Chapter 16
The Roles of Taxonomy and Systematics in Bat Conservation

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Abstract Taxonomy—the description, naming, and classification of organisms—and systematics—the study of the evolutionary relationships of organisms—are both crucial components in conservation, providing a necessary framework for any conservation initiative. With more than 200 new bat species identified or raised from synonymy in the past decade and additional taxa described monthly, the Age of Discovery is ongoing for bats. New taxonomic and systematic discoveries clarify the status of populations, and the recognition of distinct species and lineages allows appropriate conservation strategies to be crafted, increasing the likelihood of recovery. In addition to identifying species and specimens, taxonomists care for vouchers, provide species lists for localities, and communicate taxonomic ideas to non-experts, especially through descriptions, keys, and field guides. Taxonomists can also provide conservation planning tools such as inventory data, estimates of extinction risk and extinction rate, and information for defining protected areas. Despite the importance of taxonomy, a lack of financial and institutional support impedes the training and employment of taxonomists and such factors need to be

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C.C. Voigt and T. Kingston (eds.), *Bats in the Anthropocene: Conservation of Bats in a Changing World*, DOI 10.1007/978-3-319-25220-9_16

overcome. Taxonomic and systematic discoveries, especially those involving cryptic species and unrecognized diversity, are rapidly increasing with the advent of modern genetics. Researchers must be cautious to argue from multiple lines of evidence when naming new species and be clear about the species concept they employ, as these have wide ranging impacts beyond taxonomy. Creating new ties between taxonomists and non-experts will be crucial in conservation of a diverse range of organisms in increasingly fragile landscapes.

16.1 Introduction

Global biodiversity is being lost at an unprecedented rate as a result of environmental change and human activity. Like other organisms, bats are at risk and many populations and species are threatened. As of 2013, the International Union for Conservation of Nature and Natural Resources (IUCN) Red List recognized 81 bat species as Near Threatened, 95 as Vulnerable, 51 as Endangered, 26 as Critically Endangered, and 5 as Extinct (IUCN 2014). It is clear that decisions must be made now to combat ongoing loss of species and populations. However, appropriate management decisions cannot be made without a marriage among conservation biologists, taxonomists, and legislators. Before conservation strategies can be implemented, the species composition of a locality must be well understood; otherwise, the effectiveness of any conservation effort cannot be accurately quantified.

Clearly defining species boundaries—while often difficult—is crucial to basic research and conservation. Some level of agreement on the organisms and populations considered part of any species is necessary for studying and tracking the health of organisms and ecosystems. Taxonomy—the description, naming, and classification of organisms—provides this necessary framework. Taxonomy, along with classification, often is conflated with systematics (Schuh 2000), which is more properly defined as the study of the diversification and evolutionary relationships of organisms through time. Despite often being used interchangeably, they are distinctly different, though systematic research includes recognition of taxa (i.e., taxonomy) as a necessary ingredient to reconstructing the past. Phylogenies produced by systematists provide a crucial foundation for examining biological phenomena and hypotheses, such as adaptive radiation or biogeographic scenarios, some of which are important for informing conservation decisions. Phylogenies help predict where biodiversity hotspots may be located, inform how distinct populations may be from one another, and identify unique lineages that preserve critical genetic diversity. Without systematics, other aspects of natural history lose their historical framework; and without taxonomy, systematics loses its basic operational unit. This chapter will demonstrate the many ways in which taxonomy and systematics have contributed to past conservation efforts and how they will continue to enrich protection of bat species globally.

16.2 The Continuing Age of Discovery

Taxonomy is not a dead science; the Age of Discovery is ongoing, especially for bats (Fig. 16.1). The number of bats discovered in the last couple of decades is higher than expected when compared to other mammalian orders (Reeder et al. 2007). With each subsequent volume of *Mammal Species of the World* (Honacki et al. 1982; Wilson and Reeder 1993, 2005), the number of recognized bat species has increased dramatically, with new species described from every corner of the world. Between publication of the last edition in 2005 and the end of 2013, nearly 200 new bat species were described or resurrected from synonymy, including 120 species new to science (Table 16.1), putting the total number of bat species at just over 1300 at the time of writing of this chapter. The continuing high rate of discovery (or recognition) of new bats can be a potential impediment to conservation since it is difficult to assess the status of each newly discovered species within a short period of time, and because it is difficult to make management plans in the absence of abundance or natural history information (both of which are typically lacking for newly recognized taxa). However, new discoveries may clarify the status of isolated populations, and the recognition of these distinct species can allow appropriate conservation and management strategies to be crafted.

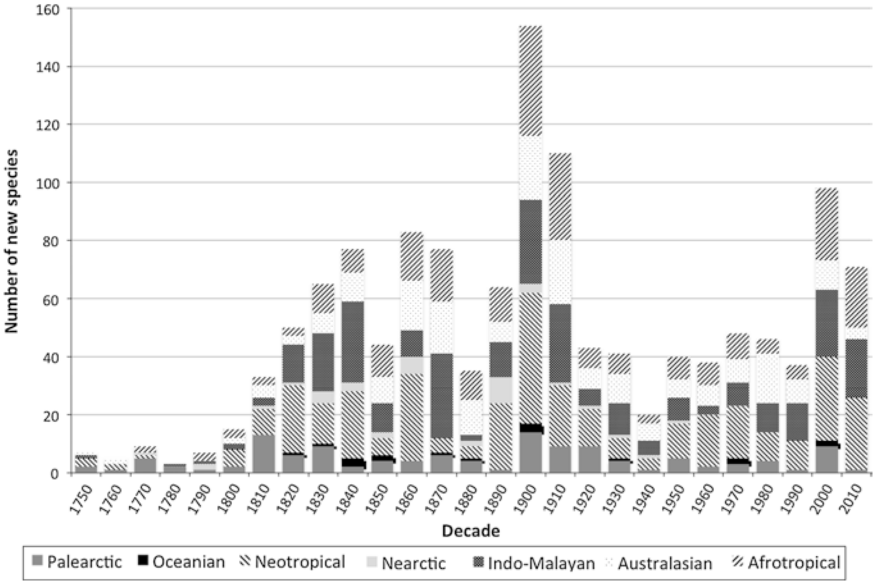

Fig. 16.1 Number of new bat species described per decade since 1750. Species were categorized to zoogeographic region (as defined by Newton 2003) of discovery according to type localities. Species since 2010 only reflect discoveries prior to the writing of this chapter (early 2014). New species are constantly being described from the tropics, with rates of discovery in the Afrotropics and Indo-Malayan regions catching up with the Neotropics

Table 16.1 New bat species by family since the previous edition of Mammal Species of the World (Wilson and Reeder 2005)

Family	Species	Year	Family	Species	Year
Phyllostomidae	*Anoura cadenai*	2006	*Vespertilionidae*	*Barbastella beijingensis*	2007
	Anoura carashina	2010		*Eptesicus lobatus*	2009
	Anoura fistulata	2005		*Eptesicus taddei*	2006
	Carollia benkeithei	2006		*Glischropus bucephalus*	2011
	Carollia manu	2004		*Harpiola isodon*	2006
	Carollia monohernandezi	2004		*Hypsugo lanzai*	2011
	Chiroderma vizottoi	2010		*Kerivoula kachinensis*	2004
	Dryadonycterix capixaba	2012		*Kerivoula titania*	2007
	Lonchophylla cadenai	2006		*Murina balaensis*	2013
	Lonchophylla chocoana	2004		*Murina beelzebub*	2011
	Lonchophylla fornicata	2007		*Murina bicolor*	2009
	Lonchophylla orcesi	2005		*Murina chrysochaetes*	2011
	Lonchophylla orienticollina	2009		*Murina eleryi*	2009
	Lonchophylla pattoni	2006		*Murina fionae*	2012
	Lonchophylla peracchii	2013		*Murina gracilis*	2009
	Lophostoma kalkoae	2012		*Murina guilleni*	2013
	Lophostoma yasuni	2004		*Murina harpioloides*	2008
	Micronycteris buriri	2011		*Murina harrisoni*	2005
	Micronycteris giovaniae	2007		*Murina jaintiana*	2012
	Micronycteris yatesi	2013		*Murina lorelieae*	2011
	Platyrrhinus albericoi	2005		*Murina pluvialis*	2012
	Platyrrhinus angustirostris	2010		*Murina recondita*	2009
	Platyrrhinus fusciventris	2010		*Murina shuipuensis*	2011
	Platyrrhinus guianensis	2014		*Murina tiensa*	2007
	Platyrrhinus ismaeli	2005		*Murina walstoni*	2011

(continued)

Table 16.1 (continued)

Family	Species	Year	Family	Species	Year
	Platyrrhinus masu	2005		*Myotis annatessae*	2013
	Platyrrhinus matapalensis	2005		*Myotis badius*	2011
	Platyrrhinus nitelinea	2009		*Myotis dieteri*	2005
	Sturnira bakeri	2014		*Myotis diminutus*	2011
	Sturnira burtonlimi	2014		*Myotis handleyi*	2013
	Sturnira koopmanhilli	2006		*Myotis indochinensis*	2013
	Sturnira perla	2011		*Myotis izecksohni*	2011
	Sturnira sorianoi	2005		*Myotis lavali*	2011
	Uroderma bakeri	2014		*Myotis midastactus*	2014
	Xeronycteris vieirai	2005		*Myotis phanluongi*	2008
Emballonuridae	*Coleura kibomalandy*	2012		*Neoromicia robertsi*	2012
	Paraemballonura tiavato	2006		*Neoromicia roseveari*	2013
	Peropteryx pallidoptera	2010		*Nyctophilus corbeni*	2009
Thyropteridae	*Thyroptera devivoi*	2006		*Nyctophilus shirleyae*	2009
	Thyroptera wynneae	2014		*Pipistrellus hanaki*	2004
Molossidae	*Chaerephon atsinanana*	2010		*Pipistrellus raceyi*	2006
	Chaerophon jobimena	2004		*Plecotus strelkovi*	2005
	Eumops wilsoni	2009		*Rhogeessa bickhami*	2012
	Molossus alvarezi	2011		*Rhogeessa menchuae*	2012
	Mops bakarii	2008		*Scotophilus andrewreborii*	2014
	Mormopterus eleryi	2008		*Scotophilus ejetai*	2014
	Mormopterus francoismoutoui	2008		*Scotophilus livingstonii*	2014
	Mormopterus halli	2014		*Scotophilus marovaza*	2006
	Mormopterus kitcheneri	2014		*Scotophilus tandrefana*	2005
	Mormopterus lumsdenae	2014		*Scotophilus trujilloi*	2014

(continued)

Table 16.1 (continued)

Family	Species	Year	Family	Species	Year
Pteropodidae	*Casinycteris campomaanensis*	2014		*Tylonycteris pygmaeus*	2008
	Desmalopex microleucopterus	2008	*Natalidae*	*Natalus lanatus*	2005
	Dyacopterus rickartii	2007	*Myzopodidae*	*Myzopoda schliemanni*	2006
	Epomorphorus anselli	2004	*Miniopteridae*	*Miniopterus aelleni*	2008
	Pteralopex flanneryi	2005		*Miniopterus brachytragos*	2009
	Pteropus allenorum	2009		*Miniopterus egeri*	2011
	Pteropus coxi	2009		*Miniopterus griffithsi*	2009
	Styloctenium mindorensis	2007		*Miniopterus mahafaliensis*	2009
	Thoopterus suhaniahae	2012		*Miniopterus maghrebensis*	2014
Rhinolophidae	*Rhinolophus chiewkweeae*	2005		*Miniopterus mossambicus*	2013
	Rhinolophus cohenae	2012		*Miniopterus petersoni*	2008
	Rhinolophus huananus	2008		*Miniopterus sororculus*	2007
	Rhinolophus indorouxi	2013	*Hipposideridae*	*Asellia arabica*	2011
	Rhinolophus kahuzi	2013		*Hipposideros boeadi*	2007
	Rhinolophus mabuensis	2012		*Hipposideros einnaythu*	2011
	Rhinolophus mossambicus	2012		*Hipposideros griffini*	2012
	Rhinolophus schnitzleri	2011		*Hipposideros khaokhouayensis*	2006
	Rhinolophus smithersi	2012		*Hipposideros khasiana*	2006
	Rhinolophus willardi	2013		*Paratriaenops pauliani*	2008
	Rhinolophus xinanzhongguoensis	2009		*Triaenops menamena*	2009
Rhinopomatidae	*Rhinopoma hadramauticum*	2009		*Triaenops parvus*	2009

Most species discoveries in the past decade have been made in Neotropical families, though more genetic and phonic data on Rhinolophidae and Hipposideridae are now uncovering greater species diversity in the Paleotropics

Species discoveries and recognition may bring attention to previously overlooked areas or act as a symbol of local pride. For example, in the Mekong Delta of Vietnam, a sixteenth-century Khmer pagoda in Soc Trang City called Wat Matahup, or Chua Doi—the Bat Pagoda—is home to a mixed colony of thousands of flying foxes (*Pteropus vampyrus* and *Pteropus lylei*), which are listed by the IUCN as Near Threatened and Vulnerable, respectively. The pagoda is a cultural and historic icon and the only pagoda in the region with a resident bat colony. The locals feel a sense of pride, as these rare bats roost only in the trees within the temple grounds. Monks actively protect the bats from increasing hunting pressure. This interest has resulted in the creation of bat and sustainability education campaigns by locals. These programs are aimed at educating young children on the importance of the bats to the ecosystem.

16.3 The Role of the Taxonomist in Conservation

The most basic contribution of the taxonomist to conservation is to identify and name the species being protected (Table 16.2). Being unable to differentiate among species makes it virtually impossible to manage wildlife, leads to poor decision-making, and causes unforeseen ecological consequences. Taxonomists are often the only people who can identify an animal—an underappreciated skill. For bats, this is of special importance as bats are an extremely diverse group, and many bat species are cryptic and therefore cannot be readily identified by amateurs and other biologists based on obvious external features. Taxonomists also form the backbone of any museum system. They are responsible for identification of voucher specimens that include whole organisms, skins, skeletons, skulls, and, increasingly, frozen tissues. Along with other museum personnel, they are responsible for ensuring that these specimens are preserved as a reference for future researchers. Natural history collections curate and maintain critical data associated with specimens including species identification, locality, sex, date of collection, collector, and other pertinent information. Much important taxonomic work takes place in these collections, with major taxonomic revisions of museum material often clarifying the status of particular species.

One of the most common requests to taxonomists from other researchers is for a species list for a particular locality. Without an easy way to identify species, non-taxonomists may not be able to accurately interpret collected data that are relevant to conservation, including information on habitat, geographic distribution, abundance, and basic features of ecology (e.g., roost sites for bats). Field researchers collect these ecological data; but many field researchers only observe animals and do not collect vouchers. Their observations—e.g., “bat species X and Y occur in caves all along the northwest coast”—form the basis of our understanding of fauna and species distributions alike. But, without vouchers, current and future research may not actually address the questions at hand. What happens when species Y is later recognized to be three species? What happens if species X has been

Table 16.2 The process of describing a new species can be broken down into two parts: the research necessary prior to description and the publication

Part 1: Research prior to description	
Collect data corroborating unique species identity	
Several lines of evidence	
Morphological, genetic, behavioral, ecological, phonic	
Literature review	
Is it a variant?	
Was it previously reduced to synonymy?	
Is it a new record in that area for a known species?	
Did it use the wrong name?	
Visit reference collections	
Compare to reference, voucher, or type (if possible) specimens of similar species	
Collaborate with systematist if necessary	
Part 2: Publication	
What kind of paper?	
Species description	Redescription
Revision	Synopsis
Review	Catalog
Monograph	Phylogeny
Checklist	Subspecies description
Description of Higher Taxon	
Create scientific binomial following rules set by ICZN	
Establish type specimen(s) and type locality	
Sections	
Diagnosis (distinguishing characters only)	
Description (all traits)	
Taxonomic characters	Color
Life history characters	Quantitative characters
Life stages	Behavioral/ecological characters
Discussion—significance?	
Ecology	
Distribution	
Material examined	

The above-mentioned table is derived from taxonomic procedures described in Winston (1999), a reference which is recommended by the International Commission on Zoological Nomenclature (ICZN)

misidentified? In such circumstances, how are we to know which bats are really present in the area? Effective gathering, consolidation, and analysis of data for conservation efforts require accurate species identifications as well as collection of voucher material, if possible.

Taxonomists must also communicate their work to non-experts, including other biologists. The taxonomic literature is notoriously inaccessible to non-specialists as it is often filled with obscure terminology and outdated names. Many historically important papers were published in journals that are not accessible to researchers in developing countries. Taxonomic revisions are not always readily available and widely circulated, allowing old names to persist in the literature and, more recently, Web-based faunal lists. This may complicate species delimitation and confuse consolidation of other ecologically important information necessary for effective conservation.

Best practices for species identification/documentation include the following: (1) use of a broad range of data to support species identifications, including morphological, genetic, and (if relevant) echolocation data; (2) a thorough review of the literature for names applied to the group(s) or specimens examined so that the oldest valid name is used; and (3) publication in an open-access journal for the broadest possible exposure. Examples of recent papers that use one or more of these best-practice approaches are as follows:

1. Larsen et al. (2010), who raised a previously recognized South American subspecies of *Artibeus*, *Artibeus jamaicensis aequatorialis*, to full species, *A. aequatorialis*, based on combined morphometric, mitochondrial, and AFLP (amplified fragment length polymorphism) data. The paper provided detailed context, including a review of the history of research on the species and a literature review of previous work on the genus. The study also provided a clear species account of *A. aequatorialis* and was published in the widely available journal *Zootaxa*.
2. Taylor et al. (2012), who recognized, on the basis of distinct echolocation calls, possible cryptic species within the *Rhinolophus hildebrandtii* complex of southern Africa. Subsequently, he described four new species supported by a combination of acoustic, morphometric, and molecular data.
3. Buden et al. (2013), who revised the Micronesian species *Pteropus insularis*, recognizing two subspecies, *P. pelagicus pelagicus* and *P. pelagicus insularis*. The authors examined a series of specimens and evaluated morphological features and conducted a thorough literature review of past names prior to revising the taxonomy of this species.
4. Velazco et al. (2014), who described the new species *Thyroptera wynneae* from South America. In this case, the morphological data unambiguously supported specific status for the collected voucher material, despite there being several other congeners found in sympatry.

The studies of *P. pelagicus* and *T. wynneae* were both published in the open-access journal, *ZooKeys* and *American Museum Novitates*, respectively, and are readily available to researchers from developing countries.

Products produced by taxonomists for use by experts and educated non-experts alike include keys and descriptions. Keys use mutually exclusive statements that help lead users to identifications of unknown organisms. Good keys use diagnostic features illustrated by line drawings or photographs to differentiate between species and include redundancy to ensure correct identifications at earlier steps. Incomplete keys often cause problems when they are the only means available to identify an animal. A good key enhances the work of land managers and other decision makers as well as researchers studying ecology, zoonotic diseases, and agriculture by allowing them to identify easily confused species and to access updated information on taxonomic nomenclature.

Taxonomists must understand the skills and facilities that are available where the key will be used. Keys that rely on external characters from a living animal must take precedence over features that can only be seen in museum preparations or with the use of a microscope (although some craniodental data may be needed to supplement external characters, especially in bats). Microscopes may not be available under field conditions, or at all at the locality under study. Extracting and cleaning skulls, or measuring morphological features requires training. Good examples of accessible keys are Barquez et al. (1993), which is available bilingually, and Taylor (2000), which includes acoustic profiles. Both of these keys use easily distinguishable external characteristics along with illustrations to assist in identification.

Taxonomists sometimes also produce field guides, drawing on knowledge of collection records, phylogenetic relationships, species distributions, and natural history to enlighten experts and non-experts alike. Field guides engage the scientifically literate public and can act as an illuminating form of outreach for bats. Top-notch field guides, such as those by Francis (2008) for the mammals of Southeast Asia and Reid (2009) for the mammals of Central America, are produced by experts and include detailed notes on species identification, natural history, distribution maps, and color illustrations or high-quality photographs. While not quite a field guide, Bat Conservation International freely provides species profiles on their Web site for all 47 species of North American bats. It is likely that Web-based field guides, or mobile device apps, will come to play a larger role in field identifications in the future, and these resources will benefit from attention by taxonomists during their development.

16.4 Taxonomy and International Agreements

The importance of taxonomy is recognized by the Convention on Biological Diversity's (CBD) Global Taxonomy Initiative program. Inadequate taxonomic information is recognized as an obstacle to making informed management decisions in conservation, sustainable use of resources, and availability of genetic resources (Secretariat of the Convention on Biological Diversity 2008). The legally binding CBD was signed by 193 governments in 1992–1993 at the UN Conference for Environment and Development. Article 7 (identification and monitoring), Article 12 (research and training), and Article 17 (public awareness and education) of the CBD directly address the need for taxonomic research to be conducted and used for conservation. Furthermore, the strategy plan for 2011 to 2020 specifically referenced the need to "improve the status of biodiversity and by safeguarding ecosystems, species, and genetic diversity" (Secretariat of the Convention on Biological Diversity 2012). The CBD indicates a willingness of governments to recognize the importance of taxonomy in resolving environmental challenges.

The importance of taxonomy in protecting species is most immediately visible under the Convention for International Trade of Endangered Species (CITES) agreement. With 179 Parties having now joined the Convention, to which they agree to voluntarily adhere, CITES provides a rank system with varying degrees of protection to more than 35,000 plant and animal species. Under CITES, all *Acerodon* and *Pteropus* species, or flying foxes, are listed as Appendix I or II. Appendix I species are deemed as threatened by extinction and all international trade is prohibited except for non-commercial purposes (e.g., scientific research). Appendix II affords protection to species that are not currently threatened, but may become threatened without controlled trade. Appendix II also protects similar-looking species in order to discourage illegal wildlife trafficking. All members of *Acerodon* and *Pteropus* are listed at both the genus and species level because many species have very restricted ranges and some are endangered, but species identification—especially by non-experts—is extremely difficult. The only non-pteropodid currently listed by CITES is the Uruguay population of the white-lined broad-nosed bat (*Platyrrhinus lineatus*), which is listed under Appendix III. Appendix III species are protected within a signatory country, but that signatory country has indicated it requires extended cooperation from other countries to prevent exploitation.

