VWJD Workshop Tutorial: How to use Movebank

Vereinigung der Wildbiologen und Jagdwissenschaftler Deutschlands e.V.
Wildtiere in Raum und Zeit
Rheinische Friedrich-Wilhelms-Universität Bonn
Workshop: Telemetrie in der Wildtierforschung—Möglichkeiten und Grenzen
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Movebank Tutorial Instructor: Sarah Davidson, sdavidson@orn.mpg.de

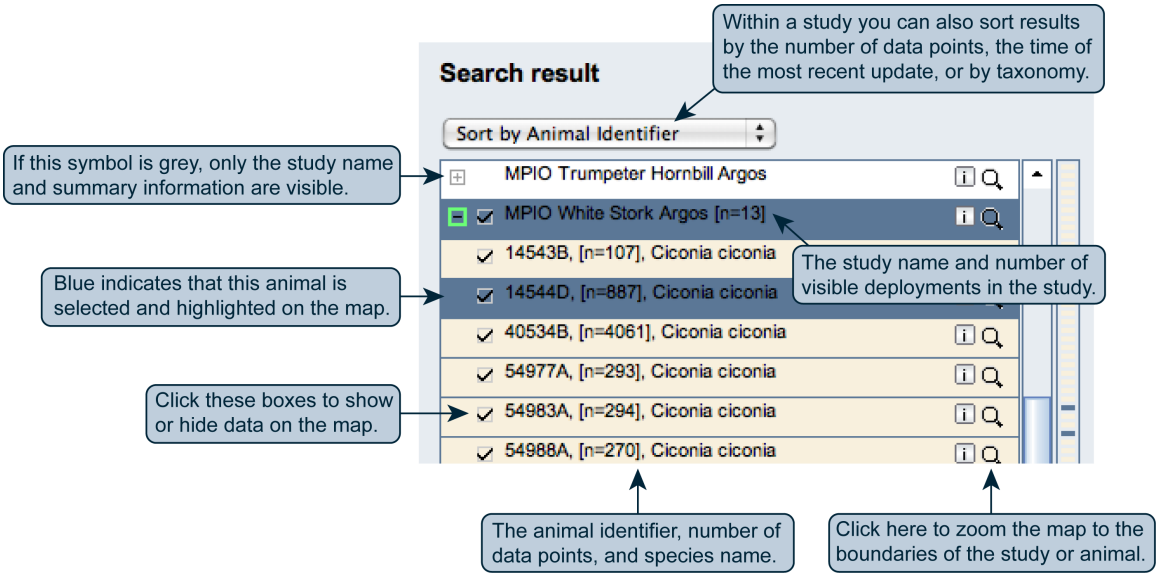
In this tutorial, you will first learn how to look for animal tracking data in the database. Then, you will create your own study and upload a sample dataset that we can work with. This will give you a chance to see how researchers use Movebank to store, share, manage, and analyze their data.

Browsing the database

Anyone can browse the Movebank database without registering on the site or asking for any special permission. If you are not logged in, you will have access to all the information that researchers have chosen to make available to the public.

1. Go to www.movebank.org and click on **Tracking Data Map** from the main menu.

This is where you can find and use data from the database. Once the page loads, you will see a list of studies on the left and a map on the right, with dots indicating the reference location for each study. The color of the dots on the maps, along with the color of the small square to the left of each study name, indicates the level of access available to the study. Gray indicates that only the study name and summary information are visible; light green indicates that one or more animal tracks can also be viewed; and dark green indicates that all of the animal tracks can be viewed and downloaded by the public. Remember that there are also studies in Movebank that users have not made visible to the public, so the studies you see do not represent everything in the database.



2. Try searching for a study that interests you. In the main **Search** field, you can search for any words that are included in the study details, which commonly contain geographic locations, common species names, and the names of researchers leading the project. In the **Advanced Search** field, you can search by the scientific name

of a species or taxonomic group. You can also filter for studies with data collected using a specific sensor type or for studies that allow you to view the tracks.

3. Once you find a study name that looks interesting, go to the **Studies** page to read more about it: Click on the "i" to the right of the study name and select **Open in studies page**. Here you can see a description of the study provided by the data owner and statistics about the dataset, including the species and number of animals, the time of the first and last locations, and the type of sensor used to collect the data.

Uploading data

Movebank users who collect their own animal tracking data can create Movebank studies and import their data to the database. The data owners control what is in their study and who can access the study and data. Now you'll learn how to create a study and import custom-format data to the Movebank database.

For this workshop, we will upload a dataset containing tracks of five European roe deer (*Capreolus capreolus*). GPS sensors attached to collars on the animals tracked their movements in northern Italy between 2005 and 2008. These data were collected by Dr. Francesca Cagnacci, from the Fondazione Edmund Mach, under grant no. 3479 from Autonomous Province of Trento to FC (BECOCERWI-Behavioural Ecology of Cervids in Relation to Wildlife Infections). These data are part of the EURODEER database, a collaborative database of roe deer tracking data collected by 22 research groups (https://sites.google.com/site/eurodeerproject).

Step 1. Register or log in on Movebank.

To add content to Movebank, you must be logged in.

1. To log in, enter a username and password in the **User login** box. For this tutorial, we will use the following user account:

   Username: VWJD 2012
   Password: vwjd2012!

