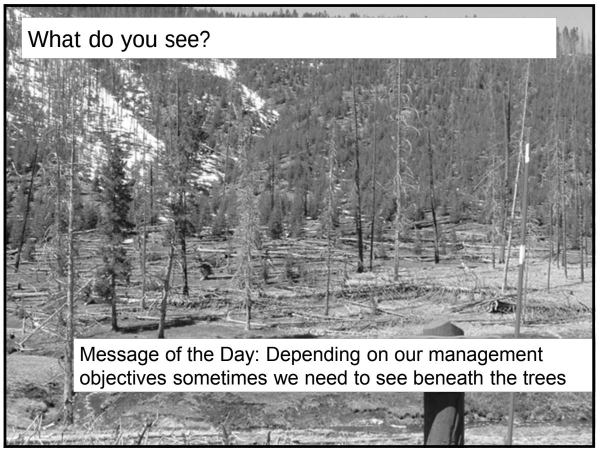
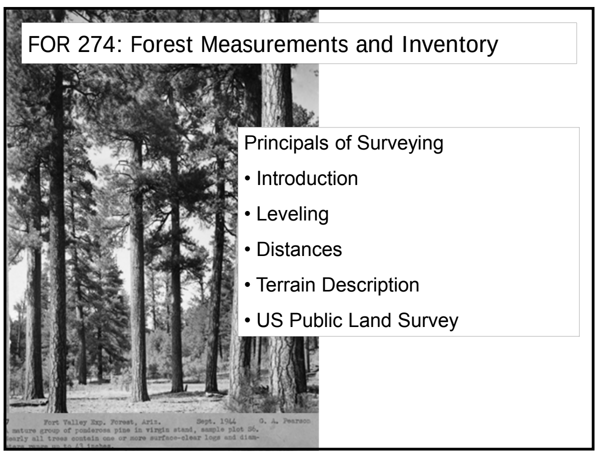
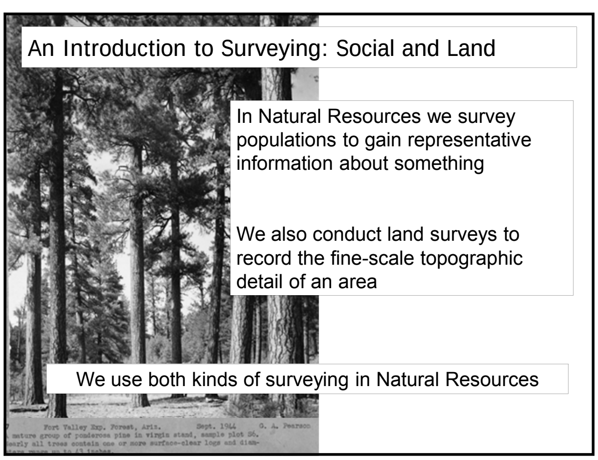
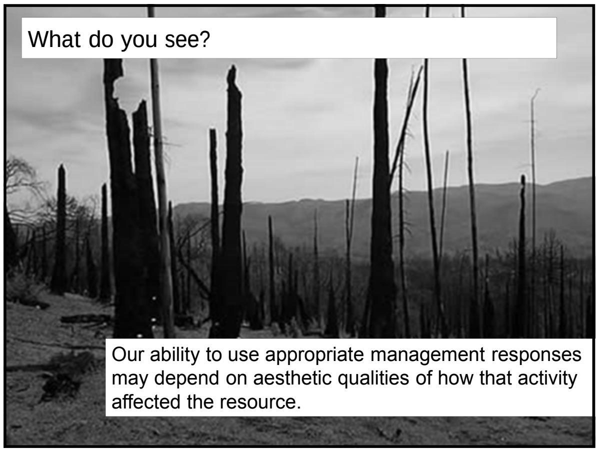

What do you see?
Message of the Day: Depending on our management objectives sometimes we need to see beneath the trees


FOR 274: Forest Measurements and Inventory
Principals of Surveying
• Introduction
• Leveling
• Distances
• Terrain Description
• US Public Land Survey

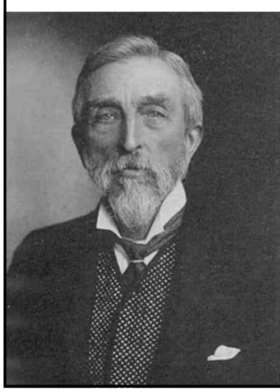

An Introduction to Surveying: Social and Land
In Natural Resources we survey populations to gain representative information about something
We also conduct land surveys to record the fine-scale topographic detail of an area
We use both kinds of surveying in Natural Resources

What do you see?



Our ability to use appropriate management responses may depend on aesthetic qualities of how that activity affected the resource.

Social Surveying: Where it all Began



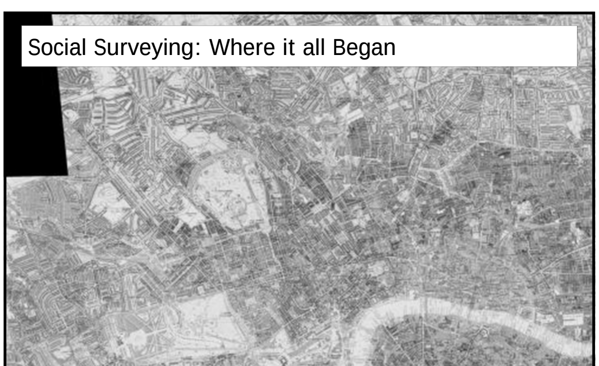
Charles Booth:

“The Life and Labor of the People in London”

He used direct observations of a sample of London’s populations with repeated standard measurements

