KBA
KEY BIODIVERSITY AREAS

Tutorial on using QGIS for KBA Identification and Delineation

Version 1.2

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Cover image: Screen grab from QGIS showing the northern border of Mozambique.

Contents

Topic 1: Welcome

Welcome to this tutorial on *Using QGIS for KBA Identification and Delineation*. This tutorial is designed to provide new users with a practical task-focused guide to using a Geographic Information System (GIS) for KBA identification and delineation.

This tutorial is not a comprehensive GIS primer. There are many excellent GIS training resources available online, designed for various levels of experience and learning styles — we encourage you to check those out.

We chose to focus on QGIS for this tutorial as it provides the functionality needed for KBA identification and delineation, is freely available, and widely used in the conservation community. KBA Proposers are welcome to use any other GIS software that meets their needs, with the proviso that final KBA boundaries and spatial data on the distribution of trigger biodiversity elements must be submitted as ESRI shapefiles.

Please see the [KBA Standard](), the [KBA Guidelines](), the [KBA Proposal Process guidance]() and the [KBA online training course]() for general guidance on KBA identification, delineation, documentation and mapping. This tutorial is a complementary resource, focused on the GIS tasks commonly used in KBA identification and delineation, not a substitute for the KBA Standard or KBA Guidelines.

Learning objectives

By following the steps in this tutorial you will be able to:
- Understand key concepts and terms used in GIS
- Install QGIS on your computer
- Set up a new QGIS project
- Add high-resolution satellite imagery as a base map
- Add national borders and boundaries of existing KBAs and protected areas
- Merge several spatial layers into a single spatial layer
- Download locality data from the IUCN Red List and add to a project as a spatial layer
- Install the GBIF plugin and add GBIF occurrence data to a project
- Download a range polygon from the IUCN Red List and add it to a project as a spatial layer
- Download an ecosystem distribution map from the Red List of Ecosystems
- Digitise a new polygon on-screen and create a new spatial layer

- Adjust or refine an existing polygon on-screen
- Dissolve multiple features into a single feature
- Calculate the area of a polygon feature and store it in the attribute table
- Intersect a range or extent polygon with a site polygon to calculate the area of biodiversity element in a proposed site
- Add attribute data to a spatial layer and edit attribute data
- Export a spatial layer using a standard template for inclusion in a KBA proposal

Important warning and recommendation

Some KBA and species range polygons have incorrect projection metadata, resulting in polygons that are spatially offset from their true location (as in the examples below, for a KBA in the left panel and a species range map in the right panel). This can lead to significant errors in estimates of the proportion of a species' population size found at a site or the extent of an ecosystem type at a site. It is therefore strongly recommended that KBA Proposers review all imported KBA or range shapefiles carefully by overlaying polygons on high-resolution satellite imagery before conducting KBA assessments.

If you detect an apparent projection error, please alert your KBA National Coordination Group (NCG) or KBA Regional Focal Point (RFP). The KBA NCG or RFP can address any projection errors in KBA shapefiles; the KBA RFP can request that the IUCN Red List Unit address any errors in IUCN Red List range maps.

You can find more information on the importance of projection in Topic 2.

Topic 2: The importance of projection

In this topic, we'll cover some useful background information on the importance of projection and explain the difference between geographic and projected `coordinate reference systems`.

This is the only theoretical topic in the tutorial — it is essential background for successfully using GIS in KBA identification and delineation. It draws heavily on material originally developed by [USFWS](#).

The Earth is not a sphere

While we often think of the Earth as a sphere, the circumference at the Equator is actually slightly greater than the circumference at the poles. This shape is represented in GIS by an ellipsoid, i.e. a smooth sphere that has been vertically compressed.

The Earth represented as an ellipsoid (scale is greatly exaggerated). Source: [USFWS](#)

Various models of the true shape of the Earth have been developed, including the widely used WGS 84 `ellipsoid` that is optimised for global use. The precise location of a point on the surface of an ellipsoid can be described using a standard reference system or `datum`. The standard `datum` for the WGS 84 `ellipsoid` is called WGS 84. Other examples of datums include NAD27 and NAD83, both based on `ellipsoids` optimised for North America.

Geographic Coordinate Reference Systems (CRS)

The coordinates (e.g., latitude and longitude) of a particular point on the Earth's surface vary, depending on the `ellipsoid` and `datum` used. The position of a point on the Earth's surface can be simply and adequately described (or "georeferenced") by recording the coordinates plus `datum`. This is a geographic `coordinate reference system` (CRS). The geographic CRS of latitude and longitude (decimal degrees) combined with the WGS 84 `datum` is referenced by the code "EPSG:4326" in QGIS and "GCS_WGS_1984" in ArcGIS.

Global Positioning Systems (GPS) commonly use EPSG:4326 by default, but this can be modified, so that your GPS returns data in a different CRS. For this reason, it is essential that you document the CRS of your GPS when recording occurrence data. If the datum is unknown, your GIS may assign the wrong datum and position data points in the wrong place.

Projected Coordinate Reference Systems (CRS)

To represent the near-spherical surface of the Earth on a flat surface, such as a map or a screen, a map `projection` is needed. Map `projections` mathematically stretch and transform the curved surface to make it lie flat for easier representation.

Map projections are also used to `reproject` spatial data layers from a 3-dimensional `geographic coordinate system` to a 2-dimensional flat (or "planimetric") surface when calculating the area of a site, a species' range or an ecosystem's extent.

Many different `projections` have been developed, optimised for different purposes. For example, the Mercator `projection` prioritises accuracy of direction and is widely used in navigation. In contrast, the Mollweide and World Cylindrical Equal-Area `projections` prioritise accuracy of area and can be used to compare the size of species' ranges or sites around the globe.

Mercator projection – directions are accurate, but area is greatly distorted. Source: USFWS

Mollweide projection – areas are accurate, but direction is distorted. Source: USFWS

For the purposes of KBA assessment, the ability to measure area accurately and consistently anywhere on the globe is a high priority. The KBA Guidelines therefore specify that area should be calculated in the World Cylindrical Equal-Area `projection` (specifically "+proj=cea +lat_ts=0 +lon_0=0 +x_0=0 +y_0=0 +datum=WGS84 +units=m

+no_defs"). This `projected coordinate reference system` can be referenced by the code "ESRI: 54034" in QGIS and "World_Cylindrical_Equal_Area" in ArcGIS.

As we'll see in the Polar Bear experiment below, it's important to specify the projected CRS when calculating area if we want accurate and consistent results. If we don't tell the GIS exactly how we want to convert our 3-dimensional geographic data to a 2-dimensional planimetric surface for the purposes of calculating area, the GIS may use a default method and give results that are inconsistent with other GIS, or it may simply produce an error message.

Technical Box: Projections for area measurement

Area measurements should be performed using a **Cylindrical Equal Area** projection, i.e.:
 	
      CRS: "+proj=cea +lat_ts=0 +lon_0=0 +x_0=0 +y_0=0 +datum=WGS84 +units=m +no_defs"
 	
      QGIS name: "ESRI:54034"
 	
      ArcGIS name: "World_Cylindrical_Equal_Area"

Topic summary

Well done — you've completed the topic on the importance of `projection`.

In the next topic, we'll install QGIS and set up a new `QGIS project`.

Topic 3: Installing QGIS and setting up a new QGIS project

This topic is provided for new users of QGIS. We'll provide guidance on how to install QGIS on your computer and set up a new QGIS project.

Install QGIS on your computer

QGIS is a freely available GIS software package that can be run on a desktop computer (MacOS, Windows, or Linux).

QGIS can be downloaded [here](). For new users, we recommend you use the "most stable" all-in-one installer for your operating system.

You can find more detailed guidance on how to install and use QGIS [here]().

When your installation is complete, navigate to the application and open QGIS.

You'll see a notice at the bottom of your QGIS page whenever a new version is available.

Set general options

Set the default `Coordinate Reference System` (CRS) for use in new projects:

> Click on `Settings > Options`
>
> Under `CRS for Projects,` check the option for `Use a default CRS` and make sure the box says EPSG:4326 – WGS 84.
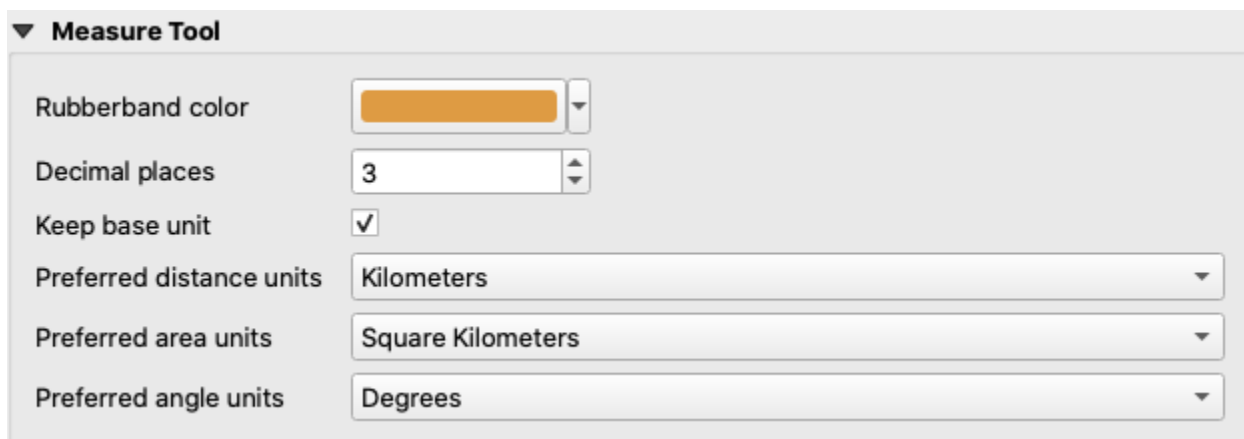>
> Click on `OK`
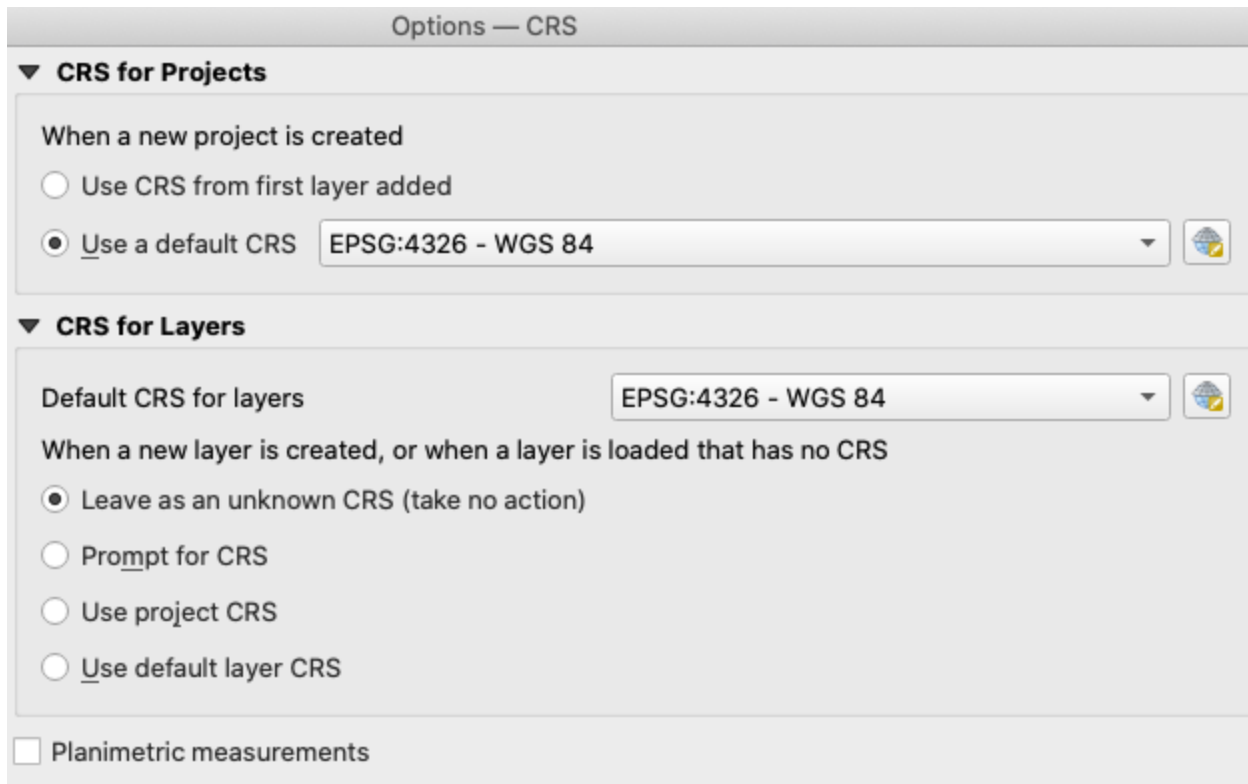
If you like, you can also change your general settings to work in kilometers rather than meters.

> Click on `Settings > Options > Map Tools`
>
> For `Preferred distance units`, select Kilometers
>
> For `Preferred area units`, select Square Kilometers

Set up a new QGIS project

To set up a new `QGIS project`, go to the menu bar at the top of your QGIS page.

Select `Project > new`

You'll see a new blank project.

If you check the lower-right of your `QGIS project` page, the CRS should be "EPSG:4326".

Save the project

We recommend that you save your `QGIS project` regularly, so that you don't need to repeat steps every time you work on a similar project.

We also recommend that you keep all your spatial data in a single `spatial data folder` with subfolders added as needed.

Click on the button to `save` the project with an appropriate name in your QGIS folder.

Open a project

To open an existing project

Select `Project > Open` or `Project > Open Recent`

Topic summary

Well done — you've completed the topic on setting up a new `QGIS project`.

We recommend you `Save` your project now.

In the next topic, we'll add some base maps to your `QGIS project`.

Topic 4: Adding base maps to your QGIS project

When delineating terrestrial, freshwater or coastal marine KBAs in a GIS, we strongly recommend that you use high-resolution satellite imagery as your background layer as this can help identify areas where the boundary needs to be refined.