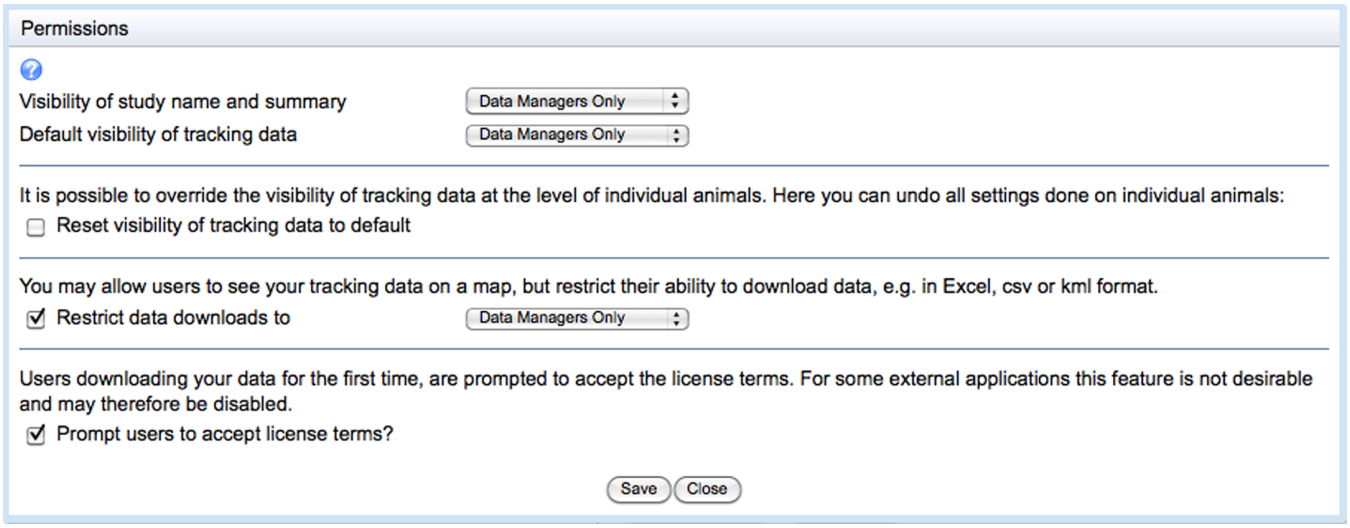
Step 2. Create a new study.

1. From the **Tracking Data Map**, select **Studies** and then select **New Study**.
2. You'll now be asked to provide some study details. Name your study "VWJD workshop Capreolus capreolus Italy <your last name>".
3. Use the description above to provide some study details. For the reference location, use the location of the Fondazione Edmund Mach in northern Italy, at 11.135° E, 46.195° N.
4. Once you are finished, click **Save**.

Step 3. Set permissions.

Because you haven't yet uploaded and organized any data, let's set the permissions so that the study is totally private. This way no one else will be able to see your study. We can change these settings later if we want.

1. From the study menu for your new study, go to **Sharing** > **Permissions**.
2. Make sure that **Visibility of study name and summary** and **Default visibility of tracking data** are set to **Data Managers Only**.
3. Make sure the **Restrict data downloads to** button is checked, and select **Data Managers Only** from the dropdown box to the right.
4. Select **Save**.



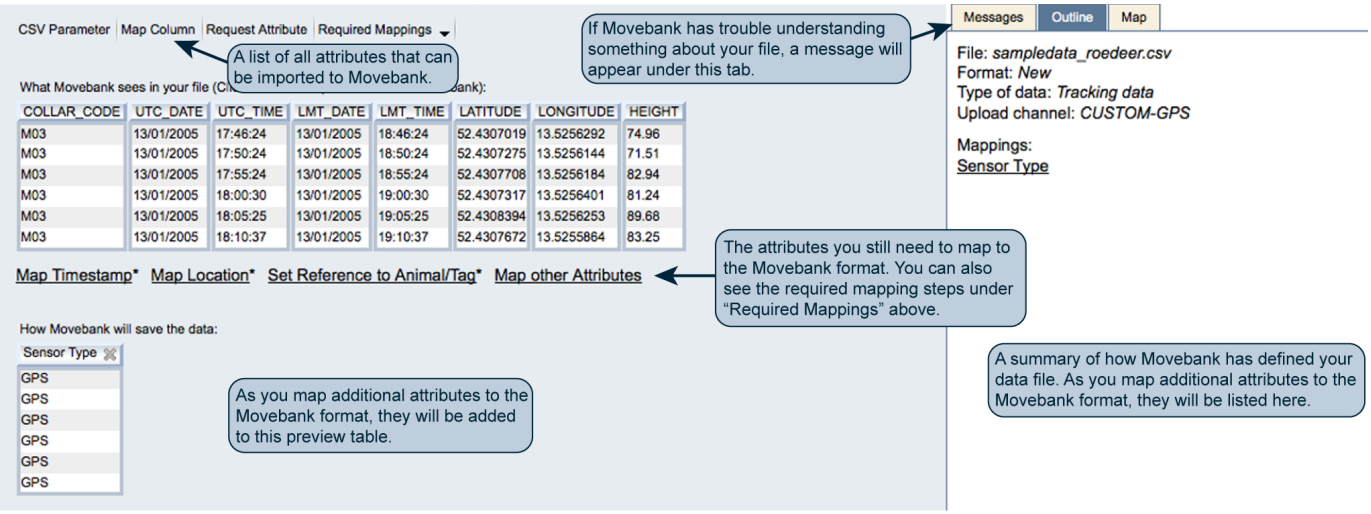
Step 4. Upload a custom format dataset.

