Map Basics: Datums and Coordinate Systems

ESRM 304

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Datums, land division systems, & coordinate systems

Datums (from Wikipedia)

- A geodetic datum (plural datums, not data) is a reference from which measurements are made.
- In surveying and geodesy, a datum is a set of reference points on the earth's surface against which position measurements are made, and
- (often) an associated model of the shape of the earth (reference ellipsoid) to define a geographic coordinate system.

Datums, land division systems, & coordinate systems

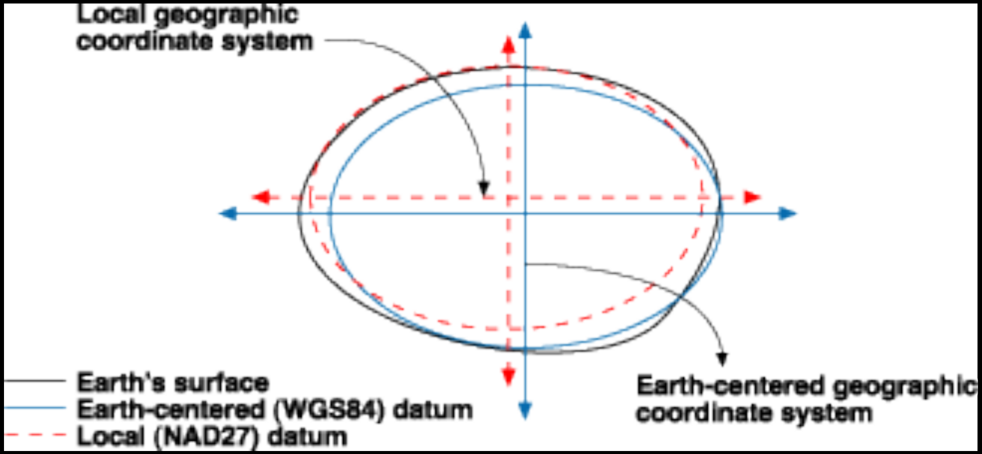
Datums (from Wikipedia)

- Horizontal datums are used for describing a point on the earth's surface, in latitude and longitude or another coordinate system.
- Vertical datums measure elevations or depths. In engineering and drafting, a datum is a reference point, surface, or axis on an object against which measurements are made.

Datums, land division systems, & coordinate systems

Datums

- Is the earth a sphere? No, it is a spheroid/ellipsoid
- The earth is irregularly shaped
- Deformations in the crust (e.g., from gravitational pressure of ice)
- Gravitational forces different where crust thickness varies



Datums, land division systems, & coordinate systems

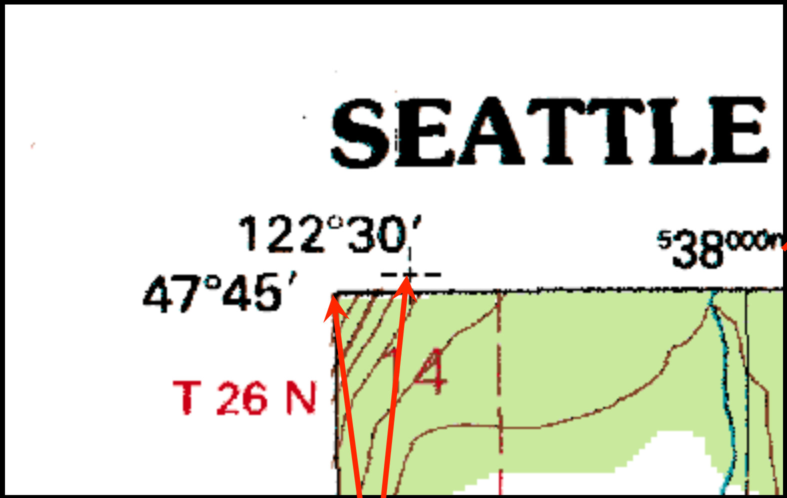
Datums are mathematical models of the shape of the earth created to provide control over the survey measurement framework

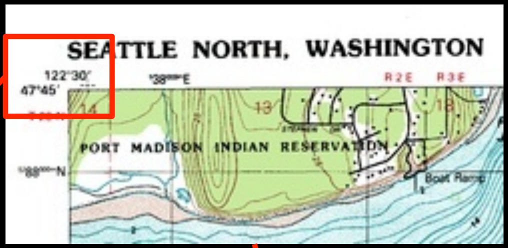
Provide a frame of reference for measuring locations on the earth's surface

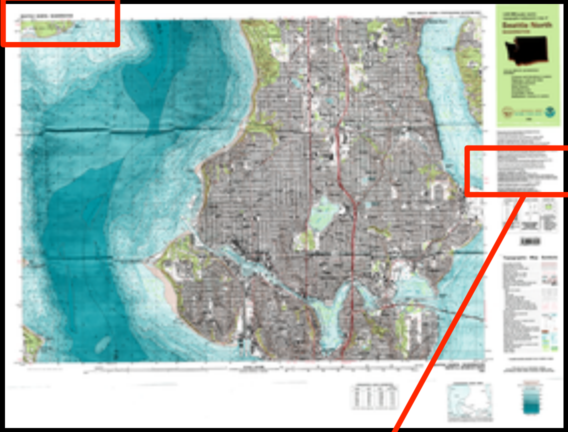
Earth-centered datums (e.g., WGS84) provide locational control for the entire planet but do not fit specific locations particularly well