In this topic, we'll show you how to add base maps to your `QGIS project`, together with other useful layers, such as national borders, boundaries of existing KBAs and projected areas. We'll also show you how to implement some related tasks such as merging several spatial layers into a single layer and selecting features (e.g., KBAs) by attributes (e.g., name).

Load ESRI high-resolution satellite imagery into QGIS

Here, we'll walk you through the process of adding high-resolution satellite imagery from the ESRI Living Atlas website. This is the base map we'll use throughout this tutorial. Later, we'll show you where to find additional base maps that might be useful for delineating KBAs.

From the main [ESRI Living Atlas](#) webpage, click on `Browse` and `Base maps`.

Click on `World Imagery`.

In the bottom right of the `World Imagery` page, you'll see a link for the `URL` of this map server layer. `Copy` this.

In the QGIS menu bar, select `Layer > Data Source Manager > ArcGIS Map Server`.

Then choose to create a `New` connection and complete the details for the ArcGIS Map Server Layer. In this case enter a `Name` (e.g., "Living Atlas – World Imagery") and paste in the `URL` that you copied from the ESRI Living Atlas webpage

Click `OK` to save the new connection

Note. You'll only have to do this once. This layer will now be available to you in QGIS whenever you want to use it as a base map.

**Add ESRI high-resolution satellite imagery as a base map to your project**

Next, you'll want to add the satellite imagery as a base map to your project.

In the QGIS menu bar, select `Layer > Data Source Manager > ArcGIS Map Service` and select the base map that you just saved

Click `Connect` and select "World Imagery"

Click `Add` and the map server layer will be added to your `QGIS project` as the base map

Your `QGIS project` page should now look similar to the image below (right-click on "World Imagery" and select `Zoom to Layer` if the base map doesn't fill your page):
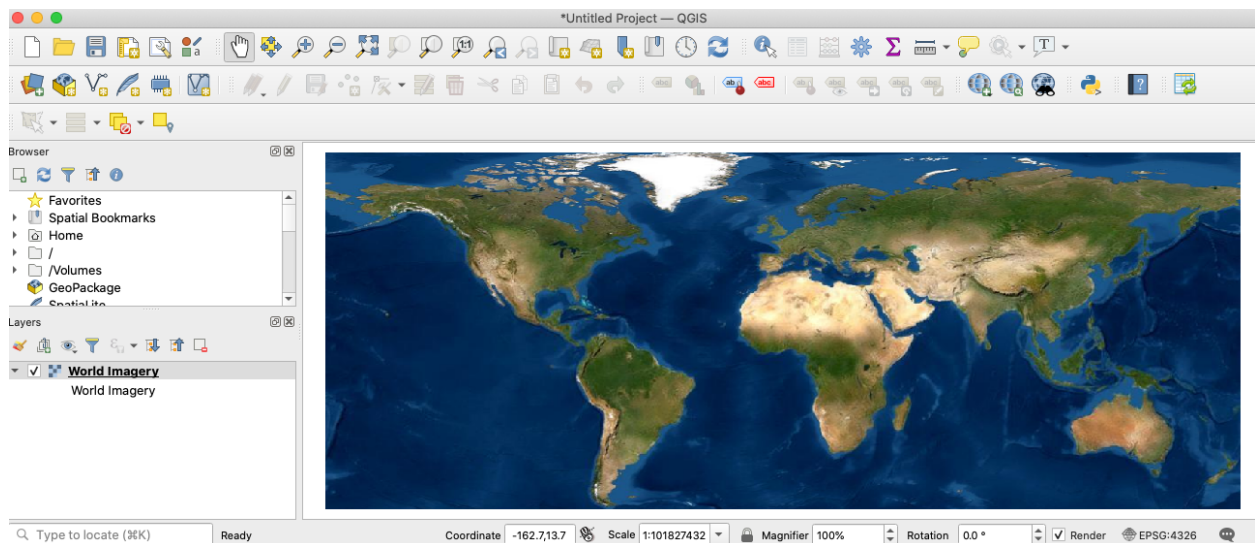
Check your project projection

Check again that the lower-right of your `QGIS project` page says "EPSG:4326". The World Imagery layer is in a projected CRS (a pseudo-Mercator projection), but is displayed in the specified geographic CRS based on your `QGIS project` settings.

You can explore different projections by selecting `Project > Properties > CRS`:
● if you copy-paste "EPSG: 3857" into the `Filter box`, highlight "WGS 84/ Pseudo-Mercator" in the box below, and then click `Apply` and `OK`, you'll see that the base map has been transformed and Greenland is now about the same size as Africa;
● if you copy-paste "ESRI: 54034" into the `Filter box`, highlight "World_Cylindrical_Equal_Area" in the box below, and then click `Apply` and `OK`,

you'll see that the base map has been transformed again and Africa is now much larger than Greenland.

In reality, Africa is approximately 30 million km², whereas Greenland is approximately 2 million km², so you can see that the World Cylindrical Equal-Area projection is more appropriate for estimating and comparing the size of species' ranges and sites around the globe.

Remember to switch back to EPSG:4326 when you've finished experimenting.

We recommend you `Save` your project now.

Add national borders

The Database for Global Administrative Areas (GADM) is a good source for spatial data on administrative boundaries. We'll use Mozambique for the purposes of demonstration throughout this tutorial.

From the [GADM country page](#), select your `country` in the drop down box, and then select `shapefile` to download the shapefile as a zipfile

Navigate to the downloaded zipfile in your downloads folder, `unzip` it, and copy all the files to your `spatial data folder`

To add the new country spatial data layer to your `QGIS project`:

In the QGIS menu bar, select `Layer > Add Layer > Add Vector Layer`, click on the ... at the right of the `Vector Datasets` box and then navigate to your `spatial data folder`

Select the "gadm .. " file with "0.shp" at the end (e.g., gadm36_MOZ_0.shp") and click `Open`

Click `Add` then `Close`

On the left of your `QGIS project` page, you'll see a list of the spatial data layers, right-click on your new `country layer` and select `Zoom to Layer`

Note that the GADM files with higher numbers represent lower-level administrative boundaries. You can follow a similar process to add those to your `QGIS project` if they might be useful.

If you choose to use a different shapefile (e.g., the official shapefile for your country's national boundaries), follow the same process above but select the appropriate ".shp" file.

To switch from a filled polygon to an outline:

Click again on your `country layer` and then click on the ![brush icon] button above-left to open the `Layer Styling Panel`

Select one of the outline options (e.g., the pink square — you may need to scroll down) and then click `Apply`

Close the `Layer Styling Panel` by clicking on the `x` in the upper-right

Your `QGIS project` page may now look similar to this:
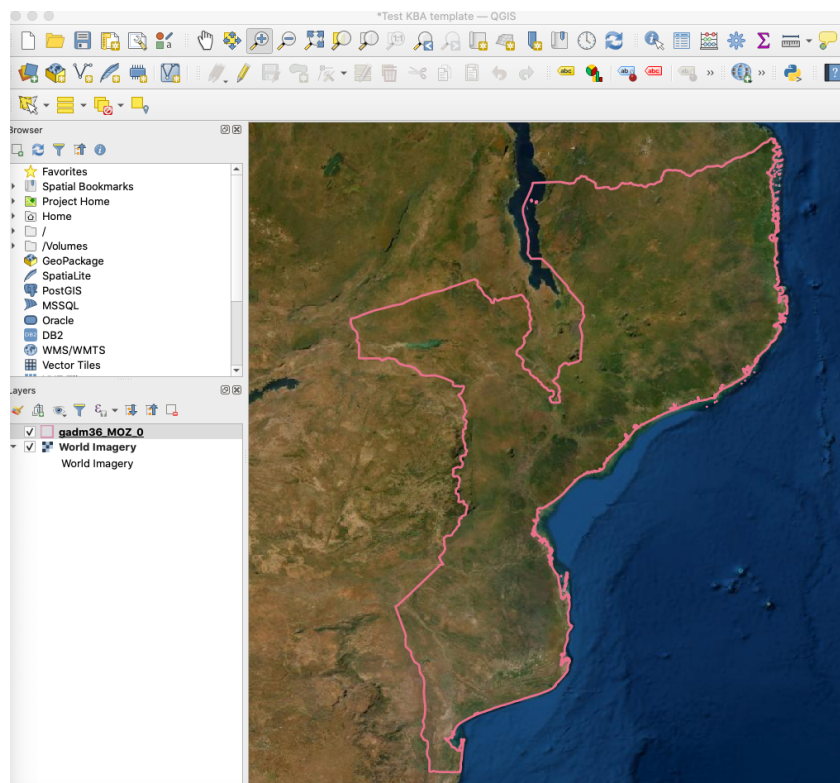
If you want to zoom in to check how well the country borders align with natural features:

Select the ![zoom icon] button in the main toolbar and then select the area on the map where you want to focus

To move the area in view without changing the zoom level, select the ⟨image⟩ button in the main toolbar and then use your mouse to pan around the map

To switch between displaying and not displaying a spatial data layer, check or uncheck the box next to the layer in the `Layers Panel` on the left

For example, the image below shows how the northeastern border of Mozambique, as represented in the GADM shapefile, follows the River Rovuma and the coastline.

We recommend you `Save` your project now.

Import existing KBAs

Request KBA spatial data for your country from the [KBA website](#). When you receive them, save the files in your `spatial data folder`.

To add the global KBAs spatial data layer to your `QGIS project`:

In the QGIS menu bar, select `Layer > Add Layer > Add Vector Layer`, click on the ... at the right of the `Vector Datasets` box and then navigate to your `spatial data folder`

Select the "KBAsGlobal … POL.shp" and click `Open` then `Add`

Click on the ... again, then select "KBAsGlobal ...PNT.shp" (if it exists) then click `Open` then `Add` then `Close`

Note. You'll only have a "KBAsGlobal ...PNT.shp" if some of the KBAs in your country are denoted by points rather than polygons.

If you want to identify a polygon:

Make sure the relevant `spatial data layer` is highlighted in the left `Layer Panel`

Click on the button in the main toolbar to `Identify Features` and then click on the polygon in question

A table will pop up showing the `attribute` data for the selected feature; click on the `x` to close

You can follow the instructions above to change the `Layer Styling` (hint: click on). If you choose a turquoise fill and 50% opacity, your `QGIS project` will now look similar to the image below:
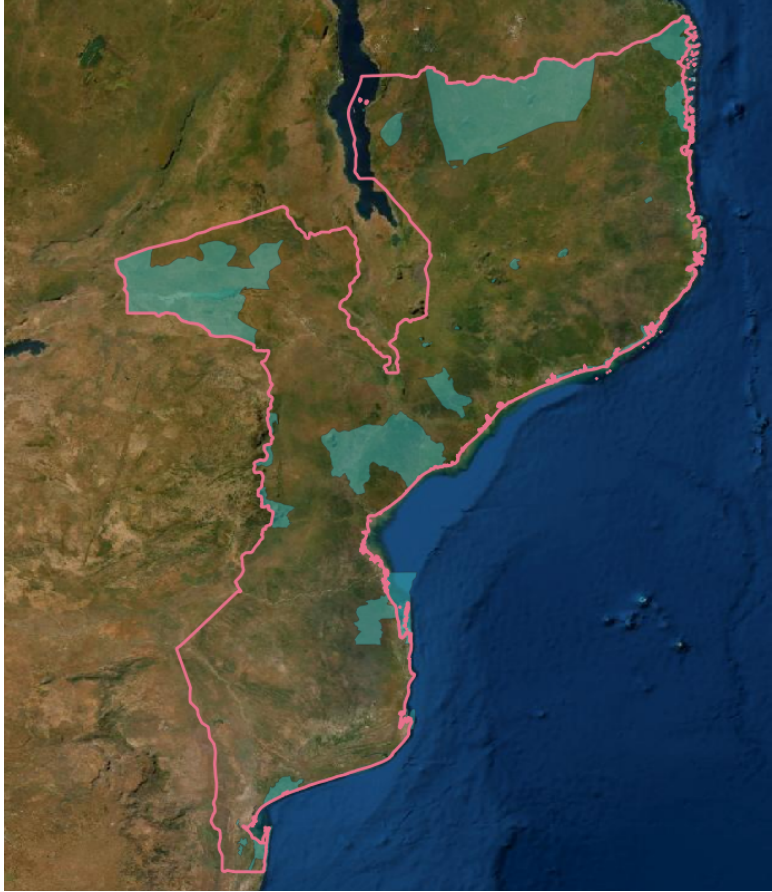
We recommend you `Save` your project now.

Import existing protected areas

Run a Google search for protectedplanet.net and your country name. (We'll use Mozambique's protected areas in the examples below so you may want to download those to follow along.)

> `Download` the relevant dataset by following the relevant on-site instructions, and selecting `SHP`
>
> Navigate to the downloaded zipfile in your downloads folder, `unzip` everything, and copy all the files to your `spatial data folder`

This dataset is generally packaged as 3 separate polygon shapefiles.

> In QGIS, follow the process above to add each of the 3 polygon shapefiles to your `QGIS project` (hint: start by selecting `Layer > Add Layer > Add Vector Layer;` click `Open` and `Add` for each layer, then `Close` when you're done)

Merge several spatial layers into a single layer

You can choose to merge these 3 shapefiles (or layers) into a single layer:

> In the QGIS menu bar, select `Vector > Data management Tools > Merge Vector Layers`
>
> Click on … next to the `Input Layers` box and `check` the 3 folders containing your 3 shapefiles (e.g., named "WDPBA_WDOECM…"), then click `OK`
>
> Under `Destination CRS,` select EPSG:4326 – WGS 84
>
> Click on … next to the `Merged` box, select `Save to File` and then save your new merged shapefile in your `spatial data folder`, then click `OK`
>
> Finally click `Run` at the lower-right
>
> Your new shapefile will be added to your `QGIS project`; you can right-click on the old "WDPBA_WDOECM…" files and select `Remove Layer` to remove from them from your `QGIS project`; the files will be removed from display, not deleted
>
> You may also want to move the `KBA layer` above the `WDPA layer` in the `Layers Panel`, so that KBAs are superimposed on protected areas

Repeat this process for point data if necessary.

