Georeferencing Paleontology Collections

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What is a georeference?

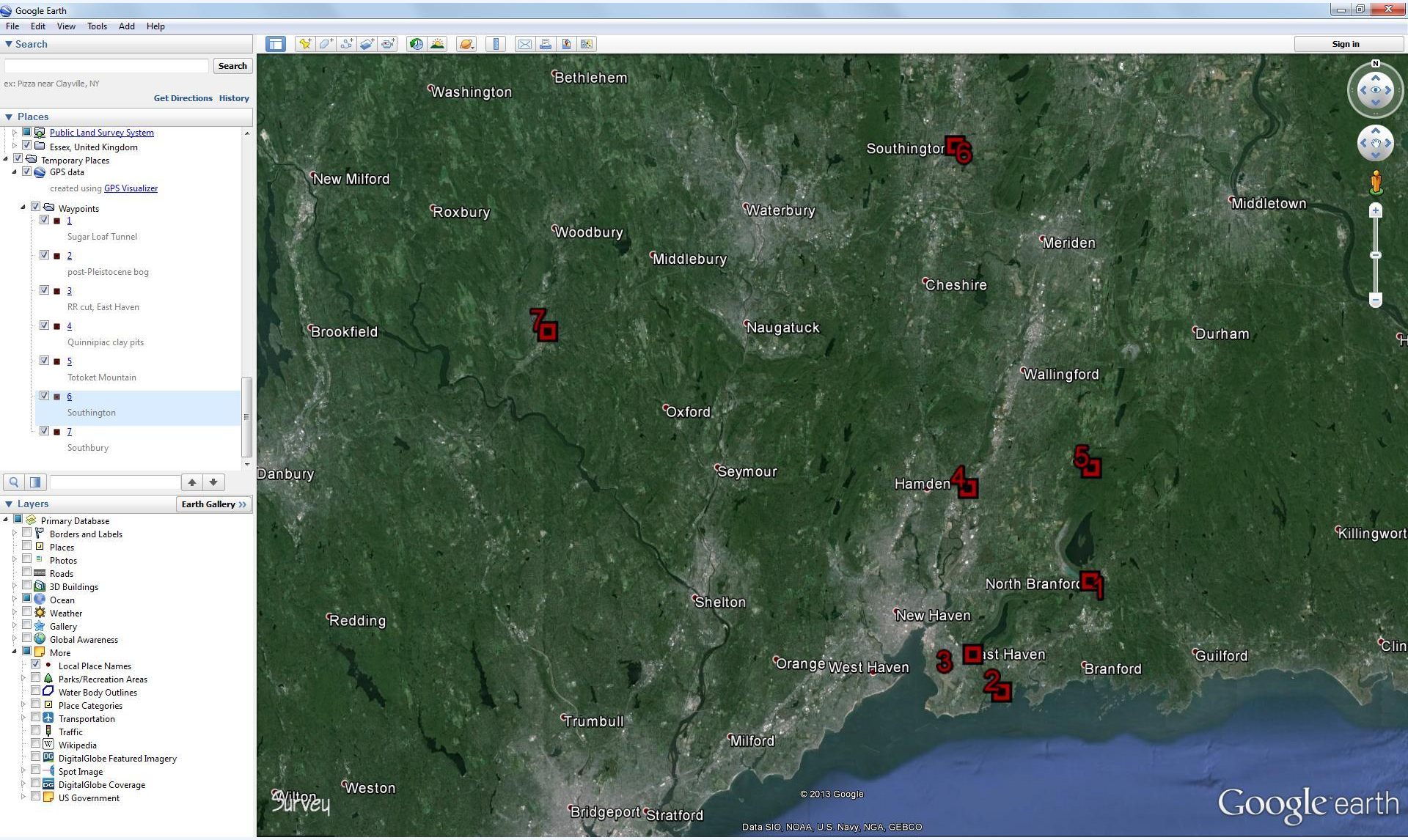
What is a georeference?

A numerical description of a place that can be mapped.

What we have: locality descriptions

ID	Taxon	Locality description	Stratigraphy
1	*Anchisauripus hitchcocki*	232 ft in from west portal, Sugar Loaf Tunnel. North Branford, CT.	Triassic. "Posterior shales."
2	*Littorina palliata*	6-8 ft below surface of post-Pleistocene bog, 0.25 mi S10E of intersection of Shore Dr. & Killams Point Rd. Branford, CT.	Quaternary. Holocene.
3	*Clathropteris meniscoides*	NH RR cut, East Haven, CT.	Late Triassic. Newark Supergroup. Shuttle Meadow Fm.
4	*Rangifer tarandus*	11 ft below surface, Quinnipiac clay pits. North Haven, CT.	Quaternary. Pleistocene.
5	*Diplurus longicaudatus*	W slope of Totoket Mountain, south part of Durham, CT.	Newark Supergroup.
6	*Fucusopsis angulatus*	Southington, CT.	Triassic.
7	*Pomperaugoxylon connecticutense*	David Blersch farm, on N slope of Horse Fence Hill. Southbury, CT.	Late Triassic. Newark Supergroup. South Britain Fm. Pierce Hollow Mbr.

What we want: localities we can map



Why georeference?

- Correct geographic and specimen identification data = dependable **occurrence data**
- Occurrence data validates the importance of paleontological and biological collections
  - Distribution of populations and species ranges
  - Phylogeography
  - Niche modelling
  - Conservation planning and biodiversity management
- Provides uncertainty data, which allows data to be evaluated with regards to its **fitness for research** application and resulting quality of output.

The scale of the georeferencing problem for natural history collections…

~2.5×10^9 records

~6 records per locality*

~14 localities georeferenced per hour*

~15,500 years

* based on the MaNIS Project

Darwin Core Location Terms

- higherGeography
- waterbody, island, islandGroup
- continent, country, countryCode, stateProvince, county, municipality
- locality
- minimumElevationInMeters, maximumElevationInMeters, minimumDepthInMeters, maximumDepthInMeters

Darwin Core Georeference Terms

- decimalLatitude, decimalLongitude
- geodeticDatum
- coordinateUncertaintyInMeters
- georeferencedBy, georeferenceProtocol
- georeferenceSources
- georeferenceVerificationStatus
- georeferenceRemarks
- coordinatePrecision
- pointRadiusSpatialFit
- footprintWKT, footprintSRS, footprintSpatialFit

What is a georeference?

A numerical description of a place that can be mapped.

Location:
New Haven,
Connecticut

Coordinates:
41.30861, -72.92468
(NAD27)

Method: Point

What is a *acceptable* georeference?

