Georeferencing Specimen Locality in Specify

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LSA HERBARIUM
UNIVERSITY OF MICHIGAN

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1. Specify Fields available in Locality table: Collection Object → Collecting Information → Locality → Geo Coordinate Details (Geo Coord Details)

Fields highlighted in yellow should be considered a minimum best practices, but is at divisional discretion

a. **Locality Name** – may need to be adjusted slightly for spelling and formatting; try to maintain as close as possible
b. **Verbatim Locality** – exactly how written on specimen tag or in source of data
c. **Remarks** – any details connected to changes made to locality if specimen locality is moved to Verbatim Locality.
d. **Geography** – linked into the Geography Tree: Continent, Country, State, County (if using GEOLocate to find coordinates, Country, State, County and Locality Name/String is used)
e. **Verbatim Coordinates** – exact format of coordinates given on specimen labels
f. **Latitude** – May be expressed as "Decimal Degrees", "Degrees Minutes Decimal Seconds" or "Degree Decimal Minutes"; decimal degrees is preferred Darwin Core Standard
g. **Longitude** – may be expressed as above
h. **Datum** – most maps use WGS84 (GEOLocate, GoogleEarth/Maps, Bing Maps, Acme MAPPER)
    i. It seems common now, but what if it changes in the next few years?
    ii. Older geodetic datum (i.e., coordinate system) like NAD27 is not the same location as datums NAD83 or WGS84; maps could change to use the Earth Gravitational Model 2008 (EGM2008) for more accurate modeling
    iii. Recommended to add a "Pick-list" for Datum
i. **Locality Details** – specific fields in Specify (Verbatim Coordinates may take the place of this)
    i. Township, Range, Section, Section Details, UTM Zone, UTM Easting, UTM Northing, Island, Island Group
j. **Elevation (Min Elevation and Max Elevation) in meters** – sometimes possible in GEOLocate with "Get Elevation" button, but does not autofill
    i. Enter coordinates in Google Earth – zoom into the location as far as possible to get the coordinates listed on the bottom-right of the screen including the elevation
    ii. A single coordinate point elevation should be entered into the "Min Elevation" (if Min and Max are present) and "Elevation Units" must be entered
    iii. If you right-click on the mouse at a given location in Google Earth and select "Show Elevation Profile", a Min and Max Elevation can be viewed and recorded – this does not work all the time
k. **Max Uncertainty Estimate (maxUncertaintyEst)**
    i. This is autofilled if using GEOLocate within Specify; also available in Standard Client version of GEOLocate on-line
        1. Uncertainty and error polygon options are available in the Specify GEOLocate preferences (Edit>Preferences>GEOLocate)
        2. Check "Return uncertainty radius in meters" and "Return error polygon" (It may be worth checking all except "Restrict to lowest administrative unit")
        3. See details in section 3 Georeferencing with GEOLocate Plugin: Activate GEOLocate Functions
    ii. Uncertainties not given by GEOLocate should be calculated with the Georeferencing Calculator (http://georeferencing.org/georefcalculator/source/gci2.html); includes map scale, coordinate precision and locality extent (differs for orthogonal information) → directions for calculator (http://goo.gl/G5RM9)

iii. Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015). Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].

l. **Max Uncertainty Est Units** – should be a point radius in **meters (**or **m)**

m. **Error Polygon –** available in GEOLocate (point-radius method is preferred best practices)

n. **Protocol** – (Georeference Protocol: a reference to the method(s) used for determining the coordinates and uncertainty estimates); Recommended to add a "Pick-list"

i. Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.

ii. Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].

iii. GEOLocate (Rios and Bart 2010) – Rios, N. E. and H. L. Bart. 2010. GEOLocate (Version 3.22) computer software. Belle Chasse, LA: Tulane University Museum of Natural History. – Georeferencing software for natural history collections. http://www.museum.tulane.edu/geolocate/

iv. MaNIS/HerpNet/ORNIS Georeferencing Guidelines (Wieczorek 2001) – Wieczorek, J. 2001. MaNIS/HerpNet/ORNIS georeferencing guidelines. Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://manisnet.org/docs/GeorefGuide.html

v. Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.

vi. Point-radius method for georeferencing (Wieczorek et al. 2004) – Wieczorek, 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(8): 745-767.

o. **Geo Ref Accuracy** – used for relative distance error; does not account for other errors (indicated above) like the "Max Uncertainty Estimate"

i. Listed as Latitude/Longitude Accuracy, Extent, Location Accuracy, Named Place Extent

p. **Geo Ref Verification Status** – Example: reviewed - high confidence; date should be indicated

i. Used to identify when coordinates were proofed

q. **Geo Ref Det By** – Not Batch Editable; connected to the "Agent Table" in Specify; will autofill if using the GEOLocate Plugin or single-record edit

r. **Geo Ref Det Date** – This will be autofilled with GEOLocate Plugin or single-record edit; can be filled during all batch edit georeferencing

s. **Geo Ref** (Source of coordinates) – Latitude and Longitude or Lat/Long Source/Method

i. **GEOLocate**, Google Earth, Google Maps, Bing Maps, Map Quest, ACME Mapper, US Army Corps of Engineers Map, DeLorme

ii. Click GEOLocate, and allow the coordinates it provides (unless there is reason to choose something else)
iii. GEOLocate will autofill "GeoRef Det By" (= Agent on computer), "Geo Ref Det Date" (= date that Georeferencing is done) and "Geo Ref" (= source of coordinates – GEOLocate in this example) using the GEOLocate Plugin or single-record edit; must be manually entered in batch edit
iv. Other sources used for coordinates will need to manually entered
v. ACME Mapper: Good resource to locate addresses, place names, natural features and road names around the world, with exact coordinate precision (https://www.gbif.org/en/tool/81595/acme-mapper); Gives geographic center of national forests across county boundaries
vi. Mi-HUNT Michigan Department of Natural Resources (https://www.mcgi.state.mi.us/mi-hunt/): good resource for Michigan including Township, Range & Section, Trails, Cover Types, Recreational Facilities and Hunting Lands
vii. Gazetteer of Obscure Michigan Place Names (http://webapps.lsa.umich.edu/herb/michvoss/michvosscty.html) by the University of Michigan Herbarium
viii. Other sources (from NY Botanical Gardens Georeferencing Guide page 34):
    1. Statoids: Administrative divisions of countries (www.stadoids.com)
    2. GeoNames (www.Geonames.org, crowd/open source)
    3. Wikimapia (www.wikimapia.org, crowd/open source)
    4. OpenStreetMap (www.openstreetmap.org, crowd/open source)
    5. Mapcarta (www.mapcarta.com, crowd/open source)
    6. TravelingLuck (www.TravelingLuck.com)
    7. Google Web and Image Search

t. **Geo Ref Remarks** – Comments on methods and assumptions used in determining coordinates or uncertainties when those methods or assumptions differ from, or expand upon, the methods referenced in the Georeference Protocol field
    i. Best place to add assumptions made by locality information
    ii. If process of attaining coordinates is not clear, add details here
        1. EXAMPLE: Maximum point-radius uncertainty determined with Georeferencing Calculator; Elevation determined in Google Earth with given coordinates
        2. EXAMPLE: Lat/Long taken at ?????. Point radius uncertainty is ????? plus error determined with georeferencing calculator.
        3. EXAMPLE: Lat/Long taken at ?????. Point radius uncertainty is ????? plus error determined with georeferencing calculator via GEOLocate. (GEOLocate has the calculations available with the georeferencing calculator in the available uncertainty.)
        4. EXAMPLE: Lat/Long taken 1 km NW from geographic center of Langside. Point radius uncertainty is 0.5 km plus error determined with georeferencing calculator via GEOLocate (using direction, offset distance, locality extent, measurement error and distance precision).

u. **Batch Edit Geo Ref By** – Modified field caption "Text 1" to this in Herbarium (directions below on page 5 for how to change field caption)

i. If the record has a "Created By Agent" and "Geo Ref Det By" already filled, the individual georeferencing will not have their name autofilled
ii. "Batch Edit Geo Ref By" should be filled in during all batch edit georeferencing

v. **GUID (globally unique identifier)** – each Locality created in Specify is automatically assigned a unique GUID
    i. Each division (Herbarium, Birds, Fish, Insects, Mammals, Mollusks and Reptiles & Amphibians) has a unique GUID for each Locality and Collection Object
        1. Collection Object → Collecting Information → Locality → GUID
        2. If GUID is part of query parameters, you can quickly determine if a locality is unique or if it is used for multiple Collection Objects
    ii. All Collection Objects with the same GUID number will be updated
    iii. If any alternative spelling or punctuation exists in the "Locality Name", it will not autofill; it will have a unique GUID

Query for localities; DOUBLE CHECK CONSISTENCY for spelling, punctuation and higher geography

- If Verbatim Locality field is not present, have LSA IT add field, or use Verbatim Coordinate field or Locality Remarks.
- **GEOLocate (or other Sources) may not find localities if spelled incorrectly or odd verbatim format**
- If georeferencing coordinates as a "single record edit", **ALL entries with same COUNTRY, STATE, COUNTY and LOCALITY NAME (i.e., the same GUID number)** with GEOLocate (or any other source) will autofill
- "Batch editing" records with the same Locality GUID **will update independently and a new GUID will be assigned to the Locality record**

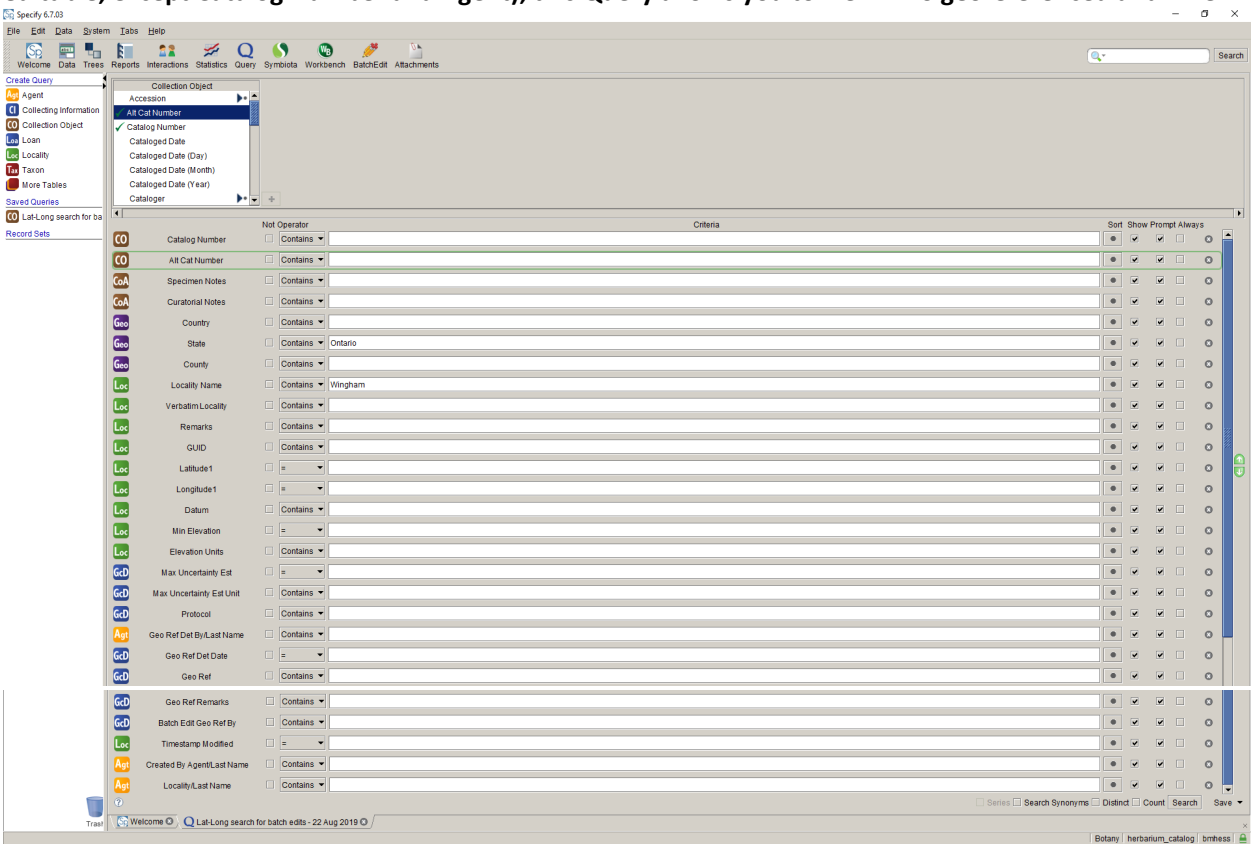
**** It is the BEST PRACTICE to georeference through the GEOLocate Plugin (see section 3)

How to Unhide a Field in Specify (https://vimeo.com/117295445)
This allows you to query the field, but not to add the field into the form view. You can add the field to the data entry form or workbench by contacting: specify@ku.edu
Must be logged in as an administrator to make these changes

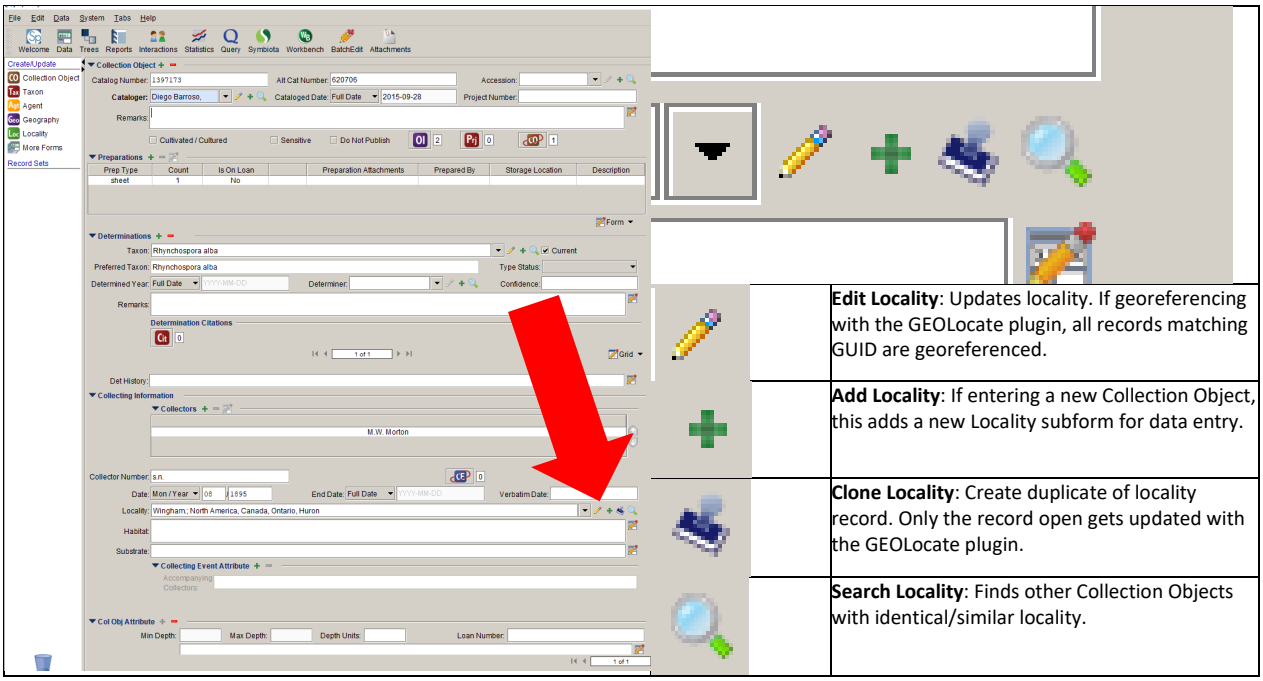
How to Modify a Field Caption (https://vimeo.com/119899050)
Edit the Schema Configuration in the correct table, edit the field
Must be logged in as an administrator to make these changes

How to Modify the WorkBench Fields
Contact specify@ku.edu or attempt to do it yourself if you know how to modify Extensible Markup Language (XML) files (https://www.screencast.com/users/SpecifySupport/folders/Default/media/96bf1096-8e66-46ac-8a54-b1be16d0a9fd)

2. Specify Screenshots: Query for Georeferencing across all Collection Objects (ALL fields are batch editable, except Catalog Number and Agent); this Query allows you to view who georeferenced and when

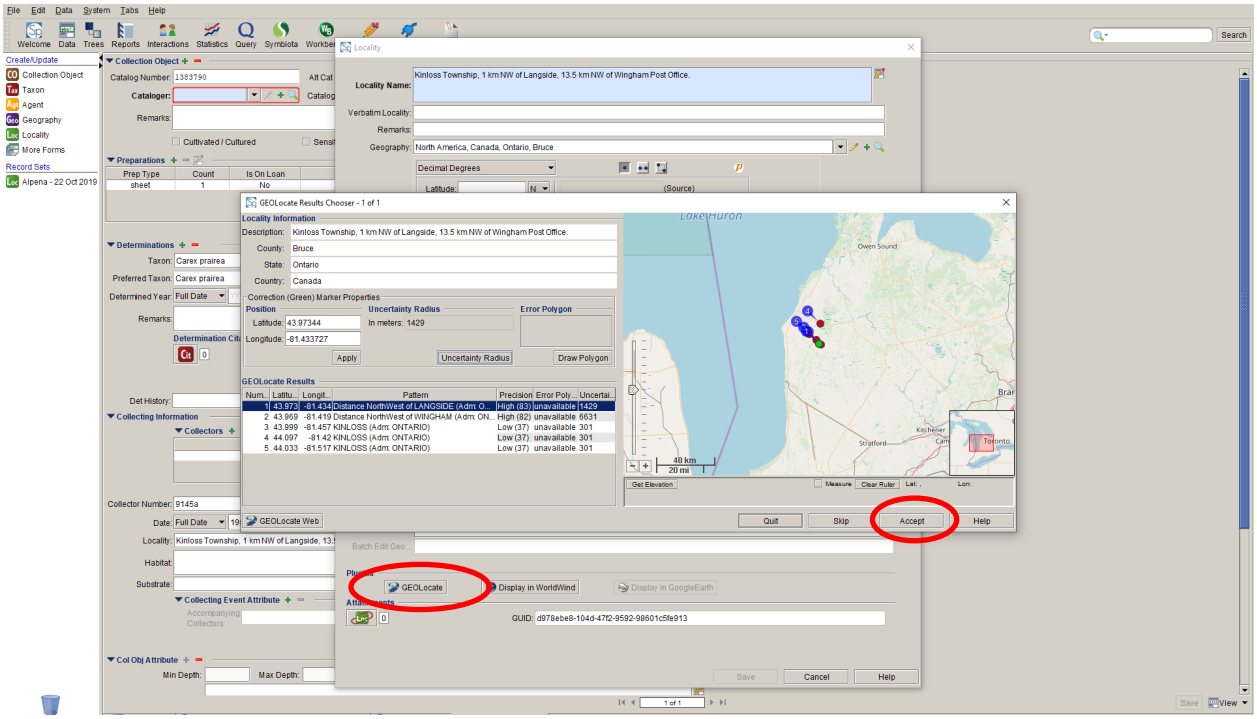


Collection Object Edit Options (click the edit button in the bottom-right corner)

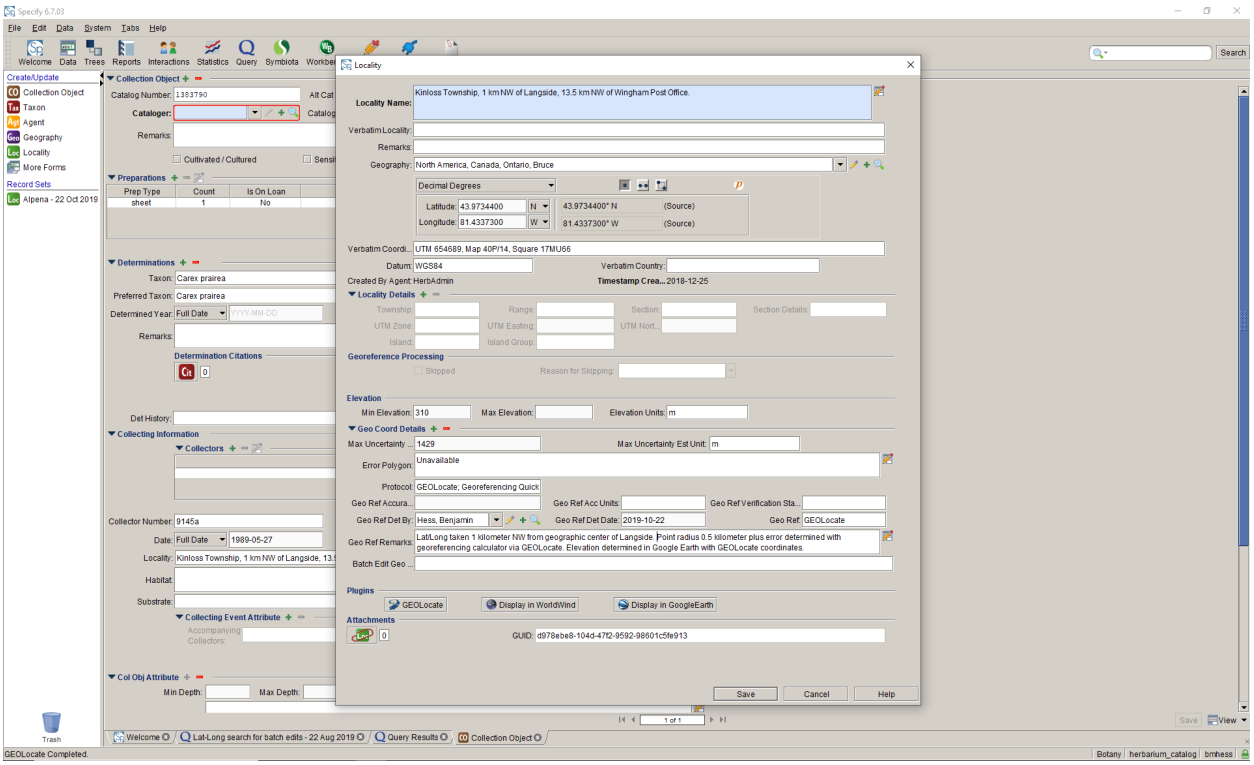


	Edit Locality: Updates locality. If georeferencing with the GEOLocate plugin, all records matching GUID are georeferenced.
	Add Locality: If entering a new Collection Object, this adds a new Locality subform for data entry.
	Clone Locality: Create duplicate of locality record. Only the record open gets updated with the GEOLocate plugin.
	Search Locality: Finds other Collection Objects with identical/similar locality.

