Editorial Comment. – This section has been established as a forum for the exchange of ideas, opinions, position statements, policy recommendations, and other reviews regarding turtle-related matters. Commentaries and points of view represent the personal opinions of the authors, and are peer-reviewed only to the extent necessary to help authors avoid clear errors or obvious misrepresentations or to improve the clarity of their submission, while allowing them the freedom to express opinions or conclusions that may be at significant variance with those of other authorities. We hope that controversial opinions expressed in this section will be counterbalanced by responsible replies from other specialists, and we encourage a productive dialogue in print between the interested parties. The editors reserve the right to reject any submissions that do not meet clear standards of scientific professionalism.

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A Plea to Redirect and Evaluate Conservation Programs for South America's Podocnemidid River Turtles

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Abstract. – We review the current practices of podocnemidid turtle conservation programs in South America and summarize the direct and indirect negative consequences that some of these practices may have on the populations we are attempting to manage. We argue that programs that only focus on nest transfer and head-starting as their conservation strategies would be better served by redirecting their efforts toward the protection of subadults and adults and in conducting monitoring programs designed to evaluate the impact of their management practices. Also, we make suggestions for other ways that the management of podocnemidid populations may be improved without resorting to manipulative ex situ practices that may well do more harm than good.

Resumen. – Revisamos las prácticas actuales de los proyectos de manejo de podocnemididos en Suramérica y resumimos las consecuencias negativas directas e indirectas que algunas de estas prácticas pueden tener para las poblaciones que se están tratando de manejar. Argumentamos que los programas que se enfocan exclusivamente en transferencia de nidos y en levantamiento de juveniles como estrategia de conservación podría contribuir mucho más si re-direccionan sus esfuerzos hacia la protección de subadultos y adultos y si se realizan programas de monitoreo diseñados a evaluar el impacto de las prácticas de manejo. También hacemos sugerencias sobre otras estrategias de conservación de poblaciones de podocnemididos diferentes a las prácticas manipulativas ex situ, ya que éstas últimas pueden hacer más daño que bien.

All 7 turtle species in the family Podocnemididae are currently listed as Vulnerable, Endangered, or Critically Endangered (Turtle Conservation Coalition 2011). Although most species face multiple threats (Schneider et al. 2011; Morales-Betancourt et al. 2012), the primary and best documented cause of declines for these species is overexploitation of subadults and adults, especially reproductive females (Escalona and Fa 1998; Hernández and Espín 2003; Conway-Gómez 2004; Fachín-Terán et al. 2004; Lee 2004; Fordham et al. 2006; De la Ossa 2007; Mogollones et al. 2010; Schneider et al. 2011; Páez et al. 2012; Peñaloza et al. 2013). In the freshwater turtle and tortoise literature, evidence indicates that, in those species with a life-history strategy that exhibit slow growth rates, late sexual maturity, multiple reproductive events, and high subadult and adult survival rates (hereafter, "late-maturing species"), even moderate increases in the mortality rates of subadults and adults may produce declines and local extinctions (Smith 1979; Klemens and Thorbjarnarson 1995; Heppell 1998; Burke et al. 2000; Klemens 2000; Moll and Moll 2004; Turtle Taxonomy Working Group 2014). Harvest of large turtles, which is often directed at nesting females, may have not only direct demographic effects related to sex ratio skews and a concomitant reduction in the effective population size but also transgenerational impacts on population growth rates. This is because in late-maturing species, reproductive values are highest for subadult and adult females (e.g., in podocnemidid river turtles, this is known to be the case for female *Podocnemis expansa* and *Podocnemis lewyana,* Mogollones et al. 2010; Peñaloza 2010; Páez et al., in press). First, harvest of large breeding females results in a reduction in mean clutch size and mean egg size, which also translates into smaller, less fit hatchlings (Filoramo and Janzen 2002). Other indirect effects of selective removal of highly fecund females from a turtle population are genetic in nature, by reducing the input of

