"Advertising" Biodiversity to the Public: Designing Graphics to Encourage Active Discovery and Engagement

MICHAEL L. FERRO AND ANDREW J. FLICK

What has variety and novelty, is big enough to crush you or small enough to make you itch, may be revolting or fascinating, and is both everlasting and ephemeral? Biodiversity.

Biodiversity, the variety of life on Earth, encompasses more variation than is known in any other part of the universe available to human senses. Biodiversity is important to human endeavors, both functionally (food, pollination) and emotionally (inspiration). Human choices directly impact biodiversity; for example, urban landscapes favor cockroaches, but may deter bumble bees. Biodiversity advocacy has become an important part of the work of scientists and organizations. However, when scientists try to illustrate biodiversity to the public, they often fall short. Simply listing taxa is one option that provides much information but little inspiration. Another common technique is to create a graphic consisting of a conglomeration of images of enigmatic or bizarre species (Fig. 1): inspirational, but without accompanying information, the audience is unable to learn more. These presentations can be thought of as "advertisements" for biodiversity.

One purpose of advertising is to make the viewer feel discontented with the status quo. Dissatisfaction drives the viewer to pursue the action desired by the advertiser. The discontented feeling may be about products you don't own (buy this!), your lot in life (get a degree!), homeless people (donate now!), or condition of the nation (vote for me!).

The more dissatisfaction the viewer feels, the more effective the advertisement is. While this may sound devious, consider that entomologists constantly engage in this activity by using images of the most amazing and bizarre species they can find in order to capture the attention of the public (Fig. 2). Suddenly the audience is dissatisfied that they don't know about the beast in the photo, curiosity is increased, so they attend the talk, buy the book, or read the caption to find out more.

Recent availability of a large amount of high-quality information via the Internet, coupled with development of volunteer-based "crowd-sourced" activities, allows for expanded opportunities when presenting biodiversity information to the public. This essay describes and explores development of biodiversity graphics (advertisements) that juxtapose discovered and undiscovered biodiversity at a specified location and invite the viewing public to take a more active role in their own education and participation in biodiversity related activities, such as BioBlitzes.

Figure 1. Graphic on display at the Field Museum of Natural History, Chicago IL illustrating biodiversity.

Different Approaches to Biodiversity

Several ways to view biodiversity exist, and each approach affects how biodiversity can be advertised. A recent short-term species inventory event ("BioBlitz") at Jean Lafitte National Historical Park and Preserve, Louisiana, provided a contrast of two common approaches to biodiversity. People from all over, citizens off the street and professional biologists, gathered in the park and worked to name every living thing they could find during the period 17–18 May 2013. Members from the Louisiana State Arthropod Museum (LSAM) concentrated on insects, spiders, and other arthropod taxa. Through diligent effort, the LSAM team delivered 431 unique taxa to the data management group, but during the closing ceremonies, LSAM was credited with only 121 arthropod "finds" on the big board. Why this discrepancy?

The difference resulted from two contrasting approaches to recording biodiversity, each easily illustrated by visualizing the tree of life. This analogy of a tree is often used to help describe and picture the relatedness of all life forms on Earth. A single trunk represents the common ancestry of all living organisms. Branches leaving

Figure 2. An example of a devious graphic. The species name and other info are lacking. See Conclusion for closure.

the trunk represent major groups of organisms that differ greatly from one another; for example, fungi and animals. As we move out on any given branch, the divisions become finer and finer until finally we find ourselves perched on the very tip of a twig. At the end of a twig is a population.

Twig to Trunk. Our short-hand notion of a population is the "species." We live in a very species-centric society: invasive species, endangered species, "How many species?" Many vertebrates, flowering plants, and charismatic invertebrates are identifiable to species in user-friendly field guides. Naïve consumers of taxonomic knowledge are led to believe that any given organism can always be identified to species and that failure to do so is only because the organism was in the wrong life stage (immature, pupae, not flowering), wasn't available for observation long enough (flew away), or due to ignorance of the individual observer ("I don't know that one, but Matt could tell you.").

