Elephants in Sri Lanka: past present and future

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Introduction

The Asian elephant (*Elephas maximus*) is considered an 'endangered species'. Historically, the range of the Asian elephant extended from the Euphrates and Tigris Rivers in west Asia to the Yangtze-Kiang River in China (Olivier, 1978). Exponential growth of human populations and attendant land use changes over the past few decades have extirpated Asian elephants from approximately 85% of their former range. As a 'free ranging' or 'wild' species, the Asian elephant (hereafter, 'the elephant') is now limited to a number of isolated and fragmented populations in thirteen south and southeast Asian states with a total estimated population of 35,000–50,000 (Sukumar, 1989; Santiapillai and Jackson, 1990).

In Sri Lanka, as in the rest of Asia, the elephant has been closely associated with man and has played a central role in the country's economy, conflicts, religion, and culture for many millennia (Jayewardene, 1994). It continues to hold an important position in the religious and cultural traditions of the country and plays a significant and high profile role in the country's conservation efforts.

Elephant population history

The current Sri Lankan population of free ranging elephants has been estimated at approximately 2,000–4,000 (McKay, 1973; Santiapillai and Jackson, 1990; Jayewardene, 1994). Over the recent past, much apprehension has been expressed over the precipitous decline of the elephant in Sri Lanka, based on the premise that the 'historical population' in the island was in the range of 12,000 (McKay, 1973) to 20,000 (Jayewardene, 1994). McKay's estimate was based on the density of elephants in his study area in southern Sri Lanka and extrapolation of it to the total land area of the island. The higher number of 20,000, was based on reported annual losses of approximately 195 elephants in the 19^{th} century (Jayewardene, 1994), and does not take into account the reproductive potential of elephant populations. An annual loss of 195 animals can probably be sustained indefinitely (without any decrease in numbers) by a population of around 4,000–5,000 elephants with a rate of increase of 4–5%, which is well within the rate of increase observed in elephant populations

Thus, a more realistic evaluation of the possible history of elephant populations in Sri Lanka is in order. Undoubtedly, the chronicle of elephant populations in Sri Lanka is intricately linked with that of human presence in the island, and could be divided into four distinct periods: prehistoric, ancient civilization, colonial, and post-independence.

The prehistoric period. During this period the island was sparsely populated by hunter-gatherers. There is no evidence of hunting of elephants by these people, who were also unlikely to have had a major impact on landuse patterns. Thus, elephants would have inhabited the entire island during this period and have had a stable population. The elephant under 'natural' conditions is a low-density species (Rudi van Aarde, pers. com), and ecologically it is an 'edge species' and a 'pioneer species'. Thus, the wet and dry zone climax forests that would have clothed the island in the prehistoric era would not have supported high elephant densities. Given the extremely low densities of elephants reported from primary forest areas (McKay, 1973; Eisenberg, 1981) the total number of elephants is likely to have been comparatively low. The density of elephants in Wilpattu, which has a large extent of mature forest, has been estimated as 0.12 elephants per sq. km. (Eisenberg and Lokhart, 1972). As the entire island was likely to have been under primary forest cover, the average density of elephants in Sri Lanka during the pre-historic period can be assumed to have been around 0.1 per sq. km. Thus, if elephants inhabited 90% of the island, the total elephant population would have been around 5,000.

The ancient-civilization period. In 5th century BC, people from the ancient civilization in India colonized Sri Lanka and founded an agro-based civilization in the dry zone of the country. Over the years, they constructed countless numbers of freshwater reservoirs by damming rivers and tributaries, and converted large extents of land in the dry zone to irrigated agriculture. The 'hydraulic civilization' that prospered as a result, used elephants extensively in cultural events, wars, pageants, and as work animals (Jayewardene, 1994). Thus, while the agricultural land-use patterns no doubt excluded elephants from the centers of civilization, their capture for domestication would have depleted elephant populations in surrounding areas.