Georeferencing with GEOLocate – once you enable the editing, select the GEOLocate plugin and "Accept" the coordinates and uncertainty if you approve (i.e., coordinates clearly match verbal locality description)

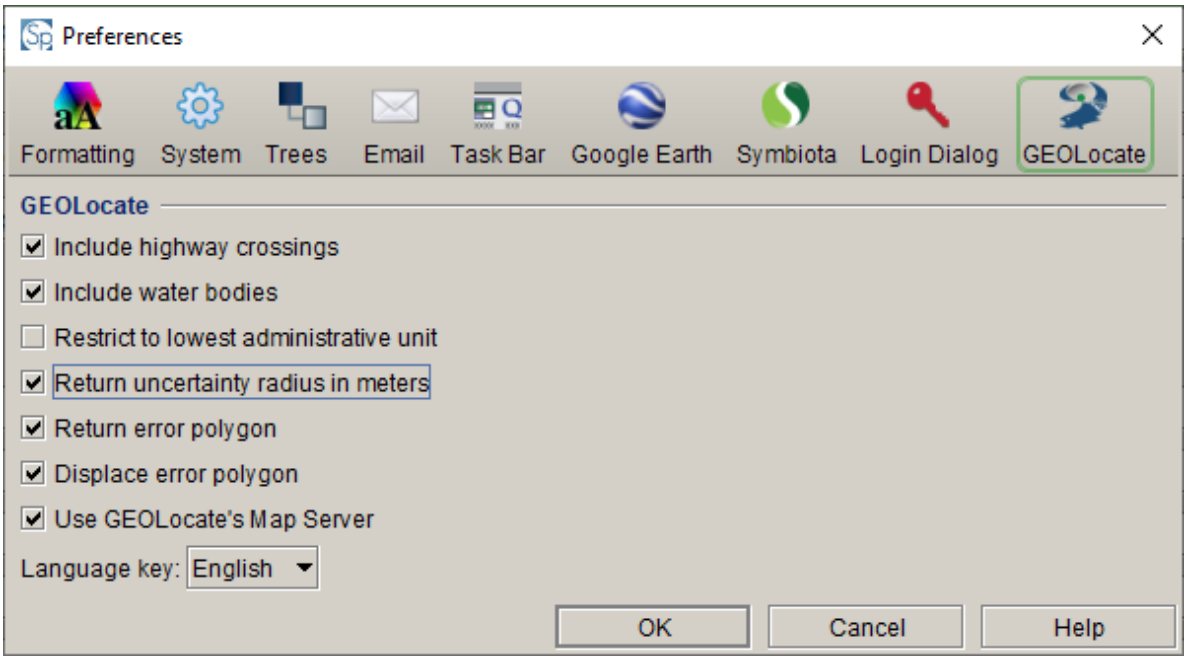


Collection Object and Locality Form View – complete Locality form with other fields

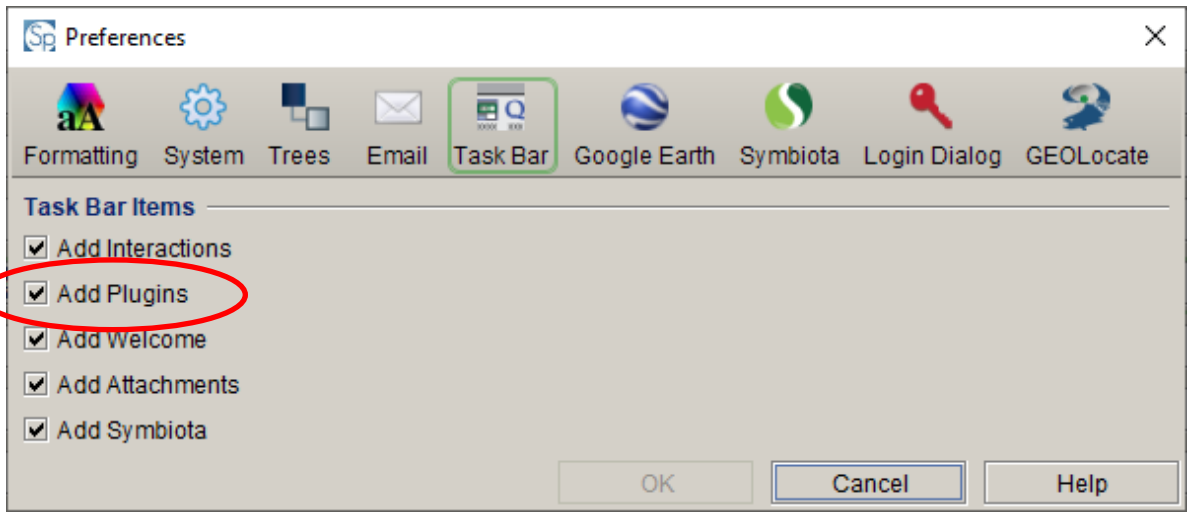


3. Georeferencing with GEOLocate Plugin (Best Practices Method to target unique localities, regardless how many Collection Objects have the associated locality)

Activate GEOLocate Functions: Go to Edit→Preferences→GEOLocate and check desired options

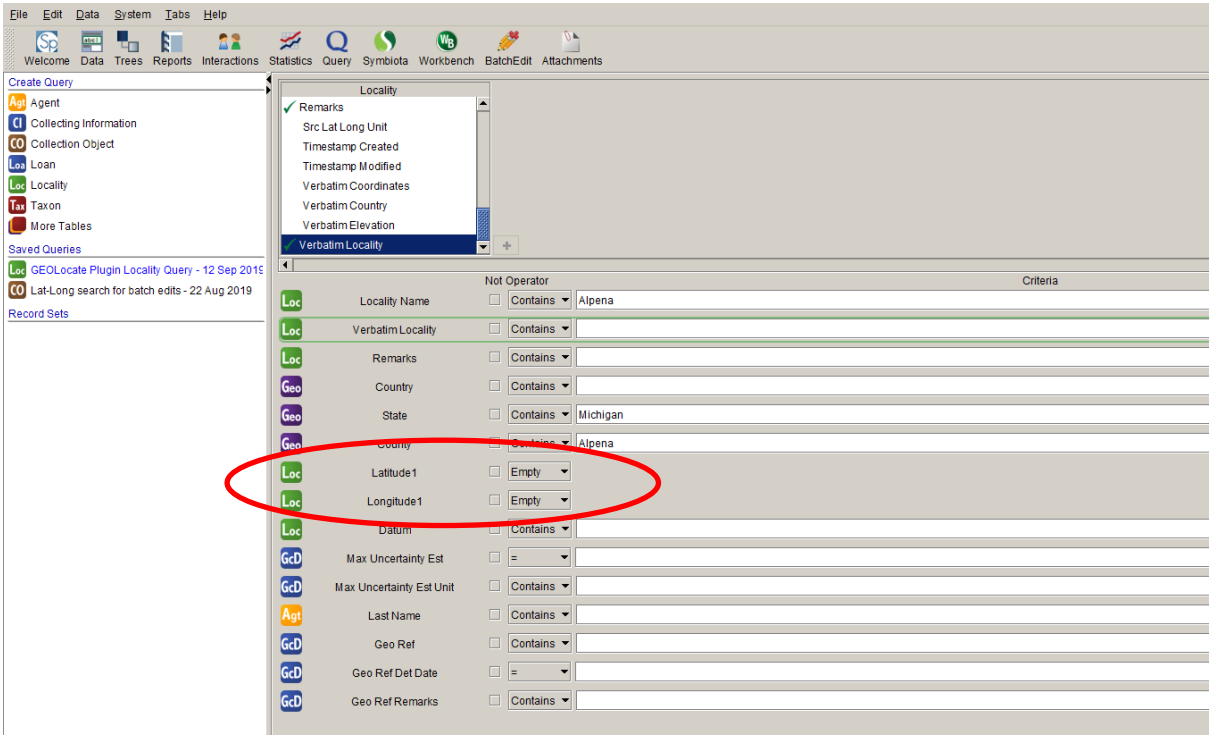


Go to Edit→Preferences→Task Bar and select Add Plugins

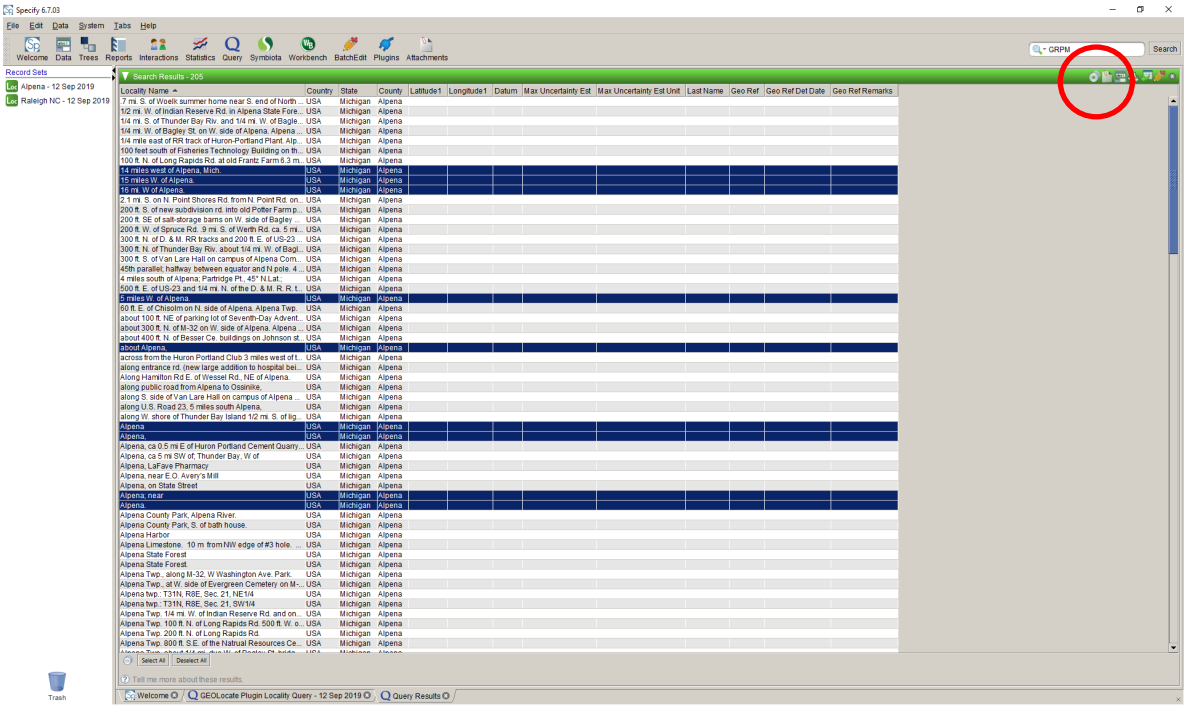


Query localities for desired search parameters. A query based upon the Locality only (i.e., not including the Collection Object) prevents duplicating efforts for collection objects from the same location. Selecting localities where the Latitude 1 and Longitude 1 are "empty" (see below) will maximize georeferencing localities without coordinates. Changing Latitude 1 and Longitude 1 to "=" will show ALL localities from a given query.

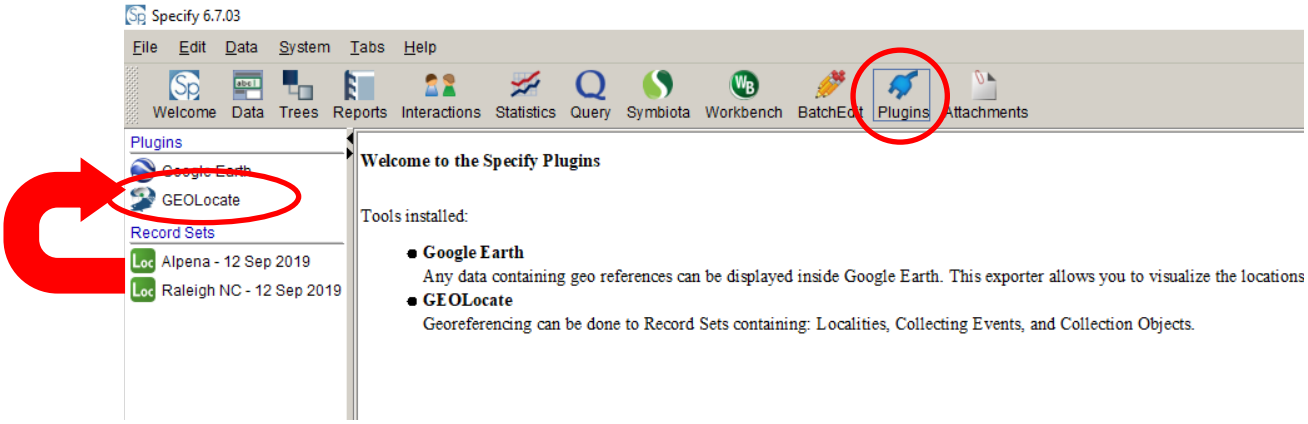
The query below will limit the search to unique localities, but will allow the localities to be batch edited for "Verbatim Locality", "Remarks", "Datum" or "Geo Ref Remarks"



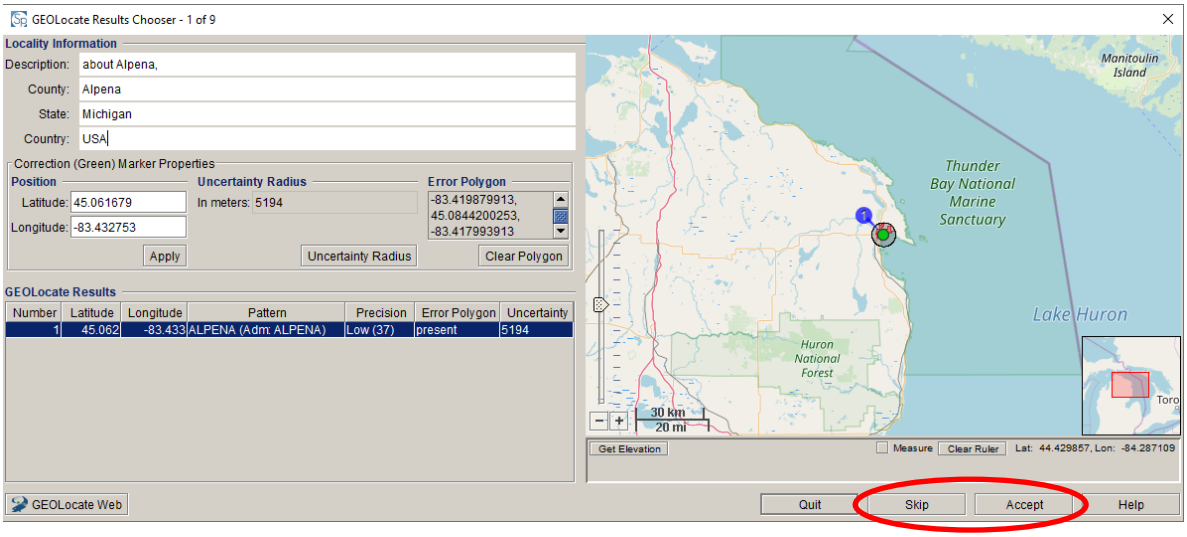
From the results page of the query, create a Record Set of the records you wish to have georeferenced – all or subset by highlighting with "Shift click" or "Ctrl click"



Then from the Plugins page (Select the Plugins icon on the top menu), you can drag and drop the record set just created onto the GEOLocate Plugin and step through each record to georeference them



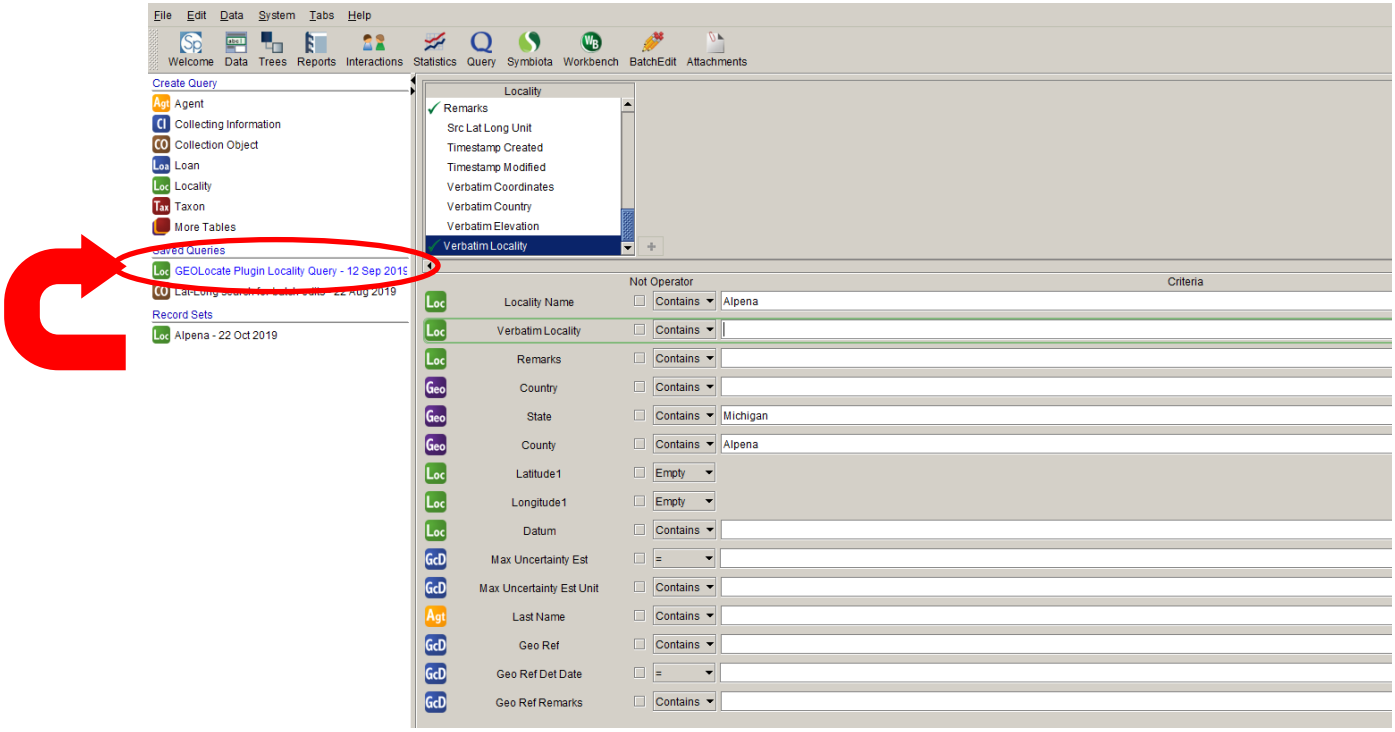
You must select "Accept" on the GEOLocate window for every locality you wish to georeference. If you do not agree with GEOLocates coordinates, select "Skip". You can modify the Locality String (Description) and re-run GEOLocate, or use another source to georeference.