Follow the instructions above to change the `Layer Styling` (hint: click on). If you choose a green fill and 50% opacity, your `QGIS project` will now look like the image below:

We recommend you `Save` your project now.

Select features by attribute

It is often useful to select one or more features from a set of features in a spatial layer. Here, we'll demonstrate one way to do this, but QGIS provides several different options.

In the `Layers Panel` at the left of your QGIS project, right-click on your merged

protected area layer and select `Open Attribute Table` (or click on the button in the toolbar)

Click on the button at the top to `Select/filter features using form`

At the box labelled NAME, type "Chimanimani"

At the lower-right, click on the button; 2 features should now be selected, both named "Chimanimani", corresponding to the Chimanimani National Park and its buffer zone

Close the `Attribute Table` and you'll see the selected features highlighted in bright yellow — you can right-click on your merged protected area layer and select `Zoom to Selection` to zoom in.

Sometimes it's useful to save selected features as a new shapefile:

Right-click again on your merged protected area layer and select `Export > Save Selected Features As …`

Click on the … at the right of the `File name` box and then navigate to your `spatial data folder`; save the layer with a suitable name (e.g., "Chimanimani"); click `save`

We recommend that you keep the data layer in its original geographic CRS at this stage; the CRS box should say EPSG:4326 – WGS 84

Click `ok`

Your new shapefile will now be listed as a spatial layer in the `Layers Panel`

Follow the instructions above to change the `Layer Styling`. If you choose a blue fill and 50% opacity, your `QGIS project` will now look similar to the image below. (We have unchecked the merged WDPA layer in the `Layers Panel` and changed the `Layer Styling` of the KBA layer to a turquoise outline to show the recently confirmed Chimanimani KBA based on the Chimanimani National Park and its buffer zone.)
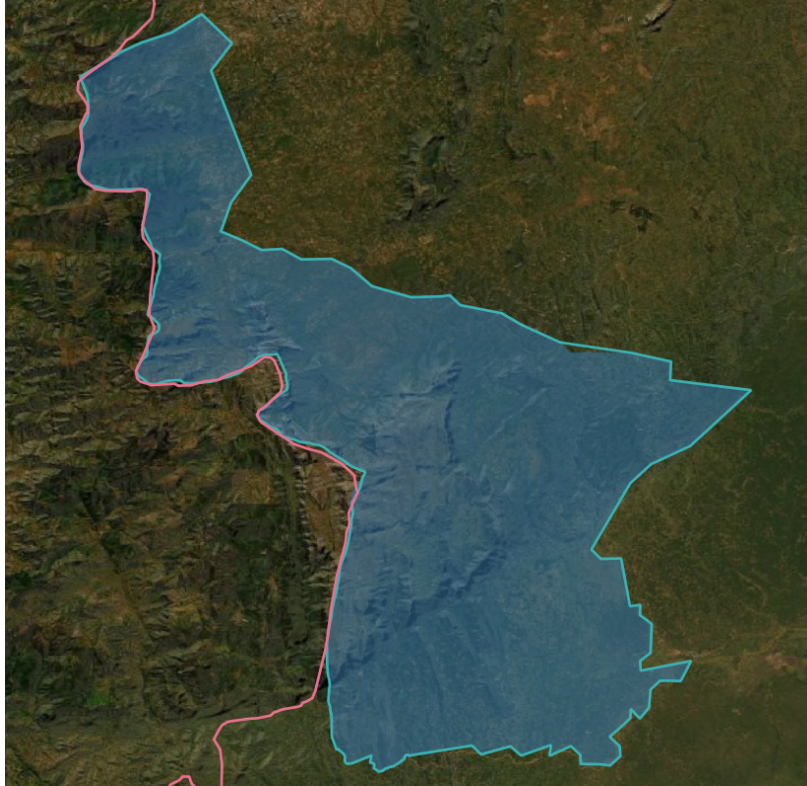
Topic summary

Well done — you've completed the topic on setting high-resolution satellite imagery as a base map for your project and on importing spatial data on existing KBAs and protected areas.

We recommend you `Save` your project now.

In the next topic, we'll add some occurrence data to your project.

Topic 5: Working with species occurrence data

In this topic, we'll show you how to download occurrence data from the IUCN Red List and add it to your QGIS project as a spatial layer and how to import occurrence data from the Global Biodiversity Information Facility (GBIF). Even if you do not plan to use number of localities as an assessment parameter, recent and reliable occurrence data can be useful in providing confirmation of presence.

In addition, we'll show you how to count the number of points (e.g., occurrences) in a polygon, although we note that it is often better to estimate the number of localities in a proposed site visually, in consultation with experts.

Download occurrence data from the IUCN Red list and add to a project as a spatial layer

Many plant species that have been assessed for the IUCN Red List have occurrence data and no range map. For the purposes of demonstration, we'll look at the occurrence data for *Aloe plowesii* (VU), a geographically restricted species confined to the rocky grasslands of the central Chimanimani Range on the border of Zimbabwe and Mozambique.

Go the [IUCN Red Lis](#)t and search for "*Aloe plowesii*", click on the `download` button in the upper-right, and select `Range data — Points (CSV)` and complete the data request form. You may need to create an account first

Navigate to the downloaded zipfile in your downloads folder, `unzip` everything, and copy all the files to your `spatial data folder` — we recommend you save the data to a subfolder named "Aloe_plowesii" or similar.

In the QGIS menu bar, select `Layer > Add Layer > Add Delimited Text Layer`, click on the … at the right of the `File name` box and then navigate to the relevant species subfolder in your `spatial data folder`

Select the "points_data.csv" file and click `Open`

Note that the section on `Geometry Definition` should have `Point Coordinates` checked, the `X field` should be "longitude", the `Y field` should be "latitude", and the `Geometry CRS` should say "EPSG:4326 – WGS 84"

Click `Add` then `Close`

In the `Layers Panel` on the left of your `QGIS project` page, you'll see a list of the spatial data layers, including a new layer called "points_data". This is not very descriptive, so you can rename the layer in your `QGIS project` by right-clicking on the layer and selecting `Rename Layer` (e.g., as "Aloe_plowesii"); this is just cosmetic — it does not change the name of the underlying file)

You can change the `Layer Styling` just as you did for polygons. If you choose yellow and increase the size to "3", then `Zoom to Layer` your `QGIS project` will now look like the image below. (The pink line represents the border between Zimbabwe to the west and Mozambique to the east.)
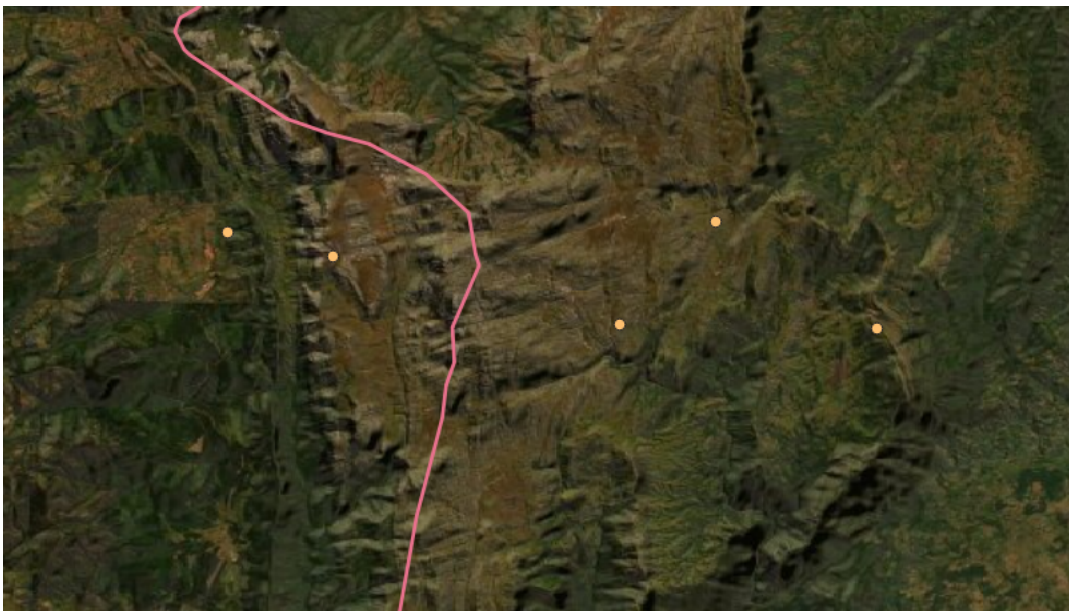

If you check the IUCN Red List account for *Aloe plowesii*, you'll see that 2 threat-defined locations have been identified from a total of 8 collections. The Mozambique KBA Secretariat reviewed this information in consultation with relevant species experts and determined that each of these locations likely represents a discrete population for the purposes of KBA identification: one in Mozambique (represented by 3 georeferenced occurrences in the spatial data table) and one over the border in Zimbabwe (represented by 2 georeferenced occurrences in the spatial data table).

If you click on the button in the main toolbar to `Identify Features` and then click on a point, you'll see information about that particular occurrence, including the collection date (i.e. event_year).

Count the number of occurrences in a polygon

Please review the KBA Guidelines and consult with species experts before using number of localities as an assessment parameter. QGIS includes functionality to count the number of points in a polygon feature, but, given that one discrete population may be represented by multiple points, it is often better to estimate the number of localities in a proposed site visually. (Note that it's important to involve species experts in the process of identifying discrete populations from occurrence data as they will have knowledge of the species' dispersal range. Also, some known occurrences may not be included in the spatial data table.)

For example, if we wanted to estimate the number of localities of *Aloe plowesii* in the Chimanimani KBA, we would overlay the points on the polygon, right-click on the points layer and select `Zoom to Layer`. In the image below, you can see clearly that all the georeferenced occurrences in Mozambique (representing a single locality according to relevant experts) fall within the Chimanimani KBA (we have zoomed out so that you can see the whole KBA).
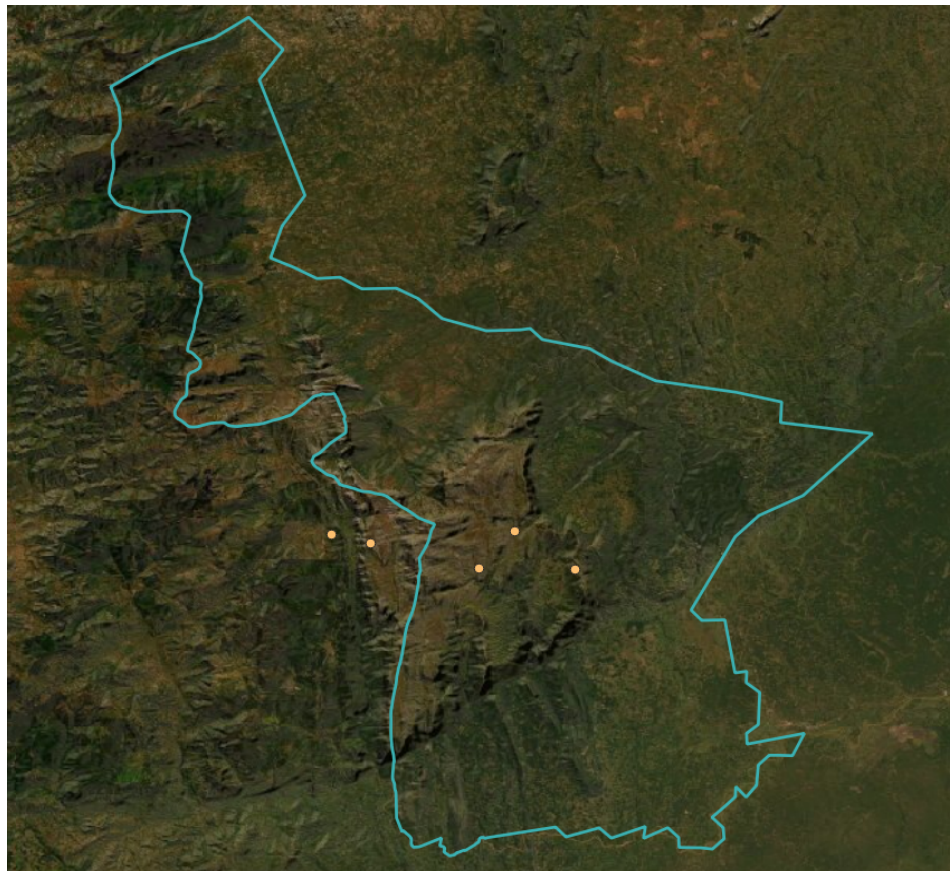
As a final step, we should check whether the occurrence data can be used to confirm recent presence of the species in the KBA. Here, we'll demonstrate one way to do this, but QGIS provides several different options.

In the main toolbar, click on the button to select `Select Feature(s)` and then draw a box that encompasses all the points in the KBA

Now open the `Attribute Table` for the occurrence data layer (hint: click on) and you'll see the 3 points in the KBA highlighted

If necessary, click on the button at the lower-right to `Switch to table view` — you can then easily see the event_year for each of the selected points.

In this case, all 3 georeferenced occurrences from the Chimanimani KBA were collected in 2014 — this information can be used to confirm the recent presence of the species in the KBA.

**Import occurrence data from the Global Biodiversity Information Facility (GBIF)**

There is a plugin for retrieving occurrence data from the Global Biodiversity Information Facility (GBIF) and importing it directly into QGIS. GBIF data may contain errors, but datasets provided by museums and recognised experts are often useful, especially for species that do not yet have an IUCN Red List account.

In the QGIS menu bar, select `Plugins > Manage and install plugins`. In the left panel, click `All` and in the `search box`, type "GBIF occurrences". Select `GBIF Occurrences` and click on `Install Plugin`. Once the plugin is installed, click on `Close`

Once the `GBIF Plugin` is installed, click on the button to open the `GBIF Occurrences` window. Enter the name of the species you wish to search for (e.g., "Nadzikambia baylissi", which occurs in Mozambique) and click on `Load occurrences`

The occurrence data for the species will show up in your `Layers Panel`. In this case, there is a single occurrence. If you open the `Attribute Table`, , you'll see that 4 specimens were collected in 2009 by Bill Branch (Professor W. R. Branch of the Port Elizabeth Museum in South Africa).