A numerical description of a place that can be mapped,

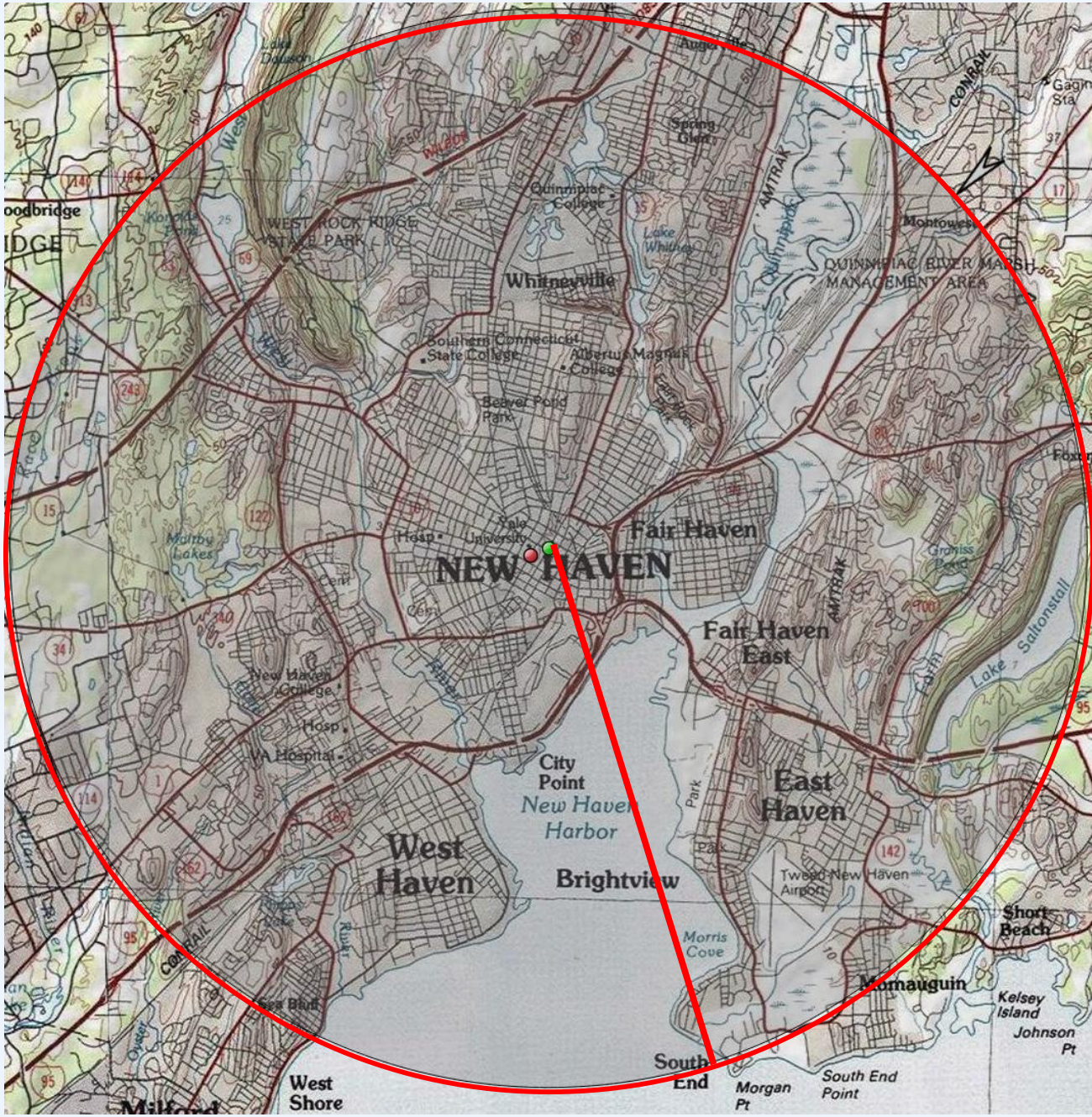
*and that describes the **spatial extent** of a locality and its **associated uncertainty**.*

Location:
New Haven,
Connecticut

Coordinates:
41.30861, -72.92468
(NAD27)

Uncertainty: 7642m

Method: Point-radius



What is an *ideal* georeference?

A numerical description of a place that can be mapped,

and that describes the spatial extent of a locality and its associated uncertainty

as well as possible.

Location:
New Haven,
Connecticut

Coordinates:
41.30861, -72.92468
(NAD27)

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Protocol: MaNIS/HerpNET/ORNIS (MHO) Guidelines
GBIF Best Practices

- Uses **point-radius** representation of georeferences
- Circle encompasses **all sources of uncertainty** about the location
- Formalizes assumptions, algorithms, and documentation standards that promote **reproducible** results
- Methods are **universally applicable**

GEOREFERENCING QUICK REFERENCE GUIDE

Version: 2012-10-02

John Wieczorek, David Bloom, Heather Constable, Janet Fang, Michelle Koo, Carol Spencer, Kristina Yamamoto

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].

https://www.idigbio.org/wiki/images/1/1e/GeoreferencingQuickReferenceGuide.pdf

Locality Types

Named Place: Towns, farms, quarries, street address, junctions, rivers…

Offset from a named place: Distance along a path (e.g. along a highway), distance at a heading (e.g. miles N), orthogonal offset (e.g. miles N and E)