During this period Sri Lanka was also famed as a center of elephant commerce, both exporting and importing elephants to and from the mainland (Jayewardene, 1994). The export of elephants to the mainland could be explained in terms of the higher value placed on Sri Lankan elephants for use in work and war (Jayewardene, 1994). The need for importing elephants into the country is more difficult to understand, especially given the effort that must have been entailed in transporting elephants between the mainland and Sri Lanka in that period. The only logical reason to import elephants from the mainland would have been that they were different to those in Sri Lanka in some manner, the most obvious possibility being that they were tuskers. At present less than 7% of Sri Lankan males have tusks, whereas the incidence of tuskers varies between 45% in north India to almost 95% in south India (Sukumar, 1989). Culturally, tuskers are highly prized and held in high esteem and even today, they are imported from the mainland by prominent Sri Lankan temples. While it has been suggested that the paucity of tuskers in Sri Lanka is human induced (Kurt et al., 1995), it could also have been a genetic cause such as a 'founder effect' or the greater impact of genetic drift in a smaller Sri Lankan population. A cause pre-dating the ancient civilization, therefore of genetic origin, is supported by the historical import of elephants, even during the early periods of the ancient civilization.

While the landuse changes and capture for domestication by people of the ancient civilization is likely to have depleted elephant populations in the dry zone during this period, the sparsely settled wet zone and the central hills would have served as a refugia for elephants. Thus, the total elephant population is likely to have reached a low level as elephants would have been largely limited to the low carrying capacity wet-zone forests. Assuming a density of around 0.1 per sq. km. and that elephants inhabited one-third of the island, the total population at this time could have been around 2,000.

The colonial period. Around 15th century AD the civilization in the dry zone of the country declined, and the center of civilization shifted to the wet zone. Shortly thereafter, the country came under colonial rule, during which period the wet zone became densely populated and settled. Large-scale land-use changes through growing of cash crops and the systematic killing of elephants by shooting, practically eliminated elephants from the wet zone during this period. However, the secondary forests in the abandoned dry zone of the country, together with the countless artificial freshwater reservoirs that were constructed during the height of the ancient civilization, now presented ideal elephant habitat, and would have offered important refugia for elephants. The low-intensity slash and burn agriculture practiced by remaining inhabitants of the dry zone would have maintained the habitat in an ideal condition for elephants and helped to support high elephant densities. Thus, during this period, while the wet-zone elephant populations were exterminated, the populations in the dry zone are likely to have undergone a resurgence and the total elephant population would have risen to unprecedented heights. Assuming elephants inhabited two-thirds of the land area at a density similar to that observed by McKay (1973) in his study area, of 0.19 elephants per sq. km., the total elephant population in this period could have been as high as 8,000.

Post-independence period. The period following independence from colonial rule represents the fourth (current) phase of the saga of elephants in Sri Lanka. With exponential human population growth aided by the introduction of western medicine and modern technology, subsequent governments in Sri Lanka turned to re-developing the dry zone for agriculture as the answer to feeding the burgeoning human population. Fueled by large-scale irrigation projects that dammed major rivers and diverted the flow to rehabilitated and newly-constructed reservoirs, extensive areas of the dry zone were once again brought under irrigated agriculture. Large-scale trans-migration programs re-settled people from the crowded wet zone of the country in the newly-opened dry zone.

However, this time there was an important difference in how people perceived the elephant. Previously, when extensive areas were converted to agriculture, elephants in those areas were eliminated, possibly by capture during the ancient civilization period, and by shooting in the colonial period. In contrast, during this fourth phase, modern environmental attitudes and the growing awareness of the endangered status of elephants led to attempts at preserving the elephants that inhabited areas cleared for agriculture, resulting in a dichotomy of attempting to conserve elephants while drastically decreasing their habitat. The origin of the present high level of human-elephant conflict (HEC) in Sri Lanka can be attributed to the attempt at pursuing these two fundamentally incompatible objectives.

In the post-independence era, a number of protected areas (PAs) were designated, where elephants that inhabited land cleared for agriculture were to be accommodated. Elephants were translocated to these PAs by elephant drives and chemical immobilization and transport. However, in most instances, translocations failed to eliminate elephants from developed areas, which was attributed to translocated elephants returning to their homelands (Jayewardene, 1994). In order to prevent 'backtracking' by translocated elephants, and to prevent elephants in PAs from venturing out, barriers were set up on the boundaries of PAs.

Challenges for conservation and management

One of the main impediments to the conservation and management of Asian elephants is the paucity of scientific data on free-ranging or 'wild' elephants, which applies to Sri Lanka as well as the rest of Asian elephant range. Much of the available 'knowledge' of Asian elephants is based on extrapolation from studies of domesticated elephants and studies on African elephants. However, current research indicates that behavior, genetics, and ecology of free ranging Asian elephants is very different from African elephants: clearly, Sri Lanka needs data based on Sri Lankan elephant populations, in order to conserve them.