Local datums exist for better local control (e.g., NAD27 or NAD83 for North America)

Datums, land division systems, & coordinate systems







These points represent the same location in two different datums

Projection and 1000-meter grid, zone 10, Universal Transverse Mercator
10,000-foot grid ticks based on Washington coordinate system, north zone
1927 North American Datum
To place on the predicted **North American Datum 1983** move the projection lines 23 meters north and 93 meters east as shown by dashed corner ticks

Datums, land division systems, & coordinate systems

Coordinate systems and land divisions extend the concept of the datum

Establish a (Cartesian) measurement framework

Allow referencing of all features on, above, or below the surface of the earth to each other

Datums, land division systems, & coordinate systems

Examples of different referencing systems

- Metes and bounds
- US Public Land Survey System (PLSS)
- State Plane
- Universal Transverse Mercator (UTM)

Metes and bounds

Based on physical features of local geography, directions, and distances

E.g., "beginning with a corner at the intersection of two stone walls near an apple tree on the north side of Muddy Creek road one mile above the junction of Muddy and Indian Creeks, north for 150 rods to the end of the stone wall bordering the road, then northwest along a line to a large standing rock on the corner of John Smith's place, thence west 150 rods to the corner of a barn near a large oak tree, thence south to Muddy Creek road, thence down the side of the creek road to the starting point."

Metes and bounds

What problems could there be with metes and bounds?

[Discussion]

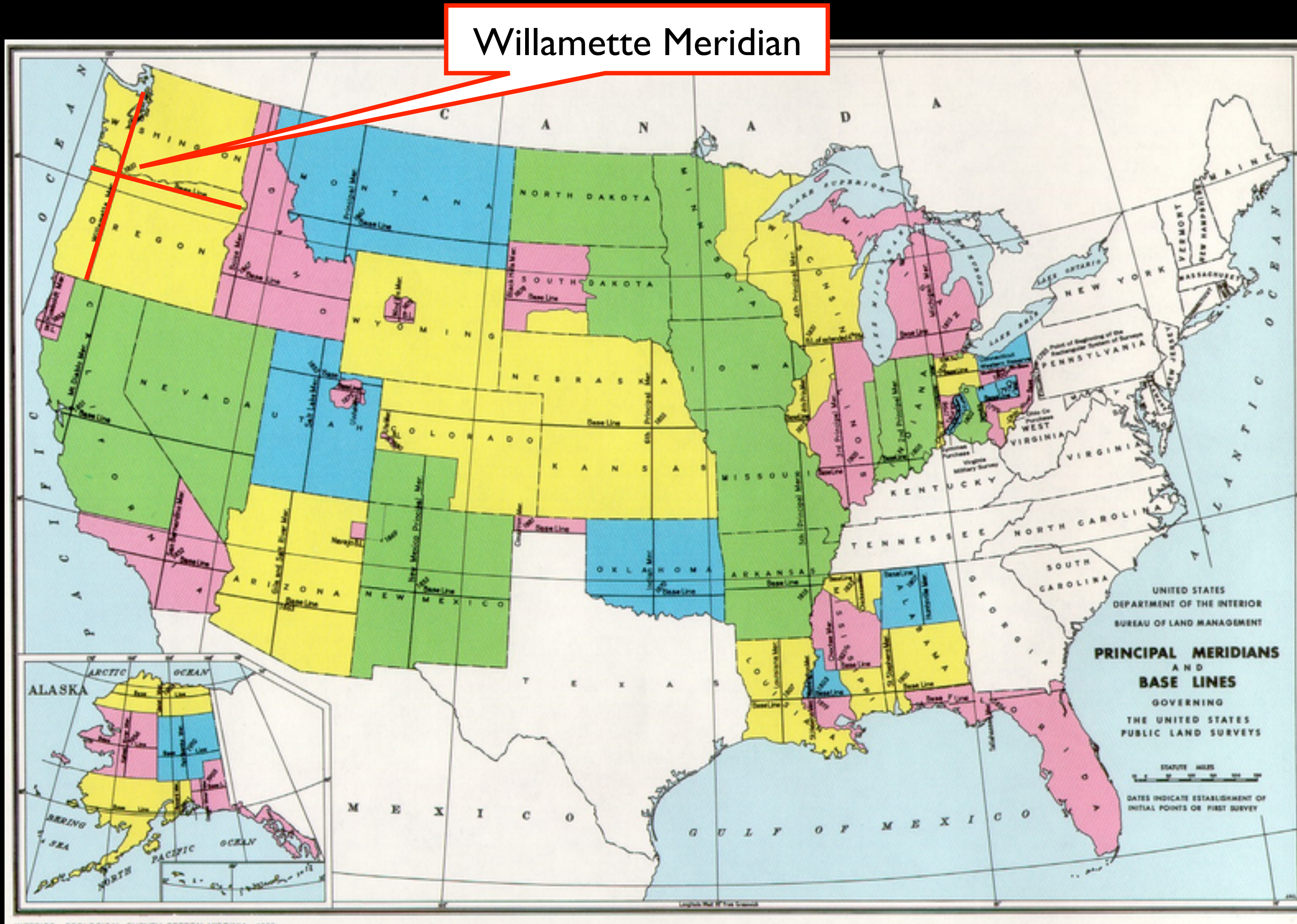
- Irregular shapes for properties lead to complex descriptions
- The only thing constant is change: trees die, streams move by erosion, properties are sold
- Not useful for large, newly surveyed tracts of land being opened in the west, which were being sold sight unseen to investors

