

as an alternative to oak forest harvest. Another option is to promote the conservation of the last forest remnants through the formal participation of these communal properties within the Guatemalan system of protected areas. This strategy would require a strong political effort by the leaders of the communities that own the land. For these political leaders to promote these conservation actions will require the implementation of an effective and sustained program for the conservation of the last cloud forest remnants in northwestern Sierra de los Cuchumatanes.

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Note added in proof: In May 2011 another specimen of *Abronia frosti* (SVL 79.62 mm) was found by a local villager near the type locality. This individual is probably a female and was captured for the captive breeding program at Zootropic.

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Prime Time for Turtle Conservation

In the race to extinction among all large groups of well-known animals, turtles hold the lead with 47.6% of 320 currently recognized turtle species identified as “Threatened” with extinction (Turtle Taxonomy Working Group [TTWG] 2010). Hoffmann et al. (2010) calculated threat levels a bit differently, by excluding data deficient or unevaluated species from the calculation; this method yields a higher percent of Threatened turtles, 54%. This exceeds global threat estimates

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for amphibians (41%), mammals (25%), bony fishes (15%), and birds (13%), and is similar only to primates, with 48% Threatened (Hoffmann et al. 2010). Furthermore, if our view is expanded to include ‘modern’ turtles and tortoises, those species that have occurred in the last 400 years, then 50% are threatened or already extinct (TTWG 2010). This percentage increases to 57% if data deficient and unevaluated species are eliminated from the calculation. By any of these approaches, turtles are in dire straits.

Partners in Amphibian and Reptile Conservation (PARC) is working with turtle and tortoise conservation groups to raise awareness for turtles by designating the year 2011 as the ‘Year of the Turtle.’ Their hopes are to: 1) communicate the need for conservation, research and education to the public, nature enthusiasts, biologists, and managers; 2) showcase ongoing work and species concerns; 3) acquire critical new

information for selected species; 4) look for opportunities to leverage across diverse efforts to enhance effectiveness of actions; and 5) work to develop new procedures and policies that will benefit chelonians. Their website (www.yearoftheturtle.org) features monthly newsletters, calendar pages, partner links, and selected project information. Modeled, in part, after the highly successful 2008 – Year of the Frog that was organized by the Association of Zoos and Aquariums, the 2011–Year of the Turtle is a mechanism to network among those doing turtle and tortoise work, and those private citizens, groups or specialists that are interested in their plight.

Although Year of the Turtle is gaining worldwide momentum, it has a particular focus on chelonians in North America, where PARC has a growing constituency. Also, among world nations, the United States is a turtle and tortoise biodiversity hotspot. There is heightened concern to preserve the unique natural heritage of turtles in this geographic area. Currently, 57 of the 320 (18%) species of turtles known worldwide occur in the United States, with Mexico being the second-most turtle-rich nation, having 46 species (TTWG 2010). Furthermore, these two North American nations rank highest in turtle species diversity if the counts exclude sea turtles, with USA having 51 species (81 species and subspecies) and Mexico having 40 species (58 species and subspecies) (TTWG 2010). Twelve species of freshwater turtles and tortoises occur in Canada. Retaining the North American turtle natural heritage is a specific conservation concern. Here, we offer a primer on the status of world turtles, with some specific information and conservation and research recommendations for the North American fauna.

TURTLE STATUS AND THREATS

The conservation status of world turtles and tortoises is currently under reassessment. The International Union for the Conservation of Nature (IUCN) Red List is the official list of the conservation status of turtles and tortoises. An update to the list will be released this year, 2011, with scores of new species evaluations to be added. The current Red List, version 2010.4, includes 207 species (Table 1). Draft Red List designations for re-evaluated and newly evaluated turtles were released in December 2010, showing a raise in species in Threatened categories, from 129 to 152 (shaded rows, Table 1). The Convention on Trade in Endangered Species (CITES) species lists address international trade guidance. International law is enforced by countries that are party to this treaty; nearly all countries are signatories. CITES classifies species into three Appendices that are grades of protection. These Appendices are due for revision in 2012, and draft revisions to turtle and tortoise listings are being made now. Currently, there are 21 species of freshwater turtles and tortoises, as well as all sea turtles, on Appendix I, the most endangered group. CITES prohibits international trade for these species, except when the purpose of import/export is not commercial (e.g., scientific research). There are 23 species, seven genera, and one family (tortoises: Testudinidae)

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FIG. 1. Eastern Box Turtle (*Terrapene carolina*).