This article provides some more information about the discovery of the Mount Mabu Chameleon (*N. baylissi*). The species is restricted to the forested slopes of Mount Mabu, as indicated by the species' range map in the IUCN Red List account. It is a trigger species for the Mount Mabu KBA. In the image below, you can see how the species' range (blue dotted outline) encompasses the forested area, extending slightly beyond the boundaries of the KBA (turquoise outline). The GBIF occurrence data collected in 2009 (red point) can be used to confirm the species' recent presence in the KBA.
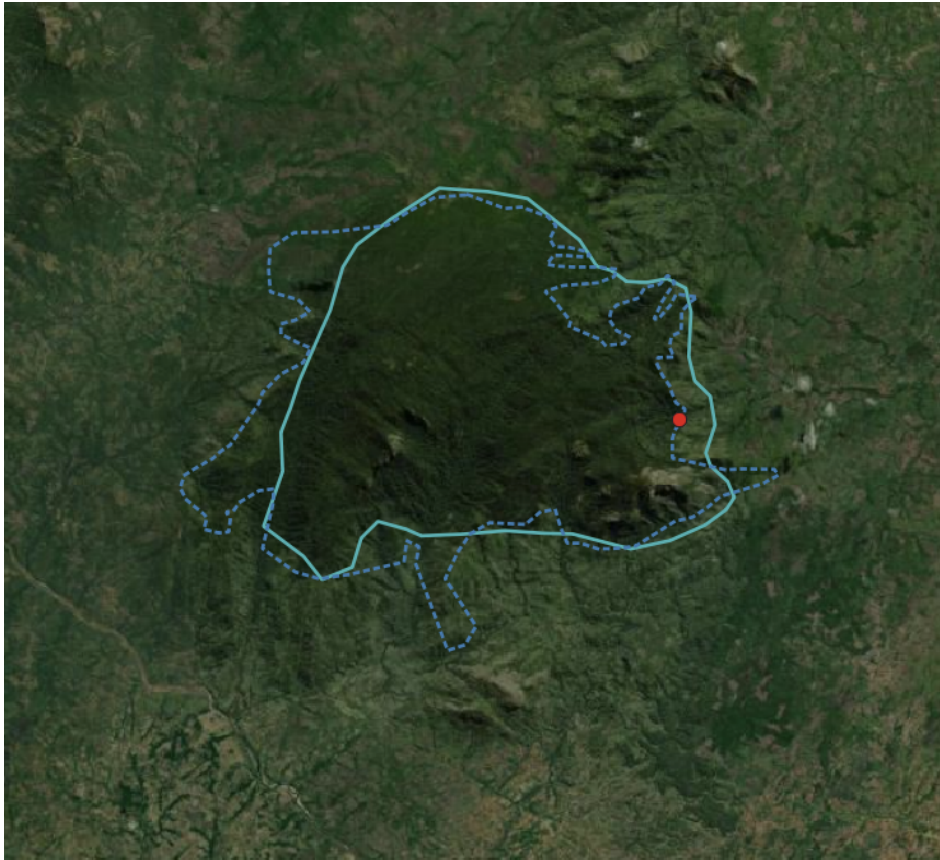
Topic summary

Well done — you've completed the topic on working with occurrence data.

We recommend you `Save` your project now.

In the next topic, we'll add some range maps to your project.

Topic 6: Working with species range polygons

In this topic, we'll switch from point data to polygon data. We'll show you how to download a range polygon from the IUCN Red List and add it to your `QGIS project` as a spatial layer. We'll also introduce the coding system used to distinguish different types of range polygon. It is essential that you check these codes to confirm that you are using the appropriate polygons when estimating range. For example, you should only use range polygons coded as "Extant" or "Probably Extant".

Download a range polygon from the IUCN Red List and add it to a project as a spatial layer

For many species, range maps can be downloaded from the IUCN Red List account. IUCN range shapefiles often comprise multiple features (i.e. individual polygons or groups of polygons), each coded in terms of Presence, Origin and Season.

For non-migratory species, the [KBA Guidelines](#) specify that KBA Proposers should use polygons coded as follows:
- Presence = 1 (Extant) and 2 (Probably Extant);
- Origin = 1 (Native) and 2 (Reintroduced) and 6 (Assisted Colonisation); and
- any Season code (see below for migratory species).

For migratory species that have distinct breeding and non-breeding ranges identified in IUCN Red List range maps, breeding and non-breeding ranges will typically be assessed separately:
- KBA Proposers should use the area of the range coded as follows for the breeding range:
  - o Presence = 1 (Extant) and 2 (Probably Extant);
  - o Origin = 1 (Native) and 2 (Reintroduced) and 6 (Assisted Colonisation); and
  - o Seasonality = 1 (Resident) and 2 (Breeding Season) and 5 (Seasonal Occurrence Uncertain).
- KBA Proposers should use the area of the range coded as follows for the non-breeding range:
  - o Presence = 1 (Extant) and 2 (Probably Extant);
  - o Origin = 1 (Native) and 2 (Reintroduced) and 6 (Assisted Colonisation); and
  - o Seasonality = 1 (Resident) and 3 (Non-breeding Season) and 5 (Seasonal Occurrence Uncertain).

Let's consider a specific example, the Whooping Crane (*Grus americana*, EN):

Go to the [IUCN Red List](#) and search for "Whooping Crane", click on the `download` button at the upper-right, and select `Range data — Polygons (SHP)`

Navigate to the downloaded zipfile in your downloads folder, `unzip` it, and copy all the files to your `spatial data folder` — we recommend you save the data to a subfolder named "Grus_americana" or similar.

In the QGIS menu bar, select `Layer > Add Layer > Add Vector Layer`, click on the … at the right of the Vector Datasets box and then navigate to the relevant species subfolder in your `spatial data folder`

Select the "data_0.shp" file and click `Open`

Click `Add` then `Close`

The new layer is called "data_0", which is not very descriptive, so you can rename the layer in your project by right-clicking on the layer and selecting `Rename Layer` (e.g., as "whooping_crane"); this is just cosmetic — it does not change the name of the underlying file)

Right-click on the Whooping Crane layer again and select `Open Attribute Table` (or highlight the layer in the `Layers Panel` and click on the button in the toolbar)

The panel on the left indicates that there are four separate "features" (i.e. polygons or groups of polygons); highlight each one in turn and check how they differ in terms of `Presence`, `Origin` and `Season` — each polygon is coded Presence = 1 (i.e. the species is considered Extant throughout the mapped range); and Origin = 1 (i.e. the species is considered Native throughout the mapped range), but Season is coded 1, 2, 3, or 4.

If you like, you can click on the button to `Dock Attribute Table`, which will allow you to select different polygons in the `Attribute Table` and see their spatial extent in your QGIS Project simultaneously

Let's imagine we want to assess possible KBAs for the Whooping Crane in its breeding range only. Following the KBA Guidelines, we want to select Seasonal = 1 (Resident) and 2 (Breeding Season) only:

> With a single species and just 4 polygons, the simplest method is to highlight the relevant polygons (i.e. those coded Seasonal=1, or Seasonal=2), using the shift key to highlight multiple rows — you'll see the 2 small polygons in the northwest and southeast of the range highlighted in bright yellow on your map

> If you want to save this as a new shapefile, right-click on the Whooping Crane layer, select `Save Selected Features As ...`, then save the selected features in your `spatial data folder` under a new name (e.g., "Grus_americana_breeding")

You can repeat this process to select the non-breeding range.

> Click on the button to `Deselect all features from the current active layer`

> Select polygons coded Seasonal=1, or Seasonal=3. If you want to select multiple polygons that are non-adjacent in the table, click the button at the lower-right to `Switch to form view` then check the relevant boxes.

The non-breeding range comprises 2 small polygons in the south of the range. The migration corridor or passage range (Seasonal = 4) is not included in either the breeding or non-breeding range.

Remember that, for species that have been extirpated from part of their range or introduced for non-conservation purposes outside their native range, you only want to include polygons coded Presence = 1 or 2 and Origin = 1, 2 or 6.

In the image below, the passage range is shown in pale yellow, the breeding range in purple, and the non-breeding range in red hatch.

We'll not return to the Whooping Crane for a while, so you can tidy up your `Layers Panel` by right-clicking and selecting `Remove Layer`.

Topic summary

Well done — you've completed the topic on working with species range polygons.

We recommend you `Save` your project now.

In the next topic, we'll look at how to calculate area and values of area-based parameters.

Topic 7: Calculating area and area-based assessment parameters

In many cases, accurate estimation of area-based parameters (e.g., species' range or ecosystem extent) is essential for assessing whether a site qualifies as a KBA. Area calculations for the same polygon may vary depending on the projection used — it is important that you specify the projection correctly to ensure that area calculations used in KBA assessments are consistent.

In this topic, we will take some time to demonstrate this point, by using various methods to calculate the area of the global range polygon for the Polar Bear. We provide two methods for calculating area correctly for the purposes of KBA assessment in QGIS — you may use whichever you prefer as the answer will be the same.

We'll also show you how to intersect a range polygon with a site polygon and calculate the area of the range that falls within the site. We'll first demonstrate this using a non-migratory species as an example, and then look at how to do this for a migratory species with multiple range polygons coded by season.

A Polar Bear experiment to demonstrate the importance of projection

As explained above, it's important that any layers used for area calculations are based on the standard equal-area projection used in KBA analysis: the World Cylindrical Equal-Area projection (i.e. ESRI: 54034).

QGIS is a user-friendly GIS package that provides several methods for estimating the area of a polygon. It's important that you use the correct method for KBA identification. If you don't, the results may not match calculations from other GIS packages — the scale of the error will depend on the size of the area and its geographic location. Given that KBA assessment often relies on accurate estimation of the proportion of a species' range or an ecosystem's extent at a site, it's essential that area calculations are accurate and consistent. We'll demonstrate this issue with an experiment using the range map for the Polar Bear.

Polar bear range map

For the purposes of this exercise, we'll use the IUCN Red List range map for the Polar Bear (*Ursus maritimus*, VU):

Go the [IUCN Red List](#) and search for "Polar Bear", download the range data and add the Polar Bear range shapefile to your `QGIS project` as you did for the Whooping Crane. We recommend you save the Polar Bear data to a subfolder named "Ursus_maritimus" or similar

The new layer is called "data_0", so you might want to rename it as you did for the Whooping Crane

Rough-and-ready area estimation: $area

First we'll estimate the area of the Polar Bear range using a rough-and-ready method for area estimation using unprojected spatial data. In this method, QGIS can estimate the area of an unprojected polygon (e.g., a polygon in EPSG:4326) by referring to the underlying ellipsoid (e.g., WGS 84). This method can produce good results, especially for small areas near the Equator, but it's not reliable.

Check the CRS by right-clicking on the Polar Bear layer, selecting `Properties` and then `Source`; you'll see that the `Assigned CRS` is EPSG:4326 – WGS 84. This means that the spatial layer is the standard geographic coordinate system based on the WGS 84 ellipsoid and has not been projected. Close the `Layer Properties` box.

Now open the `Attribute Table`, , for the Polar Bear layer

Click on the button at the top to open the `Field Calculator`

In the center box, select Geometry and then double-click on "$area"

The area estimate will show in the lower-left by `Preview`: 22,634,789 (plus a few decimal places); the estimate will be in square kilometers if you set that as your `Preferred area units` earlier.

Note down the area estimate somewhere handy for comparison and click `Cancel`; close the `Attribute Table`

Reprojecting the spatial data layer

Next we'll reproject the Polar Bear range data in standard World Cylindrical Equal-Area projection and repeat the experiment.

Highlight the Polar Bear range layer in the `Layers Panel` on the left

In the QGIS menu bar, select `Vector > Data Management Tools > Reproject Layer`

In the `Target CRS` box, select Project CRS: ESRI; 54034 – World_Cylindrical_Equal_Area, and then click `Run`

The new temporary layer will show up in the `Layers Panel` on the left, labelled Reprojected

Now use the same rough-and-ready method as before to estimate the range area. The area estimate will be almost the same as the previous estimate because both estimates are based on the same underlying ellipsoid (i.e. WGS 84).

Based on the experiment so far, it looks like it doesn't really matter whether or not you reproject the data layer as the rough-and-ready estimates are almost the same, even for this large range area. The problem is that they are not accurate and a different GIS would calculate area differently.

Correct area calculation based on the specified projection: area($geometry)

Now let's calculate area correctly, based on the specified projection:

Open the `Attribute Table` for the reprojected Polar Bear layer again and then open the `Field Calculator`

In the left box under `Expression`, copy-paste "area($geometry)/1000^2"; the 1000^2 converts from m^2 to km^2 for comparison with our previous estimates

The area calculation will show in the lower-left by `Preview`: 22,637,383 (plus a few decimal places)

Note down the area calculation somewhere handy for comparison, click `Cancel`, and close the `Attribute Table`

If you compare the new calculation with the rough-and-ready estimate, you'll find a difference of some 2,500 km^2!

The correct method calculates the area based on the projection we specified. Essentially we use the projected CRS (in this case the World Cylindrical Equal-Area projection) to

tell QGIS exactly how we want to convert our 3-dimensional geographic data to a 2-dimensional planimetric surface for the purposes of calculating area.

Another user should get the same result for the same shapefile in the same projection in any other GIS.

Correct area calculation using on-the-fly projection: area(transform($geometry, …, …)

If the correct method summarised above seems rather cumbersome, QGIS has provided an alternative method for estimating area in a specified projection without creating a new projected shapefile:

> Right-click on the original spatial layer in the geographic CRS (i.e. EPSG:4326) and open the `Attribute Table` and then the `Field Calculator`

> Copy-paste "area(transform($geometry, 'EPSG:4326','ESRI:54034'))/(1000^2)" into the `Expression` box

The new area calculation will be identical to the previous correct area calculation. The transform() function implements an on-the-fly projection (from EPSG:4326 to ESRI: 54034 as specified).

You can use either correct method to calculate area in QGIS for all KBA assessments, as they give the same results. We recommend the method based on on-the-fly projection as you don't need to save a copy of each shapefile in a different projection.

