

GEOREFERENCING QUICK REFERENCE GUIDE

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This is a practical guide for georeferencing using the point-radius method [1, 2, 3] using the Georeferencing Calculator [4, 5], maps, gazetteers, and other resources from which coordinates and spatial boundaries for places can be found. This guide is an update of "Georeferencing for Dummies" [6], and explains the recommended calculation procedure for localities encountered in the georeferencing process.

Georeferences using the methods in this guide will be maximally useful if as much information as possible is captured about and during the georeferencing process in the following fields defined in the Darwin Core standard [7]. For additional community discussion and recommendations, see the Darwin Core Project wiki [8].

Darwin Core Georeferencing terms:

- **decimalLatitude, decimalLongitude, geodeticDatum** – the combination of these three fields provide the reference for the center of the point-radius representation of the georeference.
- **coordinateUncertaintyInMeters** – The horizontal distance (in meters) from the given decimalLatitude and decimalLongitude describing the smallest circle containing the whole of the Location. Leave the value empty if the uncertainty is unknown, cannot be estimated, or is not applicable (because there are no coordinates). Zero is not a valid value for this term.
- **georeferencedBy, georeferencedDate** – who last modified the georeference and when.
- **georeferenceProtocol** – A description or reference to the methods used to determine the spatial footprint, coordinates, and uncertainties. If following the protocol in this guide, use "Georeferencing Quick Reference Guide Version 2012-10-02".
- **georeferenceSources** – A list (concatenated and separated) of maps, gazetteers, or other resources used to georeference the Location, described specifically enough to allow anyone in the future to use the same resources.
Example: "USGS 1:24000 Florence Montana Quad; Terrametrics 2008 Google Earth".
- **georeferenceVerificationStatus** – A categorical description of the extent to which the georeference has been verified to represent the best possible spatial description. Recommended best practice is to use a controlled vocabulary.
Examples: "requires verification", "verified by collector", "verified by curator".
- **georeferenceRemarks** – Notes or comments about the spatial description determination, explaining assumptions made in addition or opposition to the those

formalized in the method referred to in georeferenceProtocol.

Example: "assumed distance by road (Hwy. 101)".

This document uses the following terms in reference to the Georeferencing Calculator:

- calculation type – a choice of calculating only error (because the coordinates are already known) or calculating new coordinates (using offsets from a starting coordinate) and error.
- locality type – a choice of category of locality description that affects how calculations are done and presents only those parameters needed for the particular calculation.
- extent – the distance from the geographic center to the furthest point of the geographic area covered by a named place or feature.
- error – similar to Darwin Core coordinateUncertaintyInMeters, except that the units of measure must be the same as those given for offsets (if any) in the original locality description, and therefore not necessarily meters.
- coordinate precision – this concept refers to the source of uncertainty related to number of significant digits in the source coordinates.

References:

1. MaNIS/HerpNet/ORNIS Georeferencing Guidelines.

<http://manisnet.org/GeorefGuide.html>. Accessed 2012-10-02.

2. Wiecek, J., Q. Guo, and R. Hijmans. 2004. The point-radius method for georeferencing locality descriptions and calculating associated uncertainty. *International Journal of Geographical Information Science*. 18:745-767.

3. Chapman A.D., and J. Wiecek (eds.). 2006. *Guide to Best Practices for Georeferencing*. Copenhagen. Global Biodiversity Information Facility.

4. Wiecek, J., Q. Guo, C. Boureau, C. Wiecek. 2001. Georeferencing Calculator.

<http://manisnet.org/gci2.html>. Accessed 2012-10-02.

5. Wiecek, J., D. Bloom. 2011. Georeferencing Calculator Manual v2.

<http://goo.gl/G5RM9>. Accessed 2012-10-02.

6. Spencer, C., K. Yamamoto, J. Fang, H. Constable, M. Koo. Georeferencing for Dummies.

<http://www.herpNet.org/herpNet/documents/georeffordummy.xls>. Accessed 2012-10-02.

7. Darwin Core Task Group. 2009. Darwin Core Terms: A quick reference guide.

<http://rs.tdwg.org/dwc/terms/index.htm>. Accessed 2012-10-02.

