May 8th, 12:30 PM - 2:00 PM

Room to Roam: Using GPS to Determine the Effect of Exhibit Size and Herd Size on Zoo Elephant Movement

Matthew Holdgate
Portland State University

Deborah A. Duffield
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David J. Shepherdson
Oregon Zoo

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GPS & wildlife

- Minimal researcher effort
- Large quantity of data
- Diverse applications
- Lowered costs
- Improved accuracy

Movement and zoo elephant welfare

- Limited opportunities for exercise
- Condensed diet
- Skeletal anatomy & foot health
- Historical considerations

Movement and elephant management

- How big are the enclosure?
- How many elephants share the space?
- How do these factors affect movement?

GPS use at Wild Animal Kingdom

RESEARCH ARTICLE

GPS Determination of Walking Rates in Captive African Elephants (*Loxodonta africana*)

Katherine A. Leighty,[1]* Joseph Soltis,[1] Christina M. Wesolek,[1] Anne Savage,[1] Jill Mellen,[1] and John Lehnhardt[2]

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The movements of elephants in captivity have been an issue of concern for animal welfare activists and zoological professionals alike in recent years. In order to fully understand how movement rates reflect animal welfare, we must first determine the exact distances these animals move in the captive environment. We outfitted seven adult female African elephants (*Loxodonta africana*) at Disney's Animal Kingdom with collar-mounted global positioning recording systems to document their movement rates while housed in outdoor guest viewing habitats. Further, we conducted preliminary analyses to address potential factors impacting movement rates including body size, temperature, enclosure size, and social grouping complexity. We found that our elephants moved at an average rate of 0.409 ± 0.007 km/hr during the 9-hr data collection periods. This rate translates to an average of 3.68 km traveled during the observation periods, at a rate comparable to that observed in the wild. Although movement rate did not have a significant relationship with an individual's body size in this herd, the movements of four females demonstrated a significant positive correlation with temperature. Further, females in our largest social group demonstrated a significant increase in movement rates when residing in larger enclosures. We also present preliminary evidence suggesting that increased social group complexity, including the presence of infants in the herd, may be associated with increased walking rates, whereas factors such as reproductive and social status may constrain movements. Zoo Biol 28:16–28, 2009.

Keywords: animal movements; welfare; exercise; enclosure size

Grant sponsor: NSF; Grant number: NSF-IIS-0326395.

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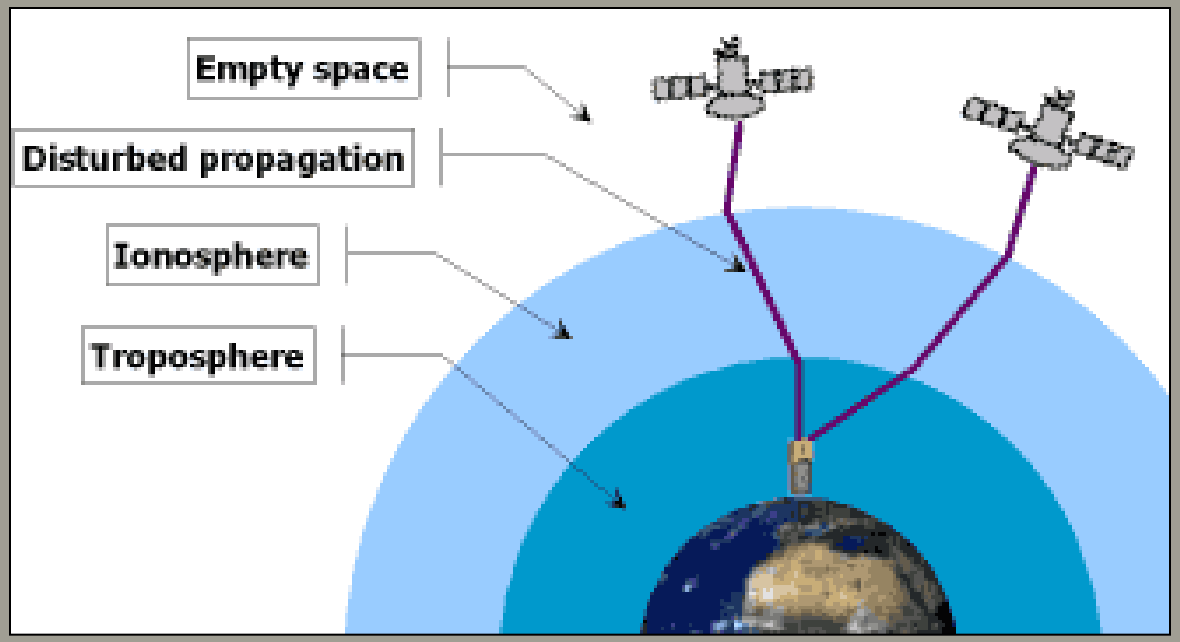
Published online 9 July 2008 in Wiley InterScience (www.interscience.wiley.com).

Developing the plan

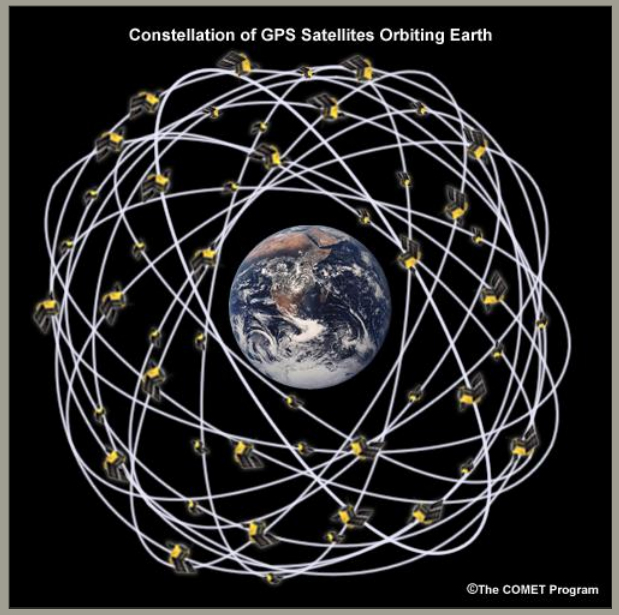
- Anklets > collars
- 5 days of data per elephant (24 hrs/day)
- GPS coordinates every 5 seconds
- Simultaneous tracking of functional exhibit & herd size

