

**EXPANSIVE, DIVERSE HABITATS
ARE VITAL FOR THE WELFARE OF
ELEPHANTS IN CAPTIVITY**

A report by Dr Rob Atkinson & Dr Keith Lindsay
Published June 2022



“Thankfully, we now have a much deeper understanding of the needs of elephants and we have a choice about how to care for them. They need to be in the company of their own kind to build lasting relationships, and they need space to live their lives.”

**SIR DAVID ATTENBOROUGH
ATTENBOROUGH & THE GIANT ELEPHANT, 2017**

Endorsed by 25 leading specialists, this fully-referenced report explains why expansive, diverse habitats are critical to keeping captive elephants physically and psychologically healthy.

We strongly conclude that these uniquely sentient, intelligent and social beings cannot lead completely meaningful lives in captivity, given the enforced restrictions on their dynamic and complex behaviour, which requires both ample natural space and an abundance of other elephants.

Quality space means that elephants can forage in natural, diverse vegetation, walk for miles each day, and exert a high degree of control over their social interactions. They suffer in captivity psychologically and physically because of the limits of what can be provided within such restricted environments. Most captive elephants spend their lives in enclosures no larger than a hectare - they can walk across them in little over a minute.

This report considers the evidence from wild, semi-wild, sanctuary, and zoo conditions to draw its conclusions. The wild is the only place where elephants can breed and truly flourish, but, sadly, for many zoo elephants a return to the wild is likely impossible. For these animals, however, 100ha or more of diverse, natural habitat in a warm climate would offer individual elephants the opportunity to live fulfilling lives. Only a step change such as this stands a chance of delivering the meaningful improvement in welfare these elephants deserve.

Rob Atkinson & Keith Lindsay, June 2022

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ENDORSEMENT

"We have experience of elephants in different circumstances across wild, captive, and semi-captive environments. We endorse the conclusions of the report by Atkinson and Lindsay. Elephants cannot flourish in zoos, because the complexities of their behaviour - and particularly their social lives and the scale over which they conduct them - cannot be provided for. However, elephants for which a return to the wild would be unfeasible or unethical can still be offered lives worth living in large, natural, and diverse landscapes that provide choice and agency. Such enclosures must be one or two orders of magnitude greater than typical, traditional zoo exhibits, in the region of 100 hectares."

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SUMMARY

The wild tells us what is important to elephants

Elephants present a unique challenge to zoos. They are sentient, intelligent, socially complex beings with the capacity to suffer and feel happiness. They are the world's biggest land animals and can range over thousands of kilometres. However, an elephant's natural environment differs hugely from the conditions that can be provided in zoos. We should look to the wild to understand how elephants' naturally-expressed behaviours are inhibited or enabled in captivity.

Life in captivity thwarts what we know from studies of wild elephants are highly motivated social behaviours. For males, although many commentators have noted the need to address males' natural social dynamics, not one has come up with a realistic proposal for doing it. For females, the well-known, species-typical fission-fusion sociodynamic, where families, bond groups and clans come together then separate, is impossible to replicate in captivity.

Elephants in zoos spend their lives in enclosures thousands of times smaller than wild ranges. Directly or indirectly, this likely results in poor welfare

Zoos want the best for their elephants but, despite their best efforts and small improvements, serious welfare problems persist. Elephants suffer in zoos because of the disparity between their evolved biological, psychological, and social needs and the limits of what can be provided within a zoo environment.

The clearest evidence that zoos are sub-optimal places for elephants to live is that elephants born into them have greatly shortened lifespans compared to those born in the wild and semi-wild. Mortality of zoo-born elephants in the early years of life is unnaturally high. Despite decades of husbandry experience, obesity, lameness and stereotypy in elephants are seen at levels not seen in the wild.

A large quantity of quality space is critical for good welfare

In the wild, elephants utilise large expanses of complex habitat, and captive elephants who are given significantly more space adapt accordingly. Expansive, quality captive space stimulates more natural behaviours. Choice, autonomy and diversity of experience increase. Elephants can cover longer

distances and engage in purposeful walking. They can forage on natural vegetation all year round and eat a greater variety of plants, harvesting and processing them as they would do in the wild. A wider range of social expression is also possible. They can avoid aggressive encounters or choose whether to stay close to preferred companions. Reduced frustration also lowers levels of aggression.

Spatial complexity offers more opportunities for elephants to experience positive welfare, not just an absence of poor welfare. High-quality human care can still be provided in large spaces, but the problems such care seeks to address will likely reduce.

Only the wild allows populations to flourish, but extensive habitats of 100ha or more could give captive elephants a life worth living

Space should be viewed from an elephant's perspective. Nothing less than areas equivalent to wild ranges of 100km² (10,000ha) and upwards truly enable elephants to breed and flourish, and to carry out the complex social interactions of their species.

However, we propose that, for animals that must remain in captivity, there is evidence to support a proposal that 100ha or more of diverse, natural habitat would offer individual elephants the opportunity to live fulfilling lives. Such enclosures are one or two orders of magnitude greater than the 1 to 10ha enclosures currently found in UK zoos.

Elephants in such facilities will be a dynamic part of their environment, able to exercise more of their natural behavioural repertoire. This provides the basis for a strong, educational message about the behaviour of wild elephants and their value to ecosystems. In contrast, in traditional zoos elephants consume artificially grown food and emit methane, but have no positive impact on their environment at all.



CONTEXT

1.1 Situational overview

Global elephant populations

There are just over 1,000 elephants in zoos and circuses in Europe and the Americas. Across the rest of the world, elephants living in such conditions are relatively scarce, possibly totalling a few hundred.¹ World-wide there are about 1,200 elephants in zoos. Approximately 15,000 elephants are believed to live in captive conditions in Asia - either in tourist or logging camps, or with private owners.²

In contrast, there are an estimated 48,000+ Asian elephants, 300,000+ wild African elephants, and 100,000+ African forest elephants living wild in their range states.³

Enclosure sizes

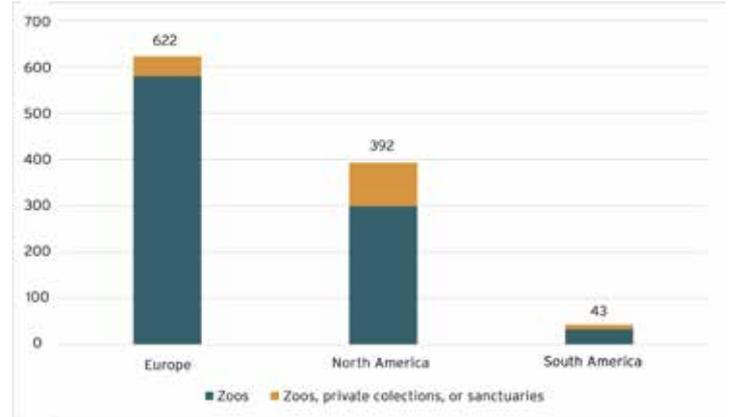
The minimum recommended size for an elephant's outdoor enclosure in Europe is 0.3ha (0.003km²).^{4,5} Recommendations in North America have previously stood at a minimum of 0.05ha (0.0005km²) per elephant.⁶ In the UK, the current outdoor elephant enclosure averages 1ha (median = 0.01km²).¹

These enclosure sizes are a tiny fraction of the natural home ranges of elephants, which vary between 10 and 10,000km² (1,000 to 1,000,000ha).ⁱⁱ

Public opinion

In a survey conducted in the UK in March 2022, 89% of people agreed that elephants belonged in the wild and not in zoos. 91% believed that elephants should be given more space than is provided for in zoos.

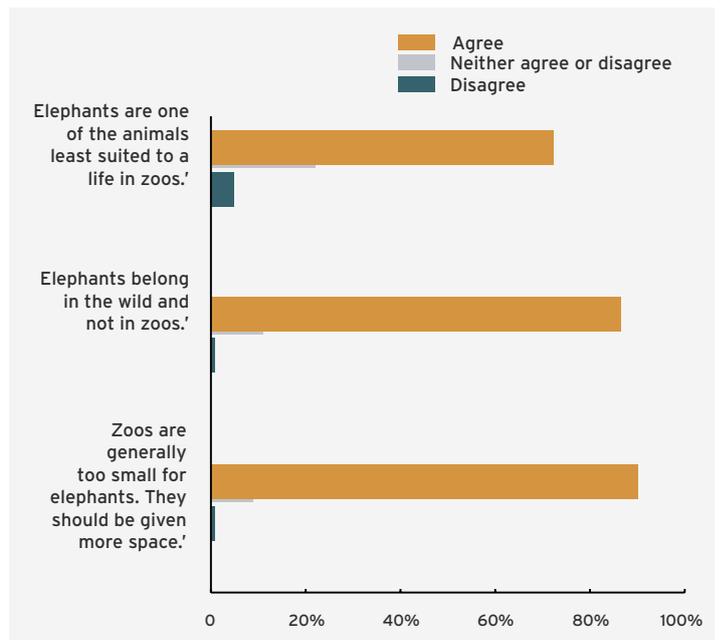
It is notable that the number of elephants in the UK has declined, as has the number of zoos keeping them. In 1995 there were 70 elephants in 18 UK zoos, but this number had fallen to 51 elephants in 11 zoos by 2021. It could drop below 40 in 10 zoos by the end of 2022.ⁱⁱⁱ



Data source: elephant.se, 2021. Figures may differ slightly due to recent births, deaths, transfers and database inconsistencies. Figures may also be underestimated for facilities other than zoos due to the difficulty in obtaining accurate numbers for circuses and private zoos/safari parks.



Elephant enclosure at San Antonio Zoo, USA



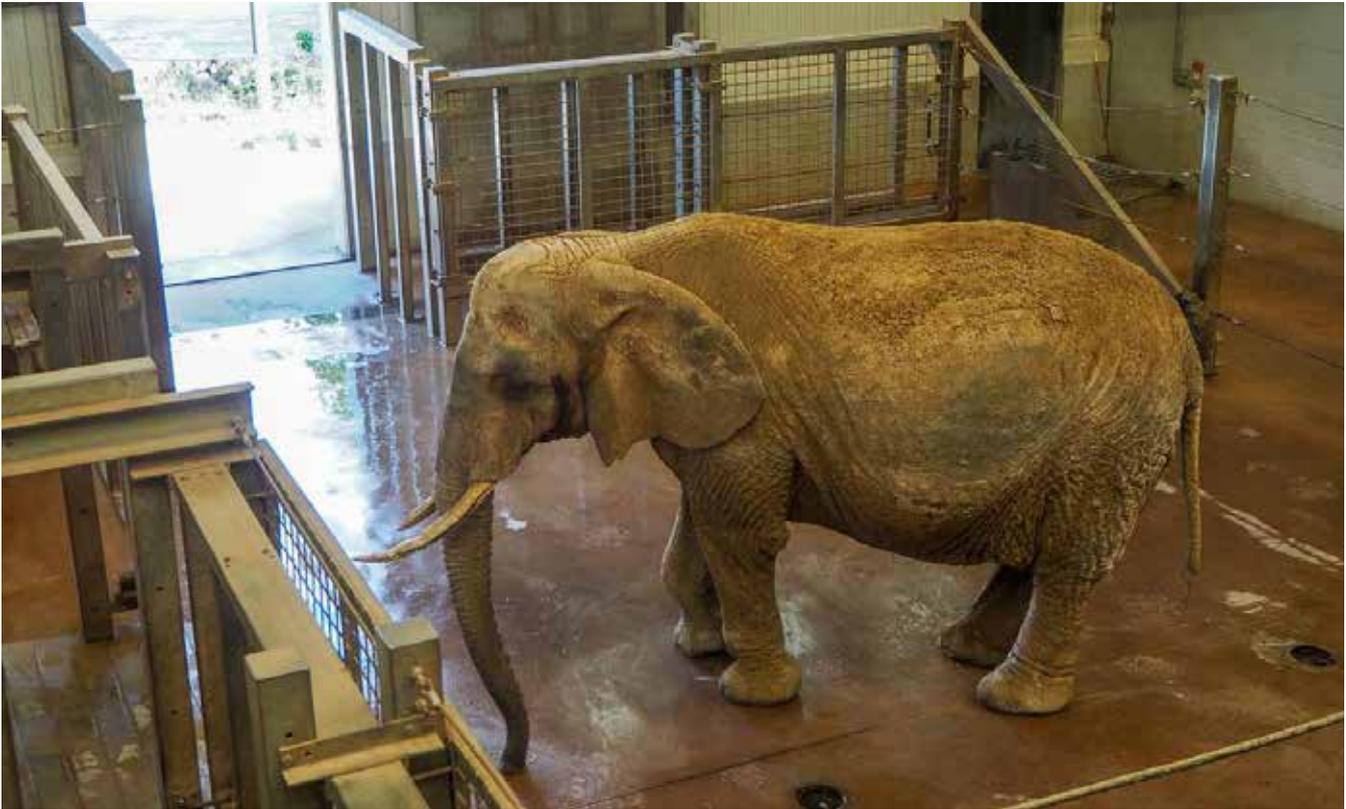
Source: YouGov Direct survey, UK. n=500. March 2022.

ⁱElephant inspection report forms for UK zoos housing elephants, obtained via Freedom of Information requests. Outdoor enclosure sizes for Belfast Zoo and Skanda Vale (both housing two elephants) were not available and are therefore excluded but are believed to be <1ha.

ⁱⁱ See section 2.1 of this report.