US Public Land Survey System (PLSS)

Established in 1785 (Land Ordinance Survey)

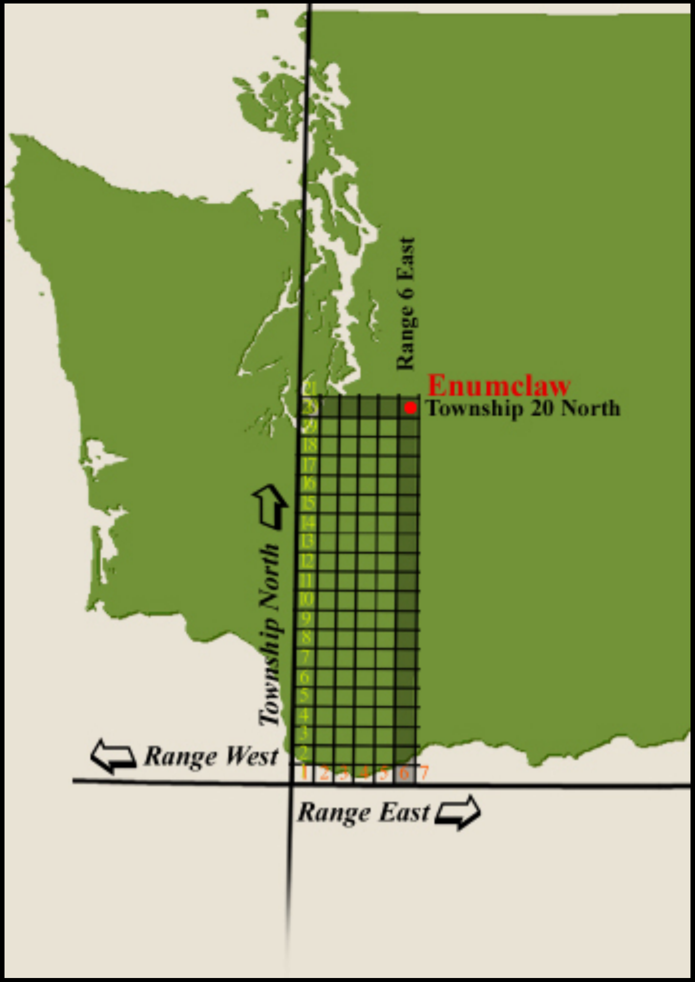
Origin point in E. Ohio

US Public Land Survey System (PLSS)



US Public Land Survey System (PLSS)

Townships and ranges are specified in relation to a meridian



US Public Land Survey System (PLSS)