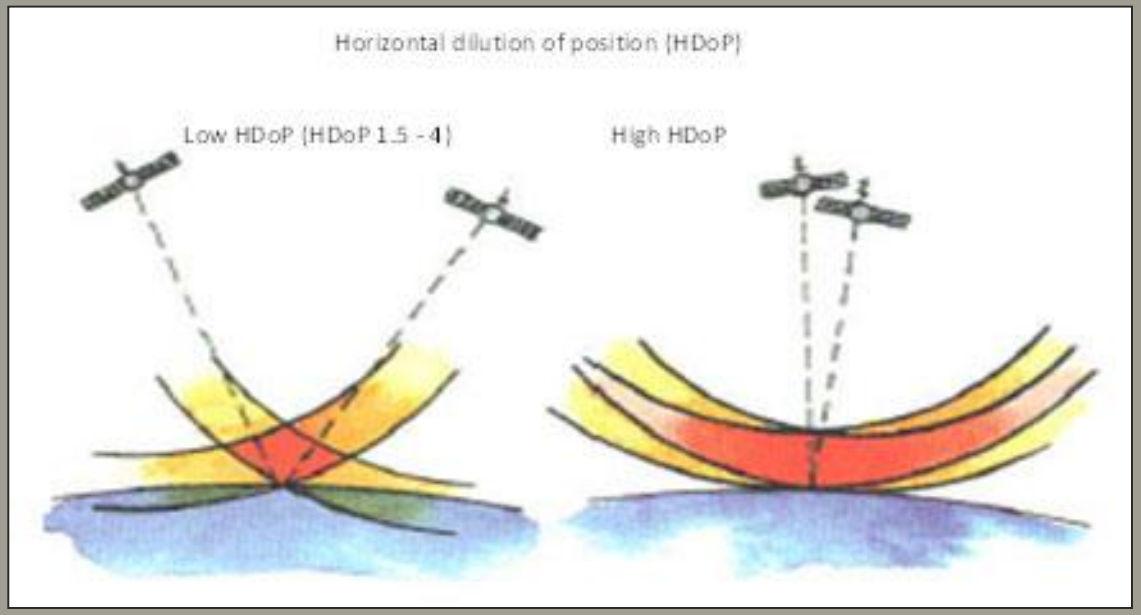
Let’s do it!
(but wait – what about GPS technology?)

