptic or not “attractive,” and those that are less encountered, like nocturnal forms, are relatively less represented, although they may be common (e.g., Nematodes [no observations], Barn Owls [2 observations], and Pocket Gophers [7 observations]). Similarly, in plants and fishes, many of the most observed families are those which are ornate and/or widespread, such as sunflowers (Asteraceae) and sunfishes (Centrarchidae). Those that are least observed tend to be inconspicuous (like mosses [Bryophyta]), or not easily collectable big river inhabitants (Paddlefishes [Polyodontidae]). Also, microscopic organisms like viruses, bacteria, and protozoa, are rarely or never reported.

This indicates that data reported in iNaturalist, due to its very nature of being citizen-driven, do not represent an unbiased, uniform, or systematic sampling of the entire gamut of biodiversity in an area. Also, due to the participation of people from all walks of life, including those with little or no scientific training, there is some inevitable “noise” in the data. For example, even some RG observations include captive animals, since observers failed to report that they were captives and because these observations evaded scrutiny of curators or reviewers. Also, due to over-reliance on the species identification system, misidentifications of similar looking species are common. For example, the Eastern Mole (*Scalopus aquaticus*) is routinely misidentified as the European Mole (*Talpa europaea*), resulting in the odd North American report (Thomas W. French, personal communication).

Citizen Science: iNaturalist's Role in Biodiversity Documentation and Education

A small group of AR users account for a disproportionate number of observations. The top 99 observers from AR comprise only 0.59% of all AR observers, but they are responsible for 50% of the total AR observations. Similarly, the top 16 observers completed 25% of all AR observations while only representing 0.01% of AR observers. The leading observer is Joseph McPhail, who goes by the handle *thebirdnerd*. He single-handedly is responsible for 3% of AR observations, documenting 25% of species reported in AR.

Leading organisms in the major taxa in Arkansas

To present an idea of the types of common information generated by iNaturalist, we provide the most observed organisms for each of the major taxa in AR (Figs. 4-15, updated August 2023). For each of the organisms, we present the total number of observations that are Verifiable (V: including Research Grade and Needs ID). Since this is entirely a citizen-driven endeavor, we also include the top observer and identifier for each species (by their site handle names) and their number of observations or identifications of that species. We also provide seasonality graphs showing the number of V and RG level observations across the year.

An overview of the seasonality graphs shows that most observations are reported in the spring and summer months, a time when people are more likely to be outdoors in AR and when species are more easily observed. Some exceptions include Monarch Butterflies (Figure 10), which are more observed during fall migration, and Northern Cardinals (Figure 14), which showed a peak in February when they are more reported during the annual Great Backyard Bird Count (Birdcount.org 2023). The graphs for V and RG observations are nearly overlapping for species that are more readily recognized and thus more likely to be moved into the higher RG category (like the vertebrates in Figs. 11-15). The two graphs that show a more pronounced difference between the more inclusive V category and refined RG are for the relatively less-known protozoans and invertebrates, which have a lower percentage of observations moved into the higher RG category (Figs. 4 and 8). All images below were downloaded from AR reports in iNaturalist.org. Photographer iNaturalist usernames are in parentheses.

Arkansas rarities and endemics documented by iNaturalist

Citizen scientists have documented (RG) rarely observed organisms from AR in iNaturalist (Figure 16).

Protozoa Dog Vomit Slime Mold

Fuligo septica
Verifiable Observations: 114
Top Observer: kmcabe73 16
Top Identifier: cosmiccat 36

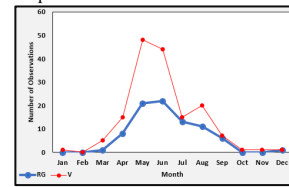


Figure 4. Dog Vomit Slime Mold, leading Protozoa species, Photo: © fishecke (Fishecke)

Fungi Ringless Honey Mushroom

Desarmillaria caespitosa
Verifiable Observations: 298
Top Observer: little_metal_weirdo 13
Top Identifier: pyknlnx 127

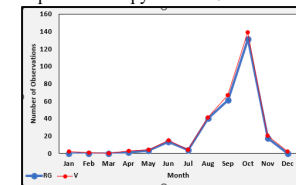


Figure 5. Ringless Honey Mushroom, leading Fungus species, Photo: © Matthew Hammond (little_metal_weirdo)

Plants American Sweetgum

Liquidambar styraciflua
Verifiable Observations: 1143
Top Observer: jrighardabbott 57
Top Identifier: brent_baker 612

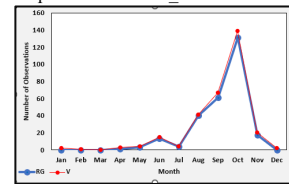


Figure 6. American Sweetgum, leading Plant species, Photo: Tony Alter

Platyhelminthes Shovel-headed Garden Worm

Bipalium kewense
Verifiable Observations: 70
Top Observer: tbrittney24 5
Top Identifier: bekahwal 68

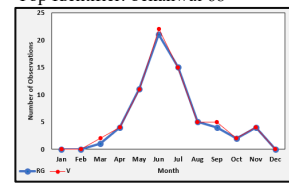


Figure 7. Shovel-headed Garden Worm, leading Platyhelminthes species, Photo: © arkansawyer (handle- arkansawyer)

These include organisms at the edge of their overall range, found only in highly specific habitats, and endemics (found only in AR or this region). Some are identified as Endangered or Vulnerable by iNaturalist. Most of these have been documented just a few times

Annelida Smooth Turtle Leech*Placobdella parasitica*

Verifiable Observations: 47

Top Observer: dustin_lynch 4

Top Identifier: moserw 21

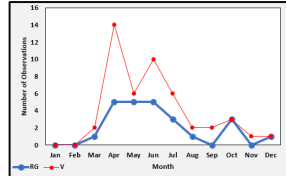


Figure 8. Smooth Turtle Leech, leading Annelida species, Photo: © Arkansas Naturalista (handle- arkansasnaturalista)

Mollusks Leopard Slug*Lima maximus*

Verifiable Observations: 105

Top Observer: little_metal_weirdo 11

Top Identifier: berkshirenaturalist 70

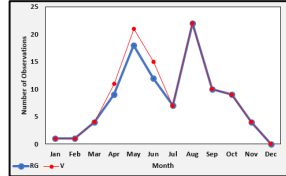


Figure 9. Leopard Slug, leading Mollusk species, Photo: © Taitmon Lynch (handle- taitmon)