Coordinates: GPS, verbatim lat-long, grid system

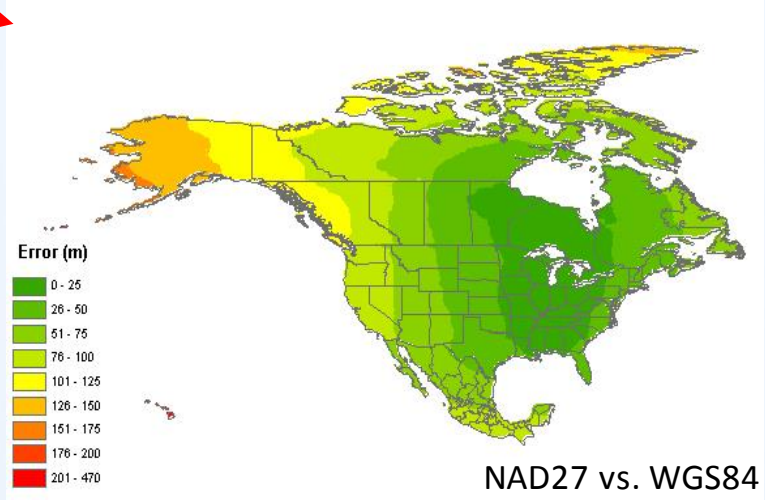
Problems/More than one possibility

Sources of Uncertainty

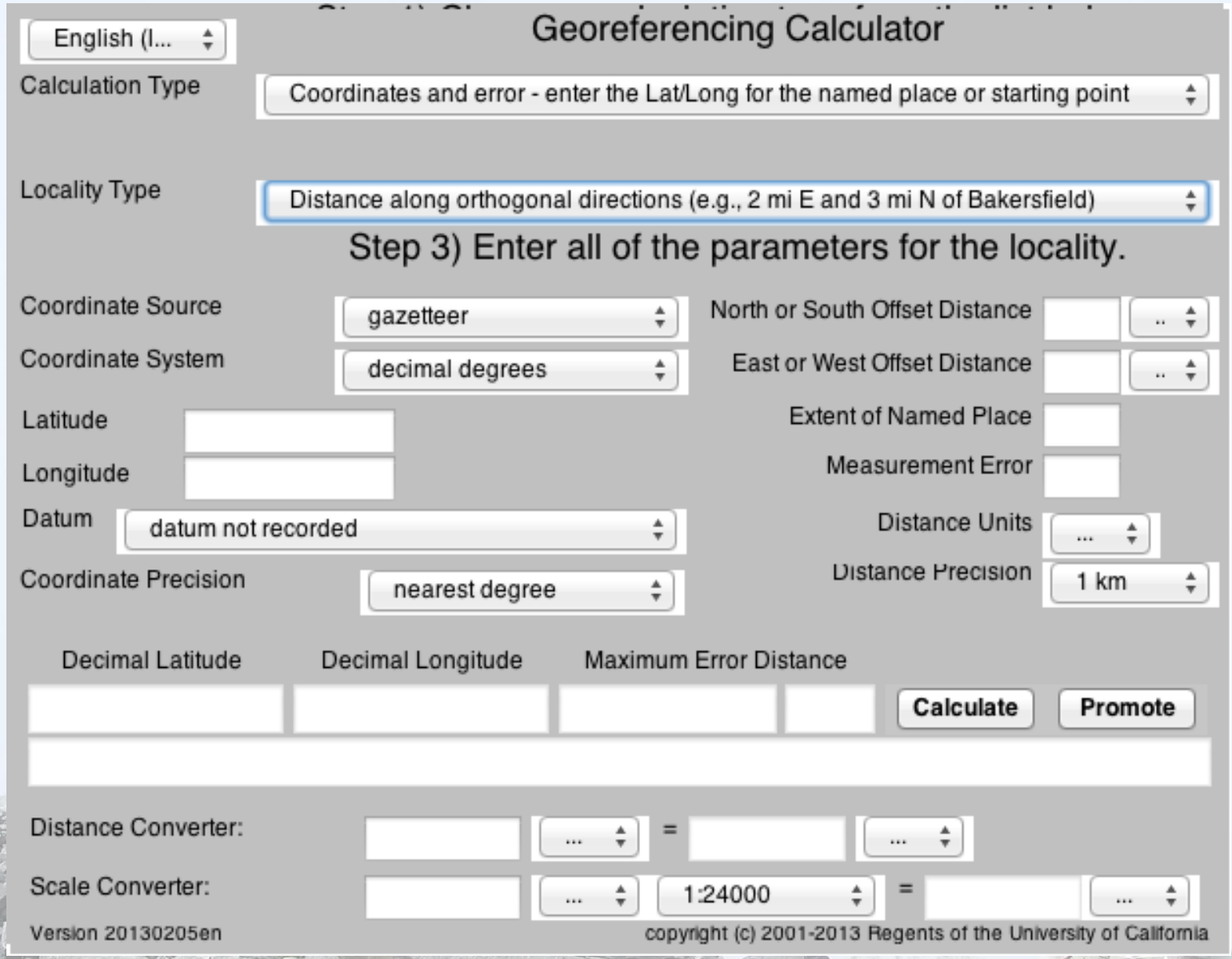
20° 30’ N 112° 36’ W

- Coordinate uncertainty
- Map Scale
- The extent of the locality
- GPS accuracy
- Unknown datum
- Imprecision in direction measurements (N vs. NNE)
- Imprecision in distance measurements (1km vs. 1.1km)

Scale	Uncertainty (ft)	Uncertainty (m)
1:1,200	3.3 ft	1.0 m
1:2,400	6.7 ft	2.0 m
1:4,800	13.3 ft	4.1 m
1:10,000	27.8 ft	8.5 m
1:12,000	33.3 ft	10.2 m
1:24,000	40.0 ft	12.2 m
1:25,000	41.8 ft	12.8 m
1:63,360	106 ft	32.2 m
1:100,000	167 ft	50.9 m
1:250,000	417 ft	127 m



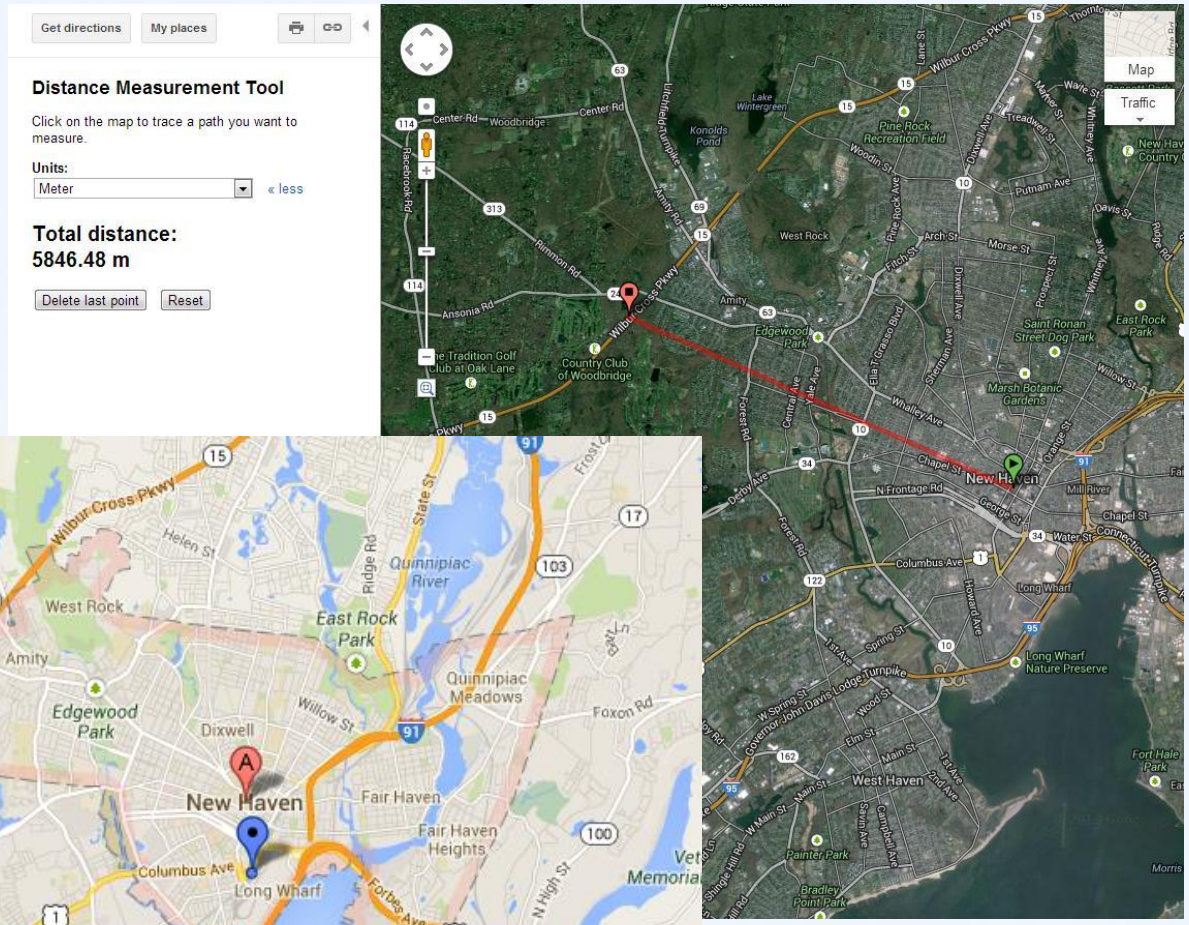
NAD27 vs. WGS84



http://manisnet.org/gci2.html

Google maps

- Measuring tools, lat-long markers in **Map Labs**
- Satellite vs. map view - old quarries may be visible
- Good for mapping addresses
- Polygons for determining extent



