Part 1 Questions & Answers Session

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Juan Torres-Perez (juan.l.torresperez@nasa.gov), Morgan Gilmour (morgan.e.gilmour@nasa.gov) or Claire Teitelbaum (cteitelbaum@uga.edu).

Question 1: Is there any guidance regarding the size/weight of the animal and size/weight of the transmitter or a 'rule of thumb' ratio for good practice?
Answer 1: Yes! Usually it's the permitting agency that allows you to deploy tags of a certain mass/size on each species. For birds, the accepted rule of thumb is 3% of the bird's body mass. Guidelines for walking (terrestrial) animals often use 5%. However, these will also depend on the types of habitats an animal uses and how fast it moves.

Question 2: In the sea lion study, what do the different colors in the graph/plot signify?
Answer 2: The different colors represent different habitat types (bare sand, kelp, etc).

Question 3: Which sensors does NASA use to locate the exact location of a particular animal? For example if it's the smallest bird that is rarely found?
Answer 3: Before deploying a tag, the animal must be located and caught, but locating and catching an animal before deploying a tag relies on a variety of methods. For some animals, acoustic recorders or cameras might help researchers locate a species. For others, it might be important to rely on local knowledge. Once a tag is deployed, a variety of systems (satellite, etc.) can be used to locate the tagged animal.

Question 4: We are facing issues of road kills for wildlife.
1. Where can we purchase tracking devices and where can we get the methods to install the device on the animals?
2. If fixing the device will affect the animal's daily life, as we are fixing something new onto their body, will it be animal cruelty?
3. Can this device provide realtime data/signal to any device that can be installed on the road area which can show a warning light/signal at the area for the road user to reduce the speed/stop?

Answer 4: A literature search (e.g., Web of Science; Google Scholar) will help you identify tags that you could use for your focal species and how to attach them. Researchers work hard to make sure that tags don't affect the animals' daily activities, and the attachment method is also regulated by permitting agencies. The idea to signal a warning light at a road crossing is a great idea! I don't know of any projects that are currently doing this, but it should be doable.

Question 5: I've noticed that some tags seem quite large relative to the size of the animal, like the one I saw on a bat. Has it been shown that some tags can affect the animal's behavior and prevent it from acting naturally?
Answer 5: Yes, some tags can affect animal behavior. This effect is relatively poorly understood because it can be difficult to compare behavior between tagged and untagged animals. However, some effects include reduced mobility, increased preening (or picking at the tag), and changes in social interactions. It is always important to understand these implications as well as possible when designing a study, which will be part of approvals for working with live animals. Finally, the weight of a tag and its size are not always directly related, so the large-appearing tag on the bat might still have been light enough.

Question 6: I'm still a little unsure about how "available" locations (or their spatial bounds, as for SDMs) are defined, if that can be clarified a bit more. It seems clear for "used" locations.
Answer 6: We will talk in more detail about this in Part 2 when we work through SDMs and SSFs. There are many different ways to define available locations. In step-selection functions, available steps are simulated starting at a used location. The distance the animal moves in a simulated step is drawn from the distribution of observed movement distances in the tracking data. Similarly, the angle that the animal moves is drawn from the distribution of observed turn angles in the tracking data. In SDMs, the available area can be defined based on the species' known range, the known range of other similar species, a buffered area around the observed locations, or a number of other methods. The selection of the available area will depend on the question being asked (for example, asking how two species differ in their distributions).

Question 7: What is the ideal time interval for identifying behavioral states, and what is an acceptable time interval (let's say for large, medium mammals)?
Answer 7: This answer depends on the types of behaviors you are trying to identify and

the time scales that they appear at. For example, it would usually be possible to distinguish migration and non-migration behaviors with daily locations for an animal whose migration takes 1 week or more. However, for an animal that transitions between behaviors rapidly (for example, searching for food and then caching it), much more frequent data would be necessary. A good rule of thumb would be to have >10 data points within each behavioral state, though this will depend on how distinct the states are.

Question 8: Is it possible to use satellite tags on small mammals, and if so, what kinds are available?
Answer 8: Yes, it's definitely possible! It depends on the species' size and how they move, and a literature search would help you find the types of tags that other researchers have used successfully.

Question 9: Is step-selection function better/more precise than species distribution models? Should step-selection function be preferably used when appropriate data is available?
Answer 9: Not necessarily. SSFs provide a more constrained and movement-specific definition of available habitat, so they are best for asking questions about how individual animals move within their home ranges or during dispersal events. SDMs can be used to ask broader questions about distributions of an entire species, and can also incorporate other data types (i.e., non-movement data, for example field observations).

Question 10: For slide 31, there was mention of a threshold used for cleaning data. Could you give an example of how a species-specific speed threshold is calculated?
Answer 10: One way is to calculate the mean and standard deviation of the animal's travel speed and make the threshold one SD away from that. Another way is to assess tracks and see what the maximum movement distance possible is, given the animal's habitat/environment (for example, if the maximum flight speed or maximum swimming speed of an animal is known).