ⁱⁱⁱ 1995 data from 8th UK Elephant Workshop, 14.06.95. 2021 data from elephants.se. Howletts Wild Animal Park has signalled its intention to relocate 12 of its elephants to Kenya in 2022 (<https://www.kentonline.co.uk/canterbury/news/animal-park-defends-plan-to-send-elephant-herd-to-africa261624/>).

1.2 What good welfare means to elephants



In March 2022, Paignton Zoo in the UK (pictured) announced that it will no longer keep elephants as it cannot meet their 'very complex social and behavioural needs'. Howlett's Wild Animal Park in the UK has also announced plans to rehome its 12 elephants to Kenya in 2022, citing concerns over the suitability of captivity for elephants.

Animal welfare has had various definitions over the years which have focused on the physical (health, physiology, accommodation, productivity), mental (feelings, fundamental behavioural needs that they must be allowed to satisfy) and natural living (living according to an animal's nature and performing its full range of evolved behaviours).

Animal welfare scientists have proposed that *'the physical, mental, and natural-living aspects of welfare are interrelated and are all of ethical concern. Thus, the most widely-accepted definition of animal welfare is that it comprises the state of the animal's body and mind, and the extent to which its nature (genetic traits manifest in breed and temperament) is satisfied.'*¹⁷

Marian Dawkins, a British biologist and professor of ethology at the University of Oxford, points out that any 'formulation of what is meant by animal welfare ... has to take into account both the long-term needs and the short-term wants that have evolved in wild animals and are still the legacy of captive ones.'¹⁸

In this regard, the challenge presented by trying to meet the welfare needs of elephants is one or more orders of magnitude greater than for most or, perhaps, all other terrestrial animals. 'While many other species may rival elephants in one capability or another, there are few that equal or surpass elephants in the totality of their social and behavioral complexity'.⁹

Elephants are large-bodied, large-brained, socio-emotionally complex, dynamic, and very long-lived. They have complex emotional repertoires and can not only suffer but have the capacity to feel happiness.

Elephants demonstrate empathy, self-recognition,¹⁰ display concern for distressed and dying elephants, and live socially complex lives. Their cultural learnings pass through their generations. They are highly sentient beings and require opportunities for individual autonomy, where their behavioural needs and preferences can be met.

This complexity of an elephant's natural life is illustrated below, and this shows the sheer challenge of replicating any of this experience in captivity.

1.2.1 The natural life of an elephant

INTELLIGENCE

Elephants have large brains, needed for complex social living. They make and use tools, and solve problems.

EMOTION

Elephants grieve, show empathy and are self-aware. They care about their own lives and those of others.

PERSONALITY

Elephants have personalities - introvert and extrovert, popular and less popular, leaders and followers.

SOCIALITY

Related elephants live in a layered society of families (2-16 adults); bond groups (50+); clans (100's); populations (1,000's). They form strong social bonds. In captivity, these even form between unrelated individuals and can last for decades - even after forced separation.

Males' behaviour and social allegiances change as they grow up, leading very different lives to females.

Both sexes need space apart to allow them to live their very different lives.

These groups come together and separate in a dynamic system of "fission-fusion". Fission-fusion is a fundamental characteristic of elephant society.

HOME RANGE

Between 10 and 10,000km²
(1,000 to 1 million hectares).

DIET & FORAGING

Elephants eat for over 12 hours a day, consuming a vast array of plant species. Carefully pick out their favoured parts using their trunks - flowers, leaves, seeds, roots, stems, bark, fruit, lianas etc.



1.2.2 Assessing elephants' needs

It is widely accepted that thwarting strongly motivated behaviours leads to greater welfare problems than thwarting those that are less motivated. A hierarchy of behaviours can be drawn up, and environments assessed to determine whether those environments meet all requirements or fail on the strongly motivated aspects. Aberrant behaviours, such as stereotypies, are evidence of environments where strongly motivated behaviours have been or are being thwarted.

Identifying which behaviours are important to animals is difficult. Work has been done on some species in controlled conditions to determine what behaviours are important to them, but not on elephants.

Veasey has assessed the relative strengths of motivation of different behaviours using a Delphi process – ‘a methodology originally developed to obtain consensus from a panel of experts tasked with predicting scenario-based outcomes using questionnaires and feedback and relying on the collective wisdom of an appropriately qualified group rather than a single expert’.^{iv} He concluded that there was consensus that some behaviours were more important than others. Foraging, walking, browsing/ grazing, and socialising were all ranked highly.

Environments where elephants forage naturally will provide for many of the most strongly motivated behaviours.

Veasey concludes the results ‘suggest that the current priorities established in husbandry guidelines do not accurately reflect the psychological needs of elephants; in particular, they appear to underestimate the importance of behaviours and mental processes associated with acquiring food’.

Veasey proposes that systems where elephants must forage for their own food will provide for many of the most strongly motivated behaviours. It follows that such enclosures must be of sufficient size to provide the challenges afforded by a landscape with continually, often unpredictably, changing natural vegetation sources.

Although ‘sociality’, or social interaction, ranked highly in Veasey’s study, we would suggest that three particular elements of it should be extracted and assessed separately. Using ‘avoidance’ as a stand-alone variable enables the assessment of the importance to elephants to avoid unfriendly conspecifics. Similarly, ‘fission-fusion’ (see section 1.3.3) allows the evaluation of the importance to elephants of experiencing the socio-dynamics so clearly expressed by wild populations. We also think males deserve special consideration (see section 1.3.4). Their social behaviour differs from females, changing throughout their lives as they mature and develop distinct foraging and social approaches. The reproductive strategies of male elephants constitute a particular set of strongly motivated behaviours, including the need for foraging areas that are separate from those of females. ‘Accommodating males’ in a manner appropriate to their specific needs should be a separate assessment.

Overall, the needs of many strongly motivated behaviours are met through allowing elephants to forage extensively for food, which requires space, which in turn allows for social needs to be better expressed, including exercising fission-fusion, catering for males, and elephants’ needs to avoid others.

^{iv} For example, see British and Irish Association of Zoos and Aquariums (2010) Management Guidelines for the Welfare of Zoo Animals: Elephants (*Loxodonta africana* and *Elephas maximus*). Third edition:p. 42: ‘Zoos MUST maintain elephants in as appropriate a social group as possible... The best way to achieve this is to replicate the social organisation seen in the wild.’ p. 50: ‘The indoor and outdoor environment MUST... encourage natural behaviour’ p. 71: ‘Elephants spend up to 18 hours a day in the wild looking for food and eating. ... Therefore it is ideal to provide a variety of feeding opportunities that ensures elephants can feed for 20 hours a day.’ p. 73: ‘Moderate body mass (using values for free-ranging wild animals as the guide) should be the aim of husbandry.’ p. 77: ‘Routine husbandry and behavioural enrichment strategies should stem from our knowledge of the biology of the species in the wild’ p. 79: ‘Ideally, we need to provide elephants with unpredictable control which... is exactly the type of contingency animals face in the wild.’

^v From the European Association of Zoos and Aquaria (2020) EAZA Best Practice Guidelines for Elephants: p. 42: ‘It is commonly accepted that feeding in captivity must mimic the feeding behaviours of wild counterparts’. p. 72: ‘Behavioural enrichment strategies should stem from our knowledge of the biology of the species in the wild’

1.3 Evidence on the welfare of elephants in zoos

Elephants suffer in zoos and circuses because of the disparity between elephants' biological needs and how those needs are met. Whereas circuses have given elephants' intrinsic biological nature little or no consideration, some of the more progressive zoos have endeavoured to address the many and deep problems their elephants face. In recent years, such zoos have increasingly acknowledged that motivated-behaviours (whose identification is often illuminated by wild elephant behaviour) can offer valuable guidance on care in captivity.^{ivv}

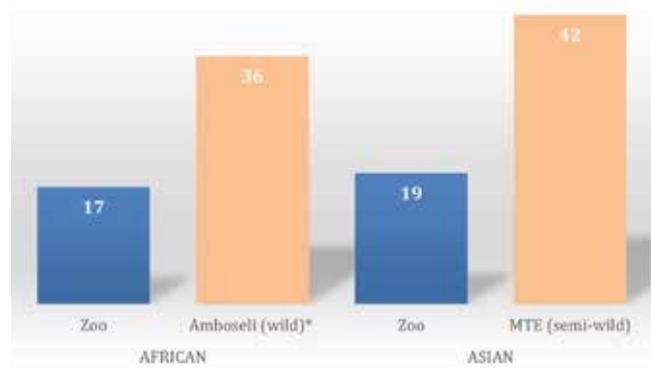
However, notwithstanding these signs of relative, low-level progress in husbandry, elephants are still widely-regarded as a species unsuited to zoos. There is now a large body of evidence pointing to poor welfare outcomes for elephants in zoos which persists, despite the effort some zoos have put into addressing these problems. Some of the more well-known problematic aspects of elephant welfare in zoos are presented next.

1.3.1 Mortality & poor breeding

The strongest evidence that zoos are sub-optimal places for elephants to live comes from the shortened lifespans of those born into them. Zoo-born Asian and African elephants live half as long as those living semi-wild in Myanmar Timber Enterprise (MTE) timber camps and completely wild in Amboseli national Park, Kenya, respectively.¹² The effect on lifespan of being born in a zoo is further illustrated by a comparison of wild-born versus captive-born elephants in MTE timber camps. Here, captive-born elephants survive longer than those caught in the wild and transferred to MTE.

Such a profoundly negative outcome is arguably the most serious effect of breeding elephants in zoos. Worryingly, the reasons are not known and this, together with the seriousness of the problem itself, calls for a cessation to breeding. Another very serious indicator that zoos are unsuitable places for elephants comes from the very high mortality of young calves. 40-45% of US and European zoo-born Asian elephants and US zoo African elephants died before they were five years old. 21% of European zoo-born African elephants died within five years.¹³

A 2008 study,¹⁴ which examined birth to death data from a range of locations, showed African and Asian elephants in European zoos lived shorter lives than wild elephants in Amboseli, Kenya, and in semi-wild MTE^{vi} elephants, respectively. Median lifespans for Asian female elephants were 19 years in zoos and 42 years in MTE. Median lifespans for African elephants were 17 years in zoos and 36 years in Amboseli (56 years, if deaths caused by humans were excluded).



Average lifespan of zoo vs wild elephant (years)¹⁵
*(56 yrs, if death by humans is excluded)

Despite many decades of keeping the species, and in contrast to other zoo animals,¹⁶ elephants in zoos in Europe and America still struggle to even sustain their numbers through breeding.¹⁷ MTE elephants used for logging, which are kept in extensive, semi-natural conditions, breed far more successfully than in zoos.¹⁸



Elephants in logging camps in Myanmar breed better and live longer than elephants in zoos and stereotypy is much lower.

^{vi} MTE was the closest the authors could find to wild Asian elephants with the required accessibility of data

Zoos have for years engaged in breeding females far younger than would usually be the case in the wild, in an attempt to bypass the captivity-induced problem of premature reproductive senescence.¹⁹

One recent study²⁰ postulates that the Asian Elephant European Association of Zoos and Aquaria Ex-situ Program (EEP) could potentially become sustainable through captive breeding but only if, amongst other requirements, females are successfully bred from the age of eight years. Asian females both in the wild²¹ and in MTE²² camps (where elephants are semi-wild, and their breeding is with wild bulls and is not managed in any way by humans) first breed at a mean age of 19. Furthermore, early reproductive output can significantly shorten a female's life. Of 213 MTE females who did not reproduce by age 19, only 16.4% died between the ages of 19 and 50 whereas, of the 188 females who produced at least one calf before age 19, 26.6% died before they were 50.²³ This effect, however, has not been noted in wild populations.

1.3.2 Obesity, lameness & stereotypy

Excess body mass in elephants is bad for their welfare. It can cause musculoskeletal disorders, increased risk of ovarian acyclicity and can have detrimental effects on pregnancy outcomes.^{24,25}

Given that humans have total control over the food elephants are given in zoos, it might be expected that weight control in captive elephants could be achieved relatively easily. However, most elephants in zoos are overweight. Seventy-five percent of the UK's captive population have been categorized as overweight or very overweight.²⁶ The figures are similar in North America: 75% of elephants are overweight, of which over 30% are classified as obese.²⁷

It has been known for thousands of years that elephants live naturally on soft, yielding surfaces. It is therefore surprising that a move towards giving elephants in zoos softer substrates has only become widespread over the last 10-15 years. It is not surprising, however, that the legacy for elephants of hard floors is poor foot health. Four different studies of elephants in North American and European zoos found prevalence of pathological foot lesions at rates ranging from 67.4% to 80.3%.²⁸ Another found them in 98.8% of the study populations.²⁹ In this latter study, many lesions were minor and considered normal, but there was also a high frequency of moderate lesions (69.6%) and major cracks (58.8%). Foot lesions occurred in 30% of the elephants studied in North American zoos³⁰. Another study concluded that the lifetime risk of developing foot pathology is 50%.³¹



Artificial insemination is widely used in zoos, owing to the difficulties involved with allowing natural breeding. Females are often impregnated far younger than they naturally would be in the wild.

Thirty eight percent of elephants in North American zoos are lame or stiff-legged,³² while in the UK, 22% had an imperfect gait, 35% were mildly lame and 23% had an obvious limp or were severely lame.³³

There is widespread agreement that stereotypy generally reflects a welfare-compromised environment, and stereotypic behaviour remains the most widely-used welfare indicators for elephants.³⁴ Furthermore, populations in which stereotypic behavior is elevated show significant increases in other signs of poor welfare.³⁵

Stereotypic behaviour is extremely common in elephants in zoos, usually found in 20% or more of a population).^{36,37,38} It is much rarer in extensively-managed timber elephants in Assam, India, and Myanmar, and minimal or absent in wild populations.



