

## How Elephant Lands Enhances Elephant Welfare Executive Summary – May 2018

**Elephant Lands was designed to encourage activity, promote a diverse range of natural behaviors, offer increased opportunities for choice and social interaction, and provide biologically meaningful challenges for Asian elephants at the Oregon Zoo. Results of this welfare study show that the zoo has achieved its goals with Elephant Lands.**

For more than 60 years, the Oregon Zoo has been advancing the care and welfare of Asian elephants as well as scientific knowledge about this highly endangered species. In designing its new Elephant Lands habitat, the zoo's decisions were informed by research on both wild Asian elephants and elephants in zoos, drawing on decades of hands-on experience and a deep understanding of individual elephant's needs. A welfare-based approach to design sought to provide Portland's elephant family with increased choice and the opportunity to engage in a wide range of natural behaviors associated with their biological, social, physiological and psychological needs.

A four-year study was designed to evaluate the effectiveness of Elephant Lands through scientific assessment of welfare measures before, during and after transition to the new habitat. Data collection began in September 2012, prior to the start of construction, and continued through the end of 2016, one year after Elephant Lands' grand opening. Welfare indicators included distance walked through GPS monitoring, reproductive and adrenal hormone analyses, and detailed behavior assessments. Results of this welfare study show the zoo has achieved its goals. The elephants are more active, they are exhibiting more choice and self-determination throughout their day, they are expressing a diverse range of species-typical behaviors, and they have biologically meaningful challenges.

**Distance Walked:** A previous multi-institutional study of zoo elephants found an average walking distance of 3.3 miles per day, comparable to reported averages of 1.9 to 7.5 miles per day in wild Asian and African elephants. As part of that nationwide study, Sung-Surin walked an average of 4.7 miles per day in the former Oregon Zoo habitat, and Chendra averaged 10.7 miles per day. In Elephant Lands, anklets equipped with GPS data loggers were worn by the same two females plus two males. Data indicated that, on a daily basis, Oregon Zoo elephants walk at least as far as – and at times farther – than their wild counterparts. Chendra walked an average 10.9 miles a day, and Samudra walked at least 6 miles a day. Sung-Surin walked an average of 9.6 miles a day, double her average in the former elephant area. The elephants are regularly utilizing the various components and features of their new environment and exerting more choice and control.

**Adrenal and Reproductive Hormones:** Hormone measurements provide information on reproductive state and adrenal activity, which helps to assess the physiological aspect of animal health and well-being. Reproductive hormones have been measured in female Oregon Zoo elephants since 1979 as part of routine management, and historically all have shown normal reproductive cycles even through periods of major social change. Females continued cycling regularly throughout the transition to Elephants Lands, which is one indicator of normal reproductive health. Adrenal hormone metabolites in fecal samples were measured in the former elephant area, during the transitional period, and for the first year in Elephant Lands. In all cases, the greatest variability in adrenal activity occurred during the transitional period, suggesting adaptive and normal adrenal responses to life changes, challenges and excitement. All elephants adapted well to the new environment, responding with reduced adrenal activity over time and returning to baseline levels during the first year in the new space. Current adrenal activity appears well within the normal range for each individual and provides an indicator of positive welfare responses.

**Behavior:** Measurements used to compare behavior in Elephants Lands to the former habitat included activity budgets (proportion of time spent engaged in certain behaviors), proportion of time engaged in active vs. inactive behaviors, proximity of elephants, and relative usage of resources in their habitat. Results show increased activity, increased foraging/feeding behavior, and increased choice and control over environment and social interactions. In Elephant Lands, the elephants spend the majority of their time socializing and interacting with their environment in a social context (22%), seeking food and feeding (40%), moving and resting (20%). The elephants are engaged in a diverse range of natural behaviors and demonstrating the social dynamics of a healthy herd 24 hours a day.

We are continuing long-term scientific monitoring, which will help fine-tune the habitat to maximize welfare for all individuals in the herd.

## How Elephant Lands Enhances Elephant Welfare Oregon Zoo Bond Citizens' Oversight Committee Report – May 2018

**Elephant Lands was designed to encourage activity, promote a diverse range of natural behaviors, offer increased opportunities for choice and social interaction, and provide biologically meaningful challenges for Asian elephants at the Oregon Zoo.** For more than 60 years, the Oregon Zoo has been advancing the care and welfare of Asian elephants as well as the scientific knowledge about this highly endangered species.

Many important discoveries have been made at the Oregon Zoo, including the characterization of the female estrous cycle using hormones (Hess et al., 1983), the chemical signals indicating females' readiness to breed (Rasmussen et al., 1996) and chemicals produced by males signaling a change in reproductive state (Rasmussen et al., 1984; Rasmussen et al., 1990; Rasmussen and Greenwood, 2003). Elephants here have participated in many studies to improve the welfare of all elephants under professional care, from research on foot health and veterinary care to studies of body condition and health markers as diagnostic tools. The Oregon Zoo was one of seven partners in a groundbreaking welfare study of more than 95% of the elephant population in facilities accredited by the Association of Zoos and Aquariums (AZA). This study evaluated how environmental variables influenced indicators of well-being (Meehan et al., 2016), and many of the outcomes supported the design decisions made for Elephant Lands, which were informed by decades of research, hands-on experience and an understanding of elephants' individual needs.

Animal welfare – according to the current AZA definition – refers to an animal's collective physical, mental and emotional states over a period of time, and is measured on a continuum from good to poor. Years before Elephant Lands became a reality, Oregon Zoo staff decided to take a welfare-based approach in its design – an approach focused on meeting the elephants' physiological, psychological and social needs 24 hours a day. Elephant Lands was designed to encourage activity, promote a diverse range of natural behavior, offer increased opportunities for choice and social interaction, and provide biologically meaningful challenges for its resident herd of Asian elephants. The importance of providing zoo animals with appropriate challenges (Clark, 2017) and the related variables of choice and control (Buchanan-Smith and Badihi, 2012) through environmental enrichment (Shepherdson et al., 1993; Shepherdson et al., 1998) has been convincingly documented for a wide variety of species, including elephants (Shepherdson, 1999; Wagman et al., 2018). The recently published multi-institutional elephant welfare study found social and management factors were important for multiple indicators of welfare in both Asian and African elephants (Meehan et al., 2016).

To promote a diverse range of species-typical behaviors, Elephant Lands needed to include everything the herd would need to thrive – flexible space with a variety of features to seek out and interact with, more choice and an increased level of self-directed control over their daily lives, and the ability to live in multi-generational matrilineal groups, which bulls can join occasionally as they would in free-ranging populations (McKay, 1973). Elephant Lands was designed with flexibility in resources to encourage foraging and exploration. A diversity of feeding methods provides foraging opportunities 14-16 hours per day, which more closely mimics the grazing habits of free-ranging elephants. Throughout the habitat, timed feeders release food at programmable intervals, overhead feeders require elephants to stretch and sometimes climb on logs, concrete herd feeders require reaching down, and other puzzle feeders demand manipulation to acquire food. The expanded habitat size allows for increased walking distances, and the hilly terrain, climbing features, and varied surfaces – including deep sand, hills of dirt, patches of grass and clay – provide stimulation and physical challenges.