Now you're ready to upload some animal tracking data to your new study. Movebank allows users to upload tabular text files (such as .csv files) and map each column in the dataset to an attribute in the Movebank database.

1. From the study menu for your study, select **Upload data**.
2. Choose **Upload GPS data** and then **Upload custom GPS data**.
3. Select **Choose file** and navigate to the file *sampledata_roedeer.csv*, located on your desktop.
4. Click **Upload**.
5. You will be asked to confirm that you are the owner of the data file you are uploading, or that you have permission from the data owner to upload the data. Select **Ok**.

Wait while the upload interface opens. This interface will assist you in correctly mapping your dataset attributes to the Movebank database. In the upper left, you should see a table that shows the first several rows of your data file. Below, you will see a table showing the attributes that have been imported to the Movebank format.

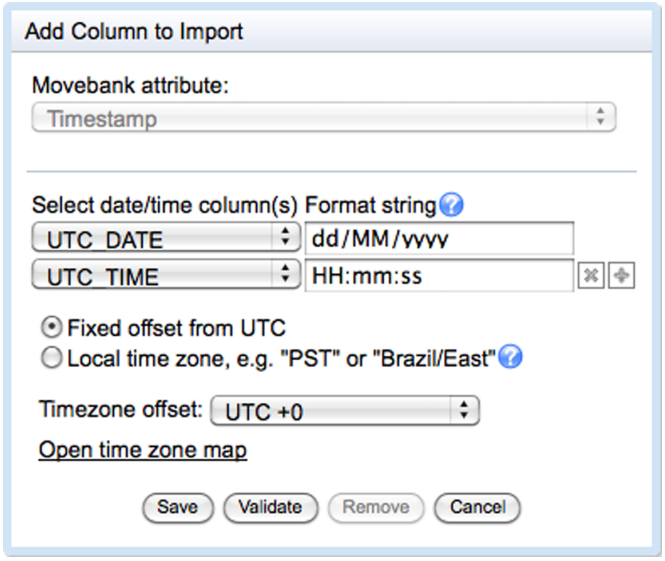
To upload tracking data to Movebank, you must provide at minimum the date and time, latitude, longitude, a sensor type, and a reference to a unique identifier for a tag or animal. Because you chose to upload GPS data, Movebank has already added the "sensor type" attribute to your dataset for you.



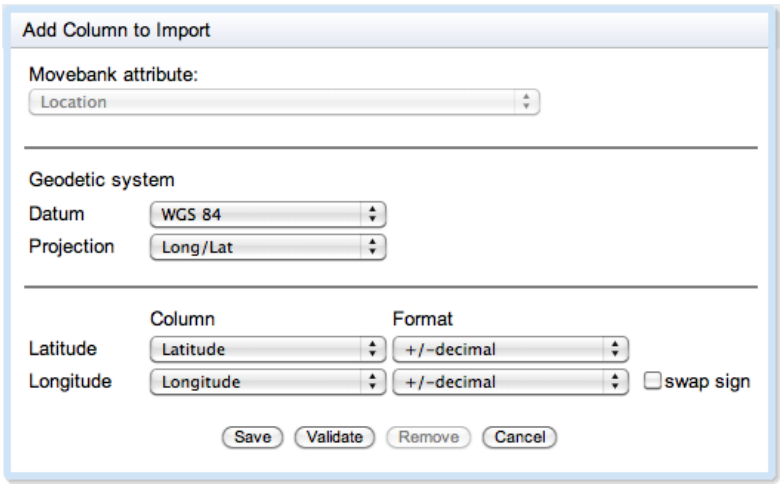
6. First, you'll map the Timestamp attribute. Click on **Map Timestamp**. A window will open to help you describe to Movebank how your date and time information are described in your data file.

In our data file, we have the timestamps both in UTC time (columns "UTC_DATE" and "UTC_TIME") and in the local time, which is UTC + 1 hour ("LMT_DATE" and "LMT_TIME"). You could use either of these to map the timestamp to Movebank, but it is slightly easier to use the UTC times:

7. Under **Select date/time column(s)**, select "UTC_DATE" from the dropdown box that lists the attributes in your dataset.
8. Under **Format string**, type "dd/MM/yyyy".
9. Now select the "+" to the right of the format string field. Another row of fields will appear to let you use an additional column of your dataset to describe the date and time information.
10. In the new dropdown box under **Select date/time column(s)**, select "UTC_TIME".
11. In the new field under **Format string**, type "HH:mm:ss".
12. Make sure the box next to **Fixed offset from UTC** is selected, and the **Timezone offset** is set to "UTC +0". (You could also map the "LMT_DATE" and "LMT_TIME" columns as described above and set the **Timezone offset** to "UTC +1". Either way, Movebank will map your timestamp information to UTC time in the Movebank format.)



13. Select **Save**. The Timestamp column will be added to the table under **How Movebank will save the data**, showing the date and time in the format "yyyy-MM-dd HH:mm:ss". Compare these timestamps to your original file to confirm the attribute was mapped correctly. If you need to edit the mapping, select the column header to re-open the import options.
14. Next, we'll map the latitude and longitude information. Click on **Map Location**. A window will open to help you describe to Movebank how your location coordinates are described in your data file.