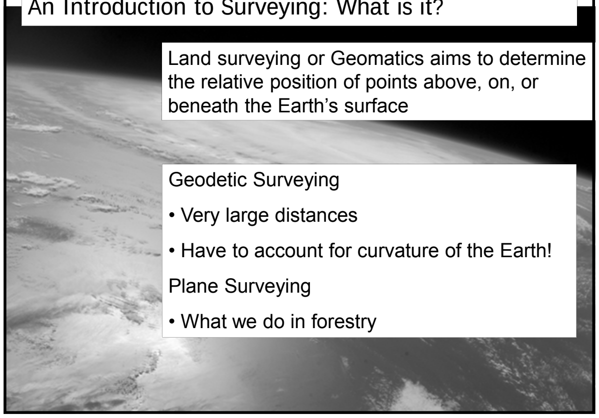
His findings had direct policy implications

Social Surveying: Where it all Began



The result of Booth’s survey was a spatially explicit map of poverty in London in 1898

An Introduction to Surveying: What is it?



Land surveying or Geomatics aims to determine the relative position of points above, on, or beneath the Earth’s surface

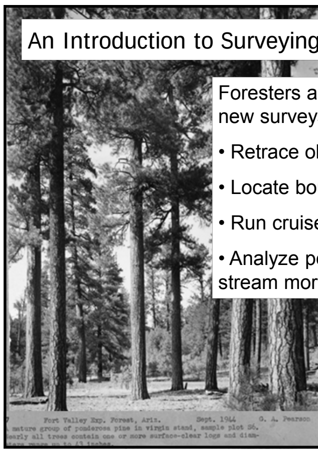
Geodetic Surveying

- Very large distances
- Have to account for curvature of the Earth!

Plane Surveying

- What we do in forestry

An Introduction to Surveying: Why do we Survey?



Foresters as a rule do not conduct many new surveys BUT it is very common to:

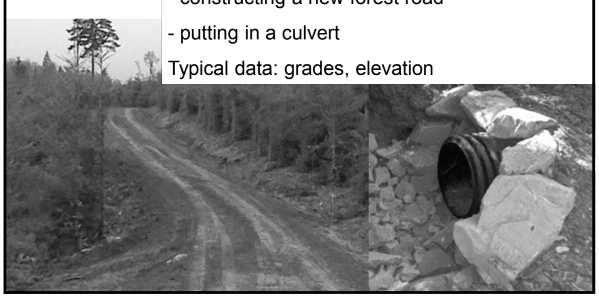
- Retrace old lines
- Locate boundaries
- Run cruise lines and transects
- Analyze post treatments impacts on stream morphology, soils, fuels, etc

An Introduction to Surveying: Types of Survey

Construction Surveys: To collect data essential for planning of new projects

- constructing a new forest road
- putting in a culvert

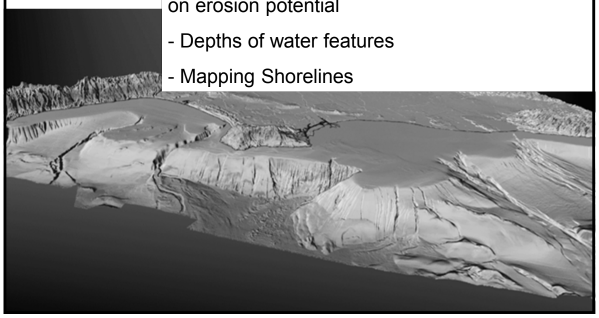
Typical data: grades, elevation



An Introduction to Surveying: Types of Survey

Hydrological Surveys: To collect data on stream channel morphology or impacts of treatments on erosion potential

- Depths of water features
- Mapping Shorelines



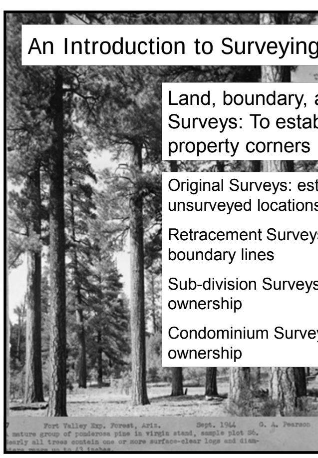
An Introduction to Surveying: Types of Survey

Topographic Surveys: To obtain data on natural and man-made features on the Earth's surface to produce a 3D topographic map

Typical Steps include:

- Establish horizontal & vertical controls
- Locating features that may be wanted by the survey
- Compute distances, angles, and elevations

An Introduction to Surveying: Types of Survey



Land, boundary, and Cadastral (public land) Surveys: To establish property lines and property corners

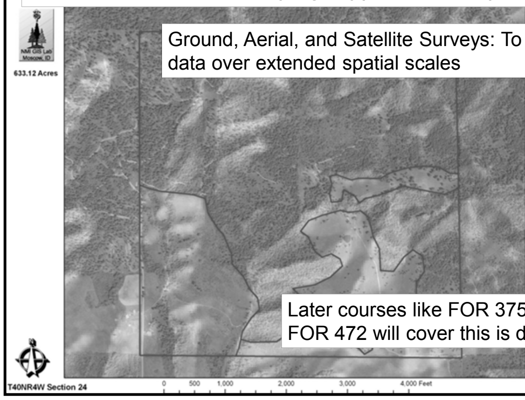
Original Surveys: establish new lines and corners in unsurveyed locations

Retracement Surveys: recover previously established boundary lines

Sub-division Surveys: delineate new parcels of ownership

Condominium Surveys: provide legal record of ownership

An Introduction to Surveying: Types of Survey



Ground, Aerial, and Satellite Surveys: To collect data over extended spatial scales

Later courses like FOR 375 and FOR 472 will cover this is detail

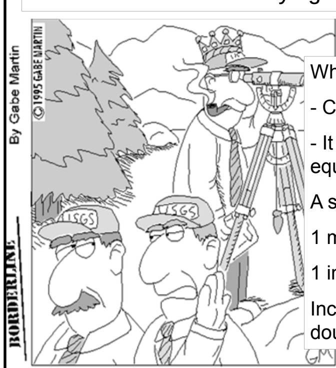
An Introduction to Surveying: The Main Points

Forestry surveying does not need engineering precision equipment

- It is rare that 1/10" accuracy is needed

However, although less $$$ the equipment we do use is still very accurate

An Introduction to Surveying: The Main Points



"There goes Lenny again-- he thinks he's king of all he surveys."