The importance of taxonomy in international agreements is also evident in the Convention on Migratory Species' (CMS) EUROBATS Agreement, which originally recognized 37 species, but now includes all 52 bat species (both migratory and non-migratory) in Europe, North Africa, and the Middle East. EUROBATS sets legal protection standards and develops and promotes management and conservation strategies across international borders, with 35 of 63 states within the targeted range as signatories. Revisions to the number of species listed, with an increase of 7 new species since 1995, are due to continuing taxonomic work in the region (CMS 2013).

16.5 Taxonomy as a Conservation Planning Tool

Taxonomy may be used as part of conservation either directly (e.g., generating species lists, defining hotspots in need of protection, inventories and monitoring, providing global perspective) or indirectly (e.g., estimating extinction risk, estimating rate of extinction). For example, the Southeast Asian Bat Conservation Research Unit (Kingston 2010) identified advancement in taxonomy and systematics research as a regional priority even though this consortium focuses on capacity building and conservation, not taxonomy. What follows is a summary of practices that conservation biologists currently employ, and also new perspectives and methods that taxonomy and systematics may bring to conservation management.

16.5.1 A Basic Question: What is a Species?

Effective species conservation requires defined taxonomic units that reflect biological reality and can be documented and tracked through space and time using survey and inventory methods appropriate to the organism and ecosystem. Defining and identifying such units is frequently much harder than it sounds. The most commonly used taxonomic unit in conservation biology is the species, though populations are occasionally considered unique enough to merit protection (Justice Department et al. 1996). Species are considered by both scientists and the public to be real, physical entities worthy of conservation. The fact that species have names makes it easier for non-experts to understand and protect them. However, species concepts in biology are far from simple (Cracraft 1989; de Queiroz 1998; Wheeler and Meier 2000; Baker and Bradley 2006; de Queiroz 2011) and applying a set of practical rules to standardize species units is helpful for making species lists in any given area. Taxonomic units for conservation recovery planning must acknowledge the ever-evolving nature of these units in natural systems. While methods of species definition and recognition are debated among researchers [e.g., reproductive isolation for the Biological Species Concept, monophyly for the Phylogenetic Species Concept (PSC), and genetic divergence for the Genetic Species Concept (GSC)], each recognizes that species are composed of populations and that by their nature they are dynamic, not static, units (de Queiroz 2005).

Compared to species of insects and birds, bats are relatively taxonomically stable, and issues related to new cryptic taxa are relatively minor in the sense that cryptic bat species are usually confined to within the boundaries of what was previously considered a single species (Jones et al. 2009). Cryptic species excepted, new information or the application of new species concepts has not tended to change species limits in most bat taxa, suggesting that species limits in bats (or at least those subject to revisionary studies within the last 25 years) are already defined to maximize stability (e.g., buffering against phylogenetic uncertainty) (Lee 2005). Despite hopes to the contrary, it seems unlikely that all taxonomists will ever agree on a single species concept, even for taxa within a relatively restricted group such as Chiroptera. A variety of factors influence the species concept employed in different studies: available data (e.g., morphology, molecules, echolocation calls, behavior), past history of work on the group, type(s) of training received by the researchers, sample sizes in the study, and available analytical tools may all play a role. In this context, it is important for taxonomists to be explicit about the species concept they employ in a study in order to make their data and conclusions transparent to other researchers.

16.5.2 Listing Species for Protection

The species lists that taxonomists assemble form the basic units used by international, national, and local authorities that provide protection to wildlife. Quantitative analysis has shown that the longer a species has been placed on a list of threatened or endangered species, the more likely it is to recover (Taylor et al. 2005). Many agencies have taxonomic standards that must be met prior to inclusion in a listing. For example, the IUCN requires that names be validly published in accordance with Codes (e.g., The International Code for Zoological Nomenclature or ICZN), and checklists, such as *Mammal Species of the World* (Wilson and Reeder 2005), should be employed where possible. The IUCN accepts the following taxa for listing: species, subspecies, varieties (only for plants), and geographically separate subpopulations. It may also allow undescribed species to be listed under extraordinary circumstances. International legislation includes multilateral environmental agreements (e.g., CITES and CMS) that directly support bat conservation, but other free-trade agreements can also uphold the goals of conservation by combating illegal wildlife trade and promoting species persistence. For example, the North American Free Trade Agreement created the Commission for Environmental Cooperation to identify and address reasons for the decline of widespread species such as the monarch butterfly (Commission for Environmental Cooperation 2010).

Protection on the national level may vary from country to country, but in most cases the species is the unit of concern. In addition to protecting species, many nations recognize the importance of protecting habitats as well; examples include both the Endangered Species Act (ESA) in the USA (US Fish and Wildlife Service 2013), the Species at Risk Act (SARA) in Canada (Species at Risk Act 2013), and the Habitats Directive of the European Union (European Commission 2014). These pieces of legislations all rely on a species list to provide protections with the listing process critical to successful conservation. Within the USA, there have been numerous critiques of the ESA from both scientific perspectives (e.g., Rohlf 1991; Pennock and Dimmick 1997; but see Waples 1998) and policy perspectives (Doremus 1997). Often species listed as threatened by IUCN are not similarly recognized as such by ESA. Taxa listed by the ESA include subspecies that are not listed by the IUCN; three of the eleven bat species on the ESA's threatened and endangered list are listed at the subspecific level (Table 16.3). Within the EU, Annex II of the Habitats Directive calls for the establishment of a Special Area of Conservation to protect recognized species, and Annex IV calls for a strict protection regime across the entire natural range of the species in the EU (Council Directive 92/43/EEC, European Commission 2014).

Differences in listing among countries and NGOs, such as IUCN, may reflect different definitions of "threatened" or "endangered," or reflect the varying ways that priority is afforded to a taxon during assessment. Monotypic genera are sometimes afforded greater priority in evaluation and listing than species, down to the level of population. The phylogenetic uniqueness of a species is an important factor in conservation assessments (IUCN 1980; McNeely et al. 1990; Tisdell 1990). Consequently, the taxonomic mindset of specialists on the group ("splitters" versus "lumpers") may play a very critical role in their decisions concerning when and if a taxon is afforded protection.

There are a handful of instances in which recognition of a new species has resulted in direct conservation action. In Thailand, the discovery of Kitti's

Table 16.3 Conservation status of bat species protected under the US's Endangered Species Act (ESA) compared to the global IUCN Red List

Species name according to ESA	US ESA	IUCN
Leptonycteris nivalis	E	E
Tadarida brasiliensis		LC
Macrotus californicus		LC
Myotis grisescens	E	NT
Diphylla ecaudata		LC
Lasiurus cinereus semotus	E	LC
Choeronycteris mexicana		NT
Myotis sodalis	E	E
Leptonycteris curasoae		V
Leptonycteris (curasoae) yerbabuenae	E	V
Pteropus tokudae	E	EX
Pteropus mariannus	T	E
Plecotus rafinesquii		LC
Corynorhinus (Plecotus) townsendii		LC
Corynorhinus (Plecotus) townsendii ingens	E	
Corynorhinus (Plecotus) townsendii virginia	E	
Eumops underwoodi		LC
Eumops floridanus	E	CR
Emballonura semicaudata rotensis	C	E
Non-American bats		
Craseonycteris thonglongyai	E	V
Aproteles bulmerae	E	CR
Pteropus rodricensis	E	CR
Hipposideros ridleyi	E	V
Emballonura semicaudata semicaudata	C	E

Blanks represent lack of listing (ESA) or lack of recognition of species or subspecies (IUCN). The ESA also lists and extends protection to some foreign bat species to discourage people under American jurisdiction from further contributing to species decline. Listing of foreign species may increase in situ conservation action and provide limited financial assistance and training

ESA abbreviations: *E* Endangered, *T* Threatened, *C* Candidate

IUCN abbreviations: *EX* Extinct, *CR* Critically Endangered, *E* Endangered, *V* Vulnerable, *NT* Near Threatened, *LC* Least Concern

Source US Fish and Wildlife Service Environmental Conservation Online System, Species Report, Listed Species; IUCN Red List

hog-nosed bat (*Craseonycteris thonglongyai*; Hill 1974) and the recognition of the distinctiveness of the taxon with the definition of a new family, led to the creation of the 500 km^2 Sai Yok National Park in 1980 under the Wildlife Animal Reservation and Protection Act, B.E. 2535. However, a population subsequently discovered outside the park in Myanmar is not protected, and relatively little is known from its status. The Myanmar population is genetically distinct from the Thai population but morphologically indistinguishable from it (e.g., cryptic), raising questions about whether or not it should be considered a distinct taxon or simply an isolated population (Bates et al. 2001; Pereira et al. 2007; Puechmaille et al. 2011). These discoveries have led to changes in the dynamic of conservation for *Craseonycteris*, since conservation priorities are often related to species range sizes. Similarly, ongoing discovery of cryptic species in Africa, such as Rosevear's serotine (*Neoromicia roseveari*), has led to calls for protection of the Upper Guinean forests, which are threatened by rampant human disturbance (Monadjem et al. 2013).

There are times when national recognition of a species as endangered comes too late, resulting in extinction. In some cases, this is in part due to taxonomic confusion—a circumstance that underlines the importance of taxonomy for conservation. The Christmas Island pipistrelle (*Pipistrellus murrayi*) is an unfortunate example from Australia. The only native insectivorous bat on Christmas Island, it was once widespread but underwent dramatic population declines by the mid-1990s (Beeton et al. 2010). The reasons for this decline remain unclear, but likely include introduction of non-native species (e.g., common wolf snake, feral cats, giant centipedes, and yellow crazy ants) that either disturbed roost sites or preyed on bats (Lumsden et al. 2007). It is also possible that control efforts focused on yellow crazy ants (*Anoplolepis gracilipes*) might have inadvertently poisoned the bats (Beeton et al. 2010). The muddled taxonomic history of the Christmas Island pipistrelle apparently contributed to poor management decisions. Koopman (1973, 1993) considered *P. murrayi* to be a synonym of *P. tenuis*, a common Southeast Asian species, apparently based on general morphological similarity. Hill and Harrison (1987) treated *P. murrayi* as a separate species based on the presence of a distinctive baculum, but this gained little attention at the time. Lack of a focused taxonomic treatment of the pipistrelle species complex resulted in lack of any real consensus about the status of the Christmas Island pipistrelle. The Australian government was slow to act upon findings from a long-term monitoring program, which recommended captive breeding programs for the Christmas Island pipistrelle in 2006 (Martin et al. 2012). It was only after genetic studies by Beeton et al. (2010) corroborated that *P. murrayi* was a distinct species that an emergency response was initiated in 2009 (Martin et al. 2012). However, these efforts came too late—the Christmas Island pipistrelle apparently became extinct in 2009 (Lumsden 2009).

Placing a species on international or national lists may be a prerequisite for local conservation actions such as habitat restoration or protection. The Indiana bat (*Myotis sodalis*) is listed as Endangered under the US's ESA. As such, the species is protected in the USA, meaning that commercial expansion must take into consideration the levels of disturbance to the population before development or operation may proceed in a given area. This has led to US Fish and Wildlife guidelines for businesses such as coal mining companies and wind farms (e.g., US Fish and Wildlife Service 2012) that describe development without harming local wildlife, such as Indiana bat populations. In a recent case against a wind energy company in West Virginia that failed to perform a due-diligence survey prior to development, the courts ordered an injunction against the company and required that it apply for incidental take permits before continuing operations. The wind turbines were allowed to be powered on only in the winter when the bats were hibernating (Woody 2009). In another case, a bat habitat restoration project has been proposed in Ozark National Forest, Arkansas, after ice storm-damaged acres of forest. The idea in this case is to ensure there will be enough healthy stands of trees for the Indiana bat (USDA 2012).

16.5.3 Downsides of Species Listing

Although well intentioned, adoption of global endangered species lists may in some cases be detrimental to more localized protection and conservation efforts. Many countries, and some subnational units, have simply adopted the IUCN Red List of species into their legislation. This practice can be inappropriate, as is recognized by IUCN itself. The criteria used in the IUCN list are specifically designed to identify the species that are most endangered at a global level, not within a region, nation, or specific locality. Consequently, the IUCN has issued "Guidelines for Application of IUCN Red List Criteria at Regional and National Levels" (IUCN 2012) to aid in the application of IUCN principles to more regional surveys. National governments that adopt IUCN listings in their entirety typically do not conduct their own taxonomic and systematic assessment of the species and population status of species that reproduce in or regularly visit the region within their borders. The IUCN advises using the globally derived Red List to set regional conservation priorities under only two conditions: (1) when there are a high number of endemics or threatened near endemics in the region, and (2) when there are little to no data concerning the species within a region. In all other situations, the IUCN advises following IUCN guidelines to assess extinction risk at the geographic scale of interest (local, national, and regional) and publishing Red Lists at this scale. Full compliance with the guidelines allows the country or region to state that their regional Red List follows the IUCN system.

Application of global lists at the local level may miss some species that need local protection. Alternatively, negative conservation outcomes may result if local values are compromised as a result of uncritical national protection of IUCN-listed species. For example, if the presence of a protected species impedes economic development, landowners in a region may destroy the species' habitat or deny the existence of that species to avoid local legal consequences stemming from its IUCN listing (Possingham et al. 2002). Planners and legislators need to appreciate that there are many dimensions to threat and protection and provide landowners and other stakeholders with incentives to protect endangered species.

16.5.4 Inventory and Monitoring Programs

Monitoring bat populations can be an important tool in efforts to understand the condition of an ecosystem, since bats have long been recognized as good indicator species (Fenton et al. 1992; Medellín et al. 2000; Jones et al. 2009). An indicator species is one whose presence, absence, and condition is suggestive of environmental health (Noss 1990). Since bats provide many ecosystem functions, such as pollination and seed dispersal, they are intrinsically linked to plant populations where they live (Fujita and Tuttle 1991; McConkey and Drake 2006). The predation of bats on insects may also reflect arthropod abundance and species diversity (Kalka et al. 2008). Bats can also be indicative of global climatic shifts. For instance, *Pteropus alecto* and *Pteropus poliocephalus* experienced increasingly frequent massive die-offs during extreme heat spikes in Australia (Welbergen et al. 2008). In early 2014, a record-breaking heat wave in central and eastern Australia resulted in one of the most catastrophic die-offs ever recorded—more than 45,000 flying foxes of the three native species (*P. alecto*, *P. poliocephalus*, and *Pteropus scapulatus*) died and more than 1000 juveniles were orphaned (Welbergen et al. 2014). These mass mortality events appear to coincide with the increasing frequency and intensity of extreme climate events that are predicted for Australia due to climate change (IPCC 2012).

Collection of voucher specimens, while sometimes controversial, is widely regarded by systematists and taxonomists as critical to inventory projects (Voss and Emmons 1996; Simmons and Voss 1998, 2009). Vouchers are necessary for any future work such as reassessments of the initial study or further extension of the initial work when new information or methods become available. Vouchers, including tissue samples, are especially necessary when species are cryptic or nearly so—some bat species can only be identified by minute morphological differences, (e.g., cranial characters, or in small vespertilionids, the baculum (penis bone) (Hill and Harrison 1987) or by molecular means (e.g., Clare et al. 2013). Vouchers are also necessary to provide type specimens (minimally a holotype but preferably also paratypes) if a new species is discovered (ICZN 2012).

In some regions of the world, taxonomists may be the only biologists with active research programs and therefore may be the only scientists positioned to collect the population and ecological data required for conservation assessments. They may also be the only biologists on hand to provide information about threats to species at particular localities. These taxonomists often have studied species throughout their ranges and are able to offer a more accurate assessment of conservation status by thinking globally instead of locally. For example, for the current revision of the Old World Fruit Bat Action Plan, the team leaders have reached out to a number of bat researchers, many of whom are taxonomists, to determine the most appropriate IUCN Red List status for each species. Most of the current specialist groups of the IUCN Red List include at least one taxonomic expert. This allows for the establishment of international versus national priorities and the creation of appropriate management strategies at the correct taxonomic level. For instance, in Britain, all bats and their roosts are protected by multiple domestic and international laws, even though a majority of these species are listed as Least Concern by IUCN (Bat Conservation Trust 2013). The UN's Global Biodiversity Outlook 3 also repeatedly references trends in population size and diversity of different taxa (Secretariat of the Convention on Biological Diversity 2010). These trends are based on species-specific data—data that are worthless without proper taxonomic identifications of the species in question.

To counter the lack of taxonomic experts during surveys, a technique called parataxonomic sorting was introduced in the late 1980s for entomological surveys in the Neotropics (Janzen 1991) and subsequently for plant surveys (Baraloto et al. 2007; Abadie et al. 2008). Parataxonomy focused on the use of "morphospecies" to sort collected specimens into Recognizable Taxonomic Units (RTUs) (Cranston and Hillman 1992; Oliver and Beattie 1993) as a preliminary method of assessment in the absence of enough taxonomic expertise. RTUs are not truly recognized biological species, and the sorting method is recognized as non-scientific, but the efficiency of the method quickly turned a preliminary sorting method into a source of data for biological surveys. However, results of parataxonomy are inconsistent and these methods have been criticized for the low quality of data and incorrectly grouped individuals (Krell 2004; Baraloto et al. 2007). Parataxonomy is largely uninformative when it comes to inventories, biogeographic studies, area selection for conservation, autecology, and habitat comparisons although it may still be useful in limited capacities for global comparisons of gross species richness or single-site descriptions of species richness of some taxa (Krell 2004). However, bats are particularly ill-suited to parataxonomic efforts because taxa are difficult to distinguish and the process of collecting specimens is time-intensive and requires specialized training and permits that are difficult to obtain even when one is an expert. Parataxonomy seems to hold little promise for chiropteran studies.

16.5.5 Defining Protected Areas

One commonly used method for defining protected areas is identification of "biodiversity hotspots" with "exceptional concentrations of endemic species…experiencing exceptional loss of habitat" (Myers et al. 2000). Generally, methods of prioritizing areas for conservation based on measuring endemicity, phylogenetic diversity, or taxon richness represent variations of the hotspot approach—they all measure some proxy for species representation and identify areas for conservation based on these variables. Such methods stand in contrast to area selection approaches that focus on threatened or degraded habitats. The hotspot approach to choosing protected areas has been criticized as susceptible to taxonomic instability (Isaac et al. 2004). Some authors have suggested that hotspots should use higher level taxonomy to identify areas that warrant protection and sidestep issues related to unstable taxonomy (Balmford et al. 2000; Amori and Gippoliti 2003). Genera and species were found to be highly correlated and may select for the same priority areas, whereas family and order are not very informative (Balmford et al. 2000; Amori and Gippoliti 2003). This approach may be inappropriate for bats, as young, rapid radiations may result in higher species diversity than would be predicted based on generic diversity. For example, in the Paleotropics, site-wide diversity is primarily driven by only a few genera (e.g., *Hipposideros*, *Rhinolophus*, *Kerivoula*) (Kingston et al. 2003). This pattern is also seen in the Neotropics, although to a lesser extent (e.g., *Artibeus*/*Demanura*, *Micronycteris*, *Lophostoma/Tonatia*) (Voss and Emmons 1996; Simmons and Voss 1998). Selection of hotspots based on species richness would value a site where selection based on genera would not, potentially leading to missed conservation opportunities.

To combat issues related to taxonomic stability, conservation should implement approaches that emphasize the uniqueness of taxa or areas (Gippoliti and Groves 2012). Newer methods for conservation often emphasize evolutionary uniqueness in concert with extinction risk when choosing priority protection areas (Collen et al. 2011). However, regardless of taxonomic resolution, the hotspot approach may be unlikely to reduce extinction risk in areas such as the Andes, where high species richness is correlated with areas with low human disturbance (Fjeldså 2000). The hotspot approach in this case ignores species at greatest risk in areas with high levels of human contact and may result in directing more resources to areas that require little intervention. Complementarity takes into account human development, selecting sites that may not have high biodiversity, but would result in conservation of more species in the area.

The relative taxonomic stability of bats means that some conservation decisions may be easier to make. But it does not mean that hotspot approaches are always appropriate. Instead of focusing on overall species richness, some area selection approaches focus on an umbrella species, or a variation thereof: focal, keystone, flagship, or threatened species (Lambeck 1997; Roberge and Angelstam 2004), with the assumption that protection of their habitat will benefit other organisms in the area. This approach often focuses on "charismatic megafauna," such as tigers, elephants, and primates, that are large-bodied as these species tend to have larger area requirements (Roberge and Angelstam 2004) and overlooks species with specialized habitat requirements or niche habitats, such as limestone karsts, that are irrelevant to large animals. Such niche habitats may be crucial to the survival of rare and endemic taxa with small ranges and narrow niches, such as threatened bat species such as Kitti's hog-nosed bat (*C. thonglongyai*) and the Thailand leaf-nosed bat (*Hipposideros halophyllus*).

16.5.6 Estimating Extinction Risk and Extinction Rate: The Role of Phylogenetics

Much emphasis is placed on extinction risk by conservation biologists in relation to climate change, habitat fragmentation, and habitat loss, but we cannot determine current rates of extinction and compare them to past rates of extinction without accurate knowledge of global biodiversity and updated phylogenies. Phylogenies allow researchers to test hypotheses related to character trait evolution, including traits related to natural history and extinction risk (Jones et al. 2003). Shared ecological traits from any one clade are by definition non-independent since all the species in a clade are linked by common ancestry. Analysis of patterns requires the removal of the historical signal in the data through the phylogenetic comparative method, otherwise known as "correcting" for phylogeny (Felsenstein 1985). Taxonomic bias for risk of extinction and for susceptibility to invasion is a known issue for conservation biologists (Fisher and Owens 2004). It may not be possible to conduct detailed research on every at-risk species within a short time span, but the comparative method allows for a quick assessment of conservation priorities based on shared risk of extinction in vulnerable clades. This may also provide perspective on causes of species decline. All of these data may allow for conservation actions to be taken sooner rather than later, with early action being more cost-effective and more successful (Fisher and Owens 2004).