Stereotypic behaviour, such as swaying and head bobbing, is common in zoos.



Elephants in the wild live in a layered society and can interact with hundreds of other elephants.

1.3.3 Small group sizes

Even elephants in zoos living in family groups that closely resemble those structures found in nature are living a socially impoverished life compared to wild elephants. Elephants live in a layered society in the wild, the core unit of which is the family (two to 16 adult females). Five or more families (50 or more individuals) may join to form bond groups. Clans consist of several hundred elephants who share the same dry season home range. Elephants live in a 'fission-fusion' society where families meet as bond-groups or clans, then disperse. Even populations (thousands of genetically related individuals) may interact with several other different populations, and there is some gene flow between them.

Too many zoo elephant management systems are small and inflexible, presenting limited opportunities for elephants to bond, socialise or exercise fission-fusion.³⁹ In addition, elephants in zoos are often introduced to

non-related animals, with which they are less likely to develop a close bond.⁴⁰

In the elephant-keeping community, with widely spaced, isolated pockets of elephants, any attempt to replicate the fission-fusion model, and to allow females access to different groups of females, means physical, artificial transfer is necessary. Transfer has been proven to seriously compromise survivorship of elephants in zoos.⁴¹

1.3.4 The challenge of males

Male elephants present a particular and serious problem for zoos. The sociality of wild males has a complexity different to that of females, and one that is even harder to cater for in zoos. Males change throughout their lives, each stage presenting specific challenges to zoo managers. Whereas females generally stay together from birth, males tend to leave their natal group between nine and 18 years, and that process itself can be drawn out over one to four years. Over the period of the transition, males must learn a whole new set of social rules from their increasingly male-only companions. They depend on their seniors for learning, and males can form lasting friendships with other males.

Sexually active males rove between families and, if they can mate (most don't), they will stay for two to three days then move on. Wild males enter musth in their late teens to early twenties. This is a condition when their testosterone levels rise steeply, and they become more aggressive. Musth becomes regular, longer and more defined at 40 and males attain peak reproduction between 40 and 55. They only start reproducing regularly at age 40.

Males' life strategies are driven by the need to compete for mating access with females. This drive is manifest from an early age in play fighting with other males but, as they get older, also drives bachelor groups to occupy and forage in areas away from females. Ultimately, as males start to come into musth, real fighting over

females starts. But males are also sociable, and their friendships with other males are a vital element of their lives.

Younger males rely heavily on older males to guide their development. When they are young they live with females and although, over an extended period of time, they leave them for life amongst other males, they return to the natal herd over this period.

Life in captivity for males is unavoidably one long process of thwarting highly motivated behaviours. It is impossible for them to live a natural life in captivity or their welfare to be assured.

Zoos cannot care for males in ways that respect their biology, with many confined to isolation in even smaller enclosures than females. Confining males in artificial attempts to replicate 'bachelor' herds can lead to aggression and death.⁴²

The use of such 'bachelor herds' for breeding purposes would involve separation of bonded males if 'natural' mating is attempted. If the males are to be used for artificial insemination, retaining the 'bachelor herd' structure, then the males in it will not be able to socialise with females in the way they would naturally be motivated to do.

It is notable that, although many commentators have noted the need to address males' natural sociodynamics, not one has come up with a realistic proposal for doing it.



Male elephants change throughout their lives, each stage presenting specific challenges to zoo managers. Under current captive conditions, isolation is often necessary.

THE CASE FOR SPACE

2.1 Space from an elephant's perspective

It is a mistake to use a human perspective when attempting to assess what size enclosures elephants need. Commonly, reference is made to an existing baseline. This baseline is often the size of enclosure the elephant is currently in and is used to compare with a proposed increase. To illustrate this, the biggest enclosure in a study of elephants in US zoos was 160 times bigger than the smallest - and yet the biggest was just 1.6ha.⁴³

Similarly, using a human perspective of scale is flawed. For example, space that may look vast to a householder with garden of 190m² (0.02ha)⁴⁴ may look small to someone whose garden is 2ha. The average UK farm of 84ha would likely be considered small by one of the UK's larger farmers with an estate of 1,000ha+.⁴⁵

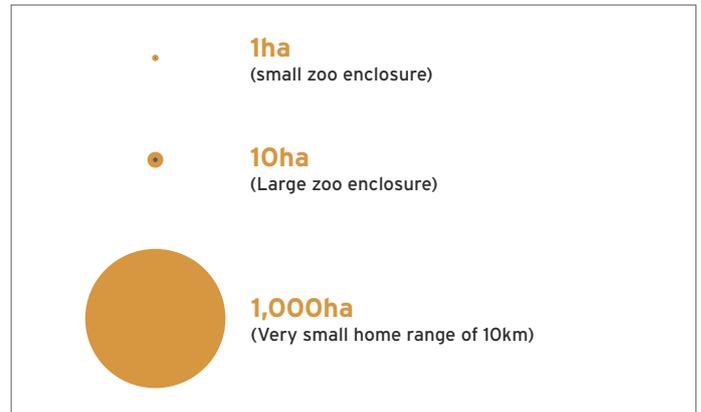
Elephant biologists are used to looking at wild elephant home ranges of at least 1,000ha (10 km²) and usually far more. It is therefore imperative to avoid the temptation to use the human perspective and instead, turn to empirical evidence provided by studies of elephants in their natural ranges.

The table below presents the range of home ranges of wild elephant species. In all three cases, home ranges at the lower end are likely to be caused by restrictions due to human activity.^{46,47,48}

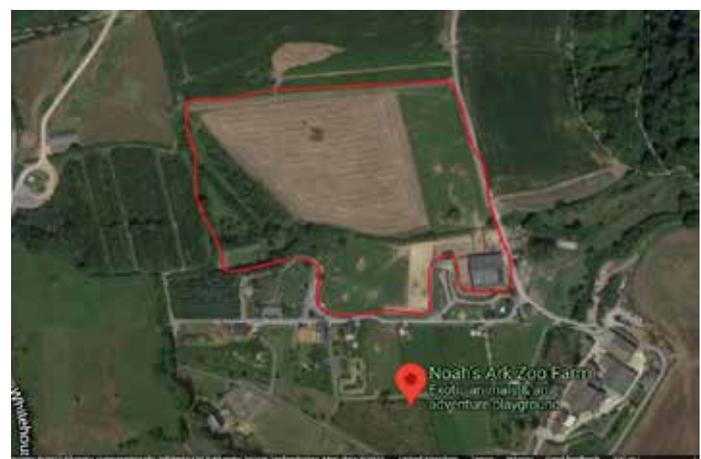
Species of elephant	Home range (km ²)
Asian	34-997 ⁴⁹
African savanna	14-10,738 ⁵⁰
African forest	10-2,000 ⁵¹

Very few zoos keep elephants in more than 10ha, and many are 1ha or less. Most zoo animals live in enclosures much smaller than their natural ranges, but in the case of elephants they must cram their immense range variety of normal daily activities into areas that are orders of magnitude smaller.

For example, the elephant enclosure at Noah's Ark Zoo



Comparison of typical zoo enclosures with a very small wild home range, noting that there are documented home ranges up to 1,000 times larger than these.



Comparison of the elephant enclosures at Blackpool Zoo (0.8ha) and Noah's Ark Zoo Farm (8.1ha).

Farm (8.1ha) is just over ten times bigger than Blackpool Zoo (0.8ha). Below are aerial shots of the enclosures, outlined in red, shown at the same scale.

However, the difference between these two captivity sites is revealed as trivial when compared to even a very small natural home range of 10km² (1,000ha).

For comparison, consider home ranges recorded during GPS-collar tracking in and around Amboseli National Park in Kenya, home to a population of some 1,900 elephants (see map below, from this study).⁵² The green circle in the centre of the map shows the very small area covered by 10km², which is 2-3 orders of magnitude smaller than the documented ranges of 12 collared elephants.

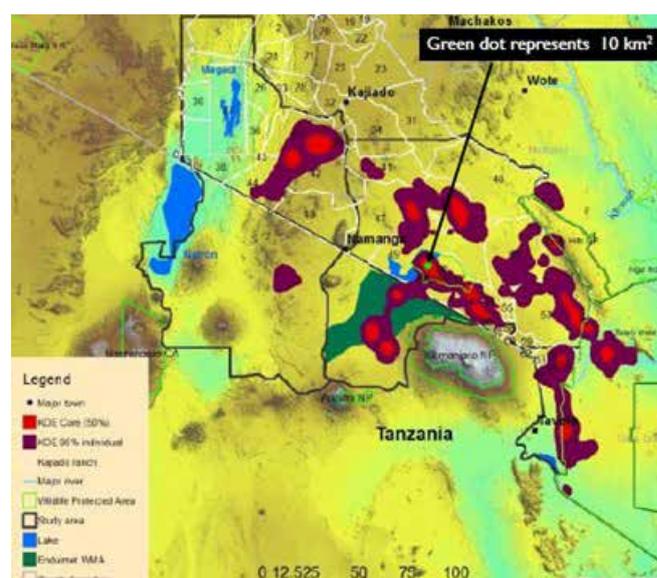
Zoo experts and elephant biologists agree that we should look to the wild to understand what is important to elephants (see section 2.4). If a captive habitat that was suitable for elephants were to be created that was truly based on this rationale, it certainly wouldn't be in the region of 1 or 10 hectares.

The key to meaningful improvement is to give all elephants in a captive facility the chance to forage all year round on a wide variety of growing vegetation (see section 2.2).

Because of its necessarily larger size, such a system would simultaneously facilitate greater choice over companions, substrates and behavioural enrichment. Such a shift may bring about improvements to

existing poor welfare states, and slow or even stop the development of new problems (see section 2.2.4). It would also enhance elephants' prospects of experiencing positive welfare (see section 2.2.1).

The obvious conclusion that elephants need abundant, quality space has been reached by scientists and zoo managers alike, but it is also a message the public are very ready to receive (see section 1.1).



Amboseli National Park and surrounding area of Kenya and Tanzania. The figure shows home range use over 2013-16 by 12 elephants (9 males, 3 females). Their ranges are shown as areas of intensive (red) and less intensive (purple) use. Individual home ranges of 3,170 km² (bulls) and 3,070 km² (females) were calculated using Fixed Kernel Density Estimator. For comparison, an area of 10km² is shown as a green circle.

2.2 Why expansive, quality space is vital for good elephant welfare

'Natural' does not always equate with 'good',⁵³ but the impoverishment of zoo environments compared to the wild presents itself as a likely explanation for the generally poor emotional and physical welfare of elephants in zoos. Whereas progressive zoos recognize the relevance of learning from the wild, not all do; we are all aware of solitary elephants kept in small enclosures with little more than a tyre for company, whose owners swear their elephant is 'happy and loved'.

Happily, this is not the case in the UK, and yet the best of UK's elephant-keeping zoos - where facilities feature a pool, environmental 'enrichment', multi-million-pound

barns with state-of-the-art flooring are still struggling to significantly improve welfare. Such facilities, which also feature trained and dedicated staff and advanced veterinary programs, often operate on a hectare or less with very few reaching close to 10ha. Small group sizes remain a challenge, with one third of the UK facilities keeping just one or two elephants, and half keeping three or less.

Underlying, or at least impacting, every aspect of the physical and psychological wellbeing of both wild and captive elephants is the availability of quality space. This can be defined in different ways, but essentially refers to the variety and complexity of the living space:

the number and configuration of different physical features, terrain and slopes, substrates, and foraging challenges. Such complexity is a primary characteristic of elephants' natural habitats. Quality space is essential to the application of nearly every important lever for good elephant welfare.

While progressive zoos recognise that space is beneficial for captive elephants^{vii} they also argue that the quality rather than quantity of that space is more important.^{viii} On this point, this paper holds a fundamentally different position: that while quality of space is very important to elephant welfare, a large quantity of quality space is vital. The amount of space is a crucial aspect of its quality.

Space itself is not a panacea to the problems elephants in zoos face, but the wise use by providers and managers of expansive space can ameliorate these problems and help prevent them occurring.

Quality space will go a long way towards enabling a solution. It is not the space per se that will matter, but what can be done in it by an elephant when there is lots of it. Below are some of the advantages of giving elephants space.



Large sanctuaries like the 1,000ha+ Elephant Sanctuary in Tennessee, above, allow elephants to access enclosures with diverse habitats with opportunities for natural foraging. ©The Elephant Sanctuary in Tennessee

Whilst space itself is not a panacea to the problems elephants in zoos face, the wise use by providers and managers of expansive space can ameliorate these problems and help prevent them occurring.

2.2.1 Opportunities for positive welfare

- The concept of 'a life worth living'⁵⁴ introduces the idea of considering welfare across an animal's lifespan, and that good management should not just avoid poor welfare but increase the opportunities for positive welfare.^{55,56}
- Providing opportunities for animals to exert agency, solve problems, or acquire rewards are all associated with positive welfare outcomes.⁵⁷
- The UK's Zoos Expert Committee's handbook (2012)⁵⁸ suggests that opportunities are provided for animals to experience positive emotional states rather than just avoiding negative ones.
- It is self-evident that the greater the amount of quality space, the more opportunities there are for elephants to experience positive welfare. This enhanced well-being is a consequence of a large area of diverse habitat; it allow elephants to make their own choices from a range of different locations for foraging and socialising, and to move purposefully between them. With abundant quality space, artificial forms of 'enrichment', itself an admission that the space provided isn't fit for purpose, become increasingly superfluous.