PHOTO BY DAVID BURK WALL



FIG. 2. Spotted Turtle (*Clemmys guttata*).

PHOTO BY GREGORY LIPPS



FIG. 3. Bog Turtle (*Glyptemys muhlenbergii*).

PHOTO BY JEFFREY G. HALL

on Appendix II, the list that identifies species that may become threatened unless trade is closely controlled. There are 18 species and one genus (*Graptemys*) on Appendix III, the list that identifies species of concern by a Party (country) that already regulates trade in the species and needs cooperation of other countries to prevent unsustainable exploitation. Permits or certificates are needed for international trade of these species. One USA species is on Appendix III.

North American turtle conservation concerns can be further assessed by their national status ranks. In the USA, 9 of 57 (16%) freshwater turtle and tortoise species are listed under the Endangered Species Act (ESA, Table 2). In Canada, 6 of 12 species have conservation status by the Committee on Status of Endangered Wildlife in Canada (COSEWIC, Table 3). These lists do not overlap. It should be noted that the COSEWIC species appear on species of concern lists for certain US States.

The two top threats to turtles worldwide and in the US and Canada are habitat loss and fragmentation, and overexploitation for food, traditional medicines, and pets. Exacerbating these threats is the basic life history of most turtles and the small total ranges of many species. Their low fecundity and the several years it takes for young turtles to achieve maturity result in populations that are not resilient to sudden losses (Congdon et al. 1993). Small ranges mean that there are fewer total individuals and that there are fewer options for conservation action. All Canadian turtles are at the northern extent of their range, attributing to concern status for half of them.

Some examples of US turtles in peril and the reasons for concern are given below. Many more could be given. Each case is an example of the general issues, but the details are always different and they do matter.

The Plymouth Red-bellied Turtle (once recognized as the subspecies *Pseudemys rubriventris bangsi* and now understood as a highly isolated population) is confined to approximately 17 ponds entirely within Plymouth County, Massachusetts, more than 400 km from the mid-Atlantic populations of the same species. Similarly, the Alabama Red-bellied Turtle (*Pseudemys alabamensis*) occurs only in parts of Mobile Bay drainage in Baldwin and Mobile counties in Alabama, and Harrison and Jackson counties in Mississippi. Other species have specific habitat requirements so that the total amount of real estate available to them is small. The threatened Bog Turtle (*Glyptemys muhlenbergii*) requires very specific, nearly pristine, bogs to thrive so that although it ranges from upstate New York to Georgia, there is too little habitat left. The Flattened Musk Turtle (*Sternotherus depressus*) occurs only within the Black Warrior River system of Alabama, but cannot now live in much of that river because of water pollution and increased human activities.

A group of special interest is the map turtles of the Gulf South. Here, eight species are restricted to one or a small number of associated drainages in the southern USA that lead to the Gulf of Mexico. For example, the Pascagoula Map Turtle (*Graptemys gibbonsi*) is restricted to the Pascagoula

River drainage in Mississippi and the newly described Pearl River Map Turtle (*Graptemys pearlensis*) is confined to the Pearl River drainage only in Mississippi and bordering Louisiana. Because each of these species is only found in riverine habitat the total amount of area occupied is necessarily quite small. Scientists are currently preparing a new Red List assessment of these species and it is likely that many of them will be found to be vulnerable or endangered.

Two of three species of US tortoises, the Gopher Tortoise (*Gopherus polyphemus*) and the Desert Tortoise (*Gopherus agassizii*), are threatened by the enormous expansion of urbanization within their ranges. In Florida, the primary home of the Gopher Tortoise, development has been displacing tortoises at an alarming rate as that state has had one of the highest human population growth rates in the country. Similarly, much of the western portion of the Mojave Desert in California has seen most of the available land put to human use in the last two decades. For example, in Victorville, California, the human population grew from 64,000 in 2000 to approximately 112,000 in 2010. Unfortunately, Desert Tortoises have also been severely affected by disease outbreaks even in relatively remote areas (USFWS 2006).