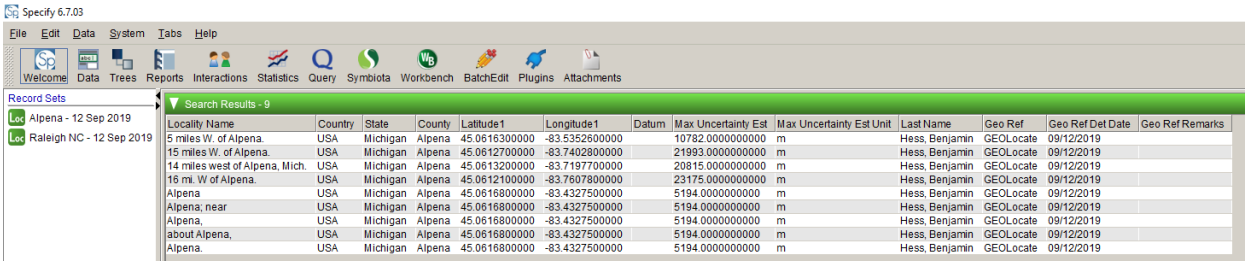
**** Take time to look at each option GEOLocate provides. Sometimes the first option is not the best, or no option clearly matches the Locality Name (Description) as it is written.**

**** You may need to move the Locality details into the "Verbatim Locality" field, and modify to original locality for GEOLocate to identify the details. Otherwise, use a different source (e.g., Google Earth, Google Maps, etc.) to georeference the locality.**

Drag and drop Record Set (after georeferencing is complete) back into the original Saved Query



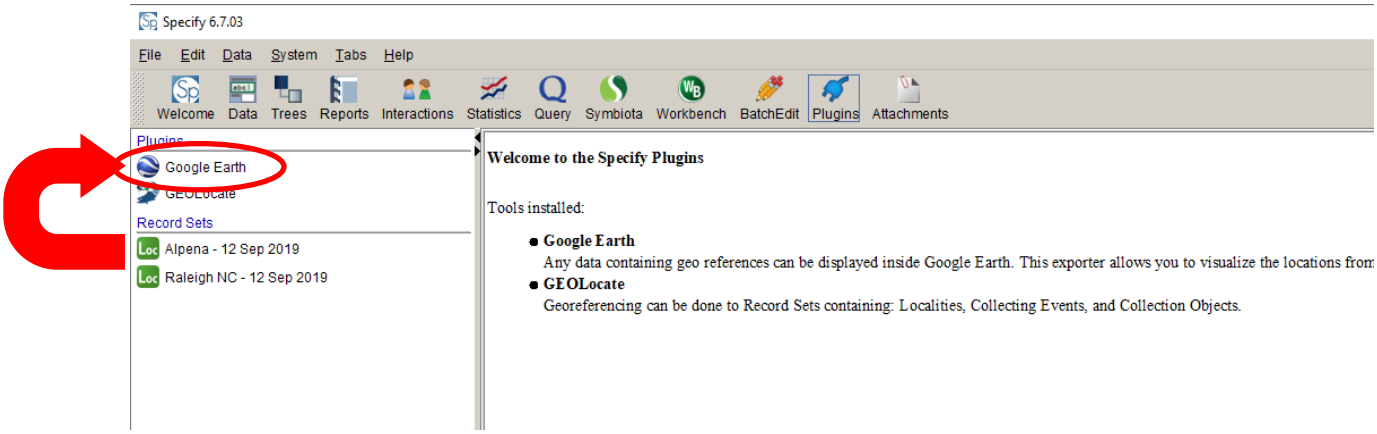
This process will autofill all fields – Latitude, Longitude, Uncertainty Radius Error Estimate, Uncertainty Error Polygon (if available), Geo Ref By (through the Agent table) and Geo Ref date, and Geo Ref (Lat/Long method). At the minimum, you should enter the Datum (most likely WGS84) as a Best Practice standard.



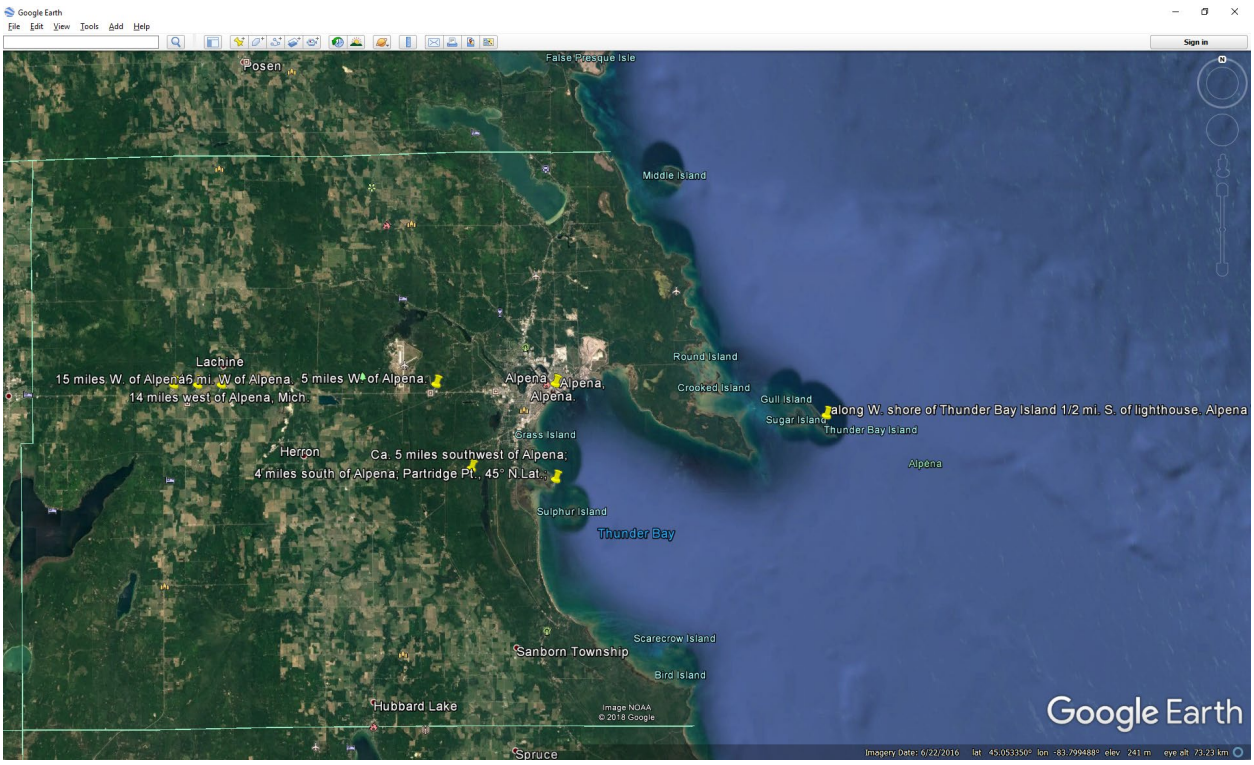
Locality Name	Country	State	County	Latitude1	Longitude1	Datum	Max Uncertainty Est	Max Uncertainty Est Unit	Last Name	Geo Ref	Geo Ref Det Date	Geo Ref Remarks
5 miles W. of Alpena.	USA	Michigan	Alpena	45.0616300000	-83.5352600000		10782.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	
15 miles W. of Alpena.	USA	Michigan	Alpena	45.0612700000	-83.7402800000		21993.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	
14 miles west of Alpena, Mich.	USA	Michigan	Alpena	45.0613200000	-83.7197700000		20815.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	
16 mi. W of Alpena.	USA	Michigan	Alpena	45.0612100000	-83.7607800000		23175.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	
Alpena	USA	Michigan	Alpena	45.0616800000	-83.4327500000		5194.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	
Alpena; near	USA	Michigan	Alpena	45.0616800000	-83.4327500000		5194.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	
Alpena,	USA	Michigan	Alpena	45.0616800000	-83.4327500000		5194.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	
about Alpena,	USA	Michigan	Alpena	45.0616800000	-83.4327500000		5194.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	
Alpena.	USA	Michigan	Alpena	45.0616800000	-83.4327500000		5194.0000000000	m	Hess, Benjamin	GEOLocate	09/12/2019	

***** This will significantly shorten the time required to georeference historical records and expedite the process across grouped localities in your query.**

Proof in Google Earth – drag the Record Set into the Google Earth Plugin to view points on a map

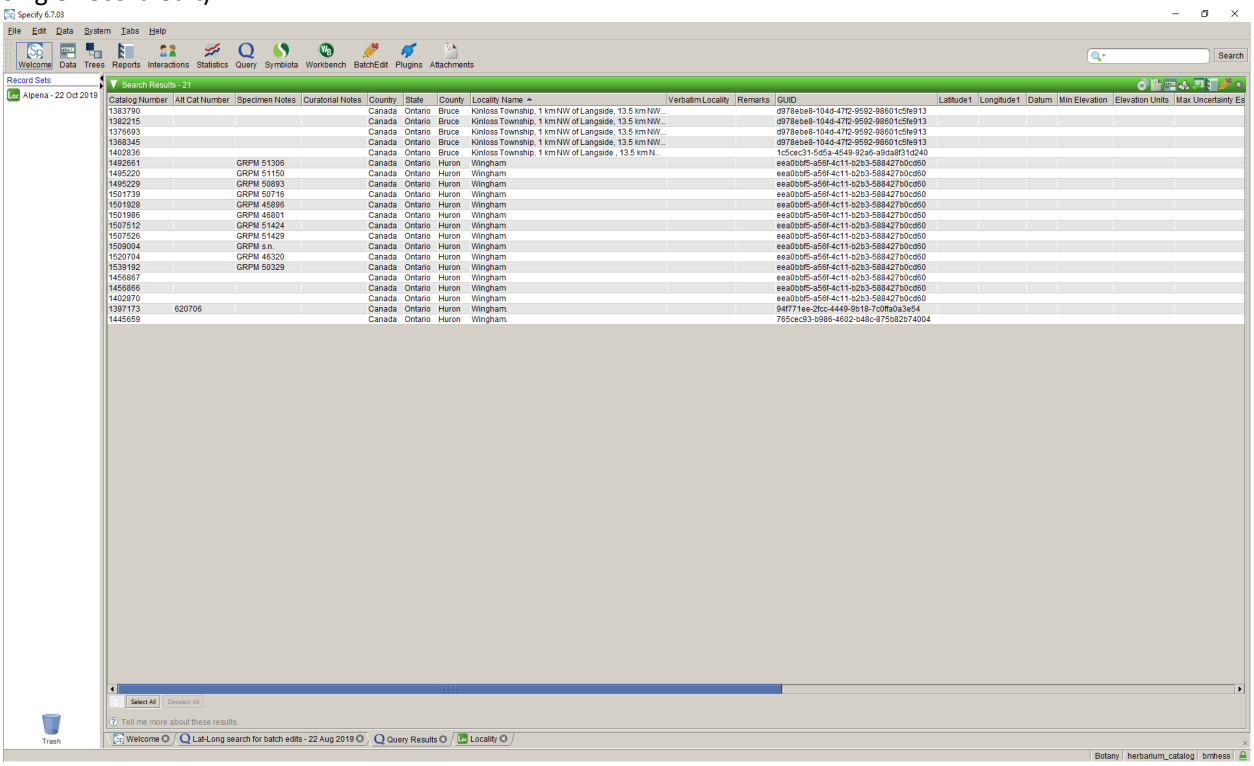


Google Earth – check each point; the Locality Name (Description) will show up for each locality georeferenced; this allows a quick view to detect errors

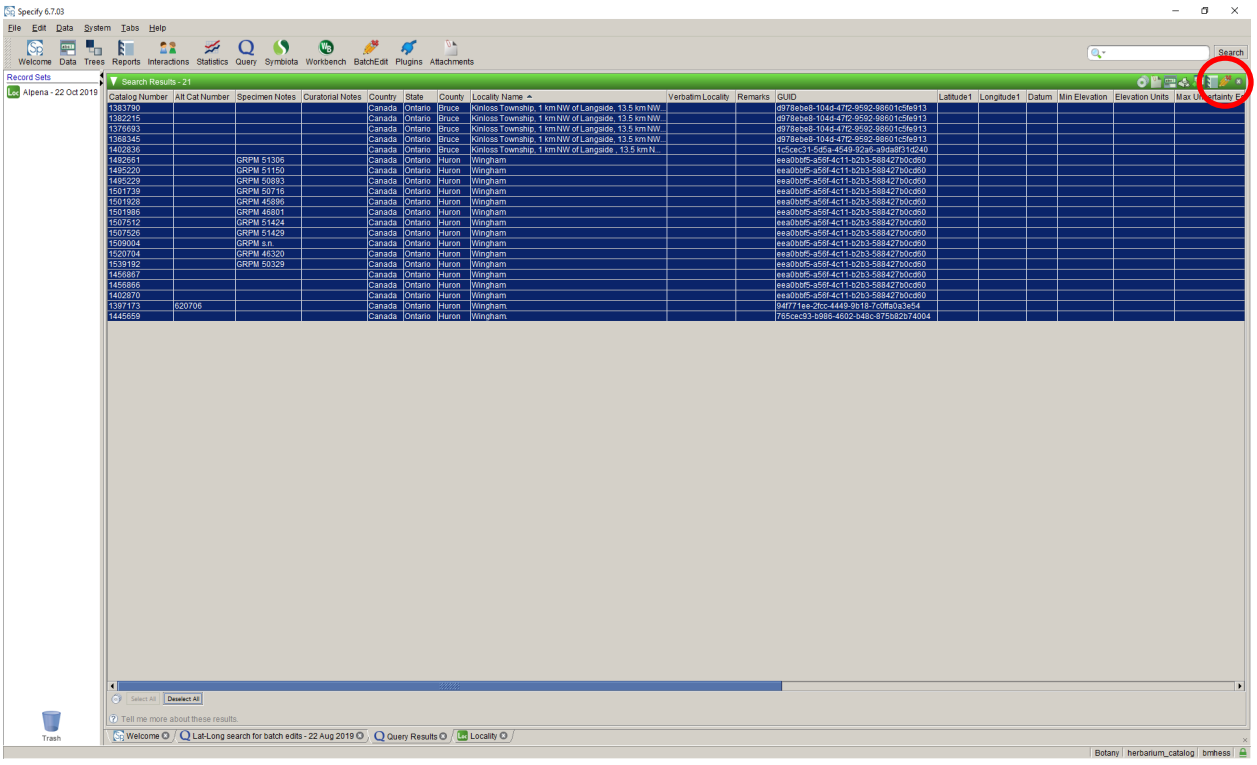


4. Batch Editing in Specify (using the query output from the example above in section 2)

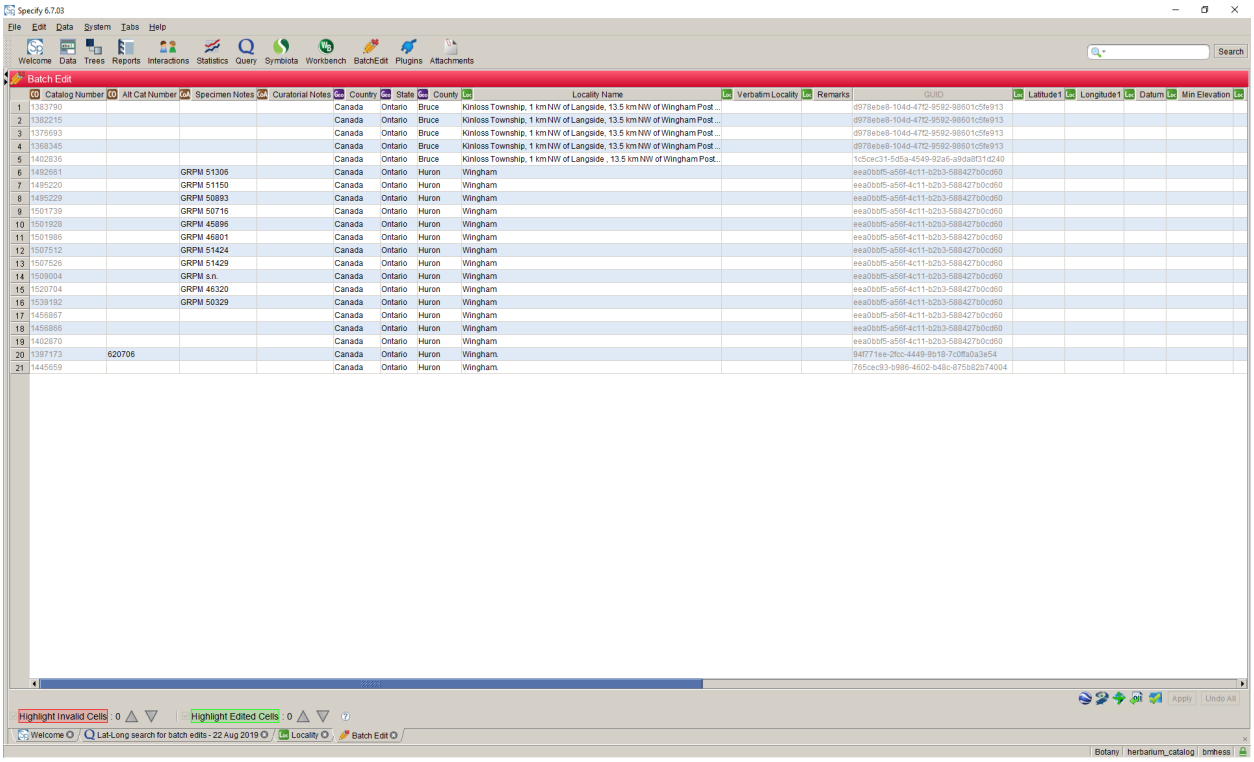
Query output (Sort by Locality Name or by GUID; if there are multiple Collection Objects with identical GUID, single-record edit)



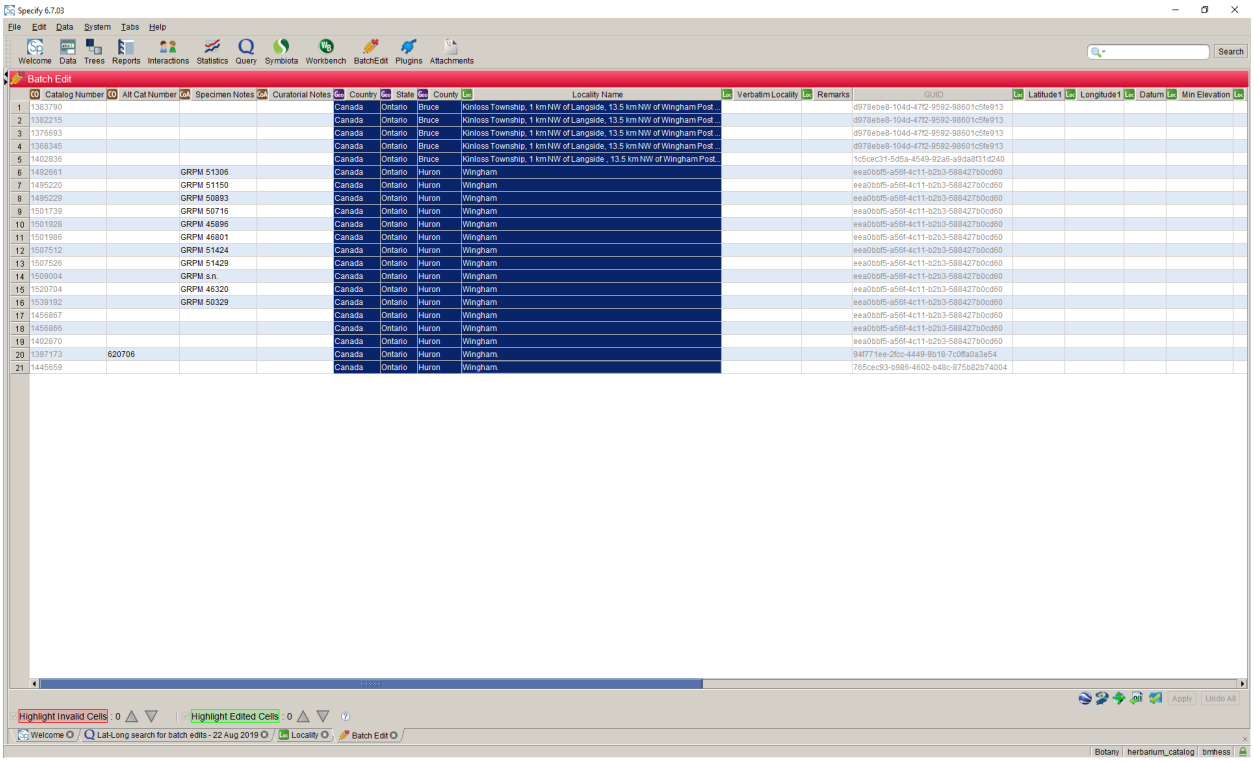
Select All – select "Batch-edit" (multiple-pencil icon)



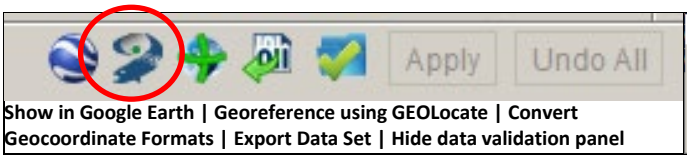
Batch Edit (left click on either locality name or GUID to sort by common localities)

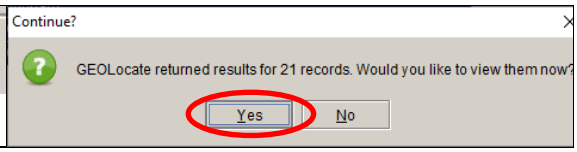


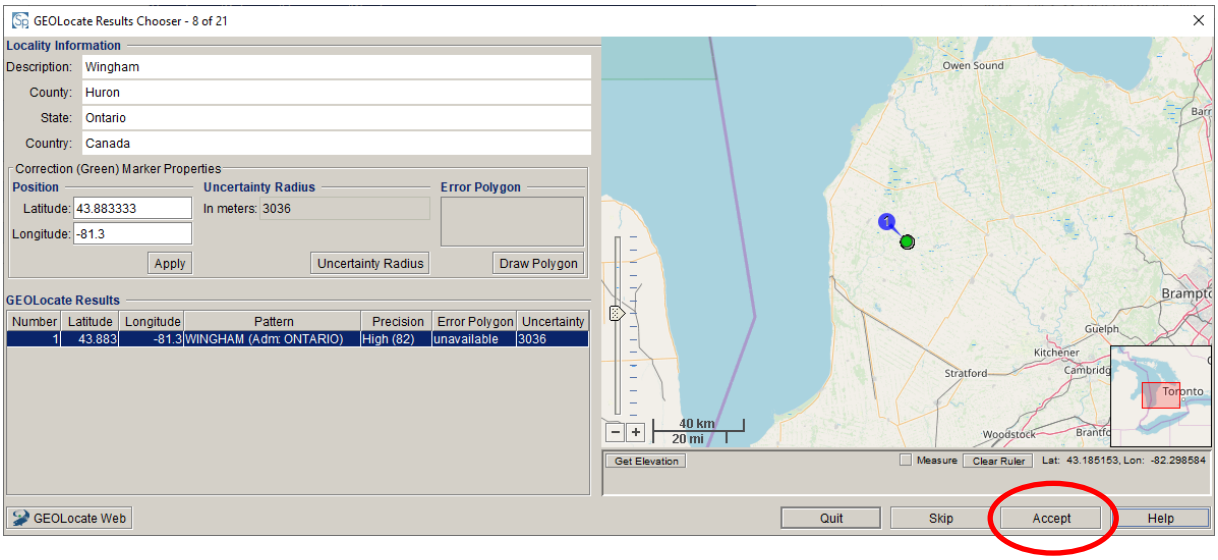
Highlight cells to georeferenced (highlighting any part of the row will select the record for georeferencing)