When surveying:

- Carefully plan the Survey
- It is difficult to find forgotten equipment

A survey can be ruined by:

1 missing point

1 incorrectly recorded point

Include in your plan ways to double check your data!!!

Leveling: Definitions

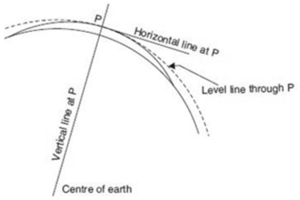


Fig. 15.2. Vertical and horizontal lines

Elevation: Distance along the vertical line from the vertical datum to a particular object.

Leveling: The process of measuring elevations of points (or differences in elevation)

Vertical Line: A line that follows the direction of gravity (defined by a plumb line)

Level Surface: A surface (curved on earth) where every point is perpendicular to the plumb line

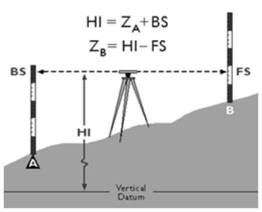
Horizontal Surface: A plane perpendicular to the plumb line

Vertical Datum: A level surface to which elevations are referenced. At the Datum, elevations are set to zero.

Benchmark: A permanent object with elevation accuracy measured.

Leveling: Measuring Elevation Differences

The most common method to measure elevation differences is differential leveling.



Foresight is often called "– sight"

Backsight is often called "+ sight"

Step 1: Place the instrument between A and B and make it level.

Step 2: Read off the scale at A (the backsight).

The Height of the Instrument (HI) is then:

$$HI = Z_A + BS$$

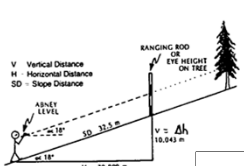
Step 3: Read off the scale at B (the foresight).

The Elevation at B, Z_B, is then:

$$Z_B = HI - FS$$

Leveling: Measuring Elevation Differences

Another common method to measure elevation differences is trigonometric leveling. We use this principal a lot in forestry!



H = SD x COS ∝
= 32.5 x COS 18°
= 30.909 m

V = SD x SIN ∝
= 32.5 x SIN 18
= 10.043 m

Height of Tree of Cliff

V = H x TAN ∝
= 30.909 x TAN 18°
= 10.043 m

Uses:
- Slope Correction
- Plot Sizes
- Heights

Land Surveying Equipment: The Theodolite

A Theodolite measures both horizontal and vertical angles

Transits are specialized Theodolites that have a telescope that can "flip over or transit the scope" to allow back-sighting

Land Surveying Equipment: Laser Rangefinders

Laser rangefinders use this relationships to calculate distance:

Distance = speed of light * (time/2)

The time refers to time of pulse to go from the instrument to the tree and back again

Land Surveying Equipment: Total Stations

Total Stations are essentially a combination of a Theodolite and a laser rangefinder

Total Stations are commonly used civil engineering projects due to there versatility and accuracy

Leveling: Sources of Error

Instrumental Errors: Errors caused by limitations in the equipment
- Loose tripod legs, crosshair out of alignment, etc.

Natural Errors: Errors caused by the environment you are working in
- Curvature of the Earth,
- Refraction of light when measuring through a scope,
- Metal measuring sticks can expand/contract depending on the temperature
- Wind can cause instruments to wobble
- Rough terrain can make leveling the instrument difficult

Human Errors and Mistakes
- Rushing or misreading a measure
- Not using equipment correctly
- Not understanding what a measure means
- Recording data incorrectly

Horizontal Distance Measurements: The Chain

The chain (66 feet) is the fundamental unit of horizontal measurement used by foresters

It is also called the surveyor's or Gunter's chain

1 Chain = 100 Links

All distances in US Land surveys are in chains and links

1 sq mile = 80 x 80 chains

1 acre = 10 sq chains

Horizontal Distance Measurements: The Chain

A Chain can be measured with:

Pacing

The Hip Chain

Surveyor's Chain or Rope

Large tapes

Horizontal Distance Measurements: The Chain

Pacing out a chain is one of the simplest and most useful assets for a timber cruiser

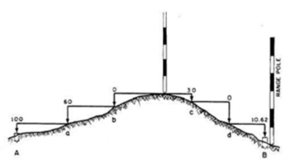
Expert pacers are accurate to 1 foot in 80 on level terrain

A pace is commonly defined as two natural steps – i.e. each time the same foot touches the ground

However, slope and obstacles may alter the length of your pace and this will need to be accounted for

Horizontal Distance Measurements: Sloping Ground

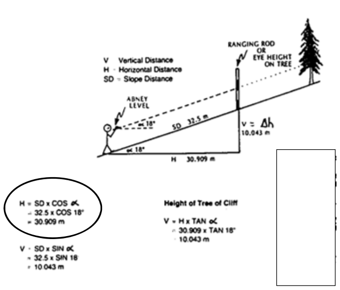
When it is not practical for two people to hold a tape level on rough sloping ground of is an object is in the way, the “breaking tape” method can be used.



