Geohazards Impacting Transportation in the Appalachian Region

Dendrogeomorphology – A Means to Assess Past, Present, and Future Landslide Activity

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Dendrogeomorphology

Origin of the tongue-twister –

Dendrochronology, the science of dating changes in the environment through tree-ring analysis

Geomorphology, the science of landform configuration and change

Landslides in the Glaciated Northeast

The common elements for landslides in the glaciated parts of New York and elsewhere are:

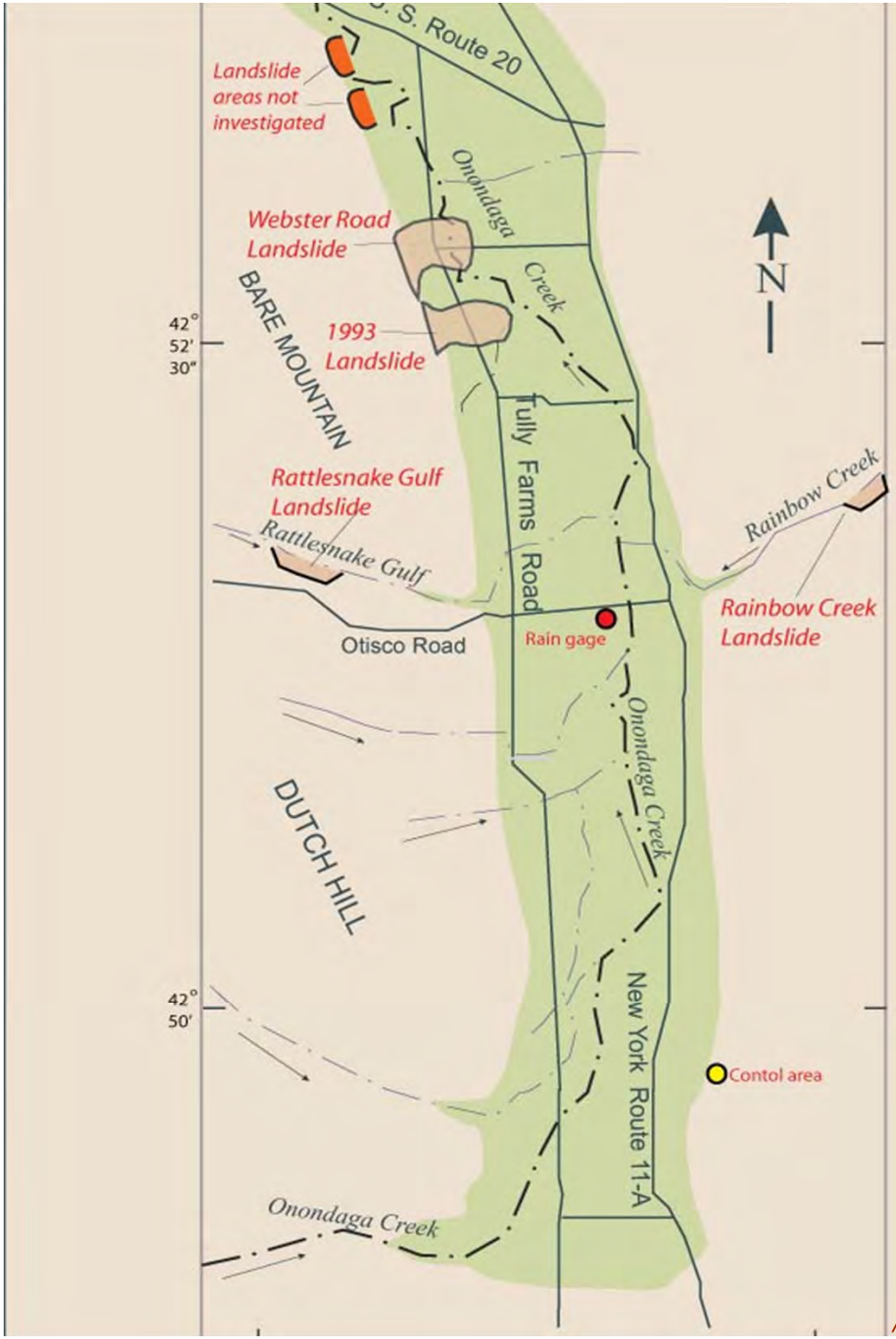
Steep slopes

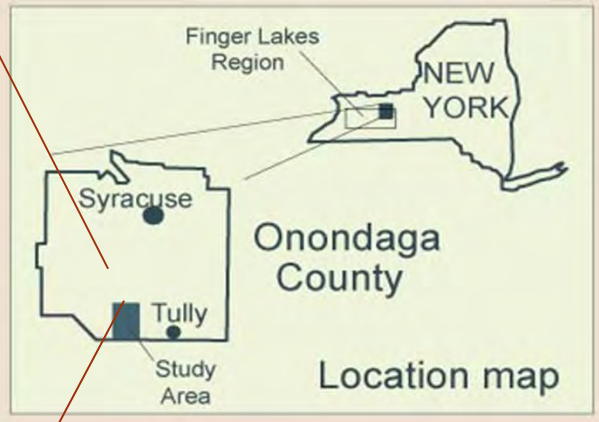