Challenge: GPS technology

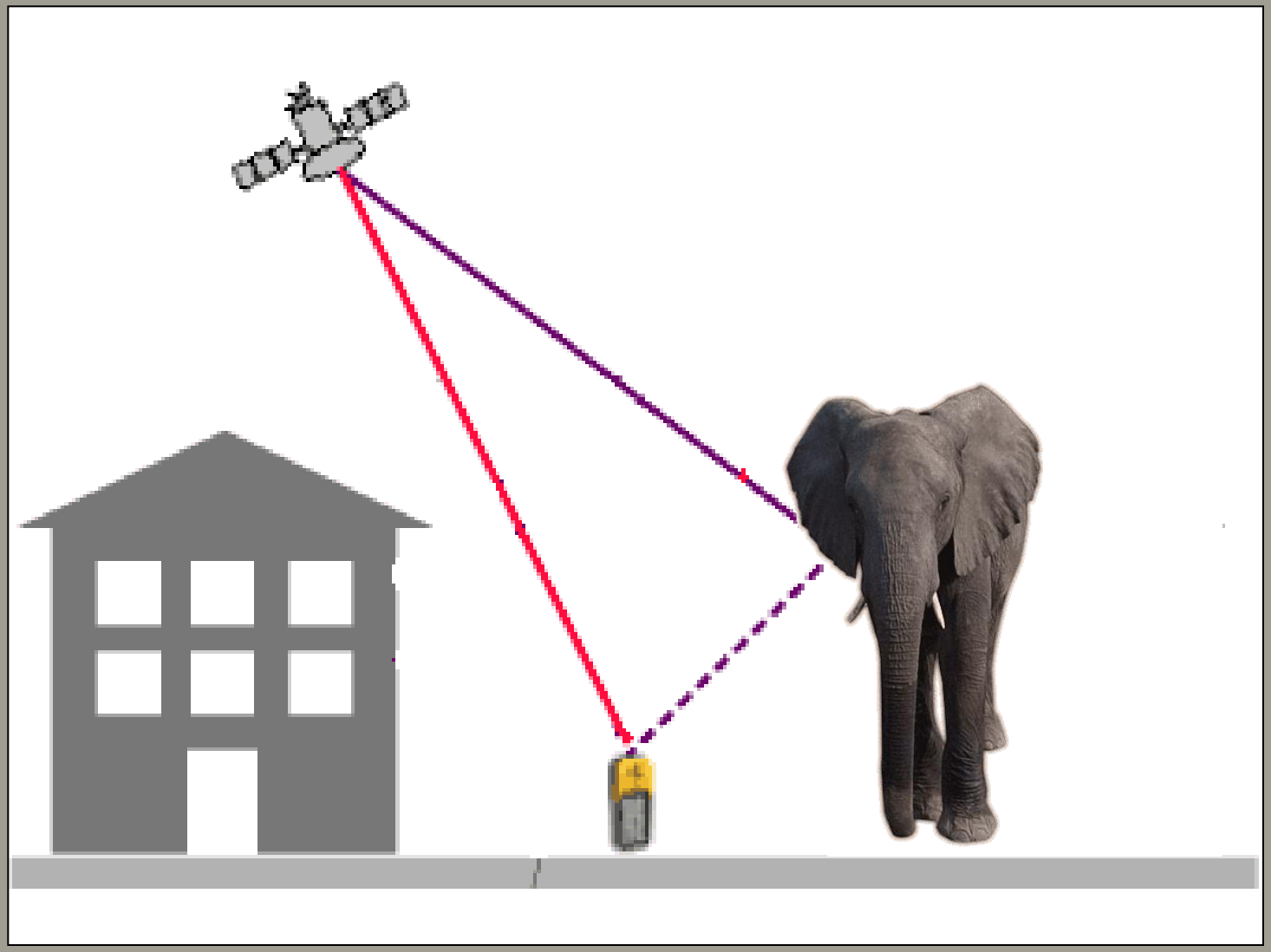


Challenge: GPS technology

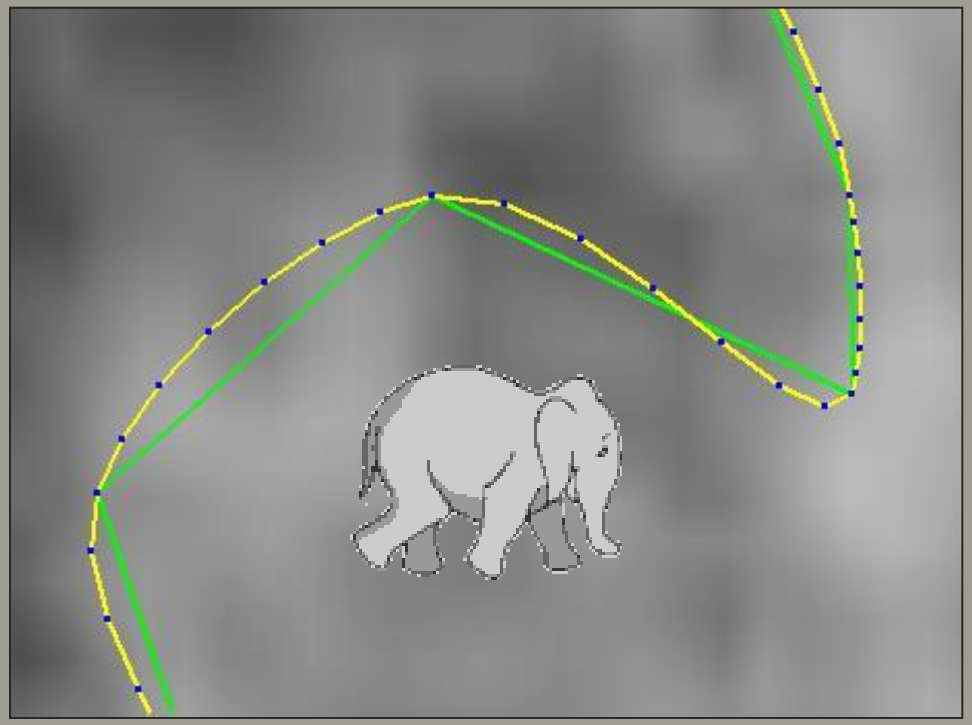


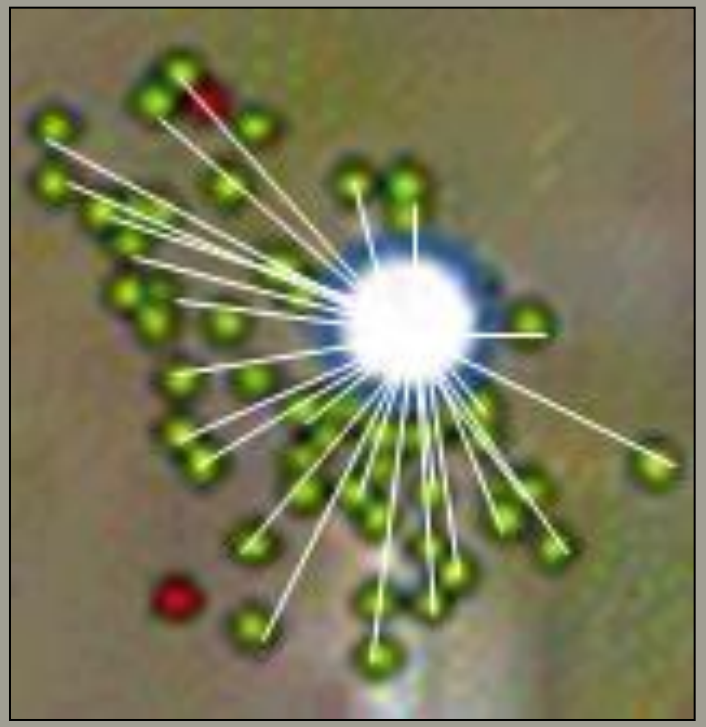


Challenge: GPS technology

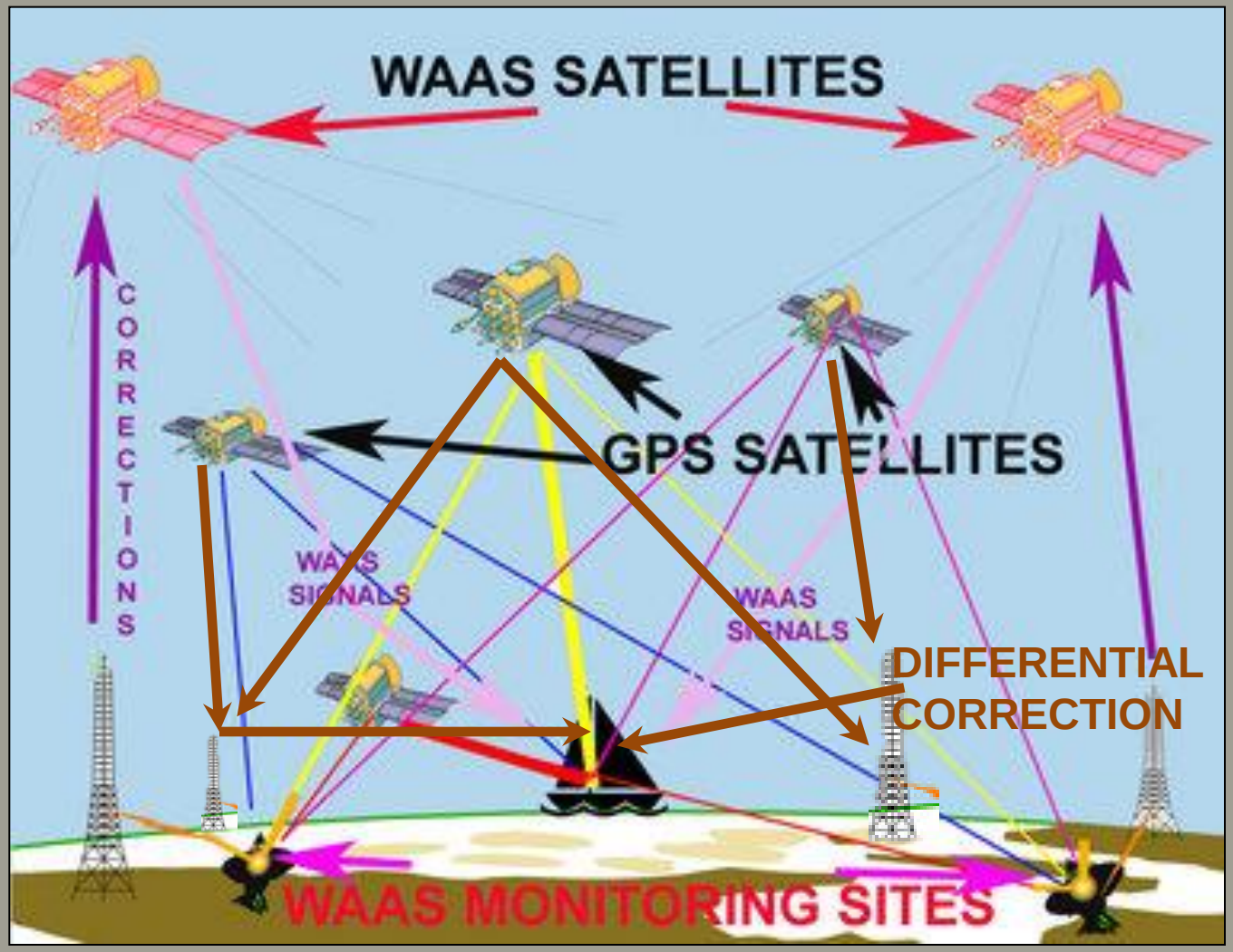


Challenge: GPS technology