1. A horizontal distance is measured out so the uphill end is on the ground (say 100’).
2. A chaining pin is then placed at the ground.
3. A 2^{nd} horizontal distance is then measured and pin placed.
4. Repeat until end and add up all the measures.

Horizontal Distance Measurements: Sloping Ground

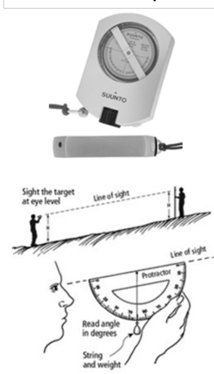
To correct for slope, we use the trigonometric leveling method.



Terrain Descriptors: Aspect, Slope, & Slope Form

Aspect is measured with your compass and is the predominant direction of the slope from plot center. Usually thought of ecologically in terms of cardinal directions but generally recorded as an Azimuth.

Terrain Descriptors: Aspect, Slope, & Slope Form



Slope is generally measured with a clinometer by averaging readings to something at eye level uphill and downhill.

Clinometers come in 3 scales:

- % scale (most common)
- Topographic scale
- degrees

tan(α) = (rise/run) = % scale reading

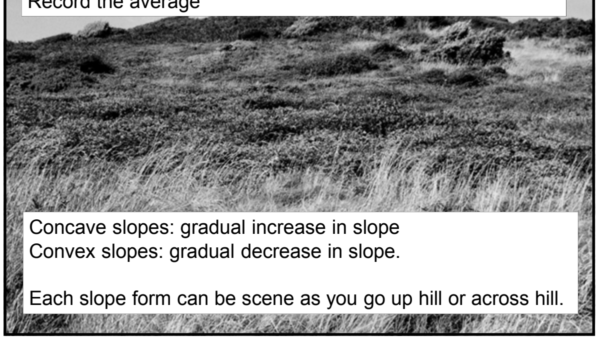
tan(35°) = (70/100) = 0.70 = 70%

Deg = tan-1 (% / 100)

43%: deg = tan -1 (0.43) = 23.27%

General Site Measurements: Aspect and Slope

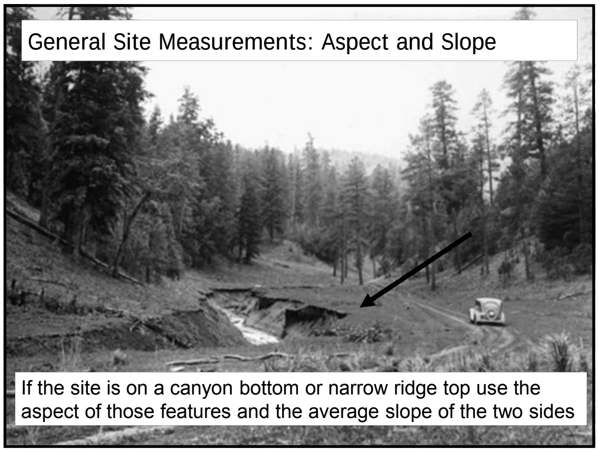
If the aspect or slope gradually changes across the site:
Record the average



Concave slopes: gradual increase in slope
Convex slopes: gradual decrease in slope.

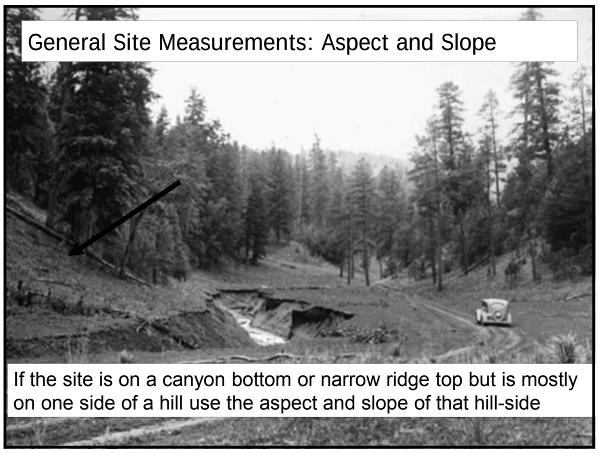
Each slope form can be scene as you go up hill or across hill.

General Site Measurements: Aspect and Slope



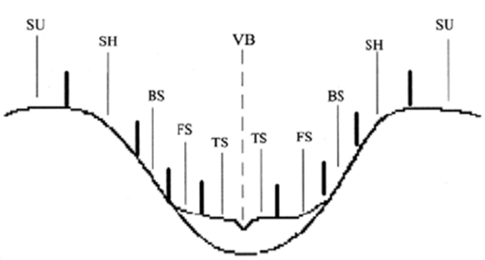
If the site is on a canyon bottom or narrow ridge top use the aspect of those features and the average slope of the two sides

General Site Measurements: Aspect and Slope



If the site is on a canyon bottom or narrow ridge top but is mostly on one side of a hill use the aspect and slope of that hill-side