Other turtles that have in the past been both widespread and common are now suffering from habitat fragmentation and the effects of roads. This creates a pattern of many small populations that cannot interact with each other. As road density increases, many scientists believe that a tipping point will be reached where many of the small populations will go extinct. The concern has been raised for the Common Box Turtle (*Terrapene carolina*), a mostly terrestrial species (Dodd and Franz 1993). So, even species that were formerly regarded as common may be prone to widespread decline.

Exploitation of turtles for Asian commercial markets has skyrocketed and is now a major conservation concern worldwide, including in North America (Turtle Conservation Coalition 2011). Turtles have played an important role in Chinese civilization at least since the Bronze-Age Shang Dynasty over 3,000 years ago. At that time, hundreds of thousands of turtles were used in divination rituals in which tortoise and turtle shells were heated and the cracks obtained were interpreted for guidance. These oracle bones fill archaeological sites. Turtles also have always been recognized for their longevity and the Chinese have sought to acquire that virtue from them. Today, turtles are consumed in China for long life and for traditional medicine. The problem, known as the Asian Turtle Crisis (van Dijk et al. 2000), arises from the combination of this long tradition with a population of over 1 billion people who are becoming wealthier. The demand for turtles in China is now almost impossible to overestimate. But the result is clear: turtles are being sent from all over the world to China for consumption at a scale unimaginable only a few years ago (Compton 2000; Chen et al 2009). Southeast Asian countries such as Vietnam now have their entire turtle fauna (over 30 species) critically endangered due to this trade (Hendrie 2000). The economic incentives for local peoples to

TABLE 1. International Union for the Conservation of Nature (IUCN) Red List current turtle designations (version 2010.4), re-evaluations to update the current list (updated numbers), provisional designations of previously unevaluated species, and sum of these columns to represent draft new list (TTWG 2010). Shaded rows are considered “Threatened” categories. * Indicates a category being phased out. — Indicates number not available or not relevant.

IUCN Red List Category	No. Species		
	Current List	Re-evaluations	Provisional List
Extinct	6	+1 (7)	1
Extinct in the Wild	1	-1 (0)	1
Critically Endangered	30	+7 (37)	6
Endangered	40	+2 (42)	4
Vulnerable	59	-9 (50)	13
Lower Risk	41	-11 (30)	9
Conservation Dependent*	1	-1 (0)	—
Least Concern	18	+3 (21)	63
Data Deficient	11	+2 (13)	16
Not Evaluated	—	—	8
Total No. Species	207	121	

TABLE 2. United States Endangered Species Act (ESA) turtle listings. Available at: www.fws.gov/endangered/species/us-species.html.

Common Name	Scientific Name	Status
Flattened Musk Turtle	<i>Sternotherus depressus</i>	Threatened
Sonoyta Mud Turtle	<i>Kinosternon sonoriense longifemorale</i>	Candidate
Desert Tortoise	<i>Gopherus agassizii</i>	Threatened
Gopher Tortoise	<i>Gopherus polyphemus</i>	Threatened
Plymouth Red-bellied Turtle	<i>Pseudemys rubriventris bangsi</i>	Endangered
Alabama Red-bellied Turtle	<i>Pseudemys alabamensis</i>	Endangered
Bog Turtle	<i>Glyptemys muhlenbergii</i>	Threatened
Ringed Map Turtle	<i>Graptemys oculifera</i>	Threatened
Yellow-blotched Map Turtle	<i>Graptemys flavimaculata</i>	Threatened

TABLE 3. Committee on Status of Endangered Wildlife in Canada (COSEWIC) turtle listing. Available at: www.cosewic.gc.ca/eng/sct1/searchform_e.cfm

Common Name	Scientific Name	Status
Eastern Musk Turtle	<i>Sternotherus odoratus</i>	Threatened
Blanding’s Turtle (Nova Scotia population)	<i>Emydoidea blandingii</i>	Endangered
Spotted Turtle	<i>Clemmys guttata</i>	Endangered
Wood Turtle	<i>Glyptemys insculpta</i>	Threatened
Spiny Soft-shell	<i>Apalone spinifera</i>	Threatened
Western Painted Turtle (Pacific Coast population)	<i>Chrysemys picta bellii</i>	Endangered

participate in this global trade are staggering. Any turtle is worth serious money to a Vietnamese peasant, but some species, such as the Three-striped Box Turtle (*Cuora trifasciata*), sell for several thousand dollars apiece (Blanck et al. 2006). They are literally worth their weight in gold.