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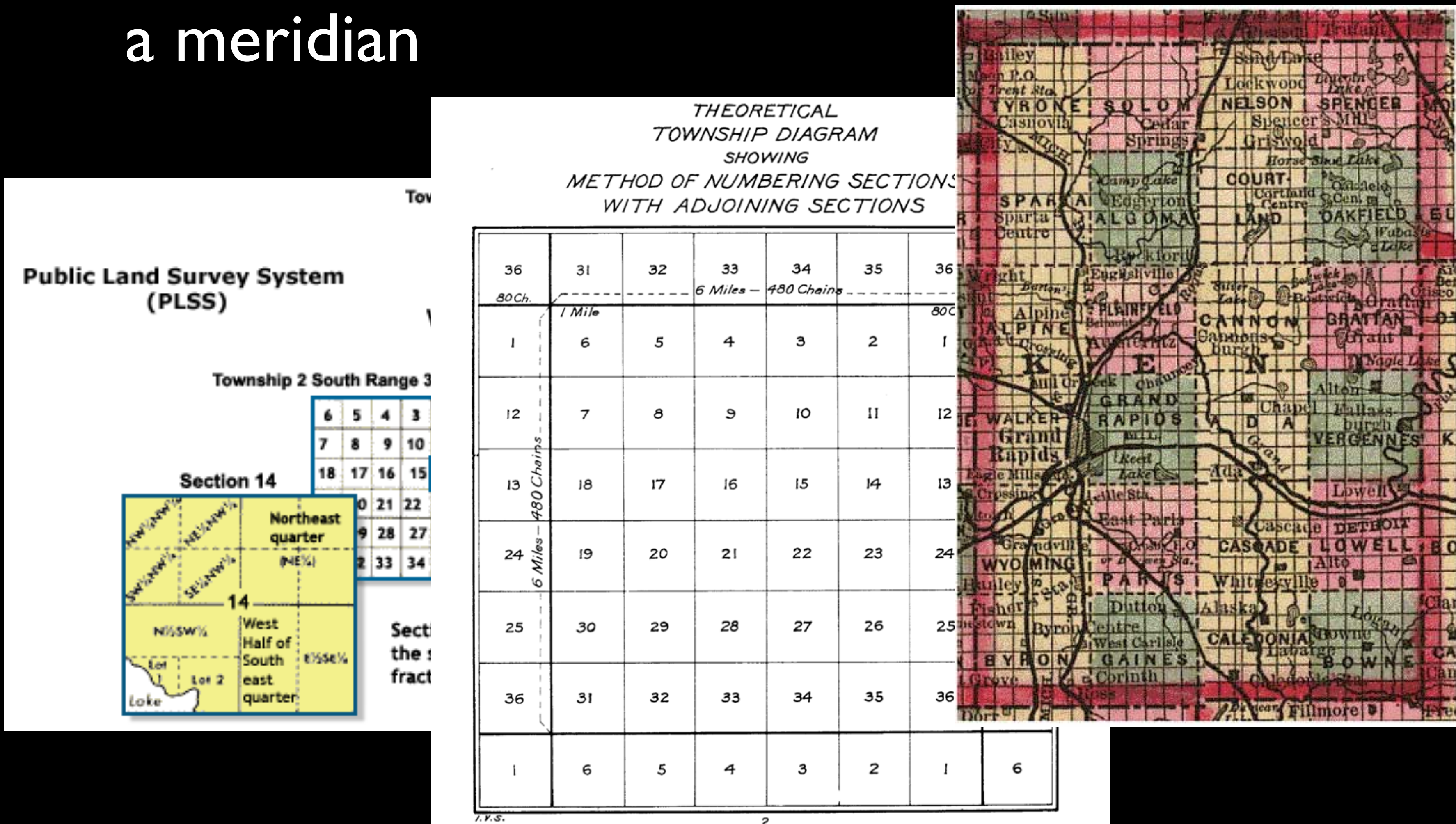
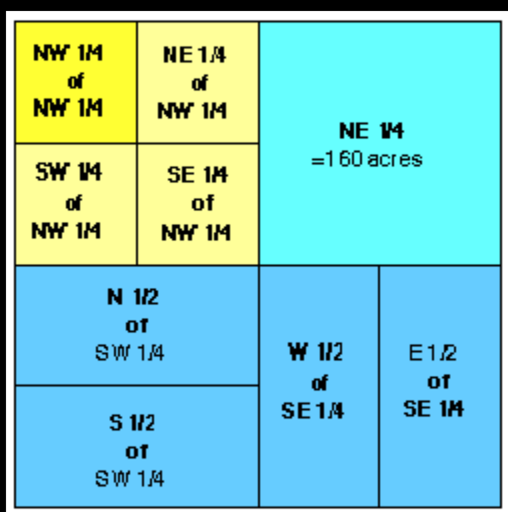


US Public Land Survey System (PLSS)

Townships are subdivided sequentially to refer to specific locations

E.g., "NE ¼ of NW ¼ of section 16 of township 23 N, range 16 E of Willamette Meridian"