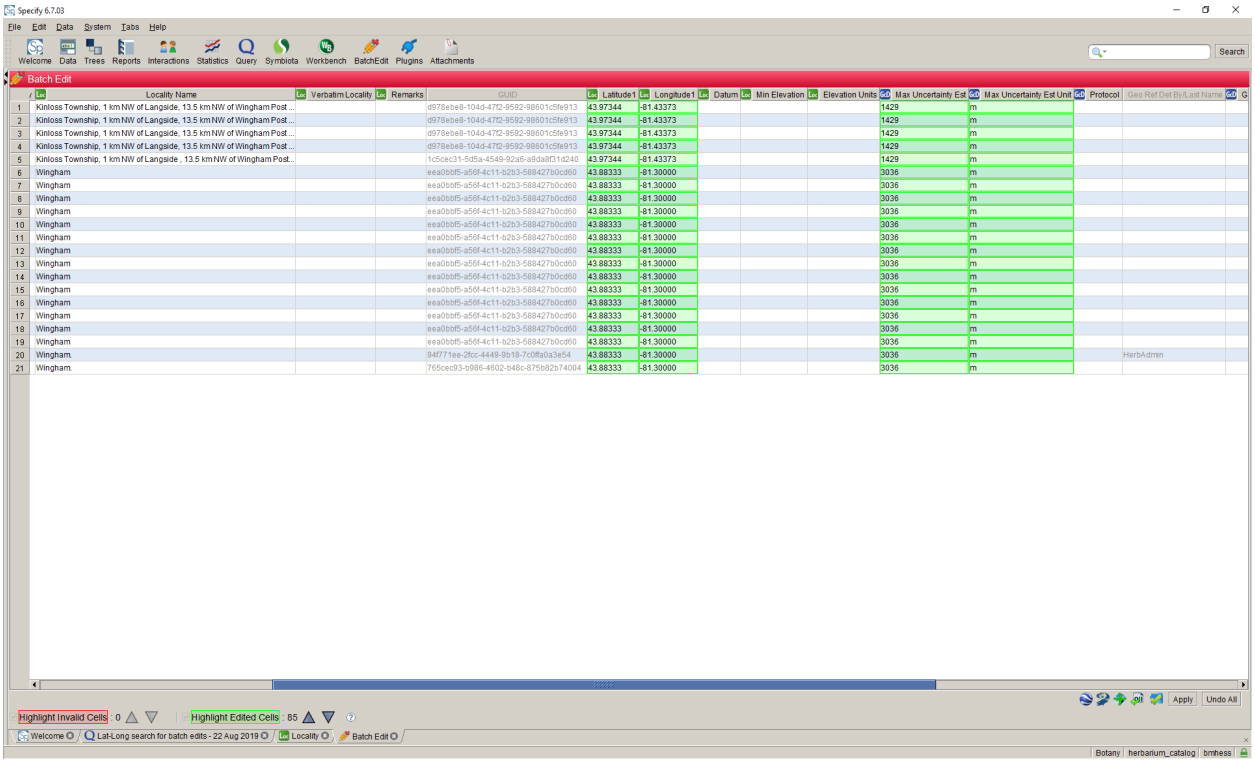
Click the GEOLocate plugin (2nd icon on bottom right)



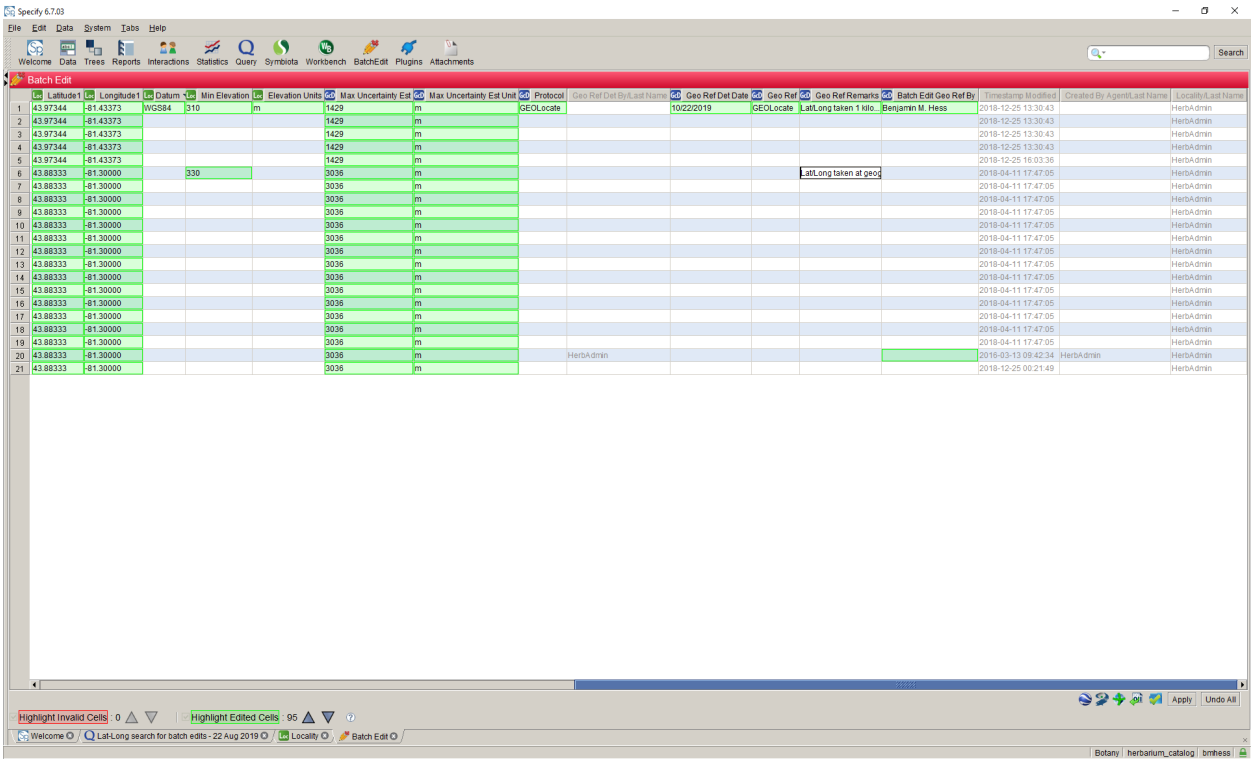




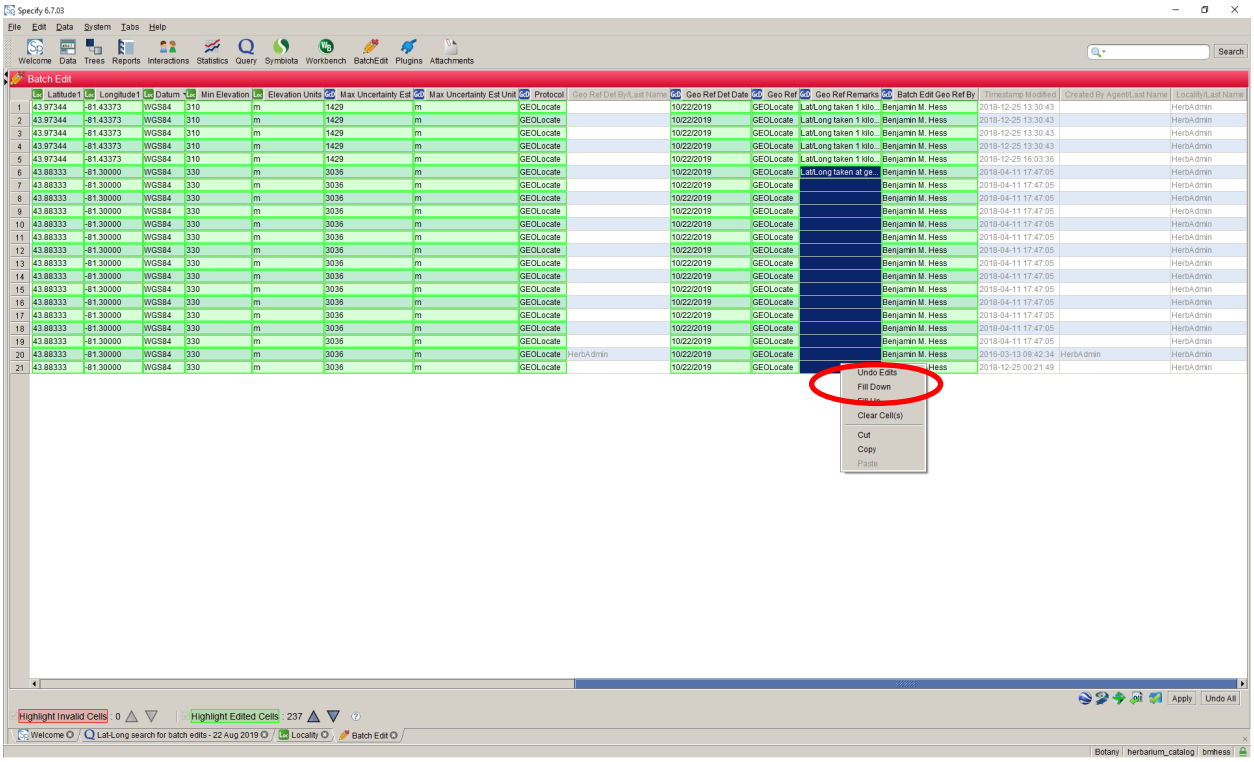
You must "Accept" or "Skip" all 21 options (GEOLocate Results Chooser – 8 of 21 shown) – coordinates will autofill, but take time to verify the location on the GEOLocate map (options may be available)



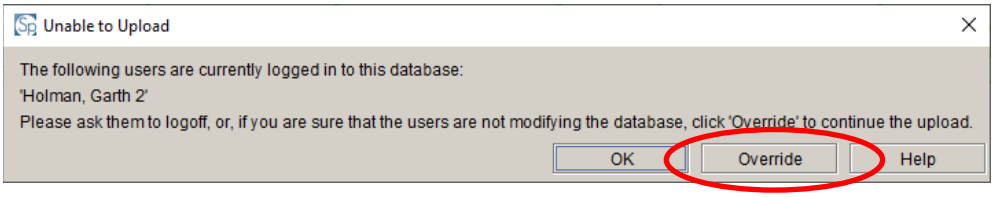
Add additional Darwin Core Fields ("Geo Ref Det By" is not batch editable) – A text field was added and changed to "Batch Edit Geo Ref By" to capture this when batch editing



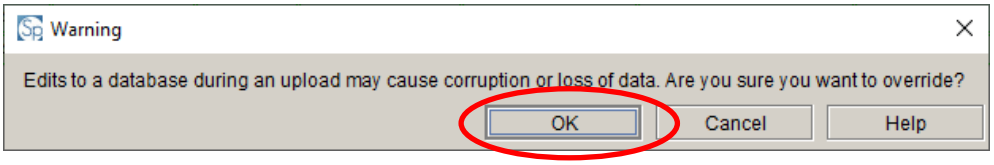
Highlight each row including the cell you wish to copy, right click, and select "Fill Down" to fill in remaining cells



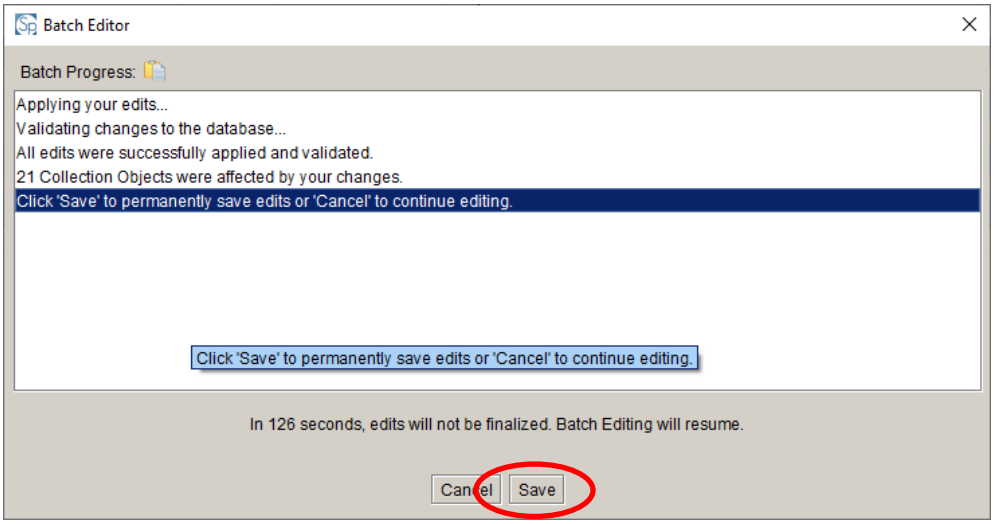
Apply and Override to continue the upload



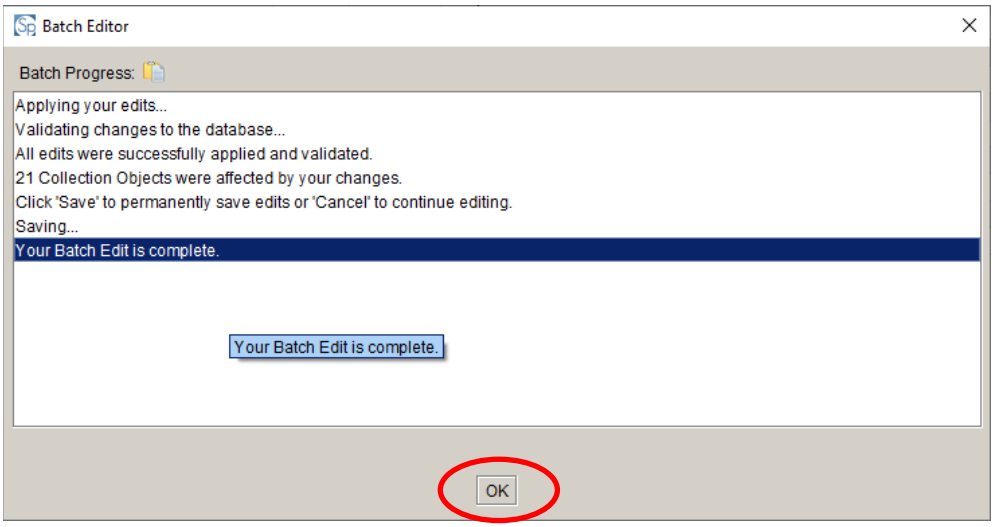
OK



Save (save every 200-300 cell changes)

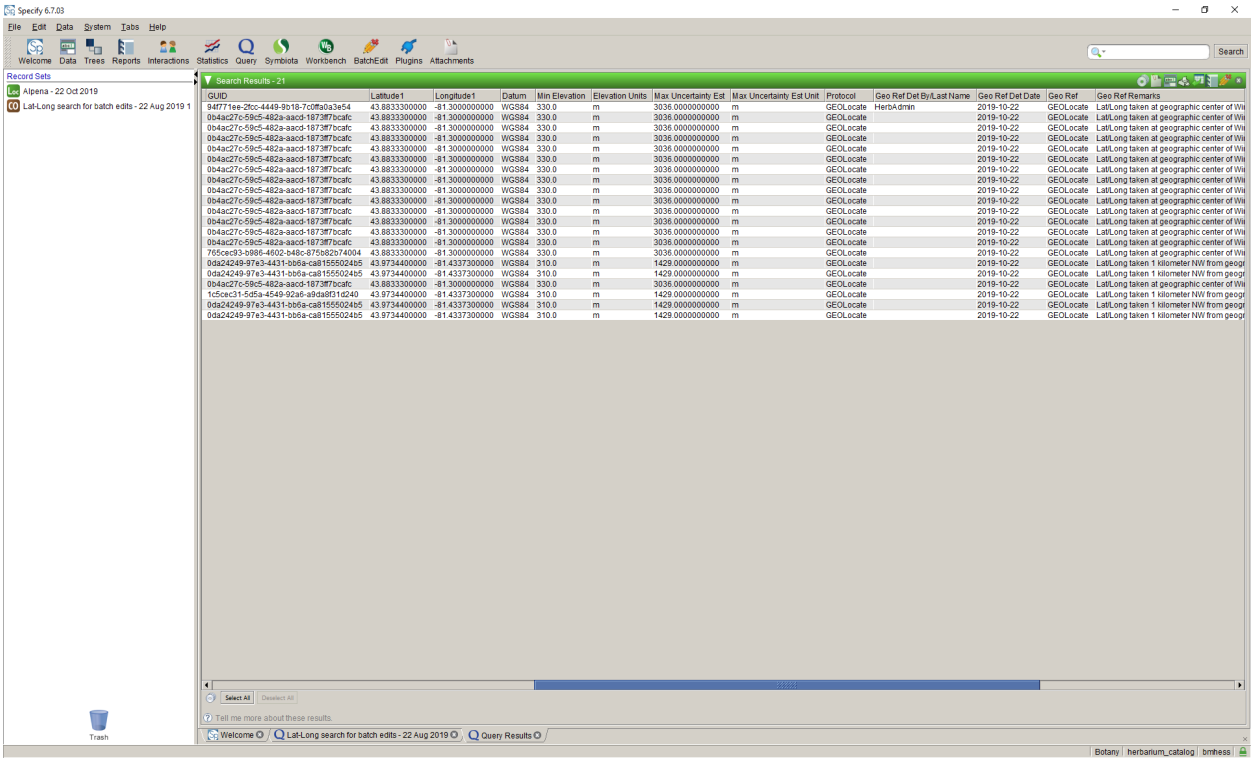


OK

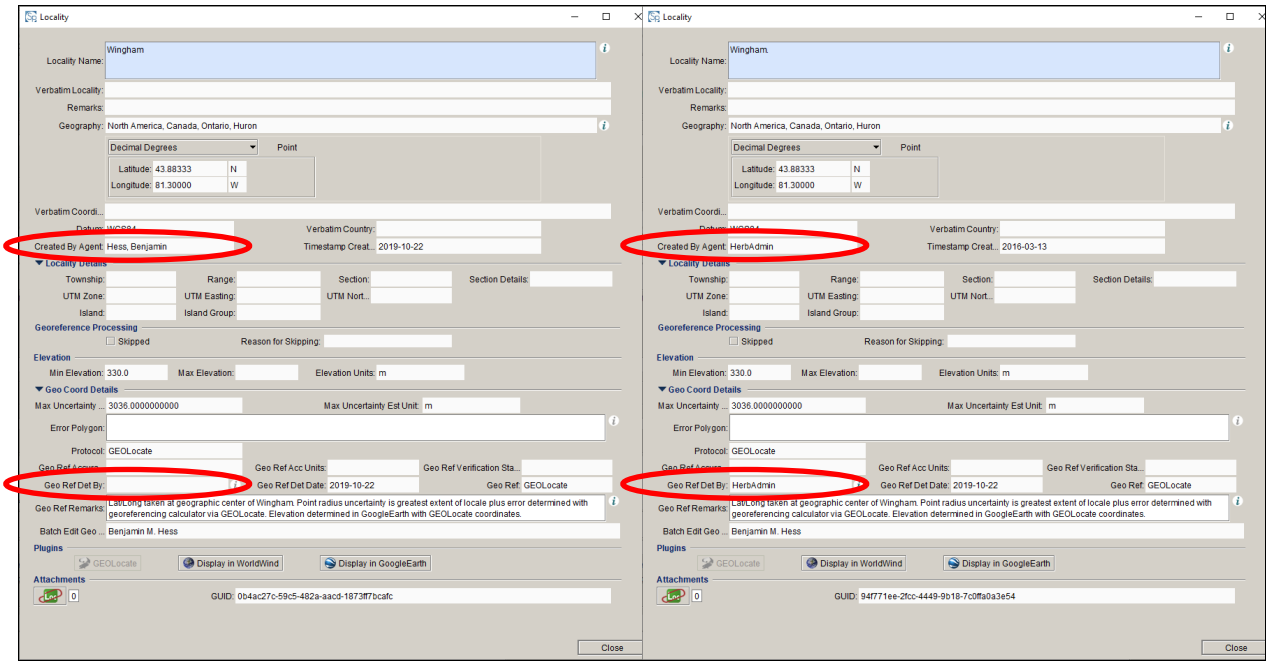


Upon selecting this final "OK", the original query output will appear with all field filled

Updated output from original query (new GUID number assigned to Locality records)



If no additional information existed in the Locality Record beyond the geography, the "Created By Agent" will be filled along with the "Timestamp Created" while in the Batch Edit mode. The "Geo Ref Det By" will always autofill using the GEOLocate Plugin or in single-record edits. If another agent name (e.g., HerbAdmin) is already entered into the field, the current agent name will not replace the original.