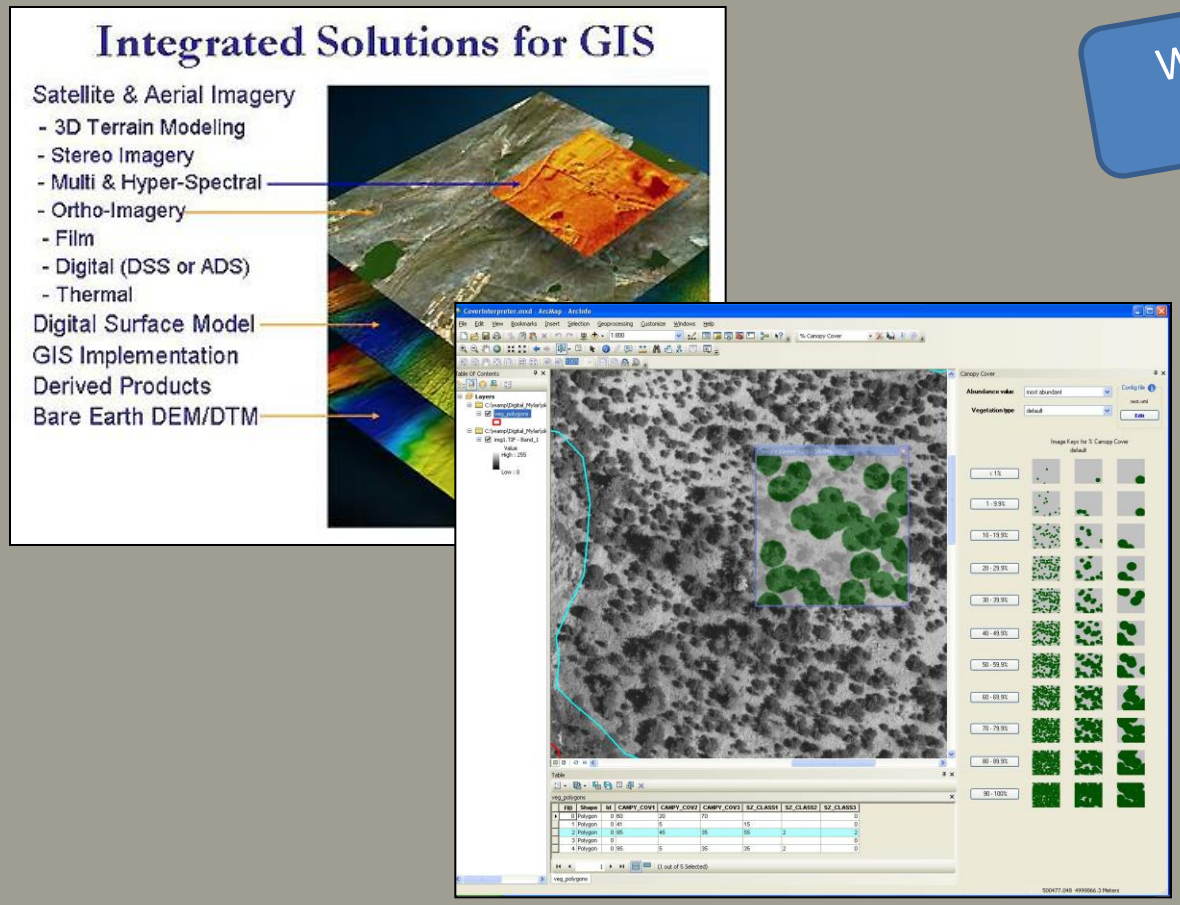
Challenge: GPS technology



Let’s do it!

(but wait – what about understanding spatial analysis?)

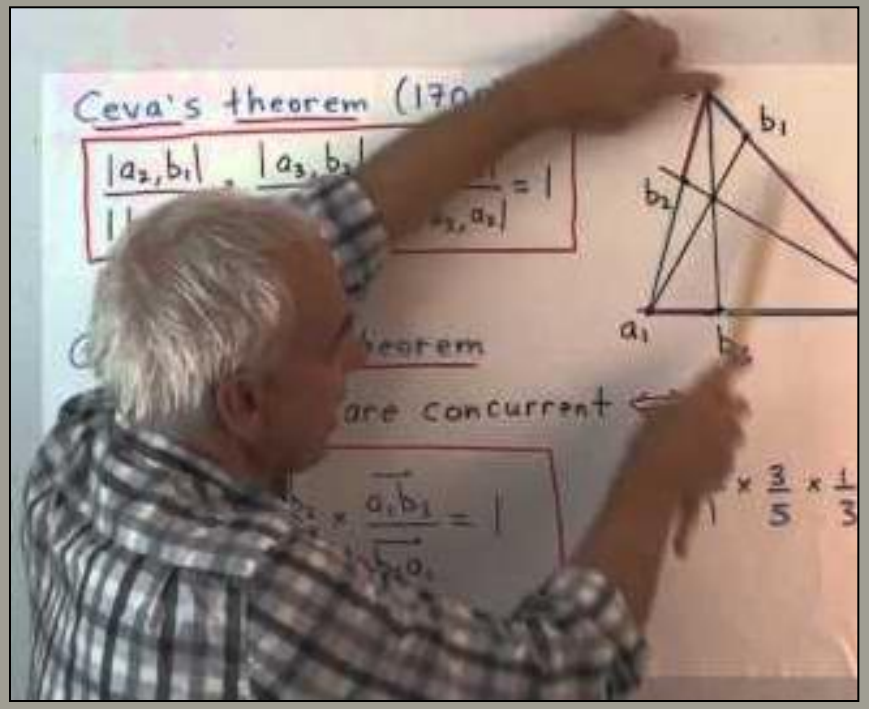
Challenge: GIS and Imagery

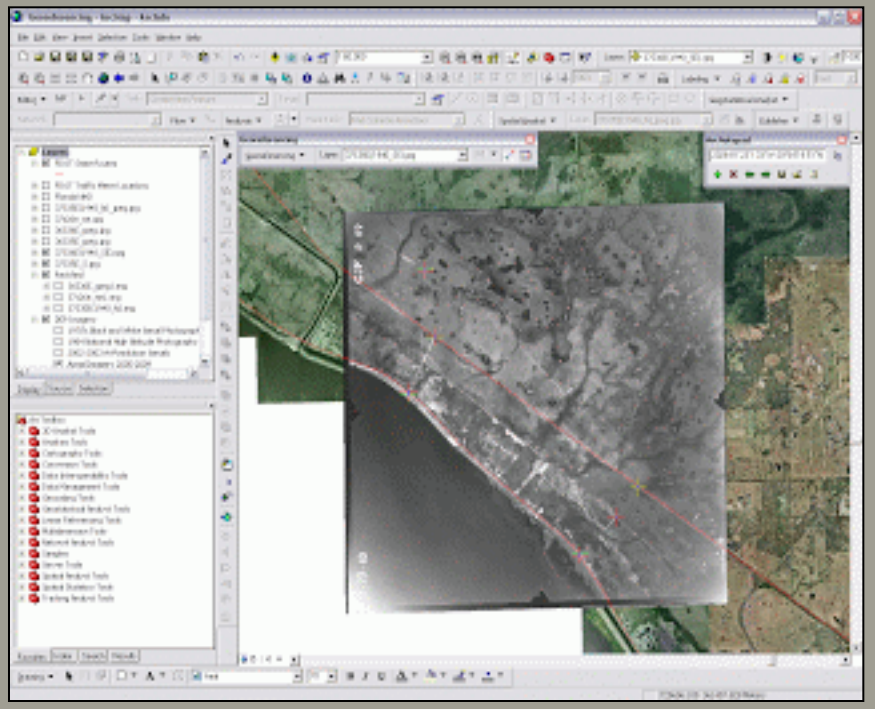


What projection are you using?