2.2.2 Choice & autonomy

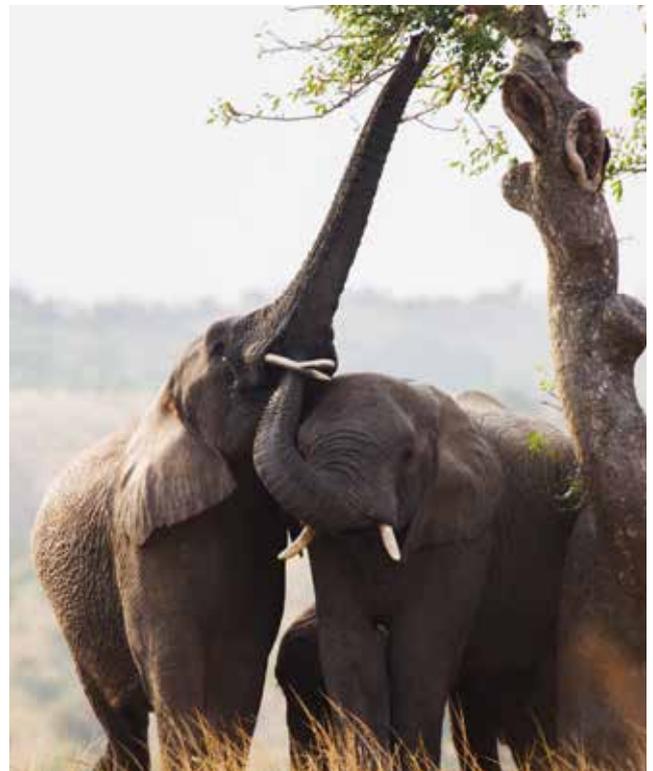
- Animal behaviourists have long-recognised the importance of choice and control to animal welfare.⁵⁹ Choice gives animals autonomy -

^{vii}EAZA, page 36: 'Of course, the more space one can give the better'

^{viii}EAZA, page 36: 'complexity and furnishing plays a more important role than simply the size of the enclosure'

the ability to make decisions and have control over their own lives, a fundamental need for such complex animals as elephants. The more quality space there is, the more autonomy elephant managers can offer their elephants. Quality space makes it easier to accommodate individual preferences and create choices that are meaningful.

- Quality space maximizes the chances of expression of natural, individual and social behaviours, the stated aim of modern approaches to captive elephant care.
- The more space there is, the more opportunities there are to plant more trees and seed more grass - or to allow the natural growth and regrowth of such forage plants (see the list below), dig more ponds, provide more dust and mud wallows, shade and mineral licks. Space allows elephants and their managers to establish a range of places for elephants to comfortably lean or lie down,⁶⁰ and also gives them choice of location and companionship.
- There is evidence that dietary choice, which increases as quality space increases, is important to both physical (maintaining homeostasis, avoiding obesity, and counteracting the effects of toxins) and psychological welfare.⁶¹
- Expansive enclosures offer elephants a greater variety of views of their environment and makes it easier for them to avoid repeating the same behaviours in the same place.
- More space allows for more plants of more species to grow, of different shapes, textures and tastes, giving the elephants more choice and more chance to express their natural range of harvesting, food preparation and feeding behaviours. Studies of foraging elephants in the wild⁶² have documented that a wide range of food items are chosen from 100 or more species of plants, including fruits, buds, leaves, climbing shoots, flowers, growing stems, woody stems and branches, bark and roots. Because it is abundant and easy to harvest, grass forms a significant portion of elephants' diets when it is abundant. All grass parts - flowers, seeds, leaves, stems, and roots - are eaten, as and when each is most nutritious at the time of year and growth stage. Each item of food requires specific processing and handling, to select the most nutritious, digestible bits and discard the less digestible parts or those holding soil or other contaminants.⁶³
- Space counters the effects of overgrazing, by allowing the vegetation the chance to regrow after offtake.
- Space means more chance of variety in natural substrates such as sand, soil, and grassy areas, providing different choices for elephants to stand, lie or walk on.
- Historically and currently, captive elephant keeping in zoos has meant the shutting of the animals inside the elephant house or barn for sometimes extended periods, such as at night time and during inclement weather. Modern approaches to elephant care call for 24/7 at-will outside access. Space means this extended time can be expended over a larger area, reducing the likelihood of over-familiarity, boredom and damage to the habitat. An elephant walking at an average speed can cover every square metre of a one-hectare enclosure in less than an hour, while in a larger area of quality space, there is the ever-present opportunity for a steady progression through different parts of the daily range. A large area may demonstrate more seasonal variability than a very small area, offering the possibility of a seasonally changing landscape.



Elephants living in the wild choose to eat dozens of different plant species and their various parts.

2.2.3 Sociality

- European research on elephants in zoos has already concluded that 'In the long-term, the best-case scenario would be to build more complex enclosures, to enlarge capacity within the EEP for sub-adult males and to allow the fission-fusion mode of management to become a routine reality'.⁶⁴
- Whether enabling fission-fusion, the humane, lifetime management of males (see section 1.3.4), or enabling the sexes to make decisions over their interactions with other, including the socio-dynamics of mate choice, it is impossible to envisage how such changes can occur in any captive facility, even those of a hundred or several hundred hectares.
- Space simply makes it possible for an elephant to maintain a comfortable distance between itself and an elephant it wants to avoid, significantly reducing the likelihood of the sort of aggression and bullying that has led to the injuries and deaths seen in zoo compounds.⁶⁵
- Space allows for bigger co-habiting groups, and hence more variety and choice as to when and with whom social interactions take place.
- Although most social groups of wild elephant females are composed of genetically-related individuals who have grown up together, this is rarely the case in zoos.
- Instead, as a consequence of trying to manage and breed from a small pool of individuals, elephants are routinely introduced to or moved between collections, and are then expected to form new social bonds with unrelated, unfamiliar animals.⁶⁶ When 53 largely unrelated elephants were introduced to two forested areas in central and northern Thailand and studied for a year, 33 of them formed 11 groups across both locations ranging in size from two to six, while the remaining 20 preferred to be alone.⁶⁷ This points strongly to the need for a large quantity of varied space, such that all elephants have opportunities to express behaviours without being forced into the company of elephants they would rather not be with.



M'Changa was attacked and killed by another bull elephant in 2021 at Noah's Ark Zoo Farm, UK

2.2.4 Quality of care

- Quite simply, whatever expert veterinary and husbandry care can be offered in a small, traditional elephant facility can be replicated in an expansive one. Elephants can be trained through protected management in their barns or out in the habitat. Individuals can have as much one-to-one, 24/7 care as they need, in a spacious facility.
- Under the careful supervision of skilled caregivers, it is possible, and indeed likely, that some of the negative welfare conditions acquired during closely-confined captivity might lessen or at least not worsen when such animals are allowed to live in a large amount of quality space.
- Furthermore, it is likely that should negative welfare conditions manifest themselves they will either develop more slowly than they would in a less spacious and varied environment, or not at all. Such conditions include obesity, lameness and psychological illness induced by frustration and/or stress, including stereotypy. Since 'both stress and the inability to perform some important species-specific behaviours contribute to the development of stereotypies',⁶⁸ it seems likely that a large, species-appropriate physical and social environment will preclude or significantly reduce the development of stereotypies.

- Expansive environments allow for a greater variety of substrates and, as importantly, slopes, providing different experiences when walking, naturally trimming foot pads and nails, keeping feet trimmed, supple and moist and contributing to better foot health. No-one looks after the feet of wild elephants, or any other wild animal, and yet they are generally healthy. In zoos, where foot problems can be common, staff can spend hours tending to foot care, often with the elephant having to stand in a posture or lie down. Such activities detract from the time the elephant could spend foraging or socialising.
- It is also likely that social incompatibility amongst confined elephants leads to aggression and non-cooperation, which can make care difficult. Such antagonistic social interactions would likely be far less common in a diverse, expansive and stimulating environment, where elephants can choose to spend their time with compatible social partners and avoid unfriendly others. In small zoo compounds, there is no opportunity for such choice or escape. Bullying can lead to minor or serious injury and, occasionally, death. Even without such external signs, the outcome of such aggression is long-term stress and depression, which takes a physical and behavioural toll on the sufferers.
- In a small enclosure, even one with a natural substrate, compaction into a hard soil surface may be unavoidable, as elephants would cover every inch very quickly and repeatedly. Large space would allow a much lower intensity of use per unit area, so that soils would be less compacted and living ground cover vegetation could be sustainably supported. Walking on such vegetation, and not on bare, compacted sand or dirt, is much better for the health of elephants' feet and joints.
- Tuberculosis, a persistent and widespread threat to elephants in captivity, can be carried dormant for years. Stress can cause the disease to manifest and for the carrier to become infective. It is possible that the same applies to elephant endotheliotropic herpesviruses. A less confined life with more space and more ways to avoid stressful situations may help reduce the expression of such diseases.

2.2.5 Movement

- A larger space increases the chance of geographic undulation, enhancing the opportunities for viewpoints and hiding. Walking on slopes also promotes exercise, joint health, and weight control.
- Quantity of space is one aspect of its quality. In larger spaces, elephants have the opportunity to walk for longer, while engaged in meaningful activities and to undertake a larger number of different journeys. This also supports improved physical health, reducing obesity and mechanical/joint or cardiovascular problems. Elephants in the wild cover an average distance of 10km (6 miles) every day⁶⁹; this can vary from 1-2km of localised foraging to more than 30km of directional walking.

2.2.6 Conservation messaging

- Elephants relocated from zoos to the spacious, natural enclosures that we propose in this paper will be a dynamic part of their environment. This provides the basis for a strong, educational message about the value of wild elephants to ecosystems.⁷⁰
- Progressive zoos claim that their captive elephants serve educational and conservation-awareness raising goals, but such messages are better delivered (including by the use of remote technology such as webcams) in expansive, naturalistic facilities.^{ix} The connection between captive elephants and the threats facing wild ones is more readily made in larger enclosures that more closely resemble the wild. The natural behavioural activities elephants engage in, such as purposeful walking over distances, grazing and browsing on living plants, and affiliative social interactions within and between social groups of females and males, occur naturally in a spacious habitat area, but are absent or must be artificially prompted in a small one.
- It is impossible not to make the contrast between the role of elephants in large, natural situations and those in zoos. In zoos, elephants consume artificially grown food and emit methane, but have no positive impact on their environment at all.

^{ix} For example, it is more likely that BIAZA's requirement that 'The guiding principles for any educational activity start from the simple statement that the purpose and output of the exercise MUST be truly educational and MUST stress aspects of elephants' natural biology and behaviour...' is easier to fulfil in a large and naturalistic captive environment (BIAZA, 2010, p. 200)

2.2.7 Research

- Zoos put forward research as one of the justifications for keeping elephants. However, it is probably fair to say that most elephant research in zoos has been aimed at dealing with the welfare zoos themselves cause, particularly in relation to diseases or conditions found primarily or only in captivity. (One area of behavioural research that requires closer observation of elephants, that of in-depth personality profiles,⁷¹ could be considered as possible only in captivity. However, such studies have, in fact, been successfully undertaken in semi-wild Asian elephants⁷² and wild African elephants.)⁷³
- Research studies that could, arguably, be of benefit to in situ conservation, focus primarily on veterinary methodologies including field immobilisation techniques for radio-collaring, examination or treatment of injuries, ultrasound investigation, blood draws for assessment of health condition or disease.
- However, the drawbacks of any research on elephants in zoos intended to shed light on wild elephants are multiple and obvious. High stress levels resulting from the lack of opportunities to express normal behaviour, lack of freedom of choice over associates, and proximity of visitors and keepers combine to prevent normal activities and lead to abnormal behaviour, including stereotypy as an extreme outcome. The prevalence of obesity, poor cardiovascular health and musculoskeletal ailments in elephants in zoos is likely to make their physiology abnormal as well.
- The primary purpose of a large-area enclosure system of elephant care is to give elephants a much higher level of welfare. However, it is compatible with this mission to undertake studies that enable better care of elephants and also in-situ research that can be used to protect them in the wild. Greater space, and the more natural physiological and behavioural repertoire it would allow, could enable more reliable and useful ex-situ research to be conducted.

2.3 Evidence that elephants need space

2.3.1 Evidence from zoo-based research

There have been few attempts to quantify the effects of space on the welfare of elephants in zoos, and those efforts that have been made have been hampered by small sample sizes and a narrow range of enclosure sizes. Caution should be exercised when trying to draw conclusions from these studies. All of them focused on identifying differences in welfare effects between enclosures of different sizes, but these enclosures may have represented little of quantifiable difference from the elephants' perspective. Nevertheless, several studies, even with such limitations, have found positive correlations between space and welfare.



Healthy, naturally worn feet of a Myanmar elephant, which forages for food in natural habitat.

Credit: Khyne U Mar.

A 2019 study found that elephants in zoos stereotyped less, explored more, and showed more behavioural diversity in bigger enclosures than smaller ones.⁷⁴

Elephants in zoos with an additional acre of outdoor space at night were recumbent more often than those without.⁷⁵

One recent study found that factors representing what the authors called 'more advanced husbandry conditions (e.g., large areas, high proportions of sand flooring)' were associated with better foot health.⁷⁶

A UK study claimed that elephants with larger amounts of outdoor space during summer had better gaits.⁷⁷

The same study found that the larger the outdoor space, the less indoor night-time stereotypies were seen.⁷⁸ In contrast, a 2016 study⁷⁹ of 68 US elephant-keeping zoos found that space alone was not a risk factor for stereotypic behavior, obesity, or female

reproductive dysfunction. It even found that increased space was negatively associated with walking distances and positively associated with the incidence of foot abnormalities (although in both cases the effect was weak).