Technical Box: Recommended method for area calculation
Copy-paste the following expression into the `Expression` box of the `Field Calculator`:   **area(transform($geometry, 'EPSG:4326','ESRI:54034'))/(1000^2)**

We'll not return to the Polar Bear, so you can tidy up your `Layers Panel` by removing all Polar Bear layers.

We recommend you `Save` your project now.

Estimating the size of WDPA sites

The WDPA polygon shapefiles include a field named GIS_AREA, calculated in the Mollweide projection. This value will be very similar to the value calculated using the World Cylindrical Equal-Area projection using the correct method summarised above. Nevertheless, it is important to recalculate the area using the World Cylindrical Equal-Area projection to ensure consistency across all sites.

Estimating global range area

For the next exercise, we'll use the IUCN Red List range map for Marshall's Pygmy Chameleon (*Rhampholeon marshalli*, VU). Follow the same steps as for the Whooping Crane and Polar Bear to download the range data from the [IUCN Red Lis](#)t and import it to your QGIS project. As before, the shapefile is called "data_0", so you might want to rename it to something more specific. If you change the Layer Styling to purple, it will look similar to the image below:
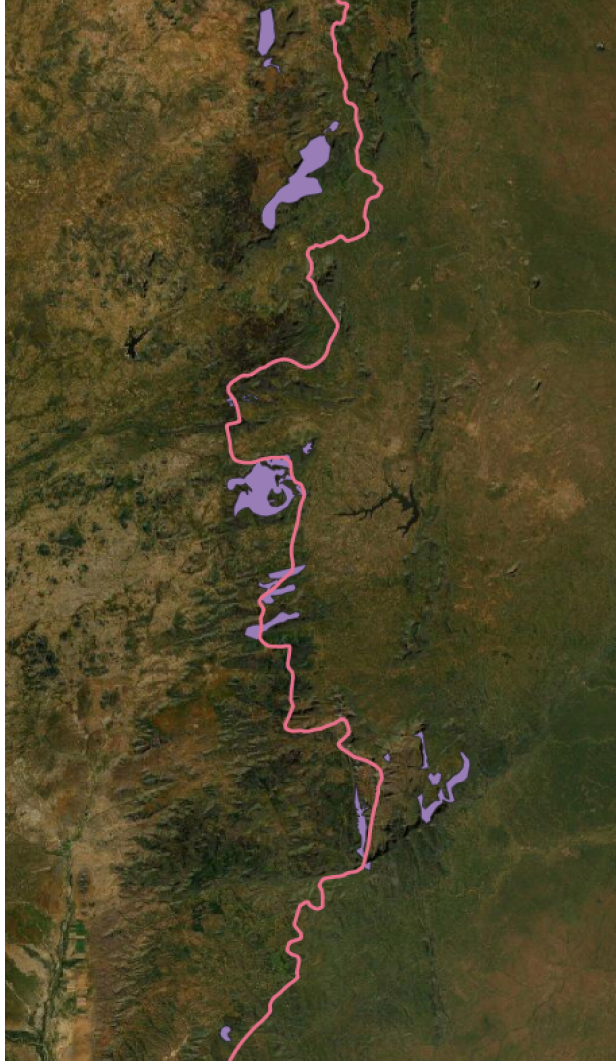
Use the correct method for area calculation using on-the-fly projection, as described above for the Polar Bear.

Right-click on the chameleon spatial layer and open the `Attribute Table`. We only have one feature in this case, but it's always good practice to check that the Presence, Origin and Season codes match your current task

Open the `Field Calculator`, then copy-paste "area(transform($geometry, 'EPSG:4326','ESRI:54034'))/(1000^2)" into the `Expression` box

This time we'll save the area calculation to a new field by typing "GLOB_AREA" in the `Output field name` box, selecting Decimal number (real) in the `Output field type` box, and setting `Precision` = 3, then selecting ok

The global range area calculation will now show up in the final column: 529.890 km^2

Close the `Attribute Table`, then right-click and `Save Layer Edits`

In this case, the total range area is slightly less than the estimated Area of Occupancy (AOO) given in the IUCN Red List account, possibly because AOO is calculated using 2 x 2 km grid cells.

Intersecting site and species range polygons to calculate the area within a site

Intersect a species' range with a KBA

If only part of a species' global range falls within a site, the first step to calculating the area of the range within the site is to create a new spatial layer based on the intersection of the species' global range polygon(s) with the site polygon. We'll save this layer as a shapefile so that it can be submitted as part of a KBA Proposal:

In the QGIS menu bar, select `Vector > Geoprocessing Tools > Intersection`

Set your chameleon layer as your `Input layer` and your site layer as your `Overlay layer`; you can use the Chimanimani layer you created earlier or the KBA layer for Mozambique if you have it

Leave `Input fields to keep` blank, so that all fields from the species range data are retained

Click on the … next to `Overlay fields to keep`, and select the SitRecID and NatName if you are using an existing KBA, or WDPA_PID, NAME and DESIG_ENG if you're using a WDPA data layer (e.g., the Chimanimani layer you created earlier) plus any other fields you think would be useful and click `ok`

Click the … next to `Intersection`, select `Save to File` … navigate to your chameleon subfolder and type in a name for your intersection shapefile, click `Save`, then `Run`[1]

---

[1] Occasionally the intersection process will produce an error message relating to invalid geometries. See the next section for guidance on how to resolve this type of error.

Your new shapefile will now show up in your `Layers Panel` — `Zoom to Layer` and you'll see it comprises the segments of the range polygons that intersect the Chimanimani KBA as shown in the image below (zoomed in to the north of the KBA, with the global range polygons in purple and the range within the site in red hatch).
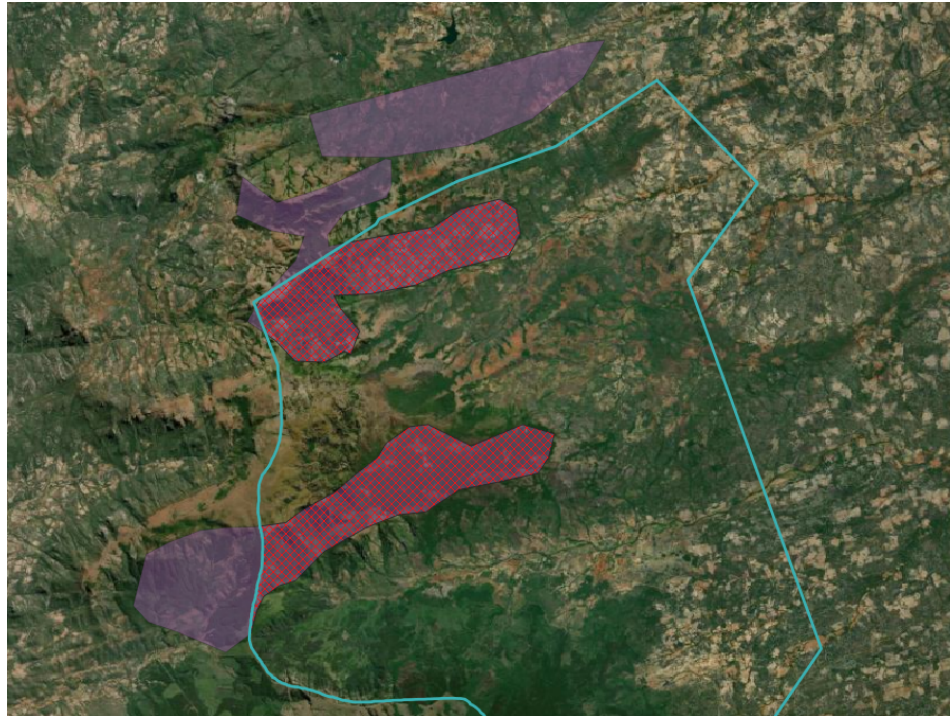

Fixing geometries

Occasionally the intersection process will produce an error message relating to invalid geometries. (This seems to be fairly common for shapefiles created in ArcGIS and imported to QGIS.) QGIS has built-in tools for detecting and fixing invalid geometries.

For example, an attempt to intersect range polygons with the Malaysia KBA polygons (as at March 2021) produces the following error message:

> Feature (55) from "KBAsGlobal_2021_March_Malaysia" has invalid geometry. Please fix the geometry or change the Processing setting to the "Ignore invalid input features" option.

To identify the problem, return to the main QGIS window and select `Vector > Geometry Tools > Check Validity`. Check that the layer with invalid geometries is shown under `Input layer`, then click on `Run`.

In the `Layers panel`, you will see 3 new layers. The `Error output` layer shows the locations and description of the geometry errors. Right-click and `Zoom to layer` to see the location; right-click and select `Open Attribute Table` to see a description of the error (e.g., ring self-intersection, where a polygon contains an interior hole, as in the example shown here).
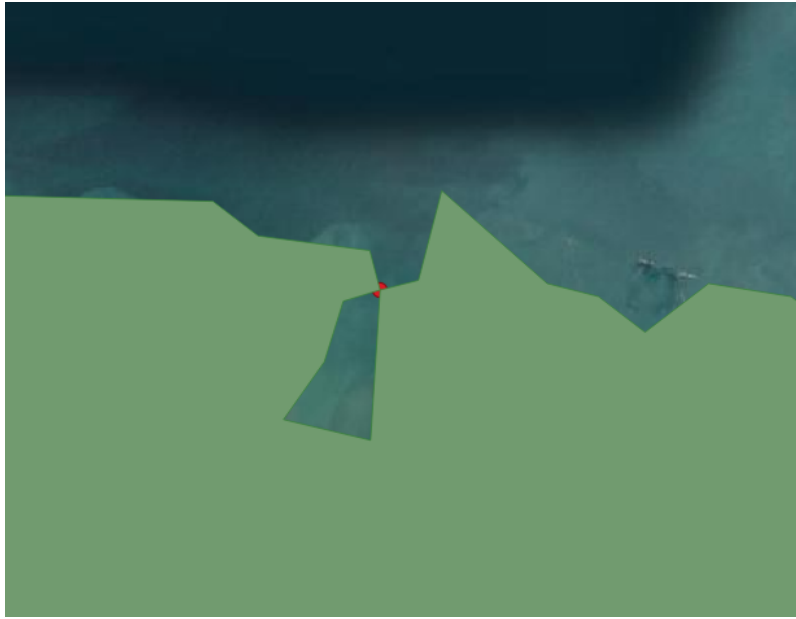
To fix the problem, select `Processing > Toolbox`, then search for "fix geometries" and select that option.

In the `Fix Geometries` window, check that the original layer with invalid geometries (not the `Error output`) is shown under `Input layer`, then click on `Run`. In the `Layers panel`, you will see a new layer, Fixed Geometries, which resolves the geometry error without changing the KBA boundaries, as shown here. (The original KBA polygon is shown in green; the boundary of the fixed KBA polygon is shown as a dotted black line.)
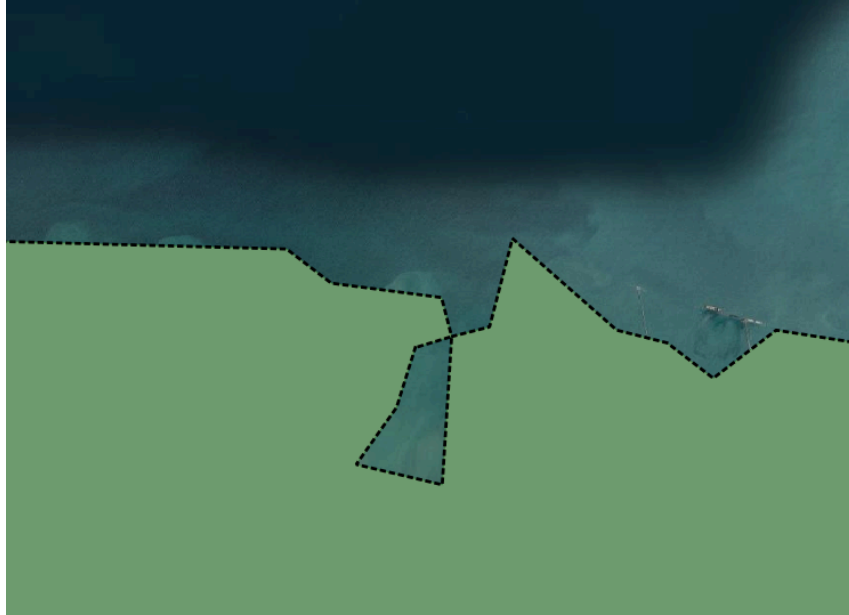
Now, re-run the intersection process on the fixed layer and the invalid geometries error will be resolved.

Calculate the area of the intersection

> Next open the `Attribute Table` for the new intersection layer
>
> Calculate the area as before, but this time use the `Output field name` "SITE_AREA"
>
> In the toolbar, click the button to `Save Layer Edits`

If you used the KBA layer, you'll see the range area in the KBA is 105.934 km² (i.e. 19.99% of the species' global range).

If you used the Chimanimani layer you created earlier, you'll see the range area in the National Park is 55.214 km²and the range area in the Buffer Zone is 50.841 km².

Sum the area of multiple features

While we could easily sum the range area within the National Park and the Buffer Zone on a calculator, QGIS also provides a convenient tool to do this.

In the main toolbar, click the button for `Statistics`; select the relevant species layer, then select the relevant `Field name` immediately below (e.g., SITE_AREA), and

you will see the sum of the area of all features in the row labelled `Sum`. In this case, we have 2 features (Count) and the total area is 106.055 km² (Sum). This is slightly greater than for the KBA as there are minor differences in the boundaries.

Estimating the range size of migratory species

In the case of Marshall's Pygmy Chameleon, we have a single feature, comprising multiple spatially distinct polygons, coded Presence = 1 (i.e. Extant); Origin = 1 (i.e. Native); and Seasonality = 1 (i.e. Resident). How would we adapt the process for estimating global or site-level range areas for migratory species with multiple features coded by season?

For migratory species that have distinct breeding and non-breeding ranges identified in IUCN Red List range maps (i.e. separate polygons coded by season), the KBA Guidelines say that breeding and non-breeding ranges will typically be assessed separately.

Let's return to the Whooping Crane example. If you previously removed the crane layer, add it back to your `QGIS project` now. Then apply the same procedure as for the chameleon to calculate the area of each of the four features, but this time set the `Output field name` to "FEAT_AREA".