Insects Monarch Butterfly*Lima maximus*

Verifiable Observations: 2,573

Top Observer: ksanders 207

Top Identifier: thebirdnerd 997

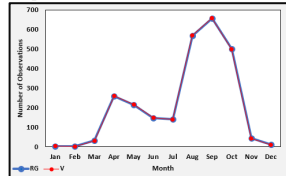


Figure 10. Monarch Butterfly, leading Insect species, Photo: © bill1953 (handle- bill1953)

Fishes Longear Sunfish*Lepomis megalotis*

Verifiable Observations: 389

Top Observer: dustin_lynch 66

Top Identifier: uconnbirdfish 185

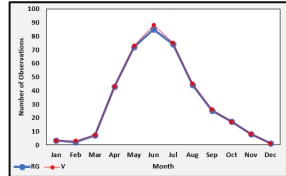


Figure 11. Longear Sunfish, leading Fish species, Photo: © Coley Turner (handle- coleylikeoptera)

Amphibians American Toad*Anaxyrus americanus*

Verifiable Observations: 1,181

Top Observer: kaptankory 56

Top Identifier: kaptankory 1,140

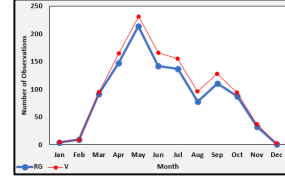


Figure 12. American Toad, leading Amphibian species, Photo: © Gerry Salmon

Reptiles Common Box Turtle*Terrapene carolina*

Verifiable Observations: 2,579

Top Observer: jdwilson 83

Top Identifier: kaptankory 2,540

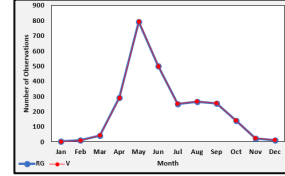


Figure 13. Common Box Turtle, leading Reptile species, Photo: © Tony Gerard

Birds Northern Cardinal*Cardinalis cardinalis*

Verifiable Observations: 1,371

Top Observer: puidwen 233

Top Identifier: thebirdnerd 384

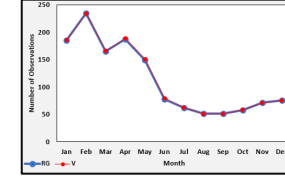


Figure 14. Northern Cardinal, leading Bird species, Photo: © Ad Konings

Mammals Black Bear*Cardinalis cardinalis*

Verifiable Observations: 1,436

Top Observer: lynnettaward 384

Top Identifier: oviscanadensis_connerties 1,169

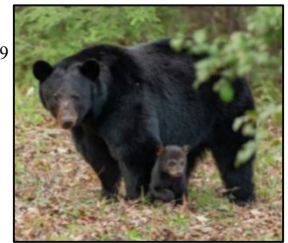
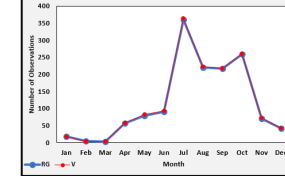


Figure 15. American Black Bear, leading Mammal species, Photo: © Dan LaVorgna

Citizen Science: iNaturalist's Role in Biodiversity Documentation and Education

American Badger

Taxidea taxus



Photo: © aerussom
1 report, edge of range

Eastern Spotted Skunk

Spilogale putorius



Photo: © brantport14
(brantport14)
2 reports, Globally
Vulnerable; at the edge of
range

Interior Least Tern

Sterna antillarum
ssp. *Athalassos*



Photo: © Jared Gorrell
(ildlandblogger)
2 reports, Federally listed as
Endangered

Graham's Crayfish Snake

Regina grahamii



Photo: © Joe Neal
60 reports, State Species of
Greatest Conservation Need,
endemic to central United States

Leopard Darter

Percina pantherina



Photo: © Dustin Lynch, Arkansas
Natural Heritage Commission
3 reports, Globally Endangered
(IUCN Redlist); found only OK/AR

Ouachita Madtom

Noturus lachneri



Photo: © (maurer416)
5 reports, Federally listed as
Endangered

Strawberry Darter

Etheostoma fragi



Photo: © (maurer416)
2 reports, Federally
listed as Endangered

Caddo Mountain Salamander

Plethodon caddoensis



Photo: © (tomfeid)
94 reports, Arkansas endemic

Appalachian Filmy Fern

Vandenboschia boschiana



Photo: © Sunny Fleming
(trichomanes)
3 reports, Found only in damp
limestone grottoes or sandstone
overhangs in the Boston Mountains

Newton's Larkspur

Delphinium newtonianum



Photo: © (tallpultheforester)
13 reports, Arkansas endemic

French's Shooting Star

Primula frenchii



Photo: © Kristin Adams
(knlongm87)
3 reports, Relict in the Boston
Mountains

Arkansas Fatmucket

Lampsilis powellii



Photo: © Ben Thesing
(benthising)
2 reports, Threatened in the
United States

Figure 16. Some Arkansas rarities and endemics documented in iNaturalist. List gleaned from: ANHC [Arkansas Natural Heritage Commission] 2023.

(Figure 16), emphasizing the scope for vastly improving this aspect of the database. Notable species with no RG observations recorded in AR include the endangered Indiana Bat (*Myotis sodalis*) and the Ozark Cavefish (*Troglichthys rosae*).

Relative status of iNaturalist usage in Arkansas

Arkansas ranks at the median (25th) among all states in terms of the number of RG observations per capita (0.094) posted in iNaturalist, placing AR just below the national mean of 0.114 in RG observations per capita (Table 1). To further put that in perspective, AR ranks 33rd in population and 29th in area (<https://worldpopulationreview.com/states>). Two states with similar populations as AR, Nevada and Mississippi, showed lower per capita rates (0.067 and

0.069, respectively) than AR. Two states with similar areas, North Carolina and Alabama, had only slightly higher per capita number of observations than AR (0.10 each). Therefore, AR may be considered about average in representation in iNaturalist, highlighting the scope for further improvement in participation and education of our citizenry about this invaluable pedagogic and documentation tool.