Commercial markets for turtles include the pet trade. Around the world people keep pet turtles and tortoises. In the last few decades they have become much more popular and, most importantly, the number of species found in the pet trade has increased dramatically (Shepherd and Nijman 2007; Shepherd and Nijman 2008). While most pet owners have relatively common species and do not pose a major conservation threat, some collectors become fanatic about getting rare or unusual species. Today, almost every species of turtle can be found for sale, legally or not, on the internet. Fanatic collectors can buy the world’s rarest turtles if they have enough money, and many do. Prices for adult Ploughshare Tortoises (*Astrochelys yniphora*) from Madagascar can range to well over US \$10,000 (Smith 2011). This market has driven many species to near extinction (Turtle Conservation Coalition 2011). Especially frustrating to turtle biologists is that when a new, rare species is described in the scientific literature, this publication immediately creates a market for the new turtle (Stuart et al. 2006). For example, the Roti Island Snake-necked Turtle (*Chelodina mccordi*) was described from a single small island in Indonesia and within a very few years most of the population had disappeared into the international trade.

Several US states have tightened their regulations over the commercial exploitation of any turtle species (P. Nanjappa, pers. comm.), in part because of increased evidence for the growing demand for turtles in Asia and worldwide. Turtles are still captured for the pet trade but it is hard to know how much of a conservation concern this harvest is. Formerly, both Common Box Turtles (*Terrapene carolina*) and Ornate Box Turtles (*Terrapene ornata*) were sent to Europe in large, unsustainable numbers. But this trade has been much reduced after the genus was put on CITES Appendix II. The individual state laws governing collection of turtles in general are a patchwork with most states allowing collection for personal use

and others not. State herpetofaunal regulations have been compiled recently to aid in management of these animals (P. Nanjappa, unpubl. data). Unfortunately, much of the trade in rare species is illegal and therefore very hard to track, and few states have the capacity to establish effective monitoring programs.

An emerging threat for turtles is hybridization and genetic swamping. A major discovery in the biology of turtles became apparent recently when it was determined that almost any species of Old World freshwater turtle (Family Geoemydidae) could hybridize with any other species even if they were in different genera. More startling is that these hybrid offspring are fertile and capable of reproduction. Turtle farms in China have now produced turtles descended from three different genera between their parents and grandparents (T. Blanck, pers. comm.). These turtles are like orchids - endless new varieties can be produced. Hybrids have no legal protection under international law so a hybrid of two of the rarest turtles in the world is legal anywhere. These hybrid turtles show that habitat alteration that permits species that do not normally encounter each other to mix could cause a distinctive form to be lost through genetic swamping. Similarly, although this has not happened yet as far as we are aware, releasing hybrid turtles could cause the loss of native species. This threat is new and there is no other group of animals that faces a similar problem. We really have no idea how dangerous it could be. In the US, the chief concern is the introduction of the Red-eared Slider (*Trachemys scripta elegans*) into habitats of its close relatives, such as the Big Bend Slider (*Trachemys gageae*) which occurs in the Rio Grande drainage of Texas and New Mexico. This hybridization has the potential to wipe out the Big Bend Slider as a distinct species (T. J. Papenfuss, pers. comm.).

CALL TO ACTION: CONSERVATION AND RESEARCH RECOMMENDATIONS

Hoffmann et al. (2010) demonstrated that conservation actions can improve species status. We have the opportunity to change the fate of turtles around the world by taking steps implementing conservation actions, and doing so quickly. Let us use the Year of the Turtle as our Call to Action – we can work together to benefit turtles worldwide. The Partners page at the Year of the Turtle website (www.yearoftheturtle.org) lists some organizations that work on turtle and tortoise conservation, and many more groups and individuals are working to benefit these animals. Join one or start a new one. A source to learn more about the challenges and opportunities is Craig Stanford's *The Last Tortoise* (Stanford 2010). The most endangered species are reviewed by the Turtle Conservation Coalition (2011).