If you like, click on the button to `Dock Attribute Table` — you'll now see the `Attribute Table` below your map. You'll notice that several of the features are overlapping. Consequently, if we simply summed the area for all four features, we would overestimate the combined spatial footprint.

To calculate the global area of the breeding range:

> First check the Presence and Origin codes for all features, then select the relevant features that are coded Seasonal = 1 (i.e. Resident) or Seasonal = 2 (i.e. Breeding Season)

> Check that the selected polygons do not overlap (this can often be done visually, but see below for a more technical approach)

> In the main toolbar, click the button for `Statistics`; select the relevant species layer, then select the relevant `Field name` immediately below (e.g., FEAT_AREA)

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You'll see the sum of the area of all features. In this case, the Count shows that we have 4 features, but we can check the `Selected features only` box to focus on the 2 features that comprise the breeding range: the sum of the area of selected features is 6,122.73 km^2.

To calculate the global area of the non-breeding range:

Click on the button to `Deselect all features` from the layer

Select polygons coded Seasonal=1 (i.e. Resident) and Seasonal=3 (i.e. Non-breeding) and check that the selected polygons do not overlap

Use the `Statistics` tool, , to calculate the sum of the area of the selected features: 10,919.7 km^2.

Handling overlapping features when estimating range size

The `Topology Checker` plugin can be useful for checking whether range polygons overlap without relying on visual inspection.

In the QGIS menu bar, select `Plugins > Manage and Install Plugins`. Search for "Topology Checker" and make sure it's checked.

In the QGIS menu bar, select `Vector > Topology Checker`. Click on the button to configure. Under `Current Rules`, select the relevant species layer. In the next box, select the rule "must not overlap". Click `Add Rule`, then click `OK`.

Then click the button in `Topology Checker` to `Validate All`. Any overlaps will show up as "errors" in the box below. Note, however, that these may include marginal overlaps between adjacent polygons.

If there are overlaps between features that should be included in the same range size estimation (e.g., polygons coded as Seasonal = 1 (i.e. Resident) and Seasonal = 2 (i.e. Breeding Season)), the best approach is to `Dissolve` the relevant features into a single feature before calculating the area:

In the QGIS menu bar, select `Vector > Geoprocessing Tools > Dissolve ...`. Select the relevant species layer, checking `selected  features` if appropriate.

You can leave the box under `Dissolved` as "[Create temporary layer]" or or click on the … to `Save to File`…

Open the `Attribute Table` for the new `Dissolved` layer. Then calculate the area using the correct area calculation method with on-the-fly projection (i.e. by opening the `field  calculator` and pasting "area(transform($geometry, 'EPSG:4326','ESRI:54034'))/(1000^2)" into the `Expression` box).

If you try this for the crane layer, the result will be 1544372.885, which is approximately the same as the sum of all 4 features (i.e. 1.54437e+06) as overlaps are marginal.

Topic summary

Well done — you've completed the topic on calculating area and values of area-based parameters.

We recommend you `Save` your project now.

In the next topic, we'll look at ecosystem distribution data.

Topic 8: Working with ecosystem distribution data

In this topic, we'll focus on working with ecosystem distribution data.

[This section will be completed in the next version of this Tutorial.]

Download an ecosystem distribution map from the Red List of Ecosystems

Estimating global ecosystem extent

Intersecting site and ecosystem extent polygons to calculate the ecosystem extent within a site

Intersect an ecosystem's distribution with a KBA

Calculate the area of the intersection

Topic summary

Well done — you've completed the topic on working with ecosystem distribution data.

We recommend you `Save` your project now.

In the next topic, we'll look at GIS tools for delineating KBAs.

Topic 9: GIS tools for delineating KBAs

This topic focuses on GIS tools and techniques for adjusting the boundaries of existing KBAs or delineating new KBAs. Please see the KBA Standard and KBA Guidelines for guidance on the principles that should be followed in KBA delineation.

We'll start by showing you where to find additional base maps that might be useful for KBA delineation. We'll then show you how to digitise a new polygon or refine an existing polygon. We'll also use this opportunity to show you how to dissolve multiple features (e.g., polygons) into a single feature (e.g., set of polygons with shared attributes). This can be useful if, for example, you digitise several spatially separate polygons representing the range of a species (with the same values for presence, origin and season).

Additional base maps for delineating KBAs

When working on KBA delineation, you may want to refer to additional base maps. You can access a wide variety of base maps through the `QuickMapService` plugin.

First, load or update the plugin as follows:

> In the QGIS menu bar, select `Plugins > Manage and Install Plugins`
>
> Check `Installed` to see whether `QuickMapServices` is already installed and upgrade if a new version is available
>
> If `QuickMapServices` is not already installed, check `Not installed` and follow the instructions

Next, search for additional base maps and add them to your project:

> In the QGIS menu bar, select `Web > QuickMapService > Search QMS`
>
> Try searching for "google satellite hybrid" or "google terrain hybrid" and adding those to your project
>
> To identify additional layers that are available for your country, zoom to your country and then click `Filter by extent`

Basemaps for marine applications

If you are working on marine KBAs, you will probably want to refer to a basemap that shows ocean bathymetry. After installing the `QuickMapService` plugin, as above:

In the QGIS menu bar, select `Web > QuickMapService > Search QMS`

Search for "ocean" and add the ESRI ocean basemap to your project

When delineating marine KBAs, it may be useful to reference bathymetric contours (i.e. contours indicating the depth of the sea floor). Bathymetry data can be downloaded from the General Bathymetric Chart of the Oceans (GEBCO) in various forms. Here we will demonstrate how to download bathymetric data for a specific area and display the data as bathymetric contours.

On the GEBCO page for [gridded bathymetry data](#), click on "download data for user-defined areas" and then "application"

Select your region of interest on the map; in the panel on the left, select the latest version, and then check the box under GeoTIFF and Grid, then click on "Add to basket" and then "View basket".

Once your data have downloaded, navigate to the downloaded zipfile in your downloads folder, `unzip` it, and copy all the files to your `spatial data folder`

In the QGIS menu bar, select `Layer > Add Layer > Add Raster Layer`, click on the ... at the right of the `Raster Datasets` box and then navigate to your `spatial data folder`

Select the "gebco .. " file with ".tif" at the end and click `Open`
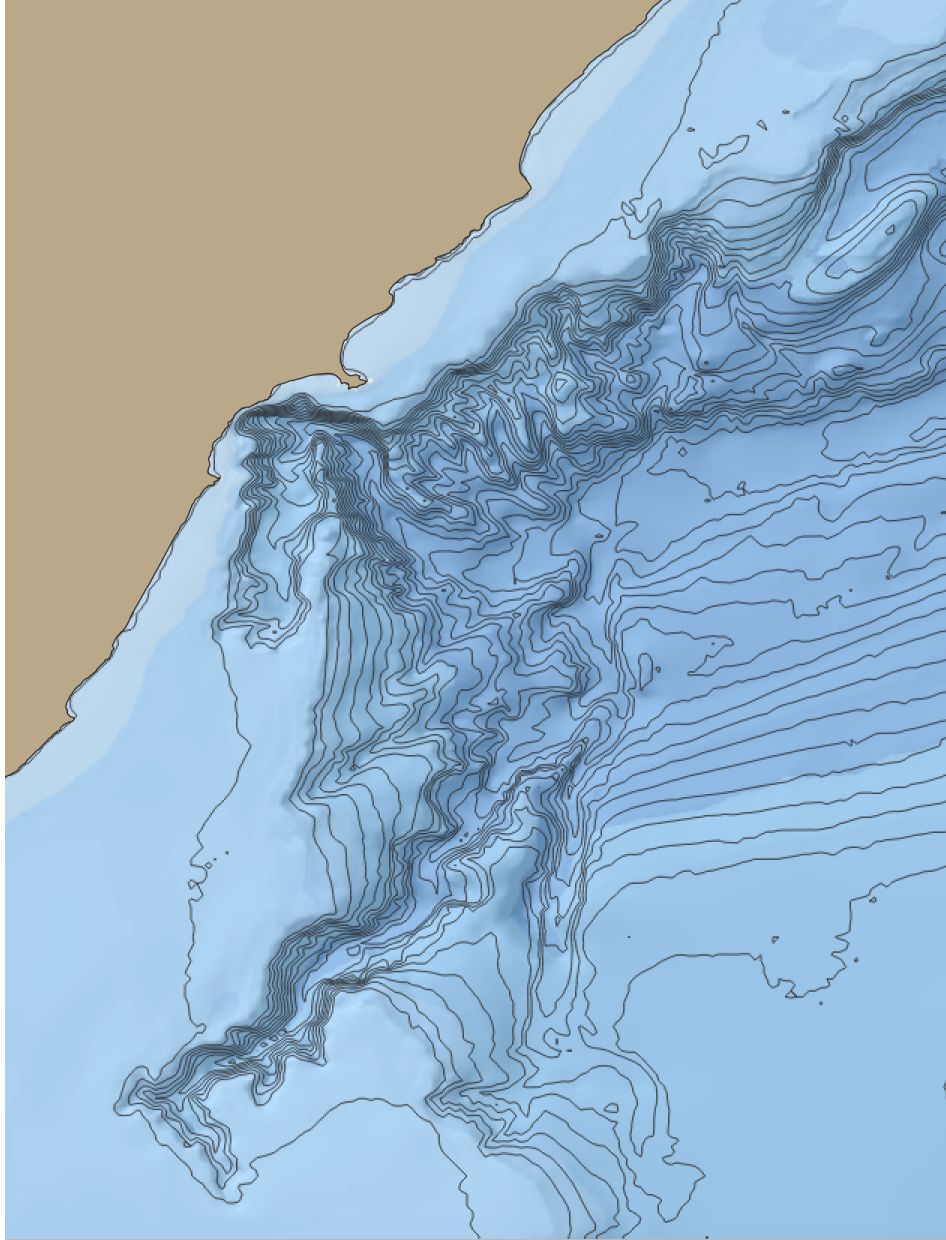
Click `Add` then `Close`

In the `Layers Panel`, highlight your new `bathymetry layer` and open the

`Layer Styling Panel`,

In the dropdown box at the top, select `Contours`

The image below shows the ESRI ocean layer with GEBCO contours overlaid, revealing the complex bathymetry around New Zealand's Kaikoura Canyon.

Note that the GEBCO datasets have traditionally focused on deeper waters (e.g., depths greater than 200 m), but work is ongoing to incorporate datasets for shallower waters (see [here](#) for details). In the meantime, you may need to reach out to your national hydrographic service to access bathymetric data for shallower waters in your region.

Digitise a polygon and create a new spatial layer

You may wish to delineate an entirely new site which requires a new polygon to be digitised. To do so, first make sure that the appropriate `Layers Panel`, `Digitising Toolbar`, `Manage Layers Toolbar` and `Map Navigation Toolbar` are displayed.

(Panels and Toolbars can be added or removed by right-clicking the grey panel above the base map.)

In the `Manage Layers Toolbar`, click the `New Shapefile Layer` button,

Your `File name` should be something useful (e.g., the proposed name for the new KBA). Click the … next to the `File name` field, navigate to the appropriate folder, and click `Save`

Change `Geometry type` to `Polygon`

By default, the CRS is set at EPSG:4326 – WGS 84. Once the new polygon layer has been created, it can be projected into World Cylindrical Equal-Area projection later, if necessary.

Polygon attributes can be added within the `New Field` section and the `Type` specified as Text Data, Whole Number, Decimal Number, or Date. For each new field, type the `Name`, then select the appropriate `Type`, click `Add to Fields List`. After all fields have been added, click `OK`. (Please see the shapefile templates provided on the KBA website (on the [Tools page](#)) for standard `Field Names` and `Types` for KBA shapefiles.)

Your new shapefile will now show up as a spatial layer in your `Layers Panel`.

To draw the polygon:

First make sure the new `Layer` is highlighted, then click the `Toggle Editing` button, , followed by the `Add Polygon Feature` button,

On your base map, select as many points as necessary to delineate an accurate and precise boundary. When satisfied with your boundary, `right-click`.

In the pop-up window, fill in the `Attributes` for the new polygon. You can leave the `id` field as NULL or assign a name or number. Then click `OK`.

In most scenarios, you will only create one polygon. However, if you are proposing a site that consists of more than one polygon:

Assign a unique `id` to your initial polygon and click `OK`.

Then, draw a new polygon boundary, right-click, assign a unique `id` to the new polygon, then click `OK`. Repeat this process until all desired polygons have been delineated.

Finally, click `Save Layer Edits` button, , to save your new polygon layer.

You can practice by delineating polygons around lakes or islands, as shown in the image below.

For large polygons, it will often make sense to delineate an initial polygon roughly at a relatively broad spatial resolution (e.g., 1:50000) and then refine it at a finer resolution (e.g., 1:15000). You can check the `Scale` at the bottom of your `QGIS project` window. See below for how to refine an existing polygon.

Adjust or refine an existing polygon on-screen and create a new spatial layer

When adjusting an existing polygon, we strongly recommend that you first save a copy of the existing polygon and edit that.

Right-click on the target layer and select `Export > Save Features As…` to save the layer under a new name. The new layer will show up in your `Layers Panel`

Highlight the new layer, click the `Toggle Editing` button, , then select the `Vertex Tool (Current Layer)`, . Hover the cursor over the polygon to reveal the points used to delineate the existing polygon; click on a point then move the cursor to shift the point

Note that you can add and remove points as part of this process. To create a smoother boundary, create a new point by clicking on the line midway between two existing points and then move the new point

To remove a point, highlight the point and then press `delete` on your keyboard

Repeat this process to redelinate the polygon, then click the `Save Layer Edits` button, , to save your new polygon.

For example, we edited the polygon in the image above to include some of the sand bars. The image below shows both the original and edited polygons.

Dissolve multiple features into a single feature

In some cases, it may be useful to combine multiple polygons represented as different features into a single one. For example, it may be useful to dissolve different polygons representing a species' breeding or non-breeding range into a single feature.