8. Darwin Core Project wiki. <http://code.google.com/p/darwincore/wiki/Location>. Accessed 2012-10-02.

LOCALITY TYPE	CALCULATION PROCEDURE (instructions on how to use the Georeferencing Calculator)
<p>Named Place</p> <p>Bounded Area: Locality refers to a geographic feature with discernible spatial boundaries</p> <p><i>Examples: "Las Vegas", "Puerto Madryn", "San Fernando", "Verónica"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: Use the coordinates of the geographic center (the midpoint between the extremes of latitude and longitude) of the boundaries of the named place. If the geographic center does not fall within the boundaries of the named place, select the point nearest to the geographic center that lies on the boundary of the named place.</p> <p>Note that coordinates from geographic indexes such as gazetteers often use reference points that are not necessarily in the geographic center of the named place. For example, a river may be referenced by its mouth, and a town by its main post office, courthouse, or central plaza. It is best to use a visual reference to determine coordinates and extents.</p> <p>Extent: Measure the distance from the center of the named place to the border of the named place farthest from the center.</p>
<p>Named place</p> <p>Undefined Area: Locality refers to a geographic feature that does not have a clear spatial boundary</p> <p><i>Example: "Pampa Grande" (the extent is 4.7 km given that the center of the nearest named place, "Colonia Mariano Sarratea" is 9.4 km distant)</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: Determine the coordinates for the named place as well as possible using visible evidence near the label for the named place on the map.</p> <p>Extent: Use half the measured distance from the selected coordinates to the center of the nearest named place. Make note of the measure and the nearest named place in georeferenceRemarks.</p>
<p>Named Place</p> <p>Street Address</p> <p><i>Examples: "Av. Angel Gallardo 470, Buenos Aires, Argentina", "1 Orchard Lane, Berkeley, CA"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: Locate the address and its coordinates using sites such as Google Maps, OpenStreetMap, or Mapquest. If you are only able to find an address on a site or map that does not give coordinates, use one of the other sites to find the same location on the map and get the coordinates for it.</p> <p>Extent: Determine the extent as for a Named Place - Undefined Area where the center of the nearest named place is the location of an address on either side of the given address. If the next address is too difficult to determine, use half of the distance from the coordinates of the address to the further end of the block on which it sits.</p>

<p>Named Place</p> <p>Ranch, Farm, Finca, Granja, Estancia</p> <p><i>Examples: "Mathae Ranch", "Haskell Farm", "Estancia 9 de Julio"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: Treat as a Named Place - Bounded Area if you are able to find the borders of the property, otherwise use the main building or building complex as the location for the coordinates and treat the locality as a Named Place - Undefined Area.</p> <p>Extent: As Named Place - Bounded Area if you are able to find the borders, otherwise, as Named Place - Undefined Area.</p>
<p>Named Place</p> <p>Junction, Intersection, Crossing</p> <p><i>Examples: "junction of Coora Rd. and E Siparia Rd.", "Ruta Provincial N° 6 y Arroyo Feliciano", "bridge over the River Kwai"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: Consider the intersection as a Named Place - Bounded Area. Use the coordinates of the center of the intersection. Use resources such as Google Maps, Guía YPF, OpenStreetMap to find the names and routes of highways, roads, and rivers.</p> <p>Extent: If possible, Use satellite or aerial images to find the extent of the intersection by measuring the distance from the center to the furthest part of it. If unable to measure the intersection, use the number of lanes of the larger of the two roads and multiple by 4m.</p>
<p>Named Place</p> <p>Cave</p> <p><i>Examples: "Carlsbad Caverns", "Cueva de Las Brujas"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: If a map of the interior of the cave with measurements and orientation to the surface is available, treat as a Named Place - Bounded Area, otherwise, use the entrance to the cave as the position for the coordinates.</p> <p>Extent: Use a description of the cave to determine its size.</p>
<p>Named Place</p> <p>River, stream, road, path</p> <p><i>Examples: "Sacramento River", "Jones Road", "Río Paraná", "Arroyo Urugua-í"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: Make a straight line between the two points on the geographic feature that are most removed from each other within the administrative boundaries specified in the locality description. Choose the point on the geographic feature nearest to the midpoint of the line. Do not use the coordinates given by a gazetteer, as these typically do not refer to the geographic center of the feature, nor do they take into account the constraints of the administrative boundaries.</p> <p>Extent: The extent is distance from the chosen point on the feature to the farthest point on the feature that is within the administrative boundaries specified in the locality description.</p>