Glacial lake (lacustrine) clay and silt

Slope toe-cutting by high streamflow conditions

Destabilization of slopes by construction activities

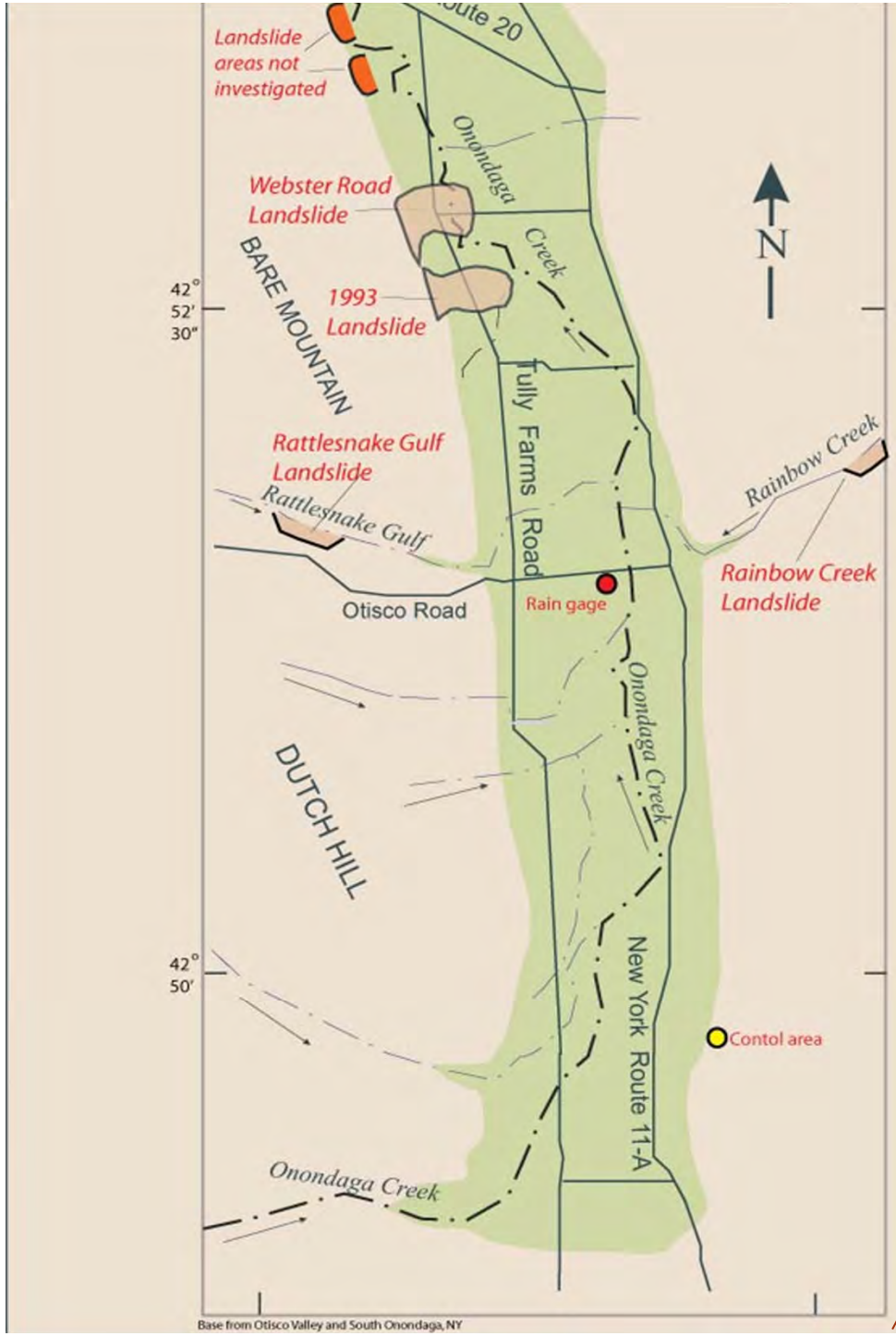
Tully Valley Landslides Old and New

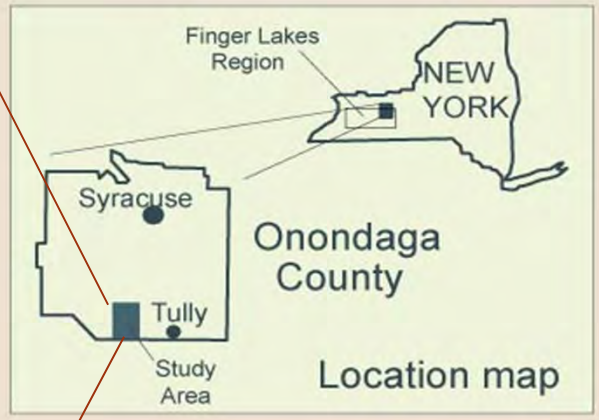


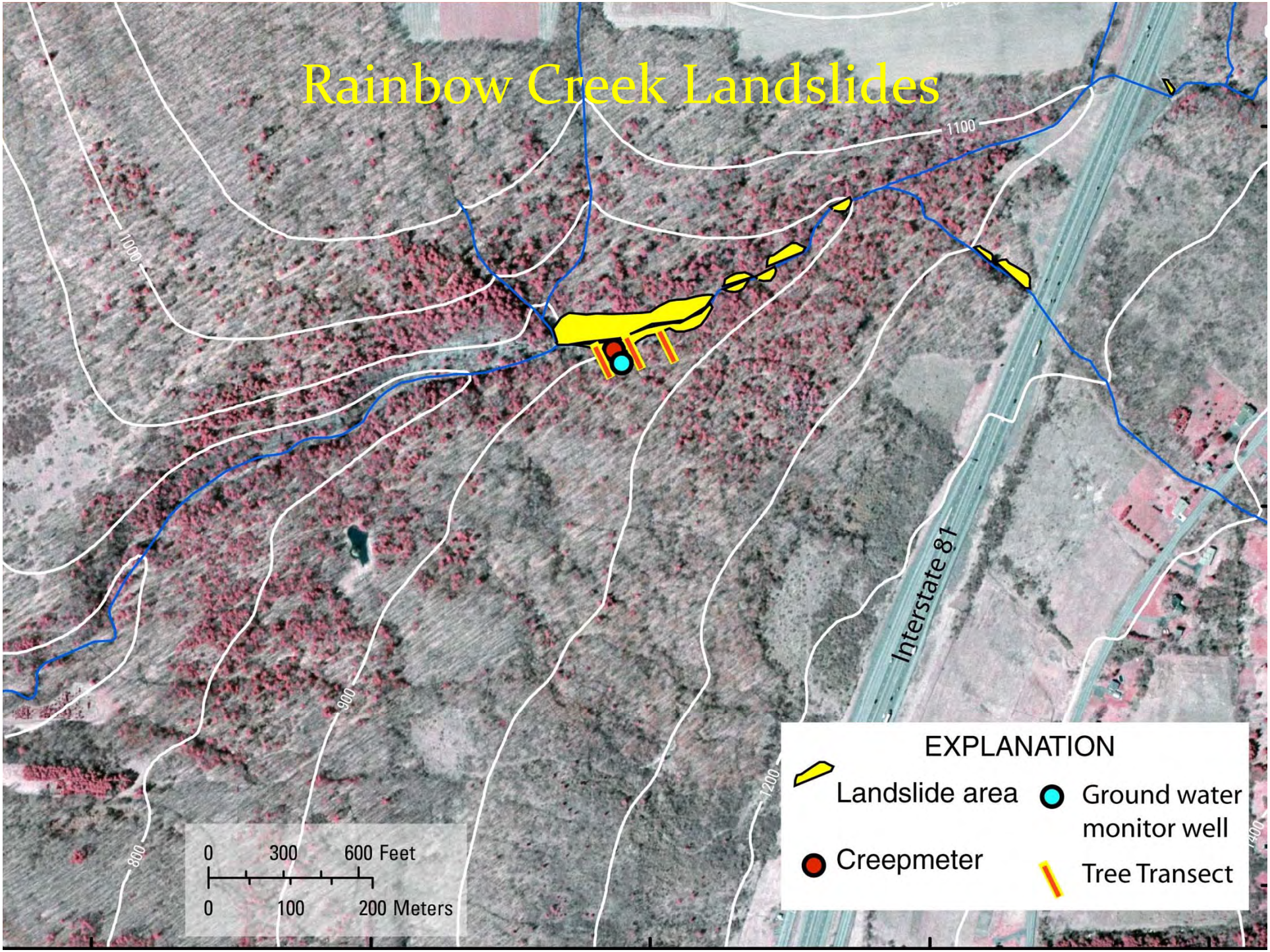