The 2016 study illustrates the caution needed when drawing inferences from these studies of enclosure size and welfare. In that study, the space available to elephants ranged from 0.01 to 1.6ha, with a mean of just 0.28ha.⁸⁰ Even the smallest recorded range of a wild elephant, likely restricted by human activity, was 10km² (1,000ha),⁸¹ and elephant home ranges can commonly be three orders of magnitude greater than this. Elephants operate on this scale, their home ranges varying over the year depending on season and other variables, by orders of magnitude from 10km² upwards. It is therefore not surprising that elephants in zoos do not differentiate their responses to enclosures within areas that are many orders of magnitude smaller than even the smallest natural home range.

Zoos have long argued that their enclosures don't need to be large, because elephants are well-provisioned and protected,^{82,x} but research has yielded a different perspective. Although there has been no scientific attempt to correlate wild elephants' ranging behaviour with welfare in captivity, it has been done for another group of animals - the Carnivora. Carnivores in zoos are often subjects of public concern, with the polar bear, especially, ranking similarly to elephants (they too have high infant mortality and incidence of stereotypy). A seminal 2003 paper⁸³ showed 'wide-ranging lifestyles in the wild predict[ed] stereotypy and the extent of infant mortality in captivity'.

Principally, the study showed that carnivore species with bigger home ranges in the wild have higher infant mortality and stereotypy more in captivity. There is a similar correlation between minimum daily distance travelled in the wild, but not with median distance travelled. This all suggests some animals have a hard-wired need to cover minimum areas and distances. The authors conclude 'that a particular lifestyle in the wild confers vulnerability to welfare problems in captivity. Our study also reveals species that are inherently likely to fare badly in zoos and similar establishments'. It is also pertinent to note that the polar bear is top of the carnivore pile for infant mortality and stereotypy, and has the biggest home range.

The 2003 carnivore paper also sheds light on attempts to link zoo enclosures to welfare problems (such as the 2016 elephant study mentioned above). The 2003 paper found no correlation between any aspect of zoo husbandry, including enclosure size, and stereotypy or infant mortality in carnivores. The only correlation was between minimum home range size and minimum daily distance travelled. This reinforces the conclusion that zoo enclosure sizes may simply be too small to elicit clear differences in the welfare response of wide-ranging animals such as elephants.

2.3.2 Evidence from wild, semi-wild, and extensive conditions

If, as argued above, the size range of zoo enclosures is too small to demonstrate the welfare effects of enclosure size and there is evidence that ranging behaviour in the wild may be a better predictor, does that mean that captive elephant welfare is best served by enclosures the size of minimum wild home ranges? With animals so intelligent, long-lived and emotionally and socially complex, and which have such long memories, it is impossible to rule this out.

But is there something smaller, not as big as a naturally sized home range but that would nevertheless afford an elephant adequate well-being? There are four lines of evidence that point to the size of enclosures that might go some distance towards providing satisfactory living conditions.



When unrestricted by humans, elephants in the wild have large home ranges of 100km² and more © Virunga.org

^xFor example, the recent statement of Mike Jordan, Director of Collections at Chester Zoo: 'Asian elephants in the wild travel huge distances because they're following the rain, availability of food, and moving in and out of areas of threat. In captivity they don't need to do that. Here we find that those needs are met. We provide that into their enclosures.' <https://news.sky.com/story/keeping-elephants-in-zoos-could-be-made-illegal-amid-warnings-animals-suffer-mental-illness-es-in-captivity-12353302>

From natural home ranges

Natural habitats with an abundance of food may provide insight into elephant enclosure sizes for zoos. Home range sizes vary between 10 and 10,000km² (although home ranges measured in the tens of square kilometres are likely to be artificially restricted by human activity).^{84,85,86} These are wild-born elephants, the offspring of elephants born in the wild which have lived in natural systems and environments for millennia.

From semi-wild elephants

There are semi-wild elephants which, although they now roam freely or semi-freely, have had or have some degree of involvement with humans. The conditions of such elephants include:

- They may be under human control for a period of the day and for a section of their lives, such as the timber elephants in Myanmar.⁸⁷
- They are roaming in natural habitats but under some degree of supervision by humans, as is the case with the elephants in some tourist camps in Thailand,^{88,89} Cambodia,⁹⁰ Vietnam⁹¹ and Laos.⁹²
- They have come from logging or tourism backgrounds and have been used in reintroduction programs in India,⁹³ Thailand,⁹⁴ Botswana,⁹⁵ South Africa.⁹⁶ In Kenya, orphans are rehabilitated and reintroduced.⁹⁷

Despite the wide variation in practices and in the backgrounds of the elephants involved, some generalisations can be drawn from these operations. Given abundant natural space, elephants from captive backgrounds will make use of it. They frequently interact with wild elephants and may in some cases join wild herds or form their own, or at least form bonds with other, wild, elephants. They can experience difficulties but in general they appear to adapt well. This may be because they receive a high degree of attention, because elephants are naturally adaptable, or because many of the elephants come from semi-captive backgrounds where natural foraging and interactions, often with wild elephants, were common. Reintroduced elephants and logging elephants (rather than those in free-ranging tourism situations) often breed with their free-ranging counterparts and their offspring can be seen as a first generation on the road to full wildness.

The elephants in these projects have access to natural habitats from 1,500ha upwards into tens of thousands of hectares.

From sanctuaries

Sanctuaries, as we understand the term,^{xi} have similarities to the better tourism camps in that they provide a refuge for captive elephants that have been exploited by humans, and aim to provide those elephants with a semi-autonomous existence in natural or naturalistic surroundings. They generally differ in that in sanctuaries visitors are separated from the elephants by a fence, and staff do not accompany the elephants. Importantly, sanctuaries also differ from the tourism camps in the sources of their elephants. Sanctuary elephants come almost entirely from zoos and circuses.

Sanctuaries share with progressive zoos the belief that the biology and behaviour of wild elephants is the most valuable source of knowledge to inform husbandry. Zoos and sanctuaries also understand that animals' individual histories must be considered when aiming to provide optimal care. Like some zoos, sanctuaries aim to give as much space as possible to elephants.

The difference is that sanctuaries are founded on a fundamental belief in the need for quality space - far bigger in size and more diverse in content than any zoo enclosure, with living vegetation available all year round - and they are usually better placed to expand.

Elephants that are rehomed to sanctuaries from zoos and circuses have been observed to adapt well to their new surroundings: foraging naturally and increasing their range and social interactions.

^{xi}'Sanctuaries' refers here to the four best known elephant sanctuaries that currently have elephants: Elephant Sanctuary in Tennessee, Performing Animals Welfare Society, Elephant Refuge North America (all USA), Global Sanctuary for Elephants (Brazil). The modus operandi and sizes of these sanctuaries are well-known. Many sanctuaries worldwide are sanctuaries only in name. They vary from good to bad, as do the tourist camps. Getting reliable information on size and operating procedures is difficult.

The four well-known elephant sanctuaries which currently have elephants, range from 340ha to 1,130ha in size. They hold between 1 and 11 elephants, and none has reached its full capacity. Sanctuaries are usually in a position to increase space when funds become available and in response to perceived need. The Elephant Sanctuary in Tennessee is the longest established, expanding over the years from 40ha in 1995 to 1,090ha by the early 2000s. The area increased because the sanctuary's managers observed the elephants showing interest in exploring areas beyond their fence. When given that extra space, they used it.

All the managers of these sanctuaries recount similar stories of the changes their elephants go through, in natural foraging (most never foraged naturally before arrival), ranging behaviour, and increased social interactions. See for example Scott Blais^{xii} statements.⁹⁸

From inferences

The consequences for animals (and humans) of preventing the expression of natural behaviours can be and often are severe. It can cause stress and frustration,^{99,100} and impair the development of the brain, thus reducing the animal's ability to behave flexibly and appropriately.^{101,102} It is reasonable to assume some such damage has occurred in the brains of some captive elephants, particularly those with highly disrupted histories, including early, enforced separation from mothers, forced separation from bonded companions, chaining and confinement, cruel training and handling with the use of bullhooks, or living in environments where the opportunities to express normal behaviours are very restricted. Myanmar Timber Enterprise (MTE) elephants breed better and live longer than elephants in zoos¹⁰³ and stereotypy is much lower (K U Mar, pers.com.) MTE elephants have and may always have had access to natural foraging for part of their daily or monthly activity cycles, as well as other elephants including wild elephants, thus potentially enabling more normal brain development.

Therefore, without dismissing the notion that captive elephants' enclosures should ideally resemble wild elephants' range in size, it may be that elephants from zoo and circus backgrounds may be unable to ever fully recover a full behavioural repertoire, even if presented with the opportunity.

There is one piece of pertinent evidence here. At



©The Elephant Sanctuary in Tennessee

The Elephant Sanctuary in Tennessee, Asian female elephants in the largest enclosure had access to about 690ha but disregarded about a quarter and used about 520ha (R. Atkinson, pers. obs.). There may be various reasons for this but it may be evidence that these elephants, all from zoos and circuses, have reached a limit on their own ranging behaviour. Furthermore, the Tennessee sanctuary elephants did not use all of the 520ha every day, but rather shifted the focus of their use over time. In this respect, on a smaller scale, they resembled wild elephants, who exercise choice of the plant communities they use for foraging at different times of year, and between years.

While these preferences may yet change over time, with fluctuating environmental conditions, or with arrival of new elephants, it would be beneficial to commission further research on how elephants introduced from circuses and zoos into more extensive habitats naturally utilise such space.

2.3.3 Lessons from agriculture

Progressive agricultural regimes have responded to public opinion by placing considerations of physical and psychological well-being centre-stage in their efforts to improve both the welfare of livestock and the quality of product.^{104,105,106,107,108} Increasingly, it is seen as desirable to keep animals in open-air, more natural and extensive systems.¹⁰⁹ A worldwide review of 80 scientific papers¹¹⁰ on the public's perception of

^{xii} Co-Founder, The Elephant Sanctuary in Tennessee and Global Sanctuary for Elephants. Scott Blais has managed over 50 elephants, in circus-
es, zoos and sanctuaries. Half have been under his care in sanctuaries.

farm animal welfare revealed attitudes are changing: *'two core concepts emerged as central to good welfare for the public; naturalness and humane treatment... Naturalness was associated with more extensive production systems, (for example, sufficient space and outdoor access)... This suggests that concern is moving towards a more holistic approach to animal health incorporating both their biological needs and behavioural characteristics'*.

Elephant keeping in zoos is analogous to a failed agricultural system. If elephant keeping were to adopt a progressive agricultural best practice model, then that model would be an extensive or ranching system where the animals can meet their nutritional needs through feeding on species-appropriate, naturally growing vegetation.

There is nothing outlandish or novel in the principle of animals collecting their own food from natural sources. It is what all wild animals do, and it is the original husbandry system for livestock. It has persisted across the world for ten thousand years and is currently experiencing a revival as concerns over intensive farming grow. Nevertheless, elephants are not livestock, which are kept for what most people think are essential reasons.

We do not think that any of the claims made by zoos for keeping elephants justify compromising their welfare.

Elephants' captive environment is their home, not a place where they are bred and grown for human consumption. Elephants should be allowed to graze and browse on live vegetation at all times and throughout their lives.

Wild elephants benefit from a wide variety of foraging and feeding opportunities. Giving captive elephants similar opportunities to forage, harvest and process a wide variety of fruits, buds, leaves, climbing shoots, flowers, growing stems, woody stems and branches, bark and roots should be essential.

Whereas supplemental feeding as an insurance policy against any dietary deficiencies is wise management, we do not think it should be used to justify restricting elephants' access to naturally growing foodstuffs. Every move from the natural to the artificial reduces the benefits elephants get from finding and eating their own food.



The public increasingly favour natural and extensive farming systems (left) over more intensive methods (right).

2.4 How much space is enough?

Zoo associations such as BIAZA and EAZA often propose that elephant exhibits should be based on learnings drawn from wild elephants.^{xiii} Attempts to quantify the effects of space on zoo elephant welfare have failed due to the small size of the enclosures studied – from 0.01ha to, at most and rarely, 10ha, and usually less than 1ha. However, it is possible to draw well-informed conclusions by considering what physical, cognitive, and social functions are achievable within space at increasing orders of magnitude from 1ha or less, covering all situations from a typical UK zoo, through extensive and semi-wild conditions, through to wild home ranges of 10,000ha or more.



It takes an elephant slightly over a minute to walk across a 1ha enclosure. Despite investments in environmental enrichment such as this water installation at Chester Zoo, in the UK, a small enclosure simply cannot offer a sufficient diversity of experience.

It is not possible to grow a sufficient quantity and diversity of vegetation in a small enclosure, thus preventing the expression of the basic foraging behaviours. However, this becomes more possible in extensive habitats of 100ha and above. For example, a 1ha enclosure might contain ten 'focal points' for feeding or comfort behaviour (mainly created by the enclosure's designers) such as a pool, scratching posts, hay feeders, feed pellet feeders, and sand mounds. One hundred hectares could contain dozens, likely larger and more complex. For example, not one rubbing rock but a series of rubbing rocks of different sizes. Instead of a stump a woodland with hundreds of trees of various sizes and ages. These features could also be further apart to allow for avoidance). Such benefits increase as enclosure size exceeds 100ha.