General Site Measurements: Slope Position



Slope Position

General Site Measurements: Slope Position

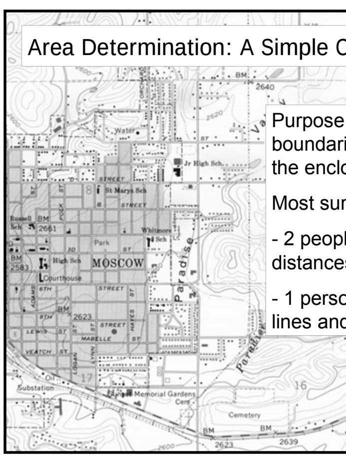
Code	Description
SU	**Summit/Ridgetop/Plateau**. The topographically highest hillslope position of a hillslope profile and exhibiting a nearly level surface.
SH	**Shoulder**. The hillslope position that forms the uppermost inclined surface near the top of a hillslope. It comprises the transition zone from backslope to summit.
BS	**Backslope**. The hillslope position that forms the steepest inclined surface and principle element of many hillslopes. In profile, backslopes are commonly steep, linear, and bounded by a convex shoulder above and descending to concave footslope. They may or may not include cliff segments. Backslopes are commonly erosional forms produced by mass movement and running water.
FS	**Footslope**. The hillslope position that forms the inner, gently inclined surface at the base of a hillslope. In profile, footslopes are commonly concave. It is a transition zone between upslope sites of erosion and transport.
TS	**Toeslope**. The hillslope position that forms the gently inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear, and are constructional surfaces forming the lower part of a hillslope continuum that grades to a valley bottom.
VB	**Valley Bottom**. Wide valley bottom beyond influence of toeslope.

FOR 274: Forest Measurements and Inventory

Measures of Land Area

- Area Measures
- Reading Maps
- US Public Land Survey

Area Determination: A Simple Closed Transverse



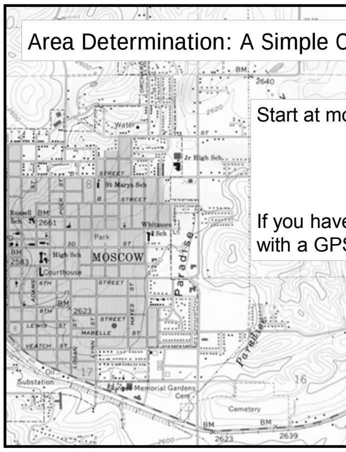
Purpose: Locate approximate boundaries of a tract and determine the enclosed area

Most surveys involve 3 or 4 people:

- 2 people chain horizontal distances

- 1 person establishes compass lines and records values

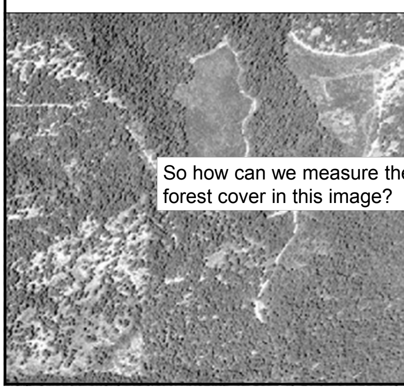
Area Determination: A Simple Closed Transverse



Start at most reliable property corner:

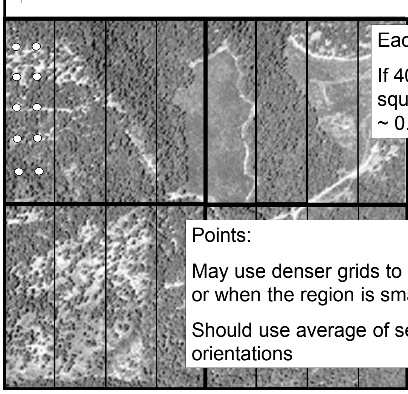
If you have one record each corner with a GPS unit

Area Determination: An Example of Methods



So how can we measure the forest cover in this image?

Area Determination: Dot Grids



Each block = 8 ac

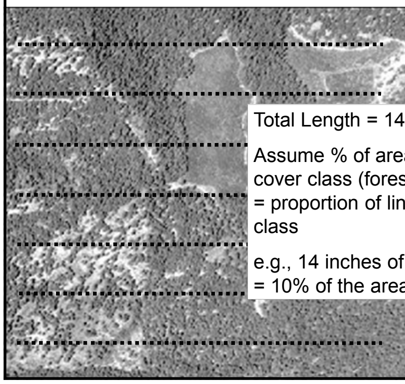
If 40 dots per block square then each dot ~ 0.2 acres

Points:

May use denser grids to increase precision or when the region is small

Should use average of several random orientations

Area Determination: Line Intercept

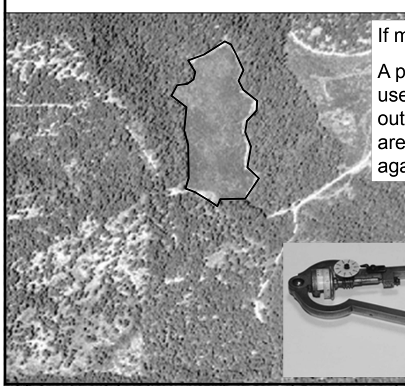


Total Length = 140 inches

Assume % of area of each land cover class (forest, clearcut, ag, etc) = proportion of line intercepting that class

e.g., 14 inches of clearcut = 14/140 = 10% of the area

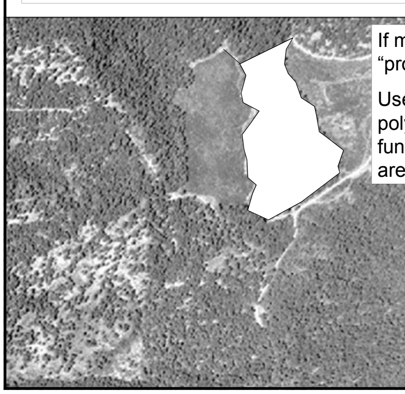
Area Determination: Planimeter



If map scale is known

A planimeter can be used by tracing the outline of the desired area and scaling it against a know area.