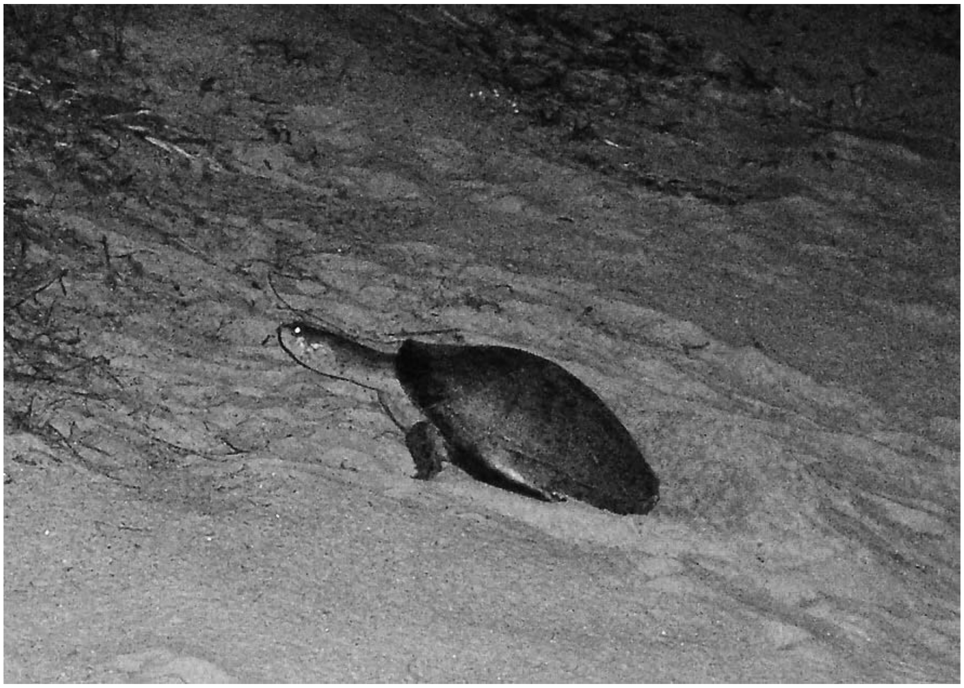

Figure 1. Female *Podocnemis unifilis* nesting in the Paragua Ríver, Perú. Photo by Alison Lipman.

the fittest individuals to future generations and producing an overall decrease in the levels of genetic variability in the population. Low and highly variable survival rates of eggs and hatchlings in these species is quite typical, and they have compensated for this with naturally long lifespans to allow females to lay many clutches over time. Harvest reduces the average lifespan of females, thereby reducing their fitness and population growth rates (Fig. 1).

In October 2010, the International Union for Conservation of Nature (IUCN) hosted a workshop in Rio Trombetas, Brazil, on the conservation status of South America's freshwater turtle and tortoise species. In the process of assessing each species, the panel of experts arrived at 4 main conclusions regarding the podocnemidid river turtle species. First, evidence presented suggested that the situation for these species is worse than previously suspected. For example, the panel recommended that *Podocnemis unifilis* be upgraded to Endangered status and that *P. expansa* and *P. lewyana* (Fig. 2) be upgraded to Critically Endangered status. Second, it also was apparent that most conservation efforts directed at turtles in South America (excepting sea turtles) have focused on these overexploited podocnemidid river turtles. Third, it was clear that for most countries, despite the considerable conservation efforts expended on these species during the last 3 decades, the conservation strategies employed have not reversed the trends of declining populations. In all South American countries that contain populations of podocnemidid river turtles, most past and existing conservation programs have relied almost exclusively on manipulative ex situ management techniques (primarily nest transfer and head-starting). When such projects also actually attempt to somehow quantify turtle abundance, their data show little or no evidence of population recovery, nor even a reduction in the rate of decline. In those projects that have demonstrated increases in podocnemidid abundance, such as many projects in Brazil (Saikoski Miorando et al. 2013; Cantarelli et al. 2014) and one in Ecuador (Townsend et al. 2005), the conservation strategies included the protection of reproductive sites (aggregations of reproductive females in deep river stretches and their associated nesting areas) and/or the strict enforcement of regulations that prohibit or limit harvests of adults. Finally, it was surprising to workshop participants how few of these numerous management programs included rigorous attempts to evaluate the impacts of their activities from a demographic perspective.