15. Under **Geodetic system**, make sure that the **Datum** is set to "WGS 84" and the **Projection** is set to "Long/Lat".
16. Next to **Latitude**, select "LATITUDE" from the dropdown box that lists the attributes in your dataset.
17. Next to **Longitude**, select "LONGITUDE" from the dropdown box.
18. Make sure that the **Format** for both latitude and longitude is set to "+/- decimal".
19. Select **Save**. The "Location Lat" and "Location Long" columns will be added to the table under **How Movebank will save the data**, showing the latitude and longitude, projected in the WGS 84 datum, formatted in decimal degrees. Compare these values to your original file to confirm the attribute was mapped correctly.
20. Next, we'll map information about our tags. Click on **Set Reference to Animal/Tag**.
21. Under **Select tag id column** in the window that opens, select "COLLAR_CODE" from the dropdown box.
22. Under **Select animal id column**, make sure none of the columns are selected (a blank field is located at the top of the list in the dropdown box). We will provide Movebank with information about the animals later.
23. Select **Save**. The "Tag Id" column will be added to the table under **How Movebank will save the data**, showing the tag identifiers provided in the "COLLAR_CODE" column of our dataset. Compare these values to your original file to confirm the attribute was mapped correctly.

At this stage, you have told Movebank everything we need to in order to import the data. However, you can also map an additional column of the dataset.

24. Click on the column header "HEIGHT" from the table under **What Movebank sees in your file**.
25. In the window that opens, select "Height Above Ellipsoid" from the list under **Movebank attributes**.
26. Make sure that "HEIGHT" is selected under **Select file column**.
27. Select **Save**. The "Height Above Ellipsoid" column will be added to the table under **How Movebank will save the data**. Compare these values to your original file to confirm the attribute was mapped correctly.
28. Now we're about ready to import the file to Movebank. Before we finish, take a look at the summary under the **Outline** tab on the right. Here we can see a summary that includes our file name and a list of the attributes we have mapped to the Movebank format.
29. Click on the **Messages** tab on the right. This is where Movebank will warn you about any potential problems Movebank has noticed. Messages in blue are just notes you might find useful, and do not indicate errors. Messages in orange indicate that Movebank has noticed a possible mistake in your data file, such as a row where the latitude and longitude fields are blank. Messages in red indicate that there is an error and Movebank will be unable to import your file until the problem is fixed; for example, if you have text values in a field that can only contain numbers.

30. Lastly, click on the **Map** tab on the right. Here you will see a map with a pink dot showing the location of the first few rows of your data file. For this file, the dot should be located in northeastern Germany, near Berlin. If this dot is in the wrong place, then you may have made a mistake while mapping the location coordinates.
31. If everything looks ok, go ahead and select **Finish**.
32. Before you finish the import, you can choose whether to save a file format and whether to remove duplicate rows in your data file. Saving a file format allows Movebank to remember the settings you used to describe your data file, so that you can upload additional files in the same format quickly, without having to define every attribute in the file again. You can keep the selections Movebank has made, saving a file format and filtering for duplicates by tag and timestamp. Select **Ok**.
33. After the import is complete, a window will open saying that the import was successful. Now let's take a look at the uploaded tracks! Select **View Data** from the list of options.

By exploring the map, you will notice that there seem to be some locations on the tracks that are outliers or unrelated to the true animal tracks. The locations that look like animal tracks are located near Trento in northern Italy. You'll also see that the tracks listed on the left all say "unmapped". This is because all we have done so far is upload some GPS data to Movebank, without defining what animals the GPS tags were deployed on and when. To explain this information to Movebank, and organize the tracking data in our study, we need to give Movebank some reference data.

Describing tracking data with reference data

If we want to view and understand animal tracking data, we need more than just times, locations, and tag identifiers. Most importantly, we need to know what species of animal the tags were deployed on and when. We also might want to know other information: Who manufactured the tags? Are the animals male or female? Do the animals represent multiple study groups in a research project?

To help describe the animals, tags, and deployments in our study, we can add "reference data" to our study in Movebank. We will do this by uploading a table of descriptive information to our study.

1. From the study menu for your study, select **Upload data**.
2. Select **Upload tables about animals or tracking tags**.
3. Select **Use custom reference data format**.
4. Select **Combination (animal, tag, and deployment data in a single file)**.
5. Select **Choose file** and navigate to the file *sampledata_roedeer_referencedata.csv*, located on your desktop.
6. Click **Upload**.
7. You will be asked to confirm that you are the owner of the data file you are uploading, or that you have permission from the data owner to upload the data. Select **Ok**.

When the upload interface opens, you will see that it looks very similar to the interface you used to import your tracking data. To upload reference data to Movebank, you will need to provide unique identifiers for the tags and animals, and specify species names or other taxonomic names for the animals.

8. If Movebank does not show your data in columns correctly under **What Movebank sees in your file**, it is because it does not recognize that the values in the file are separated by commas. Select **CSV Parameter** and choose **comma** from the list next to **Field Separator**. Hit **Save**, and Movebank should now read the file correctly.
9. First, map the tag identifiers. These will match the Tag IDs we imported with the tracking data file, and will allow Movebank to associate the tracking data with the reference data. Click on **Map Tag ID**.
10. A window will open to let you select the column of the dataset that contains the Tag IDs. Under **Select file column**, choose "COLLAR_ID" and select **Save**.