<p>Named Place</p> <p>Mouth or headwaters of a river, confluence of waterways, trailhead</p> <p><i>Examples: "headwaters of the Missouri River", "Bear Lake trailhead"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: For a river mouth or a confluence of waterways, select the midpoint of the line connecting the opposite shores where the waterways meet. For a river source, select the point of highest elevation on the river if there is an obvious single choice, otherwise create a boundary around the multiple streams contributing to the river and georeference that as a Named Place – Bounded Area. For a trailhead, select the point where the trail begins.</p> <p>Extent: For a river mouth or confluence of waterways, use the distance from the chosen point to the shore. For a single river source or for a trailhead, use 10m. For a multiple source riverhead, use the distance from the chosen point to the farthest point among the sources.</p>
<p>Named Place</p> <p>Near a Named Place</p> <p><i>Examples: "vicinity of General Conesa", "before Ceibas", "near Dina Huapi"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: Determine the coordinates as for Named Place - Bounded Area or Named Place - Undefined Area as appropriate</p> <p>Extent: Case A (the center of the nearest named place is farther from the center of the named place than the extent of the named place itself): Determine the extent for the locality as you would the extent of the named place for a Named Place - Undefined Area. Case B (the center of the nearest named place is closer to the center of the named place than the extent of the named place itself): Determine the extent for the locality as you would the extent of the named place for a Named Place - Bounded Area.</p>
<p>Named Place</p> <p>Between two Places</p> <p><i>Examples: "between Missoula and Florence, Montana", "Entre Pampa Blanca y Pampa Vieja, Jujuy"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: Use the midpoint between the centers of the two named places.</p> <p>Extent: The extent is half the distance between the centers of both named places.</p>

<p>Offset</p> <p>Direction only, no distance</p> <p><i>Examples: "N Palmetto", "N of Berkeley", "Saladillo N", "Al N de Saladillo"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: As for Between two Places where the nearest named place to use is in the specified direction. For example, "N Palmetto" could mean "northern part of Palmetto" or "North of Palmetto". Since we have no way of knowing which was intended, we choose the latter interpretation, which is more inclusive and will entirely contain the less inclusive interpretation. Use the rules for direction uncertainty to determine angle within which to find the nearest named place. For example, for "N Palmetto" look for a nearest named place somewhere between NE and NW of Palmetto.</p> <p>Extent: As for Between two Places.</p>
<p>Offset</p> <p>Offset only, no direction</p> <p><i>Examples: "5 km outside Calgary", "12 km fuera de Purmamarca"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Distance only"</p> <p>Coordinates: As for Named Place – Bounded Area or Named Place – Undefined Area as appropriate.</p> <p>Extent: As for Named Place – Bounded Area or Named Place – Undefined Area as appropriate.</p> <p>Offset Distance: enter the distance and units given in the locality description.</p>
<p>Offset</p> <p>Offset at a heading</p> <p><i>Examples: "50 miles W of Las Vegas", "10 km E de Amamá"</i></p>	<p>Calculation Type: "Coordinates and error - enter the Lat/Long for the named place or starting point"</p> <p>Locality Type: "Distance at a heading"</p> <p>Coordinates: If "by road" or other path is specified in the locality description, use the method under Offset Along a Path. If the description could be interpreted reasonably either by a route or by air, use the method under More Than One Possibility. Otherwise, assume that the heading is "by air" and note this assumption in georeferenceRemarks. In this case use the coordinates of the geographic center of the named place as a starting point in the Georeferencing Calculator. These are not the coordinates of the locality, which will be given in the fields to the left of the Calculate button when it is clicked after all the fields above it have been entered.</p> <p>Extent: As for Named Places – Bounded Area or Named Places – Undefined Area, as appropriate.</p>