An important lesson that has emerged from consideration of the difficulties of turtle conservation is that all possible conservation tools must be considered and that each species and country have their own opportunities and challenges. This lesson leads to an overall ecumenical approach in which

the effective use of any one conservation tool does not preclude the use of another tool. Sometimes there are conflicts between strategies, such as when trade regulations are written so tightly that they exclude (often unintentionally) the development of assurance colonies that may be needed for some species. It is important to global turtle conservation that these conflicts be minimized.

We can divide the strategies into 3 basic approaches: 1) rare species management; 2) keeping common species common; and 3) crisis management. Furthermore, we have learned much about the threats to turtles and how to combat them. These lessons result in additional key guidelines for both conservation and research directions; the common thread among these guidelines is the need for monitoring both to understand the status of species and to determine if conservation actions are working. The following are 7 conservation action examples from North America, combining these basic approaches and guidelines.

Manage rare species.—Rare species management is the traditional focus of conservation. The primary tool is, of course, native habitat protection and preservation. In the best of circumstances this may be all that is needed. In other cases the habitat may have to be restored and repopulated by animals raised elsewhere, often in captivity. Conservation efforts for the Bog Turtle (*Glyptemys muhlenbergii*) have involved protecting good habitat, restoring degraded habitat, and releasing captive-bred animals that have been raised to a size to offer them a better chance of survival ("headstarting"). Taken together these efforts have resulted in real success in strengthening this species' hold on survival. To aid communication among headstarting efforts, for which trial-and-error management is common, PARC is compiling projects for all herpetofauna (www.parcplace.org). Long-term monitoring of populations is a critical element in the management of both rare and common species.

Manage common species.—More conservationists are focusing efforts on managing common species to keep them common. There are three reasons for this approach. The first is that, as the case of the Passenger Pigeon (*Ectopistes migratorius*) reminds us, being common, even abundant, is no guarantee that a species will never go extinct. Second, we now realize that it is much less expensive to save a species while it is common rather than to wait for it to become rare before acting. The sooner action is taken, the greater the options available are, and when there are more options, one can be more effective. Third, if no one pays attention to a species because it is common, problems and declines may go unnoticed because of a faulty assumption. The Common Box Turtle (*Terrapene carolina*) is generally perceived to live up to its name. But many turtle researchers have emphasized that being complacent about this species is a serious mistake. One of the most important aspects of managing common species is addressing mortality and population fragmentation caused by roads. Fencing roads has proved useful for the Desert Tortoise (*Gopherus agassizii*) and may work for

other species. Road patrols during Diamondback Terrapin (*Malaclemys terrapin*) nesting season are a labor intensive, but mainly successful method for reducing road mortality for that species. The search for creative solutions to this problem continues.

Manage crises.—Environmental crises can affect turtles. The Gulf oil spill of 2010 imperiled sea turtles and those species became icons of the disaster. In fact, the Diamondback Terrapin (*Malaclemys terrapin*) was perhaps even more at risk. There are three subspecies of terrapin living only in the estuaries along the Gulf of Mexico and their narrow ribbon of habitat was affected by oil washing on shore. Although only some populations were affected, terrapin biologists organized and were prepared to move animals out of harm's way if that became necessary. For sea turtles, over 25,000 eggs were moved during the Gulf oil spill, and this proved to be an effective conservation measure (Pittman 2010).

Almost unique to turtles is the crisis management problem presented by large-scale confiscations of illegal animals. Sometimes these confiscations can include thousands of turtles of over a dozen species. Emergency programs by turtle conservationists and veterinarians have been set up to sort, treat and relocate these animals that are often in very poor health.