5. EXAMPLES

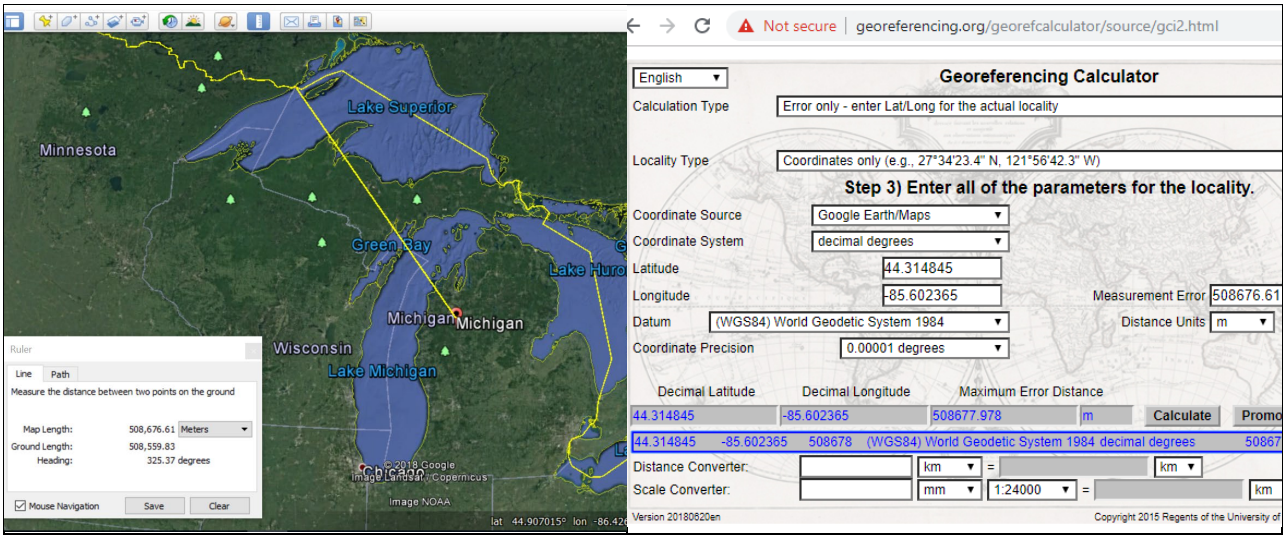
a. **GPS Unit**

i. What is the GPS unit precision? (most today are less than 10 meters of uncertainty – 10 meters is a recommended average for new GPS coordinates)
ii. Older units ranged from 30 to 100 meters or worse
iii. Record the make, model and precision of GPS unit (if known) – if older GPS coordinates 30 meters may be average
iv. Coordinates with 5 digits of coordinate precisions and 10 meter of GPS Accuracy yields 21.383 meters of maximum uncertainty with Georeferencing Calculator.
v. Source: GPS – verbatim coordinates; Datum: WGS84; Elevation from Google Earth (may need to enter coordinates in Google Earth if elevation not available)
vi. Max point-radius uncertainty with georeferencing calculator = 61.384 meters (with 5 digits of coordinate precision and 30 meter GPS accuracy) or 73.839 meters (with 4 digits of coordinate precision and 30 meter GPS accuracy)
vii. Geo Ref Remarks: Lat/Long taken at locale with GPS. Point radius uncertainty is average GPS precision (30 meters) plus error determined with georeferencing calculator.
viii. Protocol:
- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
- Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].

b. **Geographic Center of a State**

i. Use Google Earth (gives geographic center)
ii. Enter "state name, USA"
iii. EXAMPLE: Michigan, USA: 44.314845, -85.602365, elev. 414m (zoom-in on point as far as possible to get best coordinate precision)
iv. Extent: greatest extent of state = 508,676.61 meters (measured in Google Earth)
v. Elevation: 414 meters (coordinates entered into Google Earth)
vi. Source: Google Maps/Google Earth; Datum: WGS84; Elevation from Google Earth
vii. Max point-radius uncertainty with georeferencing calculator = 508,677.978 meters
viii. Geo Ref Remarks: Lat/Long taken at geographic center of state. Point radius uncertainty is greatest extent of state boundary plus error determined with georeferencing calculator.
ix. Protocol:
- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
- Georeferencing Calulator (Wieczorek and Wieczorek 2015) – Wieczorek, C. and J. Wieczorek. 2015. Georeferencing Calculator (version 20160929). Museum of

Vertebrate Zoology, University of California, Berkeley. Available: http://41.242.99.131/sigcalc/source/gci2.html. Accessed [yyyy-mm-dd].



c. **Geographic Center of a State County**

i. Use GEOLocate (gives geographic center for U.S. state counties); Google Earth and Google Maps will give the geographic center for many other countries

ii. Leave the Locality String empty; only fill the Country, State, County

iii. GEOLocate gives: silhouette of the county, geographic center point, uncertainty to the greatest extent of county plus other uncertainty, and error polygon if desired

iv. EXAMPLE: USA, Michigan, Huron County: 43.910068, -82.855508, 76395 m uncertainty

v. Elevation: 213 meters (coordinates entered into Google Earth)

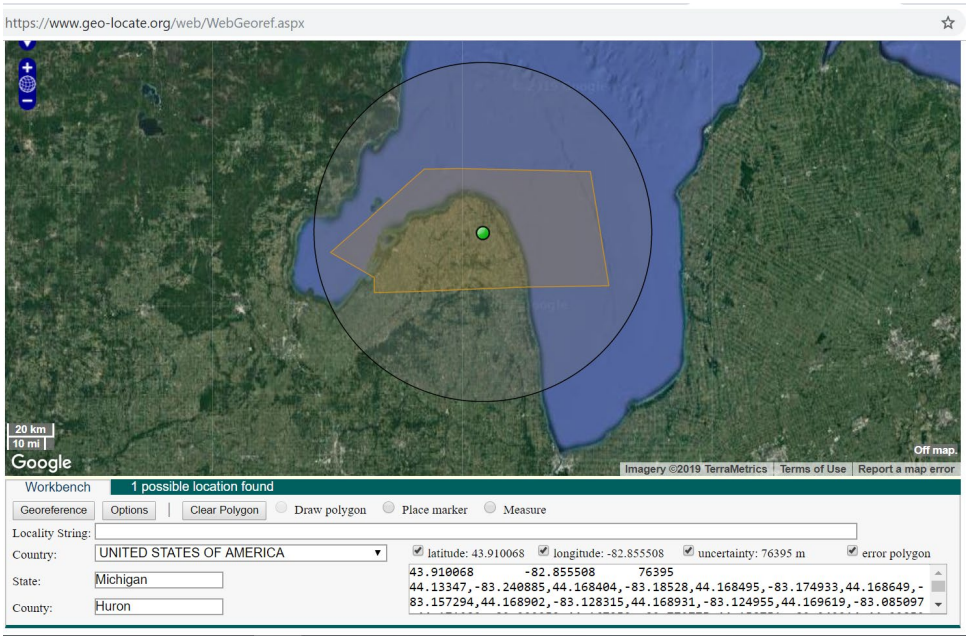
vi. Source: GEOLocate; Datum: WGS84; Elevation from Google Earth

vii. Geo Ref Remarks: Lat/Long taken at geographic center of Huron County. Point radius uncertainty is greatest extent of county boundary plus error determined with georeferencing calculator via GEOLocate. (**GEOLocate includes calculations done with georeferencing calculator)

viii. Protocol:

- GEOLocate (Rios and Bart 2010) – Rios, N. E. and H. L. Bart. 2010. GEOLocate (Version 3.22) computer software. Belle Chasse, LA: Tulane University Museum of Natural History. – Georeferencing software for natural history collections. http://www.museum.tulane.edu/geolocate/
- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.

c. **Geographic Center of a State County – continued**



d. **Geographic (or Population) Center of a City/Town/Locale**

i. Use GEOLocate (gives geographic center)

ii. Add the location in the Locality String, and add the Country, State, County (optional, but may give multiple choices with same locale name)

iii. GEOLocate gives: polygon of larger cities, geographic center point, uncertainty to the greatest extent of location plus other uncertainty, and error polygon if desired

iv. EXAMPLE: USA, Michigan, Washtenaw County, Ann Arbor: 42.270872, -83.726329, 7236 m uncertainty

v. Extent: If not found with GEOLocate, use the following information:

- Determine the extent with Google Maps or Google Earth visually, or
- Use 1/2 the distance from the selected coordinates to the nearest named place

vi. Elevation: 278 meters (coordinates entered into Google Earth)

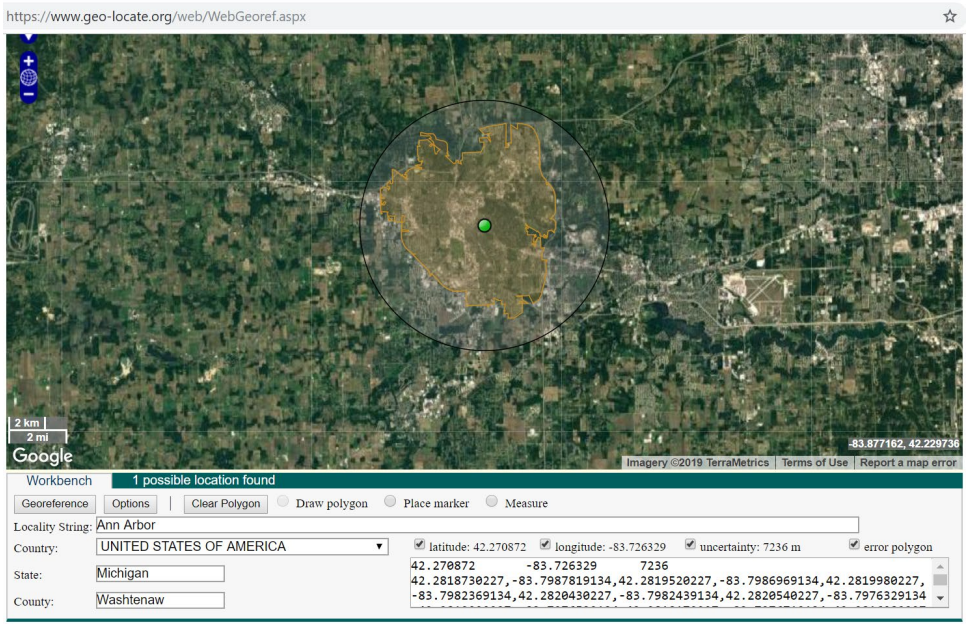
vii. Source: GEOLocate; Datum: WGS84; Elevation from Google Earth

viii. Geo Ref Remarks: Lat/Long taken at geographic center of Ann Arbor. Point radius uncertainty is greatest extent of locale plus error determined with georeferencing calculator via GEOLocate. (**GEOLocate includes calculations done with georeferencing calculator)

ix. Protocol:

- GEOLocate (Rios and Bart 2010) – Rios, N. E. and H. L. Bart. 2010. GEOLocate (Version 3.22) computer software. Belle Chasse, LA: Tulane University Museum of Natural History. – Georeferencing software for natural history collections. http://www.museum.tulane.edu/geolocate/
- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.

d. Geographic (or Population) Center of a City/Town/Locale – continued



e. **Township, Range, and Section (TRS)**

i. Use GEOLocate (gives geographic center of TRS data in U.S.)

ii. If you are tracking down Township, Range, and Section (TRS) data that did not get automatically converted due to some format or other problem, a good site is allowing the reading of Lat & Long from a TRS coordinate is: https://www.mcgi.state.mi.us/mi-hunt/ for Michigan, or https://catalog.data.gov/dataset?q=PLSS

iii. *** This can be entered into GEOLocate in the format (T42N R37W Sec 2) [S2, Sec2 or Sec. 2 formats also work] with Country (United States of America) and State (Michigan)

iv. EXAMPLE: USA, Michigan, T42N R37W Sec 2: 46.066311, -88.896743, 969 m uncertainty

v. Extent: if not found with GEOLocate, use the following information:

Extents of divisions of a township				
Division	**Example**	**Extent**	**Orthogonal Extent**	**O-Extent (meters)**
Township	T6S R14E	4.243 mi	3 mi	4828.03
Section	T6S R14E Sec. 23	0.707 mi	0.5 mi	804.672
1/4 Section	T6N R14E Sec. 23 NE 1/4	0.354 mi	0.25 mi	402.336
1/4 of 1/4 Section	T6N R14E Sec. 23 NE 1/4 SW 1/4	0.177 mi	0.125 mi	201.168
1/4 of 1/4 of 1/4 Section	T6N R14E Sec. 23 NW 1/4 NE 1/4 SW 1/4	0.089 mi	0.0625 mi	100.584

Source: MaNIS/HerpNet/ORNIS Georeferencing Guidelines

vi. Elevation: 359 meters (coordinates entered into Google Earth)

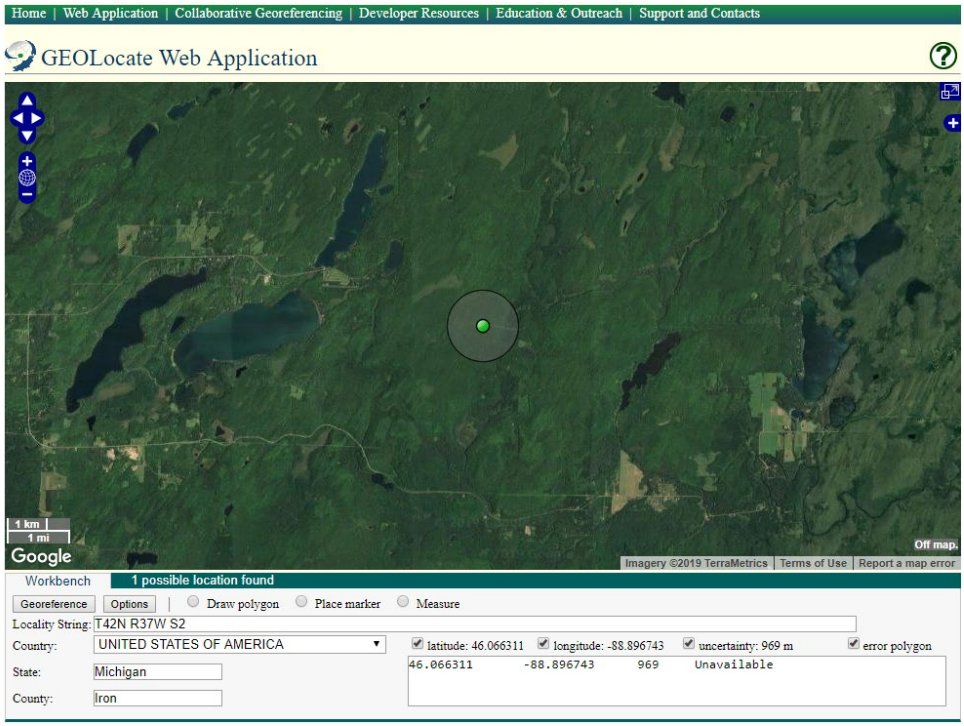
vii. Source: GEOLocate; Datum: WGS84; Elevation from Google Earth

viii. Geo Ref Remarks: Lat/Long taken at geographic center of Township, Range, and Section (TRS) data. Point radius uncertainty is greatest extent of TRS area plus error determined with georeferencing calculator via GEOLocate. (**GEOLocate includes calculations done with georeferencing calculator)

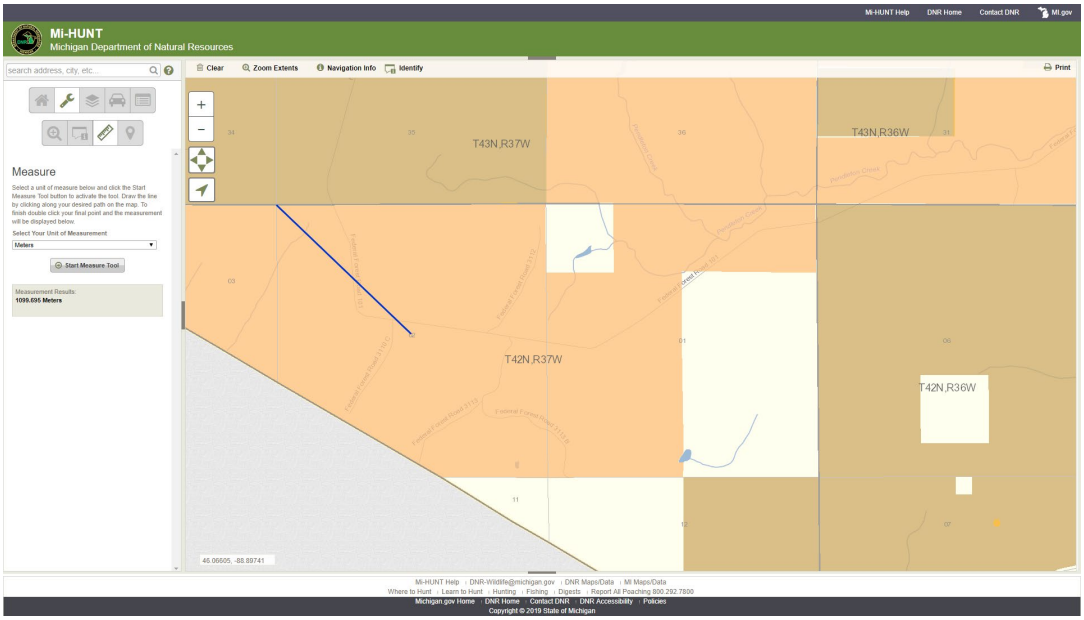
ix. Enter coordinates in Google Maps → Stambaugh Township (right-click and left-click "What"s here?" to find additional information – can find Iron River nearby); moving TRS data to Verbatim Coordinates or elsewhere and adding township and city name improves record future searchability (must document this was not part of original locality data)

x. Protocol:

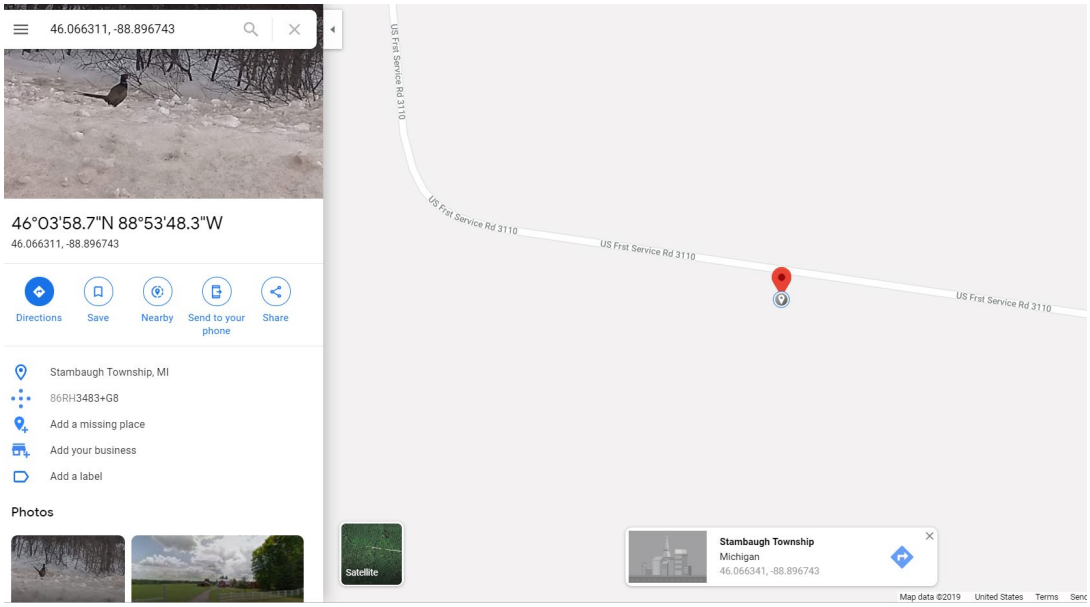
- GEOLocate (Rios and Bart 2010) – Rios, N. E. and H. L. Bart. 2010. GEOLocate (Version 3.22) computer software. Belle Chasse, LA: Tulane University Museum of Natural History. – Georeferencing software for natural history collections. http://www.museum.tulane.edu/geolocate/
- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
- Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.