Challenge: GIS and Imagery

Challenge: GIS and Imagery



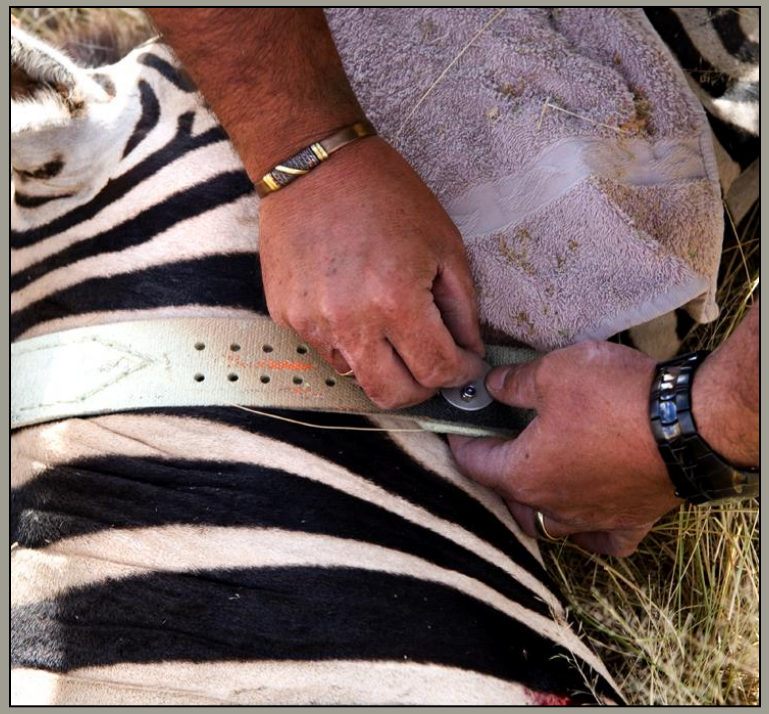


Challenge: GIS and Imagery

Let’s do it!

(but wait – what about a pilot study?)

Challenge: Pilot Study



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The effects of GPS collars on African elephant (*Loxodonta africana*) behavior at the San Diego Zoo Safari Park

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GPS

ABSTRACT

The use of tracking devices (e.g., VHF radio collars, GPS collars, ear transmitters) enables researchers to assess activity budgets, species-specific movement patterns, effects of environmental enrichment, and exercise levels in zoo animals. The fundamental assumption in these studies of tagged animals is that attachable tracking devices have negligible effects on the animals' behavior. The present study examined solitary and social behavior rates, as well as overall activity budgets, in eight African elephants living at the San Diego Zoo Safari Park, Escondido, CA, USA. Each elephant was trained over several months to wear leather collars affixed with GPS units encased in watertight plastic containers. Behavioral data collected while the GPS collars were worn (16 daylight hours, 16 night hours) were compared to behavioral data when the GPS collars were not worn (16 daylight hours, 16 night hours) throughout June and July 2010. No significant differences ($P < 0.05$) in behavior rates or average percent of observation time the subjects were recorded in particular states were found. During the morning hours, while the collars were both worn and not worn, feeding was the most common behavior state ($M = 44.7 \pm 3.8\%$, $M = 49.3 \pm 15.3\%$), followed by resting ($M = 35.5 \pm 10\%$, $M = 37.3 \pm 12\%$) and walking ($M = 10 \pm 3.1\%$, $M = 8.7 \pm 1.9\%$). During the evening hours, feeding remained the most common behavior state for both worn and not worn conditions ($M = 66.1 \pm 12.3\%$, $M = 63.3 \pm 13.7\%$), followed by resting ($M = 17.6 \pm 7.7\%$, $M = 19.4 \pm 9.5\%$), and sleeping ($M = 8.1 \pm 8.9\%$, $M = 7.8 \pm 8.1\%$). This distribution of daily behavior state is similar to previous activity budgets examined in other zoo elephant herds. These results suggest that, with adequate training, GPS collars may have minimal impact on the behavior of zoo elephants.

1. Introduction

African elephants have been in North American zoos for over 200 years (Schulte, 2000). The current AZA studbook for the African elephant, a computerized database of each individual animal under human care, states that there are approximately 171 females and 73 males being exhibited in 65 institutions across North America (Olson, 2011). While 36 of these animals were born on-site at zoological institutions, the vast majority of the adults were caught in the wild as juveniles during the ivory trade of the 1970s and 1980s (Olson and Wiese, 2000). The maintenance of elephants in zoos requires that careful consideration given to exhibit size, compatible social grouping, sheer physical management, and health care (Clubb and Mason, 2003; Mason and Veasey, 2010; Veasey, 2006). There is an increased interest in the activity budgets of zoo elephants as it relates to both physical well-being (i.e., obesity, degenerative joint disease, foot health: Gage, 2001; Roocroft, 2005)

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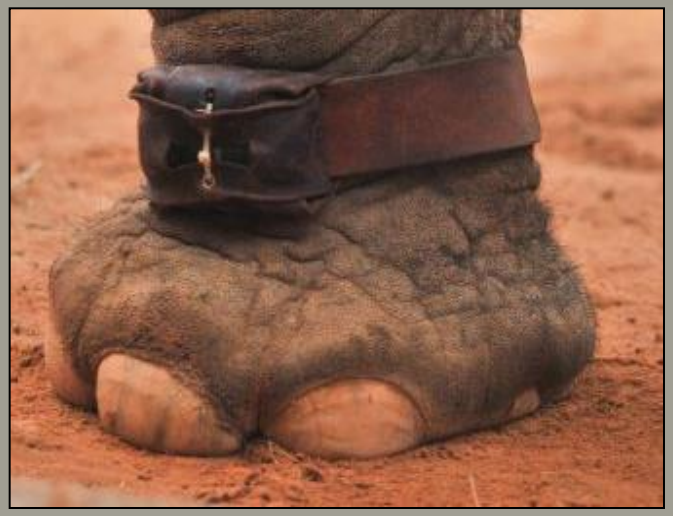
Challenge: Pilot Study



Training and Desensitization Protocol

IMLS Elephant Welfare Study: GPS

Step 1. Train foot presentation

The same behavior used to attach front leg chains and perform routine foot work; it's likely that your elephant is already trained for this.

Step 2. Introducing a prop

A prop is a device used to get your elephants used to wearing anklets. Most zoos will start with a length of chain slipped inside a piece of firehose, attached on the ends with a shackle. Practice putting the prop on and taking it off until the elephant gets used to the procedure. When putting on the prop, the safest method is to first position the prop on/over the bar, and then ask the elephant to present their foot (similar to image at left showing ankle-measuring procedures). Alternately, ask her to present her foot first, then reach around the leg to affix the prop.

Step 3. Beginning training

To properly desensitize your elephant to wearing the anklet, you need to employ traditional DRI (differential reinforcement of incompatible behavior) techniques. Begin by asking the elephant to perform behavior that takes her attention away from her anklet (e.g., ask for her trunk; ask for behaviors that she likes). The goal is to keep her occupied doing behaviors that are difficult to complete if she is also fussing with her anklet. Slowly lengthen the amount of time she wears the anklet while also desensitizing her to varying environmental and social situations. In all of the above situations you are trying your best to have her not play with the anklet. Have her come back and let you remove it *before* she starts playing with it. Eventually you must let her wear the anklet without you actually training her. When you do this watch her from a distance and gradually lengthen the time that she can wear the anklet without concern over it. Again, call her over and remove the anklet before she start playing with it.