Jones et al. (2003) conducted a multivariate analysis of correlation between extinction risk in bats (represented by IUCN threat level) and various natural history and morphological traits known to correlate with extinction risk in other taxa (Purvis et al. 2000; Isaac et al. 2005; Forero-Medina et al. 2009). Jones et al. (2003) found extinction risk to be highly correlated with evolutionary history, meaning clades shared similar levels of threat. Correlation of extinction risk with evolutionary history indicates the necessity of accounting for the phylogenetic history of clades when making such determinations, opening opportunities for determining the critical factors for clades. For example, geographic range size was the most important predictor of extinction risk across Chiroptera, though it was found to be an order of magnitude higher in pteropodids, which have smaller mean geographic ranges, than other bats. Among non-pteropodid bats, larger body size, larger group size, and low wing aspect ratios were significantly correlated with higher extinction risk. In pteropodids, smaller litter size was significantly correlated with extinction risk. These findings explained approximately half of the variance in extinction risk, and more work remains to be done. In a recent study of vespertilionid bats, those in threatened categories were more likely to be dietary specialists than those listed as Least Concern (Boyles and Storm 2007). As robust phylogenies are assembled and more ecological data are collected, the comparative method will be of great use for identifying important contributors to extinction risk in bats.

High genetic variation is generally thought to be associated with lower extinction risk, as species with greater amounts of variation are more able to adapt to changing environmental conditions (Lacy 1997; Hermisson and Pennings 2005). Endangered species generally have reduced genetic variability and, even after their numbers have recovered, may not be able to recover genetic variability and thus still face high extinction risk (Frankham 2005). While recovery rates may vary depending on how long populations were bottlenecked, a slow recovery would be predicted for bats, as they generally have low reproductive rates. Since populations recover too slowly, there would be a greater loss of genetic diversity as well. Rapid and irreversible loss of genetic diversity further increases extinction risk of a species and underscores the need for preemptive conservation action. However, reduced genetic variability must be shown to be truly a recent bottleneck through anthropogenic disturbance, as in the case of sea otters being impacted by the fur trade (Larson et al. 2002). In other mammalian species, such as cheetahs (Menotti-Raymond and O'Brien 1993) and wolverines (Schwartz et al. 2007), low genetic variability is a result of previous historical demographic changes (e.g., bottlenecking from Pleistocene glacial cycles, founder effects at periphery of distribution). Phylogenetic research is necessary to approximate expected levels of genetic variation before statements about genetic health of an endangered species can be made. There are currently no examples in bats using these methods, but comparisons of extant populations to historical specimens in museum collections may help determine whether threatened populations are experiencing anthropogenic bottlenecks. This research is now made possible by new methods in high-throughput sequencing of ancient DNA from degraded material (Gilbert et al. 2007; Mason et al. 2011; Dabney et al. 2013) and modeling of heterochronous data (Ho et al. 2007; Navascués et al. 2010; Drummond et al. 2012).

Estimations of speciation and extinction rates may also be made from phylogenies (Ricklefs 2007; Fitzjohn et al. 2009; but see Rabosky 2010 about the need for inclusion of fossil data) using speciation–extinction models derived from birth–death models in population ecology. Greater availability of time-calibrated phylogenetic trees now makes this method viable for estimating the likelihood that a clade will go extinct during a particular time slice. However, these estimates of likelihood of speciation and extinction are tied to the completeness of the phylogeny, meaning more phylogenetic work must be completed if these estimates are to be used for making predictions about species diversity in that clade. These model-based methods allow researchers to investigate speciation or extinction rates as compared to random chance. Anthropogenic effects on extinction can thus be more accurately assessed. Such research may also be used as a second test of hypotheses of species loss in concert with current methods favored by conservation biologists, such as species–area relationship and endemics–area relationship (e.g., Lane et al. 2006).

From phylogenetic studies, researchers now know that some species may be the only remaining representative of an old lineage, while others are one of many in very diverse clades. These old lineages, known as relict species, have genes and traits that have survived from deep timescales and tell a tale of resilience (and luck) in the face of regime shifts and faunal turnover. These taxa may have survived previous major extinction events, and researchers can study them to understand how species may continue to survive in the face of the current extinction crisis (Habel and Assmann 2010). Relict species may also represent the only living relatives of fossil taxa, allowing systematists to place fossil taxa correctly in a tree. Representing both extant and extinct taxa is necessary for accurate estimates of extinction rates (Rabosky 2010). How accurate these estimates may be for bats is still unclear, as there are few dated phylogenies and the only study in non-volant mammalian extinction rates found that clade age was not correlated to higher extinction (Verde Arregoitia et al. 2013). *Mystacina tuberculata* is an example of a relict species. It is a New Zealand endemic and the sole extant representative of an entire family that was once more widespread. The fossil record of mystacinids includes the bat genus *Icarops* from the Oligocene and Miocene of Australia (Hand et al. 2001), but the family also includes *Mystacina robusta*, a species that went extinct in historic times (Daniel 1990). Even with molecular tools, researchers have had difficulties resolving the sister taxon of Mystacinidae, likely a result of deep, rapid radiations that created short internal branches with conflicting phylogenetic signal (Kennedy et al. 1999).

16.6 Impediments to Taxonomic Research

A decline in both amateur and professional taxonomists has been documented (e.g., Stuessy and Thomas 1981; Hopkins and Freckleton 2002), with reductions or elimination of jobs in museums and universities for those trained in taxonomy. There are few skilled and trained bat taxonomists, slowing fieldwork as well as the publication of comprehensive taxonomic revisions, species lists, field guides, and popular works on bats. In part, this appears due to what has been described as a "classic market failure" for taxonomy (Aylward et al. 1993; Hoagland 1996). Taxonomy is an "externalized" cost:

> Growing out of a tradition of reciprocity and collegiality, taxonomists frequently do not charge clients directly for their specialized services and products, such as identifications and biodiversity databases, even though the users of these services and products now extend far beyond their fellow taxonomists. These service activities are often ancillary to a taxonomist's basic monographic work, for which he or she receives grant funds, or subsidizes on his own or through his employers. The cost of doing taxonomy is not factored into most biodiversity or ecology projects. Research grants (even in taxonomy) and ecological monitoring activities rarely include funds for the curation and care of voucher specimens, or the establishment and maintenance of museums. (Hoagland 1996)

The result? A reluctance by employers to hire those who do not bring in funds and cause a perceived drain on the institution, and a reluctance by students to pursue taxonomy as a career in favor of fields offering more money and jobs. While there are a growing number of young bat taxonomists in the developing world (Anwarali Khan et al. 2010; Douangboubpha et al. 2012; Soisook et al. 2013) where educational institutions are newly committed to developing and protecting local biodiversity, the lack of funds for taxonomy still presents a substantial impediment (Aylward et al. 1993). The few taxonomic experts in developed countries that still remain are discouraged from pursuing taxonomy in regions of the world where both the biota and their ecosystems are most understudied due to a combination of stricter local specimen export laws and lack of funding. Additionally, the low impact factor of taxonomic journals is a major impediment for academics at non-museum institutions whose performance reviews for promotion hinge largely upon the impact factor of journals in which they publish (Venu and Sanjappa 2011).

In most scientific fields, including other disciplines of systematics, specialists have grouped themselves in associations that publish journals and act as lobbies to promote their discipline and defend their members. However, there exists no international or national scientific society specifically devoted to the promotion of taxonomy, the publication of general papers on the discipline, its theoretical background, its history, or its problems and its future. In part as a result, taxonomists are typically under-represented in official or unofficial bodies that play significant roles in shaping scientific policies, budgets, and definition of priorities. Yet, taxonomists are critically needed for research in understudied groups, such as bats, especially in developing countries. Without any formalized society, it becomes difficult to pass on the expertise and shared standards that are essential to all other fields in biology, including conservation.

The reduction in numbers of taxonomists in institutions in developed countries and the increase seen in developing countries is complicated by a great deal of historical baggage. Type specimens (the actual specimens to which scientific names are attached) and important taxonomic literature are still based in institutions in developed countries, and there is still an imperative need for repatriation of information as well as capacity building outside these centers. Capacity building can occur at three different levels: individual (build individual ability to contribute to taxonomy), institutional (modernize museum infrastructure and policies, increase the level of curatorial proficiency in staff), and societal (engage the public in understanding and learning about biodiversity and being held accountable for it). Lack of access to available information is then also a part of the taxonomic impediment to conservation, not just lack of research in the discipline.

Progress has been made recently to increase accessibility of resources housed in institutions in developed countries. Digitization of type specimens of bats by some of the larger museums (e.g., American Museum of Natural History), increased availability of literature through online sources, increased training in developing countries, and increased collaborations between Western taxonomists with young taxonomists from developing countries have begun to counter gaps in knowledge and training. Collections research fellowships are now available at some institutions to provide researchers with funds needed for visiting museums and inspecting specimens first-hand. Developing countries now see an increase in new bat taxa described in international, open-access journals by in-country scientists. New, well-maintained, and actively used natural history collections now exist in places like the University of Phnom Penh, Cambodia; Prince of Songkla University, Thailand; and the National University of Laos, thanks to local support and funding by NGOs such as the Darwin Initiative, the Systematics Association, and the MacArthur Foundation. Older collections in species-rich tropical countries, such as at the National Museum of the Philippines, the Museo de Zoología-Mamíferos, Pontifica Universidad Católica del Ecuador, and the Museu Nacional, Universidade Federal do Rio de Janeiro in Brazil, have refurbished outdated collections spaces and benefited from increased access to information and increased local capacity as talented local scientists have helped reignite interest in conservation and biodiversity initiatives.

Museum collections and historic taxonomic descriptions themselves may, counterintuitively, present impediments to taxonomic research. While today's taxonomists use morphological and genetic data (when available) to establish species limits, such modern methods have only come to the fore recently. Many older species names are attached to poorly preserved type specimens, sometimes dry skins, museum taxidermy mounts, or specimens that survived long sea voyages pickled in rum or other spirits. These specimens may be so damaged that viewing important features, or any features, from the published descriptions is impossible, leading to confusion regarding the recognition of the species in question. In some cases, the type specimens have been lost or destroyed and new type specimens (known as neotypes) must be designated, again introducing the possibility of confusion. Older names are often based on brief and sometimes inadequate descriptions that fail to provide sufficient detail to facilitate distinction from similar species. Even when faunas have been well surveyed, these issues of taxonomy frequently cause confusion about the number and identity of species inhabiting a particular region. Taxonomic confusion may contribute to the inability to properly attribute a name to organisms or integrate new data, barring species from protection that they may have been granted had they been accurately recognized and complicating conservation efforts.

16.7 Conservation in the Era of Molecular Phylogenetics

Molecular tools have given systematists new ways to resolve phylogenies and population networks and thus new ways to delimit species and other units of conservation concern. Genetics has created new ways of thinking about what a species is, and this has led to healthy debates about species delimitation. In some countries such as Germany, conservation legislation takes into account the genetics of organisms as well as their species limits. The Nationale Strategie zur Biologischen Vielfalt (National Strategy for Biological Diversity of Germany, BMU 2007) recognizes that the entire gene pool of a species must be protected. While this may not always be possible, the reason for this approach is based on the desire to protect distinct lineages.

Populations are often locally adapted and may be on different evolutionary trajectories even within what is recognized as a single species. The term Evolutionary Significant Unit or ESUs was originally coined to reflect the importance of these units in conservation decisions (Ryder 1986; Moritz 1994). ESUs may be at the species level or below and ESU definitions generally include the idea that the ESU is currently geographically isolated from other ESUs, that there is genetic differentiation at neutral markers, or that there is local phenotypic variation. The term ESU has since changed to reflect both evolutionary processes along with ecological exchangeability. The crosshair analysis advocated by Crandall et al. (2000) uses tests of null hypotheses in four categories (genetic, ecological, recent, and history) to determine whether populations should be considered ESUs or not. Species are not static, but evolving; if given enough time, ESUs may evolve into entities that require a different taxonomic status, e.g., a population may become a new species. ESUs may represent unique gene pools and may be of special conservation concern; proper conservation action can be taken only if they are recognized.

Molecular genetics has also allowed researchers to identify cryptic species, species that are morphologically indistinguishable (or nearly so) but exhibit significant genetic divisions that form species boundaries (Pfenninger and Schwenk 2007). These discoveries have helped systematists further understand the mechanisms that drive the speciation process, such as sympatric reproductive isolation without morphological differentiation, but they also have conservation implications (Bickford et al. 2007). Cryptic species represent a previously unrecognized part of the biota of a region and thus may be important to conservation biologists who are interested in identifying and understanding biodiversity hotspots. In bats, many previously unrecognized cryptic species are now being found through molecular assays even in very well-studied areas (Mayer et al. 2007). Early results from bar coding work in Southeast Asia suggest that the number of bat species may be twice that currently recognized (Francis et al. 2010). The level of discovery of new taxa in the last decade has generally corroborated this estimate (Table 16.1).

A classic example of a cryptic species hiding in plain sight is the European pipistrelle (*Pipistrellus pipistrellus*). One of the most common bats throughout its range, the European pipistrelle was not recognized as a cryptic complex until echolocation data suggested the presence of more than one species of pipistrelle occurring in sympatry throughout much of Europe (Jones and van Parijs 1993; Barlow 1997; Barlow and Jones 1997). Since the early echolocation studies, mitochondrial data (Hulva et al. 2004), microsatellite data (Hulva et al. 2010), information on foraging (Davidson-Watts and Jones 2005), and habitat selection data (Davidson-Watts et al. 2006) have further corroborated the split of the European pipistrelle into two distinct species (*P. pipistrellus* and *Pipistrellus pygmaeus*). Similar echolocation studies in Southeast Asia of hipposiderid bats (Kingston et al. 2001; Thabah et al. 2006) and African *Rhinolophus* (Taylor et al. 2012) have shown that these groups likely contain many cryptic species that can be distinguished by distinct phonic profiles, but not so easily by morphology. In many cases, molecular work remains to be conducted to clarify the numbers and limits of species in these complexes.

Molecular tools can now be used to characterize biodiversity in a more efficient manner than could be done in the past, particularly in poorly studied regions of the world. However, these tools must be used with caution, as not every new mitochondrial clade warrants recognition as a distinct species—some genes are known to be hypervariable and poor indicators of species limits (Engstrom et al. 2004; Lohse 2009; Galtier et al. 2009). The phylogenetic signal for hybridizing species may look very similar to incomplete lineage sorting (e.g., both phenomena would result in non-monophyletic trees) and therefore requires more genetic data and stricter quantitative assessments of genetic data to test different evolutionary scenarios (Maddison 1997; Yu et al. 2012). Many molecular studies of bats published in recent years have failed to review important elements such as the morphology or echolocation call structure of putative species, or have failed to include a sufficient number of genes or individuals. Mitochondrial clades may point to the need for more research into a potential species complex, but such clades cannot be readily assumed to represent a new species. The recent discovery of multiple allopatric mitochondrial lineages of *Pteronotus parnellii* (Clare et al. 2011) *Chrotopterus auritus*, *Glossophaga soricina*, and *Saccopteryx bilineata* (Clare 2011) indicates that deep divergences may exist within these species, but further study of genetic, morphological, or behavioral characters is needed as noted by these authors. Even in well-studied regions, such as Europe, cryptic species may have only been recently recognized as new phylogenetic methods and more nuclear data have become available, such as the Natterer's bat (*Myotis nattereri*) complex (Salicini et al. 2011). Mitochondrial divergence may also reflect sex-based differences in dispersal rather than new species. For example, Ozark big-eared bats (*Corynorhinus townsendii ingens*) have low levels of mitochondrial divergence between caves, but their microsatellite data indicate that there is likely male-mediated gene flow between populations (Weyandt et al. 2005).

Examples exist of cases where mitochondrial data have been misleading in bats. A cautionary tale is that of two subspecies of *Myotis lucifugus* (*M. lucifugus* and *M. carissima*), which exhibited enough mitochondrial divergence that they could have been recognized as separate species on the basis of molecular evidence alone (Dewey 2006). However, analyses of ten additional nuclear markers have shown that both these subspecies are experiencing high levels of gene flow, resulting in the absence of population structure even if these were historically separate populations. Additionally, no morphological characters diagnose the mitochondrial clades (Lausen et al. 2008). Consequently, there is no justification, despite the mitochondrial indicators, for recognizing these subspecies as separate species.

In contrast, Goodman et al. (2009) used a combined molecular and morphological dataset to resolve cryptic species in *Miniopterus manavi*. This study demonstrates a "best practices" approach to resolving widespread species complexes. Previous research using only mitochondrial data suggested that *M. manavi* in Madagascar and the Comoros represented unique lineages. However, sampling was limited and the relationships between clades were not fully resolved (Weyeneth et al. 2008). Using increased geographic sampling and morphological comparisons of type specimens, each of the clades was more clearly defined. *Miniopterus aelleni* was recognized as a new species, and its species diagnosis and description was accompanied by photographs of a live individual and skulls, and illustrations of dental characters (Goodman et al. 2009). Despite the relative rarity of *M. aelleni* to *M. manavi* on Madagascar, both species were found in several protected areas and the authors did not suggest further conservation action.

Extensive sampling throughout the geographic range of the relevant species is needed when attempting to resolve the relationships within a species complex. Simulation data suggests that more complete taxonomic sampling improves phylogenetic accuracy (Pollock et al. 2002). Too much missing data, either in the form of missing characters (e.g., missing genetic loci or using only mitochondrial data for some taxa) or missing taxa (e.g., incomplete geographic sampling) can lead to unresolved trees or incorrect inferences through phenomena such as long-branch attraction (Wiens 2003, 2006).

Currently, the field of molecular phylogenetics is undergoing a major shift away from locus-by-locus data collection to next-generation sequencing methods (also called high-throughput sequencing) that will allow for the collection of massive datasets in a relatively short period of time (Faircloth et al. 2012; Lemmon et al. 2012; Lemmon and Lemmon 2012). As prices fall and computational pipelines are developed to deal with the influx of data, taxonomically complex problems may be resolved by the increased availability of molecular character data. Genomic advances will also allow for detection of signs of natural selection in recent history (e.g., Pickrell et al. 2009 in humans; vonHoldt et al. 2010 in dogs), which could be used to determine how recent historical events such as climate change or human disturbance have affected natural populations. Having more data may not be the only solution to taxonomic problems, however—more powerful computational models means greater ability to analyze multilocus datasets that are already available. By taking cues from population genetics and phylogeography, historical models can now be incorporated into analyses to understand the effects of microevolutionary processes on species histories (Edwards and Beerli 2000). Establishing that a tip on a phylogenetic tree is truly representative of a species, and not just a genetic lineage, is fundamental to the goals of systematics and necessary prior to further analyses about speciation and diversification (Edwards 2009).

16.8 The Problem of "Taxonomic Inflation"

Taxonomic inflation caused by improper species delimitation can have profound effects on conservation, as biodiversity hotspots may be misidentified, or conservation priorities are selected based on poor evidence. With the advent of molecular phylogenies, imprudent application of the PSC or the GSC has been criticized for greatly inflating the number of recognized species in mammals, where many subspecies have been raised to full species rank. The examples cited by critics, such as Zachos et al. (2013) for Cetartiodactyla and Isaac et al. (2004) and Mace (2004) for Primates, however, are not due to application of the PSC or molecular phylogenetics; instead, they are generally due excessive splitting of inadequate datasets. For instance, critics cite splitting the mainland serow (*Capricornus sumatraensis*) into six species from one as evidence of taxonomic inflation. Yet the split of this species was based on pelage characteristics and was complicated by small sample sizes (Groves and Grubb 2011), and as such it has nothing to do with a new understanding of genetics. While the mainland serow may not have warranted such splitting, the critiques against taxonomic inflation ignore the fact that newly recognized species in these complexes may reflect biological reality (Gippoliti and Groves 2012; Gutiérrez and Helgen 2013). A more comprehensive set of data may be needed to confirm species boundaries, but new research should not be thrown out in favor of older taxonomy just because the latter is more convenient. Like other branches of science, our knowledge, and views of taxonomy change, other researchers also need to embrace this aspect of defining species.

Gippoliti and Groves (2012) responded to criticisms of taxonomic inflation by citing several examples of how integrative modern taxonomy (including multiple lines of evidence) has positively affected conservation. Critics of taxonomy are not wholly against the findings of modern taxonomy. For example, Zachos et al. (2013) recognized several legitimate cases of cryptic species in African elephants, giraffes, and European badgers. In each case, multiple lines of evidence corroborated species boundaries and warranted species-level recognition. Critics of taxonomic inflation seek the same comprehensive data collection that taxonomists do and generally make the same recommendations that we have outlined above. If uncertainty surrounding preliminary mitochondrial data exists, decision makers should determine if clades of interest correspond to any ESU or other management units (Miralles and Vences 2013), not throw out the new taxonomic information entirely.

It is important for taxonomists to state methods used to delimit species so that new candidate assessments can be easily made in the future. Explicit enumeration of methods, species concepts, and data makes taxonomic assessments more repeatable and testable by others. Clearly written species descriptions based on multiple lines of evidence help maintain the species identity over time, reducing confusion in the long run about the species and its associated name. A recent study in the Malagasy lizard genus *Madascincus* found that different species-delimitation protocols (e.g., Bayesian Assignment Test, HaploWeb, or Generalized Mixed Yule Coalescent Approach) result in wildly different recognized species, with the Bayesian Assignment test approach being in the most agreement with integrative taxonomy (Miralles and Vences 2013). Clearly stating methods can also reduce noise from new species concepts or new data, since it can be quickly determined if this new information will change how the species is viewed and understood. If species limits are known to be stable, that helps maintain the credibility of the lists that legislators and agencies so heavily rely upon for conservation.