Google Earth

Measuring tools

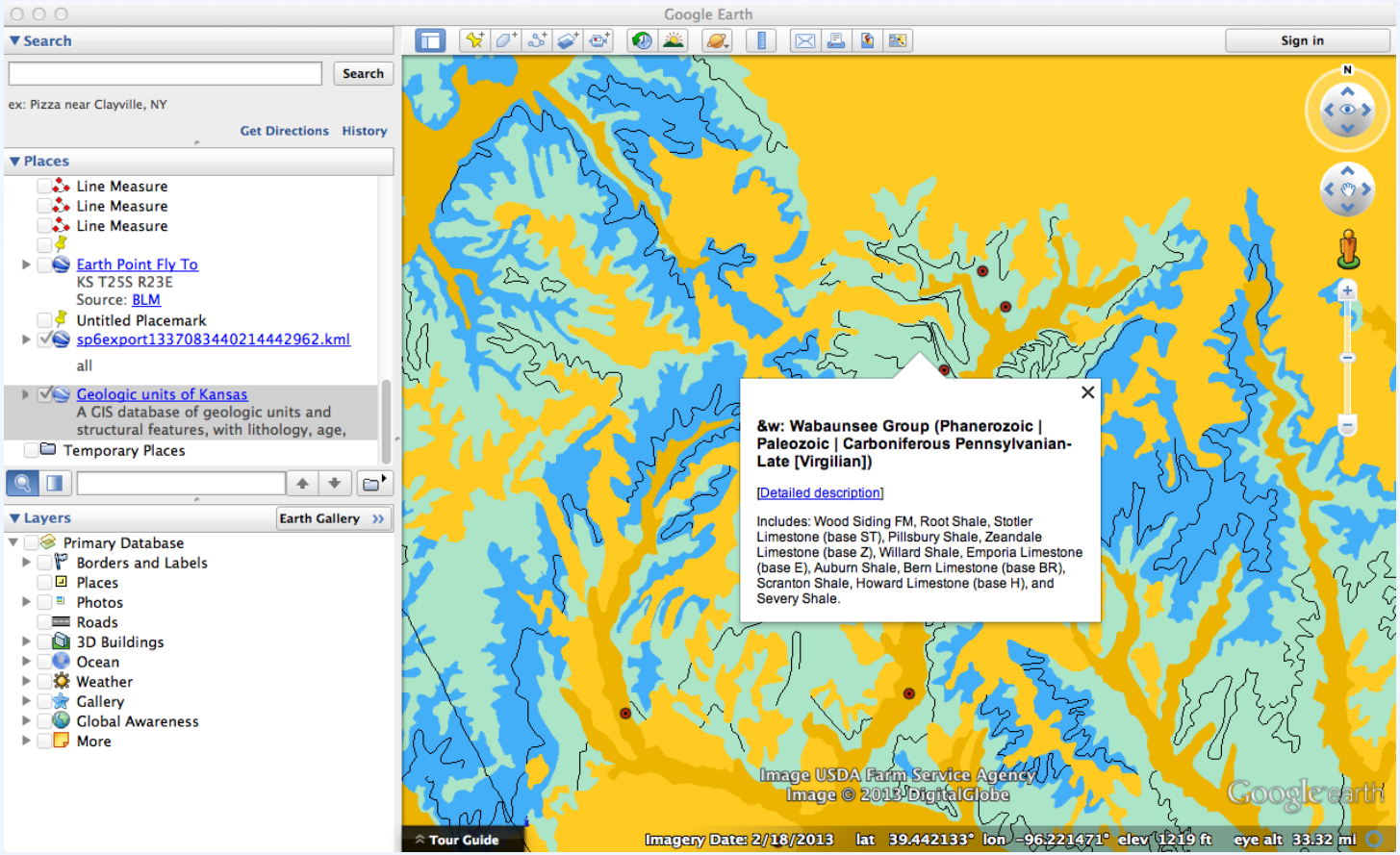
Outcrops,
roadcuts, quarries

Google Earth

Measuring tools

Outcrops, roadcuts, quarries

Geology
http://mrdata.usgs.gov/geology/state/



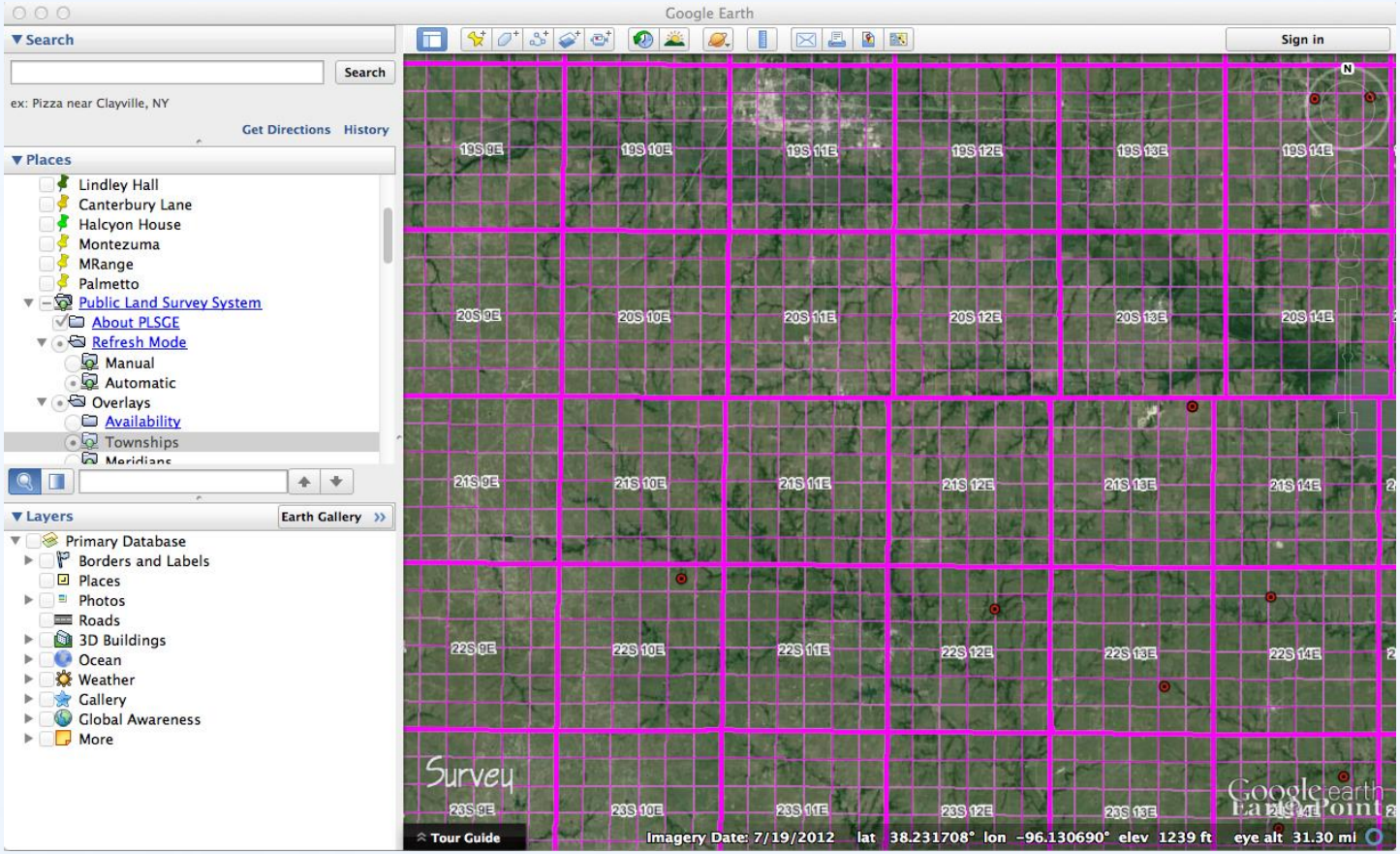
Google Earth

Measuring tools

Outcrops, roadcuts, quarries

Geology
http://mrdata.usgs.gov/geology/state/

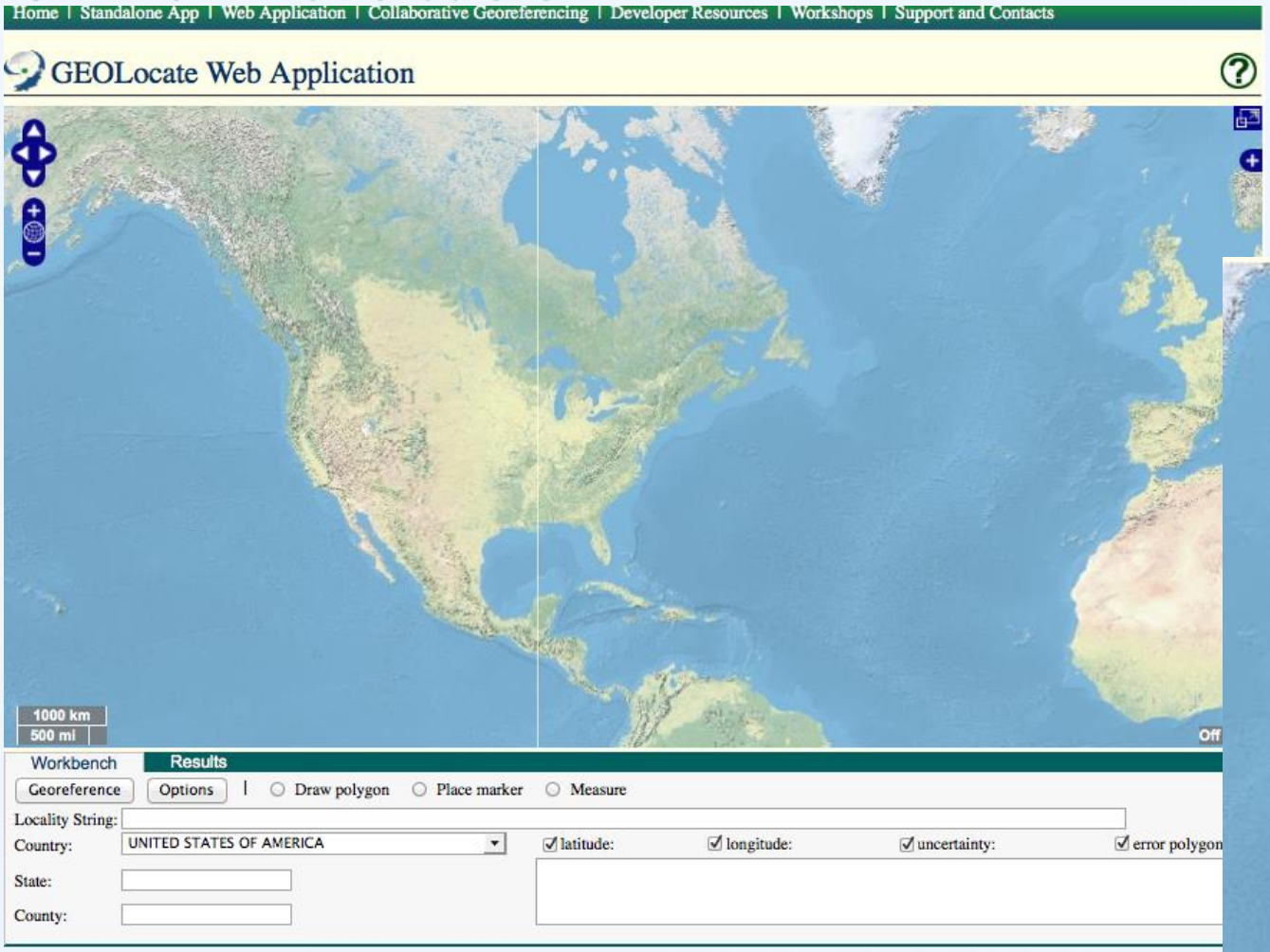
Township-Range-Section
http://www.metzgerwillard.us/plss/plss.html



GEOLocate

automated georeferencing