The twig-to-trunk approach—cataloging the species that live in a given location and letting the branches sort themselves out—is appropriate either when all or nearly all species are known; or when dealing with well-known groups (mammals, reptiles, etc.). For example, at Jean Lafitte, birds are well known. The checklist contains 203 common bird species plus an additional 47 occasional and rare species (Anonymous 2005). A report listing only major bird groups (ducks, hawks, etc.) is of little value to scientists and the public alike. However, a comprehensive list of species is useful; the resulting species count is immediately comparable to other species counts at other times or locations.

Trunk to Twig. Taxonomists are modern explorers that discover and describe new twigs on the tree of life, and systematists sketch the branches and limbs that connect the twigs. Although birds are often well-known, insects and other invertebrates are not. Invertebrate workers tend to take a different view of biodiversity. Rather than start at the species level, they begin on branches of the tree of life (at class, order, or family) and work their way out to species. As tree builders, taxonomists have an appreciation for both what is and what is *not* known about the tree of life. Importantly, inability to identify a specimen to species may not be a personal failing. Understanding this is critical to invertebrate taxonomy. It highlights that we, as a global society, have not yet sufficiently described a significant portion of life on Earth.

The trunk-to-twig approach (gathering a baseline of higher taxa such as orders or families, then working towards species) is appropriate when:

- identification to genus or species is currently unobtainable (either because species are undescribed or because of lack of resources such as expertise, literature, equipment, or time);
- only higher taxa would be meaningful to the public (few people know the tribes of Carabidae, for example);
- the volume of names would be visually overwhelming, such as in a graphic or on a presentation slide.

Illustration or "Advertisement" of Biodiversity for the Public

Life on Earth today consists of a cascading rabble of populations. Living species are just the tips of the twigs on the tree of life. All the rest of the tree, the base of the twigs, all the limbs, branches, and the trunk, represent a conceptual model of relatedness of these species. The general short-hand notation for any of these limbs, branches, or even twigs is "taxon," plural taxa. We are able to construct the tree of life with increasing accuracy and precision using many sources of data including fossils, anatomy, behavior, biogeography, and most importantly DNA and/or RNA.

While the BioBlitz organizers at Jean Lafitte were interested in "species," the LSAM team was interested in "taxa." The difference between arthropod numbers (121 vs. 431) was the result of differing approaches to biodiversity: twig to trunk vs. trunk to twig.

List Method (Twig to Trunk). Often, when the public is presented with information on biodiversity, they are provided with a total number of species, or a list, such as number of species within major groups (Table 1). The list method is based on a twig-to-trunk view of biodiversity and has several virtues: it is succinct; it is readily interpretable; and it can be easily created, updated, and displayed using available resources. However, the list method has limitations: it does a poor job representing and comparing higher-level diversity, such as orders and families, among locations; it is limited by the public's prior knowledge, because only well-known taxa are typically reported; and it places the user in a passive role. For example, the "Other" category is a dead end, and the single dimension (species found) fails to provide a sense of what is left to discover.

Table 1. List of invertebrates collected during the BioBlitz event at Jean Lafitte National Historical Park and Preserve, Louisiana.

Animals	
Invertebrates	122
Spiders & Mites	5
Crustaceans	2
Mollusks	1
Worms	0
Others	0
Insects	114+
beetles	68
true bugs	5
flies	8
dragonflies/damselflies	10
roaches	2
termites	1
butterflies/moths	7
grasshoppers	2
mantids	0
other insects	11

Note: The total of 122 Invertebrates includes one mollusk; the arthropod count is 121.

Graphic Method (Trunk to Twig). One potential way to overcome the shortcomings of the list method is a graphic method of biodiversity illustration that capitalizes on the trunk-to-twig approach and takes into account new technologies and public attitudes. For example, mention of taxa not widely known by the public would no longer be a liability, because smartphones and the Internet allow the public immediate access to information at virtually any time and location. Therefore, poorly known taxa provide an opportunity to invoke curiosity and learning by generating dissatisfaction with one's knowledge base of less well-known taxa. Internet and ground-based, crowd-sourced projects such as BioBlitzes, Wikipedia.com, BugGuide.net, Lostladybug.org, etc., prime the public to take a proactive role in contributing to, or even creating, projects. Therefore, graphical illustration of what we don't know (e.g., how many possible taxa have not been reported from a location) creates a goal that can be acted upon by the public. Standardization of biodiversity graphics allows for comparisons among sites and can create a spirit of friendly competition that may drive further discovery. Overall, well-designed graphic representations of biodiversity may be better advertisements than lists, and can be created in a variety of ways.