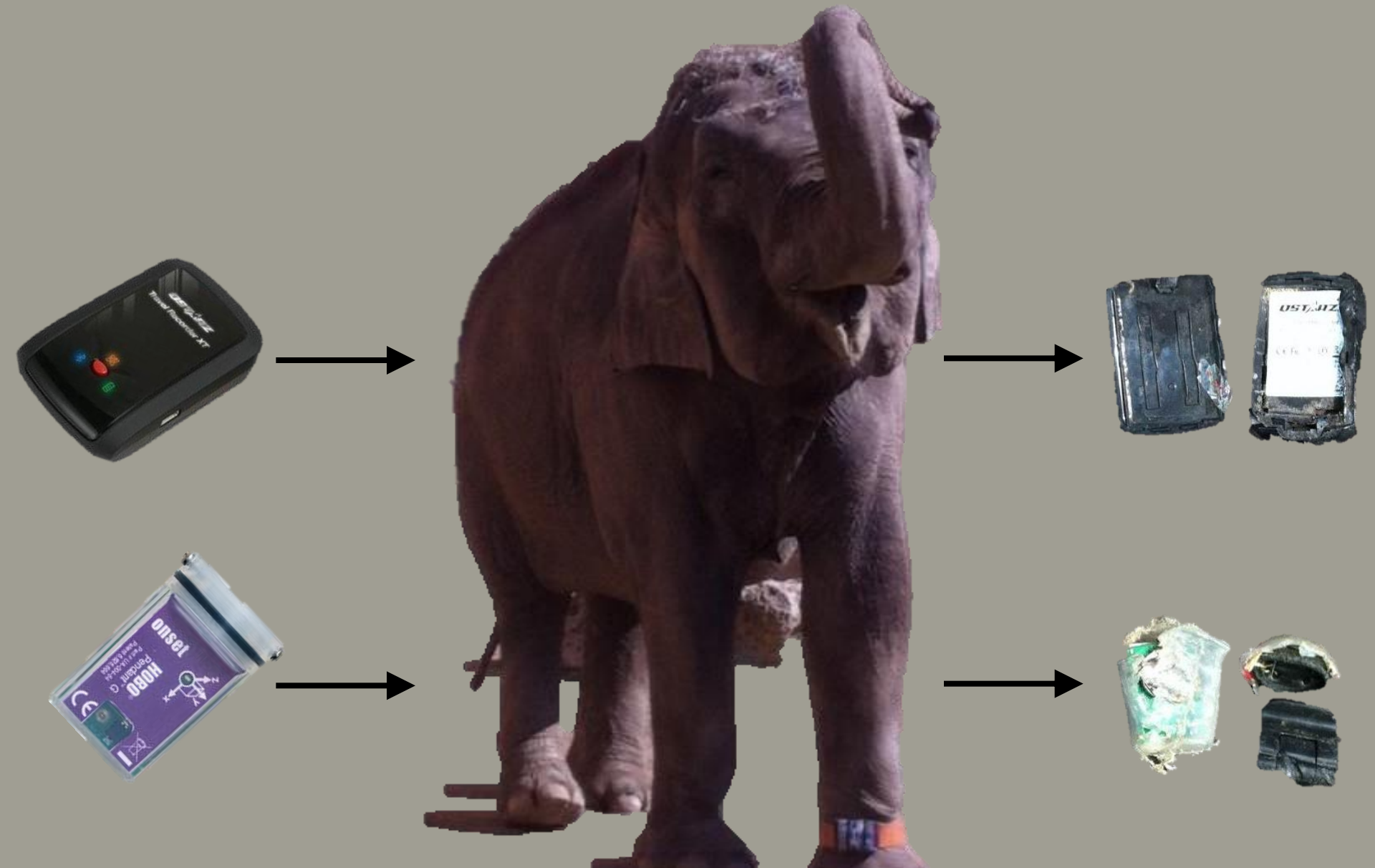
Step 4. Anklet training

If possible, work with a handy staff member or a local tack shop to develop your own training anklet. If this is not possible, don't worry. When you receive your kit from us, you will have 1-2 weeks of training time. Use the steps described above to desensitize your elephant to the new anklet before beginning data collection. During training, keep the otterbox in the pouch, but do not put the electronic equipment inside. Good luck and thank you!

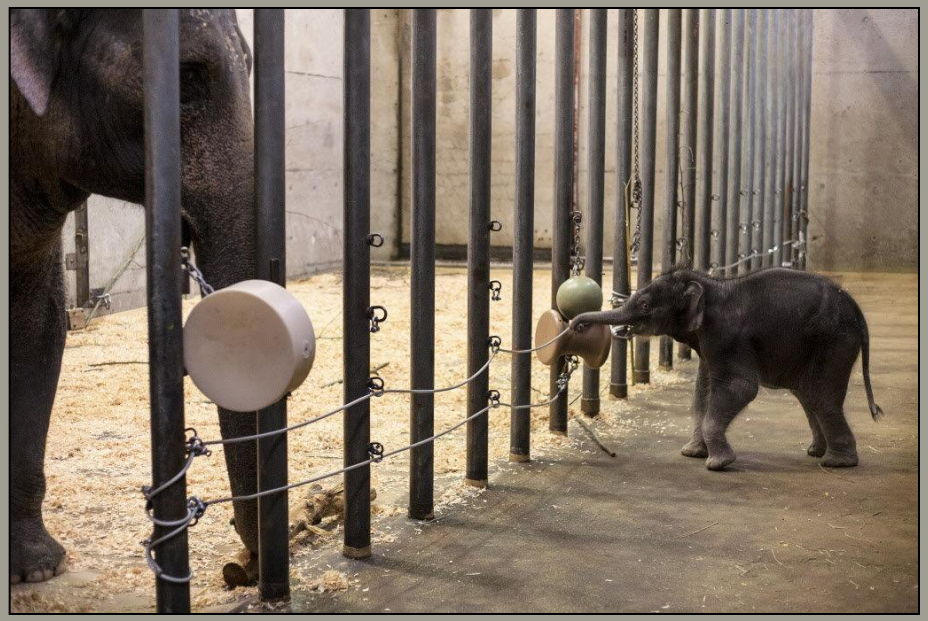
Have a problem elephant or need training advice?
Contact Jeff Andrews at **jandrews@sandiegozoo.org** or (760) 738-5063

Have questions about the project or want to know where to find brummel hooks, etc.?
Contact Matthew Holdgate at **mholdgate@gmail.com** or (503) 915-4919