Question 11: Are there any commonly used tools or packages suggested for animal tracking analysis?
Answer 11: We will give some examples of R packages and tools in Part 2. There are a lot of packages and tools available to help with these analyses! Here is a review (now a

little outdated, from 2020) of packages for analyzing animal movement data: https://doi.org/10.1111/1365-2656.13116

Question 12: Hi. I am studying the spatiotemporal ecology of yellow mongooses using only VHF collars (no GPS units on the animals), I'm currently relying on triangulation from multiple observer points. Are there any recommended complementary methods—such as passive remote sensing, autonomous receivers, or other spatial proxies—that could enhance data resolution without needing GPS collars?
Answer 12: Yes, passive approaches like RFID might help you record when an animal passes through a location, if you had a network of sensors through the animal's habitat.

Question 13: How did you get into this field of study? / What are some tools or skill sets that a student or an early-career researcher can learn on their own to get into the field of animal tracking and monitoring? Are there any open-source tools or initiatives one can take part in? Also, how can someone start a project from scratch with minimal resources?
Answer 13: I did field work with mainly birds for sometime, and others were doing tracking projects that I connected with while also going to grad school for it. First hand experience is recommended like volunteer opportunities. Coding skills are beneficial. Resources can be found in the slides on the training webpage. Claire has more of a background with GIS and math. From that perspective, a great way to get started is to work with others who have already collected data. It is important because data can be expensive to collect, so making the most of data that is already available is essential. https://science.nasa.gov/citizen-science/

Question 14: Are there public repositories of animal tracking data, or, do you have suggestions for networking with folks that have such data who are interested in working with data scientists?
Answer 14:
https://motus.org/ Also www.movebank.org and other links we have/will provide in slides from today and on Thursday. These organizations also provide guidelines for collaboration; for example, data on Movebank have an associated license and notes that indicate restrictions around their use. In many cases, researchers that collected data will note that they would like to be contacted.

Question 15: Could you also shed light on using Machine learning or deep learning algorithms for this purpose. I mean already computational complexities exist.
Answer 15: ML and other computational methods can help with analysis of animal tracking data and remote sensing data individually, as well as for the integration of the two. In Part 2, we will use boosted regression trees to perform a species distribution model. ML can also be used to process remote sensing data to get biological information.

Question 16: How are the outliers handheld in the aggregation of groups in the same species? I am thinking about horses in this question.
Answer 16: Outliers (points that are far away from the rest of the data) are typically removed, but if you keep them in, they will likely average out across your whole group.

Question 17: Does surveying drone is incorporated in animal tracking , can you give some insight regarding drone and animal tracking drone surveying used in animal tracking? Please provide insights into the application of drones in this field.
Answer 17: Drones are sometimes used to identify areas where animals hang out, and sometimes to make counts of animals. I'm not aware of drones that receive tracking data, but that could be cool!

Question 18: What types of land cover can be mapped using remote sensing?
Answer 18: We have a number of ARSET trainings on this topic. Please see:

- Hyperspectral Data for Land and Coastal Systems
- Remote Sensing for Conservation and Biodiversity
- Land Cover Classification with Satellite Imagery

Question 19: I downloaded R and & Rstudio, will that be needed for the homework?
Answer 19: No, R is needed to follow along with the examples in Part 2 but not for the homework. The homework will be posted to the training webpage on Thursday, under Part 2.

Question 20: Is it feasible to study the spatial distribution of wild animals in protected areas and estimate their future distribution inside it ?

Answer 20: Yes! We can combine animal tracking data and remote sensing and projected environmental condition models to do this, and we'll provide an example in Part 2.

Question 21: Where/when will you be posting the results of your Internet of Animals report, where you gathered input on needs and recommendations from the community/experts? Looking forward to it!
Answer 21: Our team is working on a manuscript draft of this as we speak!

Question 22: When someone wants to study movement patterns of tracked animals and how they select habitat in response to habitat features, what are the best covariates they should consider and what will be the best model approach if they want to study at the individual variability level?
Answer 22: We'll cover this in the second session on Thursday. A literature search is a good place to start thinking about this for your focal species and study system.

Question 23: If I have tracking data over a suspected ontogenetic shift in relation to environmental covariates, can the panelists recommend some methods that allow the relationship of the covariates to the movement data to change over time?
Answer 23: SSFs could be a good option for this question, if you fit an interaction between ontogenic state (or time) and your environmental variable. This general approach of using an interaction would also work with other regression-type analyses.

Question 24: When should (i)SSF be used rather than RSF ?
Answer 24: This depends on the data you have available and the question you want to answer. SSFs are very well suited for understanding third-order habitat selection (the selection of specific habitat patches or resources within an animal's home range), but are not as flexible for other questions (for example, for mapping species ranges). SSFs also require regularly sampled data.