II. Biodiversity education in Arkansas

iNaturalist has the potential to contribute significantly to science teaching. In particular, high school students who demonstrate understanding of the standards on Interdependent Relationships in Ecosystems from the National Science Teaching Association (NSTA) should be able to “Define,

evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity” (HS-LS2-7, NSTA 2023). Students involved in iNaturalist projects on how to promote and conserve biota in their campuses or neighborhoods can gain practical insights on this concept. Campus projects outlined below foster such ventures.

iNaturalist Projects in Arkansas

We compiled 87 special projects from AR in iNaturalist and listed the number of RG observations and species (Appendix II). These projects focus on the biota of a particular locale or taxonomic group. The top three were Native Arkansas Organisms (225,961 observations, 4,382 species), Arthropods of Arkansas (78,817 observations, 3,755 species), and BioBlitz at Bearitage Spring 2019 (102,957 observations, 18,636 species). The various projects ranged the taxonomic array from invasive plants and moths, to fungi, wildflowers, thistles, and leafhoppers (Appendix II). They also covered a variety of localities ranging from the specific (e.g., Jewel Moore Nature Reserve [Faulkner Co.], Greater Memphis Metro Area [Crittenden Co.]) to the general (Washington Co., Ouachita Mountains). (A project named Biodiversity of Arkansas is omitted here because of its generic nature).

Of pedagogic interest were the 15 college campus projects (Appendix II). “Plants of the University of Arkansas at Monticello (UAM)” listed the greatest number of RG observations (23,988) and species (1,315), followed by “Biodiversity of Arkansas State University” (1,020 observations, 347 species) and “Plant Tax – Arkansas State University” (556 observations, 194 species). Campuses with natural or semi-natural vegetation (like UAM) led the group, whereas more urban campuses were near the bottom of the list, highlighting the importance of native vegetation and habitat diversity to promote biodiversity and biota education in our higher education institutions.

We started the “Biodiversity of UAFS campus” project to develop a baseline of biodiversity in our campus (University of Arkansas - Fort Smith) and to make the campus more biota friendly over time. As of September 2023, the project has notched 342 RG observations (46.3% of all observations reported) and 302 species. Students from two courses, freshman biology and junior level ecology, have done “BioBlitzes” (Lundmark 2003, National Geographic 2023), intensive flora and fauna documentation for short periods of time inside the campus, often during designated lab periods. Students are encouraged but not

Table 1. iNaturalist Observations Per Capita by State

State	RG	Population	Per capita
Vermont	622,375	643,077	0.968
Alaska	231,719	733,391	0.316
Maine	327,389	1,362,359	0.240
Hawaii	287,016	1,455,271	0.197
New Hampshire	266,199	1,377,529	0.193
California	7,384,326	39,538,223	0.187
New Mexico	391,914	2,117,522	0.185
Oregon	771,630	4,237,256	0.182
Texas	5,001,740	29,145,505	0.172
Wyoming	95,562	576,851	0.166
Maryland	978,905	6,177,224	0.158
Massachusetts	985,611	7,029,917	0.140
Delaware	134,741	989,948	0.136
Virginia	1,168,457	8,631,393	0.135
Arizona	861,999	7,151,502	0.121
Montana	128,377	1,084,225	0.118
Washington	909,986	7,705,281	0.118
Minnesota	637,563	5,706,494	0.112
USA Total	37,788,974	330,759,736	0.114
North Carolina	1,123,485	10,439,388	0.108
Colorado	603,096	5,773,714	0.104
Florida	2,236,303	21,538,187	0.104
Ohio	1,223,829	11,799,448	0.104
Alabama	506,651	5,024,279	0.101
Wisconsin	575,495	5,893,718	0.098
Arkansas	284,336	3,011,524	0.094
West Virginia	168,367	1,793,716	0.094
Idaho	162,049	1,839,106	0.088
Connecticut	308,132	3,605,944	0.085
Utah	278,465	3,271,616	0.085
Pennsylvania	1,069,014	13,002,700	0.082
New York	1,624,203	20,201,249	0.080
Tennessee	551,325	6,910,840	0.080
New Jersey	736,680	9,288,994	0.079
South Carolina	397,765	5,118,425	0.078
Oklahoma	303,533	3,959,353	0.077
South Dakota	66,841	886,667	0.075
Louisiana	347,139	4,657,757	0.075
Illinois	940,482	12,812,508	0.073
Mississippi	205,564	2,961,279	0.069
Nevada	207,895	3,104,614	0.067
Rhode Island	72,944	1,097,379	0.066
Michigan	646,651	10,077,331	0.064
Missouri	376,999	6,154,913	0.061
Kentucky	271,447	4,505,836	0.060
Kansas	164,401	2,937,880	0.056
Indiana	368,716	6,785,528	0.054
Georgia	529,374	10,711,908	0.049
North Dakota	38,135	779,094	0.049
Nebraska	95,414	1,961,504	0.049
Iowa	118,735	3,190,369	0.037

Citizen Science: iNaturalist's Role in Biodiversity Documentation and Education

required to participate (iNaturalist works best when students are not required to do observations for a grade). Many have then followed up with posting more observations off-class, made incidentally while moving about the campus. Some have even recorded observations made while inside classrooms (for example, Brown Recluse *Loxosceles reclusa* <https://www.inaturalist.org/observations/133074997>). These were done spontaneously and voluntarily, indicating that iNaturalist has sparked their curiosity on the living world around them, potentially inspiring a new generation of scientists and naturalists to monitor the state's biodiversity.

iNaturalist fostering interest and research on a cryptic Arkansas mammal—a case study

On 26 February 2023, one of us (Luke Barnes), an undergraduate biology major and aspiring wildlife biologist, found a dead shrew (Soricidae, Mammalia) in Fort Smith, AR (Sebastian County) and uploaded a photograph (Figure 17) in iNaturalist (<https://www.inaturalist.org/observations/149752130>). Shrews are one of several organisms which cannot be conclusively identified based solely on photographs (Kays *et al.* 2022).

In response to LB's posting, Thomas W. French, an iNaturalist curator, suggested that it was one of the Short-tailed Shrews (*Blarina*). He also commented that the zone of contact between the Northern Short-tailed Shrew (*Blarina brevicauda*) and the Southern Short-tailed Shrew (*B. carolinensis*) probably runs through Sebastian Co., but the precise delineation in range is unknown. He suggested that the specimen be obtained and donated to a mammal research collection to help define the zone of contact between these two species. Upon French's advice, LB collected the specimen and sent it to Russell Pfau, who co-authored a paper on this matter (Pfau *et al.* 2011). In March 2023, Pfau advised LB that DNA extractions are in progress from the heart, liver, and toe of the specimen. This case illustrates the invaluable nature of iNaturalist in piquing and fostering interest among field biology students and in advancing further inquiries regarding little-known, seclusive, nocturnal, or cryptic species. It also reinforces the importance of museum collections. Photographs can supplement, not replace, museum voucher specimens, which remain the gold standard for taxonomic descriptions (Kannan 2007).