Challenge: Pilot Study

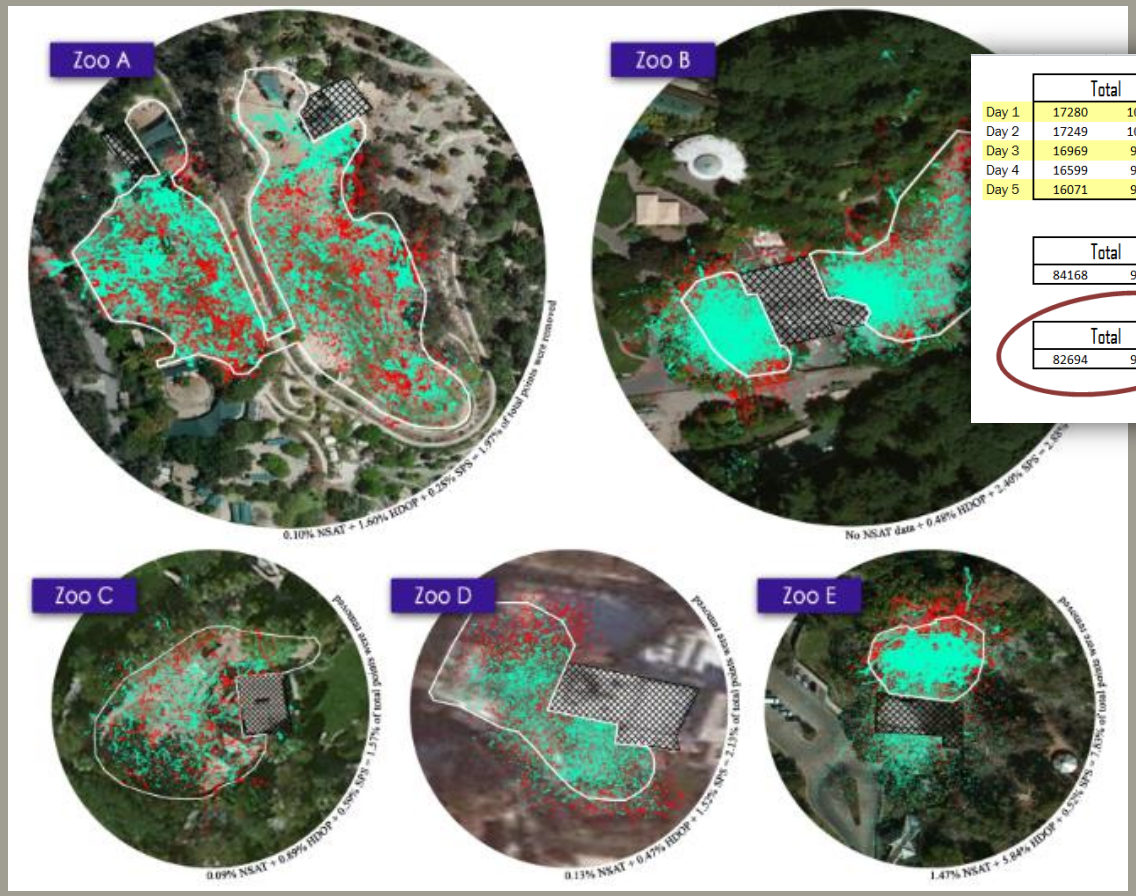


Challenge: Pilot Study



Challenge: Pilot Study

	Bad RCR		Bad VALID		HDOP >= 2		HDOP >= 3		Benefit		NSAT <6		NSAT <4		Benefit	
Total Fixes	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
113067	0	0.0%	292	0.3%	1835	1.6%	514	0.5%	1321	1.2%	1401	1.2%	52	0.0%	1349	1.2%
111257	5	0.0%	326	0.3%	1745	1.6%	569	0.5%	1176	1.1%	1430	1.3%	174	0.2%	1256	1.1%
14756	0	0.0%	308	2.1%	48	0.3%	10	0.1%	38	0.3%	81	0.5%	8	0.1%	73	0.5%
14588	0	0.0%	138	0.9%	91	0.6%	43	0.3%	48	0.3%	134	0.9%	31	0.2%	103	0.7%
40810	0	0.0%	163	0.4%	2216	5.4%	839	2.1%	1377	3.4%	7799	19.1%	744	1.8%	7055	17.3%
43812	3	0.0%	280	0.6%	2723	6.2%	806	1.8%	1917	4.4%	6717	15.3%	496	1.1%	6221	14.2%
47207	0	0.0%	392	0.8%	392	0.8%	60	0.1%	332	0.7%	367	0.8%	66	0.1%	301	0.6%
46517	0	0.0%	157	0.3%	442	1.0%	78	0.2%	364	0.8%	399	0.9%	21	0.0%	378	0.8%
432014	8	0.0%	2056	0.5%	9492	2.2%	2919	0.7%	6573	1.5%	18328	4.2%	1592	0.4%	16736	3.9%



	Total		RCR		VALID		HDOP >=2		NSAT <4	
Day 1	17280	100%	1	0%	2	0%	197	1%	3	0%
Day 2	17249	100%	0	0%	1	0%	85	0%	1	0%
Day 3	16969	98%	2	0%	105	1%	46	0%	6	0%
Day 4	16599	96%	0	0%	5	0%	181	1%	34	0%
Day 5	16071	93%	0	0%	13	0%	708	4%	84	1%

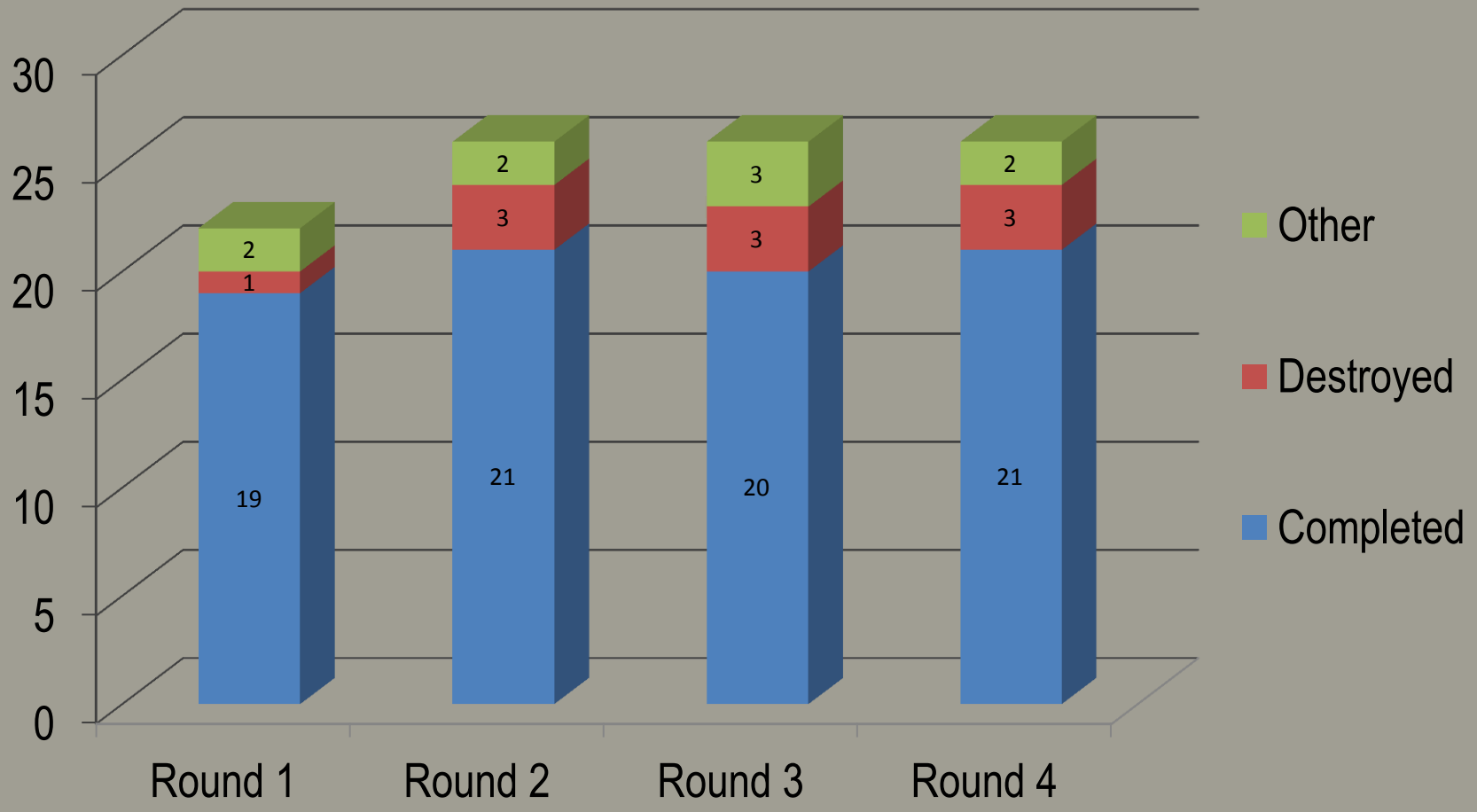
Total		RCR		VALID		HDOP >=2		NSAT <4	
84168	97%	3	0%	126	0%	1217	1%	128	0%