16.9 Conclusion

The Age of Discovery is not over for chiropteran taxonomists, who play a critical role in efforts to ensure the documentation and protection of bat diversity by providing a necessary framework for conservation initiatives. Use of a broad range of data (morphological, molecular, behavioral, acoustic) has had a marked effect on the number of bat species identified in the past decade; molecular and acoustic data have indicated that there may be numerous cryptic bat species that cannot be successfully identified using morphology alone.

In addition to identifying species and caring for museum specimens, taxonomists create species lists for localities and communicate taxonomic ideas to non-experts, especially through species lists, descriptions, keys, and field guides. These activities lead to important opportunities for outreach via public exhibits at home institutions or in the field. Taxonomists also provide conservation planning tools such as inventory data, estimates of extinction risk, and information to help define protected areas. These activities allow researchers and government agencies to lower extinction risks and improve the likelihood of species recovery.

More training should be provided to non-taxonomic experts through short workshops focusing on specimen collection and identification techniques. When conducting research, taxonomists may provide the first close-up look at bats to local populations. Capitalizing on this opportunity to inform people about their local biota through leaflets, talks, and training, can advance local and regional conservation goals.

Impediments to the training of new taxonomists remain substantial, including a lack of funding for the identification and storage of voucher specimens, the absence of a taxonomy "lobby" and journal devoted to taxonomic practice, and the low status often accorded to taxonomic publications. However, accessibility to museum materials in developed countries—both voucher material and literature—is increasing through ongoing digitization efforts. Worldwide interest in local biodiversity is also increasing and new bat taxonomists, with new or growing collections, are now practicing around the globe. It is our hope that all taxonomists advocate for appropriate management strategies for bats on a global scale by reaching out to local populations, non-expert scientists, and legislators; effectively communicating complex scientific ideas and listening to local concerns; and continuing to provide a robust scientific basis for conservation as we work to prevent bat extinctions in the Anthropocene.

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Chapter 17
Networking Networks for Global Bat Conservation

Tigga Kingston, Luis Aguirre, Kyle Armstrong, Rob Mies, Paul Racey, Bernal Rodríguez-Herrera and Dave Waldien

Abstract Conservation networks link diverse actors, either individuals or groups, across space and time. Such networks build social capital, enhance coordination, and lead to effective conservation action. Bat conservation can benefit from network approaches because the taxonomic and ecological diversity of bats, coupled with the complexity of the threats they face, necessitates a wide range of expert knowledge to effect conservation. Moreover, many species and issues transcend political boundaries, so conservation frequently requires or benefits from international cooperation. In response, several regional bat conservation networks have arisen in recent years, and we suggest that, with the globalization of threats to

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C.C. Voigt and T. Kingston (eds.), *Bats in the Anthropocene: Conservation of Bats in a Changing World*, DOI 10.1007/978-3-319-25220-9_17

bats, there is now a need for a global network to strengthen bat conservation and provide a unified voice for advocacy. To retain regional autonomy and identity, we advocate a global network of the regional networks and develop a roadmap toward such a meta-network using a social network framework. We first review the structure and function of existing networks and then suggest ways in which existing networks might be strengthened. We then discuss how regional gaps in global coverage might best be filled, before suggesting ways in which regional networks might be linked for global coverage.

17.1 Introduction

Individuals have formed groups to address conservation issues for decades, but with the application of network theory to social settings, we can now gain insights on the consequence of the structure of conservation-oriented groups for group function. Networks comprise nodes that are linked together by some form of interaction. In social networks, nodes (or actors) are typically individuals, but they may also be groups or entities in their own right, linked by relationships that typically reflect socially oriented values such as friendship, reputation, altruism, and reciprocity (Fig. 17.1).

Conservation networks link actors involved in conservation activities across space (Guerrero et al. 2013). A network may be specifically formed to address a management objective, or arise organically and informally through stakeholder interactions. Interest in network approaches to conservation and natural resource governance (e.g., Bodin and Prell 2011) has been precipitated by the growing realization that top-down centralized approaches often fail to engage stakeholders, are rarely adaptive to local conditions, and as a consequence often fail to achieve sustainable conservation outputs (Bodin and Crona 2009). Regardless of the specific issue, conservation networks have three implicit objectives: (i) The network builds *social capital* [information, resources, knowledge, connections held by the group (Putnam 2000) or individual actors (Portes 1998)] (Newman and Dale 2007); (ii) the network strengthens relationships among activities in a system such that their common effectiveness is enhanced (*coordination*—Hessels 2013); and (iii) that the increase in social capital and coordination will have *agency* (Newman and Dale

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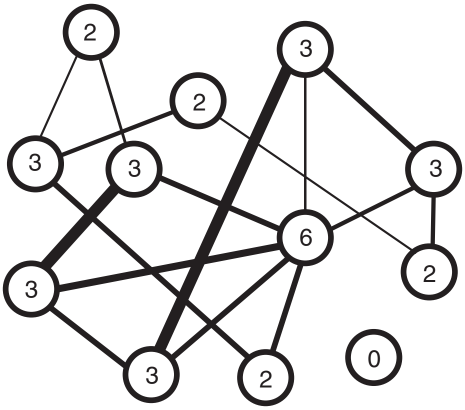

Fig. 17.1 A simple social network. *Circles* are nodes (or actors) connected to one another by links (*straight lines*), also called vectors. Links may be bi- or unidirectional and can be weighted by the strength of the connection between nodes, depicted here by link thickness. Bidirectional links may differ in strength (weight) with direction, for example, if a local coordinator in a bat conservation network commonly sends more information out than she receives, but this has been omitted for clarity. The number of links connected to a node is the degree centrality, shown here within each node. The mean degree for this network is 2.67, and the network density is 0.24 (16/66)

2007), i.e., ability of a group to turn social capital derived from the network into conservation action.

Bat conservation may be facilitated by network approaches for several reasons. First, conservation networks can be particularly effective in dealing with issues operating at multiple spatial and temporal scales and thereby preventing mismatches between the scale at which conservation actions are undertaken and that of the problem (Guerrero et al. 2013). Bat conservation is susceptible to scale mismatches in both space and time. From a geographical perspective, coordinated effort across political boundaries may be required to ensure species' protection across their entire range and to manage migratory species. The Agreement on the Conservation of Populations of European Bats (UNEP EUROBATS), which came into force in 1994, was set up under the Convention on the Conservation of Migratory Species of Wild Animals (CMS), precisely for these reasons. Thirty-five of the 63 range states have acceded to the Agreement, which aims to protect all 52 species of European bats. In the Paleotropics, larger Pteropodidae are known to move across borders [e.g., *Eidolon helvum* (Richter and Cumming 2008), *Pteropus* spp. (Epstein et al. 2009; Breed et al. 2010)], while the continuous north–south latitudinal orientation of the Americas has promoted seasonal migration across borders in several genera (Popa-Lisseanu and Voigt 2009). Stable taxonomy is essential for conservation (Tsang et al. 2015) and similarly may require international cooperation to resolve taxonomic conundrums and test systematic hypotheses of taxa distributed across multiple countries (e.g., Ith et al. 2011). Commercial trade in *Pteropus* spp. for human consumption and traditional medicine has imperiled many species, particularly in the Pacific Islands and western Indian Ocean Islands (Mickleburgh et al. 2009; Mildenstein et al. 2016). Although one *Acerodon* and 10 species of *Pteropus* are listed under Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the remainder together with *Acerodon* spp. on Appendix II (June 2014), illegal trade will likely continue without coordinated international enforcement among parties.

From a temporal standpoint, because bats are long-lived (Wilkinson and South 2002) decades of observations/monitoring may be required to detect population numbers responding to disturbance or management (Meyer et al. 2010). Moreover, long-term efforts deploying standardized methods across funding cycles and staff turnover require substantial training and coordination. The UK's National Bat Monitoring Programme was established in 1996, but it took a further 15 years of work before statistically robust population trends could be estimated, and then for "only" 10/11 of the UK's 17 breeding species (Barlow et al. 2015). The enormous citizen science effort is spearheaded and coordinated by the Bat Conservation Trust (BCT), a network of 100+ local bat groups. In addition, long-term social or political change may be needed to address particular threats to bats, particularly if the threat is embedded in cultural practices or superstitious beliefs (Kingston 2016).

Second, the social capital and coordination brought by a network approach are important because bats are so diverse taxonomically and ecologically that few practitioners can hold knowledge of more than a handful of species; most researchers are taxonomically or geographically limited. Similarly, varied skill sets are required to garner the basic knowledge that underpins conservation efforts (e.g., taxonomy, ecology, acoustics, genetics and phylogenetics, population monitoring, disease ecology, outreach/engagement, policy), and many issues require an integrative approach to conservation action. Finally, bat research expertise is patchily distributed in many parts of the world, residing in particular institutes within countries, or absent entirely from some countries. Connecting experts through a network accelerates both knowledge transfer among them and the development of capacity in underrepresented areas.

Given the potential for networks to coordinate and strengthen bat conservation, it is not surprising that several bat networks have evolved over the last 25 years. The purpose of this chapter is to review the structure and function of existing bat conservation networks and to discuss the ways in which application of social network theory might strengthen existing networks, facilitate the establishment of new networks, and ultimately guide efforts to link regional networks into a global network of networks.

17.2 Existing Bat Conservation Networks

We focus our review on networks that have conservation as a primary mission and that encompass two or more countries, namely Agreement on the Conservation of Populations of European Bats (UNEP EUROBATS); the Australasian Bat

Society (ABS); Bat Conservation Africa (BCA); BatLife Europe; BCT; Chiroptera Conservation and Information Network of South Asia (CCINSA); North American Bat Conservation Alliance (NABCA); Red Latinoamericana para la Conservación de los Murciélagos (Latin American Bat Conservation Network) (RELCOM); and Southeast Asian Bat Conservation Research Unit (SEABCRU) (Table 17.1,

Table 17.1 Summary information for existing bat conservation networks

Name (acronym)	Agreement on the Conservation of Populations of European Bats (UNEP EUROBATS)
Web presence	Web site: http://www.eurobats.org
Founded	1994
Geographical scope	63 range states (countries) of Europe, North Africa, and the Middle East
Structure	An agreement to which range states (countries) accede and thereby becoming parties. Working group substructure
Membership	35 range states have acceded of a possible 63
Communication	Electronic newsletter, Web presence, annual Meeting of the Advisory Committee (AC), four-yearly Meeting of the Parties to the Agreement. Inter-sessional working groups report to AC, resulting documents published/available on Website
Leadership	EUROBATS is now part of the United Nations Environment Programme and is administered by an executive secretary, with a small administrative staff. An Advisory Committee (AC) comprising invited representatives from range state government departments, Statutory Nature Conservation Organizations (SNCOs), NGOs, and observers meets annually to prepare resolutions for adoption by parties to the Agreement (the signatory governments) who meet every four years
Funding	Member states pay an annual subscription. EUROBATS established the separately funded European Projects Initiative to provide grants of up to 10,000 Euros
Mission and objectives	(1) Exchange information and coordinate international research and monitoring initiatives; (2) arrange the Meetings of the Parties and the Advisory and Standing Committee Meetings; (3) stimulate proposals for improving the effectiveness of the Agreement and attract more countries to participate in and join the Agreement; (4) stimulate public awareness of the threats to European bat species and what can be done at all levels to prevent their numbers dwindling further
Primary activities	(1) The fifteen intersessional working groups produce authoritative reports which help to inform conservation practice. (2) The annual Meetings of the Advisory Committee, in addition to providing valuable opportunities for exchanging ideas about best practice in bat conservation, produce resolutions which are presented to and generally adopted by the four-yearly Meeting of the Parties. An example is the resolution on rabies, the full text of which appears on the Web site, which urged signatories to the Agreement which had not already done so, to introduce surveillance programs. That was successful and several more range states introduced such programs. (3) European Bat Night is an annual awareness-raising activity. (4) The Year of the Bat 2011–2012 was introduced initially as a European Initiative but quickly went global

(continued)

Table 17.1 (continued)

Name (acronym)	Agreement on the Conservation of Populations of European Bats (UNEP EUROBATS)
Major successes	The commitment of 35 European governments to conserve bat populations

Name (acronym)	Australasian Bat Society, Inc (ABS)
Web presence	Web site: http://ausbats.org.au/. Facebook: Australasian Bat Society, e-mail Discussion List, Twitter, YouTube uploads
Founded	1992 (origins 1964)
Geographical scope	Australasia: Australia, New Zealand, Melanesia
Structure	A conservation society with an elected executive team, plus various subcommittees and formalized positions that are created as required
Membership	Researchers, environmental consultants, wildlife rehabilitators, advocates, land managers, naturalists, and educators c. 350 members
Communication	Biennial conference, biannual newsletter, Web presence, quarterly executive meeting, and e-mails (online)
Leadership	Executive committee elected by membership for 2-years term. Comprise President and 2 VPs, Secretary, Treasurer, Editor, Membership Officer. Advisory "extended executive" of past office bearers and helpers. Informal positions—public officer, bat night coordinator, communications officer, social media officer, sponsorship officer, conservation officer, media spokesperson
Funding	Membership subscriptions, conference registrations and sponsorship, advertising in newsletter, account interest, donations, fundraising events
Mission and objectives	*Mission* "To promote the conservation of all populations of all species of bats in Australasia." *Objectives* Encourage membership, disseminate information and outreach materials, advocate for bat conservation and management by advising decision makers, encourage bat research, fund raising, organize biennial conference, build relations and work with other organizations, promote ethical and humane practices in study of bats, support carer and rehabilitation organizations, maintain a public fund for donations
Primary activities	Biennial research conference and workshops, liaising with Local and State Government on issues of bat management and conservation (e.g., flying fox dispersals, bats in mines and bridges, threatened species), produce fact sheets and position statements about bat–human conflict issues (e.g., shooting as control method for flying foxes), media statements on selected issues, survey standards, assist all levels of Government with their information and policy documents, community education events ("Bat Nights" talks and walks)
Major successes	Input to Government policy—Guidance Notes, Action Plans, Conservation Status listings, threatened species survey guidelines. 16 well-attended biennial conferences. 42 editions of newsletter since 1993, plus other similar periodicals since 1964, integration of wildlife carers, significant promotion of bats to the public

Name (acronym)	BatLife Europe
Web presence	Web site: http://batlife-europe.info. Facebook: BatLifeEurope
Founded	2011

(continued)

Table 17.1 (continued)

Name (acronym)	BatLife Europe
Geographical scope	Europe and North Africa
Structure	Country-based network comprising national conservation NGOs (“partner organizations”), usually 1 per country. 33 partners from 30 countries (2013)
Membership	NGOs involved in bat conservation, but not necessarily exclusively so. Membership to NGOs open
Communication	Newsletter, Web presence, triennial conference (European Bat Research Symposium). Trustees meet up to 6× per year online
Leadership	Board of 14 trustees nominated and elected by partner organizations every three years at a meeting of partners at the European Bat Research Symposium. The Board is run by the Chair, with support from the Vice Chair, Secretary, and Treasurer
Funding	Partner NGOs pay an annual subscription or are sponsored by another member. Small grants
Mission and objectives	To promote the conservation of all wild bat species and their habitats throughout Europe, for the benefit of the public. Objectives focus on the following: (1) communication and knowledge sharing; (2) identifying priorities for action; (3) developing projects; and (4) building capacity and international support
Primary activities	Member of the European Habitats Forum seeking to influence European environmental policies, active within the Eurobats Agreement. Disseminates knowledge and experience to build capacity across network (workshops planned). Working on development of a European biodiversity indicator based on bat hibernation surveillance data
Major successes	Bringing together 33 NGO’s to form the network. Capacity building survey completed to guide development actions. Contributed to the Pan European Indicator and the European Union Bat Action Plan

Name (acronym)	Bat Conservation Africa (BCA)
Web presence	Web site: http://www.batconafrica.net. Facebook: Bat Conservation Africa Google Listserv: batconafrica@googlegroups.com
Founded	2013
Geographical scope	Africa and the island nations of the western Indian Ocean
Structure	Organized around six regions (southern, eastern, central, western, northern Africa, and western Indian Ocean Islands)
Membership	Individuals joining the list serve, c. 80 members from 25 countries
Communication	List serve and e-mail
Leadership	Steering Committee of representatives from each region, led by a Chair and Vice Chair selected by the Steering Committee. External Advisory Committee to be established
Funding	
Mission and objectives	*Vision* Bats and humans live in harmony in Africa. *Mission* To create a platform for the promotion of bat conservation in Africa. *Objectives* (1) Establish a platform for information sharing; (2) capacity building-skills transfer, education and training, leadership, resources; (3) identify and promote regional conservation priorities; and (4) identify and respond to knowledge gaps on African bats

(continued)

Table 17.1 (continued)

Name (acronym)	Bat Conservation Africa (BCA)
Primary activities	Current emphasis on establishing network operations and lines of communication. Future emphasis on meeting objectives with targeted activities
Major successes	

Name (acronym)	Bat Conservation Trust (BCT)
Web presence	Web site: www.bats.org.uk. Facebook: Bat Conservation Trust. Twitter @_BCT_, LinkedIn Forum
Founded	1990
Geographical scope	England, Wales, Scotland, Northern Ireland (UK)
Structure	Networks c. 100 local Bat Groups
Membership	5600 members including members of the public, volunteers, ecologists and environmental consultants, government workers, academics and teachers
Communication	Newsletters (adult and youth), monthly e-bulletins (general, bat workers, National Monitoring Programme), Web presence, annual national conferences, and separate annual conferences/forums in Scotland and Wales. Regional meetings biennially
Leadership	BCT is a fully constituted NGO and registered charity and must conform to the regulations of the Charity Commissioners in England and Wales and the Office of the Scottish Charity Regulator in Scotland. It is governed by a board of 12 trustees with elected officers. The board appoint the CEO. There are presently 30–35 staff
Funding	Donors, government conservation agencies, charitable trusts and foundations, Heritage Lottery Fund, contracts for service provision (e.g., National Bat Helpline), fees for conferences and training, membership fees, donations from public and major donors
Mission and objectives	*Vision* A world where bats and people thrive together in harmony. *Mission* To secure the future of bats in a changing world. Key objectives that lead work conducted—*Discover* To establish the capacity of the landscape to support viable populations of bats. *Act* To secure and enhance bat populations to the full capacity of the landscape. *Inspire* To win the level of support required to achieve and maintain these bat populations
Primary activities	Monitoring bats, conservation research, landscapes for bats, buildings, development and planning, biodiversity policy and lobbying, training and best practice for professionals, bat crime investigations, education and engagement
Major successes	Establishing and growing the National Bat Monitoring Programme (trends for 10 of UK's 17 breeding species). Lead on Biodiversity Action Plans for bats, which led to targeted advice for buildings industry and woodland managers, and establishment of bat crime investigations, and a training program for professionals whose work affects bats. Public education effectively changed people's attitudes to bats in UK

Name (acronym)	Chiroptera Conservation and Information Network of South Asia (CCINSA)
Web presence	Web page: www.zooreach.org/Networks/Chiroptera/Chiroptera.html

(continued)

Table 17.1 (continued)

Name (acronym)	Chiroptera Conservation and Information Network of South Asia (CCINSA)
Founded	1999
Geographical scope	South Asia (Bangladesh, Bhutan, India, Nepal, Maldives, Pakistan, Sri Lanka and Afghanistan)
Structure	None
Membership	Academic, government, NGO, teachers, volunteers c. 270 members
Communication	Newsletter
Leadership	Founded and run by Sally Walker with help from staff and President invited by her
Funding	Support for workshops from Zoo community, plus other small grants
Mission and objectives	*Mission* To encourage and promote the study of bats of South Asia, by organizing and running a network of bat specialists, and to provide them useful services. *Objectives* (1) To maintain a check list and database of bats; (2) implement a program of bat research training workshops; (3) develop and disseminate outreach materials; and (4) lobbying for the protection of bats
Primary activities	Organizing and conducting workshops on techniques for studying bats, lobbying for specific causes by contacting appropriate governmental departments
Major successes	Development of bat conservation community in S Asia, 9 workshops with 251 participants. Established Pterocount, a program using volunteers to monitor local populations of *Pteropus giganteus*. Successful public education program and dissemination of outreach materials. Successfully lobbied to get two threatened bats moved from Schedule V (“vermin”) to Schedule I (absolute protection) of the Indian Wildlife Protection Act 1972

Name (acronym)	North American Bat Conservation Alliance (NABCA)
Web presence	Facebook: North American Bat Conservation Alliance
Founded	1997 as North American Bat Conservation Partnership, 2008 as Alliance, relaunched 2013
Geographical scope	Canada, USA, Mexico
Structure	A federation of working groups and organizations in North America
Membership	Working groups and organizations involved in bat conservation. Membership to working groups open. c. 500 individuals
Communication	Annual open meeting at varied national or international professional meetings (2014 onward), tied biennially to North American Society for Bat Research meeting. Monthly conference calls among organizing committee. List serves with quarterly summaries (planned)
Leadership	Organizing committee comprising representatives form member organizations and working groups. Leadership to rotate between USA, Canada, Mexico
Funding	
Mission and objectives	To promote the conservation of bats in North America by facilitating collaboration, coordinating priorities, and elevating awareness, for the benefits of bats, people, and their ecosystems

(continued)

Table 17.1 (continued)

Name (acronym)	North American Bat Conservation Alliance (NABCA)
Primary activities	Facilitating communication among bat working groups across North America, developing conservation priorities, and assisting the bat community in addressing important issues impacting the conservation of North American bats
Major successes	List of conservation priorities completed. Trilateral agreement to promote cooperation in the conservation of bat populations in North America. Letter of Intent signed by representatives of Environment Canada, secretariat of the Environment and Natural Resources for the United Mexican States, and the Fish and Wildlife Service of the USA, April 2015