2.4.1 Walking

Walking ranks highly amongst in situ and ex-situ experts as a strongly motivated behaviour.^{xi} Wild elephants walk some 10km per day at an average rate of 7.2km per hour, suggesting they would become very familiar very quickly with a small enclosure. With a larger area, a greater diversity of experience can be provided by different slopes, views, substrates, features, etc.

Walking at 7.2km/hr, an elephant in a typical UK zoo enclosure of 1ha would take just over a minute to cross its enclosure and, theoretically, under an hour to cover every square metre.^{xiv}

2.4.2 Foraging and spatial diversity

Foraging involves searching for, harvesting, preparing, and eating food and is considered a highly motivated behaviour¹². Wild elephants forage for over 12 hours a day on 100 or more different plant species and their various parts. The fruits, buds, leaves, climbing shoots, flowers, growing stems, woody stems and branches, bark and roots all provide variety of experience and choice.¹³



An elephant's trunk is designed to pull up vegetation, knock off soil, dispose of inedible parts, pluck small leaves and tear off branches, manipulate and prepare different sizes and shapes of food. Artificial enrichment such as hay feeders cannot provide for this experience.

^{xiii} For example, see British and Irish Association of Zoos and Aquariums (2010) Management Guidelines for the Welfare of Zoo Animals: Elephants (*Loxodonta africana* and *Elephas maximus*). Third edition. p. 42: 'Zoos MUST maintain elephants in as appropriate a social group as possible... The best way to achieve this is to replicate the social organisation seen in the wild.' p. 50: 'The indoor and outdoor environment MUST... encourage natural behaviour'. p. 71: 'Elephants spend up to 18 hours a day in the wild looking for food and eating. ... Therefore it is ideal to provide a variety of feeding opportunities that ensures elephants can feed for 20 hours a day.' p. 73: 'Moderate body mass (using values for free-ranging wild animals as the guide) should be the aim of husbandry.' p. 77: 'Routine husbandry and behavioural enrichment strategies should stem from our knowledge of the biology of the species in the wild'. p. 79: 'Ideally, we need to provide elephants with unpredictable control which... is exactly the type of contingency animals face in the wild.' From the European Association of Zoos and Aquaria (2020) EAZA Best Practice Guidelines for Elephants: p. 42: 'It is commonly accepted that feeding in captivity must mimic the feeding behaviours of wild counterparts'. p. 72: 'Behavioural enrichment strategies should stem from our knowledge of the biology of the species in the wild'

^{xiv} The calculation is based on assumptions of a square 1ha enclosure of side 100m and diagonal 141m. An elephant, assumed 1.5m wide, walking at 7.2km/hr can cover every square metre in 57 minutes, and cross the diagonal in 70.5 seconds.

2.4.3 Social structure and socio-dynamics

It is widely acknowledged that sociality is the single most important aspect of elephants' lives besides basic physical functions. Wild elephants live in a layered society with the family as the base unit. They naturally interact with hundreds of other elephants at different layers of the hierarchy over the course of a year. The smaller the enclosure, the smaller the number of elephants that can be accommodated, and the fewer chances there are for complex interactions and relationships. This includes the fission-fusion socio-dynamic, where elephants join companions for a time and then go their separate ways.

Notwithstanding the compromised welfare of elephants kept in small spaces, enclosures of between one and 100ha can accommodate a low number of small affinity groups. However, any further layer of sociality within an elephant population (multiple friendship groups, families, clans, bachelor bull associations, sub-populations) can only occur at the level of wild ranges (10,000ha and above), at which point large-scale, natural fission-fusion socio-dynamics also become realistic.

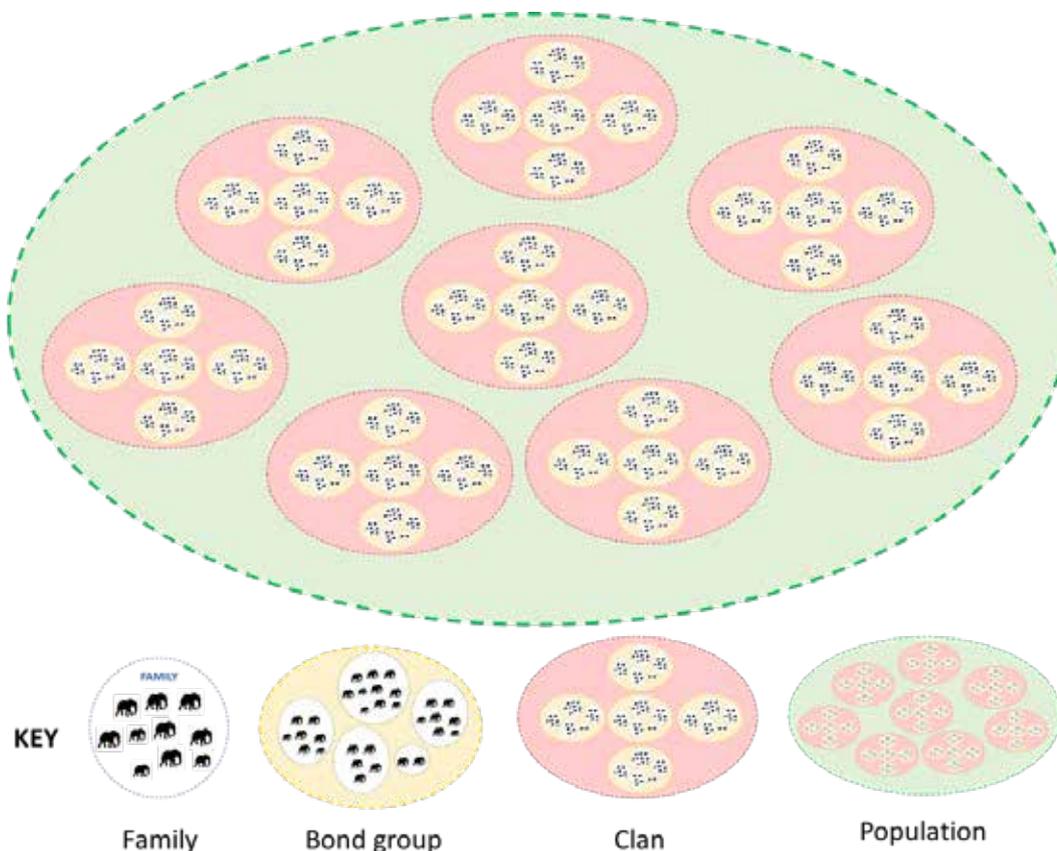
Choice of social partners

Elephants can be very strongly bonded to kin or to voluntarily chosen associates ('friends'). However, even closely bonded elephants choose to spend some part of their time alone. In the wild, elephants can easily avoid each other because there is always space to get away. In captivity, it is common for unrelated elephants to be housed closely together, but close bonds are less likely to develop than with their relatives, and this further inhibits the freedom of choice and autonomy.¹¹⁴

Males also have social needs, and they are different from females' (see section 1.4.3). They are based in part on kinship, as brothers often associate together, as well as on voluntary attachments between compatible animals, and they may remain consistent or change gradually over decades. Attempts to manage males, such as through isolation, separation, or repeated transfer between locations, is likely to impact welfare.

The smaller the area, the less chance there is for consensual association or avoidance. This increases the likelihood of aggression and bullying, which has led to the injuries and deaths seen in zoo compounds.¹¹⁵ In 1ha enclosures, it is not possible to avoid other elephants, or

Understanding elephant social hierarchy:



Family: The basic unit of elephant female society that includes between 2 and 16 adult females plus their young (males and females).

Bond group: Five or more families - 50 or more individuals

Clan: several hundred individuals who share the same dry season home range.

Population: thousands of genetically related individuals. Each population may interact with several different other populations and there is some gene flow between them.

cater for the changing needs of over their lifetime (see section 1.3.4). A 10ha enclosure improves opportunities to avoid other elephants, but at the cost of choice over where and how to spend time. For example, an elephant whose primary motive is to avoid another may be forced to abandon a preferred bathing or foraging spot, or another, favoured companion.

In an area of 100ha or more, elephants can avoid or approach each other, and it starts to become possible for them to make choices on social partners without compromising choice on other activities. However, even at 100ha, it is extremely difficult to envisage opportunities to manage the lifelong, changing social needs of males without compromising the welfare of males, females or both. Whether males can be managed along with females in an extensive space of 100ha or more can only be assessed when such circumstances are possible. If it proves not be possible, further efforts will then need to be made to manage bulls in their best interests and the best interests of the other elephants in the facility.

2.4.4 Cognition

For such highly intelligent animals as elephants it is reasonable to assume that mental stimulation is beneficial for welfare. Opportunities to alleviate boredom and cognitive decline increase with larger quantities of quality space.

For example, all else considered, interacting with multiple other elephants through evolved and complex social systems is more stimulating than interacting with one other elephant or the limited number of individuals that can be held in a small enclosure. Elephants' long memory is a lifesaver in the wild, but may have much less value in a small, managed enclosure where there is little that needs to be remembered. Elephants have also evolved to communicate over long distances acoustically, through seismic vibrations and through smell. There is no opportunity for this ability to manifest in small enclosures, and this thwarting of an activity that is commonplace in and intrinsic to a normal elephant's life may also be a welfare cost.

2.4.5 Alleviating captivity-induced welfare problems

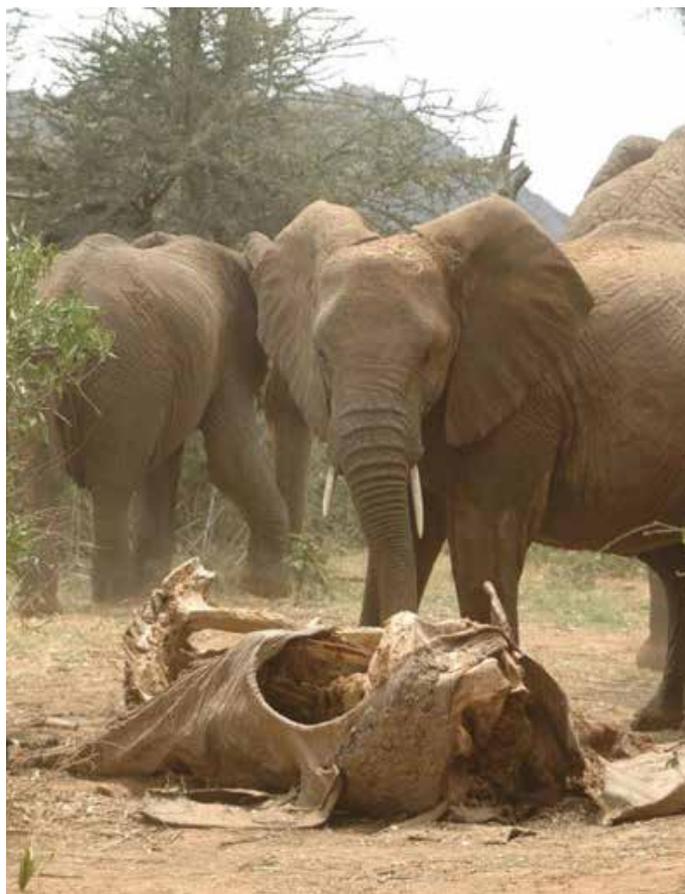
Welfare problems induced by the species-inappropriate circumstances of captivity include stereotypy, foot problems, obesity, low breeding success and shortened lifespans, and have been found through scientific evaluation in elephants living in enclosures of up to

10ha. They arise from causes related to cramped living conditions, impoverished environments, inappropriate substrates, unnatural socio-dynamics or lack of choice.

Whilst the impact of intermediate extensive management ranges of 100-10,000ha has not yet been documented, and even such large-scale improvements cannot replicate the socio-dynamic opportunities offered in the wild, the evidence outlined in this report suggests that welfare outcomes will likely improve substantially in the region of 100ha and more.

A larger quantity of quality space offers increased diversity and stimulates more natural behaviours which in turn ameliorates captivity-induced welfare problems.

Elephants evolved to live in spaces 1,000 to a million times bigger than even a large zoo enclosure of 10ha. We would only expect really significant differences to emerge at larger sizes. What we know of elephants from zoo, circus, tourism and logging backgrounds, is that once given the chance to access areas of in the region of 100ha and above, changes do occur.



Elephants live in complex social groups and form relationships that last decades and have a concept of death that lasts for years. They have been observed to mourn their dead in groups and with apparent ritualistic behaviours, which generally involves the elephants touching the bones and tusks and gently picking them up with their trunks while remaining very quiet. Sometimes they go about covering the body with leaves and grass¹⁶.

APPENDIX

Comparing the lives of wild and captive elephants

In nearly every case, improvements in husbandry conditions of the magnitude necessary for acceptable welfare are impossible without very expansive, quality space. It is a simple extrapolation: such space, competently constructed and managed, increases the opportunities for larger group sizes and for elephants to do the things that are important to them.

This table largely comprises an abridged and edited version of ElephantVoices' 'Sense and Sociality'.¹¹⁷ Its intention is to demonstrate the challenge facing those who keep elephants in captivity if they want to provide for elephants' needs.