Trunk-to-Twig Biodiversity Graphic "Advertisement" Examples

Taking the above into consideration, a graphic illustration of biodiversity designed for the public would ideally:

- illustrate basic taxonomy and hierarchy of taxa involved;
- show all taxa at a given level;
- provide a measure of how many taxa were recorded versus how many are possible; and
- be comparable with other such graphics.

Additionally, the graphic should be easy to create and edit using available resources.

Excel/PowerPoint. The Excel/PowerPoint example (Fig. 3) represents an attempt to fulfill the above requirements. In this example, primary taxa are represented by four major "groups" of arthropods, which are shown with a loose phylogenetic arrangement, as indicated by the stylized green branches underneath. Groupings are simplified: for example, Hexapoda *sensu lato* are combined and

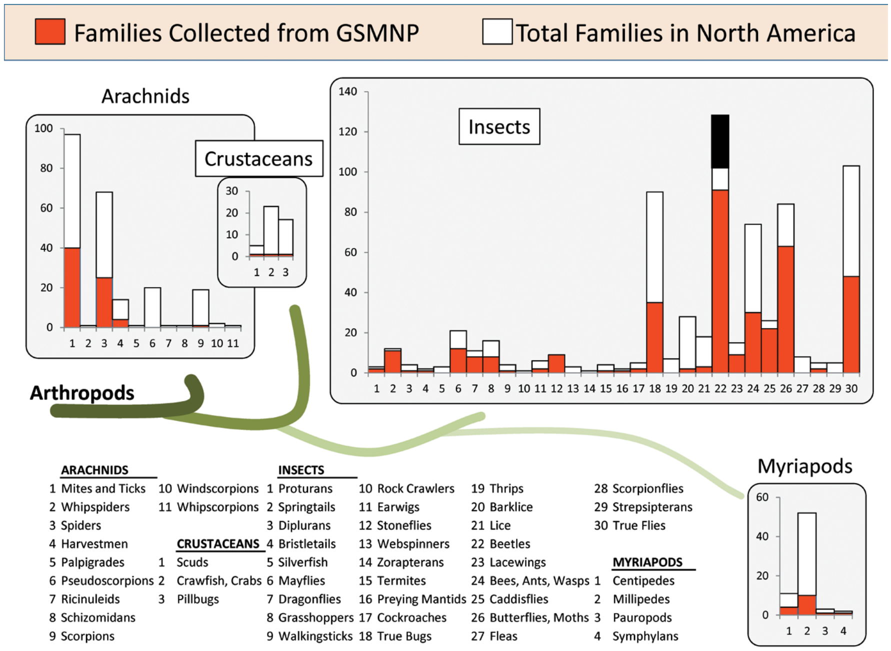

Fig. 3. Example biodiversity graphic created using Excel and PowerPoint. Bar 22 (Coleoptera) also includes an exemplar black portion that signifies beetle families unlikely to be found in GSMNP.