Figure 17. Short-tailed Shrew *Blarina* spp. found and photographed by Luke Barnes.

Conclusions

Many Arkansans reject science or distrust science-based recommendations (King 2021, USAfacts 2023). Connecting people to science promotes appreciation of the scientific process and credence in its findings. Citizen science endeavors like iNaturalist offer hope to make such liaisons. Also, in this current digital age, many students rely more on online and digital learning than traditional means. Adapting to their comfort zones and switching to digital content could be a more effective means to connect to them. Digital learning can provide more interactivity, engagement, and retention than traditional modes (Goode *et al.* 2022). iNaturalist is a boon to aspiring field biology students and amateurs because it provides all the benefits of online learning. iNaturalist has even broadened horizons for professional scientists by making them more versatile as teachers and naturalists. We hope that this compilation will stimulate further usage of this tool in AR to develop a more informed citizenry and to better monitor and conserve our Natural State's biological treasures.

Acknowledgments

The Molly and Thurman Jordan Memorial Endowment for Biology Research (UAFS) helped fund this project. Two iNaturalist curators, Thomas W. French and Bob Jacobs, and an anonymous reviewer reviewed the manuscript and offered several helpful suggestions. Tom Buchanan offered insights into the fishes database. We thank all the 16,328 observers from AR who recorded their observations in this invaluable

database and the 9,467 identifiers who kept the engines of taxonomy humming. iNaturalist exists and flourishes due to its phalanx of observers, volunteer identifiers and curators, generous donors, software engineers, supporting NGOs and academic institutions, and its talented staff.

Literature Cited

- ANHC [Arkansas Natural Heritage Commission] 2023. Endangered, Threatened, and Rare Species [of Arkansas]. <https://encyclopediaofarkansas.net/entries/endangered-threatened-and-rare-species-2622/> Accessed 17 April 2023.
- Aristeidou M, C Herodotou, HL Ballard, AN Young, AE Miller, and L Higgins. 2021. Exploring the participation of young citizen scientists in scientific research: The case of iNaturalist. PLOS ONE 16(1): e0245682. DOI: <https://doi.org/10.1371/journal.pone.0245682>
- Bhattacharjee Y. 2005. Citizen scientists supplement work of Cornell researchers. Science 308:1402-1403. DOI: <https://doi.org/10.1126/science.308.5727.1402>
- Bonney B, TB Phillips, HL Ballard, and JW Enck. 2016. Can citizen science enhance public understanding of science? Public Understanding of Science 25:2-16. DOI: <https://doi.org/10.1177/0963662515607406>
- Bonney R, CB Cooper, J Dickinson, S Kelling, T Phillips, KV Rosenberg, and J Shirk. 2009. Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy. BioScience, Volume 59, Issue 11, December 2009, Pages 977-984. DOI: <https://doi.org/10.1525/bio.2009.59.11.9>
- Birdcount.org. 2023. www.birdcount.org. (Accessed 7 April 2023).
- Callaghan CT, T Mesaglio, JS Ascher, TM Brooks, AA Cabras, M Chandler, WK Cornwell, IC Ríos-Málaver, E Dankowicz, NU Dhiya'ulhaq, RA Fuller, C Galindo-Leal, F Grattarola, S Hewitt, L Higgins, C Hitchcock, KJ Hung, T Iwane, P Kahumbu, R Kendrick, S Kieschnick, G Kunz, CC Lee, C Lin, S Loarie, MN Medina, MA McGrouther, L Miles, S Modi, K Nowak, R Oktaviani, BMW Olewe, J Pagé, S Petrovan, C Saari, CE Seltzer, AP Seregin, JJ Sullivan, AP Sumanapala, A Takoukam, J Widness, K Willmott, W Wüster, and AN Young. 2022. The benefits of contributing to the citizen science platform iNaturalist as an identifier. PLoS Biol 20(11):e3001843. <https://doi.org/10.1371/journal.pbio.3001843>
- Goode E, J Nieuwoudt, and T Roche. 2022. Does online engagement matter? The impact of interactive learning modules and synchronous class attendance on student achievement in an immersive delivery model. Australasian Journal of Educational Technology 38:76-94. DOI: <https://doi.org/10.14742/ajet.7929>
- iNaturalist. 2023. <https://www.inaturalist.org/pages/about>. Accessed 15 March, 2023.
- Kannan R. 2007. New bird descriptions without proper voucher specimens: reflections after the Bugun Liocichla case. Journal of the Bombay Natural History Society 104:12-18.
- Kannan R and DA James. 2009. Effects of climate change on global biodiversity: a review of key literature. Tropical Ecology 50:31-39.
- Kays R, M Lasky, ML Allen, RC Dowler, MTR Hawkins, AG Hope, BA Kohli, VL Mathis, B McLean, LE Olson, CW Thompson, D Thornton, J Widness, and MV Cove. 2022. Which mammals can be identified from camera traps and crowdsourced photographs? Journal of Mammalogy 103:767-775.
- King K. 2021. Starting at the beginning: Student misconceptions about evolutionary theory as assessed on the first day of class. Journal of College Science Teaching 50 (May-June 2021):41-46.
- Lundmark C. 2003. BioBlitz: Getting into backyard biodiversity. BioScience 53:329. DOI: [https://doi.org/10.1641/0006-3568\(2003\)053\[0329:BGIBB\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2003)053[0329:BGIBB]2.0.CO;2)
- National Geographic. 2023. Guide to BioBlitz. A program in conjunction with iNaturalist.org. <https://media.nationalgeographic.org/assets/files/NationalGeographicBioBlitzGuide.pdf>. Accessed 2 March 2023.
- NSTA [National Science Teaching Association]. 2023. Science Standards. <https://my.nsta.org/ngss/DisplayStandard.aspx?view=topic&id=47> Accessed 7 April 2023.
- Pfau RS, DB Sasse, MB Connior, and IF Guenther. 2011. Occurrence of *Blarina brevicauda* in Arkansas and notes on the distribution of *Blarina carolinensis* and *Cryptotis parva*. Journal of the Arkansas Academy of Science: 65:61-66. DOI: <https://doi.org/10.54119/jaas.2011.6507>