Tully Valley Landslide - 1993

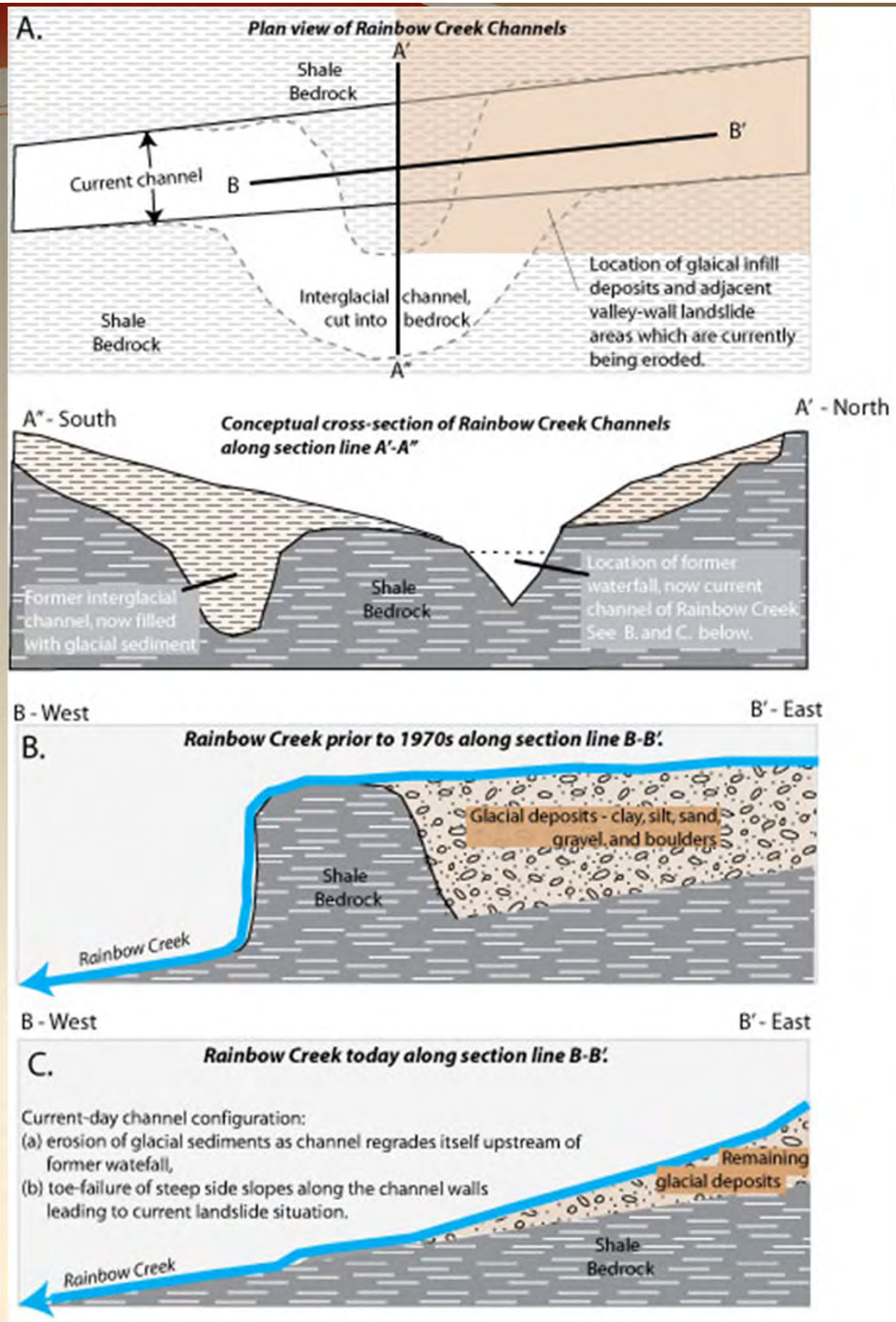
Tully Valley Landslides Old and New






Rainbow Creek Landslides
1100
1000
900
800
1200
1400
Interstate 81
0 300 600 Feet
0 100 200 Meters
EXPLANATION
Landslide area
Ground water monitor well
Creepmeter
Tree Transect