The present commentary is intended to enumerate the shortcomings of those South American podocnemidid conservation programs that focus exclusively on ex situ methods, identifying the negative effects these practices may produce, as well as their tendency to draw attention away from the real causes of population declines. We stress the need to redirect conservation strategies toward protection of subadult and adult turtles across the continent and to encourage rigorous evaluation of the impact of each conservation program on the demographics of the population they are attempting to manage.

Problems Associated with Ex Situ Management Methods. — The most common ex situ management method employed in podocnemidid conservation projects is nest relocation, that is, moving natural nests either to

Figure 2. Female *Podocnemis lewyana* basking in the Magdalena River, Colombia. Photo by Beatriz Rendón-Valencia.

artificial nests constructed in the nesting beaches or to incubators. Reasons given by conservation programs for moving nests include the need to concentrate nests in sites where they are easier to guard from natural and human nest predation or the justification that, by moving nests to higher areas of the beach or off the beach, they will be saved from flooding. Unfortunately, there also are many potential harmful effects of transferring turtle nests. The most well-known of these effects is the alteration of sex ratios of the hatchlings produced in species with temperature-dependent sex determination (TSD) attributable to changes in nest incubation temperatures (Valenzuela and Lance 2004; Valenzuela and Ceballos 2012). A change in nest temperature also may negatively affect hatching success rates (Bull and Vogt 1979; Gutzke and Packard 1987; Bobyn and Brooks 1994; Remor de Souza and Vogt 1994; Spotila et al. 1994; Páez and Bock 1998; Oz et al. 2004; Ferreira Júnior and Castro 2006; Páez et al. 2009a; Correa-H. et al. 2010), the size and condition of the hatchlings produced (Gutzke and Packard 1987; Packard et al. 1987, 1988; Remor de Souza and Vogt 1994; Spotila et al. 1994; Rhen and Lang 1999; Filoramo and Janzen 2002; Páez and Bock 2004; Páez et al. 2009a, 2009b), posthatching growth rates (McKnight and Gutzke 1993; Spotila et al. 1994; Rhen and Lang 1995; O'Steen 1998; Páez and Bock 2004), and behavioral traits of the juveniles (Crews et al. 1994; O'Steen 1998; Fig. 3). Hatchlings from transplanted clutches also may exhibit higher incidences of morphological abnormalities in marginal and plastral scutes compared to hatchlings from naturally incubated clutches (Jaffe et al. 2008).

Nests that are relocated to higher sections of a nesting beach or to incubators also may experience altered hydric conditions (typically, lower water potentials). Drier incubation conditions result in embryos that are smaller, grow more slowly, obtain less calcium from their egg shells, metabolize energy reserves less efficiently, have lower hatching success rates, and produce hatchlings that run and swim more slowly (Packard et al. 1981, 1983, 1987, 1988; Morris et al. 1983; Gettinger et al. 1984; Gutzke and Packard 1987; Miller et al. 1987; Janzen et al. 1995; Packard and Packard 2001). Higher locations on a beach also may have coarser-grained substrates, another variable that has been shown to lower hatching success rates (Remor de Souza and Vogt 1994; Ferreira Júnior and Castro 2006, 2010).

Thus, although flooding and predation are important factors that may lead to loss of natural nests, it is not clear if nest transfer actually improves the survival of nests and especially of the hatchlings they produce. Conservation programs should develop explicit criteria to determine which nests really have to be transferred and also should attempt to quantify the differences in the sex ratios, morphology, and performance of hatchlings produced by naturally incubated nests versus transferred nests.