A four-year study was designed to evaluate the effectiveness of Elephant Lands through scientific assessment of welfare before, during and after transition to the new habitat. Data collection began in September 2012, prior to the start of construction, and continued through the end of 2016, one year after Elephant Lands' grand opening. Welfare indicators included distance walked through GPS monitoring, reproductive and adrenal hormone analyses, and detailed behavior assessments.

## Distance Walked

It is well known that wild elephants are highly mobile, and daily walking distances vary dramatically depending on conditions. The walking behavior of wild elephants has been measured under different environmental conditions using a variety of techniques, from radio-collaring to observers following individuals and herds. Methodology for measuring movement of free-ranging animals is often based on relatively low sampling rates, which may result in an underestimate of total distance walked. Reported average walking distances of wild Asian and African elephants are 1.9 to 7.5 miles per day under normal environmental conditions, and can range up to 16.8 miles per day or more for seasonal migrations and under extreme conditions such as drought (Sukumar, 2003; Leighty et al., 2009; Rowell, 2014). Data gathered by Smithsonian scientists in Myanmar show that wild elephants there typically walk less than 1 to 4 miles per day, and that their home range size varies depending on quantity and quality of food and whether or not the area is occupied by bulls or by cows and their offspring (2018).

Movement in wild elephants is affected by a variety of factors, including age and sex of the individual, the distribution and availability of resources, and social groupings (McKay, 1973; Whitehouse and Schoeman, 2003; Slotow and van Dyk, 2004; Leighty et al., 2009). The relationship between resource availability and distances traveled suggests that walking varies in response to external conditions. Under professional care, food and water resources are provided so the need for walking is reduced. However, walking also supports exploratory behavior, which has an information-gathering function and may be rewarding in itself. In addition, there is evidence that exercise provided by walking improves animal health.

### Walking Distance in Zoo Elephants and in the Former Oregon Zoo Habitat

In 2012, scientists measured outdoor walking distance in 56 adult female African and Asian elephants, 12 years and older, in 30 North American AZA zoos (Holdgate et al., 2016) as part of a larger multi-institutional welfare study (Meehan et al., 2016). Elephants with outside access for at least 20 hours in a 24-hour period walked between 0.75 and 10.8 miles per day with an average of 3.3 miles (Holdgate et al., 2016), comparable to reported averages of their wild counterparts.

Feeding strategy and social groupings were important factors in the study. More diverse feeding regimens correlated with increased walking, and elephants that were fed on an unpredictable schedule walked 0.8 miles a day more than elephants fed on a predictable schedule. Distance walked was also positively correlated with an increase in the number of social groupings and negatively correlated with age – i.e., younger adults walked farther (Holdgate et al., 2016).

As part of that nationwide study, Sung-Surin walked an average 4.7 miles per day in the former Oregon Zoo habitat, and Chendra averaged 10.7 miles per day.

### Methods for Measuring Walking Distance in Elephant Lands

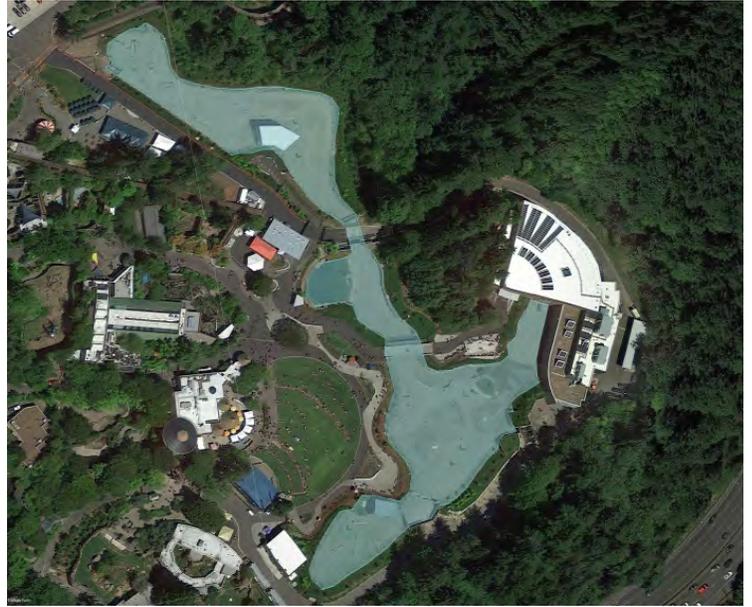
Anklets equipped with GPS data loggers were worn by two females and two males (Figure 1) for 24-hour periods approximately every two weeks from June 2014 through December 2016. We wanted to compare outdoor daily walking distance in Elephant Lands to the previous habitat, so we used the same proven methods as the 2012 study.

GPS units were programmed to record data points at five-second intervals. Each data point includes the date, time, latitude, longitude, and two indices of estimate quality – number and geometry of satellites used – in each location (Holdgate et al., 2016).



Figure 1: Samudra wearing a GPS anklet and walking with Lily

GPS data is unreliable when communication between satellites and receivers is obstructed, for example under a dense forest canopy or inside a building. Data points known to have occurred while the elephants were indoors were removed. In ArcMap software, we used Google Earth imagery and defined habitat boundaries (Figure 2). We then mapped the GPS data onto the exhibit and used the clip function to remove any remaining data from indoor areas and any data that fell outside of the boundaries. Clipped data was exported to Excel, then data points that failed to meet location estimate quality criteria were removed. The Euclidean (straight line) distance between consecutive data points was calculated, then screened for distances greater than an elephant can travel using a near maximal velocity of 6.8 m/s measured for elephants (Hutchinson et al., 2006). The final straight-line distance between consecutive data points was then summed to get total distances traveled for each day.



*Figure 2: Outdoor habitat area in ArcMap*

In 2012, GPS data was collected for five days during one month that minimized inter-zoo variation in predicted daily temperature (August for the Oregon Zoo). Walking distance was measured only for elephants that had outdoor access for at least 20 of the 24 hours for at least three days. For comparison of distance walked in Elephant Lands to the previous habitat we used the same criteria of 20 hours and the same season.

### **Walking Distance in Elephant Lands**

Sung-Surin has doubled her average daily walking distance to 9.6 miles per day, with a maximum of 12.9 miles outside. Chendra is still walking long distances on a daily basis at an average of 10.9 miles per day, with a maximum of 14.7 miles outside. Samudra walked about 6 miles per day outside, but on the days when we measured his walking he chose to spend most of his time indoors. (We know that the elephants walk even farther than GPS calculations show since we counted movement only in outside habitats due to GPS receiver limitations; they also walk and exercise regularly in the large indoor habitat known as Forest Hall.)

GPS mapping (Figure 3) shows how elephants use the space and resources in the outdoor portion of Elephant Lands. From these maps, we can see they are using all the habitat areas and features rather than concentrating their use in just a few preferred areas. The space-use patterns clearly suggest this is the result of the increased variety of feeding and enrichment opportunities designed into the habitat.