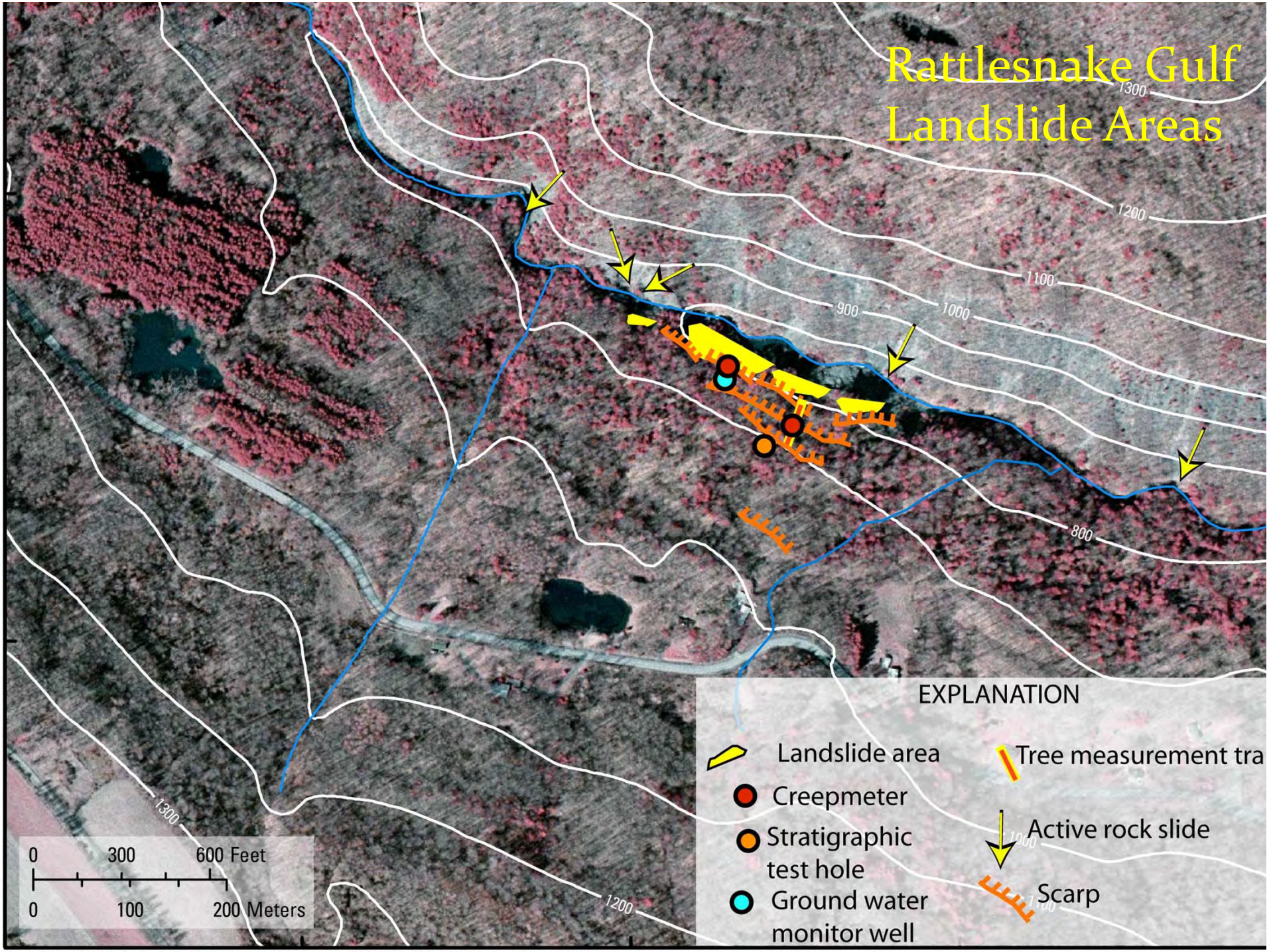

Former Waterfall Crest


A.
Plan view of Rainbow Creek Channels
A'
Shale Bedrock
B'
Current channel
B
Location of glaical infill deposits and adjacent valley-wall landslide areas which are currently being eroded.
Interglacial channel, cut into bedrock
Shale Bedrock
A"
A" - South
Conceptual cross-section of Rainbow Creek Channels along section line A'-A"
A' - North
Location of former waterfall, now current channel of Rainbow Creek. See B. and C. below.
Shale Bedrock
Former interglacial channel, now filled with glacial sediment
B - West
B' - East
B.
Rainbow Creek prior to 1970s along section line B-B'.
Glacial deposits - clay, silt, sand, gravel, and boulders
Shale Bedrock
Rainbow Creek
B - West
B' - East
C.
Rainbow Creek today along section line B-B'.
Current-day channel configuration:
(a) erosion of glacial sediments as channel regrades itself upstream of former watefall,
(b) toe-failure of steep side slopes along the channel walls leading to current landslide situation.
Remaining glacial deposits
Shale Bedrock
Rainbow Creek

Rainbow Creek at NYS-Route 11-A

Alluvial Fan build-up on
the floor of the Tully Valley

2 five-foot squashed culverts filled
with coarse-grained sediment
from Rainbow landslide area.



Base from NYC Digital Orthoimagery Program (NYCDOP), 2004

Rattlesnake Gulf Earth Slumps, and Mudflows

Note inclination of trees on the upslope.