Name (acronym)	Red Latinoamericana para la Conservación de los Murciélagos [Latin American Bat Conservation Network) (RELCOM)]
Web presence	Web site: http://www.relcomlatinoamerica.net/. Blog: http://reddemurcielagos.blogspot.com/. Facebook: Relcom Murciélagos. iNaturalist: (http://www.inaturalist.org/projects/murcielagos-de-latinoamerica-y-el-caribe): Groups: Yahoo RELCOM. Twitter: @Relcom
Founded	2007
Geographical scope	Latin America and the Caribbean
Structure	Country-based network constituted by local Programs for Bat Conservation (PCMs), one program per country. 5 countries at foundation, 22 countries currently
Membership	1 PCM per country, but PCM membership open to all interested in bat welfare, large academic membership. c. 800 people
Communication	Quarterly newsletter, Web presence, biennial conference (since 2014), subregional initiatives (e.g., Central and South America)
Leadership	Acting General Coordinator (AGC) elected by 51 % majority of voting members, one from each PCM, during General Assembly. Serves 3 years. AGC appoints a board of directors with individual responsibilities for research, conservation, and education. Board also includes Elected GC and Past GC. Governed by Bylaws approved by General Assembly
Funding	Donors support General Assembly. PCM's generate local funding, apply for national and international academic and conservation grants, sell merchandizing and have membership contributions
Mission and objectives	Guarantee the persistence of healthy bat species and viable populations in Latin America and that in all the countries their importance is acknowledged and recognized. *Research* Promote and stimulate the generation of scientific knowledge that contributes to the conservation of bats and their habitats. *Education and public outreach* Spread the knowledge about bats over the civil society and involve local people in their conservation. *Conservation* Promote the implementation of specific actions and policies aimed at preserving the species and bat populations in Latin America
Primary activities	Promotion and designation of Important Bat Conservation Areas/Sites. Conservation research projects. Task force for rapid response to problems associated with vampire bats and rabies. Public outreach supported by traveling education kit. Capacity building within and outside PCMs

(continued)

Table 17.1 (continued)

Name (acronym)	Red Latinoamericana para la Conservación de los Murciélagos [Latin American Bat Conservation Network) (RELCOM)]
Major successes	Creation and consolidation of Important Bat Conservation Areas/Sites. Publication of action plans for threatened species. Delisting of *Leptonycteris yerbabuenae* reflects the success of conservation action by one of RELCOM associates from Mexico (PCMM)
Further reading	Aguirre et al. (2014)

Name (acronym)	Southeast Asian Bat Conservation Research Unit (SEABCRU)
Web presence	Web site: http://www.seabcru.org. Facebook: Southeast Asian Bat Conservation Research Unit (SEABCRU)
Founded	2007
Geographical scope	SE Asia: Brunei, Cambodia, East Timor, Indonesia, Laos, Malaysia, Myanmar, Philippines, Thailand, Singapore, Vietnam
Structure	Organized around four conservation priorities—flying foxes, cave bats, forest bats, and taxonomy and systematics
Membership	Open to all interested in SE Asian bats, core membership comprises those with research background c. 400
Communication	Web site, Facebook, conferences, workshops
Leadership	Led by Principal Investigator while supported by NSF, with Steering Committee comprising experts in the priority research areas (2–3 per priority) from SE Asia, USA, UK. Steering Committee supported by student teams from USA and SE Asia (3–4 per priority)
Funding	Established with funds from BAT Biodiversity Partnership. 5-years grant from US's National Science Foundation (NSF) as a Research Coordination Network (2011–2016)
Mission and objectives	*Mission* To provide an organizational framework to coordinate and implement research, capacity building, and outreach to promote the conservation of Southeast Asia's diverse but threatened bat fauna. *Objectives* under NSF funding: (1) Effect a regional assessment of the distribution, abundance, and status of SE Asian bats through the implementation of research activities centered on the four priority areas. The SEABCRU network will develop standardized research protocols for each priority and train Southeast Asian bat researchers in the protocols through a series of workshops. (2) Recruit students and researchers to the SEABCRU, engage them in the research priorities, promote effective international communication, and stimulate collaboration
Primary activities	Conferences and expert workshops to develop protocols, training workshops to build capacity across the region. Establish a regional database for bat locality data. Online community of practice
Major successes	Protocols for research rolling out in 2015. 3 international conferences organized, international workshops in Thailand (2012), Cambodia (2013), Myanmar (2014), Vietnam (2014)
Further reading	Kingston (2010), Kingston et al. (2012)

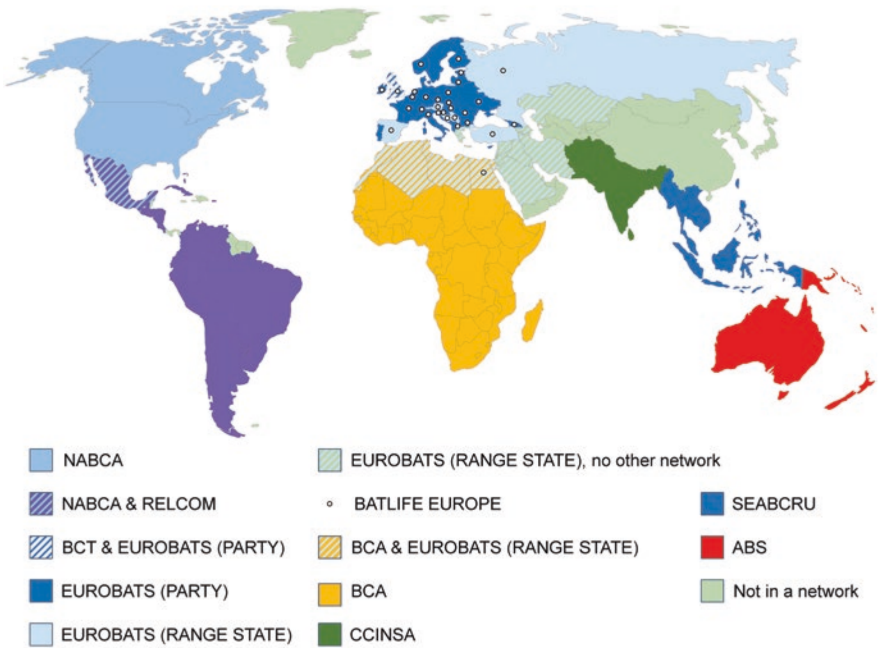

Fig. 17.2 Map of the world with coverage provided by existing bat conservation networks. Countries that are not within a network are filled with *light pink*. Note that some networks require active membership of nations, so countries may fall within the geographic scope of a network but not be members (RELCOM, EUROBATS, BatLife Europe). For networks based on individual membership, geographic scope is illustrated (*BCA*, *CCINSA*, *SEABCRU*, *ABS*). Network acronyms as in Table 17.1

Fig. 17.2). We recognize that there are a growing number of very active national networks (e.g., Asian Bat Research Institute, Bat Association of Taiwan, Bat Study and Conservation Group of Japan, and Indian Bat Conservation Research Unit), as well as NGOs such as Bat Conservation International (BCI) and the Lubee Bat Conservancy, discussed in Racey (2013). The IUCN Bat Specialist Group has a global network structure, but its primary role is to provide member expertise to the IUCN in support of Red List assessments and the development of Action Plans (e.g., Mickleburgh et al. 1992; Hutson et al. 2001). In addition, the North American Society for Bat Research (NASBR) is a large and active network, but the Society's mission is the promotion and development of the scientific study of bats, which it achieves by organizing an annual symposium. Although scientific study extends to conservation and public education, and the society puts forth resolutions on conservation issues, conservation is not the primary focus of the network, so is not included in this review. Together, our focal eight conservation networks unite bat researchers and conservation practitioners in over 130 countries, but major gaps persist and geographical coverage within networks is heterogeneous. Despite active national groups in Japan and Taiwan, as a region East Asia lacks coverage, as does Central Asia, the Middle East (although Israel, Jordan, Lebanon, Syria, and Saudi Arabia are included as range states within EUROBATS and BatLife Europe), and much of the Russian Federation.

17.2.1 Commonalities of Existing Networks

17.2.1.1 Origins and Activities

Most of the networks were founded as a response to the prevalence and intensity of threats to bat populations, lack of scientific knowledge about bats to support conservation action and changes to public policy, and to combat the contribution of public antipathy or ignorance to bat conservation issues. The common overarching goal in all cases is to halt declines and support sustainable populations. To achieve this goal, common foci or organizational themes are research, education/outreach, and conservation. In regions with few bat researchers, or high variance in expertise, research also encompasses building local academic and sometimes volunteer capacity to implement research, typically through workshops and development and sharing of guidance documents (e.g., CCINSA, RELCOM, SEABCRU, BatLife Europe, EUROBATS).

Most networks see themselves as providing a regional organizational framework, guiding or coordinating local activities, and facilitating transboundary communication and capacity building. They aim to realize broader-scale impacts and identify priorities for action at larger scales (NABCA, SEABCRU, RELCOM, BatLife Europe, EUROBATS). Several networks are also instigating, or already implementing, region-wide initiatives, with particular focus on surveying and monitoring populations (BCT, NABCA, RELCOM, SEABCRU, BatLife Europe), data collation and storage (SEABCRU, BatLife Europe, BCT), and evaluation and priority-setting of species, habitats, and threats (all).

Several networks play a direct role in policy development and implementation. In some cases, individuals or groups representing the network act as advisors to governments, in others the network directly lobbies decision makers. Because of its conspicuous foundation in published science and other scientific activities, the ABS has had a strong advisory role at all levels of Government in Australia, having major input into guidance notes (the information used to assess major development proposals by Government), producing action plans and associated recommendations for Conservation status listing, and survey guidelines for threatened listed species, and making submissions to parliamentary inquiries. As a member of the Wildlife and Countryside Link, BCT regularly contributes to joint responses on bat-relevant issues to government bodies, while EUROBATS is a network of parties to an agreement directly influencing conservation policy, as it pertains to bats, in member states. Networks may also take a more direct lobbying approach. CCINSA has been working for years to move India’s fruit bats from Schedule V of the Wildlife Act of India 1972, which defines them as vermin that can be exterminated without legal penalty. Two threatened species were afforded protection (moved to Schedule I), but the influence of the agricultural lobby has kept the remaining 12 species on Schedule V (Singaravelan et al. 2009). RELCOM has been lobbying for the creation and acquisition of legal status of Areas and Sites of Importance for the Conservation of Bats across Latin America (see Sect. 17.4.1) and promoting the implementation of bat conservation action plans.

17.2.1.2 Structure and Membership

Most of the networks exhibit substructure. In many cases, independent subgroups hold membership to the network. These are national Bat Conservation Programs (PCMs) in RELCOM, national conservation NGOs in BatLife Europe, range states in EUROBATS, local bat groups in BCT, and regional working groups in NABCA. Thematic structure is seen in some networks. SEABCRU is organized around four conservation priorities; the ABS has subcommittees addressing flying fox issues, outreach and education, and a small-grants program; EUROBATS has intersessional working groups, reporting on key conservation issues (15 currently); and RELCOM is implementing key strategies organized by subregion (e.g., Central and South America). Individual membership is varied, whereas some networks formed around a core of bat researchers in academic settings (SEABCRU, RELCOM), others have greater representation of members from NGOs (BatLife Europe), Statutory Nature Conservation Organizations/Agencies (SNCOs) and government departments (NABCA, EUROBATS), volunteer members of the public (BCT), or a combination (ABS, BCA). As networks mature, membership tends to diversify. The ABS was founded by bat researchers as a scientific society in 1992 (with an informal origin associated with a research newsletter launched in 1964), but now includes members from universities, government, other conservation societies, and private industry.

17.2.1.3 Challenges to Network Sustainability

By far the greatest challenge to network scope and sustainability is funding. Outside Europe, the networks do not have a paid staff or executive (with the exception of a small staff in CCINSA) and are run by volunteers. While volunteer origins and membership often confer network strength (Bodin and Crona 2009), time constraints can slow or limit responses to new challenges. Moreover, although several networks have a core of conservation researchers that remains relatively stable, as network activities can to some extent be integrated with their research agenda, there may be high turnover of volunteers involved with local activities (outreach programs, surveys etc.). Maintaining or rebuilding capacity because of volunteer turnover is a challenge, e.g., for PCMs within RELCOM.

Generally, it is a lot easier to attract funding for specific projects and programs than for staff or volunteer compensation, but these projects may be short term and tied to specific areas. Conservation solutions that require long-term monitoring with standardized methodologies (mandatory for statistical inference of success or failure of interventions) often lack “innovation appeal” to referees and funding organizations. Access to core or unrestricted funding which can be used for key strategic work, or to maintain basic network administration, is hard to secure. BCT has managed to grow its unrestricted income through donations, membership, legacies, and community fundraising, with some success, but this takes time and investment, and can be hard to maintain during periods of economic downturn. Ironically, while lack of protective legislation hampers conservation progress for some networks, protective legislation can lead to negative attitudes toward bats in other areas, particularly during recessions when protection of species can be seen as a barrier to economic growth. In addition, perceived “exaggerated” bat protection efforts can lead to reluctance among citizens to admit to the occurrence of bats in their property at all, for fear of losing partial control over their property.

In a social network, links between actors are almost entirely based on forms of communication, so mechanisms for communication (from face-to-face to online contact) are critical for the success of a network, particularly when members are geographically dispersed. All the bat conservation networks have a Web presence for interaction and/or issue newsletters, and many have regular face-to-face meetings, but gaps in communication can cause network stress, particular when node diversity is high (i.e., members come from many different backgrounds and perspectives). Effective communication is critical if network members differ in their position on a key issue. For example, tensions between the core actors in BCT and supporters and volunteers in 2006 over BCT’s stance on a government study of rabies in bats generated very strong concerns (Racey et al. 2013). This led to a review and new model of working with volunteers (partner and network agreements, regular meetings and communication) which proved very beneficial.

17.3 What We Can Learn from Theories of Network Structure and Function

17.3.1 Network Structure and Function

Network functioning describes the process by which certain network conditions lead to various network-level outcomes (Provan and Kenis 2008). Network structure influences individual and group agency, that is, the ability of a group to turn social capital derived from the network into conservation action at the network level. Network structure can be thought of as a map of the relationships (links) between the nodes (actors) in the network. Not all actors are connected to each other. Degree centrality measures the number of links an actor has, and betweenness centrality describes the extent to which an actor links actors that are otherwise disconnected (Burt 1992). The distribution of degree and betweenness centrality across the network is used to characterize network-level characteristics such as network density (number of existing ties divided by the number of possible ties—a measure of degree) and network centrality (variability in degree among network members) (Wasserman and Faust 1994). In general, a network with high density (one with many highly connected actors) (e.g., Fig. 17.3a) facilitates rapid transfer of knowledge and development of trust, is resilient to the loss of individual actors, and promotes collective action (Bodin and Crona 2009). High link density would therefore seem to be a desirable network characteristic. However, there can be trade-offs. Very high link density can lead to network homogenization and homophily. In a homogenized network, all nodes share similar knowledge and perspectives, which limits responses to novel problems, decreasing network resilience. Homophily describes the tendency for people to interact with individuals with characteristics similar to themselves, whether by preference or restricted opportunities (McPherson and Smith-Lovin 1987) and can lead to reluctance to interact with dissimilar others, promoting a "them versus us" environment (Newman and Dale 2005, 2007). Homophily can also restrict individual freedom (Portes 1998) and discourage dissenting opinions (Newman and Dale 2007). Homophily consequently hinders innovation by cutting off actors from needed information and imposing social norms that discourage innovation and inhibit links to dissimilar others (bridging ties).

More typically, the degree of individual actors varies quite widely. Centralized networks in which a few individuals are highly connected (Fig. 17.3b) similarly have benefits and costs. Central actors can prioritize and coordinate activities resulting in effective collective action (Sandström and Carlsson 2008), but this is most effective if problems are relatively simple and short-term. Long-term planning and more complex solutions require a more decentralized structure to access different knowledge and expertise more readily (Bodin and Crona 2009). Moreover, high network centrality can leave the network vulnerable to the removal or dysfunctionality of a few central actors, and to asymmetries of influence and power (Ernstson et al. 2008).

Betweenness (linking disconnected actors), also described as bridging (bridging links and bridging actors), is important in several regards. First, bridging links reduce the path lengths (shortest distance between actors) and network diameter (longest distance) and create "small world" networks (Watts 2003) that can lead to the rapid dissemination and penetration of ideas across the network. Second, bridging actors can connect disparate subgroups. The extent to which a network comprises cohesive subgroups is referred to as network cohesion or modularity (Bodin and Crona 2009) (Fig. 17.3d). Subgroups may hold different sets of knowledge and skills that can be vital to the resolution of a complex problem, but this expertise must be integrated across the network through bridging links. If subgroups are poorly connected (Fig. 17.3c), they can tend internally toward homophily and homogenization (Bodin and Crona 2009).

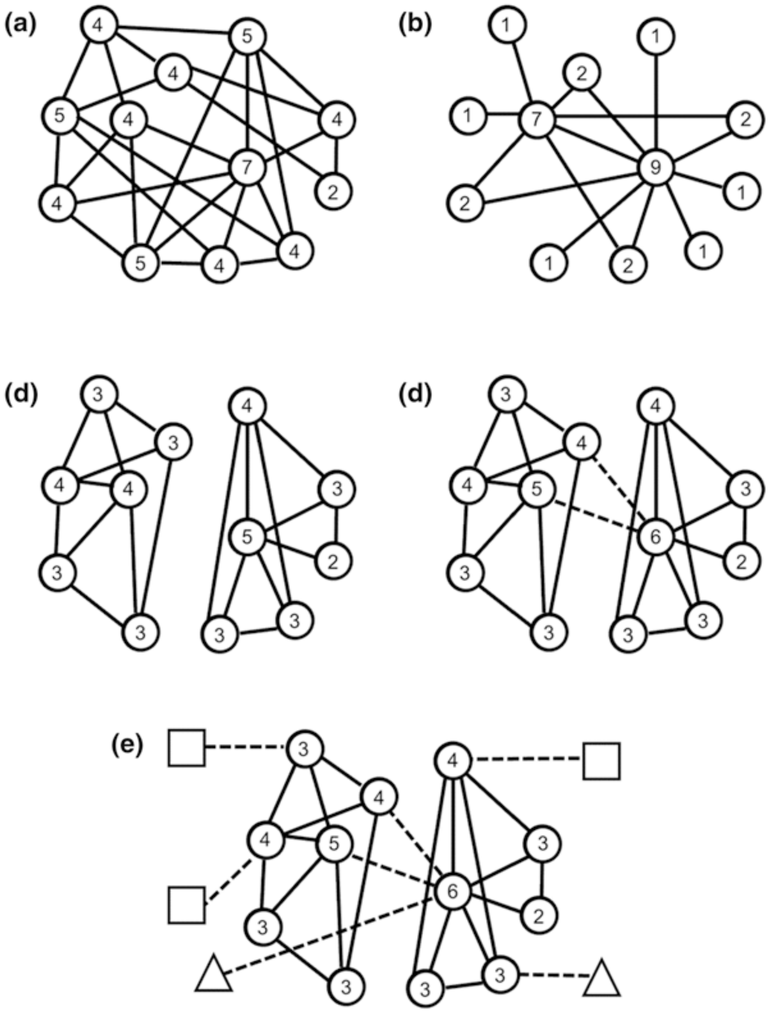

Fig. 17.3 Archetypal network configurations of the social network presented in Fig. 17.1. **a** A highly connected network, with no clear modularity (subgroups) (mean degree 4.33, network density 0.38). **b** A highly centralized network, in which two actors who are highly connected reducing mean degree (2.50) and network density (0.23). **c** Extreme modularity in which the network divided into two isolated subgroups. The subgroups are highly connected or cohesive (mean degree 3.33 and density 0.67). **d**. Network with high modularity with two distinguishable, cohesive subgroups, connected by bridging links (*dashed lines*). **e** Network with high modularity but connected subgroups (**d**) with peripheral ties to actors outside the network (*open squares* and *triangles*)

Just as the distribution of links between actors can vary across the network, the links themselves may vary both qualitatively (type of link) and quantitatively (strength). Links can be a form of communication, a collaboration, an agreement, knowledge, or data transfer. The strength of the link can be suggested by simple frequency counts (number of new joint conservation projects started), or more holistically as suggested by Granovetter (1973): "The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, and intimacy (mutual confiding), and the reciprocal services which characterize the tie" (p. 1361). Actors linked by strong (or bonding) ties are more likely to influence one another, promoting mutual learning and sharing of resources but at the price of information redundancy and social "imprisonment" (Borgatti and Foster 2003). Weak or "bridging" ties promote the sharing of diverse information as they are usually between dissimilar others. On one hand, this promotes network resilience and adaptability to change, but on the other hand, these links may be broken more easily.

17.3.2 Structural Characteristics of Effective Conservation Networks: Within Subgroup Cohesion, Across Subgroup Collaboration, Bridging Actors, and Peripheral Actors

Given the trade-offs between network characteristics outlined above, is there such a thing as an "ideal" network structure for effective conservation? Recent reviews (Vance-Borland and Holley 2011; Mills et al. 2014) suggest that polycentric networks in which multiple, heterogeneous subgroups are linked by bridging ties maintain the greatest diversity of response options. Each subgroup has high within-group cohesion so is characterized by dense linkages (high degree centrality, strong or bonding ties) among people sharing specific knowledge that work together productively—enhancing knowledge development (Bodin et al. 2006; Bodin and Crona 2009). Within the network as a whole, there are multiple subgroups, which differ in the knowledge areas and expertise (subgroup diversity—Newman and Dale 2007), developing the diversity of knowledge held by the network as a whole (Bodin et al. 2006; Ernstson et al. 2008; Bodin and Crona 2009; Sandström and Rova 2010). Such functional diversity enhances network adaptability and resilience (Newman and Dale 2007; Mills et al. 2014), cultivates creativity (Aslan et al. 2014) and obviates internal turf battles in large networks (Reuf et al. 2003). Critical to network success are bridging relationships (actors with high betweenness centrality) among the diverse subgroups to promote sharing of expert knowledge and counter tendencies toward subgroup homophily. Network sustainability and adaptability are further enhanced if there are connections to actors outside the network (peripheral actors) who hold specialized knowledge, skills, or resources. Put simply, we can identify four network characteristics indicative of success—within subgroup cohesion, across subgroup collaboration, availability of bridging actors, and inclusion of peripheral actors (Fig. 17.3e).