Total	
82694	96%

Let’s do it!
(okay!)

We did it!

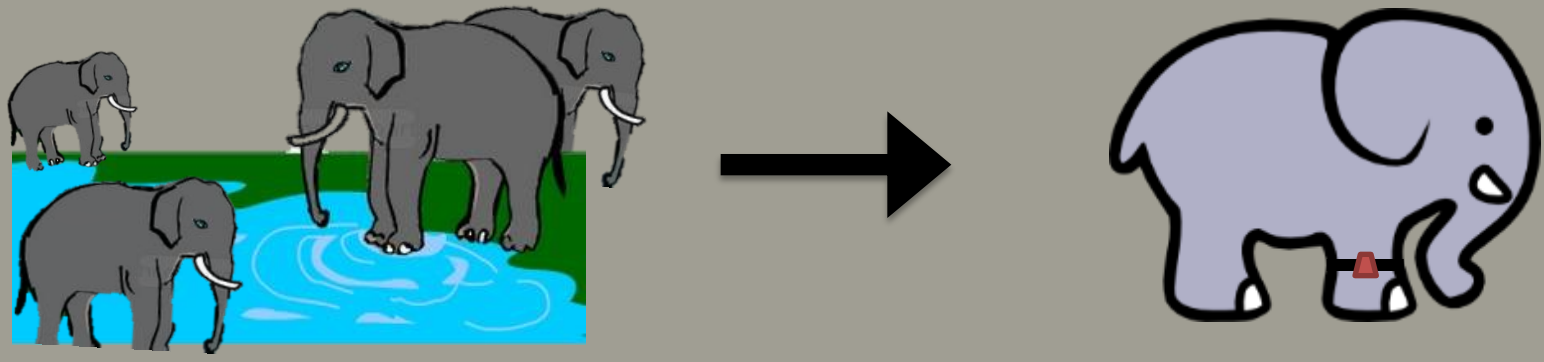
- Target population: 500 days of data from 100 elephants at 50 zoos
- Actual population: 386 days of data from 80 elephants at 43 zoos



Data Processing

- 86,400 data points/elephant; 6,912,000 total
- Inclusion criteria, GPS filters, spatial analysis
- Elephant survey data (species, age, body condition, health history, reproductive status, exercise)
- Zoo survey data (exhibit sizes, substrates, temperature, disturbance)
- Calculations of functional exhibit size and herd size

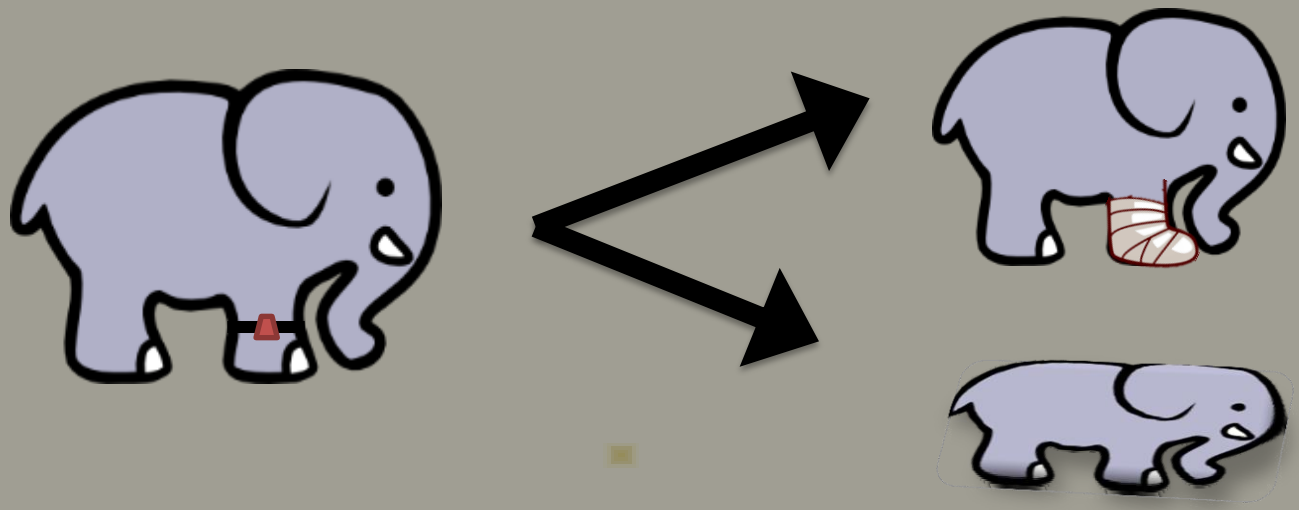
Research Questions



What are the factors that affect zoo elephant movement?

- Emphasis: exhibit size
- Emphasis: herd size

Research Questions



How does movement affect zoo elephant welfare?

- Emphasis: body condition score
- Emphasis: foot health

What factors affect zoo elephant recumbence?

- Emphasis: substrate

The elephants and I would like to recognize…

- Debbie Ethell, data intern
- Tim Alder, GIS intern
- Institute of Museum and Library Services
- Pittsburgh Zoo and PPG Aquarium's Conservation and Sustainability Fund
- Forbes-Lea Research Fund
- Marie Brown Travel Award
- Zoo visitors!

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Any questions?