uncertainty determination



geographic visualization

interoperability

kml export

batch processing

multi-lingual

collaborative georeferencing

verification & correction

Typical GEOLocate Workflow

1. **Data Entry & Preparation**

   pushepatapa creek, trib. to pearl river, 7.8 miles north of bogalusa at hwy 21; Washington; LA; USA

2. **Automated Processing**

   Georeferencing Algorithm

3. **Manual Verification**

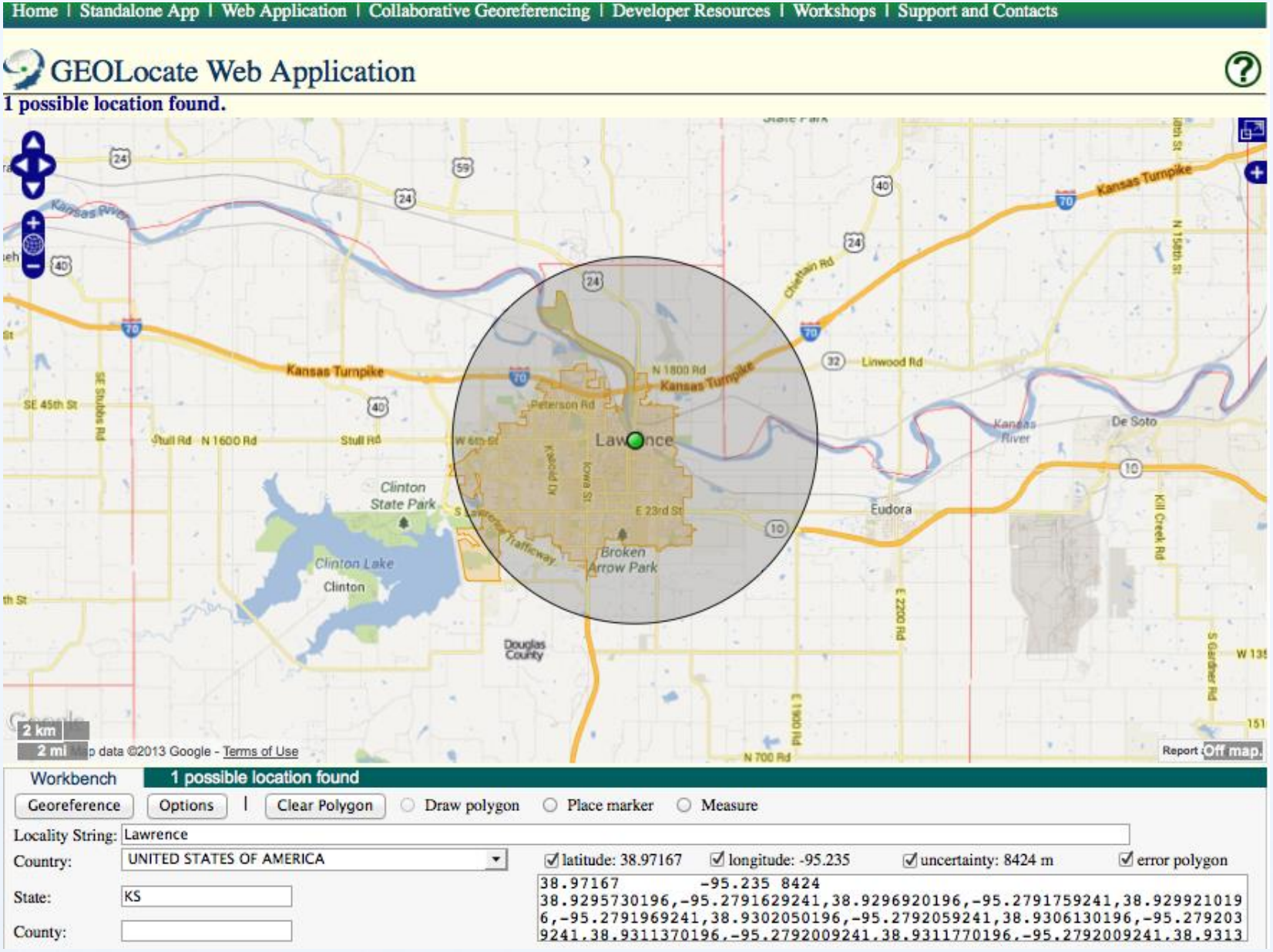
   Visualize, verify & adjust output coordinates & uncertainties