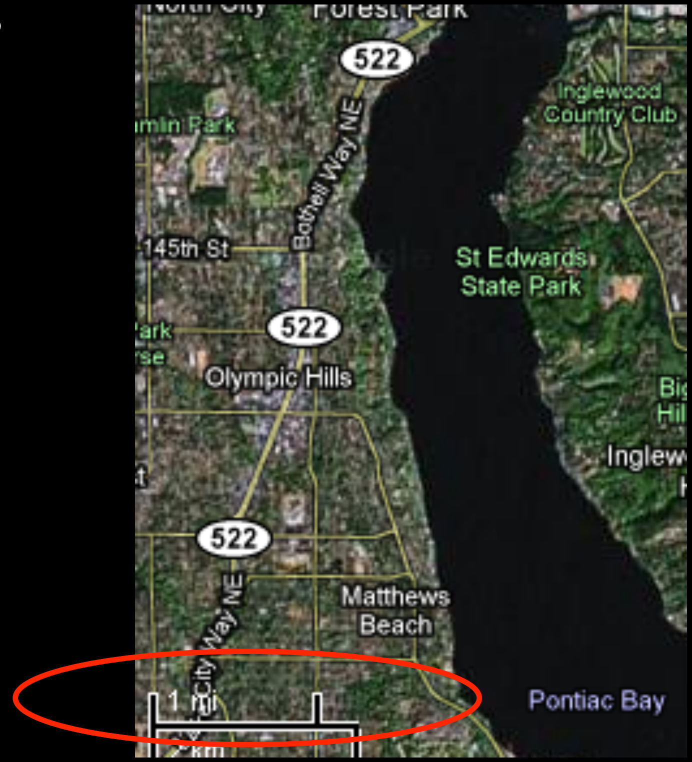


	miles	$mile^2$	acres	m^2	km^2	
Quadrangle	24 by 24	576	368,640		1,492	Usually 16 townships
Township	6 by 6	36	23,040		93	Usually 36 sections
Section		1	640		2.6	
Half-section		1/2	320	1,294,999	1.3	
Quarter-section		1/4	160	647,500		
Half of quarter-section		1/8	80	323,750		
Quarter of quarter-section		1/16	40	161,875		

US Public Land Survey System (PLSS)

The legacy persists:

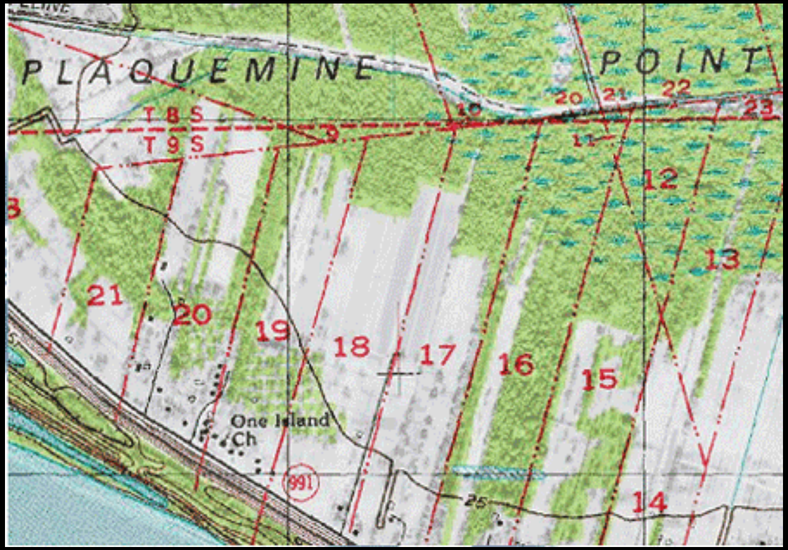
- Each 16th section was originally set aside for support of public schools (in WA, managed by DNR); you should be grateful!
- Land division artifacts



US Public Land Survey System (PLSS)

Problems with PLSS

- Because the earth is an ellipsoid, rectangular divisions will ultimately lead to discrepancies (can you cut an orange peel into squares?)
- Imposition of new system conflicted in some locations with previously existing land divisions



State Plane Coordinate System (SPCS)

- Codified in the 1930s
- Based on a Cartesian coordinate system
- Breaks the US up into a number of zones (124 in US)
- Most states' zones are based on Lambert Conformal Conic or Transverse Mercator projection
- Originally based on NAD27 datum, recently updated to NAD83 with GPS augmentation (HPGN = "High Precision GPS Network)
- Highly accurate (error < 1:10,000 within a zone)

State Plane Coordinate System (SPCS)

Each state or division of state has its own numeric code

- Washington State has 2 zones, based on Lambert Conformal Conic projection
- North zone: 5601
- South zone: 5626

State Plane Coordinate System (SPCS)