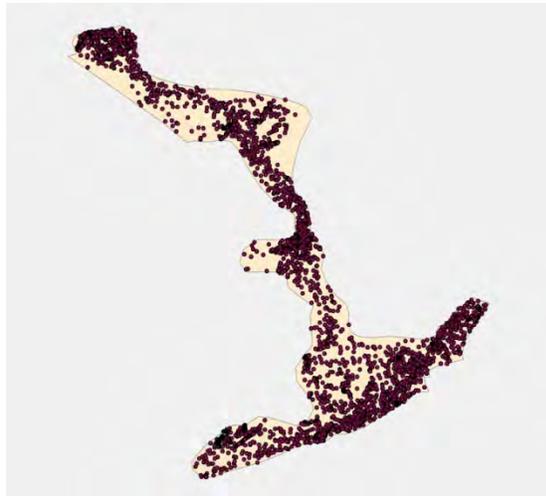
Chendra: Using habitat and resources nearest public viewing areas, plus the dirt mounds and feeders at the top of the hill in North Meadow (August 2016)



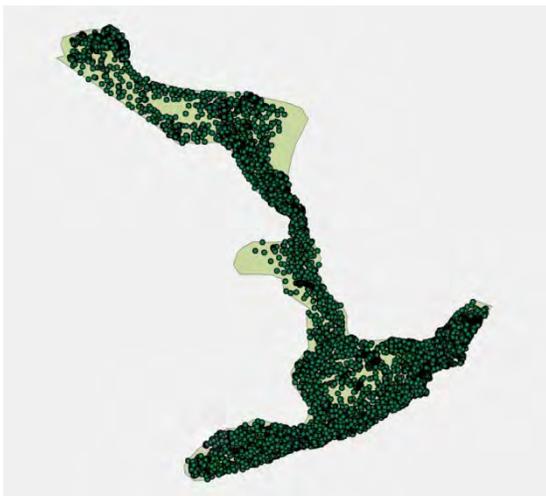
Chendra: Using entire habitat except dirt mounds (November 2016)



Sung-Surin: Checking feeders in the North but feeding mostly in the South (April 2016)



Samudra: Using the entire habitat, including pools and dirt mounds, with some preference for feeders at the top of North Meadow (12 hours, May 2016)



Sung-Surin: Using the entire habitat and diversity of food resources and features (August 2016)



Sung-Surin: Similar to usage in August 2016 (left), but in the cooler weather (November 2016)

Figure 3: GPS data in outdoor habitats of Elephant Lands for two females and one male at different times of year.

Movement in Elephant Lands is more self-directed than in the former habitat. In 2016, Oregon Zoo elephants had outdoor access for more than 20 hours a day in every month of the year except January, and individuals chose to spend anywhere from 4 to 20 hours outdoors. Even on colder days, some individuals chose to leave the heated indoor area and spend more time outdoors, while other members of the herd chose to remain indoors.

The elephant groups are dynamic and within a habitat individuals can choose who to spend time with. The zoo supports individual choice and also creates opportunities for group bonding with large browse feedings that encourage the herd to eat and interact together.

Based on the data available from studies of wild elephants, the elephants at the Oregon Zoo appear to walk at least as far as, and possibly farther, than their wild counterparts do on a daily basis. Perhaps this is in part due to the fact that they are secure to move as individuals and their movement is not limited by the group composition or need. Wild herds with a nursing calf or old or sick elephants will have to move more slowly; but the elephants here can move as individuals in safety with their resource needs met.

#### **Summary Points on Walking Distance:**

- Average daily walking distance was measured for two female and two male Asian elephants.
- Oregon Zoo elephants appear to walk at least as far as, and possibly farther, than their wild counterparts on a daily basis.
- Chendra walks an average 10.9 miles a day.
- Sung-Surin walks an average of 9.6 miles a day, double her average in the previous elephant area.
- Samudra walks at least 6 miles a day.
- The elephants are utilizing the entire habitat regularly and can choose to move indoors or outdoors.
- Movement in Elephant Lands is more self-directed – the elephants have more choice and control.

## **Adrenal and Reproductive Hormones**

Long-term research on reproductive hormones at the Oregon Zoo began with the characterization of the female estrous cycle in 1983 and is part of an ongoing endocrine-monitoring program for this species. Hormone measurements can provide information on reproductive state and on adrenal activity, which helps to assess the physiological aspect of animal health and well-being (Wielebnowski et al., 2002a; Wielebnowski et al., 2002b; Wielebnowski, 2003). Long-term monitoring facilitates the assessment of changes and trends over time, and this allows us to see normal variation that needs to be taken into account when assessing the impact of any perceived stressors (Shepherdson et al., 2004).

The zoo's longitudinal hormone data provide important baseline information for interpreting hormone results of this study on an individual and group basis. The Oregon Zoo has the longest-running elephant hormone dataset in the world, with weekly samples spanning over two decades from Asian elephants that are both wild-born and zoo-born, male and female, breeding and non-breeding, from less than 1 year of age through puberty and senescence. This dataset allows us to assess reproductive health of elephants over much of their lifetime. In our study of gonadal (Glaeser et al., 2012) and adrenal function in female Asian elephants over 20 years, we found that major life events – births, deaths, changes in herd structure – had minimal effect on estrous-cycle dynamics over time, suggesting that the zoo's female elephants are quite resilient and maintain normal reproductive health throughout their lives (Glaeser et al., 2012). Male elephants at the zoo have experienced typical cycles of musth, a physiological and behavioral phenomenon characterized by increased testosterone, heightened aggression and sexual behavior, and a temporary rise in dominance (Jainudeen et al., 1972; Hall-Martin and van der Walt, 1984; Poole, 1987; 1989a; b). In our study on the association of serum testosterone with development, aging and major life events over 20 years, the youngest male (Rama) showed an increase in testosterone concentrations with age during his early musth cycles, and we have noted similar patterns in the sub-adult male Samudra.

For our Elephant Lands study, we monitored adrenal activity specifically in addition to reproductive cycles and health. The adrenal response is an adaptive response (to a real or perceived stressor) whereby a suite of physiological and behavioral changes occur to help deal with the stressor and re-establish equilibrium. The net effect of an acute stress response is to increase glucose and oxygen for brain and muscle function. When there is a major change constituting a

real or perceived stressor, we see this adaptive physiological response that includes resilience, whereby glucocorticoid (e.g., cortisol, corticosterone) concentrations are temporarily elevated and subsequently decrease back to a baseline in an individual. Adaptive adrenal responses to changes such as moving to a new habitat, transitioning through construction and various habitat changes, breeding events, births, etc., are expected therefore and a normal part of any individual's life. Through our ongoing monitoring we wanted to make sure that individuals could properly deal with changes in a normal and adaptive manner for the species and that these responses would not have any long-term negative effects but rather beneficial effects over time.

### Methods for Measuring Hormones

Reproductive hormones in serum samples have been routinely measured in Oregon Zoo elephants. Progesterone and testosterone were measured in weekly serum samples throughout the duration of this four-year study, and continue to be measured in the zoo's endocrine lab. For this study, we used a radioimmunoassays (RIA) that has been used successfully in tracking progesterone and testosterone profiles in elephants (Brown and Lehnhardt, 1997; Brown et al., 1999; Brown, 2000; Brown et al., 2007; Glaeser et al., 2012), then switched in 2015 to an enzyme immunoassays (EIA) validated for Asian elephants (Oregon Zoo, unpublished).

Adrenal hormone metabolites were measured in fecal samples collected weekly from September 2012 through December 2016 for all individuals. Fecal samples were collected when the time of defecation was between 7 and 11 a.m. to eliminate possible effects of diurnal variation in hormone concentrations. Concentrations of glucocorticoid metabolites in fecal samples were measured at the Smithsonian's Conservation Biological Institute endocrinology lab (Front Royal, VA) using an enzyme immunoassay (EIA) previously validated for Asian elephants (Brown, unpublished data).