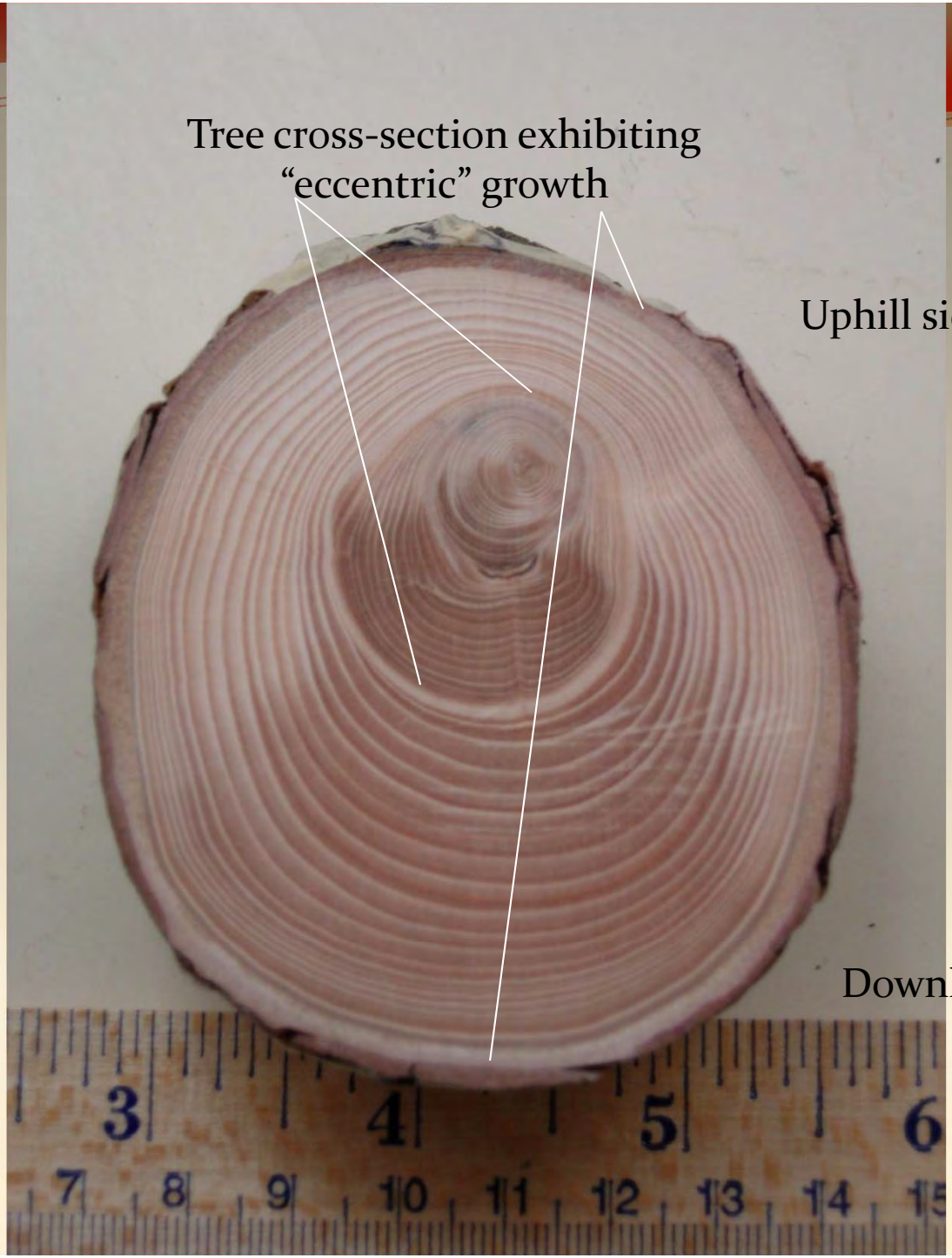

New flow material
(sandy silt)
Slump block movement
(clay and silt)


Channel Aggradation