11. The “Tag ID” column will be added to the table under **How Movebank will save the data**. Compare these values to your original file to confirm the attribute was mapped correctly.
12. Next, map the animal identifiers. Select **Map Animal ID**.
13. A window will open to let you select the column of the dataset that contains the Animal IDs. Under **Select file column**, choose “NAME” and select **Save**.
14. The “Animal ID” column will be added to the table under **How Movebank will save the data**. Compare these values to your original file to confirm the attribute was mapped correctly.
15. Next, define the species of the animals. Select **Map Species**. A window will open that lets you assign a species name based on scientific or common names in your dataset or by assigning one species for the whole studies. In our case, all the animals are the same species, and we don’t have a column in our data file that includes this.
16. Select the box next to **Set fixed Species for all rows**. A field will open that lets you type in the scientific name of the species.
17. Type in the scientific name for European roe deer, “*Capreolus capreolus*”.

Notice that you are not allowed to enter any text you like into the species/taxon field. As you type, Movebank will show you a list of taxon names that match what you have entered. Movebank only allows you to enter taxon names that are a part of the Integrated Taxonomic Information System (www.itis.org). This ensures that all species names in Movebank come from a single, established taxonomy and also prevents problems like spelling errors.

18. After you have selected or typed the correct species name, click **Save**. The “Species” column will be added to the table under **How Movebank will save the data** showing the scientific species names.

In addition to defining the animals and tags, you can add additional reference information. Most importantly, you can define when the tags were actually attached to the animals and collecting data, also referred to as the deployment start and end times. Failing to define the deployment start and end times can lead to errors or incorrect mapping and analysis, for example, if you upload tracking data that include data collected when the tag was being tested, or for tags that have been deployed on multiple animals.

19. Click on the column header “START_TIME_UTC+1” from the table under **What Movebank sees in your file**.
20. In the window that opens, select “Deploy On Timestamp” from the list under **Movebank attribute**.
21. Under **Select date/time column(s)**, select “START_TIME_UTC+1” from the dropdown box that lists the attributes in your dataset.
22. Under **Format string**, type “MM/dd/yy HH:mm”.
23. Make sure the box next to **Fixed offset from UTC** is selected.
24. Under **Timezone offset**, select “UTC +1”. These deployment times were recorded in the local time in Italy, which is one hour later than UTC time.
25. Select **Save**. The “Deploy On Timestamp” column will be added to the table under **How Movebank will save the data**, showing the date and time in the format “yyyy-MM-dd HH:mm:ss”. Compare these timestamps to your original file to confirm the attribute was mapped correctly (remember the UTC times will be one hour earlier than the local times in the file). If you need to edit the mapping, select the column header to re-open the import options.
26. Now repeat instructions 19–25 to map the column “END_TIME_UTC+1” to the Movebank attribute “Deploy Off Timestamp”.
27. Next, map the sex of the animals. Click on the column header “SEX” from the table under **What Movebank sees in your file**.
28. In the window that opens, select “Sex” from the list under **Movebank attribute**.

29. Under **Male identifier**, select “male”, and under **Female identifier**, select “female”.
30. Select **Save**.
31. The “Sex” column will be added to the table under **How Movebank will save the data**. Compare these values to your original file to confirm the attribute was mapped correctly (Movebank uses "f" for female and "m" for male).
32. Next, map the tag serial numbers. Click on the column header “GPS_SERIAL_NO” from the table under **What Movebank sees in your file**.
33. In the window that opens, select “Tag serial no” from the list under **Movebank attribute**.
34. Make sure that “GPS_SERIAL_NO” is selected under **Select file column**.
35. Select **Save**. The “Tag serial no” column will be added to the table under **How Movebank will save the data**. Compare these values to your original file to confirm the attribute was mapped correctly.
36. Repeat steps 32–35 to map the remaining reference data attributes to the Movebank format:

Your file	Movebank attribute
END_COMMENTS	Deployment Comments
TAG_VENDOR	Manufacturer Name
TAG_MODEL	Model