Network structure tends to evolve through time naturally as the goals of actors change, or the success of actors leads to greater engagement and linking. Structure and transitions can and often should also be managed more actively. For example, while diverse, polycentric networks may be a valid end-goal structure, centralized networks with a few highly motivated actors already connected to many others are good for the initial phase of forming groups (Olsson et al. 2004; Crona and Bodin 2006), and several of the bat networks began with a handful of well-connected actors (ABS, BCT, SEABCRU, and RELCOM). Once the network is more established, managed transitions can increase modularity and long-term decentralization. Moreover, during periods of stability, actors should be provided with opportunities to develop new relational ties with others, which can then be drawn upon in times of change (Olsson et al. 2006). Ideally, rather than simply increasing connectivity among all network members, inspection of network maps and data can be used to implement “network weaving”—the strategic development of new relationships among actors for their mutual benefit and to enhance overall network agency or response to a specific challenge (e.g., a new threat to bats) (Vance-Borland and Holley 2011).

17.4 Toward a Global Network of Networks

17.4.1 Do We Need a Global Network?

A global network of networks can certainly build social capital among bat researchers and conservationists, and facilitate knowledge transfer and capacity building. Moreover, the existing networks are diverse, collectively holding knowledge and skills that range from taxonomy to advocacy. Connectivity among networks could rapidly increase functional diversity, resilience, and adaptability of both individual networks and a global network of networks. It could also provide a platform to develop bridging ties to peripheral actors with greater expertise and skills in key areas, notably lobbying and environmental education. Such a meta-network could also provide a venue for discussion of issues at the global level and for explicit requests for assistance with critical issues. This assistance could be in terms of technical or strategic advice, or collaborative projects that combine resources for the common goal. But is there a need for global agency? We suggest that there are several sets of circumstances in which a global network might facilitate conservation efforts.

First, some issues are genuinely of global concern or can benefit from prioritization efforts at the global scale. For example, habitat loss is a global issue, and the use of standardized, objective criteria to identify critical biodiversity areas worldwide can galvanize and support protection efforts, and provide a basis for monitoring. The Important Bird Areas (IBAs) Program, initiated by BirdLife

International over 30 years ago, now comprises a network of over 10,000 IBAs and has had a major impact on the development of protected areas worldwide to ensure sustainable bird populations (BirdLife International 2008). RELCOM recently launched a similar program for bats in Latin America—Areas and Sites of Importance for the Conservation of Bats (Areas or Sitios para la Conservación (AICOMs/SICOMs) (Aguirre and Barquez 2013) and to date have identified 60 Areas and Sites, including 17 binational AICOMs. A coordinated initiative by a global network to develop this program worldwide could reap similar benefits for bat diversity, particularly if the network develops mechanisms to support and monitor protection of the sites after designation. Similarly, global priority-setting at the species level requires coordinated effort. While this remains the remit of the IUCN, problems arise integrating national evaluations with the global effort. Although the IUCN provides guidelines for the application of Red List criteria at regional and national levels (IUCN 2012), the guidelines and criteria are arguably difficult to apply where data are sparse, as is the case for many bat species. This has led to a proliferation of different national methods, even within regions [e.g., Aguirre et al. 2009—Bolivia, Sánchez et al. 2007—Mexico, US Endangered Species Act (ESA 1973, as amended)], which are difficult to integrate within and across regions. A global network could discuss and develop common criteria to establish the conservation status of bats at local and national scales, and provide a clearer link or integration to the global IUCN Red List assessments.

Second, several conservation issues that originated in certain areas are now “going global”—knowledge gained by regional networks could be vital for rapid responses in other parts of the world. For example, the impact of wind energy installations on bat populations has hitherto been of most concern and best studied in North America and Europe (Arnett et al. 2015). However, 103 countries used wind power on a commercial basis in 2013, with the most dynamic markets with highest growth rates in Latin America, eastern Europe, and for the first time Africa (WWEA 2014), drawing many networks into the development of guidelines to minimize bat fatalities. A global network allows for the rapid synthesis and dissemination of expertise and advocacy materials (e.g., white papers/position statements/research summaries of mitigation approaches) to support efforts in areas lacking direct experience of an issue. Similar issues are being (or could be) realized across multiple regions or globally include the role of bats as reservoir hosts in zoonotic infectious diseases (Schneeberger and Voigt 2016), white-nose syndrome (Frick et al. 2015), and hunting of bats (Mildenstein et al. 2016).

Third, a global network secures the diversity of expertise to respond to future threats. It is noteworthy that some of the biggest threats facing bats today were unimagined less than 20 years ago, with no mention in edited volumes (e.g., Kunz and Racey 1998) or action plans (Mickleburgh et al. 1992; Hutson et al. 2001) of mortality at wind installations, white-nose syndrome, or the role of bats in emerging infectious diseases (EIDs) and the attendant consequences for public and government perceptions of bats. We do not know what new threats to bats might emerge in the coming decades, nor whence they might originate. A global network would facilitate coordinated responses and support for regional issues.

Finally, a global network would provide a means for current and emergent critical issues to become widely known and, critically, could act as a single voice to promote bat conservation through global positions on recurrent, widespread issues such as wind installations, habitat loss and the protection of critical sites, EIDs. A unified voice and global position could also be key in local or national issues where governments, resilient to the dogged efforts of the local group, might be swayed by unified international scrutiny or outrage. Many of the regional networks have faced such challenges. For example, in Australia, the ABS is in urgent need of support to keep up with the number and scale of political issues and administrative actions surrounding flying foxes, and it is conceivable that unified global advocacy might have prompted earlier, precautionary, action as the Christmas Island Pipistrelle (*Pipistrellus murrayi*) declined to (presumed) extinction. Some suggestion that international opinion can influence local decisions comes from Mauritius. In 2006, the prime minister of Mauritius was heavily lobbied by British conservationists to void a cull of *Pteropus niger*, planned to placate fruit farmers. The lobbyists' influence is uncertain as the cull went ahead, *but* its success was limited by existing, *observed*, legislation precluding the discharge of firearms after dark.

We believe a global network can play a key role in bat conservation in the coming decades. However, it must retain the personality of each regional network and promote local bat conservation. Based on the effectiveness of polycentric diverse networks outlined above (Sect. 17.3.2), we envisage a global network as a meta-network of regional networks (Table 17.1) linked by bridging ties among members to generate an emergent, but decentralized global network of networks. To reach this end requires that existing regional networks be supported and strengthened, the establishment of new networks in areas of the world currently not covered, and the development of bridging links across regional networks to provide global coverage.

17.4.2 Strengthening Existing Networks

From our review of characteristics of successful conservation networks (Sect. 17.3.2), existing networks might consider activities that increase the number and strength of links among its actors. This increases mean degree, with redundancy improving resilience to member loss (Folke et al. 2005), and greater connectivity facilitating knowledge transfer. Face-to-face events (conferences, workshops, etc.) as well as online social networks (e.g., Facebook) provide for bidirectional communication among actors and an increase in connectivity through establishment and strengthening of social bonds. Although online social ties are often weak (Burke et al. 2010), they may nevertheless cultivate and crystallize otherwise ephemeral relationships established face-to-face (Ellison et al. 2007; Lewis and West 2009).

While organizations may not be in the position to conduct a full social network analysis to guide explicit network weaving (as advocated by Prell et al. 2008, 2009), development can still be strategic. Identifying and connecting or developing "missing nodes" is an important aspect of network strengthening—are there individuals, themes, perspectives, knowledge, and countries missing from the network? Do actors exist but are not connected, or does the network need to encourage the development of new capacity?

Establishing connections to existing actors not currently in a network increases network diversity and hence adaptability, which in turn is central to maintaining social capital (Newman and Dale 2007). In Southeast Asia, Myanmar has had an active bat research community for at least a decade, but for political reasons it has been difficult to connect it to the rest of the SEABCRU, a situation that the SEABCRU has actively sought to rectify with a workshop in 2014, now that political landscape has changed. From a knowledge perspective, early in SEABCRU development it became clear that the network lacked expertise in disease ecology, despite the fact that Southeast Asia is an emerging disease hotspot (Jones et al. 2008), and actively recruited an actor from Ecohealth Alliance to fill that expertise gap. As a network grows, actors with specific management skills needed to run the network may need to be recruited. BCT actively headhunted to achieve a skill mix for the board of trustees that included strategy, organizational development, funding, marketing, legal, financial, HR, bat research, and conservation as well as volunteers perspectives.

In many cases, actors or nodes may not currently exist. Lack of expertise and capacity was one of the driving motivations behind the establishment of CCINSA, a network that has focused much of its efforts on training workshops. The role that this can play in establishing new nodes is illustrated by the growth of activities in Nepal, following a CCINSA workshop in 2007. Participants went on to establish two organizations involved in bat conservation—Small Mammal Conservation and Research Foundation (2009) and Natural Resources Research and Conservation Centre (2010). RELCOM began with representatives from five countries (Brazil, Bolivia, Costa Rica, Guatemala, and Mexico) and grew network membership by actively recruiting key bat conservationists and researchers from across Latin America. In countries lacking expertise (e.g., in Central America), senior leaders from RELCOM actively built capacity through courses and workshops and identified local members needed to fill the gaps in region-wide representation. This approach grew RELCOM from five to 22 countries in just five years, and most of the remaining gaps are being filled by organizations actively petitioning to join.

The SEABCRU five-year plan allocated year three for the identification and filling of gaps in the SEABCRU network. In accord with the SEABCRU's thematic approach, gaps were defined as areas lacking expertise in, but facing, one or more of the four major threats. Activities center on fostering capacity to fill these gaps. These include a flying fox workshop in Cambodia (2013) to train biodiversity researchers in monitoring protocols, dietary studies, bat–farmer conflict resolution, and disease ecology, and a similar workshop focused on cave bat conservation in southern Vietnam (2014).

Filling in network gaps that lack existing actors can be challenging, and several networks have encountered difficulties, despite having identified clear targets. Efforts have generally been hampered by lack of funds to support foundational events (e.g., workshops), lack of suitable liaisons in the target area that can anchor events, and political constraints. Political constraints may be current (countries restricting international relations because of war or ideology), or historical. As an example of the latter, the majority of countries in Central and South America are now members of RELCOM, but the Guianas of northeastern South America have greater, recent European affiliations (comprising French Guiana, an overseas department of France), Guyana (British Guiana until independence in 1966), and Surinam (part of Dutch Guiana until 1975). These countries support high bat diversity, face similar conservation challenges to the rest of the continent, and lack local research capacity, but colonial and immigration history have limited their integration with Latin America, and hence with RELCOM.

Established networks should also work to develop links to other conservation stakeholders (Mills et al. 2014—scale-crossing to peripheral actors; Fig. 17.3e). Obvious "peripheral actors" include those engaged in similar issues (e.g., raptor fatalities at wind installations) or habitats (e.g., RAMSAR wetland groups). Perhaps, the most intuitive and common peripheral actors for bat conservation networks are cave groups. Cave groups have contributed to bat surveys from the Philippines to the USA. The Australian Speleological Federation played a major role in gathering bat knowledge in Australia in the late 1950s, and the legacy of this interaction is embodied in the ABS constitution, which seeks "to establish and maintain links, and work cooperatively, with other organizations within and outside Australia which share similar aims and objectives to the Society." More recently, the ABS became part of the Places You Love alliance of more than 40 green groups in response to pressure to weaken Australian environmental laws and has increased interaction with other smaller bat conservation and wildlife rehabilitation groups in Australia. Similarly, BatLife Europe works with "collaborating organizations," such as local NGOs, museums, and companies, to exchange information and participate in activities.

Networks should be cognizant that, as discussed above, the most effective network structure may change through time. As the network becomes more established and grows, knowledge and responsiveness can be enhanced by transitioning from a centralized structure (Fig. 17.3b) to one with greater modularity (Fig. 17.3d). RELCOM is actively transitioning to a more modular structure through the establishment of subregional groups (Central and South America), while maintaining the strong bonds already established. This structure allows the network to respond more effectively to the issues in each subregion. For example, Central America is in need of greater capacity building, as local PCMs are comprised of very young researchers, whereas expertise is more established in South America. The network is further subdividing South America into the Andes, Amazon, Southern Cone, and Caribbean to reflect the dominant conservation issues: wind turbines and habitat fragmentation in the Andes; habitat destruction in Amazonia; wind turbines in the Southern Cone; and bat migration and roost loss associated with hurricanes in the Caribbean.

As described above (Sect. 17.2.1), most of the bat conservation networks are already modular, comprising subgroups defined geographically or thematically.

Geographical subgroups are likely to be more cohesive initially (as actors within them know each other), but may tend toward homophily over time. In some cases, there may not be sufficient actors to make up a geographic subunit, as was the case with the SEABCRU at its foundation. Thematic groups promote functional diversity of the network as a whole, but it may take time for trust and strong bonds to develop within them. Ultimately, a mix of both is desirable, with members from geographical groups sitting on different thematic teams. This "jigsaw" strategy (Aronson and Patnoe 2011) promotes cooperative learning as expert knowledge developed in thematic groups is returned to the geographical groups. Currently, EUROBATS includes elements of this strategy with intersessional working group members drawn from member states. This strategy also ensures a variety of weak (bridging) and strong (bonding) ties among more actors, and explicit network weaving (Prell et al. 2008, 2009).

Network centrality is further decreased if the leadership structure transitions to a rotational one with elected officers serving for specified terms, as several of the networks do (e.g., RELCOM, ABS, BCA). Rotational leadership also avoids cliques and encourages different viewpoints. Conversely, failure to decentralize leaves the network vulnerable to loss of central actors, homophily, and poor long-term recruitment. Networks should also maintain ongoing recruitment programs to replace people, who leave, and maintain network heterogeneity (Newman and Dale 2007).

17.4.3 Filling Regional Gaps—Establishing New Networks

Major regional gaps include East Asia (covering China, Japan, North Korea, South Korea, Mongolia), Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, Afghanistan), the Middle East (18 countries), and the Russian Federation (Fig. 17.2).

The first question, rather similar to that when filling in gaps in existing networks, is to determine whether expertise (possible actors/nodes) already exists and just needs connecting in these regions, or if the area is completely lacking expertise. In East Asia, there are several active national groups, namely the Asian Bat Research Institute, Bat Study and Conservation Group of Japan, and the Bat Association of Taiwan, as well as individual actors in Mongolia and China, which could be the kernels of a regional network. Similarly, the EUROBAT range state members Israel, Jordan, Lebanon, Syria, and Saudi Arabia could serve as nodes in establishing a Middle East network.

A limited number of actors (be they individuals or national groups) should not hinder the development of a network, provided of course the actors can commit to the venture. Rather, based on the general principle that founding networks are most likely to succeed if they are fairly centralized (Olsson et al. 2004; Crona and Bodin 2006), the best approach at foundation is to identify a few actors in the region that are well connected with others (high betweenness), which could be brought together to establish or strengthen links needed to form a network. If a handful of central actors are already connected this is ideal, otherwise it is *essential* to spend time building trust and fostering interpersonal relationships (and skills) before getting into issues (Newman and Dale 2007; Cheruvelil et al. 2014). Many of the existing networks (e.g., BCT, RELCOM, SEABCRU) started with a small group of people that were already connected with strong bonds (positive interactions going back many years). In several cases, the group already had the characteristics of a network (social capital, coordination) with agency directed at a specific task. In the UK, BCT evolved from the Mammal Society Bat Group. In Australia, the ABS was preceded by the Australian Bat Banding Scheme (1960), and a collective effort to produce the first bat identification guide. Core members of what was to become the SEABCRU first came together to organize the 1st SE Asian International Bat Conference (2007). Similarly, RELCOM was created by five existing Bat Conservation Programs during the 15th International Bat Research Conference in Mérida, México (2007). Because these actors also had high betweenness (lots of links to others), they were then able to pull in diverse people to build the network. Conversely, networks may struggle to persist beyond foundation if the founding actors do not have or develop strong ties to one another and/or have low betweenness (few links to others).

The diversity of actors involved during network formation should also be considered. High diversity of members can avoid structural homophily (Prell et al. 2008; Cheruvelil et al. 2014), but there must be sufficient commonality of perspectives and expectations among members to provide cohesive network objectives and to develop and strengthen links. Diversity of actors in terms of age, career stage, and nationality has generally proven productive, and although new networks might begin with a fairly centralized structure, thought can still be given to internal structure and subgroups with inclusion of actors with diverse expertise (e.g., SEABCRU steering committee included specialists in each of the four priority research areas) or from different nationalities (e.g., RELCOM). However, communication (and hence link strength) can falter during network formation when actors come from different institutional backgrounds and hence mandates (e.g., academic, non-governmental, governmental, consultancy). In essence, social capital builds more readily when actors are diverse, but not so diverse that agendas and modes of communication differ. As the network matures, it becomes easier to integrate and capitalize on different perspectives. Whereas several of the younger networks largely comprise members with similar backgrounds (e.g., SEABCRU, RELCOM—academic, NABCA working groups drawn from government agencies, NGOs), older networks, such as the ABS, have broader membership that include representation in universities, government, other conservation societies, and private industry.

Early development of a network's mission and objectives can help establish network identity and guide membership decisions and help actors clarify what it means to be part of the network versus an independent researcher, conservationist, or NGO. Moreover, actors that are expected to play a role in the network need to be included or consulted during the establishment process. Given that most actors in bat conservation networks are volunteers, networks will be more sustainable if actors are not only committed to the overall goals of the network but also see increases in personal social capital that lead to tangible benefits. Identifying objectives that contribute to the core network mission requires collective input, but benefit actors directly can be invaluable. Benefits may accrue to the subgroup (e.g., NGO, PCM), but also to the individual in the form of publications, research proposals, or databases that facilitate their own research or applied conservation objective. For example, the SEABCRU explicitly identified publications that met the network's objectives by synthesizing regional conservation knowledge (Abdul-Aziz et al. 2016; Mildenstein et al. 2016) or resolving multi-national taxonomic concerns (e.g., Ith et al. 2011), and is currently developing a regional echolocation call library for acoustic surveying and monitoring of bat diversity in anthropogenic landscapes. Social capital built through the network can also be mobilized to apply for conservation research funding for collaborative teams from within the network. RELCOM partnered with BCI to offer seed grants for its members, and several PCMs have joined together to conduct research, such as a project on the study of migratory patterns of *Leptonycteris curasoae* (IUCN Red List as Vulnerable), which involves participants from Venezuela, Colombia, Aruba, Bonaire, and Curacao. EUROBATS launched the European Projects Initiatives with maximum grants of 10,000 euros to address urgent site- or species-based conservation issues or to fund training workshops in range states. Priority is given to transboundary projects and those promoting international cooperation between the parties and range states to the Agreement.

Fostering the development of expertise in regions with none, essentially developing sufficient nodes to actually support a network, is a significant challenge. Nonetheless, basic network principles apply, and supporting a few actors who can develop (or have) strong bonds between them and are linked to many others will likely maximize success. Broad initiatives to identify enthusiastic, key actors might target vertebrate biodiversity specialists, as it is relatively easy to transfer bat research techniques and knowledge to bird and small mammal researchers. Interest in bat diversity and conservation in Bangladesh (Group for Conservation and Research on Bats) grew out of projects on bats and EID at veterinary institutes (Nurul Islam pers. comm.), providing another avenue for identifying key actors. Involving interested actors in the activities of existing networks and the global network can expose them to the value of network approaches and suggest organizational modes.

17.4.4 Networking Networks for Global Coverage

Our vision is of a global network resulting from bridging ties across regional networks. As such, it would be a largely decentralized entity, but overseen by a coordinating committee drawn from the member networks. To foster bridging ties and accelerate exchange of best practice, thematic subgroups could be identified (e.g., research, outreach, policy) and populated with members from each network. Working groups, similar to those of EUROBATS, to address specific issues of global or multi-regional concern would further weave the network together. Such a jigsaw approach would additionally disseminate expertise back to the regional networks.

Other approaches to develop and sustain bridging ties are offered by the network literature. "Board interlocks" (Borgatti and Foster 2003) develop ties among organizations through a member of one organization sitting on the governing body of another. With so many regional networks, this might be a little unwieldy, but initial efforts might focus on the thematic subgroups, with members attending events run by other networks. In some cases, members from one network may lead a training event of another. For example, SEABCRU steering committee member Neil Furey was the key resource person for a 2014 CCINSA workshop in Bangladesh.

Joint ventures (e.g., collaborative conservation projects and joint symposia) and inter-organizational alliances provide access to information and knowledge resources that are difficult to obtain by other means and which improve performance and innovation (Borgatti and Foster 2003). Several regional networks encounter the same conservation issue (e.g., EIDs and increased pressure on declining pteropodids from a variety of factors unite BCA, SEABCRU, CCINSA, ABS; hunting of bats for bushmeat and medicine are concerns for BCA, SEABCRU, ABS) and might benefit from joint-venture approaches or alliances to seek funding for research and conservation action. Global initiatives, such as priority-setting of important areas or sites, would likewise foster bridging ties.

The challenges in establishing and maintaining a global network of networks are essentially those of the regional networks, writ large—limitations on time, resources, communication, and trust. To overcome these constraints, the global network must have a clear identity, mission, and objectives agreed upon by all member networks. Given resource limitations, and the many threats to bats that participant networks deal with within their own regions, member networks must see how involvement benefits not only the global mission but their own. Communication is pivotal to all networks, and at the global scale, there are obvious barriers associated with cultural and linguistic differences, sometimes augmented by insular attitudes. Just as important for communication and expectations is the diversity of the networks themselves; establishing bridging links between networks comprising mostly of researchers and conservation practitioners (RELCOM, SEABCRU), and those made up of NGOs (BatLife Europe), for example, require thought and active fostering of trust among actors. Moreover, clear lines of communication must be established between executives/committees representing societies, and among members at the individual level.