latitude: **30.88797**
longitude: **-89.83601**
uncertainty radius: **48m**
uncertainty polygon:
30.88823,-89.83641,
30.88815,-89.83634,
30.88808,-89.83622…

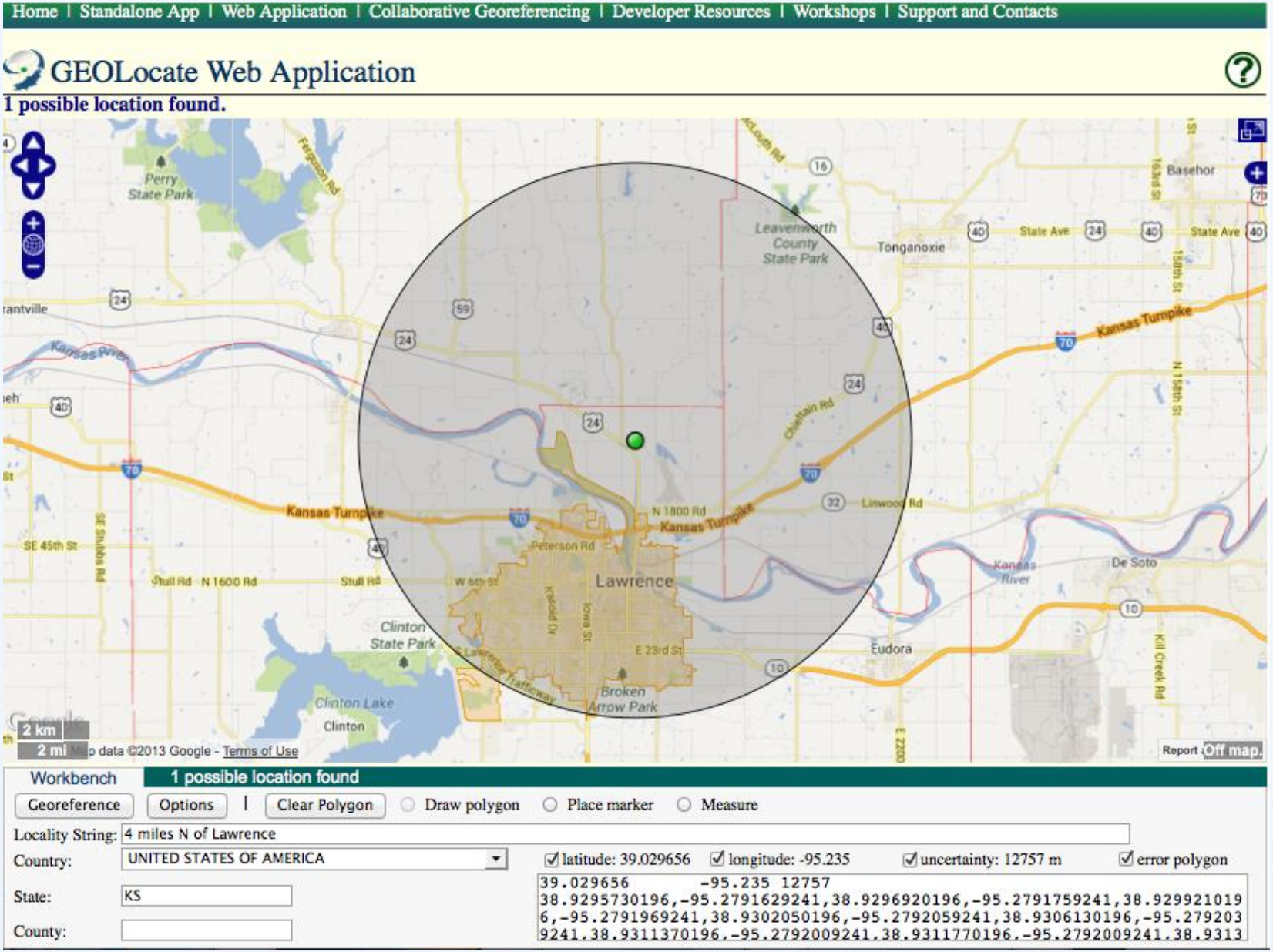
Visualization: Base Layers

Google bing NOAA ESRI

Lawrence, Kansas



4 miles N of Lawrence, Kansas

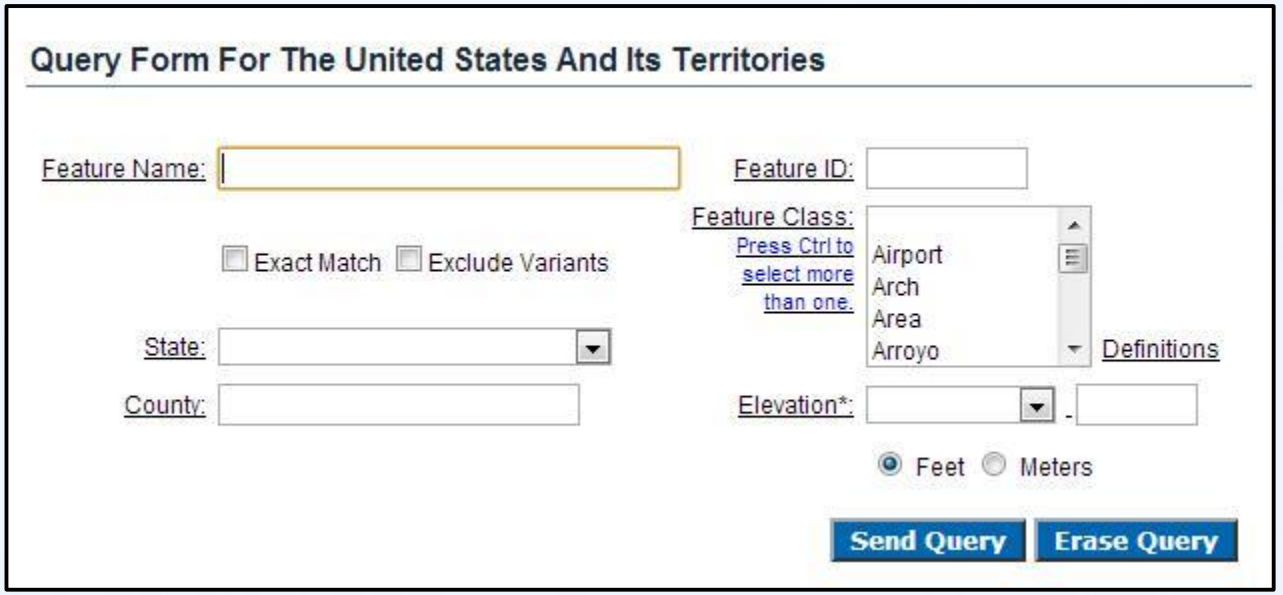


Common problems faced by paleo collections:

- Old towns which no longer exist.
- Railroad cuts which have belonged to seven different railroad companies over the years.
- Quarries which have changed names or closed.
- Localities based on “Mr. Smith’s” farm or other locally familiar terms (locally familiar at the time of collection and often not on published maps).

GNIS - USGS Geographic Names Information System

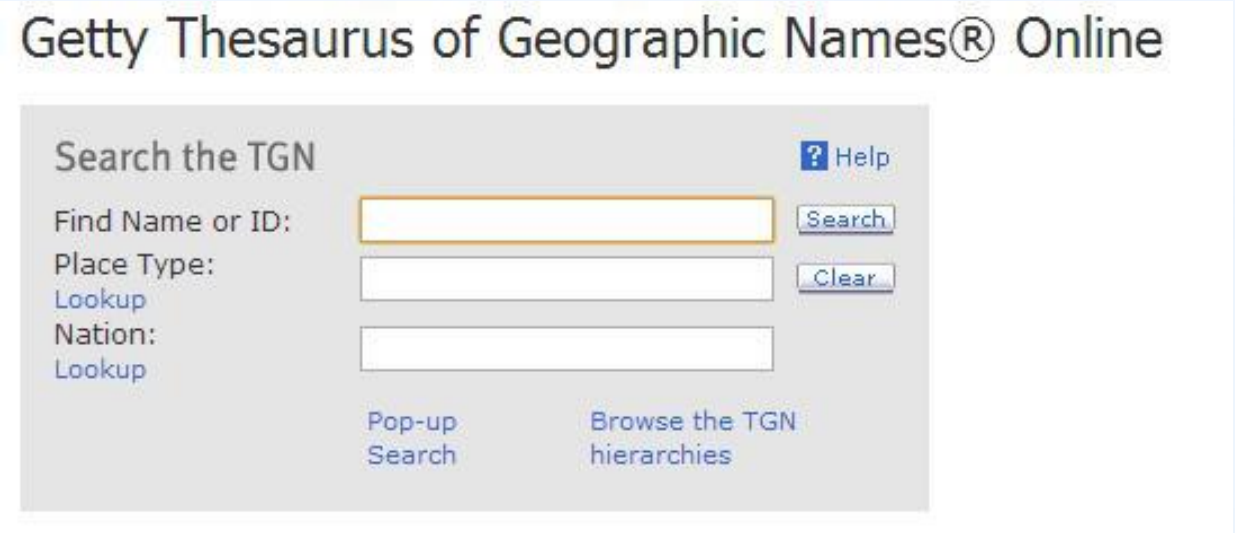
- some historical names
- lots of feature names:
  - dams
  - topographic features
  - water bodies



http://geonames.usgs.gov/pls/gnispublic/

Getty Thesaurus of Geographic Names™

- good for historical names



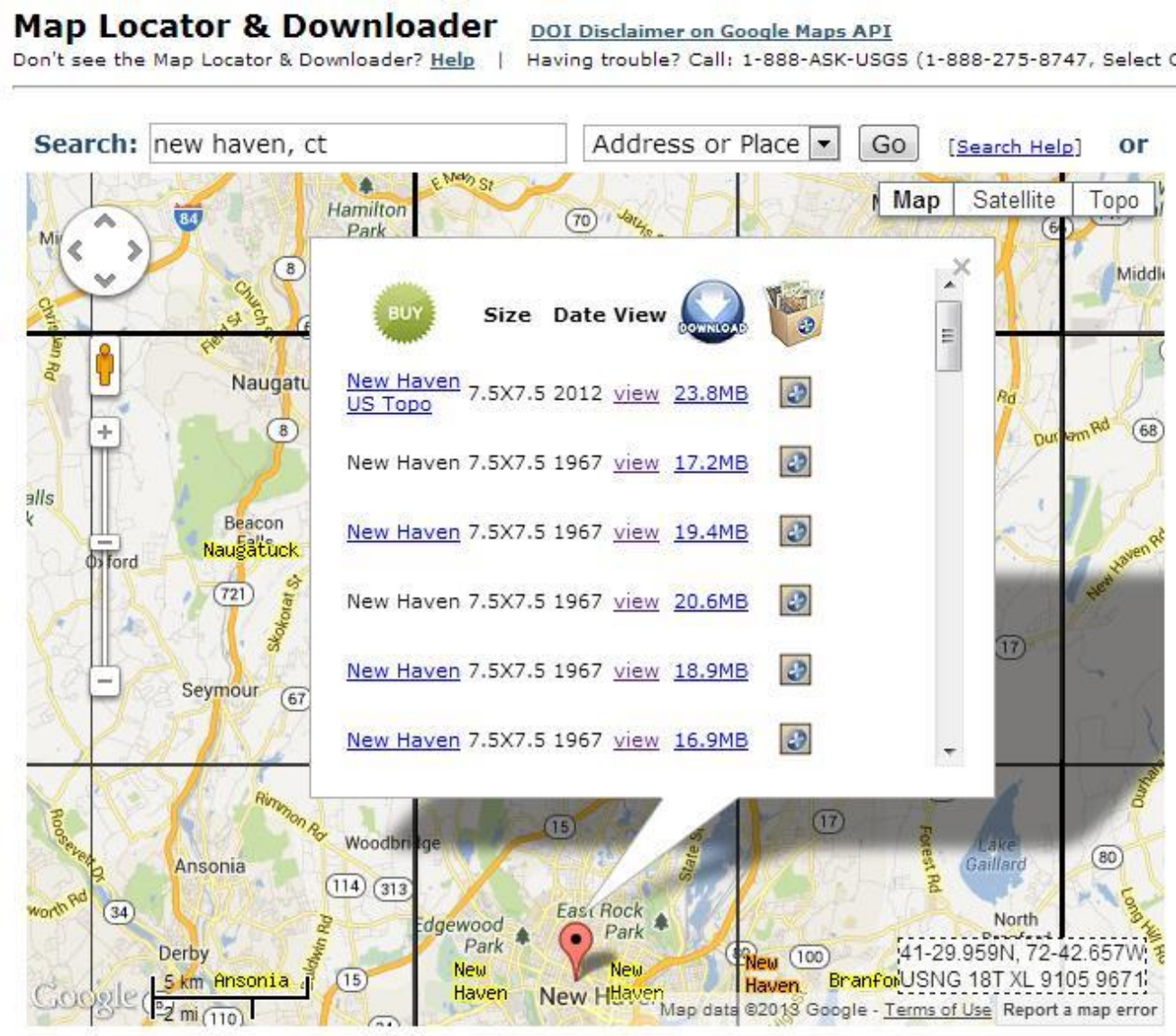
http://www.getty.edu/research/tools/vocabularies/tgn/index.html