With the rapid expansion of human populations over many parts of Asian elephant range, conflict between farmers and crop-raiding elephants has become an important socio-economic and political issue. Consequently, the driving logic behind elephant management has been the mitigation of human elephant conflict, tempered with the 'need' to conserve elephants. Thus even in the absence of a sound understanding of the ecology, behavior, or genetics of elephant populations, it has become necessary to undertake interventional management of elephants. Unfortunately, these management actions are rarely monitored and the effectiveness of actions such as translocations, elephant drives, and elephant barriers in mitigating the HEC and their effects on elephant populations remain largely unknown (Fernando, 1997). Asian elephants are forest animals and usually occupy poor-visibility habitat. Frequent conflict with humans causes behavioral adaptations in many elephants, including changing of activity patterns to be largely nocturnal in their wanderings, remaining under dense cover during day, and the avoidance of humans or the development of aggressive responses towards them. Thus, free-ranging elephants are difficult to study by direct methods, which may partly explain the dearth of information on them.

Current research. In order to promote the conservation and management of elephants, we (see Acknowledgements, below) initiated a research project for the study of their ecology and ranging patterns based on radio telemetry in southern Sri Lanka. The project was launched in 1995, through placement of radio collars on five elephants in and around the Yala National Park (YNP) by the Department of Wildlife Conservation (Desai, 1995). Subsequently, two more animals were collared in YNP and another three in and around Lunugamvehera National Park. In addition to tracking the collared animals through radio telemetry, the project involved the collection of ecological data, application of dung counts to estimate elephant density, and the collection of data on HEC. Photographic cataloging of individually identified animals, initiated prior to the project, was continued to provide information on the population structure and social organization of elephants in RNP. In addition, studies on the genetics of Asian elephants were conducted to determine the extent and distribution of genetic variability of elephants in Sri Lanka, and the genetic distinctness of Sri Lankan and mainland populations. A parallel project was initiated in the northwest region in 1997, with the radio collaring of a further 8 elephants. The findings of the project were presented to the Department of Wildlife Conservation at a recent workshop; a summary of our findings is presented below.

Ranging patterns. In contrast to previously held views, we found that elephants in Sri Lanka do not have separate wet- and dry-season ranges, and that they do not undertake seasonal long-distance migrations. This pattern of ranging has since been confirmed by the northwestern study (Devaka Weerakoon, pers. comm.). Female groups were found to have small, well-defined home ranges of 30–140 sq. km. in extent, to which they showed a high degree of fidelity (they keep to the same area year after year). Thus, unlike in southern India where female groups may have ranges in excess of 500 km^2 (Baskaran et. al., 1983), elephant management in a fragmented landscape is likely to be feasible in Sri Lanka.

Males were found to occupy small ranges, less than 100 sq. km. over most of the year; but they dramatically increased their ranging during the *musth* period of about two months, ranging over an area almost four times their range for the rest of the year. Such widespread ranging during musth is likely to be related to reproductive activity and important for preventing inbreeding (Fernando, 1998). Therefore, management of males needs to leave provision for such dispersal.

In addition to the differences in ranging patterns of females and males, we also observed that the ranging of females seemed to be much more restricted by management measures such as electric fences. Most instances of crop raiding and conflict with humans in the southern area were attributable to males, which often circumvented and breached fences. Thus, managers need to consider the differences in ranging and impacts of management measures on males and females.

Relation to land-use patterns. It was observed that elephants were not restricted to protected areas (PAs) and that the administrative boundaries of PAs in many cases did not coincide with the ecological boundaries of the elephants. Patterns of habitat use by elephants, suggested that traditional *chena* or slash and burn cultivation in unofficial buffer zones of PAs created good habitat for elephants. In Yala, we observed the movement of elephants into buffer-zone cultivation areas in the dry season once harvesting was complete, and their return to the safety of the PA in the wet season when cultivation commenced again. Elephants heavily utilized the pioneer vegetation that came up between annual cultivation cycles in areas outside the PA and these areas are likely to be critical for the survival of the elephant population in YNP through the dry season. In contrast, irrigated agriculture created an environment incompatible with the presence of elephants in non-conservation areas, and the 'non-intervention' management of habitat within PAs encouraged a secondary climax of mature scrub (which is sub-optimal for elephants) within conservation areas.