### Results of Hormones Measurements

All females at the zoo historically cycle normally (Glaeser et al., 2012) and continued cycling regularly throughout the period of major change and in Elephant Lands (Figure 4), which provides one indicator of normal reproductive health for the herd (Glaeser et al., 2012).

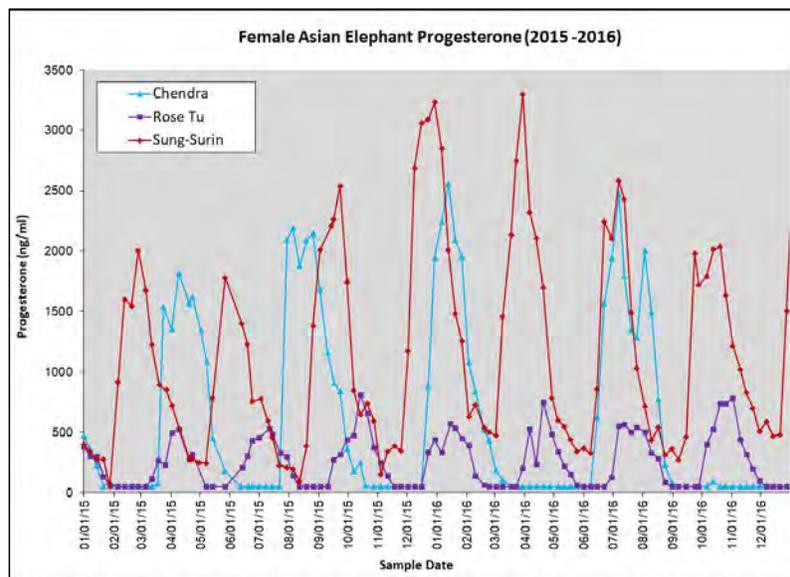


Figure 4: Serum progestagen profiles for adult female elephants 2015 and 2016 showing an example of charts sent weekly for routine elephant management.

For all individuals, the greatest variability in adrenal activity occurred during the period of major changes (Figure 5), suggesting adaptive and normal adrenal responses to life changes, challenges and excitement (e.g., moving out of known areas and exploring new areas, learning new routines and enrichment choices). Sung-Surin also exhibited some short elevations in the new habitat.

As expected in healthy individuals, Sung-Surin, Rose-Tu and Samudra showed increased levels of adrenal activity during the period of major changes and lower baseline adrenal activity levels in the former and the new habitats.

Chendra exhibited a somewhat different pattern than the other adults, showing continued increased levels of adrenal activity in Elephant Lands. However, she did show a decline in adrenal hormones immediately following the major changes and transition to the new habitat, indicating normal adaptive responses. In the new habitat, Chendra spends more time with Samudra than the other females, which may explain fluctuations in her adrenal activity leading to an overall increase in adrenal activity compared to the former habitat. Reproductive and breeding-related behaviors can temporarily increase adrenal activity and thus affect the overall mean in this case (Glaeser et al., unpublished data).

Lily was born only months prior to the start of construction and therefore we compared only the period of major change and her first year in Elephant Lands. As with the adults, she shows greater variability and higher baseline adrenal activity during the period of change; however, this study spanned ages 1 to 4, and it is not known how adrenal activity changes during early development in elephants.

It is important to note that we continue to monitor all the elephants closely to ensure that adrenal activity remains normal and adaptive.

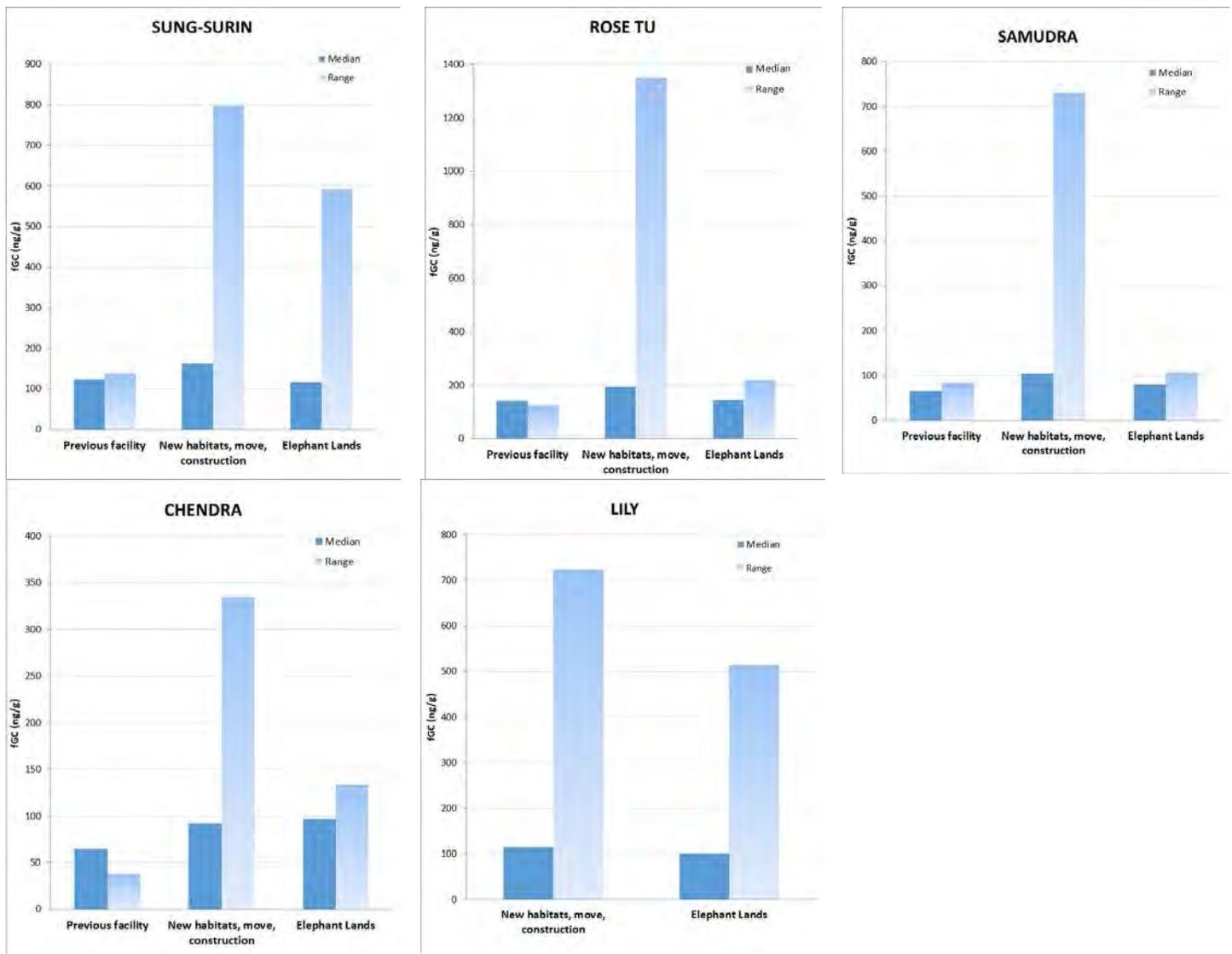


Figure 5: Concentrations of adrenal hormones (fecal glucocorticoid metabolites) comparing general levels (Median) and variability (Range) between the previous elephant area prior to the start of construction, a period of major change (new habitats, move into Forest Hall, construction), and the first year in Elephant Lands.