<p>Offset</p> <p>Offset along a path</p> <p><i>Examples: "7.9 mi N Beatty, on US 95", "3 km en el Rio Jimenez arriba de Anita Grande", "left bank of the Mississippi River, 16 mi downstream from St. Louis", "Ruta Nacional 81, 8 km W de Ingeniero Guillermo Nicasio Juárez"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Distance along a Path"</p> <p>Coordinates: Find the center of the named place as you would for Named Place – Bounded Area or Named Place – Undefined Area, as appropriate. Use a measuring tool on a printed or digital map to follow the specified route for the given distance. Use the end point as the coordinates. If no specific path is specified in the locality description, be sure to note in georeferenceRemarks which path was measured.</p> <p>Extent: As for Named Place – Bounded Area or Named Place – Undefined Area, as appropriate.</p>
<p>Offset</p> <p>Offset in orthogonal directions</p> <p><i>Examples: "6 km N and 4 km W of Welna"</i></p>	<p>Calculation Type: "Coordinates and error - enter the Lat/Long for the named place or starting point"</p> <p>Locality Type: "Distance along orthogonal directions"</p> <p>Coordinates: Find the center of the named place as you would for Named Place – Bounded Area or Named Place – Undefined Area, as appropriate. Locality descriptions with orthogonal directions from a named place are always assumed to be "by air".</p> <p>Extent: As for Named Place – Bounded Area or Named Place – Undefined Area, as appropriate.</p>
<p>Offset</p> <p>Offsets from two Distinct Paths</p> <p><i>Example: "1.5 mi E LA Hwy. 1026 and 2 mi S U.S. 190"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Distance along a Path"</p> <p>Although this is not technically a distance along a path, this locality type will include all of the relevant parameters in the calculator.</p> <p>Coordinates: Treat this type of description as two supporting sets of directions "by air" that converge at a single point. These are directions to an unnamed place rather than directions from a named place. One of the starting points in the example is somewhere along Louisiana Highway 1026, which runs north to south. The other starting point is somewhere along US Highway 190, which runs east to west. The coordinates for the locality are where the two offsets meet.</p> <p>Extent: Use half the width of the larger of the two highways, calculated as described in Named Place – Junction, etc.</p> <p>Note: In this example, set the precision to 0.5 mi., which is best precision shown in the locality description.</p>

<p>Coordinates</p> <p>Global Positioning System (GPS)</p> <p><i>Examples:</i> "38.410558, -99.140625", "38 24 38.01N, 99 8 26.35 W", "38 24.6335 N 99 8.4375 W"</p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only" Although this is not technically a named place, this locality type will include all of the relevant parameters in the calculator.</p> <p>Coordinates: Enter the coordinates in the format they were captured from the GPS (decimal degrees, degrees decimal minutes, or degrees, minutes, seconds) with all of the given digits of precision. Note: The Georeferencing Calculator preserves seven digits of precision in decimal degrees so that any transformation between coordinate systems is reversible without introducing rounding errors.</p> <p>Coordinate Source: "GPS"</p> <p>Datum: The greatest source of uncertainty in a GPS waypoint arises if the datum information is not recorded, so it is worth trying to determine the datum if possible. GPS units allow the user to select the datum they want to use, but the information may not be recorded in downloaded waypoint information. If the datum in use at the time the waypoint was taken is not known, select datum not recorded and be sure to record that in the geodeticDatum field.</p> <p>GPS Accuracy: The accuracy of the GPS depends on conditions at the time the coordinates are taken, and is generally not recorded with the waypoint information. Though it is often given by in the satellite tracking page, this information would have to be recorded separately. If the actual GPS accuracy was not recorded, use a default value of 30m for waypoints taken since 2 may 2000 when Selective Availability was turned off. Use 100m as the GPS accuracy for waypoints taken before that date.</p>
<p>Coordinates</p> <p>Verbatim Latitude and Longitude</p> <p><i>Examples:</i> "38.410558, -99.140625", "38 24.6335 N 99 8.4375 W"</p>	<p>As Coordinates – Global Positioning System, except select locality description for the Coordinate Source and there will be no Extent or GPS Accuracy.</p>