Social organization. Previously, Asian elephants and African elephants (*Loxodonta africana*) were thought to have an identical or largely similar social organization, with a multi-tiered hierarchy of social groupings consisting of families, kinship groups, clans and subpopulations among females, and the permanent dispersal of males. Our studies combining genetic data, behavioral observations, and telemetry data suggested that Asian elephants may have a social organization very different to that of African savanna elephants, with smaller groupings and a lesser degree of association among group members (Fernando, 1998). In addition, our studies suggest that males may disperse from their social groups but remain in their natal area and undertake periodic dispersal during musth as a method of preventing inbreeding (Fernando, 1998).

Genetics. In a study sampling 118 elephants from the mainland and Sri Lanka, we found that genetic diversity in Asian elephants was lower than in many large ungulate species. In common with a previous study on the mitochondrial DNA of Asian elephants (Hartl et al., 1996) our study did not support the putative subspecies distinction between Sri Lankan elephants (*E. maximus maximus*) and mainland elephants (*E. maximus indicus*). However, in contrast to Hartl et al. (1996) we did find significant genetic differences between the two populations (Fernando et al., in press). In view of previous electrophoretic studies (Nozawa and Shotake, 1990; Hartl et al., 1995), observed morphological differences (Deraniyagala, 1955), and our own data, we suggest that further studies need to be conducted before concluding that the current subspecific distinction is invalid (Fernando et al., in press).

Surprisingly, we also found that the northern, mid-latitude and southern populations in Sri Lanka were genetically different from each-other to a significant extent (Fernando et al., in press). In this connection, it is interesting to note that morphological differences have been previously observed between elephants from different geographic locations in the country. The small-stature southern elephants being called *ruhunu gataw* and the exceptionally large and bulky elephants from the mid-latitude region being termed *vil aliya*— which were in fact described as a separate subspecies previously (Deraniyagala, 1955). Thus, our findings suggest that the northern, mid latitude and southern populations should be managed as distinct populations and that elephants should no longer be translocated between these regions.

Our analysis of mitochondrial DNA also found that there were two genetically divergent lineages within Asian elephants, but that they were not geographically separated, both groups occurring in Sri Lanka and the mainland (Fernando et al., in press). Thus, our study suggests the colonization of Sri Lanka by elephants from the mainland through a land bridge many millions of years ago in the Pliocene, subsequent submergence of the land bridge isolating the two populations, and their independent evolution for a considerable time. More recent re-emergence of the land bridge during the glacial (Pleistocene) periods again caused mixing of the two populations, giving rise to the present populations (Fernando et al., in press).

Management

Previous and current management of elephants in Sri Lanka was and continues to be based on the premise that all elephants should be living within PAs. Consequently, elephants in non-conservation areas are regularly translocated to PAs and elephant barriers erected on administrative boundaries of PAs to ensure that they remain there. However, for the past few centuries, elephants have continuously occupied areas designated as PAs in Sri Lanka. Consequently, even at the time they were declared as PAs, elephants in such areas would have been at the long-term carrying capacity of those areas: i.e., , such areas were already carrying the number of elephants they could support over the long term. The long term carrying capacity of an area, especially for a long lived species such as elephants is determined by random events such as severe droughts, insect outbreaks, and severe floods that occur very infrequently, perhaps once every few decades. If a population greatly exceeds the carrying capacity of an area, when such a limiting event occurs, the results can be catastrophic and may result in the extinction of the entire population.

In addition, a segment of the elephant population ranges entirely within PAs and hence have an excellent conservation future since they do not come into conflict with humans. Translocation of additional elephants into PAs and incarcerating them there will cause intense competition for limited resources between the elephants that were previously ranging entirely within PAs and those that are translocated, thus jeopardizing the future of animals which otherwise would have had a good future (Fernando, 1997).

Thus, attempting to push elephants that are in non-conservation areas into PAs and incarcerating them there by erecting barriers is unlikely to succeed, and if it does, is likely to cause exceeding of the carrying capacity of PAs, leading to dire consequences for the entire population of elephants, the habitat, and other species that inhabit PAs.