On the QGIS menu bar, select `Vector > Geoprocessing Tools > Dissolve` …

A new window will open that will ask you to select which layer you wish to dissolve (i.e. the `Input Layer`), and which `Dissolve fields` to use. If the `Dissolve field(s)` box is left blank, all polygons in the layer will be merged into a single feature. Alternatively, if one or more fields are selected, by clicking on the … to the right of the `Dissolve field(s)` box, selecting one or more fields and then clicking `ok`, polygons with the same value for selected fields will be dissolved into a single feature.

For example, we created a new layer representing the distribution of mature males and females of a fictitious sea lion species in the breeding and non-breeding season (left panel in image below; numbers refer to polygon ids). The layer comprises 3 polygons represented as separate features — the `Attribute Table` is shown below.

	id	Species	Male	Female	Breeding	Count
1	1	sea lion	1	1	1	1500
2	2	sea lion	1	1	0	1000
3	3	sea lion	1	0	0	500

Applying the `Dissolve tool` with `Dissolve field(s)` left blank, dissolves the 3 polygons into a single feature. But, applying the `Dissolve tool` with "Breeding" selected as a `Dissolve field`, dissolves the 2 polygons coded Breeding = 0 into a single feature (shown in green in the right panel below), leaving the remaining polygon (coded Breeding = 1) as a separate feature.
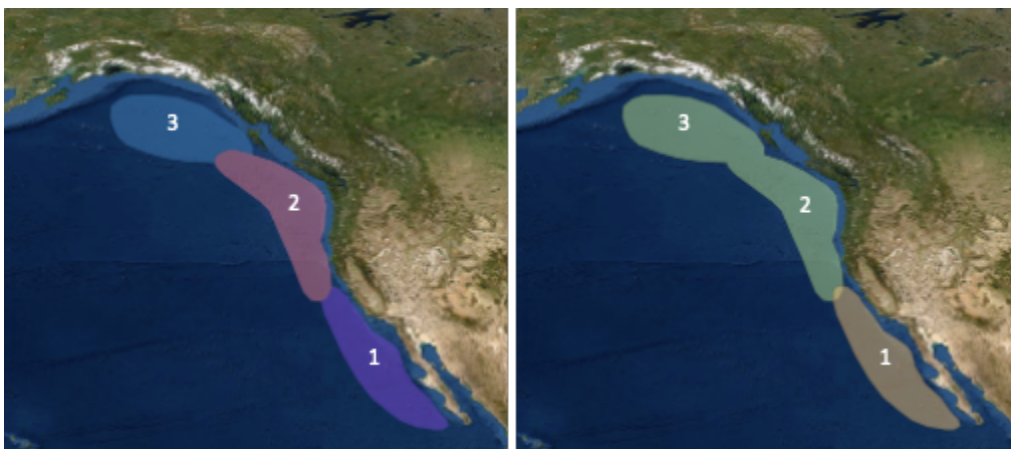
Note that, when dissolving polygons, the attributes of one input polygon will be used to populate the attributes for the dissolved polygon. Please check the `Attribute Table` carefully to make sure that it accurately represents the attributes of dissolved polygons and edit as appropriate. (For example, in this case, the count for one of the two non-breeding polygons is retained, so we must edit the attribute data (see below) to show the sum of the counts of the dissolved polygons instead.)

Topic summary

Well done — you've completed the topic on GIS tools for delineating new KBAs.

We recommend you `Save` your project now.

In the next topic, we'll look at ways to edit attribute data.

Topic 10: Working with attribute data

Shapefile templates will be provided on the KBA website (in the Tools section). You may need to add, rename or remove attribute `Fields` and/or modify `Field` data types to match the appropriate template. In this topic, we'll show you how to do this.

Adding and removing attribute fields

To add an attribute `Field` to an existing spatial layer:

Open the `Attribute Table`, , and click on the `Toggle Editing` button,

Click on the `New field` button, , to add an attribute field and complete the information required in the `Add Field` window

Click on the `Save edits` button, , to save your changes

To remove an attribute `Field` from an existing spatial layer:

Open the `Attribute Table`, , and click on the `Toggle Editing` button,

Click on the `Delete field` button, , and select the field(s) you want to remove from the `Delete Fields` window
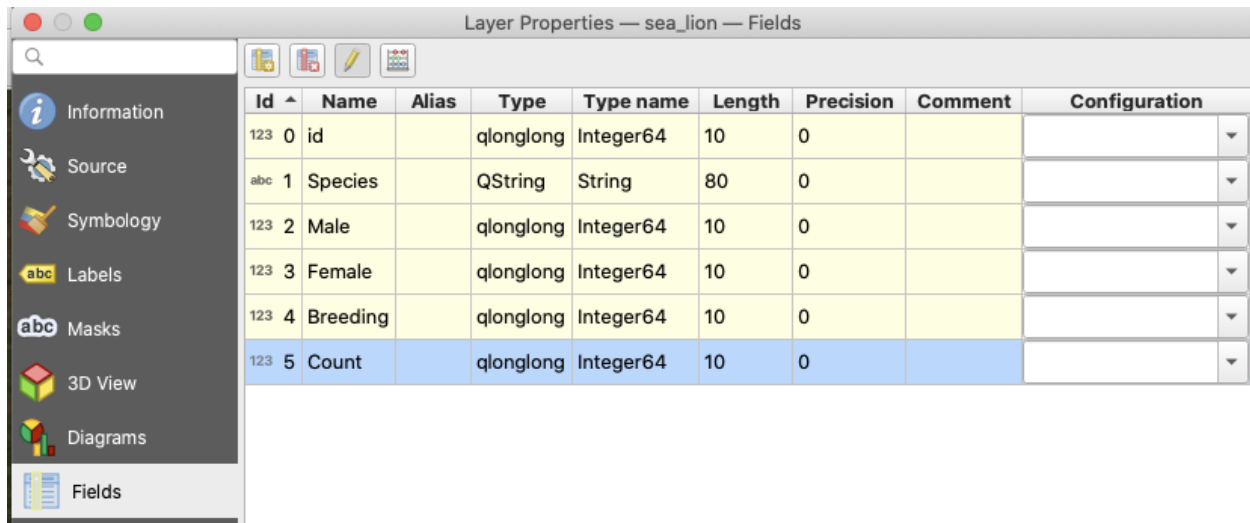
Click on the `Save edits` button, , to save your changes

Editing the properties of an existing attribute field

To change the name or edit other properties of an attribute `Field`:

Right-click on the target layer in the `Layers Panel` and select `Properties`, then click on `Fields` on the left of the `Layer Properties` window

For example, the `Fields` for the fictitious sea lion species we created earlier look like this:

To change the name of an attribute `Field`:

Click on the `Toggle Editing` button, , and type in the new name for the attribute

Click on the `Toggle Editing` button, , again and save your changes and then close the `Layer Properties` window

To change data type, open the `Refactor fields` tool:

Click on the `Processing Toolbox` button, , in the menu bar and type "refactor" in the search box to find the `Refactor fields` tool

Double-click on `Refactor fields` to open a pop-up window, select the target layer in the `Input layer` box, and then use the drop-down options in the `Fields mapping` window to change field types (see example below). (When changing from a Whole number to a Decimal number, you will also need to increase the Precision to the number of decimal places required.)
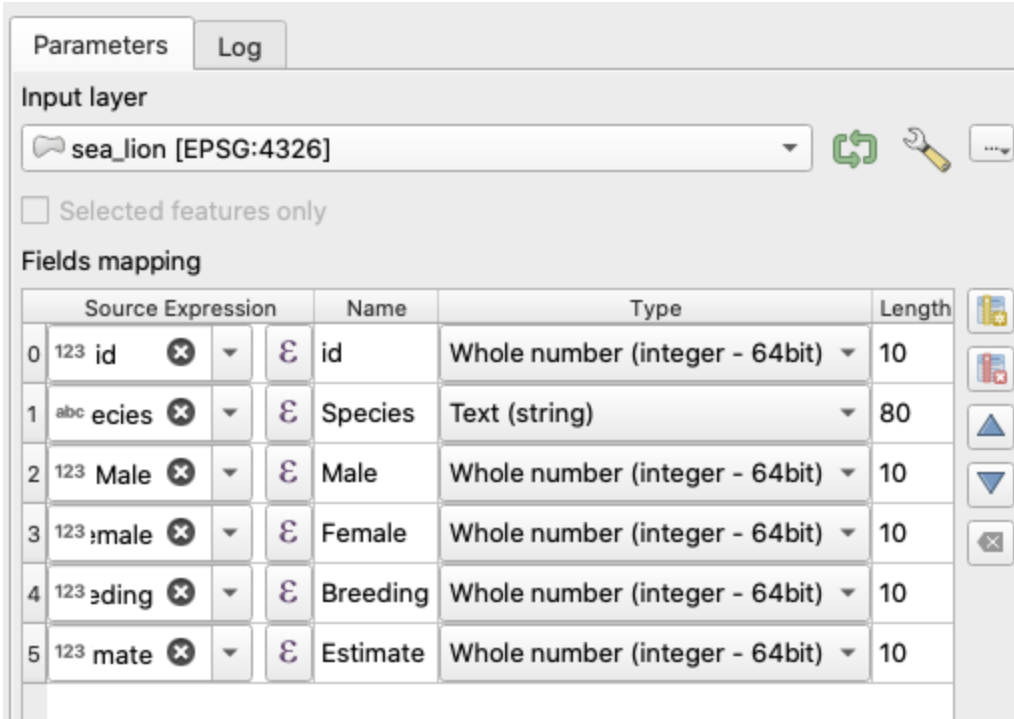
Leave the `Refactored` box blank to create a temporary layer or click on the ... to `Save to File`...

Select `Run`, then `Close`

For example, we revised the attribute field properties for our fictitious sea lion, renaming the "Count" field to "Estimate" and changed the field type from Whole number to Decimal number with Precision = 3 (see below):

	id	Species	Male	Female	Breeding	Estimate
1	1	sea lion	1	1	1	1500.000
2	3	sea lion	1	0	0	500.000
3	2	sea lion	1	1	0	1000.000

Edit attribute data

To edit attribute data in an existing `Field`:

Open the `Attribute Table`, , and click on the `Toggle Editing` button,

Edit the data as required

Click on the `Save edits` button, , to save your changes

Topic summary

Well done — you've completed the topic on working with attribute data.

We recommend you `Save` your project now.

In the next topic, we'll show you how to prepare KBA shapefiles for submission.

Topic 11: Preparing KBA shapefiles for submission

In this final topic, we'll show you how to export a spatial layer from QGIS as a ESRI shapefile so that it can be submitted as part of a KBA Proposal.

Specifications for KBA shapefiles

KBA boundaries and spatial data on the distribution of trigger biodiversity elements within a KBA must be provided as ESRI shapefiles.

Shapefiles must be provided in the standard geographic CRS and datum: latitude and longitude (decimal degrees) combined with the WGS 84 `datum` (i.e. EPSG 4326 in QGIS or "GCS_WGS_1984" in ArcGIS).

Technical Box: CRS for KBA shapefiles

Shapefiles must be provided in the standard geographic CRS and datum:
 	
    latitude and longitude (decimal degrees) and WGS 84
 	
    (i.e. EPSG 4326 in QGIS or "GCS_WGS_1984" in ArcGIS)

Shapefiles should follow a set format with specific attributes Shapefile templates will be provided on the KBA website (in the Tools section).

Please see the KBA Proposal Process guidance document (Annex B) for the complete KBA mapping standards.

Export a spatial layer as an ESRI shapefile

> In the `Layers Panel`, right-click on the target layer, select `Export`, then `Save Features As ...`
>
> Make sure the `Format` box shows "ESRI shapefile"
>
> Make sure the `CRS` box says EPSG:4326 – WGS 84
>
> Click on the ... to the right of the `File name` box and navigate to your `spatial data folder`
>
> Follow the file name and other requirements in the KBA Proposal Process guidance document (Annex B)

Then click ok

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Updates and Feedback

This tutorial will be updated periodically.

We would welcome user feedback and additional material, including step-by-step instructions for additional tasks relevant to KBA identification and delineation.

Please email Andrew Snyder (asnyder@rewild.org) if you have comments or suggestions or would like to contribute to this tutorial.

Summary of changes

Version 1.2 (November 2021)

Topic 1: New recommendation on checking for projection errors in imported shapefiles

Topic 7: New section on fixing geometries

Appendix I: New appendix with step-by-step guidance on compiling site-species tables from IUCN Red List data

Version 1.1 (September 2021)

Topics 3-10: introductory sections added.

Version 1.0 (August 2021)

Appendix I: Suggested workflow for compiling site-species tables from IUCN Red List data

This appendix provides a suggested workflow for compiling site-species tables from IUCN Red List range data as part of an initial scoping analysis. There are many ways to perform this task. The step-by-step guidance below is intended to provide a starting point for those with limited previous familiarity with GIS. The process may be readily adapted for ecosystem datasets.

For the purposes of demonstration, we will create a site-species table for existing KBAs in the Malaysia (as at March 2021) and amphibians endemic to Malaysia, but the steps will be similar for any country and taxonomic group. The final site-species table may look like this:

SitRecID	IntName	TaxonId	scientificName	taxonomicGroup	redlistCateg	redlistCrit	KBA A1cd?	restrictedRange	assessm	globalValue	siteValue	sitePercent
16001	Bako-Buntal Bay	79934933	Alcalus sariba	AMPHIBIA	EN	B1ab(iii)			range	78	24	31%
16052	Bau Limestone	88095502	Limnonectes cintalubang	AMPHIBIA	EN	B1ab(iii)			range	20	10	50%
16052	Bau Limestone	88416812	Pelophryne guentheri	AMPHIBIA	LC				range	4,533	99	2%
16005	Bintang Range	57875	Nanohyla annectens	AMPHIBIA	VU	B1ab(iii)			range	3,504	315	9%
16053	Bungo Range	78584984	Glyphoglossus capsus	AMPHIBIA	NT				range	38	10	27%
16053	Bungo Range	88320892	Leptobrachella marmorat	AMPHIBIA	EN	B1ab(iii)			range	539	43	8%
16053	Bungo Range	88416812	Pelophryne guentheri	AMPHIBIA	LC				range	4,533	297	7%
16068	Central Titiwangsa F	158637	Ansonia jeetsukumarani	AMPHIBIA	VU	B1ab(iii)			range	3,485	526	15%
16068	Central Titiwangsa F	79681353	Leptobrachella kecil	AMPHIBIA	CR	B1ab(iii)			range	10	10	100%
16068	Central Titiwangsa F	58361	Limnonectes nitidus	AMPHIBIA	EN	B1ab(iii)			range	818	690	84%
16068	Central Titiwangsa F	57875	Nanohyla annectens	AMPHIBIA	VU	B1ab(iii)			range	3,504	374	11%

Species data

On the IUCN Red List website (www.redlist.org), click on `Login/Register` in the top menu to set up a free account if you don't have one already, and log in.