Problems with SPCS

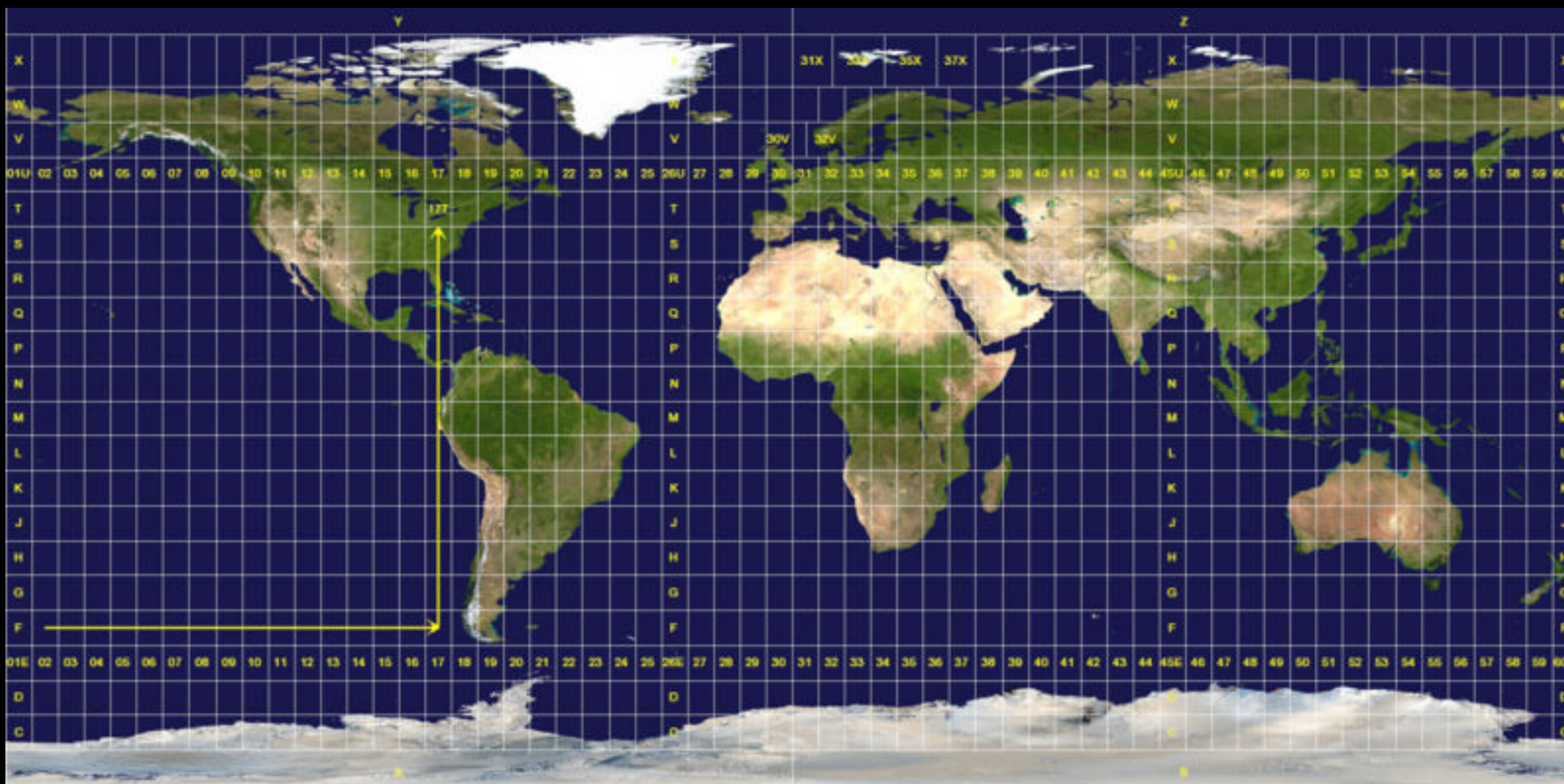
- Each state or state subdivision uses a different zone
  - Makes use of the SPCS in large areas cumbersome
- Accuracy declines outside of a zone
  - Makes use of the SPCS problematic when mapping & analyzing large areas

Universal Transverse Mercator (UTM)