17.5 Recommendations

With the globalization of threats to bats, we recommend the following:

1. The development of a global network of bat researchers and conservationists to respond to such threats and to provide a unified voice for advocacy.
2. That the global network be formed as a federation of regional networks, retaining regional autonomy and identity.

3. The establishment of new networks in regional gaps, specifically East Asia, Central Asia, the Middle East, and the Russian Federation.
4. That existing and planned networks consider social network theory and developing and refining their structure. We recommend that:
    (a) at foundation, networks adopt a centralized structure based around a few well-connected actors;
    (b) as the network matures:
        (i) actively transition to a structure comprising multiple, heterogeneous subgroups differing in knowledge areas and expertise;
        (ii) fill gaps in knowledge, expertise, or geography by developing links with new actors;
        (iii) increase overall membership diversity; and
        (iv) develop ties to peripheral actors with overlapping conservation interests.

Acknowledgements We thank the following sponsors of the networks: Bat Conservation International, Beneficia Family Foundation, British American Tobacco Biodiversity Partnership, The Brown Foundation Inc. of Houston, Disney Worldwide Conservation Fund, The Field Museum, Greater Houston Community Foundation, Island Foundation, National Science Foundation (Grant No. 1051363), Rufford Foundation, USAID, US Forest Service International Program, US Fish & Wildlife Service, Whitley Fund for Nature, WoodTiger Fund. We greatly appreciate input on the structure and functioning of the individual networks from the following: Julia Hanmer, Karen Haysom, Andreas Streit, Sally Walker.

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Chapter 18
Cute, Creepy, or Crispy—How Values, Attitudes, and Norms Shape Human Behavior Toward Bats

Tigga Kingston

Abstract Bat populations around the world are declining as a consequence of human activities. Bat conservation thus hinges on changing human behavior, but to do so, we must understand the origins and drivers of the behavior. As natural scientists, most bat biologists lack the knowledge and training to implement rigorous studies of the human dimensions of bat conservation, yet such studies are needed to guide successful intervention. As we travel through the Anthropocene, it is critical that bat conservation biologists adopt an interdisciplinary approach and work with researchers from the social sciences who hold these skills and knowledge. To facilitate conversation and collaboration with conservation social scientists, I review the key theoretical and empirical perspectives on human behavior toward wildlife and report on studies of bats in these contexts wherever possible. I also recommend ways in which bat biologists can use some of this knowledge to enhance less structured or opportunistic outreach efforts encountered during our research activities.

18.1 Introduction

Human activities have wrought such intensive and extensive environmental changes to our planet that we now witness the dawn of the Anthropocene—the human epoch. The Anthropocene is not being kind to bats; populations are declining around the world (Voigt and Kingston 2016) in response to land-use change

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C.C. Voigt and T. Kingston (eds.), *Bats in the Anthropocene: Conservation of Bats in a Changing World*, DOI 10.1007/978-3-319-25220-9_18

and management practices (Law et al. 2015; Meyer et al. 2015; Korine et al. 2015; Williams-Guillén et al. 2016), urbanization and intensification (Altringham and Kerth 2015; Arnett et al. 2015; Jung and Threlfall 2015; Rowse et al. 2016), disturbance and loss of roosts (Furey and Racey 2015; Law et al. 2015; Voigt et al. 2016), and direct exploitation for bushmeat and medicine (Mildenstein et al. 2016). As human populations grow and encroach on remaining bat habitat, human–bat interactions are increasing, often with negative consequences for both parties through disease relationships (Schneeberger and Voigt 2016), occupation of human dwellings (Voigt et al. 2016), and conflict over fruit crops (Abdul Aziz et al. 2015).

The Anthropocene is named for us, and solutions to our environmental problems rest with us, as Mascia et al. (2003) so concisely put it: "Biodiversity conservation is a human endeavor: initiated by humans, designed by humans, and intended to modify human behavior"—(Mascia et al. 2003, p. 650). Bat conservation is no different from any other aspect of biodiversity conservation in this regard; attempts to reduce the many threats to bats ultimately hinge on changing peoples' behavior (Stern 2000; Ehrlich and Kennedy 2005; Schultz 2011; St John et al. 2013; Veríssimo 2013; Clayton and Myers 2015). "People" may range from bat hunters in rural villages to government officials or politicians in administrative centers, but as stakeholders in the issues surrounding bats, they must be motivated to change their actions and decisions (Menon and Lavigne 2006). How do we determine the stakeholders involved and how do we then change people's minds and behavior? The scientific training of most bat biologists leaves us ill-equipped both practically (St John et al. 2010, 2014) and philosophically (Moon and Blackman 2014) and often extraordinarily naïve, when it comes to dealing with people. Surely, if we share our knowledge and "educate" people, they will change their ways. Hunters in Ghana and Indonesia will be so impressed by the importance of bats as pollinators of their favorite fruit, or so fearful of disease risk, that they will stop hunting them. US politicians will mandate turbine cut-in speeds that reduce bat fatalities once they appreciate the critical role that bats play in the suppression of agricultural insect pests. Home owners will learn to live with their seasonal "attic bats" because they are keeping down the summer mosquito population.

Unfortunately, providing people with environmental knowledge alone is rarely enough to promote conservation behavior, and there is an enormous body of research from the social sciences, primarily from social psychology (St John et al. 2010; Teel et al. 2015), addressing the theoretical constructs behind behavior change. These constructs have provided frameworks for empirical assessments of attitudes and behaviors toward the environment and wildlife, and new disciplines such as human dimensions of wildlife (Manfredo 2008; Decker et al. 2012) and conservation psychology (Clayton and Myers 2015) have arisen in recent years, as a growing numbers of social scientists specialize in environmental or biodiversity conservation. Indeed, the Society for Conservation Biology established a Social Science Working Group in 2003 (http://conbio.org/groups/working-groups/social-science), and a recent report from the Group provides an excellent introduction to the conservation social sciences (Bennett and Roth 2015).

I advocate that if we are to be effective in tackling the human dimensions of bat conservation, we need to work collaboratively with scientists who understand and study people in the same depth that we do our bats! But communication across disciplines requires some measure of reciprocal understanding of the theory and practice of each discipline. The goal of this chapter is to facilitate conversation and collaboration with conservation social scientists. As is clear from Bennet and Roth (2015), there are many fields within the broad realm of conservation social science, but my aim is to introduce bat biologists to the core theoretical constructs behind behavior as applied to conservation and to report on empirical studies of human–bat relationships in these frameworks. Arguably, this task should have been left to a social scientist, but I hope that a natural scientist's perspective of the field may help make it accessible to my fellow bat biologists, who share my training, and avoid bias toward particular world views prevailing within the field. Nonetheless, the basic premise of the chapter is as follows:

> very soon it will be unforgiveable to carry out second-rate social science in conservation, just as now it is unacceptable to use shoddy methods to monitor animal abundance (St John et al. 2013, pp. 357–358)

18.2 Theories of Behavior and Behavioral Change

People make behavioral choices based in large part on their values, attitudes, and to conform to societal expectations and pressures. Although early models of behavior assumed linear relationships in which knowledge influences attitude which in turn influences behavior relating to an issue of concern ("deficit" models—Burgess et al. 1998), this has rarely proved to be the case. Although the correlation between attitudes and behavior (Kraus 1995), including pro-environmental behavior, is quite well supported (Iozzi 1989), the relationship between knowledge and attitudes is complex and support variable (Kellert and Westervelt 1984; Kaiser et al. 1999; Kollmuss and Agyeman 2002; Thompson and Mintzes 2002). Providing people with knowledge about bats and logical arguments about the importance of addressing threats to them does not always change attitudes, and if it does, there is no guarantee that the attitude change will affect behavior toward them.

Psychologists came to appreciate that knowledge is just one of many factors influencing attitudes and recognized that external constraints and/or context (Guagnano et al. 1995; Stern 2000) may further influence changes in behavior. These concepts were encapsulated by the work of Martin Fishbein and Icek Ajzen who first added two factors to the simple linear pathway from attitude to behavior in the theory of reasoned action (TRA) (Fishbein and Ajzen 1975; Ajzen and Fishbein 1980). The theory of reasoned action proposes that the effects of attitudes on behavior are indirect and that there is an intermediate predictor of behavior—behavioral intention. Behavioral intention is not only predicted by attitude but also by subjective norms—the perceived social pressure to perform or not perform the

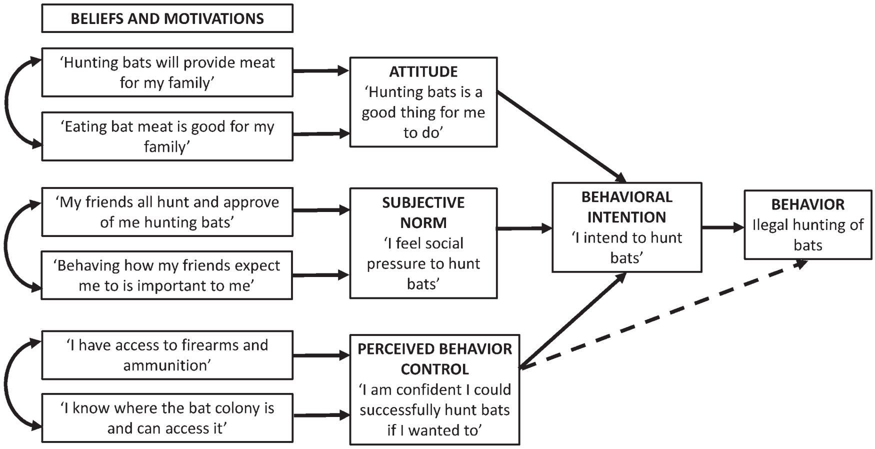

Fig. 18.1 The theory of planned behavior applied to illegal hunting of bats, for example *Pteropus vampyrus* in Sarawak, Malaysia. The strength of the components (attitude, subjective norms, and perceived behavioral control) and the beliefs that underpin them can be measured through interviews or questionnaires that ask respondents their level of agreement with the example statements. This not only provides the overall probability of a behavior, but also identifies the differential influence of the components and thus targets for intervention (adapted from St John et al. 2010, 2014)

behavior. The theory of planned behavior (TPB) added a third factor, perceived behavioral control, to the model. Perceived behavioral control describes whether or not people feel they have the resources, opportunities, or abilities to perform the relevant behavior (Azjen 1991) and can directly influence behavioral intention or the behavior itself (Fig. 18.1). Although the TPB has been a mainstay of attitude-behavior theory and research since its introduction and has received substantial empirical support (Armitage and Conner 2001), the application of the TPB to conservation is more recent (St John et al. 2010, 2013).

A related conceptual framework with a more specific history in environmental conservation and attitudes toward wildlife, particularly in the USA, is the value attitude behavior (VAB) model (Homer and Kahle 1988; Manfredo 2008). The VAB model places values at the base of a cognitive hierarchy of behavior, influencing attitudes and norms through a "value orientation." Values are defined as the set of beliefs held by an individual about what is right and wrong.

The power of these theories for practitioners aiming to induce behavioral change is that the target behavior is broken down into components which may differ in influence (St John et al. 2013) (Fig. 18.1). From a conservation perspective, analysis of the differential influences can help identify the most important barrier to change that can then be the focus of an intervention. So although attitudes are strong predictors of behavioral intention, they are commonly shaped by values, and the significance of subjective norms and perceived behavioral control in the success or otherwise of conservation interventions is becoming increasingly apparent (St John et al. 2013). But just what are these components? What do social scientists mean by values, attitudes, and norms, particularly as they relate to conservation and environmental behaviors?

18.3 Values

18.3.1 Theory

Values are fundamental beliefs about how the world should be, and they express a personal or social preference for an end state of existence or specific mode of conduct (Rokeach 1973). For example, people may value the end states of beauty, peace, wealth, friendship, equality, freedom (Rokeach 1973), and behaviors that can lead to these end states, e.g., self-expression, egalitarianism, belongingness, and humanity toward other living organisms. Values are single beliefs that form slowly in youth over many experiences (Rohan 2000). Consequently, they are stable through time, providing motivational constructs that persist through adulthood (Schwartz 1992), and are thus likely to strongly influence attitudes and guide an individual's processing of information and events.

There is a strong cultural component to values, so values tend to vary less within than they do among different cultures (Kluckhohn and Strodtbeck 1961; Schwartz 1992). Values are thought to be organized into value systems or value orientations (Rokeach 1973), and prioritization of values within these orientations is more individual and appears to explain differences among people in conservation-related attitudes and behaviors within cultures (Teel et al. 2015). Although values of an individual rarely change, they can change across generations as cultural expectations change through time (Manfredo and Teel 2008).

18.3.2 Empirical Values

Given the stability and motivational influence of values, much research has focused on identifying core values or sets of values that influence attitudes toward conservation and wildlife. A central hypothesis guiding this research is that, because of the commonalities of challenges that humans face across cultures, there should be a limited set of universal values (Kluckhohn and Strodtbeck 1961). Kluckhohn and Strodtbeck (1961) identified and tested six dimensions of cultural value orientations, one of which addressed the relationship of individuals and groups with nature. Human–nature relations fell into one of three orientations: mastery, in which humans are seen as superior to nature and have a need and responsibility to attempt to control it; harmony, whereby people work with nature to maintain harmony and balance; and subjugation, in which people cannot and should not exercise control over natural forces but, rather, are subject to the higher power of these forces. The influence of this foundational work persists, with value orientations that affect attitudes and behaviors more specifically toward wildlife variably described as mutualism/harmony/protection orientation versus materialism/domination/mastery/utilization (e.g., Fulton et al. 1996; Manfredo and Teel 2008).

Later influential work by Rokeach (1973) identified at most 36 universal values addressing all aspects of life, but most current conceptual frameworks have their origins in the theoretical structure for life values of Schwartz (1992). Schwartz proposed a typology of ten motivational life value types, comprising 56 value items, clustered along two motivational dimensions: openness to change versus conservation (meaning conservative behavior) and self-enhancement (e.g., materialism, personal ambition) versus self-transcendence (e.g., benevolence, respect for the environment) (Schwartz 1992), and these have proved remarkably consistent across cultures (Schwartz and Sagiv 1995; Schultz et al. 2005). Pro-environmental behaviors tend to correlate positively with self-transcendence values (Stern et al. 1998; Stern 2000).

While values can be hard to influence and change, there has been recent interest in their use in communication strategies intended to motivate conservation behavior (Clayton et al. 2013; Teel et al. 2015). "Deep framing" forges connections between the kind of language used in communication materials and a set of values (Crompton 2010). This approach is central to the "Common Cause" network of NGOs led by WWF-UK (http://valuesandframes.org/) seeking social and environmental change (Crompton 2010). The "Common Cause for Nature" publications comprise a detailed report and a practitioner's guide (Blackmore et al. 2013a, b) commissioned by 13 UK conservation organizations, including the Bat Conservation Trust. The reports focus on the ways in which values can be engaged as part of conservation communication. Schwartz's value topology is adopted, although grouped into "intrinsic" and "extrinsic" motivational clusters, which are broadly equivalent to self-transcendence (self-direction, benevolence, universalism) and self-enhancement (power and achievement), respectively. Blackmore et al. (2013a, b) caution strongly against the use of extrinsic frames that "sell" the conservation issue. They argue that by framing conservation messages in terms of economic or utilitarian value, campaigns appeal to self-interest motivations and may suppress environmental concern. Rather, messaging should appeal to intrinsic values which are more likely to foster environmental concern. This is a pertinent consideration as many bat conservation frames are based on ecosystem services provided by bats, and there are a growing number of studies attaching monetary values to the services (e.g., Cleveland et al. 2006; Wanger et al. 2014).

18.4 Attitudes

18.4.1 Theory

Attitude describes the tendency to think, feel, or act positively or negatively toward objects in our environment (Eagly and Chaiken 1993). Tendency arises because of "an association, in memory, of an evaluation of an object"

(Fazio et al. 1982, p. 341). Whereas values are single beliefs that transcend objects and situations and apply across time, attitudes organize several beliefs around a specific object or situation (Rokeach 1973). In the prevailing multicomponent model of attitude, attitudes are evaluations of an object that comprise three distinct components (Zanna and Rempel 1988; Eagly and Chaiken 1993). The cognitive component encompasses the beliefs and thoughts a person holds about an attitude object and the attributes they associate with it. Whereas bat researchers typically have a positive cognitive response to bats, a member of the public's belief in myths (alternative conceptions) may lead to negative responses and hence attitudes (Prokop and Tunnicliffe 2008; Prokop et al. 2009). The affective component describes the emotions a person feels toward an attitude object. Many people report that bats make them feel scared (e.g., Kahn et al. 2008); they have a negative affective response which can lead to a negative attitude. The behavioral component refers to past behaviors or experiences regarding an attitude object. The multicomponent model of attitude content is informative for educational approaches. As scientists we disdain emotional approaches to research, but this should not bleed into a solely cognitive approach to attitude change. While our training conditions us to address the cognitive component of an attitude, for example by providing information on ecosystem services, or attempting to dispel myths, appealing to affective components and behavioral components may be just as powerful (Pooley and O'Connor 2000) (Sect. 18.4.2.1).

It is also worth noting that an attitude object (bats) may not necessarily hold all three components. For example, a child present at a school visit may hold beliefs about bats and feel positively (or negatively) toward them, but have never encountered them (no behavioral component). Moreover, although associations among components are commonly consistent and even synergist in supporting a particular attitude (Eagly and Chaiken 1993), they can sometimes be inconsistent and even contradictory. This is critical to recognize in the design of conservation messages and interventions. For example, it is possible that someone is aware of and appreciates the ecosystem services that bats provide (positive cognition), but still fears them (negative affect), or has a long history of hunting and eating bats (negative behavior). Thus, appealing to single attitude component will not necessarily lead to a change in attitude, particularly if the other components are stronger. Materials and approaches that are themselves multicomponent may be more effective. For example, the Malaysian Bat Conservation Research Unit produced a comic "Gema's Home" (Benton-Browne and Palmer 2003), a story of an insectivorous bat, Gema (Malay for echo), whose tree roost was being cut down by a local farmer (Mr. Aziz). Gema's distress is palpable, and she appeals to her human friend, a little girl called Nur, for help. Nur and Gema take Mr. Aziz to visit a nectarivorous bat (Polly) and a fruit bat (Fruity), and together they explain the ecosystem services provided by bats and dispel some of the common myths about bats. Mr. Aziz changes his ways and becomes a protector of bats. The cartoon representations and characterizations of the bats are appealing (affective component), and Gema's situation is initially upsetting (affective), but there is explanation of the importance of bats (cognitive). The story is also produced as a shadow puppet show, a traditional performance art in Malaysia, as part of a children's workshop.

Attitudes and attitude components have both valence (positive vs. negative direction of evaluation) and strength. Attitude strength is an important consideration for interventions because strong attitudes are more likely to persist over time, resist change, influence information processing, and predict behavior (Petty and Krosnick 1995; Krosnick and Petty 1995; Holland et al. 2002).

Attitudes are believed to be adaptive, providing a rapid means for processing information and guiding behavior in a complex, data-laden environment and serving four broad functions (Smith et al. 1956; Katz 1960; Maio and Haddock 2014). Awareness of attitude functions is important from a conservation education perspective, because function, like the strength of the components described above, influences susceptibility to attitude change and the kinds of persuasive appeals that might work. First, attitudes can provide an *object-appraisal* function —a summary of the positive and negative attributes of an object to guide how a person should respond to it. Appraisals are commonly based on a utilitarian evaluation—bats provide ecosystem services as agents of pest control, or bats are great bushmeat, but may also derive from a feeling—bats are scary, or bats are cute. Second, attitudes can be used to convey our personal moral values and goals. This *value-expressive* function is related to our self-concept, and, perhaps not surprisingly, attitudes serving this function tend to be central and strong. Attitudes that facilitate relationships with others serve a *social-adjustment* function. Attitudes can also function to protect us against internal conflict (*ego-defensive* or *externalization)* and to defend our self-esteem (for further discussion see Maio and Haddock 2014).

By way of example, let us consider possible attitude functions toward colonies of flying foxes. Attitudes may be based on a utilitarian object-appraisal function in communities who view the bats as a source of bushmeat or income to feed their families (e.g., Kamins et al. 2014). In other communities, such as the Minahasa and Sangir tribes of northern Sulawesi, flying fox consumption may also be associated with a cultural identity (e.g., Sheherazade and Tsang 2015). Now, the attitude function may be value-expressive or social-adjustment. Contrasting attitudes toward the same bats held by biologists may be based on a utilitarian object-appraisal—bats are pollinators and seed dispersers, bats are sources of viruses that may affect human populations, and/or a deeply held belief that bats have a right to exist and not be hunted (value-expressive function). Value-expressive (core moral values and convictions) and object-appraisal functions seem especially predictive of behavior (Fazio 2000) and resistant to change. For example, Kamins et al. (2014) asked Ghanaian bat hunters and vendors what value bats have for people. Four responses were given—no value (14 %), economic value (30 %), meat (30 %), and both meat and money (26 %), reflecting a highly utilitarian object-appraisal function for their attitude toward bats. A subsequent education intervention highlighting the disease risk associated with hunting and butchering bats and the environmental importance of fruit bats had only modest influence—only 45 % of interviewees reported an intention to stop hunting, butchering, or selling bat bushmeat (Kamins et al. 2014).

Because of the adaptive role attitudes play in dealing with the barrage of information we face every day, not only do they influence behavioral intention, but they also influence how we process information about the attitude object. This is important to be aware of in educational or outreach programs. Attitudes influence what information we pay attention to (selective exposure) (Allport 1935; Frey 1986), with preference for information that fits our existing evaluation (Knobloch-Westerwick and Meng 2009); how we evaluate the new information, especially if our existing attitude is strong and hence accessible (Houston and Fazio 1989); and our ability to remember specific information (selective memory) or behaviors. In general, information processing works to minimize cognitive dissonance (Festinger 1957)—the sense of disquiet or mental tension we feel if our behavior or beliefs toward an object are inconsistent. So there is a tendency to select, evaluate, and remember information congruent with our attitudes (otherwise, we have trouble believing in ourselves). In the vernacular, we can think of this as "preaching to the converted" or having our information "fall on deaf ears."