<p>Coordinates</p> <p>Universal Tranverse Mercator (UTM)</p> <p><i>Examples: "N 4291492 E 456156", "N4291 E456"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only" Although this is not technically a named place, this locality type will include all of the relevant parameters in the calculator.</p> <p>Coordinates: The UTM coordinates must be converted to decimal degrees using a UTM to Lat/Long conversion tool. If the Zone is not given with the UTM coordinates, try to determine it from other geographic information in the locality of geography fields combined with a UTM zone map. Use all of the digits of the converted latitude and longitude in the coordinates for the calculation. Note: UTM coordinates can sometimes be truncated to fewer digits, signifying a less precise location. To make the coordinate conversion, add zeros to the right of each coordinate to make 7 digits overall in the northing and 6 digits in the easting.</p> <p>Coordinate Source: "locality description"</p> <p>Extent: If the UTM coordinates have 7 digits in northing and 6 digits in easting, the extent is 1 m (because the coordinates distinguish to the nearest meter). For every digit less of precision in the UTM coordinates, multiply the extent by 10.</p>
<p>Coordinates</p> <p>Grid System</p> <p><i>Example: "E of Bakersfield, T29S R29E Sec. 34 NE 1/4"</i></p>	<p>Calculation Type: "Error only - enter Lat/Long for the actual locality"</p> <p>Locality Type: "Named place only"</p> <p>Coordinates: As Named Place – Bounded Area. Use the coordinates for the geographic center of the named grid area.</p> <p>Township, Range, Section (TRS) is a grid system of the United States Public Land Survey (USPLS). Usually the grid is made up of bounding boxes, so determining the geographic center should be easy. Numbered grid areas (townships) tend to be areas of 6 by 6 miles, divided into 36 1 by 1 mile sections, which can be further divided in half in each dimension. Be aware that not all townships are square, however, as some were adjusted to conform to natural boundaries (rivers, for example) or other surveying constraints. Numbered Townships are not unique descriptions without a meridian, which often is not given in a locality description. The meridian must be inferred from a Principal Meridian map using other information in the locality description to determine the rough location.</p> <p>Coordinate Source: Coordinates could come from a map, in which case select the map type of the appropriate scale, otherwise select "gazetteer".</p> <p>Extent: As for Named Place – Bounded Area.</p>

<p>More than one possibility</p> <p><i>Examples: "Battle Mountain" the town near "Battle Mountain" the mountain, "Junction of Hwy 50 and Stem Road" (where Hwy 50 and Stem Road intersect more than once), "San Jose, Mexico"</i></p>	<p>At times more than one geographical feature fits a named place in a locality description. The calculation procedure depends on the geographical relationships of the possible features. These recommendations apply to all locality types.</p> <p>Overlapping: If the possible features overlap at least in part, treat the combination of them as the named place and follow the procedure for the appropriate locality type. Make note of the multiple possibilities and the procedure used in georeferenceRemarks.</p> <p>Non-overlapping, related: If two distinct places with the same name are related to each other (for example, "Battle Mountain" the town near "Battle Mountain" the mountain), for the starting coordinates choose the point within or on the boundary of one of the named places nearest to the midpoint between the centers of the places. Measure from here to the point furthest from here on the boundaries of named places to get the extent and follow the procedure for the appropriate locality type. Make note of the multiple possibilities and the procedure used in georeferenceRemarks.</p> <p>Non-overlapping, unrelated: If the possible locations with the same name are not related with each other, such as "San Jose, Mexico", do not georeference the locality and make note of the reason in georeferenceRemarks.</p>
<p>Problems</p>	<p>Do not georeference localities that fall into the following categories:</p> <p>Dubious – the locality description states explicitly that the location is in question. <i>Examples: "presumably central Chile", Isla Boca Brava?"</i></p> <p>Inaccurate – the locality description contains irreconcilable inconsistencies. <i>Examples: "Sonoma County side of the Gualala River, Mendocino County"</i></p>