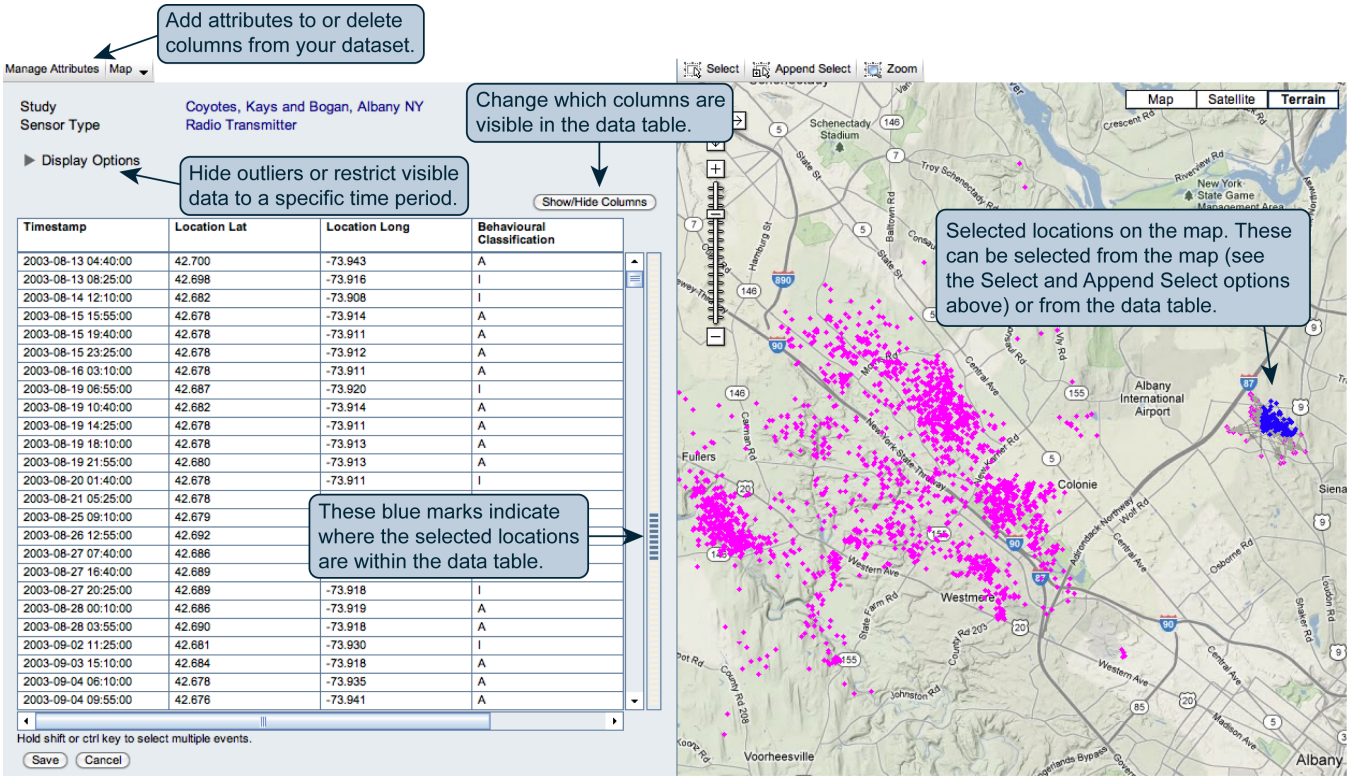
37. Now you are ready to finish the import. Click on the **Messages** tab on the right to check for any notes or possible errors. Remember, only messages in red indicate that there is an error and Movebank will be unable to import your file.
38. Once everything looks ok, select **Finish**.
39. Before you finish the import, you can choose whether to save a file format. Saving a file format allows Movebank to remember the settings you used to describe your data file, which could be helpful if you later want to re-import the reference data with slight changes or additions. Select **Ok**.
40. After the import is complete, a window will open saying that the import was successful. Select **Go back to study** from the list of options.
41. Now let’s see if adding the deployment on and off times has affected our tracks on the map. From the study page, select **Data** > **Show in Map**. We can see that a few outlying locations are still visible in the tracks, but the locations near Berlin have disappeared. This means that the removed locations were collected before or after the tags were deployed on animals, and those outliers that are still visible were collected during the time the tags were deployed on the animals, and are probably due to errors in the data provided by the GPS. By selecting the individual animals, you can see that these locations are on Daniela’s, Decimo’s, and Sandro’s tracks.

Editing data

After you have uploaded data to Movebank, you may want to make some changes or additions. To improve our study, we will mark the outliers in our tracking data and add some reference data.

Example 1. Mark outliers in the tracking data using the Event Editor.

The Event Editor allows you to add and remove attributes from your data set and manually edit your data.



Note that you are generally not allowed to delete data. Instead, Movebank encourages users to mark errors or suspicious data records, which allows them to be excluded from the visible track without being removed from the dataset. There are many reasons for managing your dataset this way: for example, you may discover later that a point that you thought was an error really was not. In addition, erroneous data collected by a tag tells you something about the tag that might be important, for example how often or under what conditions it provides false locations.

In the Event Editor, we can mark outliers by adding the attribute "Manually Marked Outlier" to our dataset, finding the outliers, and adding the value "true" to this attribute for the outlying records.

1. From your study page, select **Animals** from the menu on the left.
2. Now select **Daniela**, the first animal on the list whose track contains outliers.
3. From the menu on the right, select **Data** > **Edit**.
4. After the Event Editor opens, select **Manage Attributes** from the upper left. A list of **Available Attributes** (left) and existing **Data Point Attributes** (right) will appear.
5. Select **Manually Marked Outlier** from the **Available Attributes**.
6. Click on the → arrow in the middle of the window to add the new attribute your data set.
7. Select **Apply**.
8. Next, select **Show/Hide Columns**. A list of all the attributes in your data set will appear; those that are selected are currently displayed in the data table.
9. Select and unselect attributes so that only **Timestamp**, **Location Lat**, **Location Long**, and **Manually Marked Outlier** are selected. This way you will be able to easily see these attributes in the tabular view.
10. Select **Apply**.

11. Next, we need to identify the records that are outliers. You can select records from the table or the map, but in this case it is easier to find them on the map. Click on the location (the small pink dot) that is far to the south of the rest of the track, southeast of Florence.

When you select the location, it will turn blue, and a line with arrows will connect it to the previous and following locations on the track. You will also notice a small blue mark appears on the gray bar to the right of the data table.