Regulate commercial turtle harvest.—A recent compilation of herpetofaunal regulations for US states (P. Nanjappa, pers. comm.) shows that little capacity currently exists for coordination or monitoring of harvests of wild or captive herpetofaunal species. There is great variation among state fish and wildlife agencies with some having generally prohibited all commercial exploitation of wild turtles and others offering fewer restrictions. In 2009 and 2010, representatives of many of the US state fish and wildlife agencies met to begin to address regulatory issues and needs. This process will continue in 2011. Sea turtles benefit from federal regulation and funding, due to their rarity and international migratory nature; similar federal protections are afforded to tortoises, and could be considered for freshwater turtles. The US Fish and Wildlife Service is actively engaged in these turtle issues as well, and is a key player, with state fish and wildlife agencies, in the revision of CITES Appendices. Realistically, we may not be able to prevent or ask for bans on all harvest. However, we can encourage and support closely-monitored and well-regulated harvest; with such measures, some commercial turtle harvest could be acceptable.

Turtle farming operations have not been closely monitored or studied. In particular, how much do farms rely on native wild turtles for brood stock? In addition to understanding 'take' in wild populations, a greater understanding of the contribution of US turtle farms to US and world commercial markets is needed. This need is growing as production grows.

Create and institutionalize local interest groups for localized species.—Highly localized species need highly localized support groups; that is, groups of people that champion their

local turtle. Such groups, formal and informal, exist for some species. Even in 1952, Archie Carr could write of the Plymouth Red-bellied Turtle population that "If it were not for the interest shown by local inhabitants of Plymouth County in the conservation of this interesting population of turtles it would soon be wiped out." The turtle conservation community needs to facilitate the creation of such groups. For example, this community could help folks living near some of the Gulf South *Graptemys* to develop a sense of pride and appreciation for their neighborhood endemics.

Implement range-wide population, habitat, and risk analyses for widespread species.—GAP Analysis is a conservation evaluation process where the ranges and populations of species are overlaid on protected areas such as National Parks to determine how well protected they are over their entire range. For example, we need a range-wide GAP analysis of the Common Box Turtle (*Terrapene carolina*) to estimate how many populations are currently protected and an assessment of the real risk that this species faces. Data from all states and Canada would be needed for this type of synthesis. The PARC-initiated USA Turtle Mapping Project (www.yearoftheturtle.org) is a necessary preamble for such a large-scale species assessment.

Additionally, a meta-population analysis for widespread species is needed to look for 'tipping points.' Many species of terrestrial turtles and tortoises live in populations that are more or less loosely connected by individuals who move between the local populations. This pattern is called a meta-population, and understanding how meta-populations work, and how they can fail, is an important aspect of the conservation of these species. Connectivity focal areas could be identified in such an analysis. As increasing road traffic prevents any movement from one population to another, isolated populations may have a greater chance of going extinct. We must determine at what point fragmentation of a meta-population causes a species to go extinct, and where the critical connection points exist. Many researchers believe there is a tipping point as meta-populations become increasingly isolated where they can fail and go extinct. We must determine how and when this may be true of turtles, and geographically where the important areas are to maintain connectivity.

Develop methods to assess and ensure high genetic diversity for greater evolutionary potential to respond to global change.—Genetic diversity is the basis of evolutionary adaptation to changing environments. Many turtle environments are predicted to shift under climate change scenarios. The details of these changes as they apply to particular species are generally unknown. With this uncertainty about environmental change, it becomes important to ensure that turtle and tortoise populations are genetically diverse so that they can respond to whatever change does actually occur. This is a strategy of hedging one's bets on the future. Increased efforts are warranted to evaluate turtle genetic diversity and the trade-off between how well-adapted turtles are versus how resilient turtles are to changes based on their genetics (i.e.,

their “adaptedness” versus their “adaptability”). This knowledge is especially important for reintroduction programs where animals may be reared in captivity and then released into the wild.

CONCLUSION

Our turtle heritage is diminishing at a rate outpacing that of other main animal groups. The 2011–Year of the Turtle partnership and campaign is an opportunity to raise awareness for turtles, celebrate our turtle heritage, herald conservation and research successes, and identify gaps in our understanding that can be the focus of future work. We outline seven conservation and research implications of the current turtle crisis, and associated conservation opportunities and actions. If we, the turtle conservation community can accomplish efforts in these selected areas, we can greatly help to sustain species and bolster the recovery of declining turtle species.

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