The second manipulative ex situ technique commonly employed in South American podocnemidid river turtle conservation projects is "head-starting", defined here as obtaining hatchlings from natural or transferred nests and rearing them in captivity for some time prior to releasing them. Projects may release the hatchlings at the sites where they were collected or transport them to other

Figure 3. Elevated, shaded *Podocnemis unifilis* nest incubation facility in the Peruvian Amazon. Photo by Brian Bock.

locations for release. Reasons given by conservation programs for holding or moving hatchlings include the argument that hatchlings released at larger sizes or released in habitats different from the nesting beaches will have higher survival rates. However, rearing hatchling turtles in artificially high densities in captivity often leads to outbreaks of diseases such as mycotic pneumonia, herpes virus infections, chlamydiosis, and a profusion of other viral, bacterial, and protozoan infestations (Moll and Moll 2004). For example, 2 Venezuelan captive-rearing programs for *P. expansa* have documented problems with omphalitis, mycotic dermatitis, and septicemia in neonates (1–42 d of age), with metabolic bone disease, vitamin A deficiency, and gout in juveniles (6 wk to 3 yrs of age), and erosive lesions of the carapace and claws in adults (Boede and Hernández 2004). Thus, the assumption that captive rearing lowers early juvenile mortality rates may not be valid. Even more important, if infected captive-reared turtles are released into natural populations, there is a risk of transmitting diseases and parasites to otherwise healthy individuals in a population already experiencing declines (Fig. 4).

Additionally, holding or moving hatchlings may disrupt the development of normal behavioral processes, perhaps by denying them the opportunity to imprint on their natal nesting beach or to learn migration routes

Figure 4. *Podocnemis expansa* captive rearing facility in the Peruvian Amazon. Photo by Brian Bock.

between their nesting beach and nonbreeding habitat. Recent studies on acoustic communication in *P. expansa* suggest that there is a transgenerational transfer of such knowledge, with adult females returning to the nesting beaches at the time nests are hatching, vocalizing, and dispersing away from the beaches in the company of the hatchlings that have just emerged (Ferrara et al. 2013, 2014a, 2014b). The dispersal of sea turtles has been shown to be adversely affected by head-starting and the associated delayed release into the sea (Wyneken 2000; Pilcher and Enderby 2001; Okuyama et al. 2009). By releasing captive-reared podocnemidid hatchlings too late, even if the release is timed to correspond with the arrival of reproductive females at the nesting beaches ready to lead the next cohort of hatchlings to appropriate juvenile habitat, this will in no way ensure that the individuals held in captivity for up to their first year of life will behave as wild hatchlings would. Unfortunately, we know of no studies that have compared the dispersal behavior of naturally emerged hatchlings with that exhibited by individuals that have been head-started, although in *P. expansa* there is anecdotal evidence that individuals reared in captivity for 1 yr prior to their release at the nesting beach fail to disperse (R. Vogt, *pers. comm.*). However, it seems that head-starting in *P. expansa* is ill-advised without further study, and the precautionary principle would hold that such manipulations also should be avoided with the other podocnemidid species until the postnesting movements of females and vocal communication of females and hatchlings have been investigated in these species as well.

A final ex situ management technique sometimes used by podocnemidid management projects, with or without head-starting, is the release of hatchlings far from their nesting beach. Justifications for hatchling relocation efforts usually assume that the release sites are appropriate juvenile habitat and argue that the survival rates of transferred individuals will be higher than those of hatchlings that emerge and disperse normally (Instituto Quichua de Biotecnología Sacha Supai 2005). Anecdotal accounts of high hatchling mortality on and near the nesting beaches are common (Alho and Padua 1982; Salera et al. 2009), but we know of no studies that have attempted to quantify these mortality rates or compare them with those of transferred individuals. However, we have witnessed cases in which hatchlings released away from the nesting beaches also suffered high mortality after predators found the sites where they occurred in artificially high densities (V.P.P. and B.C.B., *pers. obs.*; for similar observations concerning sea turtles, also see Stewart and Wyneken 2004). Clearly, rigorous demographic study of naturally dispersing hatchlings versus transferred individuals should be conducted before releases away from the nesting beaches are widely adopted.

Some podocnemidid management programs that practice hatchling translocation transport them hundreds of kilometers before releasing them (Bello et al. 1996). In these cases, there also exists a risk of causing genetic contamination of the recipient population. Population genetic studies in several species of podocnemidids have revealed significant genetic differences among population (Bock et al. 2001; Valenzuela 2001; Fantin et al. 2008; Escalona et al. 2009). Also, there is evidence of fine-grain differences in local adaptations across the ranges of these species. For example, in Colombia, podocnemidid species that inhabit the Putumayo River nest from November to January, whereas the same species that inhabit the Amazon River just 150 km to the south nest from July to September, in both cases coinciding with the season when beaches form in these rivers. If there is a genetic component to the timing of reproductive behavior in these populations, mixing these divergent stocks could have disastrous consequences for the recipient population.