12. Put your cursor over this blue mark and click. The table will automatically scroll down to the record that you have highlighted on the map. This record will now also be highlighted in blue.
13. Click in the cell in the **Manually Marked Outlier** column of the table in the selected record.
14. In the **Edit Attribute** window that appears, select **True**.

The new value **True** should now appear in the table for this record, and the row will be shaded in gray. On the map, the outlying point will now appear as a red X. After we save our changes, this location will no longer be visible from the Tracking Data Map when viewing Daniela's track.

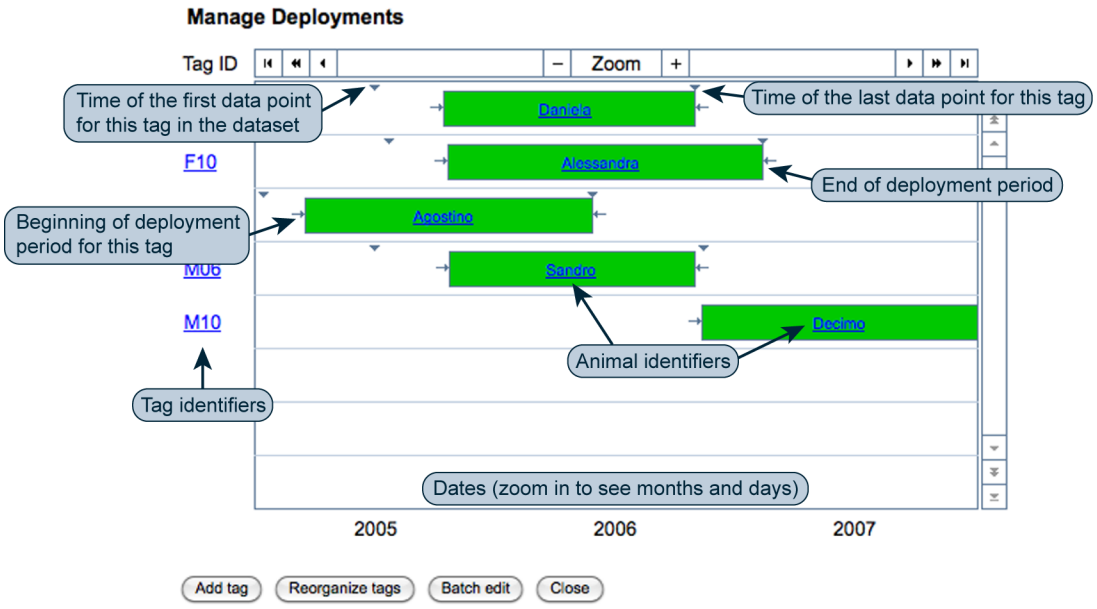
15. Select **Save**, and click **Ok** when it asks you to confirm the changes. After the changes are saved, you will be directed back to Daniela's details on your study page.
16. From the study page, select **Animals** from the menu on the left.
17. This time select **Decimo**.
18. From the menu on the right, select **Data** > **Edit**.
19. Repeat steps 8–15 to mark the outlier in Decimo's track, located about 25 km west of the rest of the track. This location is closer than the outliers on the other tracks. However, looking at the timestamps from before and after this location, we can see that the locations were collected only four hours apart. We can safely assume that Decimo did not travel all this way in four hours and then return right back to where he started within another four hours.
20. Now select **Sandro** from the list of animals on the study page.
21. Open the Event Editor and repeat steps 8–15 for Sandro, and remove the outlier in his track, located north of Dijon in France.

Example 2. Add reference data using the Deployment Manager.

The Deployment Manager provides another way to view our reference data. This tool gives you an overview of the animals, tags, and deployments in your dataset, and allows you to easily edit or add reference data without having to upload a new data file.

By looking up the product sheet for the tags used in this study, we find that these tags have a mass of 520 g. We can use the Deployment Manager to add this information to the reference data.

1. From the study menu, select **Manage Deployments** to open the Deployment Manager.



2. Select **Batch Edit**.
3. In the box that opens, under **Select type of reference data**, select **Tags**.
4. Under **Select tags** on the left, make sure all the Tag IDs are selected.
5. Under **Edit tag properties** on the right, make sure only "Weight in grams" is selected, and that "Manufacturer Name", "Model", and "Comments" are *not* selected.
6. In the field next to "Weight in grams", type "520".
7. Select **Update ALL selected Tags**.
8. A box will open saying "Confirm: You are about to update 1 property in 5 tags!" Select **Update**.
9. When the box opens saying "Done! Updates are completed" select **Ok**.
10. Select **Close** to exit the Batch Editor.
11. Select **Close** to exit the Deployment Manager.

Sharing data

Now that you have added and organized the data in our study, why don't you share it with some others? Let's make the written summary of the study visible to the public, allow a colleague to view and download the tracking data, and add the Movebank data curator as a data manager so she can help you with any questions you have with your study.

12. First, go to **Sharing** > **Permissions** from the study menu.
13. Set **Visibility of study name and summary** to **Public**.
14. Set **Default visibility of tracking data** to **Collaborators Only**.
15. Make sure the **Restrict data downloads to** button is checked, and select **Collaborators Only** from the dropdown box to the right.
16. Select **Save**.