NATURAL BEHAVIOUR OF AN ELEPHANT	IMPLICATIONS FOR ZOOS
Daily food intake 4-7% of body weight. 100 or more species incl. grass, herbs, tree foliage, fruit, bark, pith, lianas. 12 hours+ per day.	Large space provides opportunities to grow a wide natural of foods stimulating searching and different kinds of food preparation. Allows the digestive process to mimic that of wild elephants and prolongs feeding time.
Natural home ranges: Asian 34 - 997km ² ¹¹⁸ African savanna 14 - 10,738km ² ¹¹⁹ African forest 10 - 2,000km ² ¹²⁰ In all three cases, home ranges at the lower end are likely to be caused by restrictions due to human activity. ^{121,122,123}	Very few zoos keep elephants in more than 10ha, and most are likely 1ha or less. Most zoo animals live in enclosures much smaller than their natural ranges, but in the case of elephants they have to cram their immense range of activities into areas that are orders of magnitude smaller.
Very long-lived	Whatever zoos can provide, elephants must live in it every day, possibly for decades. Bearing this in mind and remembering that wild elephants cover an average of 10km per day in normal (non-migratory) ranging, it is worth noting that a zoo elephant could cover every square metre of its 1ha enclosure in less than an hour.
Very socially complex: family (2 to 16 adult females); bond group (5 or more families, 50 or more individuals); clan (several hundred who share the same dry season home range); population (thousands of genetically related individuals. May interact with several different other populations and there is some gene flow between them.) These groups are relatively stable over decades, even though individuals have come and gone.	Social relations at different levels are very important to elephants, yet it's difficult to see how a typical zoo could cater for more than a small family-sized group. Although breeding in captivity is not encouraged, a truly huge facility could keep family and possibly bond group-sized groups. The fission-fusion society of elephants, where families, bond groups come together then go their separate ways, is probably impossible to allow for in captivity, but there is a chance of providing for some version of it if there is ample space.
Very large brains with a large, convoluted neocortex, which deals with working memory, planning, spatial organization. The neocortex ratio suggests cognitive skills needed for complex social living.	Elephants evolved for complex social living. The more space, the more elephants can be accommodated and the more opportunities there are for sociality.
Very long memory (large temporal lobes), which accumulate and retain ecological and social knowledge over decades. Remember contact calls from 14 other families (100 adult females). Such knowledge is so important that families with older matriarchs have higher reproductive success than families with younger matriarchs. Can remember places, individuals and events, and can navigate over long distances.	Opportunities for using this prodigious memory are severely limited in zoos. Vastly larger, quality space, holding more elephants and more environmental variation, provides more opportunity.

NATURAL BEHAVIOUR OF AN ELEPHANT	IMPLICATIONS FOR ZOOS
<p>Contemplative, thoughtful, curious and ponderous. Sophisticated cognitive abilities, including social communication, tool construction and use, creative problem-solving, empathy and self-recognition, including theory of mind (self-awareness). They care about their own lives. Capable of keeping score and exacting revenge. Pay special attention to the dead and dying, attempting to lift them. Discriminate between bones of their own and other species, may grieve their dead.</p> <p>Behavioural innovation: vocal learning and modify and use rudimentary tools. Very vulnerable to stress and trauma and its longer-term psychological consequences. Empathetic: form coalitions to help others, assist fallen elephants, feed others who are incapable of doing so themselves. Intricate teamwork in defence, resource acquisition, offspring care and decision-making, to a large extent mediated by a complex suite of vocalizations. Matriarchs are chosen on basis of wise decision-making, excellent memory and courage.</p>	<p>It's difficult to see how anything but elephants' natural habitat can fully provide for the complete range of elephants' emotional, intellectual and behavioural repertoires. Giving them full recognition and offering many social and behavioural opportunities - far above what is commonly offered by zoos - is essential for elephants for which there is no alternative to captivity.</p>
<p>Strong individual personalities that affect how they interact with other elephants. Some elephants are popular while others are not. Some elephants show strong leadership qualities, others do not; some are highly social 'extroverts', while others are less social 'introverts'.</p>	<p>Elephants must be given space to bathe, forage, dust-bathe, stand or walk alone or in the company of other elephants. This points to the need for a rich and huge enclosure, with multiple replications of opportunities to express normal behaviour.</p>
<p>Communicate with dozens of other elephants over long distances acoustically and through olfaction, sometimes utilizing seismic vibrations through their feet</p> <p>Extraordinary sense of smell.</p>	<p>Elephants' ability to communicate seismically has been known for many years. Vast space, where elephants can stand far apart and out of sight, gives meaning to this ability.</p> <p>Such space also gives elephants the opportunity to seek out other elephants and food using smell.</p>
<p>Very strong social bonds that last decades, even after decades of separation in captivity (two ex-circus elephant reunited at a sanctuary remembered each other and resumed their close relationship after 23 years of separation)</p>	<p>Zoos acknowledge that splitting up bonded animals should be avoided, but limited space can make this a necessity.</p> <p>Zoos prefer to move males between collections for breeding purposes, but they are not always easy to move. It is rarely recognised that this severing of bonds between males and between males and females can be highly traumatic.</p>
<p>Calves gradually acquire foraging knowledge by sampling what the adults around them are eating</p> <p>Elephants have many food sources, and through such food sampling calves learn a wide range of these seasonally and geographically varying species.</p>	<p>Few of these highly evolved behaviours have the chance of expression in a traditional zoo of say, 1ha. Foraging knowledge cannot be accumulated, remembered and put to appropriate use. There is no seasonal variation and no spatial or temporal diversity in food distribution.</p>

NATURAL BEHAVIOUR OF AN ELEPHANT	IMPLICATIONS FOR ZOOS
<p>Males are born into in closely knit family groups. They participate in social events although at lower intensity than females age counterparts. They leave at 9-18 years, a process that can take 1-4 years. This is a lengthy process and the male has to learn a whole new set of social rules from his increasingly male-only companions. He joins a male group and learns about life as a male from seniors.</p> <p>Males can form lasting friendships with other males. Sexually active males rove between families. If a male can mate (although most won't) he will stay for 2-3 days then move on.</p> <p>Males enter musth in late teens early twenties. Musth becomes regular, longer and well-defined at 40 and males attain peak reproduction between 40 and 55. Males only reproduce regularly from the age of 40.</p> <p>Young males, when departing the natal herd, follow and observe older males. They watch and learn about mating Mothers teach their daughters about mate choice and how to behave during oestrous</p>	<p>Male elephants in zoos are recognised as a huge problem, and zoos continue to produce a surplus of males.</p> <p>Males need company and their social environments are complex, dynamic and vary through life. It is virtually impossible to provide for this in captivity, condemning males all too often to impoverished existences.</p> <p>Given the demands of meeting males' need over their lifetime, which range from growing up with females, to forming bacheor herds, to fighting over females and to largely living in separate areas, It is virtually impossible to see how captivity of any size can ensure their well-being.</p> <p>Male elephants in the wild must get to over thirty years old before females are interested in them, and compete with other males, after which females choose. Limited space means females in zoos cannot choose who they mate with, or even whether they mate at all - the difficulties of keeping males with limited space are so great females are often artificially fertilized. There is no opportunity to allow female calves to be taught by their mothers in such a system.</p>

REFERENCES

- ¹ www.elephant.se (2021).
- ² Zoos Forum (2010) Elephants in UK Zoos. Zoos Forum review of issues in elephant husbandry in UK zoos in the light of the Report by Harris et al (2008) (Harris, M, Sherwin, C and Harris, S (2008) The welfare, housing and husbandry of elephants in UK zoos. Defra WC05007). 7 July 2010.
- ³ Okita-Ouma, B, Slotow, R, Vigne, L, Maisels, F, Menon, V, Tiwari, S and Yang, A. (2021) Shrinking spaces for the world's largest land animal. <https://www.iucn.org/news/species-survival-commission/202108/shrinking-spaces-worlds-largest-land-animal>.
- ⁴ Secretary of Standards Modern Zoo Practice, DEFRA, 2017 Appendix 8 - Specialist exhibits, Elephants. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/654713/zoo-practice-elephants.pdf.
- ⁵ EAZA (2020). EAZA Best Practise Guidelines for Elephants. <https://www.eaza.net/assets/Uploads/CCC/BPG-2020/Elephant-TAG-BPG-2020.pdf>
- ⁶ AZA (2012). AZA Standards for Elephant Management and Care https://assets.speakcdn.com/assets/2332/aza_standards_for_elephant_management_and_care.pdf
- ⁷ Hewson CJ (2003) What is animal welfare? Common definitions and their practical consequences. *Can Vet J.* 44(6):496-499
- ⁸ Stamp Dawkins, M (2012) Why animals matter: Animal consciousness, animal welfare, and human well-being. Oxford University Press, UK
- ⁹ ElephantVoices (2021) Elephants are extraordinary. <https://elephantvoices.org/elephant-sense-a-sociality-4.html>
- ¹⁰ Plotnik, JM, de Waal, FBM, Moore III, D & Reiss, D (2010) Self-recognition in the Asian elephant and future directions for cognitive research with elephants in zoological settings. *Zoo Biol.*, 29: 179-191
- ¹¹ Veasey, JS (2020) Assessing the psychological priorities for optimising captive Asian elephant (*Elephas maximus*) welfare. *Animals* 10(1):39. <https://doi.org/10.3390/ani10010039>
- ¹² Clubb, R, Rowcliffe, M, Lee, P, Mar, KU, Moss, C & Mason, GJ (2008) Compromised survivorship in zoo elephants. *Science*, 322(5908): 1649-1649
- ¹³ Saragusty, J, Hermes, R, Göritz, F, Schmitt, DL, & Hildebrandt, TB (2009) Skewed birth sex ratio and premature mortality in elephants. *Animal Reproduction Science* 115(1-4): 247-254.
- ¹⁴ Clubb et al. (2008)
- ¹⁵ Clubb et al. (2008)
- ¹⁶ Tidière, M., Gaillard, JM, Berger, V, Müller, DWH, Bingaman Lackey, L, Gimenez, O, Clauss, M & Lemaître, J-F. (2016) Comparative analyses of longevity and senescence reveal variable survival benefits of living in zoos across mammals. *Sci Rep* 6, 36361
- ¹⁷ See review in Rees, PA (2021) Elephants under human care: the ecology, behaviour and welfare of elephants in captivity. Academic Press
- ¹⁸ Khyne U, Mar, KU, Lahdenperä, M & Lummaa, V (2012) Causes and correlates of calf mortality in captive Asian elephants (*Elephas maximus*). *PLoS ONE*. <https://doi.org/10.1371/journal.pone.0032335>.
- ¹⁹ Proctor, CM, Freeman, EW & Brown, JL (2010) Results of a second survey to assess the reproductive status of female Asian and African elephants in North America. *Zoo Biology* 29(2): 127-139.
- ²⁰ Schmidt, H & Kappelhof, J (2019) Review of the management of the Asian elephant *Elephas maximus* EEP: current challenges and future solutions. *International Zoo Yearbook* 53(1): 31-44
- ²¹ Sukumar, R (2003) The living elephants: evolutionary ecology, behaviour and conservation. Oxford University Press, Oxford
- ²² Hayward, AD, Mar, KU, Lahdenperä, M & Lummaa, V (2014) Early reproductive investment, senescence and lifetime reproductive success in female Asian elephants. *Journal of Evolutionary biology*. 27(4): 772-783
- ²³ Hayward et al. (2014)
- ²⁴ Reviewed in: Brown, JL (2019) Update on comparative biology of elephants: factors affecting reproduction, health and welfare. In: Comizzoli, P, Brown, J & Holt, W (eds) *Reproductive Sciences in Animal Conservation*. *Advances in Experimental Medicine and Biology* 1200
- ²⁵ Mirowski, A. (2019) Obesity in elephants. *ycie Weterynaryjne* 94(1): 37-39
- ²⁶ Harris, M, Sherwin, CM & Harris, S (2008) Final report on the project 'Welfare of elephants in UK zoos'. http://randd.defra.gov.uk/Document.aspx?Document=WC05007_7719_FRP.pdf
- ²⁷ Morfeld, KA, Meehan, CL, Hogan, JN & Brown, JL (2016) Assessment of body condition in African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants in North American zoos and management practices associated with high body condition scores. *PLoS ONE*. <https://doi.org/10.1371/journal.pone.0155146>
- ²⁸ Wendler, P, Ertl, N, Flügger, M, Sós, E, Schiffmann, C, Clauss, M & Hatt, JM (2019) Foot health of Asian elephants (*Elephas maximus*) in European zoos. *Journal of Zoo and Wildlife Medicine*, 50(3): 513-527
- ²⁹ Wendler et al. (2019)
- ³⁰ Edwards, KL, Miller, MA, Carlstead, K & Brown, JL (2019) Relationships between housing and management factors and clinical health events in elephants in North American zoos. *PLoS ONE*. <https://doi.org/10.1371/journal.pone.021777>
- ³¹ Bentley, CE, Cracknell, JM, Kitchener, AC, Martinez Pereira, Y, Pizzi, R (2021) "Improved diagnosis of foot osteoarthritis in elephants (*Elephas maximus*, *Loxodonta africana*) using stereoradiography," *Journal of Zoo and Wildlife Medicine* 52(1): 67-74
- ³² Edwards et al. (2019)
- ³³ Harris et al. (2008)
- ³⁴ Williams, E, Chadwick, CL, Yon, L & Asher, L (2018) A review of current indicators of welfare in captive elephants (*Loxodonta africana* and *Elephas maximus*). *Animal Welfare*, 27(3): 235-249
- ³⁵ Mason, GJ & Latham, N (2004) Can't stop, won't stop: is stereotypy a reliable animal welfare indicator? *Animal Welfare* 13: 57-69
- ³⁶ Greco, BJ, Meehan, CL, Hogan, JN, Leighty, KA, Mellen, J, Mason GJ, Mench, JA (2016) The days and nights of zoo elephants: using epidemiology to better understand stereotypic behavior of African elephants (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) in North American zoos. *PLoS ONE*. <https://doi.org/10.1371/journal.pone.0144276>
- ³⁷ Harris et al. (2008)
- ³⁸ Mason, GJ & Veasey, JS (2010) What do population-level welfare indices suggest about the well-being of zoo elephants? *Zoo Biology* 29(2): 256-273
- ³⁹ Rees, PA (2009) The sizes of elephant groups in zoos: Implications for elephant welfare. *Journal of Applied Animal Welfare Science* 12(1): 44-60
- ⁴⁰ Hörner, F, Oerke, A.-K, Müller, DWH, Westerhüs, U, Azogu-Sepe, I, Hruby, J & Preisfeld, G (2021) Monitoring behaviour in African elephants during introduction into a new group: differences between related and unrelated animals. *Animals* 2021, 11, 2990. <https://doi.org/10.3390/ani1102990>.
- ⁴¹ Clubb et al. (2008)
- ⁴² BBC new (2021) <https://www.bbc.co.uk/news/uk-england-somerset-57578702>
- ⁴³ Meehan, CL, Mench, JA, Carlstead, K & Hogan, JN (2016) Determining connections between the daily lives of zoo elephants and their welfare: an epidemiological approach. *PLoS ONE*. <https://doi.org/10.1371/journal.pone.0158124>
- ⁴⁴ Thompson, K & Head, S (undated) Gardens as a resource for wildlife. *The Wildlife Gardening Forum*. <http://www.wlgef.org/The%20garden%20Resource.pdf#:~:text=Average%20garden%20size%20was%20190%20m2although%20this%20is,m2%2C%20depending%20on%20the%20housing%20type%20and%20density4>.
- ⁴⁵ <https://www.macintyreHUDSON.co.uk/insights/article/what-size-is-the-average-farm>
- ⁴⁶ Williams, C, Tiwari, SK, Goswami, VR, de Silva, S, Kumar, A, Basakaran, N, Yoganand, K & Menon, V (2020) *Elephas maximus*. The IUCN Red List of Threatened Species
- ⁴⁷ Ecology Center (2022) <https://www.ecologycenter.us/elephant-populations/home-rangesize.html#:~:text=Home%20>