USGS

science for a changing world

Map Store

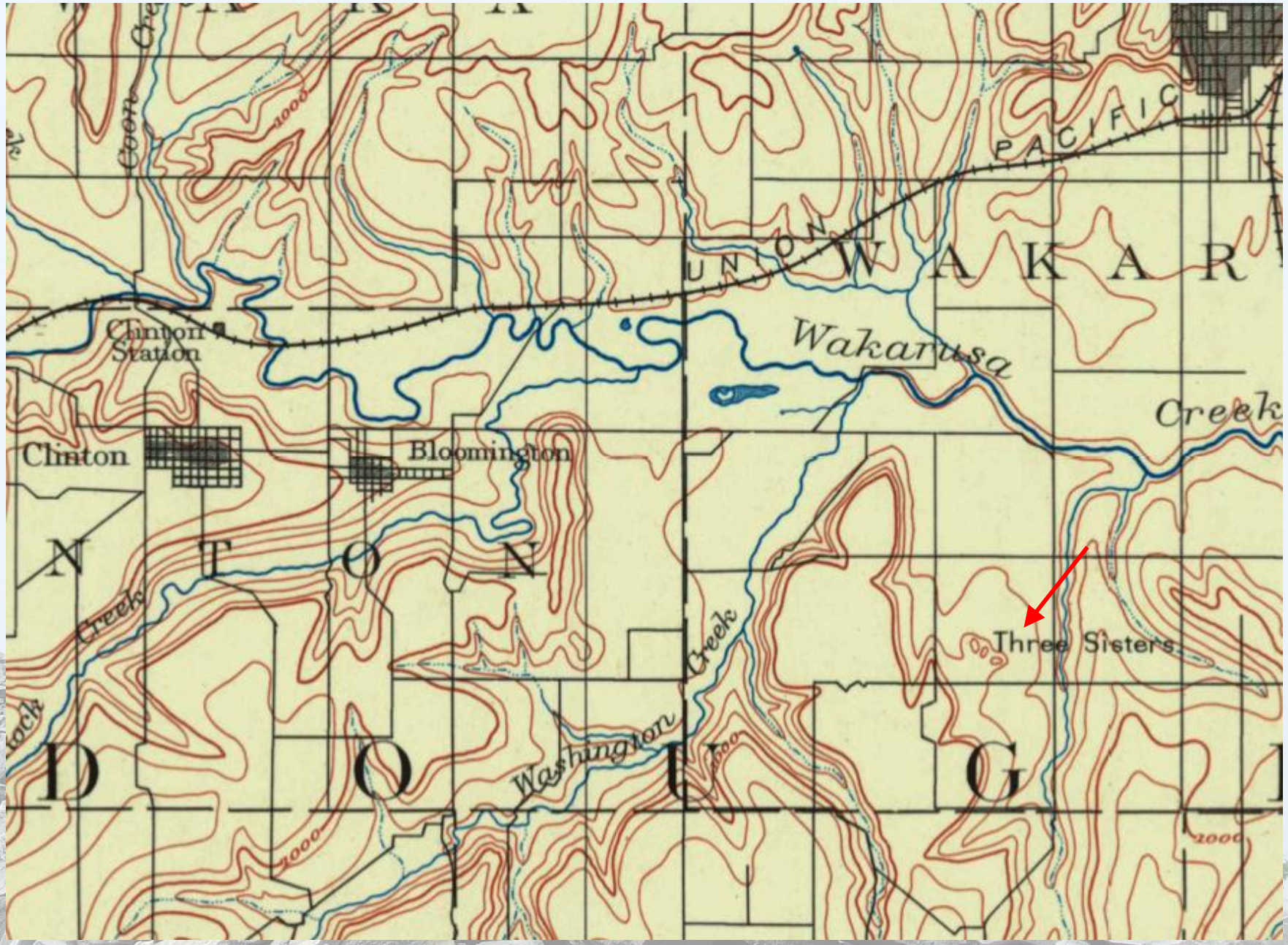
- downloadable pdfs of maps
- historical maps of different scales
- modern with satellite imagery
- geopdf toolbar for coordinates



http://tinyurl.com/USGSMapStore

Three Sisters, SW of Lawrence, KS?

USGS Topo map, Lawrence Quadrangle, 1885



To find out more….

iDigBio Georeferencing working group:
https://www.idigbio.org/wiki/index.php/Georeferencing

For powerpoints, notes, resources:
https://www.idigbio.org/wiki/index.php/GWG_Second_Train_the_Trainers_Workshop

For videos of talks:
https://vimeo.com/album/2163673

For links to Guide to Best Practices, Georeferencing calculator, Georeferencing Quick Guide:
http://herpnet.org/Gazetteer/GeorefResources.htm

Google Maps: maps.google.com

Google Earth: http://www.google.com/earth/index.html

GEOLocate: http://www.museum.tulane.edu/geolocate/

ACME mapper: http://mapper.acme.com/

USGS map store, for historical map PDFs: http://tinyurl.com/USGSMapStore

Getty Thesaurus, useful for Old & alt. names: bit.ly/Getty-TGN

Geonames: http://geonames.usgs.gov/pls/gnispublic/

LatLong crosshairs for Google Maps: www.canadensys.net/latlong-crosshairs

Hard to find localities: www.fallingrain.com

PLSS/TRS: www.earthpoint.us, http://www.metzgerwillard.us/plss/plss.html

UTM map: www.dmap.co.uk/utmworld.htm

UTM calculator: http://www.earthpoint.us/Convert.aspx

http://www.openstreetmap.org/: free, editable map of the world
http://global.mapit.mysociety.org/: can give you administrative boundaries if you have a lat-long (could be useful for verifying localities outside the US)
http://www.oldmapsonline.org/ and http://www.davidrumsey.com/: historical maps
http://www.gelib.com/ng-topo.htm: topo map overlay for Google Earth
http://mrdata.usgs.gov/geology/state/: geology layers for Google Earth
http://www.nrcan.gc.ca/earth-sciences/geography-boundary/geographical-name/11680: natural resources of Canada
http://www.lib.utexas.edu/maps/map_sites/cities_sites.html: Univ. of Texas at Austin Perry Castenada Map Library
http://www.gadm.org/: Global Administrative Boundaries Database
http://www.geody.com/ : Google Earth wiki
http://www.naturalearthdata.com/: for making maps
http://geo.data.gov/geoportal/catalog/main/home.page: various geographical datasetshttp://maps.nls.uk/: historical maps of Scotland/Great Britain/Ireland and Belgium
http://cidades-brasil-ibge-google-earth.softonic.com.br/download: cities in Brazil for google
http://www.topomapper.com/: compare topo and google maps side by side.
http://www.bl.uk/maps/, http://www.bl.uk/maps/georeferencingmap.html: British Library crowdsource project for historical maps
http://www.uwgb.edu/dutchs/usefuldata/ConvertUTMNoOZ.HTM: UTM and other useful resources