### Summary Points on Hormone Measurements:

- Reproductive hormones in elephants are measured as part of routine management.
- Adrenal hormone metabolites were measured in the previous elephant area, during the period of major change, and the first year in Elephant Lands.
- The adult females continuing cycling regularly throughout the period of major change and in Elephants Lands, which is one indicator of normal reproductive health for the herd.
- All individuals exhibited the greatest variability in their adrenal activity during the period of major changes, suggesting adaptive and normal adrenal responses to life changes, challenges and excitement.
- We continue to monitor all the elephants closely to ensure that adrenal activity remains normal and adaptive.

## Behavior

The behavior study was designed to assess Elephant Lands' effectiveness in providing increased opportunities for choice (social, food source and resource use), increased activity, and increased opportunity to express natural behaviors. Measurements of behavior included activity budgets (proportion of time spent performing behaviors), proportion of time performing active vs. inactive behaviors, proportion of time in proximity of other elephants, and relative usage of resources in their habitat.

### Methods for Measuring Behavior

Behavior data collection was designed to capture both morning and afternoon periods on a weekly basis. Video was recorded every other week, on alternating Saturdays and Mondays, during two 2-hour time periods (10 a.m.–noon and 2 p.m.–4 p.m.). Every elephant in the public viewing areas (inside and outside habitats) was monitored. Each focal animal was recorded for 2 minutes once every 30 minutes, beginning at the start of the hour and half hour. Video was recorded by a team of 14 volunteers from the zoo's Visitor Animal Survey Team (VAST).

An ethogram (list of species-specific behaviors with definitions) was constructed with elephant-specific behaviors defined in published sources (Eisenberg et al., 1990; Olson, 2004; Greco et al., 2016) and unpublished studies at the Oregon Zoo. Behavior descriptions used objective definitions (i.e., without interpretation of intent or purpose) such that behaviors could be recognized by multiple observers without expertise in elephant behavior. Specific behaviors were organized into behavior groups (Table 1), and behavior modifiers were defined for details of social interaction and resource use. This ethogram can be used at a high level for basic monitoring or can be drilled down to answer more detailed questions about social interactions and resource use; it is being used for ongoing behavior monitoring of elephants at the Oregon Zoo.

Table 1: Elephant Behavior Ethogram

<b>Proximity</b>	<b>Definition</b>
Not proximate	Focal is more than 2 body lengths from another individual.
Proximate	Focal is within 2 body lengths of or in contact with another individual. 2 body lengths defined as: 2 adult female body lengths (c.a. 10m) [modifier: Individuals within 2 body lengths of focal]
Proximity Not Visible	The focal animal or other elephants are not visible enough to determine proximity
<b>Behavior Group</b>	<b>Definition</b>
Behavior Not Visible	Elephant or activity is not visible enough to determine the behavior at the beep.
Social_Physical Contact	Physically contacting 1 or more elephants in a social context (e.g., trunk twine, play). [modifier: Sender/Receiver or Partner]

Social_No Contact	Interacting with 1 or more elephants without physical contact but within 2 body lengths (e.g., sharing food, displace). [modifier: Sender/Receiver or Partner]
Food Object Interaction	Interacting with any item that distributes food, either permanent or keeper-provided. [modifier: food object]
Feeding/Drinking	Picking up, manipulating, and/or consuming any food item without interacting with an object. Drinking water without bathing. [modifier: source of food or water]
Enrichment (non-food) Object Interaction	Interacting with non-food items that are not permanent (e.g., firehose ball or braid) [modifier: enrichment object]
Environmental Interaction	Interacting with features that are permanent in the habitat (e.g., dusting, bathing, digging, pushing or climbing on logs) [modifier: environmental feature]
Repetitive Behaviors	Repeatedly performing a behavior for 3 or more consecutive repetitions without interruption (e.g., route tracing). [modifier: form of behavior]
Locomotion	Walking or running (fast walking) more than 2 body lengths in any direction, without stopping for 3 sec or more.
Stationary	Standing, shuffling/stepping without moving 2 body lengths, sitting, or lying for 3 sec or longer. [modifier: location]

Behaviors are coded from digital video by observers trained to meet 85% inter-observer reliability criteria, which to date includes the principal investigator for this study and VAST volunteers. The behavior of each individual is measured using focal animal sampling. The frequency of behaviors is being measured using instantaneous sampling, with a sampling interval of 30 seconds – short enough to capture rare behaviors but long enough to ensure behaviors are independent. At every sampling interval, observers code keeper presence, proximity of focal to other elephants, and a single behavior within the top-most behavior group that applies. Keeper presence is recorded to ensure only self-initiated behaviors are included in the analysis.

Observation and data are exported to Excel for charting and descriptive statistics.

### Results of Behavior Measurements

In general, elephants spend the majority of their time in Elephant Lands socializing and interacting with their environment in a social context (22%), seeking food and feeding (40%), moving and resting (20%), with a smaller portion of their time spent interacting with enrichment objects and features in their environment in a non-social context (e.g., in the pool alone) (6%). By comparison, time spent performing repetitive behaviors is minimal (less than 3%) (Figure 6).

In Elephant Lands, elephants are seeking out their own food. Food Object Interaction has increased dramatically (average 20% increase), while Feeding/Drinking without interaction with a food object has decreased (average 20% decrease). This shows a switch from keeper-delivered food in the previous habitat to feeding from items that distribute food, such as the timed feeders, overhead feeders, concrete herd feeders, and puzzle feeders. In the previous habitat, keepers provided an array of food puzzles and scattered food to extend the duration of feeding and encourage investigation during and after staffed hours. The average time during staffed hours spent seeking food and eating did not change (40%), but findings here indicate that the food-delivery resources designed into Elephant Lands are achieving the goal of providing foraging opportunities through a diversity of feeding methods throughout the entire day, which is

further supported by the observed increase in locomotion for Samudra, Rose-Tu and Lily (average 7% increase) and the measured increase in daily walking distance for both Chendra and Sung-Surin (see results for GPS monitoring).

In general, the percentage of time performing active behaviors has increased (average 3.5% increase) while Stationary has decreased slightly (average 2.5% decrease), which indicates that Elephant Lands encourages activity as designed. Samudra exhibited a decrease of 2% in active behaviors; however, in the previous habitat he was ages 4 to 6 years so a decrease in activity is not uncommon.