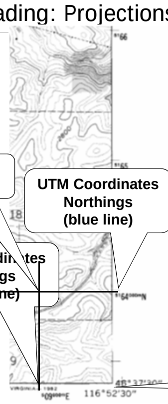
Area Determination: Via a GIS



If map scale and “projection” is known

Use ARC to create a polygon and basic functions to calculate area of each polygon

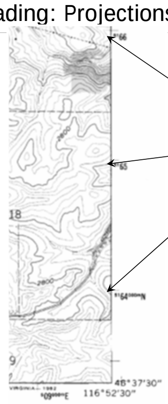
Map Reading: Projections



Universal Transverse Mercator (UTM):

- Grid system to find position (NATO)
- Entire earth divided into grid (like Lat/Long) but its put into 60 zones
- This is based on a scale in meters north and meters east (northing and easting)

Map Reading: Projections



Reading The Map:

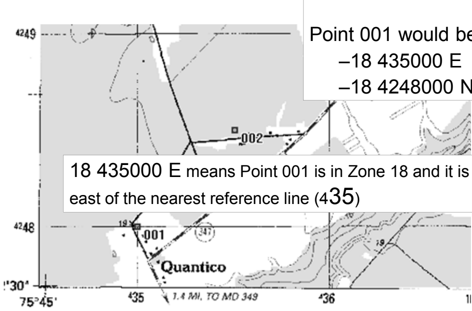
- 5166000 meters North
- 5165000 meters North
- 5164000 meters North
- One blue dash to the next is a travel distance of 1,000 meters (3,281 feet)

Map Reading: UTM An Example

USGS Topo Quad in Maryland: UTM Zone 18:

Point 001 would be read as:

- –18 435000 E
- –18 4248000 N



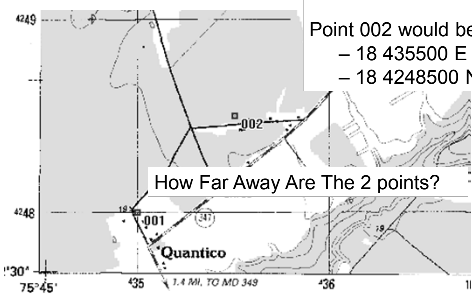
18 435000 E means Point 001 is in Zone 18 and it is 000 meters east of the nearest reference line (435)

Map Reading: UTM An Example

Point 002 is exactly half way between 435 and 436 UTM reference marks

Point 002 would be read as:

- 18 435500 E
- 18 4248500 N



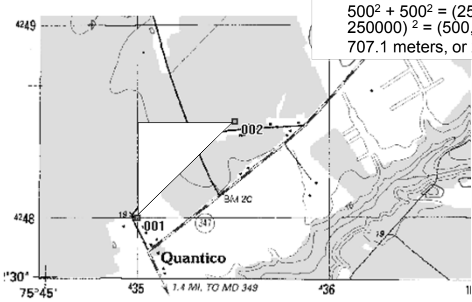
How Far Away Are The 2 points?

Map Reading: UTM An Example

$A^2 + B^2 = C^2$

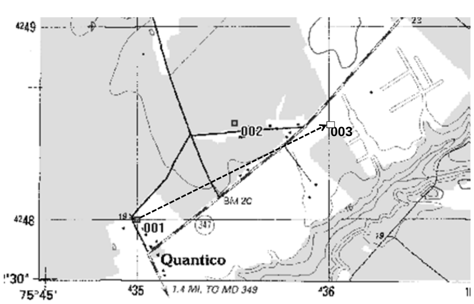
$500^2 + 500^2 = (250000 + 250000)^{2} = (500,000)^{2}$

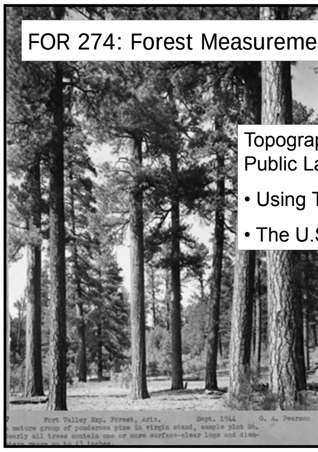
707.1 meters, or 2,320 feet



Map Reading: UTM An Example

How far from 001 to 003?

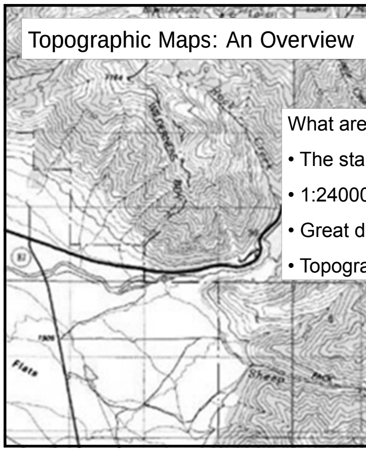




FOR 274: Forest Measurements and Inventory

Topographic Maps and the U.S. Public Land Survey

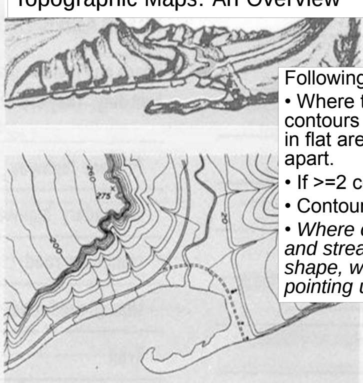
- Using Topographic Maps
- The U.S. Public Land Survey



Topographic Maps: An Overview

What are Topographic maps:

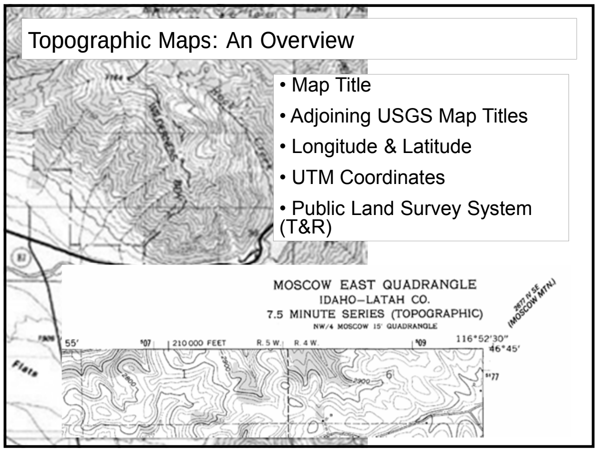
- The standard maps in forestry
- 1:24000 scale on 7.5° Topos
- Great detail
- Topographical relief

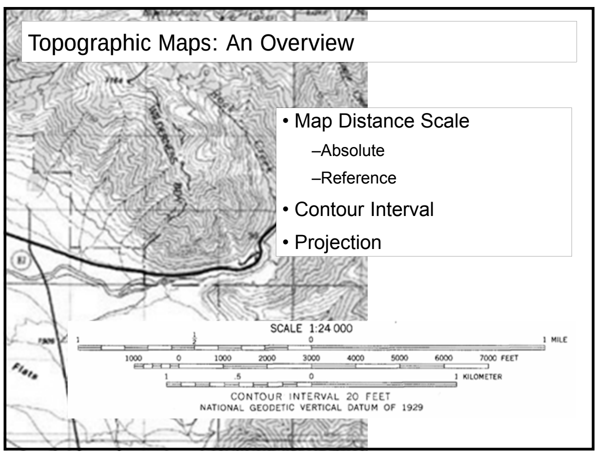


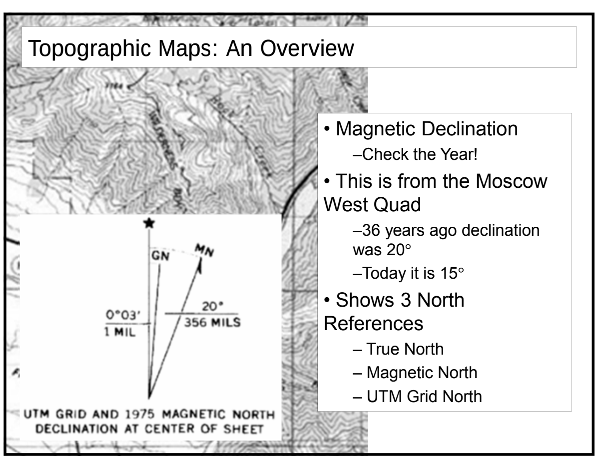
Topographic Maps: An Overview

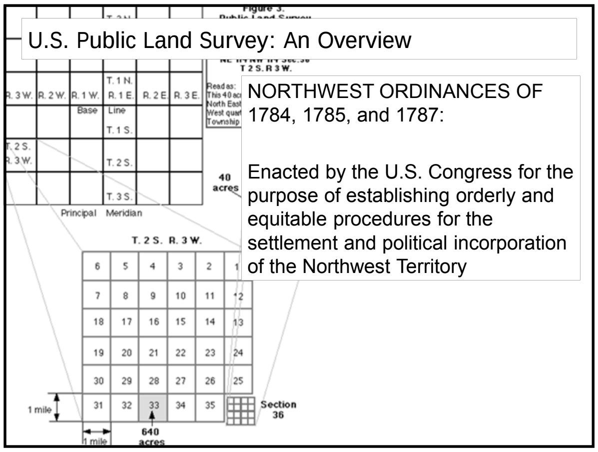
Following the Lines:

- Where the land slopes steeply, contours are close together, and in flat areas the contours are far apart.
- If >=2 contours touch = cliff
- Contours lines can never cross
- *Where contours cross ravines and stream valleys you see a "V" shape, with the V always pointing upstream.*


Topographic Maps: An Overview
• Map Title
• Adjoining USGS Map Titles
• Longitude & Latitude
• UTM Coordinates
• Public Land Survey System (T&R)
MOSCOW EAST QUADRANGLE
IDAHO–LATAH CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NW/4 MOSCOW 15' QUADRANGLE
210 000 FEET
R. 5 W. R. 4 W.
116°52'30"
46°45'


Topographic Maps: An Overview
• Map Distance Scale
–Absolute
–Reference
• Contour Interval
• Projection
SCALE 1:24 000
1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

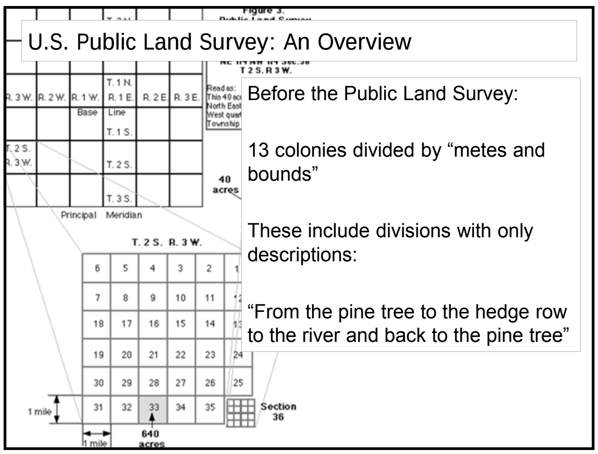

Topographic Maps: An Overview
• Magnetic Declination
–Check the Year!
• This is from the Moscow West Quad
–36 years ago declination was 20°
–Today it is 15°
• Shows 3 North References
– True North
– Magnetic North
– UTM Grid North
GN
MN
0°03'
1 MIL
20°
356 MILS
UTM GRID AND 1975 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET



U.S. Public Land Survey: An Overview

NORTHWEST ORDINANCES OF 1784, 1785, and 1787:

Enacted by the U.S. Congress for the purpose of establishing orderly and equitable procedures for the settlement and political incorporation of the Northwest Territory



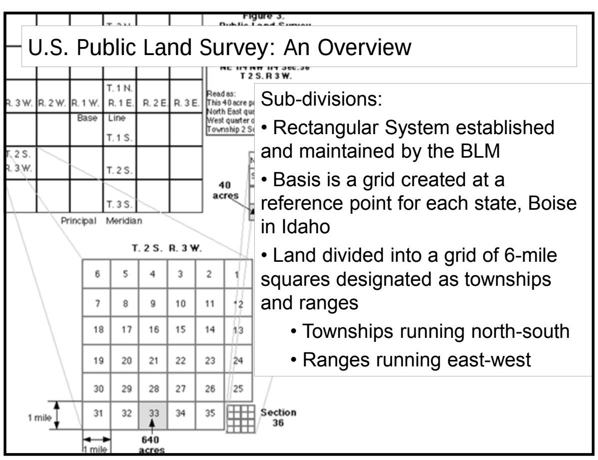
U.S. Public Land Survey: An Overview

Before the Public Land Survey:

13 colonies divided by “metes and bounds”

These include divisions with only descriptions:

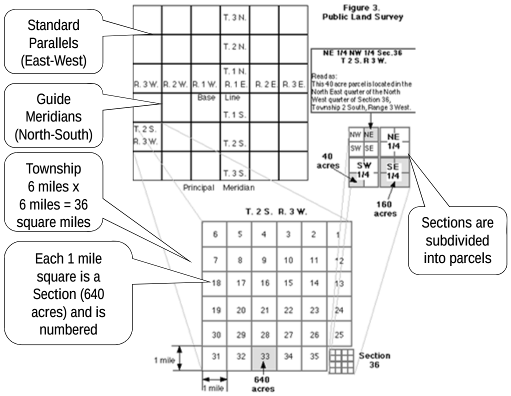
“From the pine tree to the hedge row to the river and back to the pine tree”

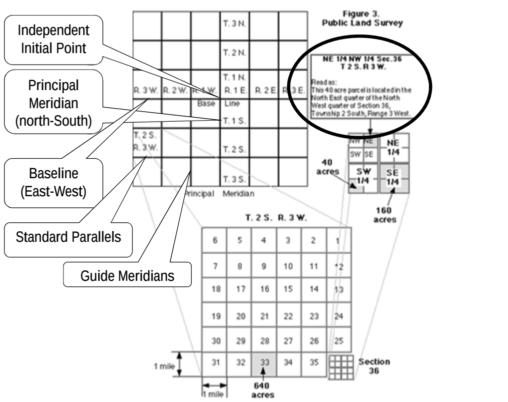


U.S. Public Land Survey: An Overview

Sub-divisions:

- Rectangular System established and maintained by the BLM
- Basis is a grid created at a reference point for each state, Boise in Idaho
- Land divided into a grid of 6-mile squares designated as townships and ranges
    - Townships running north-south
    - Ranges running east-west

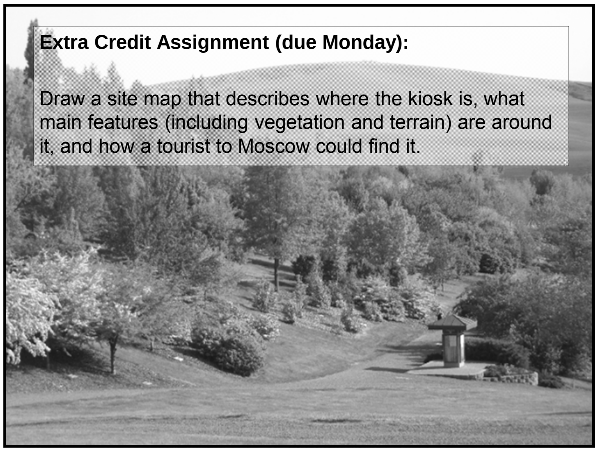

Standard Parallels (East-West)
Guide Meridians (North-South)
Township 6 miles x 6 miles = 36 square miles
Each 1 mile square is a Section (640 acres) and is numbered
Sections are subdivided into parcels
Figure 3. Public Land Survey
NE 1/4 NW 1/4 Sec.36 T 2 S. R 3 W.
Read as: This 40 acre parcel is located in the North East quarter of the North West quarter of Section 36, Township 2 South, Range 3 West.
T. 2 S. R. 3 W.
Principal Meridian
Base Line
40 acres
160 acres
640 acres
1 mile
Section 36


Independent Initial Point
Principal Meridian (north-South)
Baseline (East-West)
Standard Parallels
Guide Meridians
Figure 3. Public Land Survey
NE 1/4 NW 1/4 Sec.36 T 2 S. R 3 W.
Read as: This 40 acre parcel is located in the North East quarter of the North West quarter of Section 36, Township 2 South, Range 3 West.
T. 2 S. R. 3 W.
40 acres
160 acres
640 acres
1 mile
Section 36

** Board


BEARING TREE
CORNER IS APPROXIMATELY
DIRECTION
DISTANCE
T.
R.
SEC.
CORNER
TRACT
POSTED BY
DATE

Take Home Message: Site conditions can greatly influence how surveys and measurements are conducted


Extra Credit Assignment (due Monday):
Draw a site map that describes where the kiosk is, what main features (including vegetation and terrain) are around it, and how a tourist to Moscow could find it.