18.4.2 Empirical Attitudes Toward Animals and Factors Affecting Them

The most widely used framework for understanding people's attitudes toward animals (rather than other environmental issues more generally) remains the empirical approach of Stephen Kellert. Kellert led a five-phase report to the US Department of Interior, Fish and Wildlife Service (1977–1983) evaluating the US public's knowledge and attitudes toward animals through surveys of 3945 members of the public (Kellert 1979, 1980; Kellert and Berry 1980; Kellert and Westervelt 1981, 1983). His findings suggested that four major factors influence the US public's attitudes to animals: (i) prior attitude toward, and values of wildlife and nature; (ii) previous experience and knowledge of species or group; (iii) relationship between species and humans, e.g., cultural significance, utility value, or conservation status; and (iv) human perceptions of individual species.

Kellert's work lacked a clear conceptual framework (Manfredo 2008), so below I try to integrate some of the more theoretical perspectives that have since been developed and then examine how we might view these factors from the perspective of bat conservation initiatives and outreach. As detailed below, bats are a mix of good news and bad news when viewed in the context of Kellert's framework.

18.4.2.1 Prior Attitudes and Values of Wildlife and Nature

Kellert developed a typology of attitudes to wildlife (Kellert 1976, 1993, 2002) and identified nine groups, the most common of which were humanistic (primary interest in and strong affection for individual animals, principally pets), moralistic (primary concern for the right and wrong treatment of animals, with strong opposition to exploitation of and cruelty toward animals), utilitarian (primary concern for the practical and material value of animals), and negativistic (primary orientation an active avoidance of animals due to dislike or fear) (Kellert 1980; Kellert and Wilson 1993). In a similar vein, but starting from a theoretical standpoint, Stern and colleagues used Schwartz's work on values (Sect. 18.3.2) to develop a value-based theory of environmental attitudes, describing them as egoistic (reflecting concern about environmental problems for the self), altruistic (concern for the effect on others, such as friends, family, community, and future generations), and biospheric (concern for living things regardless of their value to people) (Stern and Dietz 1994; Stern et al. 1993). Later authors collapse these attitudes to simply anthropocentric (utilization) and biocentric (preservation) (e.g., Milfont and Duckitt 2010). Other motivational frameworks place additional emphasis on the role of emotions (Pooley and O'Connor 2000; Serpell 2004).

Knight (2008) found that people with higher moralistic attitudes report higher levels of support for protection of species (including bats) than those with dominionistic world views. Interestingly, moral reasoning and moralistic attitudes toward animals and nature can develop as early as preschool in children (Kahn 2006), and moral concern and caring can exist alongside a fear orientation (Kahn et al. 2008), the basis for negativistic attitudes. Kahn et al. (2008) interviewed children in four age groups (6–7 years, 9–10 years, 12–13 years, and 15–16 years) as they exited an exhibit of Rodrigues fruit bats (*Pteropus rodricensis*) at Brookfield Zoo (Illinois, USA) and explored caring for bats, fear of bats, and potential moral basis for keeping bats (or not) in captivity. The exhibit presented no barriers between visitors and the bats (glass or mesh), permitting potentially "fearful" encounters as bats swooped by. While just over half the children, especially in the younger age groups, expressed some fear, the same fearful children still cared about bats and the rights of bats. All children gave both anthropocentric and biocentric justifications in response to questions about caring for bats and the rights of bats.

Unfortunately, fear (Prokop et al. 2009) and disgust for bats (Prokop and Tunnicliffe 2008) are widespread. In a study across UK, India, USA, Holland, Korea, Hong Kong, and Japan, bats fell firmly into the "disgust" category falling behind cockroaches, spiders, beetles, maggots, worms, and leeches, and only just beating out wasps, lizards, rats, mice, and slugs (Davey et al. 1998)! Bats are recognized and conceptualized as "bad" animals even among kindergarteners (Kubiatko 2012). Rachman (1977) proposed that fears are learned by children through one of a combination of the following learning pathways: (1) direct conditioning, (2) vicarious learning, and (3) negative verbal information. The power of negative verbal information in engendering fear of *novel* animals has been demonstrated (Field and Lawson 2008) and is especially effective when verbal information comes from a parent (Muris et al. 2010; Remmerswaal et al. 2013). Conversely, there is a reduction in children's fear beliefs when positive information is provided about novel animals (Field and Lawson 2003; Muris et al. 2003; Kelly et al. 2010). However, fear beliefs can be difficult to reverse if they are already well established, rather than invoked toward a novel animal. Williams (2014) sought to reduce fear of bats in US 7- to 9-year-olds with positive verbal information. Although she found a slight change in scores on the Bat Attitude Questionnaire in some children, there were no significant changes in scores on the Fear Belief Questionnaire. Few children will have encountered bats by this age, so direct acquisition of fear through classical conditioning is unlikely. Rather, William's study illustrates just how powerful the indirect negative information coming from the media and culture can be in defining children's fear of bats, and this will be particularly pronounced if conveyed by parents.

If positive information, which is tackling the cognitive component of attitude, is ineffective in changing attitudes, perhaps we would do better to work on the affective component. When an object is paired with an affective sensation, we are tapping into emotion learning, or affective or evaluative conditioning (De Houwer et al. 2001), similar to the classical condition of Pavlov, more familiar to biologists. Although evaluative conditioning is strongest when people have low knowledge about the attitude object, it can still influence attitude change when knowledge or attitudes exist (Olson and Fazio 2006). Bats are frequently paired with scary, negative emotions (e.g., vampires, horror films, haunted houses), so we must work to link positive affect to them. Outreach activities should be fun and participatory: For example, the MBCRU refers to a 3-h children's workshop as the "Malaysian Bat Party" with activities and games that children enjoy. Another approach is to look beyond our rationalist scientific training and promote empathy for bats by levering the universal human tendency to anthropomorphize (project human characteristics onto non-human animals). Anthropomorphism may have been with us since Paleolithic times (Mithen and Boyer 1996), and its use as tool for conservation is receiving growing attention (Tam et al. 2013; Chan 2012; Root-Bernstein et al. 2013). Anthropomorphic bats already prevail in the children's bat literature, led by Jane Cannon's wonderful Stellaluna, although bats in some books lack names and in others look like rodents! From a campaign perspective, probably the earliest example of deliberate anthropomorphic characterization of bats comes from the work of the UK's Mammal Society and the Fauna and Flora Preservation Society to change attitudes to bats when they received full legal protection under Wildlife and Countryside Act in 1981. Artist Guy Troughton deliberately portrayed bats as friendly, fun creatures in books, stickers (Fig. 18.2), mugs, and Christmas cards, and these products were integral to the reversal of public attitudes to bats (Morris 1987).

18.4.2.2 Previous Experience and Knowledge

As nocturnal, volant mammals, people do not experience bats in the way that they might birds and this has consequences for attitudes. Bat sightings are commonly at a distance and fleeting (Sexton and Stewart 2007), while closer encounters may be in a negative or fearful setting, for example as a nuisance in dwellings (Voigt et al. 2016), and/or may prompt fears of disease(Liesener et al. 2006). Bat knowledge is commonly low (e.g., Kingston et al. 2006; Sexton and Stewart 2007; Sheherazade and Tsang 2015) and correlates with attitudes toward bats (Prokop et al. 2009).

Fig. 18.2 Car sticker from the campaign to change the attitudes of the British public to bats c. 1985. Artist Guy Troughton subtly altered the bat to confer greater anthropomorphic appeal (large, soulful eyes and a slightly tremulous smile!) (*Source* Morris 1987)

Moreover, outreach must operate not just from a position of limited or no knowledge, but contend with the abundance of "alternative conceptions" or myths about bats. For example, only 17 % of nearly 200 children (6–16 years) surveyed by Prokop and Tunnicliffe (2008) in Slovakia rejected the idea that bats can tangle in human hair and 36 % asserted that the main diet of bats is blood, a misconception that was still prevalent in undergraduates (Prokop et al. 2009). Not only do alternative conceptions about bats correlate with negative attitudes, but alternative conceptions are depressingly robust and difficult to correct (Mintzes and Wandersee 1998).

It is a rare for a bat biologist to complete a school visit without encountering the "bats lay eggs" question (or assertion!). Viewed through the lens of cognitive psychology, the paucity of knowledge about bats means that many lay people conceptualize them as an exception to the rule "if it has wings, it is a bird." Consequently, they are more likely to use knowledge of the behavior and physiology of birds to reason about bats than they would other mammals (e.g., dogs and hedgehogs) (Davis et al. 2013). Davis et al. asked subjects the likelihood that an internal trait (a protein) and a behavioral trait (a feeding behavior) described in birds or mammals would also be found in bats and dogs. People were significantly more likely to generalize the bird traits to bats than dogs and the mammal traits to dogs than bats. So non-experts automatically assume that the knowledge they have about birds applies to bats and vice versa. This is of conservation concern because bats share little behaviorally or physiologically with birds and respond differently to conservation issues.

18.4.2.3 Relationship Between Species and Humans—Cultural Significance and Utility Value

Conceptions of nature are a social construct created within a historical and cultural context (Clayton and Myers 2015). It is beyond the scope of this chapter to review all the cultural, religious, and symbolic perspectives of bats(see Lawrence

1993), but around the world, bats are commonly associated with aspects of death and sometimes rebirth. For example, bats are believed to be witches in Nigeria (Iroro Tanshi, pers. comm.), spirits of the dead in the Ivory Coast, criminals in Madagascar (Andrade 2009), and souls of the dead searching for rebirth in old Europe. They are deified in Mayan culture, although the bat god Camazotz is thought to represent some kind of giant vampire bat, and is still associated with death, unfortunately. More broadly, while the Bible describes bats as detestable, unclean birds (Leviticus 11:13–20, Deuteronomy 14:11–19), in Shi'a hadith (Nahjul Balagha Sermon 154 or 155 depends on the version), bats are viewed as a testament to "His [Allah's] delicate production, wonderful creation and deep sagacity." Famously, in Chinese, culture bats are viewed as auspicious creatures and symbols of good luck because the word "bat" is a homophone (pronounced the same) of "fortune" in Mandarin Chinese. The Wu Fu, or five lucks, is typically depicted as a ring of five bats signifying the Five Fortunes—longevity, wealth, health and composure, virtue, and a natural death in old age.

On the plus side, bats have great utility to people through the ecosystem services they provide as agents of pest suppression, pollination and seed dispersal, and sources of guano (Kunz et al. 2011). Boyles et al. (2011) estimated that bats may collectively save the US agricultural industry at least $3.7 billion a year by suppressing crop pests, and Wanger et al. (2014) put the value of a single insect-eating species (*Chaerephon plicata*) to rice production in Thailand at over $1 million annually. Such economic evaluations certainly receive substantial press coverage, and it would be interesting to study the influence of this on public attitudes toward bats. Caution is warranted because while featuring ecosystem services can be an effective frame for a campaign, attaching monetary evaluations to wildlife appeals to materialist values which may evoke values and attitudes that are less receptive to conservation (see 18.3.2 above).

18.4.2.4 Human Perceptions of Individual Species

Public support for species' conservation is strongly influenced by human perceptions, predominantly the esthetic appeal of the species (Gunnthorsdottir 2001; Stokes 2007), its similarity to humans (Kellert 1996; Batt 2009), and perceived threat to humans (Knight 2008; Kellert 1996). Unfortunately, to much of the public, bats have little esthetic appeal (Knight 2008) and frequently evoke disgust (Davey et al. 1998; Bjerke and Østdahl 2004) and, despite being mammals, bear very little similarity to humans ("where are its eyes?"). Even well-meaning educational displays may feed rather than extinguish these perceptions, particularly when imagery is at a larger-than-life scale (Fig. 18.3).

Perceptions of the threats of bats to people are becoming a major concern because of the, often alarmist, publicity surrounding their role as reservoir hosts in emerging infectious diseases (Schneeberger and Voigt 2016). This requires careful treatment in education programs because although the likelihood of a bat virus being transmitted to humans is very low, the consequences of infection can

Fig. 18.3 Some portrayals of bats in education settings can have a counterproductive influence on attitudes and perceptions (*Photo* T. Kingston)

be very high, often fatal. In many countries, populations at risk of exposure, such as bat hunters, butchers, consumers, or guano harvesters, have very low rates of risk perception (Harrison et al. 2011; Robertson et al. 2011; Kamins et al. 2014). Educational interventions are needed to reduce target behaviors that increase transmission probabilities, but the challenge from a conservation perspective is to do so without engendering an overall negative attitude toward bats or calls for destruction of populations. Education materials that simultaneously target behaviors and highlight bat ecosystem services are a start (see Appendix 3 of Kamins et al. 2014), but it is unclear how effective these approaches are, and further research on such "mixed messages" is much needed.

18.5 Social Norms

Although the social norm concept has its origins in early twentieth century anthropology and sociology (Hechter and Opp 2001) and was explicitly incorporated into the TRA and TPB (as the subjective norm), recognition of the role of the social context and pressures on people's attitude and behavior toward environmental actions and species protection is more recent (Cialdini et al. 1990; Cialdini 2003; Mascia et al. 2003; Schultz et al. 2007; Goldstein et al. 2008; St John et al. 2013; McDonald et al. 2014).

Social norms are the accepted or implied rules about how members of a social group should, and do, behave (Sherif 1936). Individuals breaking these rules may be sanctioned formally, if the norm is written into law for example, or informally through social disapproval. The more motivated an individual is to identify with a particular social group, the more likely they are to recognize and conform to the group's norms (Deaux 1996; Manfredo 2008), particularly if the norm is central to group identification (Christensen et al. 2004). Social norms are dynamic, and they depend on the person and situation (Ajzen 1971). There are several norm constructs, beginning with the subjective norm of Fishbein and Ajzen (1975) which focuses on beliefs about what important others expect one to do in a given situation. A more operational approach identifies the descriptive norm, which is based on perceptions about what others actually do, and the injunctive norm, perceptions about what others approve of (more akin to the original subjective norm) (Cialdini and Trost 1998). This division is important because appeals in which these conflict can fail to change behavioral intention (Cialdini 2003, McDonald et al. 2014). So if a persuasive appeal is intending to convey disapproval of an action (injunctive norm), but at the same time suggests that many people perform this behavior (descriptive norm), the message is normatively muddled. For example, if a message was to indicate that people should not kill bats (perhaps by hunting, or excluding them from homes) (injunctive norm) but that many people are doing so (descriptive norm), the persuasive appeal is conflicted. If there are high levels of a socially disapproved behavior, it is better to focus on the injunctive norm. Conversely, a descriptive norm approach would be effective in promoting a new behavior, for example building bat houses. In sum, descriptive and injunctive normative messages need to align and whenever possible be used together (Cialdini 2003; Kinzig et al. 2013).

Sociology identifies four basic types of norms: folkways or “customs”; mores—norms of morality including religious doctrines; taboos—behaviors forbidden by culture (which may be enacted into law); and laws—norms that are written down and enforced. The potential of taboos, and the informal institutions that proscribe them, to advance conservation agendas is of growing interest (Colding and Folke 2001), particularly in situations where the influence of external formal institutions is constrained (Jones et al. 2008). Taboos prohibit eating of bats (*Pteropus*) by the Mahafaly and Antandroy people of Madagascar (MacKinnon et al. 2003), while sacred forests provide protection in other parts of the country (Rahaingodrahety et al. 2008). Similarly, sacred groves protect colonies of *Pteropus giganteus* in Tamil Nadu, India (Marimuthu 1988; Tangavelou et al. 2013), and West Kalimantan, Indonesia (Wadley and Colfer 2004). Colonies of *Pteropus* throughout much of Indochina are associated with gardens attached to Buddhist monasteries (pers. obs.), while sacred caves protected by Buddhists provide refuge for diverse insectivorous bat species (e.g., Robinson and Smith 1997). Sacred caves and rocks provide similar protection elsewhere with known examples from Ghana (Hens 2006) and Kenya (Metcalfe et al. 2009).

People do not always adhere to taboos or mores, or practice their nominal religion, especially if there is conflict with utilitarian or cultural use of the animal. For example, although all the Abrahamic religions explicitly prohibit consumption of bats, sales and consumption of flying foxes in North Sulawesi peak around Christian celebrations (Sheherazade and Tsang 2015). Similarly, taboos may not be respected if wildlife resources are scare (Bobo et al. 2015). In addition, bats may be seen as the exception to broader social norms. For example, India’s Wildlife Protection Act (1972) schedules bats as vermin, excluding them from

Fig. 18.4 Portrait of *Eidolon helvum*, typical of bat biologists' collections (*Photo* T. Kingston) (*left*) and the author smiling with the same bat (*right*) conveying positive affect that can shape social norms and attitudes toward bats (*Photo* P. Webala)

protection. Nonetheless, appealing to neglected prior norms and taboos may be a point of leverage, but should be done with guidance from local religious/spiritual leaders.

Norms are internalized by three transmission routes (Gintis 2003), vertically from parent to child, obliquely through social institutions (e.g., religion, government, school, media), and horizontally through interactions with peers. Conveyance methods (Cialdini and Trost 1998) include active instruction (stories, myths), passive observation (nonverbal imitation), and inference from behavior around us. Bat researchers can contribute to the oblique transmission route of positive social norms about bats by publicizing their work in the popular scientific press, social media, visiting schools, etc. To be effective, we should be sure to emphasize the wonder of bats, not just our science, and not be afraid to appeal to emotion and anthropomorphic tendencies (Sect. 18.4.2.2). As biologists, when photographing bats we tend to concentrate our efforts on portraiture (head shots), to capture the diversity of bat morphology and diagnostic taxonomic features, or "researchers in action," conveying only a scientific behavioral norm toward bats which often involves trapping of some description. These have their place, but from an outreach perspective intending to lever norms, images of a researcher holding a bat smiling conveys that bats are not a source of fear but happiness (positive affect) and that many people do, and one should, behave positively toward them (Fig. 18.4).

18.6 Assessing Attitudes, Values, and Norms

From the above, it is clear that knowledge of people's values, attitudes, attitude functions, and social norms could be very useful in the design of messages aimed at influencing behavior. A detailed review of methods for measuring these psychosocial constructs is beyond the scope of this chapter, but for conservation purposes, most measures are commonly based on self-reporting (or interviews) through questionnaires with scaled responses. Good questionnaires can gather information on knowledge, values, attitudes, opinions, behaviors, facts, and other information and have been increasingly used in ecology and conservation biology to assess stakeholder opinions and perceptions of and behaviors toward species or issues of conservation concern (White et al. 2005). Although many of us have designed and given questionnaires to or interviewed stakeholders, robust design that can evaluate the values and attitudes behind behaviors and provide an unbiased assessment of the behaviors themselves requires substantial preparation. Central is a solid theoretical understanding of social psychology and psychometrics and design considerations. For example, questionnaires need to quantify and maximize validity (does the questionnaire or "instrument" measure what it intended to) and reliability (does the instrument consistently or accurately measure what it is intended to measure). The procedure for sampling the target population (e.g., random, systematic, comprehensive) needs to be considered as does non-response bias, to name but a few factors.

Measuring behavior through self-reporting or interviews can be particularly tricky if the behavior is illegal or contravenes a social norm (socially disapproved or inappropriate). Respondents may not tell the truth or may skip the question, compromising data validity (King and Bruner 2000). This is key if the prevalence of particular behaviors (such as hunting bats) is the end point of the study and is even more pertinent if the study aims to assess whether attitudes are good predictors of behavior (e.g., St John et al. 2011). Recent applications of sensitive question tools from human health research (e.g., condom use in HIV research) to conservation "rule breaking" provide much higher reporting of illegal activities than conventional approaches (St John et al. 2013; Nuno and St John 2015). If non-sensitive characteristics (attitudes or demographics) can predict sensitive behaviors, then the identification of the target audience for intervention is greatly facilitated (St John et al. 2013).

Scientists are rarely trained in appropriate social science methodologies and indeed may come at human studies from a very different philosophical perspective that can influence our understanding and interpretation of social science data and conclusions (Moon and Blackman 2014). As emphasized in the introduction, we should be collaborating directly with social scientists (Mascia et al. 2003; Sandbrook et al. 2013; St John et al. 2014), but a good introduction to methods is given in Newing (2011).

18.7 Recommendations

There remain few published studies addressing the drivers of human behavior toward bats, yet this is key to their conservation. The primary recommendation for bat biologists directly tackling bat conservation issues is to work with conservation social scientists to fully characterize the human dimension of the problem and identify targets for intervention. Key considerations in the design of interventions and messages are as follows:

- Work to establish the component (value, attitude, norm, perceived behavioral control) of the TPB pathway/VAB framework acting as a barrier to behavioral change. Target the “barrier component” for intervention.
- Recall that many components are structured. Attitudes may be based on cognitive, affective, or behavioral perspectives, and attitude functions serve different roles. If interventions are to resonate with a target audience, it is critical that they not only address the component that is the problem, but that the message matches the content or functions that are the basis for the recipients’ attitude. Similarly, social norms can be descriptive or injunctive, and messages should be sure to align with the prevailing norm and avoid conflict between them.
- Work with values and avoid framing messages that appeal to extrinsic or self-enhancement values.
- Remember that much of human behavior is driven by how we feel (affective component of attitudes, social pressure behind norms). Do not be afraid to appeal to emotion and anthropomorphic tendencies in the design of messages and materials.
- Be aware of our influence as scientists on social norms relating to bats and be sure to convey the wonder and positive affect they engender (BATS ARE COOL!!!).

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C.C. Voigt and T. Kingston (eds.), *Bats in the Anthropocene: Conservation of Bats in a Changing World*, DOI 10.1007/978-3-319-25220-9