Citizen Science: iNaturalist's Role in Biodiversity Documentation and Education

- Stephenson PJ** and **C Stengel** 2020. An inventory of biodiversity data sources for conservation monitoring. PLoS ONE. 2020;10:e0242923.
- Stevenson R, C Merrill,** and **P Burn.** 2021. Useful biodiversity data were obtained by novice observers using iNaturalist during college orientation retreats. Citizen Science: Theory and Practice 6(1) DOI: <http://dx.doi.org/10.5334/cstp.407>
- USAfacts.org.** 2023. [Comparison of Covid-19 vaccination rates of different states]. <https://usafacts.org/visualizations/covid-vaccine-tracker-states> (Accessed 22 March 2023).

Appendix I: Biota of Arkansas documented in iNaturalist (Research Grade observations reported)

Plants	Reports	Species
Vascular Plant Families		
Asteraceae (Sunflowers)	18,571	323
Fabaceae (Beans)	9,765	152
Lamiaceae (Mints)	6,927	79
Poaceae (Grasses)	3,788	241
Apocynaceae (Dogbanes)	3,565	34
Ranunculaceae (Buttercups)	3,176	53
Rosaceae (Roses)	3,132	106
Rubiaceae (Madders)	2,964	36
Fagaceae (Beeches)	2,759	29
Plantaginaceae (Plantains)	2,384	53
Brassicaceae (Mustards)	2,175	63
Caprifoliaceae (Honeysuckles)	2,090	21
Apiaceae (Parsleys)	1,940	51
Sapindaceae (Soapberries)	1,860	17
Cyperaceae (Sedges)	1,815	179
Anacardiaceae (Sumacs)	1,770	8
Vitaceae (Grapes)	1,615	12
Campanulaceae (Bellflowers)	1,591	13
Euphorbiaceae (Spurges)	1,542	49
Boraginaceae (Borages)	1,541	37
Orchidaceae (Orchids)	1,425	34
Caryophyllaceae (Pinks)	1,421	39
Berberidaceae (Barberries)	1,398	6
Violaceae (Violets)	1,392	21
Onagraceae (Evening-primroses)	1,290	32
Oleaceae (Olives)	1,266	19
Polygonaceae (Buckwheats)	1,251	33
Commelinaceae (Spiderworts)	1,212	19
Amaryllidaceae (Amaryllises)	1,119	35
Agavaceae (Agaves)	1,109	22
Asparagaceae (Asparaguses)	1,109	22
Orobanchaceae (Broomrapes)	1,072	22
Passifloraceae (Passion-flowers)	1,050	2
Solanaceae (Nightshades)	1,050	29
Cupressaceae (Cypresses)	992	3
Smilacaceae (Greenbriers)	981	11
Altingiaceae (Sweet-gums)	978	1
Polemoniaceae (Phloxes)	962	9
Malvaceae (Malloes)	873	24
Acanthaceae (Wild Petunias)	859	11
Bignoniaceae (Trumpet-creepers)	843	4
Verbenaceae (Vervains)	838	18
Cornaceae (Dogwoods)	822	7
Ericaceae (Heaths)	817	15
Aquifoliaceae (Hollies)	808	8
Lauraceae (Laurels)	800	4
Oxalidaceae (Wood-sorrels)	798	9
Melanthiaceae (Bunchflowers)	797	14
Phytolaccaceae (Pokeweeds)	797	1
Trilliaceae (Trilliums)	797	14
Dryopteridaceae (Wood Ferns)	788	10
Convolvulaceae (Morning-glories)	784	30
Araceae (Arums)	764	15
Alliaceae (Onions)	761	14
Iridaceae (Irises)	756	26
Papaveraceae (Poppies)	741	15
Aspleniaceae (Spleenwort Ferns)	736	9
Hypericaceae (St. John's-worts)	700	19

(Vascular Plants Continued)	Reports	Species
Pteridaceae (Brake Ferns)	699	11
Moraceae (Mulberries)	683	8
Rhamnaceae (Buckthorns)	682	5
Adoxaceae (Arrow-woods)	666	11
Celastraceae (Bittersweets)	663	10
Parnassiaceae (Grass-of-Parnassus)	663	10
Ebenaceae (Ebonies)	654	1
Platanaceae (Sycamores)	610	1
Betulaceae (Birches)	602	6
Araliaceae (Ginsengs)	573	11
Liliaceae (Lilies)	554	7
Geraniaceae (Geraniums)	535	7
Ulmaceae (Elms)	529	8
Polypodiaceae (Polypody Ferns)	512	2
Scrophulariaceae (Figworts)	512	6
Juglandaceae (Walnuts)	510	11
Magnoliaceae (Magnolias)	461	6
Annonaceae (Custard-apples)	437	2
Balsaminaceae (Touch-me-nots)	422	2
Urticaceae (Nettles)	411	7
Saxifragaceae (Saxifrages)	407	9
Gentianaceae (Gentians)	402	14
Ophioglossaceae (Adder's-tongue Ferns)	376	9
Theophrastaceae (Theophrastus)	345	12
Myrsinaceae (Colicwoods)	343	12
Primulaceae (Primroses)	343	12
Aristolochiaceae (Dutchman's-pipes)	330	6
Rutaceae (Rues)	330	6
Pinaceae (Pines)	313	6
Menispermaceae (Moonseeds)	312	3
Polygalaceae (Milkworts)	296	9
Phrymaceae (Lopseeds)	292	4
Colchicaceae (Bellworts)	291	3
Salicaceae (Willows)	283	9
Simaroubaceae (Quassias)	282	2
Loganiaceae (Loganias)	275	3
Juncaceae (Rushes)	268	24
Cucurbitaceae (Gourds)	267	8
Amaranthaceae (Amaranths)	263	23
Chenopodiaceae (Goosefoots)	263	23
Cannabaceae (Hempes)	250	7
Hamamelidaceae (Witch-hazels)	249	3
Lythraceae (Loosestrifes)	248	12
Crassulaceae (Stonecrops)	246	9
Dioscoreaceae (Yams)	239	2
Paulowniaceae (Princess-trees)	239	1
Woodsiaceae (Lady Ferns)	224	2
Saururaceae (Lizard's-tails)	219	2
Osmundaceae (Royal Ferns)	216	3
Nyssaceae (Tupelos)	207	3
Melastomataceae (Meadow-beauties)	198	2
Alismataceae (Water-plantains)	192	9
Hydroleaceae (Blue-waterleafs)	192	2
Hydrangeaceae (Hydrangeas)	180	8
Thelypteridaceae (Marsh Ferns)	169	6
Dennstaedtiaceae (Bracken Ferns)	168	3
Hypoxidaceae (Star-grasses)	162	2
Pontederiaceae (Pickerel-weeds)	156	7
Staphyleaceae (Bladdernuts)	144	1
Onocleaceae (Sensitive Ferns)	132	2
Phyllanthaceae (Leaf-flowers)	131	4
Santalaceae (Sandalwoods)	130	2