Question 25: Are there suggestions for what workflow and tidyapps or other resources to use when interested in doing analyses on both the individual and population levels? I have data collected at 5 minute intervals for ~50 moose and want to do both...but it's a ton of data before even bringing in remotely sensed imagery!

Answer 25: Movebank has some tools to integrate remote sensing data with animal tracking data (Env-DATA). There are other resources that we'll share in the slides from today and in Part 2. These tools can help because they allow you to extract environmental data "in the cloud" without having to bring it onto your own machine (although they have some limitations with regard to data availability or other specifications). Google Earth Engine might be another good option for this, because you can work in the cloud.

Question 26: A GNSS on a herbivore (for example, a cow) in a mountain pasture is supposed to give us its position. The question is whether we can use the accelerometer to also infer whether, through the movement of its head, it is eating. How could this information be analyzed?
Answer 26: There are toolboxes and R-packages to process accelerometry data, and so it could be possible to do this!

Question 27: How can Step Selection Functions be integrated into species distribution models to account for fine-scale movement behavior and habitat selection, and what are the implications of such integration for improving the spatial accuracy of predicted species distributions under changing environmental conditions?
Answer 27: As noted above, SSFs are particularly well suited for modeling third order habitat selection (the selection of specific habitat patches or resources within an animal's home range). By integrating SSFs with other SDM methods, you could gain a multi-scale understanding of habitat selection and species distributions. Most SSF and SDM methods can be used to make projections under changing environmental conditions, by using the models to predict on new spatial data. Because SSFs can be used to simulate movements (more on this in Part 2), they could be used to better understand whether the expected areas of expansion of a species' range are actually accessible to that species. For example, if an area that is predicted to be suitable in the future is across a mountain range from a species' current range, an SSF could inform whether an animal would be capable of crossing that mountain range.

Question 28: As I'm not from a coding background, other than R. Is there any other ways out to study species distribution?
Answer 28: The software MaxEnt could be helpful. There are also a number of R packages with tutorials and vignettes that will walk you step-by-step through data

processing and analysis. It is also possible to use GIS software to extract data at used and available (i.e., presence and absence) points, then use other statistical software of your choice to perform analysis (e.g., logistic regression).

Question 29: I always have limitations in progressing in the data filtering and preparation stage... What do you think about doing the analyses based on interpolated data, such as using the State Space Model, both for the home range and for other uses?
Answer 29: Yes, this is one approach that you can use. It is possible to use polygons instead of individual movement points to assess how species use habitats. However, it is always important to understand the assumptions you are making. For example, a point from an interpolated track may not represent an animal's true location.

Question 30: Are logistic regressions always the more appropriate tools ? Often their initial assumptions are not respected by biologging data.
Answer 30: Logistic regression is definitely not always the most appropriate tool. As you note, the assumptions of logistic regression are often violated (for example, independence). Sometimes, violating some assumptions is acceptable as long as you understand the implications for your results. However, other methods that account for temporal correlations are also useful.

Question 31: I have a question for the pre-processing of SSFs : If we remove points from the dataset, how can we deal with the "breaks" we created in the time-lags?
Answer 31: We will cover this more in Part 2, but SSFs can easily accommodate breaks in the data. In brief, breaks in the data are ignored (not used to estimate distributions of step lengths or turning angles, or used as starting locations for simulating available steps).

Question 32: Is it possible (and how) to combine camera-trapping and biologging data ? It is a very different type of information, biologging is more animal-centered and exhaustive but has a huge shortcoming: the absence of real absence. Camera-trapping are more susceptible to stochasticity because of unfrequent/unregular visits but have real absence data on some specific points.
Answer 32: These data types are very different, which is actually why it is so powerful to combine the two. SDMs can incorporate both types of data. Here is an example of a

study that does so: https://doi.org/10.1111/ddi.13223. Some key considerations might be sub-sampling data to be more similar (for example, using daily instead of hourly telemetry locations, or using the same number of telemetry and camera data points). As you suggest, it could also be possible to use cameras for true absence data while using animal telemetry/biologging as presence data. Finally, it is important to match the spatial scale of the data types; for example, a camera may capture animals in a relatively wide area whereas a GPS tag provides a very precise location. In this case, you may want to use a buffer around GPS locations to account for differences in spatial precision of the two data types.

Question 33: What are the key challenges in training AI models on irregular or sparse animal tracking datasets, especially for endangered species, and how can these be overcome using NASA's open datasets or transfer learning approaches?
Answer 33: Sparse tracking datasets in general can lead to overestimation of species' movements and habitat use, and could lead to misinterpretation of the habitats that a species actually uses. This may occur despite the data analysis approach that you choose. In fact, AI and ML tools often require more data than traditional statistical analysis, so they might require creative approaches, for example incorporating data from related (proxy) species or environmental proxies for species presence. Using data on a species' environmental niche (for example, using NASA remote sensing data) could help inform locations to search for animals in the field, which would then provide more data on these rare species.