MI DNR Mi-Hunt map (https://www.mcgi.state.mi.us/mi-hunt/) can find TRS data and get an uncertainty, but it takes extra time. [Details taken from Tony Reznicek and Kyle Lough – Aug 2019]
** Click the layers icon (third from the left, looks like layers of sheets) in the menu on the left side of the page
** Turn on the "Town Range" and "Sections" layers and turn off the "Hunting Lands" layer (The "1836 Treaty Boundary" layer is not necessary but will not get in the way either)
** You can now find the geographic location associated with the Township, Range, and Section listed in localities (e.g. T2 R5, NW1/4 of S15). Tip: Each section is one square mile, there are 36 sections per township
** To copy coordinates, click on the "Tools" icon (second from the left, looks like a wrench) in the menu on the left side of the page. Click on the "GPS Transfer" icon (rightmost icon, looks like a GPS pin)



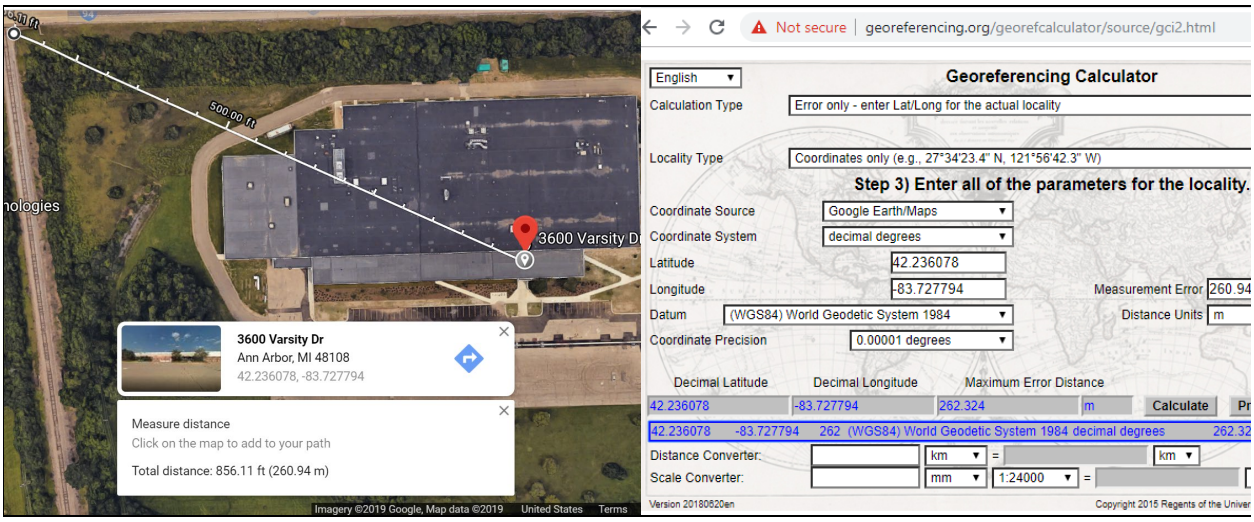
Google Maps – Copy and paste coordinates into Google Maps, right-click and select "What"s here?" – gives Stambaugh Township as more specific locale. A few additional clicks around the locality (with the "What"s here?" function) shows the City/Town is Iron River.



f. **Street Address**

i. Use Google Maps
ii. Enter exact address – point given usually as the center of the building
iii. EXAMPLE: 3600 Varsity Drive, Ann Arbor, MI: 42.236078, -83.727794 (zoom-in on point as far as possible to get best coordinate precision)
iv. Extent: taken from point to NW boundary (US 94 and W boundary as defined in Google Maps) = 260.94 meters; extent may be easier to see in satellite view
v. Elevation: 251 meters (coordinates entered into Google Earth)
vi. Source: Google Maps; Datum: WGS84; Elevation from Google Earth
vii. Max point-radius uncertainty with georeferencing calculator = 262.324 meters
viii. Geo Ref Remarks: Lat/Long taken at geographic center of address. Point radius uncertainty is greatest extent of property plus error determined with georeferencing calculator.
ix. Protocol:

- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
- Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].
- Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.



g. **Road Junction (JCT)**

i. Use Google Maps
ii. Enter road names and city – point given as the center of the road junction
iii. EXAMPLE: Liberty Street and Main Street, Ann Arbor, MI: 42.279577, -83.748601 (Google Maps will allow most variations of road name; zoom-in on point as far as possible to get best coordinate precision)

iv. Extent: 15.13 meters based on greatest extent to corner building in intersection. If the extent of road junctions cannot be measured on maps [or when it cannot be estimated by locality information], use the following extent recommendations from Frazier et al. (2004): Frazier, C., T. Neville, T. Giermakowski and G. Racz. 2004. The INRAM protocol for georeferencing biological museum specimen records. Version 1.3. [taken from BioGeomancer_Best_Practices_Guide_to_Georeferencing]
   - For 2-lane city streets and 2-lane highways, the extent is 10 m.
   - For 4-lane highways, the extent is 20 m.
   - For large highways with medians, the extent is 30 m.
   - If unknown, use 15 m.

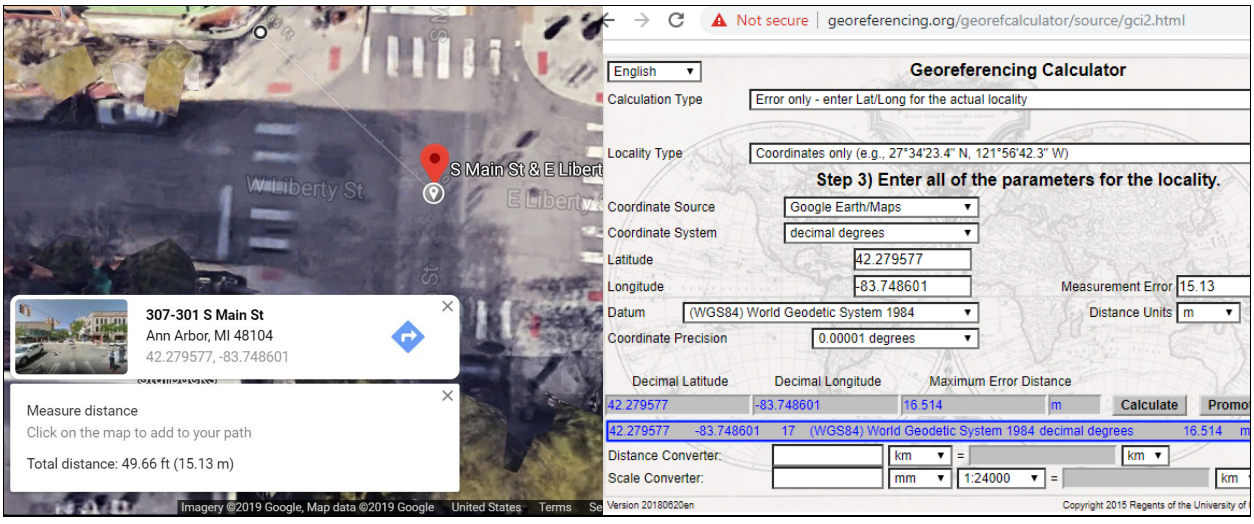
v. Elevation: 257 meters (coordinates entered into Google Earth)

vi. Source: Google Maps; Datum: WGS84; Elevation from Google Earth

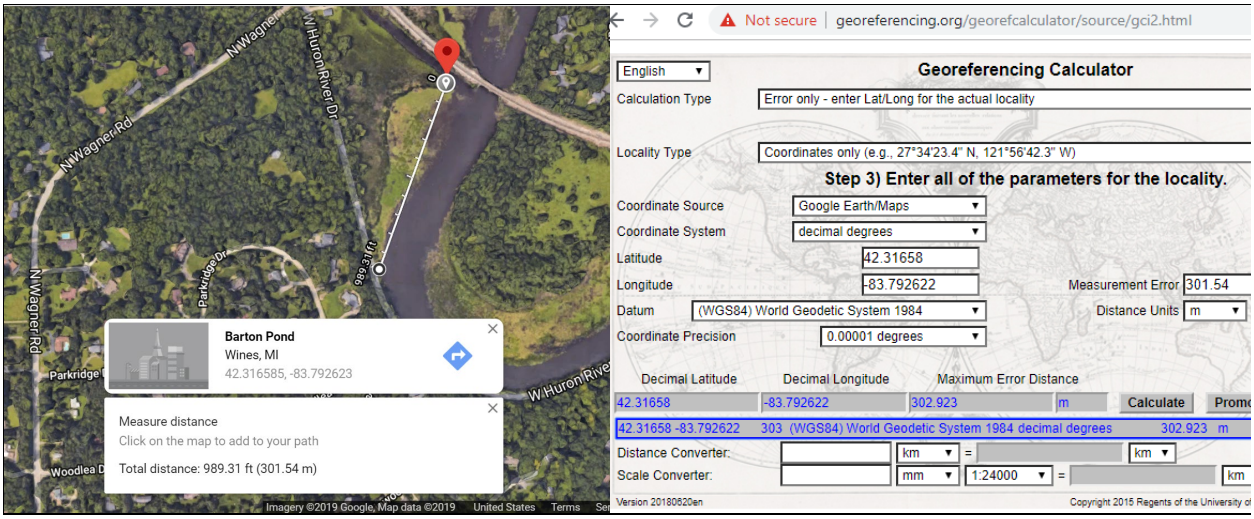
vii. Max point-radius uncertainty with georeferencing calculator = 16.514 meters

viii. Geo Ref Remarks: Lat/Long taken at geographic center of address. Point radius uncertainty is greatest extent of property plus error determined with georeferencing calculator.

ix. Protocol:
   - Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
   - Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].
   - Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.

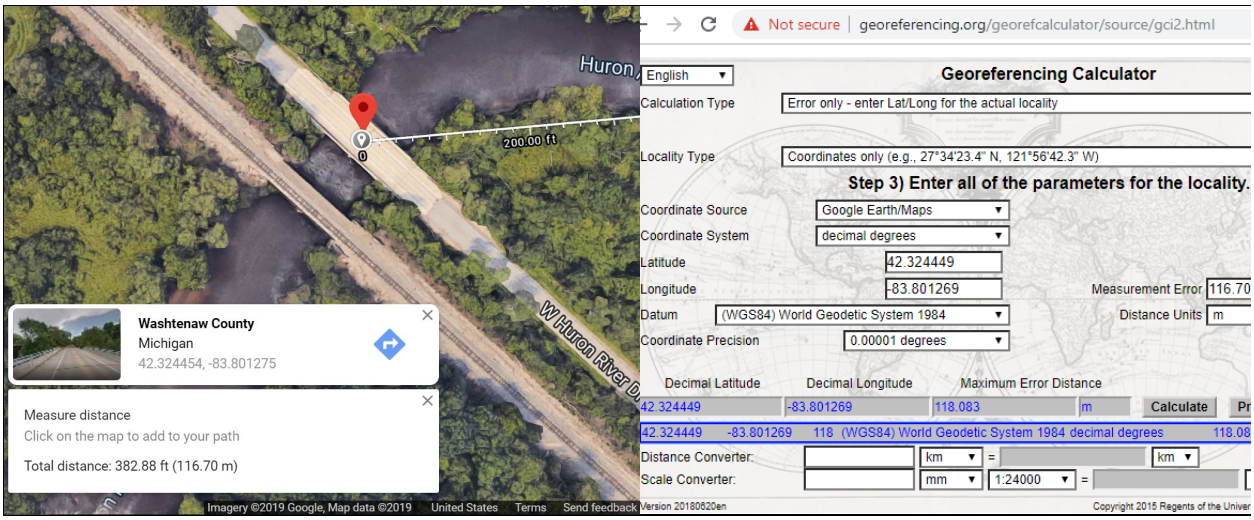


h. **River/Stream/Creek Confluence** (i.e. river/stream/creek junction where they merge)
   i. Use Google Maps
   ii. Enter river/stream/creek name and state – point given as the midpoint
   iii. EXAMPLE: Honey Creek and Huron River, Ann Arbor, MI: 42.316586, -83.792622 (Google Maps will give options for name used; example searched for Honey Creek; zoom-in on point as far as possible to get best coordinate precision)
   iv. Extent: assumption from locality information may help, but may need to look at satellite map view and give reasons for choice; 301.54 meters for this example
   v. Elevation: 245 meters (coordinates entered into Google Earth)
   vi. Source: Google Maps; Datum: WGS84; Elevation from Google Earth
   vii. Remarks: make assumptions about location; will often need to move point on land (for terrestrial organisms); assume that original locality indicated "taken from W side of Huron River at confluence with Honey Creek" – extent assumed to be distance from Honey Creek South on Huron River to W Huron River Drive
   viii. Max point-radius uncertainty with georeferencing calculator = 302.932 meters
   ix. Geo Ref Remarks: Lat/Long taken at confluence of Honey Creek and Huron River. Point radius uncertainty is greatest extent of land near confluence plus error determined with georeferencing calculator.
   x. Protocol:
      - Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
      - Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].
      - Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.



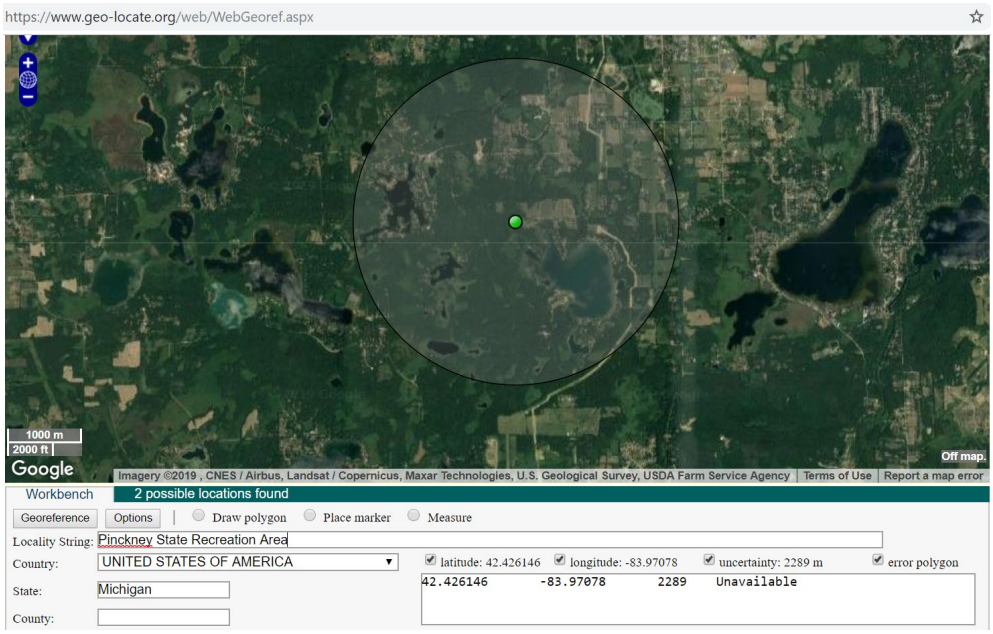
i. **Intersection of Road and River/Stream/Creek**
   i. Use Google Maps
   ii. Enter river/stream/creek name and state – point given as the center of the river/stream/creek
   iii. EXAMPLE: W Huron River Dr and Huron River intersection, Ann Arbor, MI: 42.324449, -83.801269 (Google Maps will allow most variations of road name; zoom-in on point as far as possible to get best coordinate precision)
   iv. Extent: May be determined if enough information is provided. Otherwise, chose a distance that incorporates land features where the organism may have been collected. 116.70 meters was chosen (for this example) based on satellite or Google Earth view.
      - Whichever is greater: 1) 2 km or 2) 200% of the linear extent of the Named Place / Feature
      - In this example: 2 km is far too large, and 200% of the original may be too small
      - If looking at Google Earth or Google Maps satellite view, there may be a clear extent due to the landscape
      - "Clearly there is a measure of subjectivity involved here and you should use your judgment and evidence from other sources. Let common sense prevail and document the assumptions made" - Georeferencing Best Practices Guide.
   v. Elevation: 248 meters (coordinates entered into Google Earth)
   vi. Source: Google Maps; Datum: WGS84; Elevation from Google Earth
   vii. Remarks: may need to make assumptions (probably was not taken at the center of the bridge); assumed that 116.7 meters from center of bridge incorporates "true" point
   viii. Max point-radius uncertainty with georeferencing calculator = 101.384 meters
   ix. Geo Ref Remarks: Lat/Long taken at intersection of W Huron River Drive and Huron River. Point radius uncertainty is greatest extent of land near intersection plus error determined with georeferencing calculator.
   x. Protocol:
      - Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
      - Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].
      - Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.

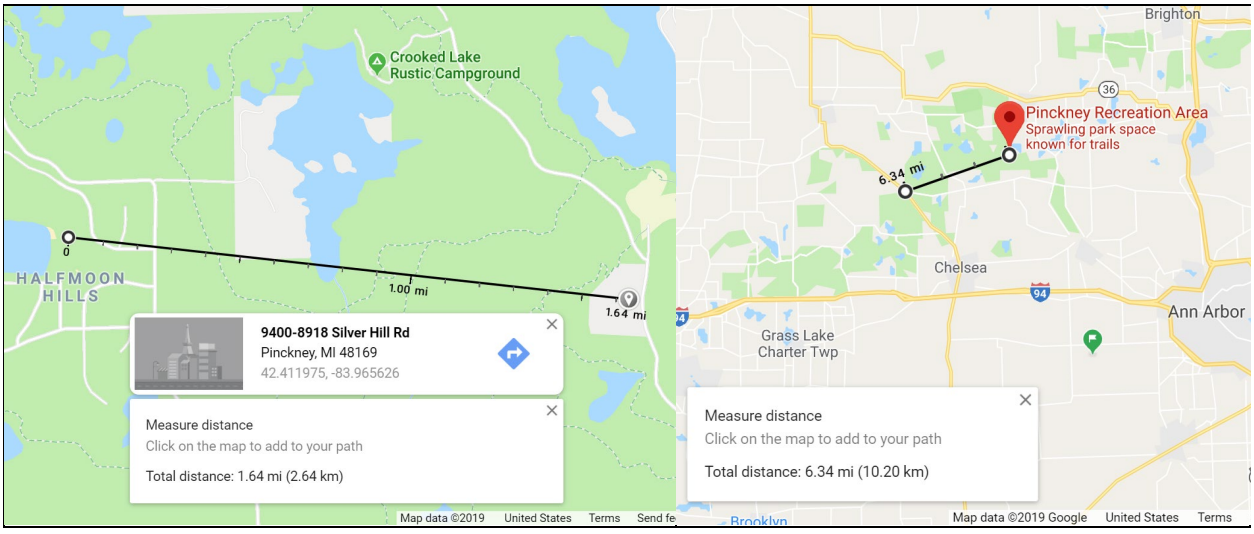
i. **Intersection of Road and River/Stream/Creek – continued**



j. **Named Place (State Park, Lake, Mountain or Other Geographic Entity)**
   i. Use GEOLocate first (use Google Maps, Google Earth and other sources to check location)
   ii. Enter location name, country and state (may need county if other named areas in the same state) – point given as the geographic center
   iii. EXAMPLE: Pinckney State Recreation Area, MI: 42.426146, -83.97078 , uncertainty = 2289 meters
   iv. Extent: may need to look at satellite view in Google Maps
      - The extent may be confined to a specific area based upon the locality information.
   v. Elevation: 297 meters (coordinates entered into Google Earth)
   i. Source: GEOLocate; Datum: WGS84; Elevation from Google Earth
   ii. Remarks: Google Maps may give a different location like a landmark (i.e. Google maps give the Pinckney State Park headquarters as the locality); the individual georeferencing may need to decide between sources; may need to make extent assumptions with Google Maps/Earth
   iii. Geo Ref Remarks: Lat/Long taken at geographic center of Pinckney State Recreation Area. Point radius uncertainty is greatest extent of natural area plus error determined with georeferencing calculator via GEOLocate. (**GEOLocate includes calculations done with georeferencing calculator)
   iv. Protocol:
      - GEOLocate (Rios and Bart 2010) – Rios, N. E. and H. L. Bart. 2010. GEOLocate (Version 3.22) computer software. Belle Chasse, LA: Tulane University Museum of Natural History. – Georeferencing software for natural history collections. http://www.museum.tulane.edu/geolocate/
      - Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.

- Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.