Finally, it is regrettable that so few of the South American podocnemidid conservation projects invest in monitoring programs designed to detect demographic trends. All of our conservation efforts should be based on rigorous evidence that they are doing more good than harm and are a wise use of resources (Frazer 1997; Pullin and Knight 2003; Pullin et al. 2004; Sutherland et al. 2004). Denying the demographic realities of the populations we are attempting to manage precludes an objective analysis of the effects of our management practices, such that modifications may be implemented if necessary. As mentioned before, all of the species that the IUCN workshop recommended be given a higher conservation risk classification have historically been managed using these traditional, ex situ management techniques, reinforcing the impression that they are not effective or, at least, that their impact has not been properly evaluated. This conclusion also is consistent with what is known of the demography of these species and leads us to our proposal for redirecting and implementing more scientifically rigorous conservation programs for South American podocnemidids.

Advantages of Redirecting Conservation Efforts toward In Situ Protection. — The redirection we are proposing is not new, but it seems turtle conservationists need to be reminded about the realities of the demographics of late-maturing turtle species every generation or so (Ehrenfeld 1974; Crouse et al. 1987; Frazer 1992, 1997; Heppell et al. 1996). The greatest lesson gained from studies of the demographics of such species is that population recoveries are not gained through an increase in the number of hatchlings produced or juveniles released but rather through the reduction of mortality rates of subadult and adult individuals (Doak et al. 1994; Cunnington and Brooks 1996; Tucker and Moll 1997; Heppell 1998; Mitro 2003; Heppell et al. 2005; Enneson and Litzgus 2008; Eskew et al. 2010; Macip-Ríos et al. 2011; Zimmer-Shaffer et al. 2014). Specifically for late-maturing podocnemidids, analyses indicate that the persistence and recovery capacity of their populations are more sensitive to changes in the survival rates of large subadults and adult females than to the survival of nests, hatchlings, and juveniles, or to increases in fecundity (Mogollones et al. 2010; Peñaloza 2010; Páez et al., in press). The case for *Podocnemis vogli* might be different, because there are suggestions that this species could be more resilient to harvest than the other larger podocnimidid species because of its faster growth rates and earlier age at sexual maturity. If this is true, the species could demographically compensate for lowered subadult and adult survival rates, in a manner similar to *Chelonida rugosa* (Fordham et al. 2007, 2008). However, the only rigorous study of the age at first reproduction for this species is Ramo (1980), who estimated that females first nest at 8 to 9 yrs of age, which is comparable to or even later than ages at maturation in the larger podocnemidid species (Table 1).

If most or all of the other podocnemidid turtle species have life histories similar to those now well documented for *P. expansa*. *P. lewyana*, and *P. unifilis* (Table 1), the maximum population growth rates that these species can exhibit are very low compared with many other vertebrate species. To put it simply, these species are "slow" animals (Heppell 1998). The rate of population growth for these species will be most dependent on the duration of the juvenile stage and on subadult and adult survival rates, which must be high to ensure that each turtle has multiple opportunities to reproduce. Therefore, the most effective way to attain stable or increasing population sizes in podocnemidids will be to maintain high annual survival rates in subadults and adults (Congdon et al. 1993, 1994; Musick 1999; Mitro 2003; Mogollones et al. 2010), precisely the classes that normally suffer the highest levels of harvest. Although captive breeding may be justifiable for species that have lost all hope of maintaining viable populations in the wild, it is a questionable practice for species where funds could be better invested for effective in situ approaches to help natural populations to recover (Frazer 1992).

In summary, to achieve a recovery of overexploited podocnemidid populations, management programs should adopt the following goals, instead of investing exclusively in ex situ methods such as nest transfer, head-starting, or hatchling translocations.