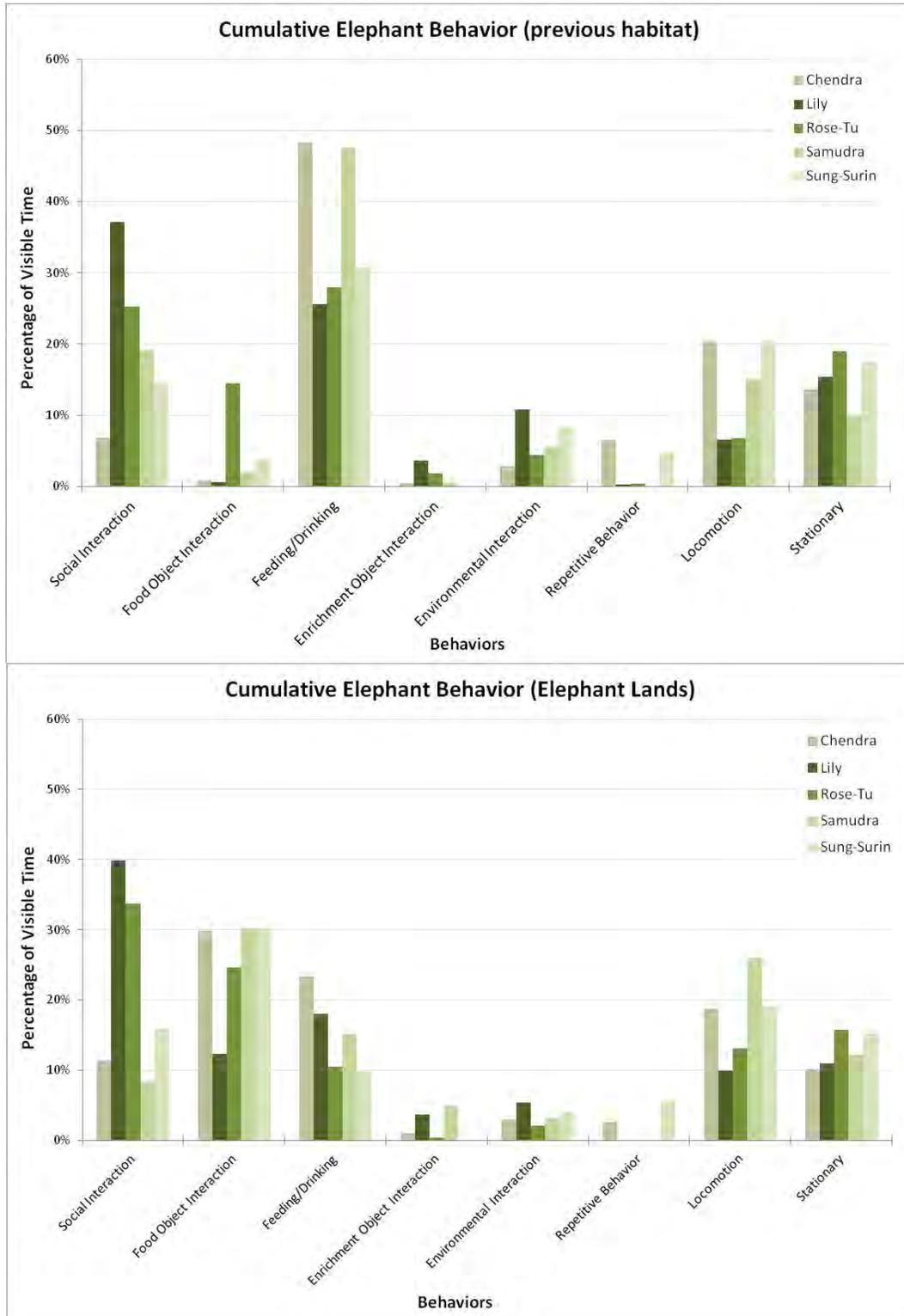


Figure 6: Cumulative behaviors in the previous elephant habitat and in Elephant Land.

The percentage of time performing social behaviors has increased (average 4% increase) for all individuals with the exception of Samudra (Figure 7 and 8), whereas the percentage of time spent in proximity of other elephants decreased (average 24% decrease) in Elephant Lands as compared to the previous habitat (Figure 8A). These findings indicate increased choice and control over whom they spend time with and how they interact socially.

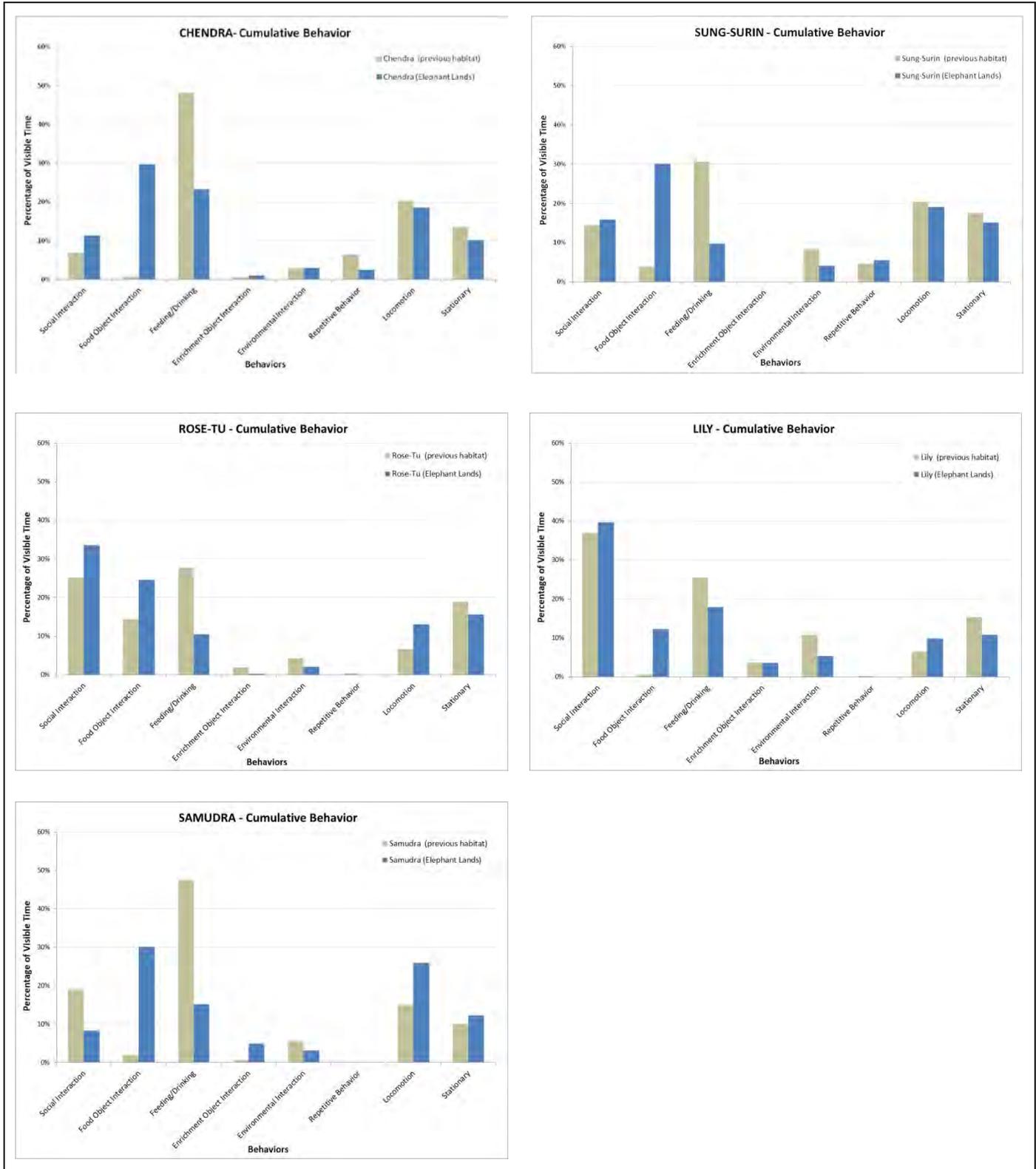


Figure 7: Cumulative behaviors for individual elephants comparing the percentage of time performing the behaviors between the previous habitat and Elephant Lands.