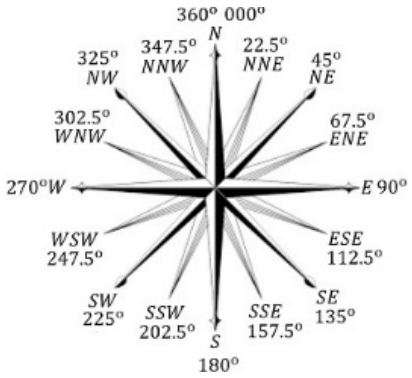


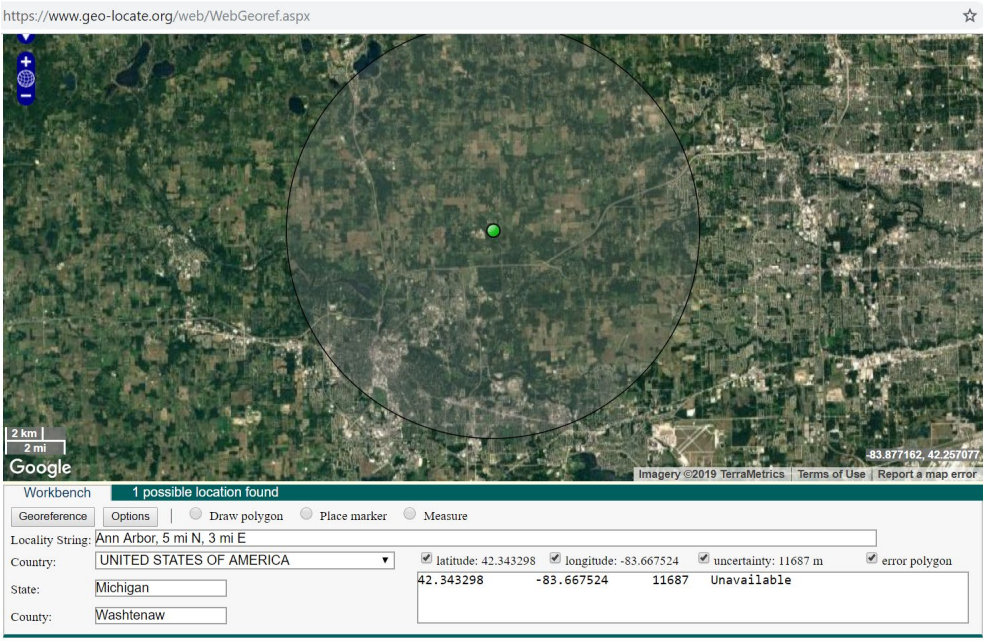
k. **Distance and Direction, Orthogonal Direction or Distance at a Heading**
   i. Use GEOLocate
   ii. EXAMPLE: USA, Michigan, Washtenaw County, Ann Arbor, 5 mi N, 3 mi E: 42.343298, -83.667524, 11687 m uncertainty
   iii. GEOLocate gives identical coordinates and uncertainty is wording is “5 mi N and 3 mi E of Ann Arbor” or “5 mi N and 3 mi E from Ann Arbor” or “Ann Arbor, 5 mi N and 3 mi E”
   iv. Elevation: 275 meters (coordinates entered into Google Earth)

v. Source: GEOLocate; Datum: WGS84; Elevation from Google Earth
vi. Geo Ref Remarks: Lat/Long taken 5 miles N and 3 miles E from geographic center of Ann Arbor. Point radius uncertainty is greatest extent of locale plus error determined with georeferencing calculator via GEOLocate. **GEOLocate includes calculations done with georeferencing calculator including offset distance (5 and 3 miles), location extent (~4.6 miles), measurement error (1.414 = √2) and distance precision (1 mile)
vii. Extent: If uncertainty is not given, use the Georeferencing Calculator with map scale
- Georeferencing Best Practices Guide and MANIS-HerpNet-ORNIS Georeferencing Guidelines
  i. 10.5 mi (fraction is 1/2 , uncertainty should be 0.5 mi)
  ii. 10.6 mi (fraction is 6/10 , uncertainty should be 0.1 mi)
  iii. 10.75 mi (fraction is 3/4 , uncertainty should be 0.25 mi)
  iv. Integer distance of 1 mile (use 0.5 times, uncertainty should be 0.5 mi)
  v. Integer distance 2-9 miles (use 0.5 times, uncertainty should be 1.0 mi)
  vi. Integer powers of ten (10, 20, 300, 4000), use 0.5 times ten to that power (10 mi = 5 mi uncertainty, 140 mi = 5 mi uncertainty, 100 mi = 50 mi uncertainty, 2000 mi = 500 mi uncertainty)
- Location extent will vary depending upon source – give source and reasoning for extent (GEOLocate gives 7235 meters = 4.49624 miles as extent of Ann Arbor; DeLorme software gives 11.4705 miles as extent.
- In Georeferencing Calculator, measurement error is calculated by Pythagorean triangle triple, $a^2 + b^2 = c^2$. From the example (5 mi N and 3 mi E) errors equal, $1^2 + 1^2 = c^2$, where $c^2 = 2$ and $c = \sqrt{2}$ or 1.41421356
- See Georeferencing Calculator examples below with these values

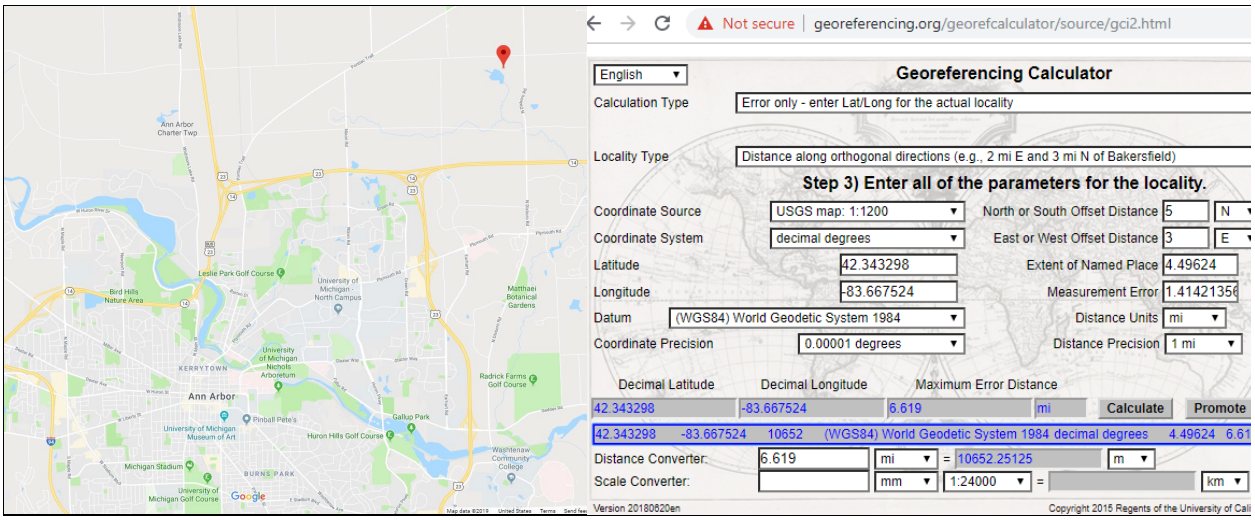
viii. Protocol:
- GEOLocate (Rios and Bart 2010) – Rios, N. E. and H. L. Bart. 2010. GEOLocate (Version 3.22) computer software. Belle Chasse, LA: Tulane University Museum of Natural History. – Georeferencing software for natural history collections. http://www.museum.tulane.edu/geolocate/
- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
- Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.
- MaNIS/HerpNet/ORNIS Georeferencing Guidelines (Wieczorek 2001) – Wieczorek, J. 2001. MaNIS/HerpNet/ORNIS georeferencing guidelines. Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://manisnet.org/docs/GeorefGuide.html.

k. **Distance and Direction, Orthogonal Direction or Distance at a Heading – continued**





Google Maps location of GEOLocate coordinates and Georeferencing Calculator for uncertainty based upon GEOLocate Ann Arbor extent.



l. **Road Distance**

i. Use Google Maps

ii. EXAMPLE: Ann Arbor, 1 mi N on N Main St from JCT with W Liberty St (i.e. 1 road mile on N Main Street from N Main Street and W Liberty Street road junction); zoom-in for best coordinate precision: 42.293919, -83.746946

iii. Search for roads (as indicated for Road Junction above)

iv. Right-click "Measure distance", place a start and stop point

v. Zoom in on map, and left-click cursor on straight-line distance to drag the line to contour roads

vi. Right-click at desired distance and left-click "What"s here?" to get coordinates at desired location

vii. Elevation: 243 meters (coordinates entered into Google Earth)

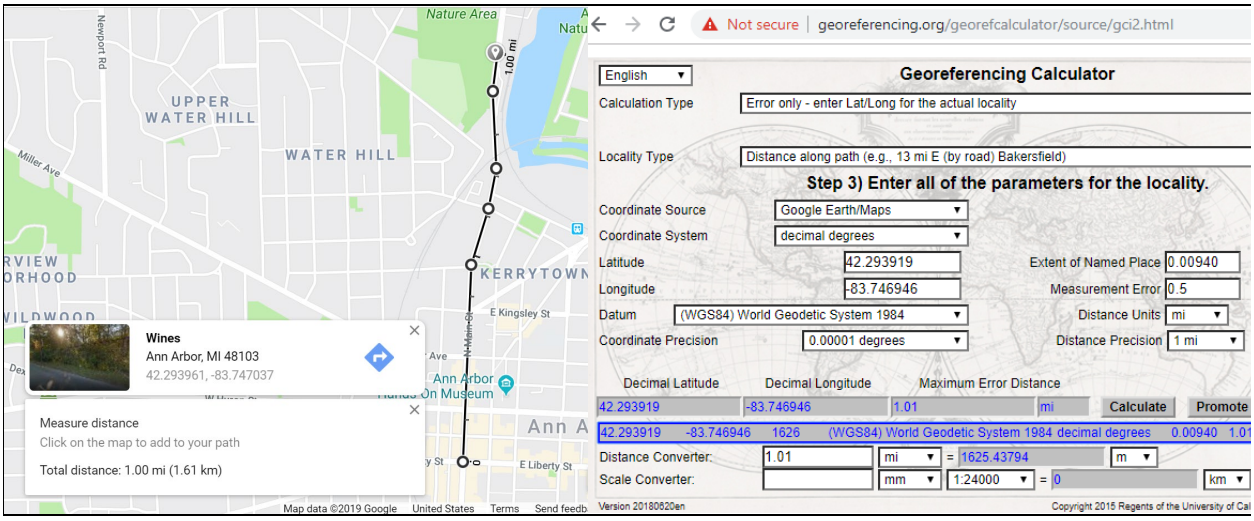
viii. Source: Google Map/Google Earth; Datum: WGS84; Elevation from Google Earth

ix. Max point-radius uncertainty with georeferencing calculator = 1625.43794 meters (with 0.5 mile of measurement error and 1 mile of distance precision)

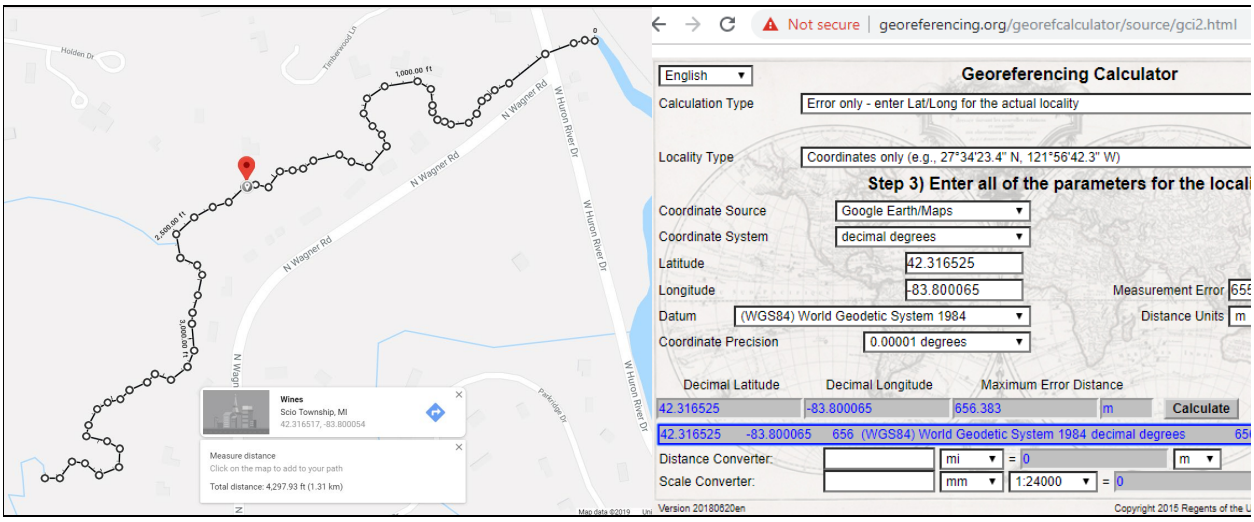
x. Geo Ref Remarks: Lat/Long taken on N Main Street, 1 road mile N from road junction with W Liberty Street in Ann Arbor. Point radius uncertainty is 1.0 mile plus error determined with georeferencing calculator.

xi. Protocol:

- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
- Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].
- Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.



m. **Stream/River/Creek Distance** – same method as road distance above
   i. Use Google Maps
   ii. EXAMPLE: Honey Creek near N Wagner Rd, Ann Arbor, MI: (zoom-in for precision) Search for creek name or other clarifiers in locality information
   iii. Right-click "Measure distance", place a start and stop point; zoom in on map, and left-click cursor on straight-line distance to drag the line to contour roads
   iv. Right-click at desired distance and left-click "What"s here?" to get coordinates at desired location (midpoint of distance): 42.316525, -83.800065 (Google Maps)
   v. Extent: half the stream/river/creek distance = 1.31 km / 2 = 0.655 km or 655 meters
      - NOTE: the more you contour the creek, the further a point-radius uncertainty extends increasing the certainty the "true point" is within the uncertainty circle.
      - Depending upon locality details, a coarse contour of the creek may be enough for the point and the uncertainty.
   vi. Elevation: 259 meters (coordinates entered into Google Earth)
   vii. Source: Google Maps/Google Earth; Datum: WGS84; Elevation from Google Earth
   viii. Max point-radius uncertainty with georeferencing calculator = 656.383 meters
   ix. Geo Ref Remarks: Lat/Long taken at midpoint of Honey Creek near N Wagner Road. Point radius uncertainty is half the creek distance plus error determined with georeferencing calculator.
   x. Protocol:
      - Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
      - Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].
      - Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.



6. EXAMPLES – Odd/Multiple Possibilities; more than one option based upon locality string

a. Two Sets of Direction and Heading Information

i. Use GEOLocate first (use Google Maps and/or Google Earth to check location)

ii. Enter location name, country and state (may need enter each possibility independently) – GEOLocate will give multiple options and point given as the geographic center

iii. EXAMPLE: Kinloss Township, 1 km NW of Langside, 13.5 km NW of Wingham Post Office (within Geography of North America, Canada, Ontario, Bruce)

GEOLocate Workbench

5 possible locations found

lat: 43.97344, lon: -81.433727, pattern: Distance NorthWest of LANGSIDE, error polygon: {4}, uncertainty: 1429 m, precision: High(83)

lat: 43.969133, lon: -81.419128, pattern: Distance NorthWest of WINGHAM, error polygon: {4}, uncertainty: 6631 m, precision: High(82)

lat: 43.999444, lon: -81.456667, pattern: KINLOSS, error polygon: {4}, uncertainty: 301 m, precision: Low(37)

lat: 44.0975, lon: -81.42, pattern: KINLOSS, error polygon: {4}, uncertainty: 301 m, precision: Low(37)

lat: 44.033333, lon: -81.516667, pattern: KINLOSS, error polygon: {4}, uncertainty: 301 m, precision: Low(37)

iv. Decision making:

- As the NW direction is the same, it could be assumed that this was measured on a map where the map scale allowed these to be nearly "identical" for the "true point"; or, the "13.5 km NW of Wingham Post Office" was the general location and the "1 km NW of Langside" is the more specific location.
- Mapping "1 km NW of Langside" or "13.5 km NW of Wingham Post Office" independently gives two points separated by 1.26 k
- Choice 3 and 4 are not near "1 km NW of Langside" or "13.5 km NW of Wingham Post Office"
- The attached image in the database states that the habitat is a "bog". Choice 2, 3, 4, and 5 are on farm land. Google Earth shows the location near a pond area.

v. Elevation: 310 meters (coordinates entered into Google Earth)

xi. Source: GEOLocate; Datum: WGS84; Elevation from Google Earth

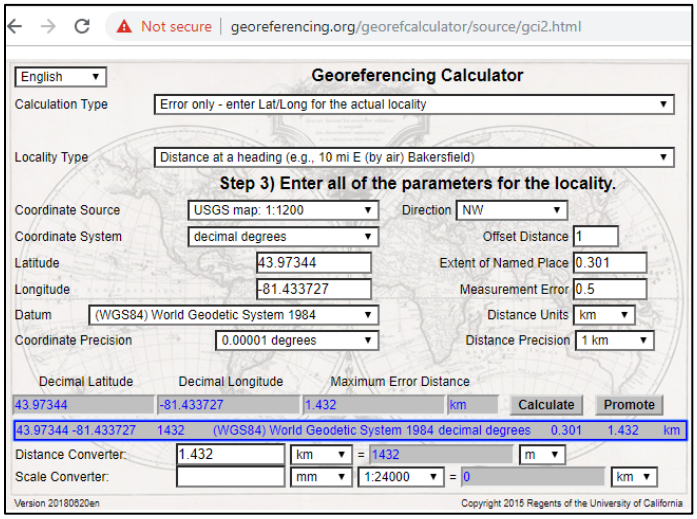
vi. Remarks: It is assumed that "1 km NW of Langside" is a more precise location, and "13.5 km NW of Wingham Post Office" was a more general description. There was no way to only eliminate options for "Kinloss Township" in the locality.

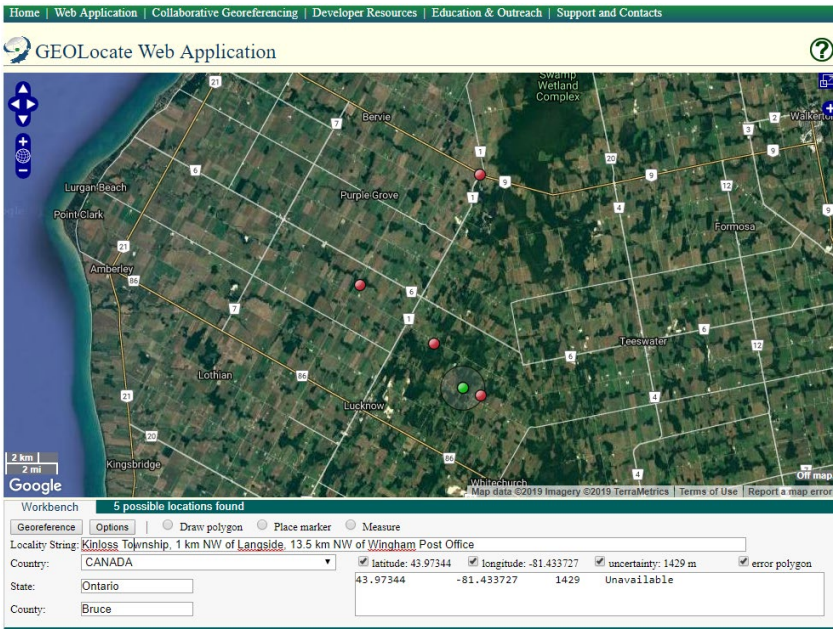
vii. Geo Ref Remarks: Lat/Long taken 1 kilometer NW from locale of Langside. Point radius uncertainty is offset distance and distance precision plus error determined with georeferencing calculator via GEOLocate. (**GEOLocate includes calculations done with georeferencing calculator)

xii. Protocol:

- GEOLocate (Rios and Bart 2010) – Rios, N. E. and H. L. Bart. 2010. GEOLocate (Version 3.22) computer software. Belle Chasse, LA: Tulane University Museum of Natural History. – Georeferencing software for natural history collections. http://www.museum.tulane.edu/geolocate/
- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
- Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.

Below is the uncertainty using GEOLocate"s extent for Langside (301 m)





b. Language Variation in Locality Description

i. Use GEOLocate first (use Google Maps or Google Earth to check location)

ii. Enter location name, country and state (may need enter each possibility independently) – point given as the geographic center

iii. EXAMPLE: **c. 35 km östl. Fortín de las Flores, Mexico, Veracruz**

- Gives 13 options in GEOLocate with top choice (Fortín de las Flores) having low coordinate precision and low uncertainty; **(c. presumably is short for circa (ca.) or about; östl. is short for the German word östlich meaning east or eastern)**
- Changing locality to "**35 km E of Fortín de las Flores**" gives greater coordinate precision and uncertainty (expected with large distance at a heading locality)
- 18.899702, -96.665988, 28555 m uncertainty

iv. Elevation: 325 meters (coordinates entered into Google Earth)

v. Source: GEOLocate; Datum: WGS84; Elevation from Google Earth

vi. Geo Ref Remarks: Lat/Long taken 35 kilometers E from geographic center of Fortín de las Flores. Point radius uncertainty is greatest extent of locale plus error determined with georeferencing calculator via GEOLocate. (**GEOLocate includes calculations done with georeferencing calculator)

vii. Protocol:

- GEOLocate (Rios and Bart 2010) – Rios, N. E. and H. L. Bart. 2010. GEOLocate (Version 3.22) computer software. Belle Chasse, LA: Tulane University Museum of Natural History. – Georeferencing software for natural history collections. http://www.museum.tulane.edu/geolocate/
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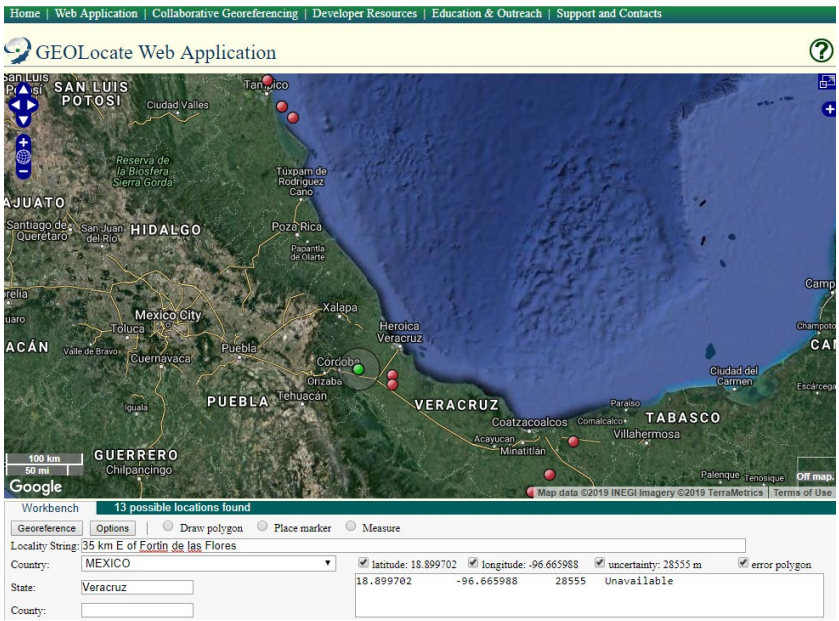
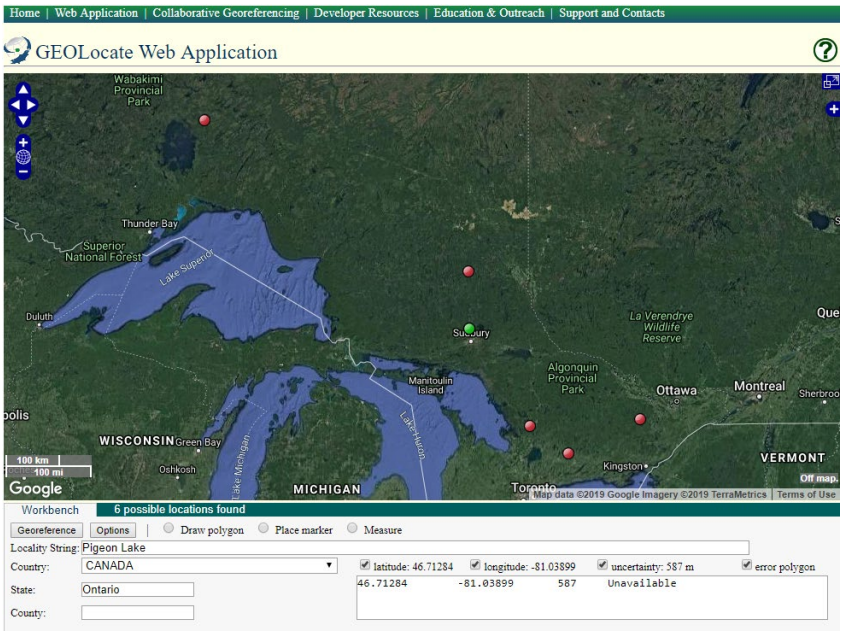
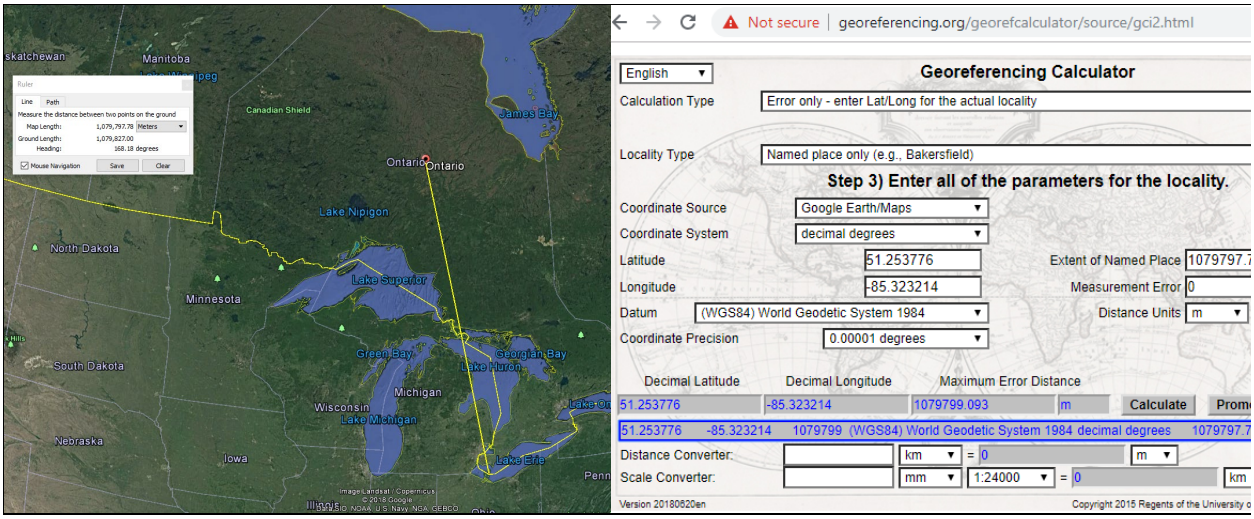


c. Multiple Possibilities with Locality Description

i. Use GEOLocate first (use Google Maps or Google Earth to check location)
ii. Enter location name, country and state (may need enter each possibility independently) – point given as the geographic center
iii. EXAMPLE: Pigeon Lake, Ontario Canada (within Geography of North America, Canada, Ontario, no county indicated): GEOLocate gives 6 options with no way to eliminate any option; the only possible coordinates are the geographic center of Ontario: 51.253776, -85.323214, uncertainty = 1,079,799.093 meters OR DO NOT GEOREFERENCE
iv. Elevation: 297 meters (coordinates entered into Google Earth)
v. Source: Google Maps/Google Earth; Datum: WGS84; Elevation from Google Earth
vi. Remarks: Geographic center given in Google Earth and the greatest extent of Ontario is Pelee Island within Lake Erie, North from Sandusky Ohio
vii. Geo Ref Remarks: Lat/Long taken at geographic center of Ontario Province in Canada. Point radius uncertainty is greatest extent of province plus error determined with georeferencing calculator.
viii. Protocol:
- Georeferencing Quick Reference Guide (Wieczorek et al. 2012) – Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide. Version: 2012-10-08.
- Georeferencing Calculator version 20160929 (Wieczorek and Wieczorek, 2015) – Wieczorek C, J Wieczorek (2015) Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].
- Georeferencing Best Practices (Chapman and Wieczorek 2006) – Chapman, A.D. and J. Wieczorek. 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.



c. Multiple possibilities (Pigeon Lake, Ontario Canada) – continued



d. Odd Locality (Depending upon how you read the description; must include assumptions)

México may be difficult to georeference in GEOLocate, especially with uncertainties

- MICH 1159531 México, Chiapas, Highway 190 at Pichucalco Junction, 11 mi E of Chiapa de Corzo (road junction of Hwy 190 and Hwy 195, approximately 11 road miles NE on Hwy 190 from Chiapa de Corzo)
- MICH 1107685 México, Michoacán, hills of Pátzcuaro ("hills" is non-descriptive part of Pátzcuaro, can only georeference Pátzcuaro with greatest extent of locale)
- MICH 526898 México, Hidalgo, Honey Station (the locale of Honey is in Puebla that borders Hidalgo, no other locale of Honey occurs in or near Hidalgo)
- MICH 1183439 México, Guerrero, Atoyac de Alvarez, Huerta de Pancho Sarabia; Galeana; Atoyac; (Can find road names Galeana, but no other connection; may be best to use geographic center of Atoyac de Alvarez)
- MICH 1494512 México, Chiapas, Rayón, In the Selva Negra 10 km above Rayón Mezcalapa along road to Jitotol. (potential duplicate locality from NYBG https://www.discoverlife.org/IM/I_NY/6116/640/Alfaroa_mexicana,I_NY611685.jpg and Smithsonian https://www.si.edu/collection/search?edan_q=*:*&edan_fq[]=p.edanmdm.indexedstructured.name:%22Keller%2C+B.+T.%22)

Philippines

- MICH 1107254 Mindanao Island, Cabadbaran (Mt. Urdaneta); Asia, Philippines, Agusan Del Norte, Agusan (Mt. Urdaneta is now known as Mount Masay)
- MICH 1196598 Lanao del Norte, Barrio Balut ("Barrio" is a Spanish word for quarter or neighborhood; used in the Philippines officially to denote division of a municipality)
- MICH 1190963 Butuan subprovince (Butuan City was the capital of the province of Agusan del Norte until 2000, when Republic Act 8811 transferred the capital to Cabadbaran City. For statistical and geographical purposes, Butuan City is grouped with Agusan del Norte but governed administratively

independent from the province while legislatively administered by the province"s 1st congressional district.

- MICH 1190741 Palao Amopo (the "Sacred Hill"), northeastwardly across the Iligan River from Camp Keithley, Lanao Province (Iligan River is not named on a map, but is considered part of the Agus River, N from Baloi Lake; Camp Keithley, Lanao, Philippines is found in Google Search with coordinates of 8.00833, 124.28361; by given information, it is assumed locale is Sacred Mountain National Park in Marawi City, Lanao del Sur in the Philippines)
- MICH 1287003 Mt. Banahaw; Mt. Mabaybay (location should be done with Mount Banahaw; Mt. Mabaybay may refer to the mountain near the town Majayjay, but there is no way to connect it to "Mabaybay")
- MICH 1111539 Palawan, Puerto Princesa, Mt. Pulgar (Thumb Peak: The mountain was formerly known as Mount Pulgar, a name it acquired during the Spanish Colonial period. Pulgar, means thumb in Spanish)

Indonesia

- UMMZ Birds 114154 Indonesia, Irian Barat, Dojobaroe (This place is known by different names: Dojobaru, Dojobaroe, Ebeli Plantation, Doyobaru or Doyo Baru.
- UMMZ Birds 65061 Indonesia, Java Island, Buitenzorg (Bogor is the name inSundanese; Buitenzorg is the name in Dutch)
- UMMZ Birds 24237 Indonesia, Moluccas, Ternate (May need to search Malukas, Maluka Islands or Moluccas)
- UMMZ Birds 158345 Asia, Indonesia, Borneo, Sabah Reg., Tawau Residency, Cocoa Research Station, Quoin Hill (A "Quoin Hill" is found NE from Tawau in Malaysia; Malaysia officially became a independent nation after the collection date)
- UMMZ Birds 158303 Asia, Indonesia, Borneo, Sabah Reg., Tawau Residency, Kalabakan, 12 Mi N (Kalabakan is located in Malaysia – collection date predates official separation of Malaysia)
- UMMZ Fish 171809 Java; Vicinity of Batavia [Pasan Ikan (fish market) at Batavia]; Indonesia (Jakarta was known as Batavia when it was the capital of the Dutch East Indies; original Pasan Ikan fish market no longer present; may be in vicinity as new Pasar Ikan Modern Muara Baru)
- UMMZ Fish 243700 Sungai Merdak in the vicinity of Sukajaya; Indonesia, Sumatra, Sumatera Selatan (2 locations of Sukajaya: Sukajaya, Sukarami, Palembang City, South Sumatra, Indonesia and Sukajaya, Bayung Lencir, Musi Banyuasin Regency, South Sumatra, Indonesia;

7. Darwin Core Standards (https://dwc.tdwg.org/terms/)

continent

Identifier	http://rs.tdwg.org/dwc/terms/continent
Definition	The name of the continent in which the Location occurs.
Comments	Recommended best practice is to use a controlled vocabulary such as the Getty Thesaurus of Geographic Names. (http://www.getty.edu/vow/TGNHierarchy?find=Philippines&place=&nation=&english=Y&subjectid=7029392)
Examples	Africa, Antarctica, Asia, Europe, North America, Oceania, South America

country

Identifier	http://rs.tdwg.org/dwc/terms/country
Definition	The name of the country or major administrative unit in which the Location occurs.
Comments	Recommended best practice is to use a controlled vocabulary such as the Getty Thesaurus of Geographic Names.
Examples	Denmark, Colombia, España

stateProvince

Identifier	http://rs.tdwg.org/dwc/terms/stateProvince
Definition	The name of the next smaller administrative region than country (state, province, canton, department, region, etc.) in which the Location occurs.
Comments	Recommended best practice is to use a controlled vocabulary such as the Getty Thesaurus of Geographic Names.
Examples	Montana, Minas Gerais, Córdoba

county

Identifier	http://rs.tdwg.org/dwc/terms/county
Definition	The full, unabbreviated name of the next smaller administrative region than stateProvince (county, shire, department, etc.) in which the Location occurs.
Comments	Recommended best practice is to use a controlled vocabulary such as the Getty Thesaurus of Geographic Names.
Examples	Missoula, Los Lagos, Mataró

locality

Identifier	http://rs.tdwg.org/dwc/terms/locality
Definition	The specific description of the place. Less specific geographic information can be provided in other geographic terms (higherGeography, continent, country, stateProvince, county, municipality, waterBody, island, islandGroup). This term may contain information modified from the original to correct perceived errors or standardize the description.
Comments	
Examples	Bariloche, 25 km NNE via Ruta Nacional 40 (=Ruta 237).

verbatimLocality

Identifier	http://rs.tdwg.org/dwc/terms/verbatimLocality
Definition	The original textual description of the place.
Comments	
Examples	25 km NNE Bariloche por R. Nac. 237

locationRemarks

Identifier	http://rs.tdwg.org/dwc/terms/locationRemarks
Definition	Comments or notes about the Location.
Comments	
Examples	under water since 2005

7. Darwin Core Standards (https://dwc.tdwg.org/terms/) - continued

decimalLatitude

Identifier	http://rs.tdwg.org/dwc/terms/decimalLatitude
Definition	The geographic latitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic center of a Location. Positive values are north of the Equator, negative values are south of it. Legal values lie between -90 and 90, inclusive.
Comments	
Examples	-41.0983423

decimalLongitude

Identifier	http://rs.tdwg.org/dwc/terms/decimalLongitude
Definition	The geographic longitude (in decimal degrees, using the spatial reference system given in geodeticDatum) of the geographic center of a Location. Positive values are east of the Greenwich Meridian, negative values are west of it. Legal values lie between -180 and 180, inclusive.
Comments	
Examples	-121.1761111

geodeticDatum

Identifier	http://rs.tdwg.org/dwc/terms/geodeticDatum
Definition	The ellipsoid, geodetic datum, or spatial reference system (SRS) upon which the geographic coordinates given in decimalLatitude and decimalLongitude as based.
Comments	Recommended best practice is to use the EPSG code of the SRS, if known. Otherwise use a controlled vocabulary for the name or code of the geodetic datum, if known. Otherwise use a controlled vocabulary for the name or code of the ellipsoid, if known. If none of these is known, use the value unknown.
Examples	EPSG:4326, WGS84, NAD27, Campo Inchauspe, European 1950, Clarke 1866, unknown

minimumElevationInMeters

Identifier	http://rs.tdwg.org/dwc/terms/minimumElevationInMeters
Definition	The lower limit of the range of elevation (altitude, usually above sea level), in meters.
Comments	
Examples	-100, 802

maximumElevationInMeters

Identifier	http://rs.tdwg.org/dwc/terms/maximumElevationInMeters
Definition	The upper limit of the range of elevation (altitude, usually above sea level), in meters.
Comments	
Examples	-205, 1236

coordinateUncertaintyInMeters (point radius uncertainty in meters)

Identifier	http://rs.tdwg.org/dwc/terms/coordinateUncertaintyInMeters
Definition	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.
Comments	

7. Darwin Core Standards (https://dwc.tdwg.org/terms/) - continued

Examples 30 (reasonable lower limit of a GPS reading under good conditions if the actual precision was not recorded at the time). 71 (uncertainty for a UTM coordinate having 100 meter precision and a known spatial reference system).

pointRadiusSpatialFit (source below gives details for point radius uncertainty)

Identifier http://rs.tdwg.org/dwc/terms/pointRadiusSpatialFit

Definition The ratio of the area of the point-radius (decimalLatitude, decimalLongitude, coordinateUncertaintyInMeters) to the area of the true (original, or most specific) spatial representation of the Location. Legal values are 0, greater than or equal to 1, or undefined. A value of 1 is an exact match or 100% overlap. A value of 0 should be used if the given point-radius does not completely contain the original representation. The pointRadiusSpatialFit is undefined (and should be left blank) if the original representation is a point without uncertainty and the given georeference is not that same point (without uncertainty). If both the original and the given georeference are the same point, the pointRadiusSpatialFit is 1.

Comments Detailed explanations with graphical examples can be found in the Guide to Best Practices for Georeferencing, Chapman and Wieczorek, eds. 2006.

Examples Detailed explanations with graphical examples can be found in the Guide to Best Practices for Georeferencing, Chapman and Wieczorek, eds. 2006.

footprintWKT (error polygon)

Identifier http://rs.tdwg.org/dwc/terms/footprintWKT

Definition A Well-Known Text (WKT) representation of the shape (footprint, geometry) that defines the Location. A Location may have both a point-radius representation (see decimalLatitude) and a footprint representation, and they may differ from each other.

Comments

Examples POLYGON ((10 20, 11 20, 11 21, 10 21, 10 20)) (the one-degree bounding box with opposite corners at longitude=10, latitude=20 and longitude=11, latitude=21)

georeferencedBy

Identifier http://rs.tdwg.org/dwc/terms/georeferencedBy

Definition A list (concatenated and separated) of names of people, groups, or organizations who determined the georeference (spatial representation) for the Location.

Comments Recommended best practice is to separate the values in a list with space vertical bar space (|).

Examples Brad Millen (ROM), Kristina Yamamoto | Janet Fang

georeferencedDate

Identifier http://rs.tdwg.org/dwc/terms/georeferencedDate

Definition The date on which the Location was georeferenced.

Comments Recommended best practice is to use a date that conforms to ISO 8601:2004(E).

Examples 1963-03-08T14:07-0600 (8 Mar 1963 at 2:07pm in the time zone six hours earlier than UTC). 2009-02-20T08:40Z (20 February 2009 8:40am UTC). 2018-08-29T15:19 (3:19pm local time on 29 August 2018). 1809-02-12 (some time during 12 February 1809). 1906-06 (some time in June 1906). 1971 (some time in the year 1971). 2007-

7. Darwin Core Standards (https://dwc.tdwg.org/terms/) - continued

	03-01T13:00:00Z/2008-05-11T15:30:00Z (some time during the interval between 1 March 2007 1pm UTC and 11 May 2008 3:30pm UTC). 1900/1909 (some time during the interval between the beginning of the year 1900 and the end of the year 1909). 2007-11-13/15 (some time in the interval between 13 November 2007 and 15 November 2007).
georeferenceProtocol	
Identifier	http://rs.tdwg.org/dwc/terms/georeferenceProtocol
Definition	A description or reference to the methods used to determine the spatial footprint, coordinates, and uncertainties.
Comments	
Examples	Guide to Best Practices for Georeferencing. (Chapman and Wieczorek, eds. 2006). Global Biodiversity Information Facility., MaNIS/HerpNet/ORNIS Georeferencing Guidelines, Georeferencing Quick Reference Guide
georeferenceSources	
Identifier	http://rs.tdwg.org/dwc/terms/georeferenceSources
Definition	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.
Comments	Recommended best practice is to separate the values in a list with space vertical bar space (|).
Examples	https://www.geonames.org/, USGS 1:24000 Florence Montana Quad | Terrametrics 2008 on Google Earth, GeoLocate
georeferenceRemarks	
Identifier	http://rs.tdwg.org/dwc/terms/georeferenceRemarks
Definition	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.
Comments	
Examples	Assumed distance by road (Hwy. 101).

8. Select Sources for Additional Information

MaNIS/HerpNET/ORNIS Georeferencing Guidelines (18pp)

- Complete pdf available; Brief set of slides available: https://slideplayer.com/slide/1407016/

Wieczorek, J., D. Bloom, H. Constable, J. Fang, M. Koo, C. Spencer and K. Yamamoto. 2012. Georeferencing quick reference guide Version: 2012-10-08. 10 pp.
http://www.herpnet.org/herpnet/documents/GeoreferencingQuickGuide.pdf

Chapman, A. D. and J. Wieczorek (eds). 2006. Guide to best practices for georeferencing. Copenhagen: Global Biodiversity Information Facility. 90 pp.
http://herpnet.org/herpnet/documents/biogeomancerguide.pdf

Wieczorek, C. and J. Wieczorek. 2015. Georeferencing Calculator (version 20160929). Museum of Vertebrate Zoology, University of California, Berkeley. Available: http://georeferencing.org/georefcalculator/source/gci2.html. Accessed [yyyy-mm-dd].
https://www.gbif.org/en/tool/81315/georeferencing-calculator
User Manual: https://code.google.com/archive/p/georef-calculator/wikis/UserManual.wiki

Wieczoek, J., Q. Guo and R. J. Hijmans. 2004. The point-radius method for georeferncing locality descriptions and calculating associated uncertainty. International Journal of Geographical Information Science 18(8): 745-767.
https://www.tandfonline.com/doi/pdf/10.1080/13658810412331280211

Constable, H., R. Guralnick, J. Wieczorek, C. Spencer, A. T. Peterson and The VertNet Steering Committee. 2010. VertNet: a new model for biodiversity data sharing. PLoS Biol 8(2): e1000309.
https://doi.org/10.1371/journal.pbio.1000309

Guralnick, R. P., J. Wieczorek, R. Beaman, R. J. Hijmans and the BioGeomancer Working Group. 2006. BioGeomancer: automated georeferencing to map the world"s biodiversity data. PLoS Biol 4(11): e381.
https://doi.org/10.1371/journal.pbio.0040381

Hill, A. W., R. Guralnick, P. Flemons, R. Beaman, J. Wieczorek, A. Ranipeta, V. Chavan and D. Remsen. 2009. Location, location, location: utilizing pipelines and services to more effectively georeference the world"s biodiversity data. BMC biodiversity 10(14): S3.
https://bmcbioinformatics.biomedcentral.com/articles/10.1186/1471-2105-10-S14-S3

Doherty, P., Q. Guo, Y. Liu, J. Wieczorek and J. Doke. 2011. Georeferencing incidents from locality descriptions and its applications: a case study from Yosemite National Park search and rescue. Transactions in GIS 15(6): 775-793.
https://onlinelibrary.wiley.com/doi/full/10.1111/j.1467-9671.2011.01290.x

Murphey, P. C., R. P. Guralnick, R. Glaubitz, D. Neufeld and J. A. Ryan. 2004. Georeferencing of museum collections: A review of problems and automated tools, and the methodology developed by the Mountain and Plains Spatio-Temporal Database-Informatics Initiative (Mapstedi). Phyloinformatics 1(3): 1-29.
https://www.paleosolutions.com/publications/Georeferencing_of_Museum_Collections.pdf

McEachern, K. and K. Niessen. 2009. Uncertainty in georeferencing current and historic plant locations. Ecological Restoration 27(2): 152-159.
http://er.uwpress.org/content/27/2/152.full.pdf+html

Wieczorek, J., M. Döring, R. De Giovanni, T. Robertson and D. Vieglais. 2009. Darwin Core terms: a quick reference guide. http://rs.tdwg.org/dwc/terms [accessed 2016-05-30]