First, create *genuine protected areas* for populations of these species, where not only nesting sites are protected but where there also is full protection of the migration routes breeding females use to travel between lakes and backwaters and the main rivers. There is ample evidence that home ranges and activity areas of these species are sizeable and that they use different habitats during the course of the year (Fachín-Terán et al. 2004, 2006; Gallego-García 2012). For some species, such as *P. expansa*, *P. lewyana,* and *P. unifilis*, whose numbers have been greatly reduced by overharvest at many sites, both commercial harvests and subsistence consumption should be banned, or at a minimum, the sustainability of traditional harvests should be fully evaluated to devise management strategies that ensure the long-term persistence of these populations. National parks or "extractive reserves" where local people are permitted to harvest turtles do not qualify as conservation areas for these turtle species. Even "traditional" levels of harvest have been shown to maintain many Neotropical game species at densities at a fraction of natural levels ("ecological extinction", Robinson and Redford 1991; Peres 2000; Thorbjarnarson et al. 2000; Robinson and Bennett 2000, 2004). And although most "bush meat" is consumed locally attributable to the lack of refrigeration in the remote areas where large game species still occur (Brashares et al. 2004; Nasi et al. 2008), podocnemidid river turtles may be easily transported alive to distant markets. This means no populations of these turtles are harvested solely for personal consumption, which is why it is urgent to offer real protection from all types of harvest to at least some populations.

Second, outside of protected areas, *commercial turtle harvests also should be completely prohibited*. Key beaches should be monitored during the nesting season specifically to protect nesting females. Any harvesting for consumption by local people should be limited to nests, especially those at greatest risk of flooding or in the first wave of *arribada*-style nesting.

Third, whenever possible, *nests that are not harvested should be protected in situ* to avoid the undesirable effects of nest transfer outlined above.

Fourth, it is essential for the success of any conservation program to include and promote *full participation of the local communities*. However, *environmental education projects* should specifically target people who actually harvest turtles (usually fishers) and stress the importance of not removing nesting females from beaches or consuming adults that they obtain as incidental by-catch from fishing activities.

Fifth, more effort should be spent on *discouraging the sale of adult turtles in markets* and restaurants of urban areas near natural populations of these species.

Finally, *nest transfer, head-starting, and/or hatchling translocation should never be the sole conservation measures* implemented for an overexploited podocnemidid population, and they only should be used under exceptional conditions (for example, in populations where natural nesting beaches are destroyed by hydroelectric facilities).

Conclusions. — The IUCN/Species Survival Commission (SSC) (1991) states that, in general, the preferred methods for turtle conservation are in situ techniques that include the protection of nesting sites (protecting both nests and nesting females), such that natural incubation and hatching can occur. Captive breeding projects are recommended only when existing habitat has been destroyed or the remnant population is entirely devastated to the extent that natural reproduction is unlikely (IUCN/SSC 1987, 1991; Snyder et al. 1996). Yet despite this and the fact that podocnemidid populations are primarily threatened by consumption of subadult and adult individuals, many conservation projects still invest funds and efforts almost exclusively in ineffective ex situ management methods. Fortunately, the South American

Table 1. Some demographic parameters for natural populations of podocnemidid turtles in South America.

Species	Rate of annual survival			Size (SCL)/age of recruitment		Annual growth rate (cm)			References
	Hatchlings	Juveniles	Adults	Males	Females	Hatchlings < 1 yr	Juveniles	Adults	
Peltocephalus dumerilianus	0–0.95		0.32–0.54		27–30 cm				Medem 1983; Vogt et al. 1994; Félix-S. 2004; De la Ossa 2007; De la Ossa et al. 2012
Podocnemis erythrocephala				16.1 cm	22.18 cm/9 yrs		4.4 ± 0.6	1.5–6	Bernhard 2010; Bernhard and Vogt 2012
Podocnemis expansa	0.05–0.2	0.44–0.86	0.86–0.93	32.1 cm	46.5–55 cm/ 5–11 4 yrs	3.2–4.5	15	5	Ojasti 1971; Alho and Padua 1982; Paolillo 1982; Hernández and Espín 2006; Chinsamy and Valenzuela 2008; Mogollones et al. 2010; Peñaloza 2010, Peñaloza et al. 2013
Podocnemis lewyana	0.057	0.20–0.40	0.67–0.82	19–21 cm/ 3–4 yrs	29–31 cm/ 5–6 yrs	4–6	3–5	Females = 2–4 Males = 1–2	Páez et al., in press.
Podocnemis sextuberculata					22–26 cm/ 4–6 yrs				Soini 1996; Bernhard 2001; Haller and Rodrígues 2006; Pantoja-L. 2007.
Podocnemis unifilis	0–0.61			19–21 cm	27 cm/ 5–9 yrs				Medem 1964, 1969; Fachín-Terán 1982; Thorbjarnarson et al. 1993; Soini 1996, 1999; Escalona 2003
Podocnemis vogli				13 cm/ 3–4 yrs	23 cm/ 8–9 yrs				Ramo 1980