- Developed by US Army Corps of Engineers in 1940s
- A global system (between 80°S latitude and 84°N latitude)
- Unambiguous location for every place on earth
- Based on the Transverse Mercator projection
- 60 zones, each 6° wide

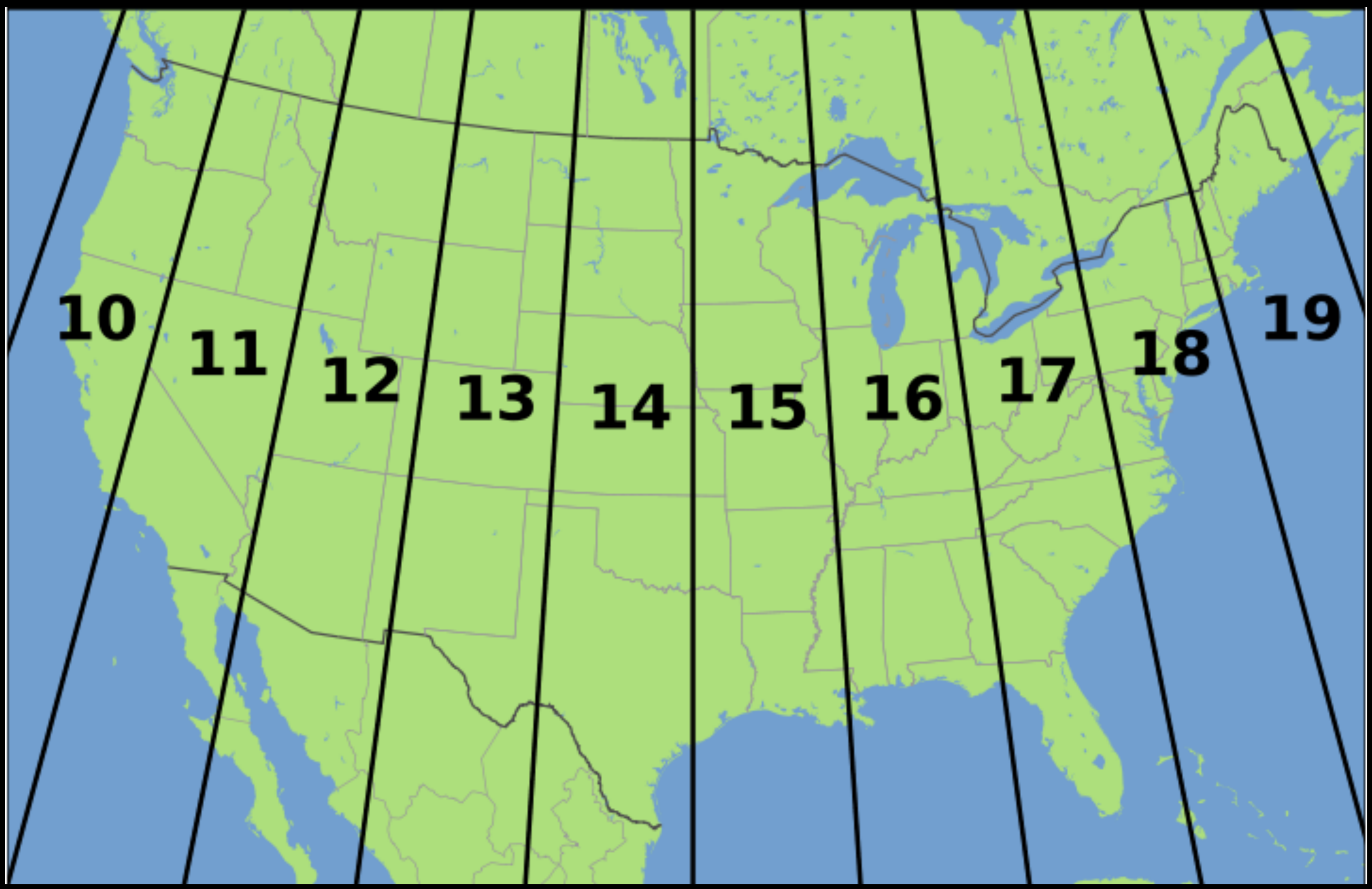
Universal Transverse Mercator (UTM)