Chendra switched from spending negligible time interacting with food objects to foraging actively and eating food items (almost 30% increase) distributed in various ways throughout Elephant lands. However, she still also spends a large portion of her time feeding from food that is available without object manipulation, such as live vegetation, browse and hay left by other elephants near food-delivery features. Performing any repetitive behaviors has decreased in Elephant Lands from about 7% of her time to less than 3% of her time.

Sung-Surin switched to feeding primarily from items that distribute food in Elephant lands (26% increase), but learning this strategy was more challenging and took longer than it did for the other elephants. During the first several weeks, she spent time near gates in anticipation of keepers delivering hay rather than exploring. Keepers attempted to “teach” her to eat out of the feeders by calling her to the feeders, which may have unintentionally prolonged the transition. She shows few repetitive behaviors (less than 6% of her time) in the previous habitat and in Elephant Lands, and such behaviors occurred in infrequent bouts, potentially related to anticipation since she was still linking keeper staff with food and was initially reluctant to actively seek food items throughout the habitat. We saw a marked decrease in repetitive behavior as she began to understand that she needed to seek food on her own rather than wait for staff.

In contrast to the GPS monitoring results, behavior results indicated the amount of time spent in locomotion is not significantly different in the two habitats for Sung-Surin and Chendra, which may be due to the different sampling frequencies and measuring techniques. Behavior observations were conducted only during zoo hours and were recorded for 2-minute intervals (see methods), whereas GPS data was collected every 5 seconds for 24 hours. In addition, behavior methods categorized locomotion while feeding as a Feeding behavior, so walking and feeding is not included in the Locomotion behavior category. The GPS data is therefore a more reliable representation for overall movement and walking distance in this case.

Rose-Tu switched to feeding primarily from items that distribute food in Elephant lands (10% increase); however, in the previous habitat she already spent more time manipulating food objects than any of the other elephants so the increase for her is not as drastic. Rose-Tu shows an increase in social interactions (8.5% increase). Locomotion increased in Elephant Lands (6% increase) and time spent stationary decreased (3% decrease). Rose-Tu shows no repetitive behaviors in Elephant lands and showed less than 1% of her time in repetitive behaviors in the previous habitat.

Lily quickly learned to seek food from a diversity of feeding methods in Elephant Lands. She adapted most readily to the new habitat. Locomotion increased (3.5% increase) in Elephant Lands and time spent stationary decreased (4.5%). Lily shows no repetitive behaviors.

Samudra learned to seek food from a diversity of feeding methods in Elephant Lands and his food object interactions were minimal in the previous habitat. Locomotion has increased in Elephant Lands (4% increase), suggesting increased foraging and exploration. Samudra shows no repetitive behaviors. Social interactions for Samudra have decreased in Elephant Lands (by 10.5%), but this is related more to his development as an adolescent male and his role in the herd. In addition, management of a maturing bull necessitates temporary separation from related females during their female reproductive (estrous) cycle.

In general, the percentage of time spent in proximity of other elephants decreased (average 24% decrease) in Elephant Lands as compared to the previous habitat (Figure 8A), reflecting the individuals’ choice within the same habitat of whether to spend time near other elephants or farther away.

For Samudra, the decrease was dramatic (Figure 8A), which is partly due to his development as an adolescent male and his role in the herd. For Lily, this decrease also reflects normal social development in young elephants in that she is spending less time near her mother and more time with other elephants (Figure 8C). In wild elephants, the distance between calves and mothers increases gradually with age (Sukumar, 2003), so these changes in proximity reflect natural behavior in social development.

Interestingly, Chendra’s overall proximity to other elephants and her social interactions increased in the new habitat (both by 5%), but the herd-mates with whom she spends the most time are opposite from that in the previous habitat (Figure 8D). In the previous habitat, Chendra was often displaced from an area or activity by Sung-Surin, whereas in Elephant Lands she can choose to move somewhere else to engage in an activity of choice, again showing more choice and control over environment and a more equitable social environment for this individual.

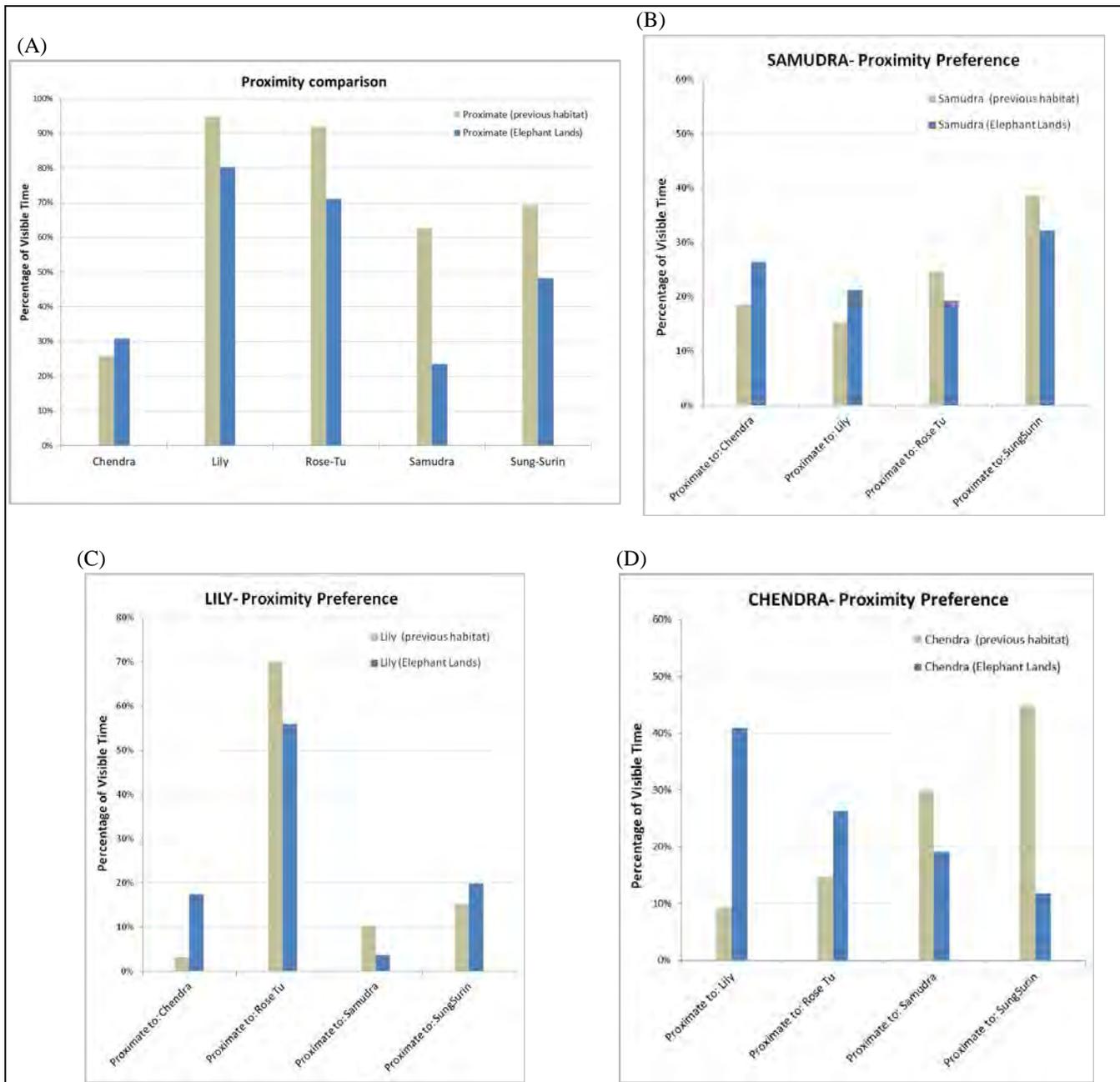


Figure 8: Proximity for individual elephants comparing the percentage of time in proximity to herd mates between the previous habitat and Elephant Lands (A), and change in preference for herd mates exhibited by Samudra (B), Lily (C), and Chendra (D).