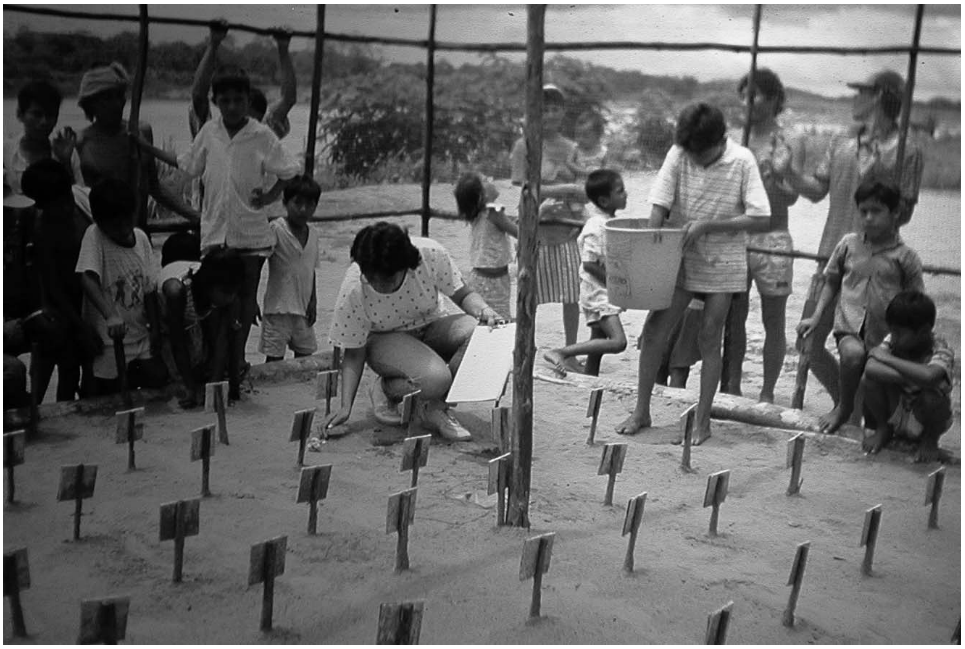

Figure 5. Community participation in collecting *Podocnemis unifilis* hatchlings for subsequent transfer and release in the Peruvian Amazon. Photo by Brian Bock.

podocnemidid species are still naturally breeding in the wild, which means we still have a chance to protect reproducing turtles in their natural habitats.

It is human nature to feel we must manipulate things to "fix" them. Nest transfer and head-starting programs result in good public relations opportunities that constitute "feel-good" conservation (Frazer 1992). This is evidenced in media reporting throughout South America, where local people and their children pose each year with the podocnemidid nests or hatchlings that are to be released (Fig. 5). Positive results for these projects are reported in terms of ever-increasing numbers of hatchlings being collected and released every year (which may only reflect increasing effort on the part of the management program), whereas actual demographic monitoring of the managed populations is rare. The truth we aim to bring to light here is that these misguided programs may be wasting scarce conservation funds by ignoring the real causes of the declines and that they generate many unanticipated additional problems for the populations being managed. Also, they give a false impression to local people that the population is in good hands, decreasing their incentive to curb their consumption. As scientists and conservationists, we need to reevaluate turtle conservation programs across South America with the goal of recovering overharvested populations while protecting natural processes.

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