- range%20size%20%20%20%20%20,%20%20%20%2011%20more%20rows%20
- ⁴⁸ Blake, S, Deem, SL, Strindberg, S, Maisels, F, L, Isia, I-B, Douglas-Hamilton, I, Karesh, WB, & Kock, MD (2008) Roadless wilderness area determines forest elephant movements in the Congo basin. <https://doi.org/10.1371/journal.pone.0003546>
- ⁴⁹ Williams et al. (2020)
- ⁵⁰ Ecology Center (2022)
- ⁵¹ Gobush, KS, Edwards, CTT, Maisels, F, Wittemyer, G, Balfour, D & Taylor, RD (2021) *Loxodonta cyclotis*. The IUCN Red List of Threatened Species
- ⁵² Ngene S, Okello MM, Mukoka J, Muya S, Njumbi S & Isiche J (2017) Home range sizes and space use of African elephants (*Loxodonta africana*) in the Southern Kenya and Northern Tanzania borderland landscape. *International Journal of Biodiversity and Conservation*, 9(1):9-26.
- ⁵³ Veasey, J, Waran, N & Young, R (1996) On comparing the behaviour of zoo housed animals with wild conspecifics as a welfare indicator. *Animal Welfare*. 5. 13-24.
- ⁵⁴ Yeates, J (2011) Is 'a life worth living' a concept worth having? *Animal Welfare* 20: 397-406
- ⁵⁵ Wolfensohn, S, Shotton, J, Bowley, H, Davies, S, Thompson, S & Justice, W (2018) Assessment of welfare in zoo animals: towards optimum quality of life. *Animals*, 8(7):110
- ⁵⁶ Whitham, JC & Wielebnowski, N (2013) New directions for zoo animal welfare science. *Applied Animal Behaviour Science* 147: 3-4: 247-260
- ⁵⁷ Krebs BL, Marrin D, Phelps A, Krol L & Watters JV (2018) Managing aged animals in zoos to promote positive welfare: a review and future directions. *Animals (Basel)* 8(7):116
- ⁵⁸ Department for Environment, Food & Rural Affairs (2012) Zoo Expert Committee Handbook. <https://www.gov.uk/government/publications/zoos-expert-committee-handbook>
- ⁵⁹ Dawkins, MS (1980) *Animal suffering*. London: Chapman & Hall
- ⁶⁰ Holdgate, MR, Meehan, CL, Hogan, JN, Miller, LJ, Rushen, J, de Passillé, AM, Soltis, J, Andrews, J & Shepherdson, DJ (2016) Recumbence behavior in zoo elephants: determination of patterns and frequency of recumbent rest and associated environmental and social factors. *PLoS ONE*: 11(7) e0153301. <https://doi.org/10.1371/journal.pone.0153301>
- ⁶¹ Manteca, X, Villalba, JJ, Atwood, SB, Dziba, L, Provenza, FD, (2008) Is dietary choice important to animal welfare? *Journal of Veterinary Behavior* 3(5): 229-239
- ⁶² Lindsay, WK (1994) Feeding ecology and population demography of African elephants in Amboseli, Kenya. PhD dissertation, University of Cambridge, 244pp.
- ⁶³ Poole, J & Granli P (2009) Mind and movement: Meeting the interests of elephants. In: Forthman DL, Kane LF & Waldau PF (Eds.) *An Elephant in the Room: The Science and Well-being of Elephants in Captivity*. Cummings School of Veterinary Medicine's Center for Animals and Public Policy, Tufts University, pp.2-21.
- ⁶⁴ Schmidt & Kappelhof (2019)
- ⁶⁵ BBC news (2021)
- ⁶⁶ Hörner et al. (2021)
- ⁶⁷ Thitaram, C, Dejchaisri, S, Somgird, C, Angkawanish, T, Brown, J, Phumphuay, R, Chomdech, S & Kangwanpong, D (2015) Social group formation and genetic relatedness in reintroduced Asian elephants (*Elephas maximus*) in Thailand. *Applied Animal Behaviour Science*. 172: 52-57
- ⁶⁸ Manteca, X & Salas, M (2015) Stereotypies as animal welfare indicators. *Zoo Animal Welfare Fact Sheet* 2, October 2015. Zoo Animal Welfare Education Centre
- ⁶⁹ Miller LJ, Chase MJ & Hacker CE (2016) A comparison of walking rates between wild and zoo African elephants. *Journal of Applied Animal Welfare Science*, 19(3): 271-279.
- ⁷⁰ Fritz, H (2017) Long-term field studies of elephants: understanding the ecology and conservation of a long-lived ecosystem engineer. *Journal of Mammalogy* 98(3): 603-611
- ⁷¹ Barrett, LP & Benson-Amram, S (2021) Multiple assessments of personality and problem-solving performance in captive Asian elephants (*Elephas maximus*) and African savanna elephants (*Loxodonta africana*). *Journal of Comparative Psychology*, 135(3): 406-419.
- ⁷² Seltmann, MW, Helle, S, Adams, MJ, Mar, KU & Lahdenperä, M (2018) Evaluating the personality structure of semi-captive Asian elephants living in their natural habitat. *R. Soc. open sci.* 5:2
- ⁷³ Lee, PC & Moss, CJ (2012) Wild female African elephants (*Loxodonta africana*) exhibit personality traits of leadership and social integration. *Journal of Comparative Psychology*, 126(3): 224-232.
- ⁷⁴ Scott, NL & LaDue, CA (2019) The behavioral effects of exhibit size versus complexity in African elephants: A potential solution for smaller spaces. *Zoo Biology* 38(5): 448-457
- ⁷⁵ Holdgate et al. (2016)
- ⁷⁶ Wendler et al. (2019)
- ⁷⁷ Harris et al. (2008)
- ⁷⁸ Harris et al. (2008)
- ⁷⁹ Meehan, Mench et al. (2016)
- ⁸⁰ Meehan CL, Hogan JN, Bonaparte-Saller MK & Mench JA (2016) Housing and social environments of African (*Loxodonta africana*) and Asian (*Elephas maximus*) elephants in North American zoos. *PLoS ONE* 11(7): e0146703. <https://doi.org/10.1371/journal.pone.0146703>
- ⁸¹ Gobush et al. (2021)
- ⁸² <https://news.sky.com/story/keeping-elephants-in-zoos-could-be-made-illegal-amid-warnings-animals-suffer-mental-illnesses-in-captivity-12353302>
- ⁸³ Clubb, R & Mason, G, (2003) Captivity effects on wide-ranging carnivores. *Nature* 425(6957): 473-474
- ⁸⁴ Williams et al. (2020)
- ⁸⁵ Ecology Center (2022)
- ⁸⁶ Blake et al. (2008)
- ⁸⁷ <https://elephant-project.science/timber-elephants/>
- ⁸⁸ Baker, L & Winkler, R (2020) Asian elephant rescue, rehabilitation and rewilding. *Animal Sentience* 28(1). DOI: 10.51291/2377-7478.1506
- ⁸⁹ <https://www.mahouts.org/life>
- ⁹⁰ www.elephantvalleyproject.org
- ⁹¹ <https://hplo.animalsasia.org>
- ⁹² www.elephantconservationcenter.com/rewilding
- ⁹³ Miththapala, S (2009) The Uda Walawe elephant transit home - another opportunity missed? *Gajah* 30: 24-28
- ⁹⁴ Thitaram et al. (2015)
- ⁹⁵ Evans, K, Moore, R & Harris, S (2013) The social and ecological integration of captive-raised adolescent male African elephants (*Loxodonta africana*) into a wild population. *PLoS ONE*. <https://doi.org/10.1371/journal.pone.0055933>
- ⁹⁶ Jachowski, DS, Slotow, R & Millsbaugh, JJ (2013) Delayed physiological acclimatization by African elephants following reintroduction. *Animal Conservation*, 16(5), 575-583. doi:10.1111/acv.12031
- ⁹⁷ <https://www.sheldrickwildlifetrust.org/orphans/calves>
- ⁹⁸ <https://globalelephants.org/sanctuary-faq/>
- ⁹⁹ Mason, GJ, Cooper, J & Clarebrough, C (2001) Frustrations of fur-farmed mink. *Nature* 410(6824): 35-36.
- ¹⁰⁰ Dawkins, MS (1988) Behavioural deprivation: a central problem in animal welfare. *Applied Animal Behaviour Science* 20(3-4): 209-225.
- ¹⁰¹ Robbins, TW, Jones, GH & Wilkinson, LS (1996) Behavioural and neurochemical effects of early social deprivation in the rat. *Journal of Psychopharmacology* 10(1): 39-47.
- ¹⁰² Lewis, MH, Gluck, JP, Bodfish, JW, Beauchamp, AJ & Mailman, RB (1996) Neurobiological basis of stereotyped movement disorder. In R. L. Sprague & K. M. Newell (Eds.), *Stereotyped movements: Brain and*

behavior

relationships (pp. 37-67). American Psychological Association.
<https://doi.org/10.1037/10202-003>

¹⁰³ Clubb et al. (2008)

¹⁰⁴ Morisse, JP, Cotte, JP, Huonnic, D & Martrenchar, A (1999) Influence of dry feed supplements on different parameters of welfare in veal calves. *Animal Welfare* 8(1): 43-52

¹⁰⁵ Ramonet, Y, Meunier-Salaün, MC & Dourmad, JY (1999) High-fibre diets in pregnant sows: digestive utilization and effects on the behavior of the animal. *Journal of Animal Science* 77(3): 591-599

¹⁰⁶ Baxter, E & Plowman, AB (2001) The effect of increasing dietary fibre on feeding, rumination and oral stereotypies in captive giraffes (*Giraffa camelopardalis*). *Animal Welfare* 10(3): 281-290

¹⁰⁷ Parker, M, Goodwin, D, Redhead, E & Mitchell, H (2006) The effectiveness of environmental enrichment on reducing stereotypic behaviour in two captive vicugna (*Vicugna vicugna*). *Animal Welfare* 15(1): 59-62

¹⁰⁸ Steinfeldt, S, Kjaer, JB & Engberg, RM (2007) Effect of feeding silages or carrots as supplements to laying hens on production performance, nutrient digestibility, gut structure, gut microflora and feather pecking behaviour. *British Poultry Science* 48(4): 454-468

¹⁰⁹ Pettersson, IC, Weeks, CA, Wilson, LRM & Nicol, CJ (2016) Consumer perceptions of free-range laying hen welfare. *British Food Journal* 118(8): 1999-2013.

¹¹⁰ Clark, B, Stewart, GB, Panzone, LA, Kyriazakis, I & Frewer, LJ (2016) A systematic review of public attitudes, perceptions and behaviours towards production diseases associated with farm animal welfare. *J Agric Environ*

Ethics 29: 455-478.

¹¹¹ Veasey, JS (2020)

¹¹² Veasey, JS (2020)

¹¹² K. Lindsay, pers. obs.

¹¹⁴ Hörner et al. (2021)

¹¹⁵ BBC news (2021)

¹¹⁶ Goldenberg, S. & Wittemyer, G. (2019) Elephant behavior toward the dead: A review and insights from field observations. <https://repository.sandiegozoo.org/handle/20.500.12634/215>

¹¹⁷ ElephantVoices (2021)

¹¹⁸ Williams et al. (2020)

¹¹⁹ Ecology Center (2022)

¹²⁰ Gobush et al. (2021)

¹²¹ Williams et al. (2020)

¹²² Ecology Center (2022)

¹²³ Blake et al. (2008)

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