Click on `Advanced` next to the search bar to use the advanced search function to select the dataset you are interested in. For example, select the following for amphibians endemic to Malaysia:

> `Taxonomy > Animalia > Chordata > Amphibia` – add a check mark next to `Amphibia`

and

> `Land Regions > South and Southeast Asia > Malaysia` – add a check mark next to `Malaysia`

and

> `Endemic` – add a check mark next to `Endemic`

If you selected these options, you should have 86 species (as at November 2021):

Click on the `Download` button and download the `Results` and `Range data`, as shapefiles (SHP) and points (CSV). (Points will be empty for most taxonomic groups other than plants.)[2]

Navigate to the downloaded Results zipfile in your downloads folder and unzip it. Open the `taxonomy.csv` and `assessment.csv` files in Excel.

In the `taxonomy.csv` file, delete the following columns: `genusName`, `speciesName`, `infraType`, `infraName`, `infraAuthority`, `subpopulationName`, `authority`, `taxonomicNotes`.

In the `assessment.csv` file, check whether any of the species are considered Possibly Extinct or Possibly Extinct in the Wild. You can do this easily by selecting the top row of your spreadsheet, selecting `Data > Filter` from the top menu and then using the filter function to check whether any cells in the columns headed `possiblyExtinct` or `possiblyExtinctInTheWild` say "TRUE". If so, add this information into the relevant cell of the column headed `redlistCategory` (e.g., as "Critically Endangered (Possibly Extinct)").

If you like, you may also abbreviate the information in the column headed `redlistCategory` (e.g., change "Endangered" to "EN"). (Hint: Change the label in the first cell, then highlight the cell and drag down from the bottom-right corner of the cell

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[2] Note that you will need an IUCN Red List account to complete this step. KBA scoping analysis qualifies as research.

to change the label in all filtered cells.) You may also delete the information in the column headed `redlistCriteria` for Near Threatened species.

Next, add the following columns from the `assessment` table to the `taxonomy` table: `scientificName, redlistCategory, redlistCriteria`. The order of species in the two tables should be identical, so you can simply use copy-paste, but it's good practice to double-check whether two tables align when merging them in this way. You can do this by adding the following formula into a column to the right and then checking that the results sum to 0 over all rows:

```
=IF(A2=I2, 0, 1)
```

where `A1` is the first cell in the column headed `scientificName` in the `taxonomy` table and `I1` is the first cell in the column headed `scientificName` in the data copied from the `assessment` table. This formula will produce a "0" if the two cells match, and a "1" otherwise. Once you have checked that the data align, you can delete the second column headed `scientificName`.

Add in a new column headed `taxonomicGroup` after `scientificName`. For each species, identify the appropriate taxonomic group for applying Criteria B2 and B3 (e.g., AMPHIBIA for amphibians) based on information provided in the restricted-range species spreadsheet on the KBA website (Tools page). It is worth noting down the Criterion B2 species threshold for each taxonomic group at the same time (e.g., this will be 2 species for most taxonomic groups). Once you've done this, you can delete the columns headed: `kingdomName, phylumName, className, orderName,` and `familyName`.

The resulting table should have the following columns:
- `internalTaxonId`[3]
- `scientificName`
- `taxonomicGroup`
- `redlistCategory`
- `redlistCriteria`

Save the species table as a `*.csv` file with a new name (e.g., "taxon_assessment.csv").

---

[3] This taxonomic ID will be used when submitting a KBA Proposal.

Spatial data

Set up a QGIS project with your preferred base map and KBA shapefiles for your country, following the steps outlined in Topic 4. The KBA shapefiles are updated periodically, so check that you have the current dataset.[4]

Range data (polygons):

Navigate to the downloaded Range data (polygons) zipfile in your downloads folder and unzip it. Copy all the files to your spatial data folder — we recommend you save the data to a subfolder with a suitable descriptive name (e.g., "Malaysia endemic amphibians"). Import the shapefiles to your QGIS project following the steps outlined in Topic 6.

Open the attribute table for the range polygons and use the `select features using an expression` function, , to select the appropriate range polygons in terms of presence, origin and season (see Topic 6 for more detailed explanation). You can check the range of values for presence in your polygon dataset by selecting `Fields and Values > PRESENCE` in the central panel, then double-clicking on `All Unique` in the right panel. Repeat for ORIGIN. Then select the appropriate range polygons by copy-pasting the following into the `Expression` panel on the left:

> ("PRESENCE" < 3) and ("ORIGIN" <3 or "ORIGIN" = 6)

This formula will select only those polygons coded 1 (Extant) or 2 (Probably Extant) for PRESENCE and 1 (Native) or 2 (Reintroduced) or 6 (Assisted Colonisation) for ORIGIN. Also check `SEASON` and determine how to handle migratory species (see the KBA Guidelines Appendix III for more guidance).

Save the results for resident species as a new shapefile, with separate shapefiles for the breeding and non-breeding ranges of migratory species if you decide to treat these separately. The rest of this appendix will focus on resident species, but the steps are essentially the same for the breeding and non-breeding ranges of migratory species.

Intersect range polygons with KBA polygons:

Intersect the new range polygon shapefile with the KBA polygons, following the steps outlined in Topic 7, and save the results as a new shapefile.

---

[4] On the KBA website (Explore Data page), check that the date given on the Dashboard (e.g., "Dashboard (2021 – 03)" matches the name of your KBA shapefiles.

Area calculation:

Calculate the size of each range polygon and add it to the shapefile as a new attribute (e.g., "feat_area"), following the steps outlined in Topic 7. We recommend that you use the correct area calculation method using on-the-fly projection based on the formula:

```
area(transform($geometry,'EPSG:4326','ESRI:54034'))/(1000^2)
```

Save the attribute table.

Calculate the size of each intersected range polygon and add it to the shapefile as a new attribute (e.g., "inter_area"), using the same method. Save the attribute table.

Create a global range size table:

If you have multiple features per species (e.g., because some polygons are coded PRESENCE = 1 and others PRESENCE = 2), you will want to sum the area of the features (e.g., "feat_area") to calculate the global range size for each species.

Install the groupstats plugin if necessary by selecting `Plugins > Manage and Install Plugins` from the main menu, then searching for "group stats". Select `Group Stats` and install it, if it is not installed already.

Once installed, click on the `Group Stats` icon, .

Select the appropriate range polygon layer in the `Layers` box.

From `Fields`, drag "BINOMIAL" to `Rows`; drag "feat_area" to `Values`; drag "sum" to `Values.`

Click on `Calculate`.

From the top menu, select `Data > Copy all to clipboard`, then paste the results into an Excel spreadsheet. Change the heading "none" to `globalValue`, then save the spreadsheet as a `*.csv` file with a new name (e.g., "global_ranges.csv"). (This approach works better than saving the data as a `*.csv` file directly.)
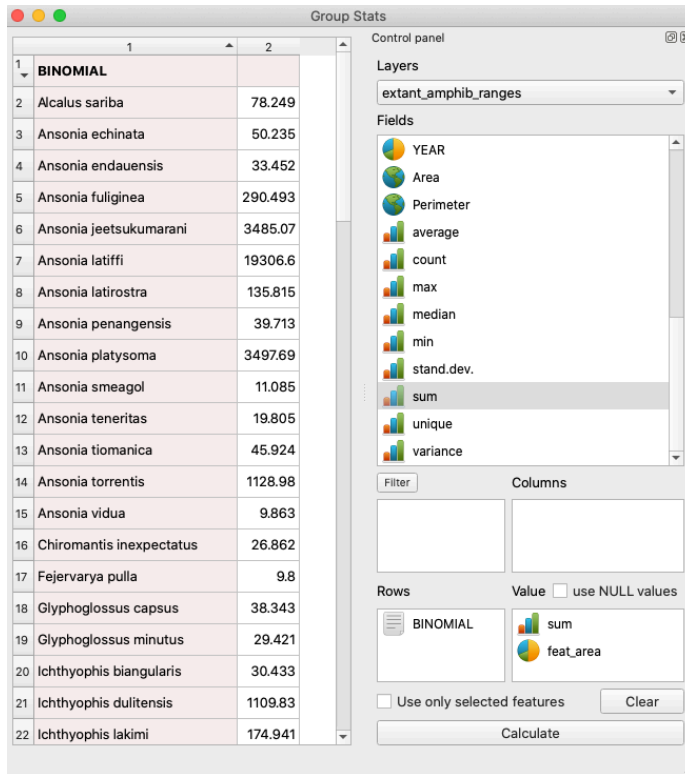
Create a site range size table:

Similarly, if you have multiple features per species (e.g., because some polygons are coded PRESENCE = 1 and others PRESENCE = 2), you will want to sum the area of the features (e.g., "inter_area") to calculate the total area of the range polygons that fall within each site for each species.

Select the intersected range polygon layer in the `Layers` box.

From `Fields`, drag "SitRecId" to `Rows`; drag "IntName" to `Rows`; drag "BINOMIAL" to `Rows`; drag "inter_area" to `Values`; drag "sum" to `Values.`

Click on `Calculate`.

From the top menu, select `Data > Copy all to clipboard`, then paste the results into an Excel spreadsheet. Change the heading "none" to `siteValue`, then save the spreadsheet as a `*.csv` file with a new name (e.g., "site_ranges.csv").

Join the taxonomy, assessment, global range and site range size data:

Finally, you will want to join the taxonomy, assessment, global range and site range size data into a single site-species table. This can be done more easily in QGIS than Excel.

Start by importing the `taxon_assessment.csv`, `global_ranges.csv`, and `site_ranges.csv` files into QGIS:

> From the top menu in QGIS, select `Layer > Add Layer > Add Delimited Text Layer`
>
> Click on the ... next to the `File name` box and navigate to the `taxon_assessment.csv` file
>
> In the `Data Source Manager` window, select `No geometry (attribute only table)`
>
> Click on `Add`
>
> Repeat this process for the other two files, then click on `Close`

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In your Layers panel:

> Right-click on `site_ranges`, then select `Properties > Joins`
>
> Click on the icon and complete the `Add Vector Join` window as follows:
>
> > `Join layer:` taxon_assessment
> >
> > `Join field:` scientificName
> >
> > `Target field:` BINOMIAL
>
> Click on `OK`
>
> Highlight `Join layer` in the window, click on the icon again, and repeat the process for global ranges:
>
> > `Join layer:` global_ranges
> >
> > `Join field:` BINOMIAL
> >
> > `Target field:` BINOMIAL
>
> Click on `OK` and then `OK` again

In your Layers panel, right-click on the `site_ranges` layer and open the `Attribute Table`. Check that the number of rows is the same as in the saved `site_ranges.csv` file and that the attribute table now includes information on the taxonomy and IUCN Red List assessment for each species and the global range size. Close the `Attribute Table`.

Export the new `site_ranges` layer by right-clicking and selecting `Export > Save Features As`, then choosing `Format: Comma Separated Value [CSV]` and a new file name (e.g., "taxon_assessment_site_global").

Final site-species data table:

Finally, open the `taxon_assessment_site_global.csv` file in Excel and reorganise and rename columns as you wish.

Add in four new columns headed: `Apply KBA A1cd? restrictedRange`, `assessmentParameter`, and `sitePercent.`

Leave the `Apply KBA A1cd?` for now – this can be completed during the assessment process.

Check the threshold for restricted range size for the taxonomic group in the KBA Proposal form (Notes tab) and then add a "yes" in the `restrictedRange` column for restricted-range species.

For example, the threshold is 10,000 km² for amphibians. Select the top row of your spreadsheet, then `Data > Filter` from the top menu, and then use the filter function to filter all species with global range size less than or equal to 10,000. Add a "yes" in the `restrictedRange` column for the filtered species.

Complete the `assessmentParameter` column by inserting "range" in all cells.

Complete the `sitePercent` column by calculating the percentage of the global range that falls within the site for each species-site combination.

The final data table might have the following fields (or similar):
- `SitRecID`
- `IntName`
- `taxonId`
- `scientificName`
- `taxonomicGroup`
- `redlistCategory`
- `redlistCriteria`
- `Apply KBA A1cd?`

- `restrictedRange`
- `assessmentParameter`
- `globalValue`
- `siteValue`
- `sitePercent`

Save the spreadsheet as an Excel workbook with a new name (e.g., "Malaysia endemic amphibians site-species table").

`Final note:`

It is often useful to check whether any species in a taxonomic group have no valid range polygons and whether the ranges of any species do not overlap any sites. You can do this easily by adapting the process for joining tables above.

To identify species without any valid range polygons, start with the `taxon_assessment` layer (which includes all species in the taxonomic group) and then join the `global_ranges` layer. Any species without valid range polygons will have "NULL" in the global range size column of the `Attribute Table`. Check the IUCN Red List account for any species that lack valid range data to find out more.[5]

To identify species that do not have valid ranges overlapping sites, start with the `taxon_assessment` layer (which includes all species in the taxonomic group) and then join the `site_ranges` layer. Any species without valid range polygons will have "NULL" in the site range size column of the `Attribute Table`.

---

[5] For example, in the case of the Malaysia endemic amphibians, three species lack valid range polygons (as at November 2021): two species are listed as Data Deficient and have not been mapped; but one (*Ansonia guibei*) is Critically Endangered, with all range polygons categorized as Possibly Extinct or Presence Uncertain. This species would likely trigger a KBA under subcriterion A1e in the site where it is most likely to occur if it still exists (see the KBA Guidelines Section 2.4.1 for more details).