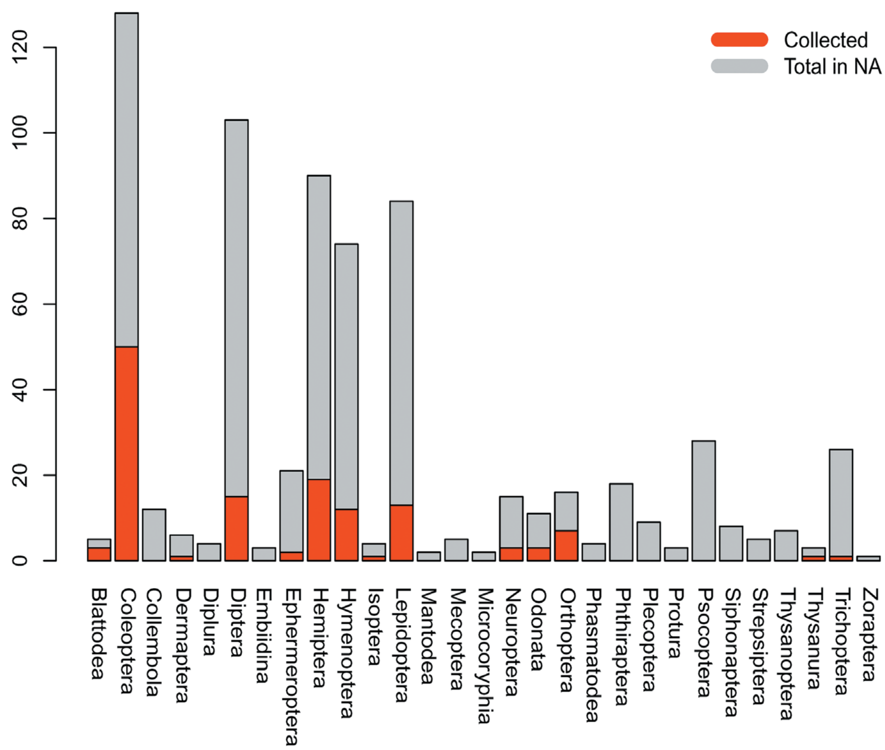

Fig. 4. Example graphic created with R. Data are from Table 1.

called Insects, and only orders of Malacostraca are shown under Crustaceans. The secondary taxa within the primary taxa are at the level of order, or in the case of Myriapods, class. Tertiary taxa, represented by the bar graphs, denote number of families within their respective order or class within North America. The bottom red portion of each bar consists of real data and represents how many families of each taxon have been reported from Great Smoky Mountains National Park (GSMNP) (Discover Life in America - All Taxa Biodiversity Inventory 2008). A key with common names is presented at the bottom of the figure.

At a glance (Fig. 3), the viewer can see two levels of relationship: among primary taxa (insects are more closely related to crustaceans than arachnids) and among secondary taxa (pillbugs and crawfish are in the same general group). A total of 48 secondary taxa are displayed, including those that are poorly known and unknown to the public. Diversity is illustrated along three dimensions: 1) width, number of orders or classes; 2) height, number of families in North America; and 3) height again, number of families reported at the site. The difference between the height of the red bar and the total height of the family bar provides a sense of how well a particular taxon has been surveyed, as well as a sense of potential for discovery. A clearly labeled black bar extending from the top of a bar down could be used to denote number of families that are very unlikely to be found in a particular location; for example, several families of beetles are restricted to western North America and would not be expected in GSMNP. A similar graph prepared with data from any other site in North America would be directly comparable (see Fig. 4, but note taxa are arranged alphabetically in Fig. 4 and phylogenetically in Fig. 3).

Figure 3 was created using standard software with no use of special techniques. Data were entered into Microsoft® Excel® (2010). Four stacked graphs were created in Excel, then copied and pasted into Microsoft® PowerPoint® (2010). The graphs in PowerPoint automatically maintain a connection to the data in Excel (as a "Related Document"); therefore, any changes made to the data in Excel are immediately expressed in the PowerPoint slide. The green branches were created using a series of curves, and the key of names was entered as a table. The slide can be projected, printed, copied and pasted into other documents, saved as a graphic (such as JPG or TIFF), or saved as a Portable Digital Format (PDF) document. Illustrations of taxa, photographs, drawings, etc. and any number of stylistic modifications can be added.

R Project for Statistical Computing. R (R Development Core Team 2010) is a free programming language widely used for statistical analyses and graphic design. The basic software can be used to create publication-grade figures, and more advanced packages are available for more specialized analyses and graphics. The R example (Fig. 4) was created using code developed by the second author (AJF) and run in standard R software. Data are stored in a text file and can be readily accessed and edited. This example includes user-defined variable names and data to create up to 14 different graphical representations of biodiversity. For presentation purposes, it automatically alphabetizes each grouping so that groups are easily discernible in the graphic.

There are several advantages to using R. The current version of the program and future upgrades are freely available online, unlike Excel and some other graphing software. R also allows the user greater control of the overall appearance of the graph, unlike other programs which may contain fixed presets and styles. Using R, any number of graphs and figures (easily >50) can be created in seconds from a single data sheet and exported in a variety of formats (PDF, JPG, etc.) at desired sizes and resolutions for immediate use in Web pages and presentations. For example, graphs exported from R can be used in Fig. 5.

R does have drawbacks. As a programming language, the R base software is difficult to use with no previous coding experience. Downloads, such as R studio, can make R easier to work with for less experienced programmers. The code used to create this example is freely available from AJF.