Citizen Science: iNaturalist's Role in Biodiversity Documentation and Education

(Vascular Plants continued)	Reports	Species
Sapotaceae (Sapodillas)	126	3
Meliaceae (Mahoganies)	121	1
Molluginaceae (Carpetweeds)	111	1
Nelumbonaceae (Lotuses)	101	1
Styracaceae (Storaxes)	100	4
Linderniaceae (False Pimpernels)	98	5
Blechnaceae (Chain Ferns)	89	2
Arecaceae (Palms)	88	2
Portulacaceae (Purslanes)	88	4
Haloragaceae (Water-milfoils)	87	6
Elaeagnaceae (Oleasters)	81	2
Cleomaceae (Spider-flowers)	78	3
Grossulariaceae (Currants)	78	4
Cactaceae (Cactuses)	77	5
Equisetaceae (Horsetails)	74	4
Hemerocallidaceae (Day-lilies)	74	1
Nymphaeaceae (Water-lilies)	74	2
Penthoraceae (Ditch-stonecrops)	72	1
Thymelaeaceae (Leatherwoods)	71	2
Symplocaceae (Sweetleafs)	65	1
Gelsemiaceae (Jessamines)	64	1
Xyridaceae (Yellow-eyed grasses)	60	6
Nyctaginaceae (Four-o'clocks)	58	3
Tetrachondraceae (Tetrachondras)	56	1
Cistaceae (Rock-roses)	55	5
Myricaceae (Wax-myrtles)	52	2
Cabombaceae (Fanworts)	51	2
Droseraceae (Sundews)	50	2
Hydrocharitaceae (Frog's-bits)	40	7
Iteaceae (Sweetspires)	40	1
Lygodiaceae (Climbing Ferns)	38	1
Lentibulariaceae (Bladderworts)	34	6
Potamogetonaceae (Pondweeds)	28	5
Typhaceae (Cat-tails)	27	4
Nartheciaceae (Colicoots)	25	1
Ceratophyllaceae (Hornworts)	24	2
Selaginellaceae (Spike-mosses)	24	3
Azollaceae (Mosquito Ferns)	20	3
Salviniaceae (Floating Ferns)	20	3
Eriocaulaceae (Pipeworts)	19	3
Linaceae (Flaxes)	19	5
Lycopodiaceae (Club-mosses)	16	3
Marsileaceae (Water-clover Ferns)	16	3
Elatinaceae (Waterworts)	12	2
Menyanthaceae (Buck-beans)	11	1
Marantaceae (Thalias)	9	1
Zygophyllaceae (Caltrops)	8	1
Aizoaceae (Iceplants)	6	1
Martyniaceae (Unicorn-plants)	6	1
Sphenocleaceae (Chickenspikes)	5	1
Isoetaceae (Quillworts)	4	1
Loasaceae (Stick-leafs)	4	1
Bromeliaceae (Bromeliads)	3	1
Hymenophyllaceae (Filmy Ferns)	3	1
Schisandraceae (Star-vines)	3	1
Tamaricaceae (Tamarisks)	3	1
Acoraceae (Sweet-flags)	2	1
Podostemaceae (Riverweeds)	2	1
Theaceae (Teas)	0	0
Non-Vascular Plant Phyla	Reports	Species
Bryophyta (Mosses)	258	60
Marchantiophyta (Liverworts)	156	10

(Non-Vascular Plant Phyla continued)	Reports	Species
Anthocerotophyta (Hornworts)	0	0
Fungi Families		
Amanitaceae (Amanita Mushrooms & Allies)	281	33
Sarcosomataceae (Devil's Urn)	280	2
Russulaceae (Milkcaps, Brittlegills & Allies)	264	28
Stereaceae (Leaf, Wax, & Shelf Fungus)	221	7
Pleurotaceae (Oyster Mushroom)	219	6
Agaricaceae (Field Mushrooms & Allies)	205	14
Boletaceae (Boletes)	177	36
Cantharellaceae (Chanterelle)	160	14
Tremellaceae (Golden Jelly Fungus)	108	2
Mycenaceae (Bleeding Fairy Helmet)	102	10
Pluteaceae (Deer Mushroom)	81	12
Psathyrellaceae (Common Crumblecap)	56	14
Morchellaceae (Morels & Allies)	53	4
Sarcoscyphaceae (Scarlet Elf Cup)	51	2
Phanerochaetaceae (White Rot Fungus)	47	5
Strophariaceae (Roundheads)	46	8
Dacrymycetaceae (Jelly Fungus)	39	5
Hygrophoraceae (Waxy Caps)	30	16
Bolbitiaceae (Yellow Fieldcap)	27	6
Marasmiaceae (Pinwheel)	22	10
Gomphaceae (Pig's Ears)	20	4
Clavariaceae (Antler & Spindle Fungi)	19	5
Entolomataceae (Unicorn Pinkgill)	15	1
Cortinariaceae (Gypsy Mushroom)	13	9
Discinaceae (False Morels)	12	2
Peniophoraceae (Giraffe Spots)	10	1
Pyronemataceae (Hare's Ear)	10	3
Tricholomataceae (American Matsutake)	9	7
Helvellaceae (Elfín Saddles)	8	4
Taphrinaceae (Leaf Curl)	5	2
Inocybaceae (White Fibercap)	2	2
Schizoporaceae	2	1
Pezizaceae (Pezizas, Truffles, & Allies)	2	2
Bankeraceae	1	1
Lyophyllaceae (Fried Chicken Mushroom)	1	1
Animals	Reports	Species
Vertebrates		
Fish families		
Centrarchidae (Freshwater Sunfishes)	1,367	21
Percidae (Perches and Darters)	716	47
Leuciscidae (True Minnows)	519	39
Ictaluridae (Freshwater Catfishes)	205	15
Fundulidae (Topminnows)	167	5
Catostomidae (Suckers)	135	14
Salmonidae (Salmon, Trout, & Whitefishes)	121	4
Lepisosteidae (Gars)	96	4
Poeciliidae (Livebearers)	69	1
Cottidae (Sculpins)	65	2
Esocidae (Pikes)	57	2
Moronidae (Temperate Basses)	55	5
Sciaenidae (Drums and Croakers)	38	1
Atherinopsidae (New World Silversides)	34	3
Amiidae (Bowfins)	32	1
Aphredoderidae (Pirate Perches)	30	1
Cyprinidae (Cyprinids)	24	3
Elassomatidae (Pygmy Sunfishes)	22	1
Channidae (Snakeheads)	16	1
Anguillidae (Freshwater Eels)	7	1
Petromyzontidae (Northern Lampreys)	4	2