Elephants are a long lived species and populations that appear to be viable in the short term may actually be in danger of certain extinction in the long term (Armbruster, Fernando, & Lande, 1999). In elephants, the first effects of overcrowding and increased competition are likely to be the activation of density dependent population control mechanisms such as increase in the age of first reproduction and birth intervals, which are not apparent in the short term. Other more evident effects such as increased intra-species aggression and high infant mortality may also occur. Thus, although a larger elephant population maybe accommodated in PAs over the short-term by translocating elephants from non-conservation areas and confining them, the long term effects will be largely detrimental, ranging from catastrophic population crashes to decrease in recruitment and increase in mortality. At best, the end result of such actions will be a population with an unhealthy population structure, composed largely of non-breeding adults and very few young.

Over much of non-conservation area elephant range, developmental activities are taking place with opening up of land for irrigated agriculture and settlements. In the absence of land use zoning, both governmental and non-governmental agencies commonly initiate developmental activities based on political and immediate socio-economic needs, without consideration of ecological and conservation consequences. The resulting escalation of HEC in non-conservation areas frequently causes the death of elephants and extols a high cost of suffering from both humans and elephants, leading to the elimination of elephants from non-conservation areas. Although the activities that result in the death of elephants in non-conservation areas are not generally viewed as part of 'elephant management', by default, they are an integral part of current management.

The end result of 'managing' elephants by 'development of non-conservation area elephant range, translocation of elephants to PAs, and confining them there by barriers, will be the elimination of elephants from non-conservation areas, and the possible overcrowding of PAs, which holds little hope for the future of elephants in Sri Lanka.

Options for the future

Given that a large segment of the elephant population in Sri Lanka depends entirely or partly upon non-conservation areas for their survival, the best option for maintaining our elephant population at the current level is to *ensure that elephants will be able to continue use of non-conservation areas as part of their range*. If this is not possible, the next option is to *alter the habitat in the PAs so that they can carry more elephants*. If neither alternative is feasible, elephants in non-conservation areas will need to be removed through *capture and domestication*. Such a management action will mean the *limiting the number of elephants to what the PAs can carry in their present state*.

Keeping elephants in non-conservation areas. Currently, management activities such as erecting electric fences that limit elephants to PAs and translocation of elephants are mainly conducted in order to alleviate the suffering of farmers who have to bear the hardships imposed by HEC. One way of achieving the objective of continuing to keep elephants in non-conservation areas but reducing the economic burden on farmers is to develop activities such as community-based eco-tourism. Activities such as elephant viewing and elephant-back photo safaris can bring in significant monetary benefits to communities in elephant range areas, so that they can obtain a tangible benefit from elephant presence rather than being called upon merely to bear the cost of the HEC. If converting elephants into a source of income for communities in elephant range areas can be made into a reality, the need to remove elephants from non-conservation areas will decrease.

Our studies indicate that traditional slash and burn agriculture creates optimal habitat for elephants by creating a mosaic of successional-stage vegetation. Currently, land under slash and burn agriculture constitutes the major portion of non-conservation area elephant range. Regularization and rotation of cultivation cycles in such areas to achieve the maximum diversity of habitat types and to provide refugia for elephants will offer the maximum benefit for elephant conservation. When combined with activities like eco-tourism such land-use management can benefit both elephants and farmers.

The down-side of such an approach is that large non-conservation areas will need to be set aside as elephant ranges, necessarily excluding 'development' activities. Therefore, the demarcation of such areas has to be done with the cooperation of all government and non-governmental agencies that are involved in developmental activities; it cannot be done by conservationists in isolation. Thus, land-use zoning of such areas, taking into consideration projected activities over the next few decades, will necessarily be crucial to such an approach.

Habitat alteration within PAs. The ecological situation of YNP in relation to elephants provides a good illustration of factors relevant to habitat management. Our studies indicated that much of habitat within YNP consisted of a secondary climax of mature scrub forest. In common with tall forest such as dry evergreen monsoon forests in parts of the PA, such areas offer sub-optimal habitat for elephants. The tall forest areas in Block III and IV of YNP represent a unique habitat with its own fauna and flora and it is advisable to manage it in that state. However, the secondary scrub forest areas represent land that was under slash and burn agriculture previously and could be managed to provide better habitat for elephants. Our observations of traditional slash and burn agriculture in the unofficial buffer zone area around the western boundary of YNP suggest that improved habitat management strategies could provide better habitat for elephants and thus increase the carrying capacity for elephants.