Next, add one of the database managers of the EURODEER project, Ferdinando Urbano, as a Collaborator to the study. He will now be able to view everything in our study and download the data, but will not be able to make any changes to the study.

17. From the study menu, go to **Sharing** > **Add/Remove Collaborators**.
18. In the **Registered Persons** filter, type "Urbano" and hit enter.
19. Select his name from the filter results the table just below. It will be highlighted in blue once selected.
20. Select the → arrow in the middle of the window to add the user to the list of current collaborators.
21. Ferdinando should now be listed under **Current Collaborators**. Select **Close**.

Lastly, add the Movebank data curator, Sarah Davidson, as a Data Manager for the study. She will have all the same access rights as you do, and will be able to upload new data to the study for you and answer questions if you have any problems.

22. From the study menu, go to **Sharing** > **Add/Remove Data Managers**.
23. In the **Registered Persons** filter, type "Sarah" and hit enter.
24. Select the "Sarah Davidson" from the filter results the table just below. It will be highlighted in blue once selected.
25. Select the → arrow in the middle of the window to add her to the list of current data managers.
26. The selected user should now be listed under **Current Data Managers**. Select **Close**.

Linking data to environmental information

Movebank allows users to link animal tracking data to global environmental datasets by annotating variables from these datasets to each record in the tracking dataset. As part of a data download, you can annotate estimates of

- Weather parameters from the NCEP Reanalysis 2 global weather model, provided by the U.S. National Oceanic and Atmospheric Administration (www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis2.html)
- Elevation from the GTOP030 digital elevation model, provided by the United States Geological Survey (www1.gsi.go.jp/geowww/globalmap-gsi/gtopo30/gtopo30.html)
- Land cover from the GlobCover project, provided by the European Space Agency (http://ionia1.esrin.esa.int)
- Large-scale geomagnetic field from the International Geomagnetic Reference Field, provided by the International Association of Geomagnetism and Aeronomy (www.ngdc.noaa.gov/IAGA/vmod/igrf.html)

In addition, we are currently building a new feature that will allow users to annotate hundreds of variables from several global environmental datasets, including MODIS, the NCEP NOAA Reanalysis 2, the ECMWF Global Atmospheric Reanalysis, global digital elevation models, and others. This feature should be added during 2013.

For the rest of the workshop, you can try out the environmental data annotation and exploring the results. You can annotate environmental data to tracking data from any studies that allow you to download data: your new roe deer study, any of your own Movebank studies, or any studies that are shared with you or the public. Here are some ideas:

1. Browse studies, limiting to **Only studies where I can see data**, and find an interesting dataset. Check the tracks and **study details** to find out the species, location, tracking method used, and research leaders for the project.
2. Download the dataset and annotate some environmental parameters (see instructions below).
3. Open the file in Excel and browse the data to see how long the animals were tracked and how frequently locations were measured.
4. Make some figures to look at the environmental data along with the tracks. Look at the tracks on Movebank or make a plot of latitude and longitude. For example, if you are looking at migration data, you might make a

graph of the temperature over time, and see whether there is a link between temperature and when the animals decide to start migrating. For the roe deer dataset, you might look at the animal's elevation over time, or how that relates to temperature.

5. Consider what you've found. What kinds of questions could you address with this information? What additional data or changes to the study design would you need to best address your questions?

What does it mean to *annotate* environmental information?

Movebank annotates animal tracking data by providing an estimate of an environmental parameter, such as temperature or wind speed, for the location and time of each record in the tracking dataset. However, each of these environmental parameters is provided at a certain spatial and temporal resolution. To annotate tracking data, Movebank must use variable values at locations and times provided by the environmental dataset to calculate an estimated value of the variable for the location and time of each record in the tracking dataset. This process of estimating unknown values from a set of known values or data points is called *interpolation*. When you annotate environmental information as part of a data download, Movebank estimates the values of environmental parameters using an inverse distance weighted interpolation.

How do I annotate environmental information to tracking data?

To get an idea how this works, try adding some weather parameter estimates to a dataset in Movebank.

1. From the **Tracking Data Map**, find a study you are interested in and that allows you to download data.
2. Click on the "i" to the right of the study name and select **Download search result**. You will see that you can download the data in several file types, including a .csv, .xls or .xlsx (Excel), ESRI shapefile (ArcMap), or (Google Earth).
3. Select **Excel 2007**.
4. Make sure the box next to **include points marked as outliers** is *not* selected. This way you will download only the actual animal tracks, which will make it easier to look at the results.
5. Now check the box next to **Annotate environmental data**.
6. Check the boxes next to the parameters you would like to annotate. More information about the weather data is available at www.movebank.org/node/35.
7. Select **Download**. Please be patient—it may take several minutes for the annotation and download to complete, especially for larger datasets.

Descriptions of each variable in your dataset, including units, are available in the Movebank attribute dictionary at www.movebank.org/node/2381.

What else can I do with data in Movebank?

Once tracking data have been imported to Movebank, they are in a format shared by all other datasets in Movebank. This makes it possible to create tools that can read this format to visualize data or perform analyses. Other tools developed to analyze Movebank-format data include the Acceleration Viewer, for acceleration data collected by e-obs tags, the Animal Ecology Explorer data visualization tool (Beta), and the R package "move" for calculating utilization densities. For more information about these tools or the environmental annotation features, or if you'd like to develop new tools that work with Movebank-format data, contact support@movebank.org.