K. Baker, L. Barnes, S. Rana, J. Jackson, and R. Kannan

(Fish Families continued)	Reports	Species
Polyodontidae (Paddlefishes)	2	1
Hiodontidae (Mooneyes)	2	2
Acipenseridae (Sturgeons)	1	1
Amphibian families		
Hylidae (Tree Frogs & Allies)	2,485	12
Plethodontidae (Lungless Salamanders)	2,230	19
Ranidae (Typical Frogs)	1,795	7
Bufonidae (True Toads)	1,425	2
Ambystomatidae (Mole Salamanders)	999	6
Microhylidae (Narrowmouth Toads)	219	2
Salamandridae (Newts)	179	1
Sirenidae (Sirens)	48	1
Amphiumidae (Amphiumas)	44	1
Scaphiopodidae (American Spadefoot Toads)	31	3
Proteidae (Mudpuppies & Waterdogs)	11	1
Reptile families/subfamilies		
Colubridae (Harmless Egg-Laying Snakes)	7,846	33
Emydidae (Box & Pond Turtles)	3,699	9
Natricinae (Harmless Live-Bearing Snakes)	3,635	15
Viperidae (Vipers)	1,483	5
Scincidae (Skinks)	1,442	5
Dipsadidae (Rear-Fanged Snakes)	1,273	5
Phrynosomatidae (Spiny Lizards)	965	1
Chelydridae (Snapping Turtles)	453	2
Kinosternidae (Mud & Musk Turtles)	418	3
Anolidae (Anoles)	347	2
Trionychidae (Softshell & Flapshell Turtles)	154	2
Alligatoridae (Alligators)	142	1
Teiidae (Whiptails & Tegus)	133	1
Anguidae (Glass & Alligator Lizards)	33	1
Crotaphytidae (Collared Lizards)	31	1
Elapidae (Coral snakes, Cobras, & Kraits)	2	1
Bird families		
Anatidae (Ducks, Geese, and Swans)	2,413	43
Cardinalidae (Cardinals and allies)	2,299	10
Picidae (Woodpeckers)	2,226	8
Passerellidae (New World Sparrows)	1,918	22
Turdidae (Thrushes)	1,634	8
Icteridae (New World Blackbirds and Orioles)	1,381	12
Accipitridae (Hawks, Eagles, and Kites)	1,370	12
Ardeidae (Heron, Egrets, and Bitterns)	1,257	11
Fringillidae (Finches, Euphonias, and Allies)	1,167	6
Parulidae (New World Warblers)	1,038	33
Tyrannidae (Tyrant Flycatchers)	923	14
Paridae (Tits, Chickadees, and Titmice)	800	2
Mimidae (Mockingbirds and Thrashers)	782	4
Corvidae (Crows, Jays, and Magpies)	676	3
Troglodytidae (Wrens)	579	7
Cathartidae (New World Vultures)	541	2
Columbidae (Pigeons and Doves)	486	5
Passeridae (Old World Sparrows)	486	1
Scolopacidae (Sandpipers and Allies)	357	26
Sittidae (Nuthatches)	343	3
Hirundinidae (Swallows and Martins)	339	6
Trochilidae (Hummingbirds)	310	4
Charadriidae (Plovers and Lapwings)	279	5
Strigidae (Typical Owls)	249	6
Sturnidae (Starlings)	226	1
Vireonidae (Vireos and Shrike-Babblers)	209	7
Rallidae (Rails, Gallinules, and Coots)	186	6

(Bird Families continued)	Reports	Species
Bombycillidae (Waxwings)	170	1
Cuculidae (Roadrunners)	168	3
Podicipedidae (Grebes)	161	4
Phasianidae (Pheasants, Grouse, and Allies)	151	4
Laridae (Gulls, Terns, and Skimmers)	139	12
Alcedinidae (Kingfishers)	138	1
Falconidae (Falcons and Caracaras)	112	4
Pelecanidae (Pelicans)	110	2
Poliophtidae (Gnatcatchers and Gnatwrens)	105	1
Certhiidae (Treecreepers)	77	1
Caprimulgidae (Nightjars and Nighthawks)	68	3
Threskiornithidae (Ibises and Spoonbills)	58	4
Phalacrocoracidae (Cormorants and Shags)	53	1
Laniidae (Shrikes)	50	1
Gaviidae (Loons)	41	1
Recurvirostridae (Stilts and Avocets)	39	2
Odontophoridae (New World Quails)	37	1
Pandionidae (Ospreys)	33	1
Motacillidae (Wagtails and Pipits)	26	2
Anhingidae (Darters)	16	1
Gruidae (Cranes)	13	2
Alaudidae (Larks)	12	1
Apodidae (Swifts)	10	1
Sulidae (Boobies and Gannets)	9	1
Calcariidae (Longspurs and Snow Buntings)	8	2
Ciconiidae (Storks)	7	1
Aramidae (Limpkins)	2	1
Tytonidae (Barn-Owls)	2	1
Mammal families		
Sciuridae (Squirrels)	1,545	5
Ursidae (Bears)	1,361	1
Cervidae (Deer & Elk)	1,168	2
Procyonidae (Raccoons)	534	1
Didelphidae (Opossums)	478	1
Dasypodidae (Long-nose Armadillos)	377	1
Leporidae (Hares & Rabbits)	317	3
Canidae (Canids)	303	4
Cricetidae (Hamsters, Voles, Lemmings, & Allies)	181	11
Vespertilionidae (Evening Bats)	161	10
Castoridae (Beavers)	129	1
Felidae (Felids)	91	2
Suidae (Wild Boars)	55	1
Soricidae (Shrews)	49	3
Talpidae (Moles)	42	1
Echimyidae (Spiny Rats & Hutias)	17	1
Geomyidae (Pocket Gophers)	7	2
Invertebrate phyla		
Mollusca (Molluscs)	565	86
Protozoa	206	23
Platyhelminthes (Flatworms)	56	1
Annelida (Segmented Worms)	34	10
Cnidaria (Cnidarians)	2	1
Nematoda (Nematodes)	0	0
Arthropoda classes		
Insecta (Insects)	71,187	3,458
Arachnida (Arachnids)	6,285	205
Malacostraca (Malacostracans)	390	44
Chilopoda (Centipedes)	248	7
Diplopoda (Millipedes)	199	15
Branchiopoda (Branchiopods)	3	3