Global UTM grid

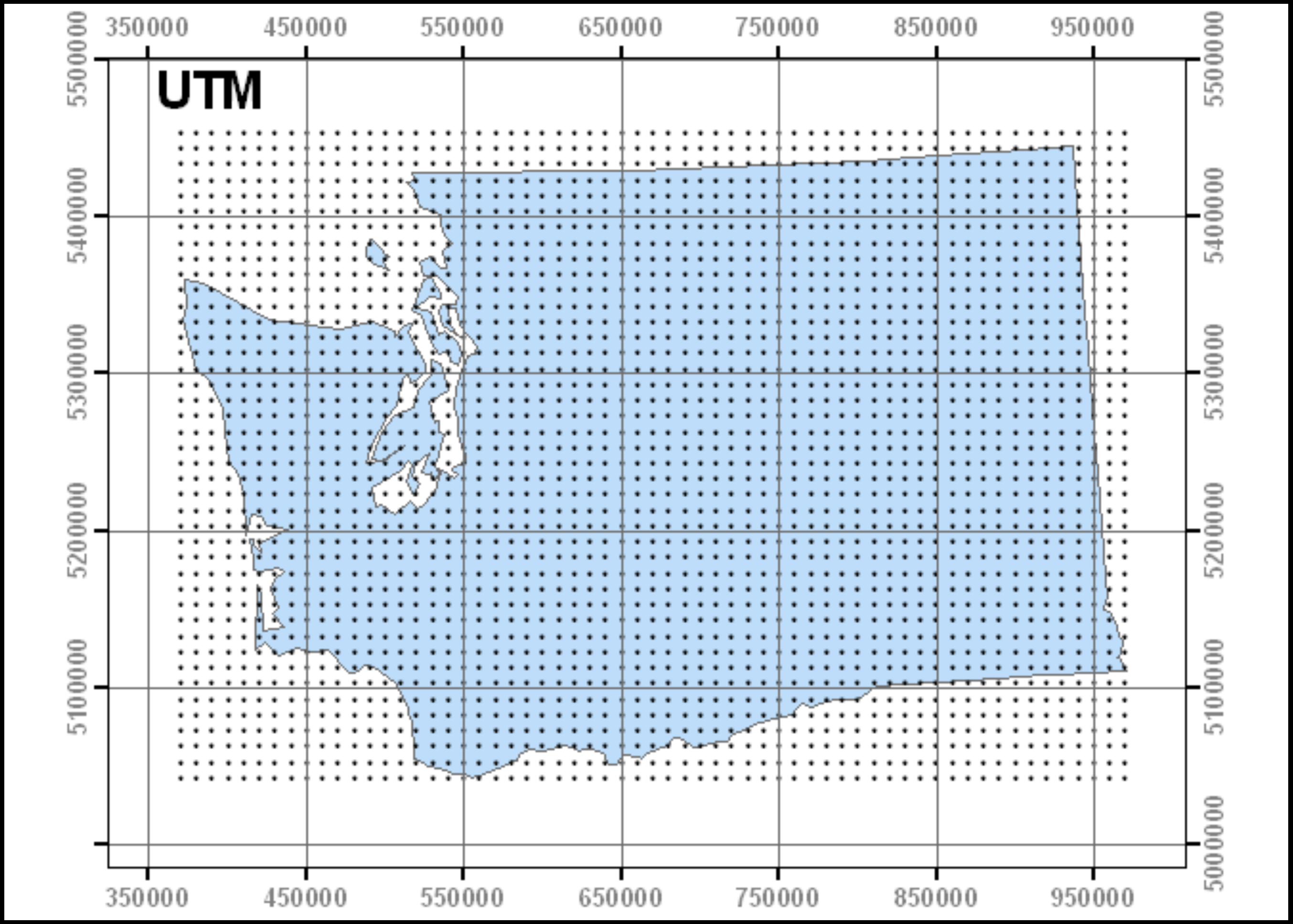


Universal Transverse Mercator (UTM)

UTM zones in the continental US



Comparing different coordinate systems



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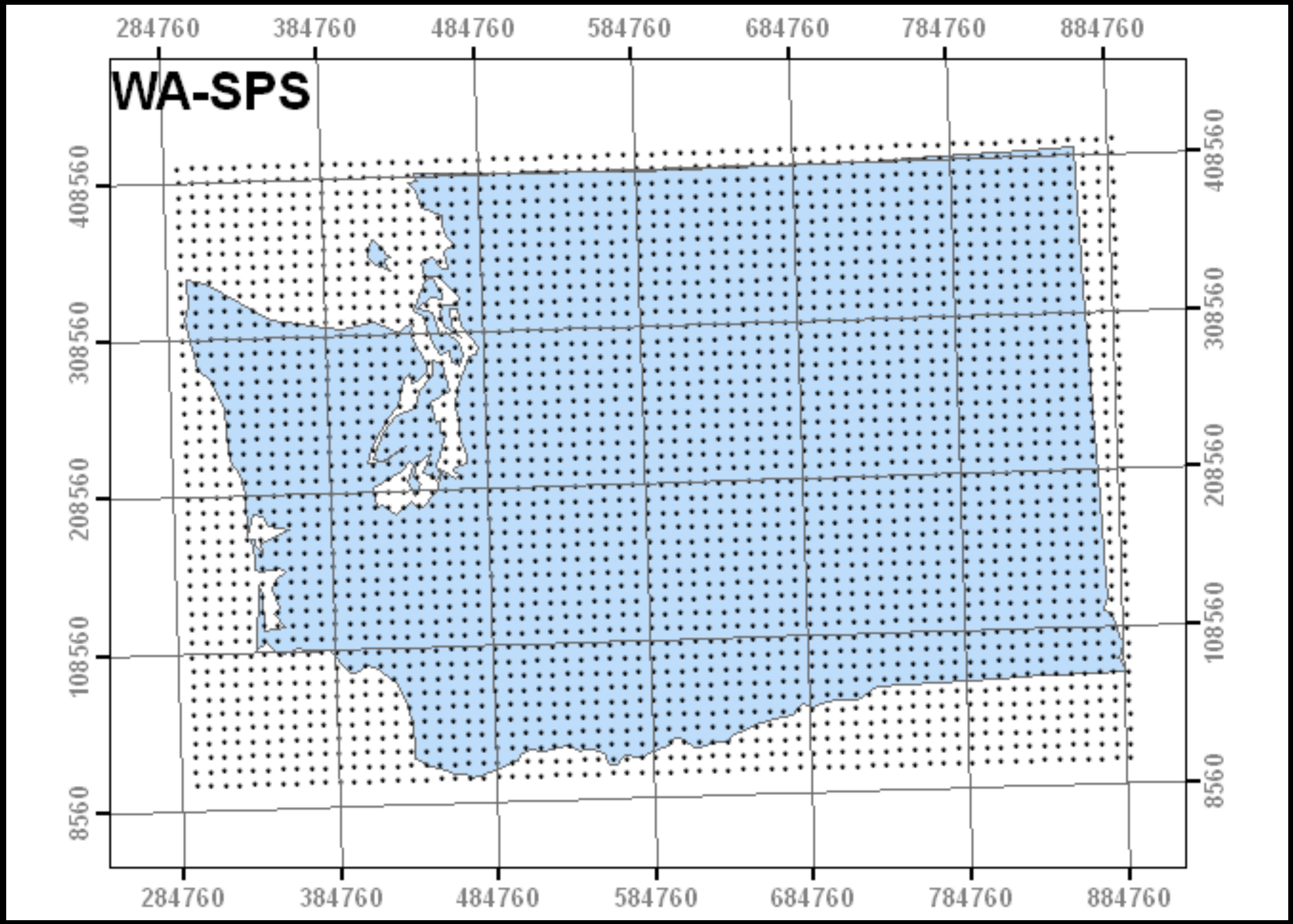

Comparing different coordinate systems

Conclusion

- Knowing where things are depends on measurement frameworks
- Measurement frameworks rely on commonly agreed-upon standards
- The great thing about standards is there are so many to choose from
- Calculation of land measurements will vary by measurement framework
- Wherever you go, there you are!