However, habitat management is a complex intervention and could have unforeseen repercussions for both target and non-target species. Therefore, it first needs to be done on a trial basis with close, long-term monitoring to assess its feasibility before adoption as a management alternative. Although habitat management can increase the carrying capacity of elephants in a PA— and hence potentially accommodate elephants that are currently in non-conservation areas— translocation of elephants from non-conservation areas into PAs with increased carrying capacity nevertheless risks creating an elephant population with an unhealthy population structure. Thus, even if the carrying capacity of PAs can be increased, it may yet be best to let natural reproduction increase the elephant population gradually to the new carrying capacity.

If management of elephants within the PA system alone is opted for, elephant populations in such areas will need to be monitored very closely and regulated so that they do not exceed the carrying capacity of such areas. In order to ensure the long term conservation of elephants and preserve genetic diversity, the genetic make up of such populations will need to be studied in detail and they will need to be managed as a meta-population with movement of individuals to mimic and preserve historical patterns of gene flow and prevention of inbreeding.

Limiting elephants to PAs without habitat alteration. The PA system in Sri Lanka consisting of National Parks and Reserves (excluding the Horton Plains and Peak Wilderness areas) inhabited by elephants is approximately 5,880 sq, km in extent (Jayewardene, 1994). Thus if we are to limit elephants to the present PA system, assuming a density range of 0.12 [as estimated for Wilpattu by Eisenberg and Lockhart (1972)] to 0.19 [as estimated for Gal Oya and Yala by McKay (1973)], and 90% occupancy of PAs, the total population that could be supported will be between 635-1,000 elephants. Such a population, which will necessarily be divided into a number of small, fragmented, and isolated subpopulations will be very detrimental to the long term survival of elephants in Sri Lanka. In addition to the danger of extinction due to demographic stochasticity, in the case of elephants, populations inhabiting small habitat fragments are much more liable to come into conflict with humans, hence run a disproportionately high risk of being exterminated. Over the long term, such fragmented populations also run a high risk of detrimental genetic consequences of small population size (Fernando, 1983). However, the conservation future of a elephant population limited to what the PA system can support will be better than that of a population limited to PAs and is also exceeding the carrying capacity of PAs.

Capture and domestication. If elephants cannot be allowed to continue use of non-conservation areas, the only way to remove them from such areas that is compatible with elephant conservation is to remove them by capture and domestication. As discussed above, the more intuitively 'obvious' solution of translocation into PAs is not really a conservation option.

Capture and domestication of elephants takes them out of the wild gene pool effectively and permanently. Reintroduction of elephants that have been in captivity into the wild, as in the case of 'orphaned' calves, is unrealistic and is not a viable conservation option. The biggest direct problem in conserving elephants in Sri Lanka is conflict with humans. Elephants brought up in close association with humans will lose their fear of people and, if sent back into the wild, are very likely to turn into 'problem animals'. In addition, irresponsible re-introductions or translocation of animals without due consideration of their geographic origins and genetic makeup can cause introduction of diseases to wild populations, disruption of natural patterns of genetic distribution, and loss of local adaptation of populations. If re-introductions and translocations are carried out, in view of the possible detrimental effects on the subject animals and those in the receiving areas, they should only be conducted with close long term monitoring.

Sri Lanka has had a long history of close human elephant association and elephants are an important and integral part of its culture, society and religion. The continued existence of captive elephants and their use in religious and cultural festivities is important in preserving traditional ties to elephants and provides an important background for their conservation. Thus, if elephants cannot be allowed to range in non-conservation areas, their capture and domestication is a viable alternative which can also provide a useful if indirect contribution to their conservation through keeping alive the close ties between man and elephant. The semi-captive form of management as in the elephant orphanage at Pinnawela is yet another option in the captive management of elephants and also a major attraction for both local and foreign tourists. The ability to successfully breed elephants, demonstrated at Pinnawela, could also provide elephants for captive management and use in religious and cultural activities.

Conclusion

We may yet be able to ensure the survival of the elephant in Sri Lanka for posterity, if we are willing to address the outstanding issues that confront the conservation of elephants. In order to conserve elephants, rather than seeking to mitigate problems after they have arisen, we need to look ahead and plan for the future, taking into consideration the ecology, genetics, and behavior of elephants as well as projections of human population expansion and development.

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