Citizen Science: iNaturalist's Role in Biodiversity Documentation and Education

Appendix II

iNaturalist Projects in Arkansas (Research Grade).
College campus projects are in **boldface blue**.

Projects	Reports	Species
Native Arkansas Organisms	225,961	4,382
Arthropods of Arkansas	78,817	3,755
BioBlitz @ Bearitage SPRING 2019	61,175	14,084
Springfield Plateau	54,993	3,834
Dissected Springfield Plateau- Elk River Hills	37,666	3,645
Biodiversity of Washington County, Arkansas	35,606	2,958
Biodiversity of Benton County, Arkansas	29,425	3,007
Birds of Arkansas!	26,814	334
NANPA- Regional- Southwest	24,893	2,872
Arkansas Valley Plains	24,790	3,082
Every Second Counts	24,545	3,113
Plants for University of Arkansas at Monticello (UAM) students	23,988	1,315
Invasive Plants of The Natural State	21,792	462
Hot Springs National Park BioBlitz	18,757	6,742
Moths of Arkansas	18,167	1,184
Red River Bottomlands	15,464	2,322
Herps of Arkansas	13,382	121
Arkansas Natural Heritage Commission- Natural Areas Inventory	13,169	2,223
Aquatic and Wetland Plants of Arkansas	11,677	765
NWA Master Naturalist Observations	10,742	1,608
UArk Herpetology	7,517	617
The Mycology of Arkansas	6,904	637
Wildflower Phenology for Arkansas Pollinators	6,052	355
Ozark Plateau and Ouachita Mountains	4,781	91
Endemic Species		
Arkansas Plants of Conservation Concern	3,997	407
Arkansas River Valley Prairie & Savanna	3,803	361
Wildflower Phenology for AR Pollinators: Flowering	3,688	329
Salamanders & Newts of Arkansas	3,537	28
Bees and Apoid Wasps of Arkansas	3,446	114
Athens Plateau	3,393	1,187
Mississippi Alluvial Plain Grand Prairie	3,360	1,032
Invasive Insects of the Natural State	2,960	84
Central Arkansas National Wildlife Refuge Complex	2,900	928
Wildlife of Logoly State Park	2,620	861
West Gulf Coastal Plain Blackland Prairies of Arkansas & Oklahoma	2,464	817
Drew County, AR	2,233	893
NWA project wingspan AR.CT2	2,193	26
Apoidea of Arkansas: Native Bees	2,177	74
Ladybugs of South- Central U.S.	1,882	47
Biodiversity of NWA Land Trust Preserves	1,743	603
Felsenthal National Wildlife Refuge, AR	1,597	627
Arkansas Wild Spaces	1,565	769
Western Lowlands Holocene Meander Belts	1,493	659
William H. Donham State Fish Hatchery	1,432	638
Biodiversity		
Gypsum Hills	1,400	446

Projects	Reports	Species
University of Arkansas Wildlife Society	1,313	743
City Nature Challenge 2022: Greater Memphis Metro Area	1,154	484
Wildflower Phenology for AR Pollinators: Fruiting	1,150	141
Bald Eagles and Streams	1,134	1
Biodiversity of Arkansas State University Campus Querétaro and Adjacent Areas	1,105	296
Arkansas Monarch Mapping Project	1,071	1
Dendro 2019- Arkansas Tech University	1,033	165
Biodiversity of Arkansas State University	1,020	347
Wildflower Phenology for AR Pollinators: No Evidence of Flowering	991	129
UArk Herp Class Sp2020	988	102
Wildflower Phenology for AR Pollinators: Budding	915	162
The Flora and Fauna of Lake Leatherwood City Park	872	376
Las Plantas de ASUCQ	870	181
Arkansas wild side.	847	525
2019 Spring Travel	838	306
Arkansas Bear Survey	816	1
Host plants of the frosted elfin butterfly	806	4
A flora of Pine City Natural Area in Monroe County, AR	716	429
Biodiversity of the Grand Prairie of Arkansas	648	170
Thistles of Arkansas	617	8
UArk Herp Class Sp2022	612	90
Invasive Plants of Fayetteville, Arkansas	594	4
Arisaema of Arkansas	578	4
Plant Tax- Arkansas Tech University	556	194
Skunks of Arkansas	519	2
Typical Leafhoppers of Arkansas	514	80
University of Arkansas at Monticello (UAM) campus	428	237
Biodiversity at the A- State Bird Observatory	425	188
Arkansas Mosses, Liverworts, and Hornworts	414	70
Arkansas Tech Plant Tax-2020	383	161
Biodiversity of UAFS campus	342	302
Buck Island/Prairie Point Towhead Plant Inventory	373	228
Bees and Wasps of Arkansas	366	110
Boyle Park Biodiversity	360	235
Expedition Blackburn Bluffs 2021	324	178
Biodiversity of Mt. Sequoyah Woods	284	165
Arkansas Aquatic Nuisance Species	283	22
Flora of the Prairie D'ane	282	125
NWACC Bentonville Campus Biodiversity	265	159
Timber Rattlesnakes of Arkansas	223	1
Jewel Moore Nature Reserve Diversity	216	130