Prezi.com. The free online tool Prezi.com offers another platform for biodiversity graphics. The canvas is a wide plane with deep zoom capabilities. The user can move on the x-y plane, and the zoom feature creates a "Farmer in the Dell" quality. In the included example (Fig. 5; available at http://prezi.com/bgr51k7nz-_w/gsmnp-biodiversity-example/), zooming in towards the branch of a stylized tree reveals a bar graph. Zooming in towards the bar representing beetles reveals a list of beetle families, zooming in towards the family names reveals exemplar photographs. Additional levels could be added easily.

Prezi has an appealing videogame-like quality with zooms and sweeps and can be used as a presentation medium in lieu of PowerPoint, or as a standalone Web page. Prezi does have several drawbacks. Currently, it will not accept graphs or tables; these must be imported as text or graphics, making changes and updates cumbersome. However, the total content of a Prezi presentation has the potential to become enormous and could ultimately rival the information in a field guide. While not capable of providing real-time updates, Prezi presentations may work well for long-term online biodiversity graphics and information.

Fig. 5. Five scenes from an example of biodiversity illustration created at Prezi.com.

Testing

Until the ideas presented above are actually tested, they represent only so many educated guesses. It is important to find out what, if any, benefits graphic representation of biodiversity provides, and whether it elicits the predicted behavioral changes (self-education, contribution, and competition). Some of the elements proposed here may work very well, while others may need to be altered or removed to invoke an optimal public response.

Many of us have a vested interest in finding better ways to advertise biodiversity, especially those who work with organizations (Discover Life in America, National Geographic, The Nature Conservancy, etc.), students interested in public relations and conservation issues, and educators working to engage and teach the public. Our interests are best served through effective strategies to educate and rally the public, and we should take an active role in developing and testing such strategies.

Conclusion

People are curious. They want to learn, are willing to teach themselves, and are interested in engaging in crowd-sourced activities. Ease of acquisition and use of information resources through smartphones and the Internet allow us to realize these goals. Graphic representation of biodiversity in a trunk-to-twig manner creates advertisements that will educate the public and may provoke responses including active discovery and engagement. The effectiveness of the proposed advertisements should be tested to demonstrate efficacy and to optimize performance.

Post script: for the curious, the species in Fig. 2 is Sibariops confusus *(Boh) (Coleoptera: Curculionidae: Baridinae). Males have prosternal spines, but what for?*

Acknowledgments

We thank the employees and volunteers of National Geographic and Jean Lafitte National Historical Park and Preserve for sponsoring and hosting the BioBlitz event that provided inspiration for this paper. The LSAM BioBlitz team included Victoria Bayless, Christopher Carlton, Michael Ferro, Stephanie Gil, Jocelyn Holt, Nathan Mercer, Brittany Owens, Jong-Seok Park, Katherine Parys, Brian Reily, and Alexey Tishechkin. This publication was approved by the Director, Louisiana Agricultural Experiment Station as manuscript number 9576.

References Cited

Anonymous. 2005. Bird Checklist. Barataria Preserve and Adjacent Lakes. Jean Lafitte National Historical Park and Preserve. http://www.nps.gov/jela/naturescience/upload/BARA%20Bird%20list%20051906.pdf

Discover Life in America - All Taxa Biodiversity Inventory. 2008. The ATBI Database. http://tremont22.campus.utk.edu/ATBI_start.cfm, Discover Life in America, Gatlinburg, Tennessee 37738. Accessed 1 June 2013.

Microsoft® Excel®. 2010. Microsoft Office Professional Plus 2010. Version: 14.0.6129.5000 (32-bit). Microsoft Corporation.

Microsoft® PowerPoint®. 2010. Microsoft Office Professional Plus 2010. Version: 14.0.6129.5000 (32-bit). Microsoft Corporation.

R Development Core Team. 2010. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, Available from www.R-project.org (Accessed 13 December 2012).

Michael L. Ferro, Louisiana State Arthropod Museum, Department of Entomology, Louisiana State University Agricultural Center, 402 Life Sciences Building, Baton Rouge, LA, 70803, spongymesophyll@gmail.com.

Andrew J. Flick, Department of Biological Sciences, Louisiana State University, 232 Life Sciences Building, Baton Rouge, LA, 70803, aflick1@lsu.edu.