In general, the elephants are choosing to utilize the entire habitat, with two areas used less frequently for passing through or for temporary holding while staff is cleaning. The usage of North Meadow and Forest Hall varies more among individuals, while the South Habitat and Encounters West usage is more consistent.

The elephants manipulate their environment more by pulling, pushing, kneeling, stretching, etc., to obtain food items or to move objects for other reasons (including play behavior). The proportion of time spent in Elephant Lands seeking food and feeding is much higher (34% higher) than for enrichment and environmental interaction in a non-social context, so behaviors of interacting with enrichment objects and environmental features are more rare, and with our sampling methods both the behavior and these resources may be underestimated. In addition, the frequency of behaviors presented for interacting with enrichment and environment does not account for these interactions when they also involve sharing of resources in a social context (e.g., sharing food, playing with another elephant in the pool, playing with an enrichment object). The observed resource use (Figure 9) shows the proportion of time spent using each resource in a non-social context, highlighting the diversity of resources available and how they are used when elephants are not interacting socially.

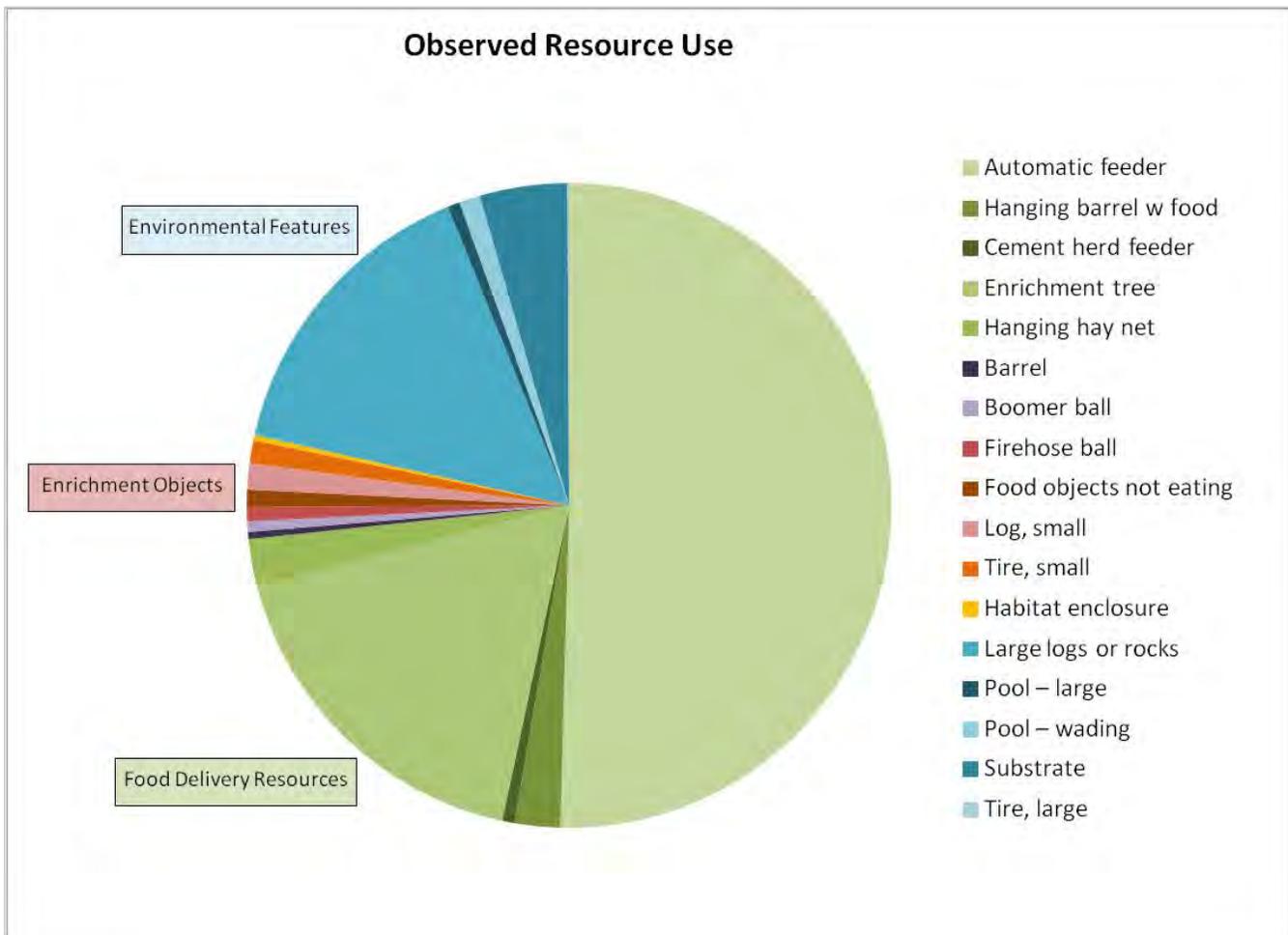


Figure 9: Observed resource use in Elephant Lands

**Summary Points on Behavior Measurements:**

- Behavior was measured in the previous elephant area, during the period of major change, and the first year in Elephant Lands.
- Results of behavior measurements show increased activity, increased foraging, and increased choice and control over their environment, with whom they spend time, and how they interact socially.
- In Elephant Lands, the elephants spend the majority of their time socializing and interacting with their environment in a social context (22%), seeking food and feeding (40%), moving and resting (20%).
- The elephants are exhibiting a diverse range of natural behaviors and social dynamics of a healthy herd.
- Behavior methods developed for this study are being used in ongoing elephant behavior monitoring.

## Summary

The Oregon Zoo has pioneered elephant care for decades, and has collected, documented and shared information with colleagues around the world. Results of this welfare study show that the zoo has achieved its goals with Elephant Lands. The elephants are more active, they are exhibiting more choice and self-determination, they are expressing a diverse range of species-typical behaviors, and they have biologically meaningful challenges. We will continue long-term scientific monitoring of the herd, which will inform fine-tuning of the habitat to maximize elephant welfare. The ultimate aim is that each elephant can exhibit a full range of natural behaviors, living in a socially stable, multi-generational matrilineal herd that is regularly integrated with bull elephants in a manner that meets or exceeds their biological, social, physiological and psychological needs. The zoo is immensely grateful for the support of this community, for helping advance the welfare of the elephants entrusted to its care.

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