Dendrogeomorphology

Finally……

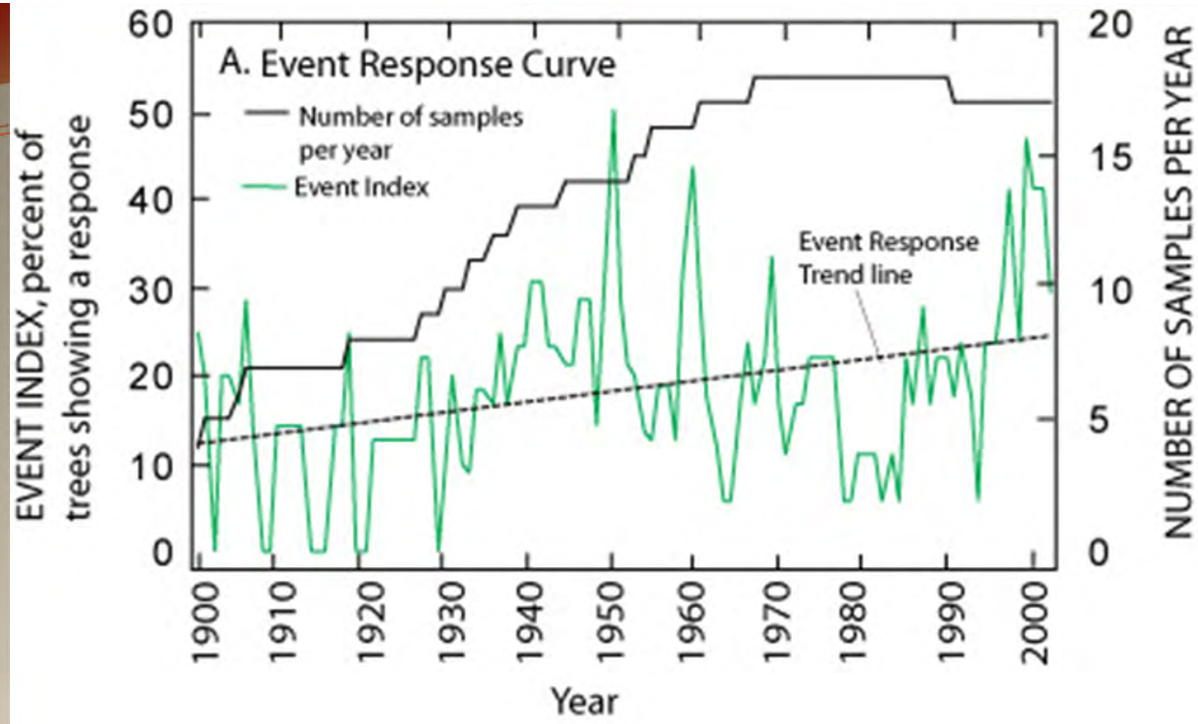
“Jayed” Trees generally indicate slope/tree movement

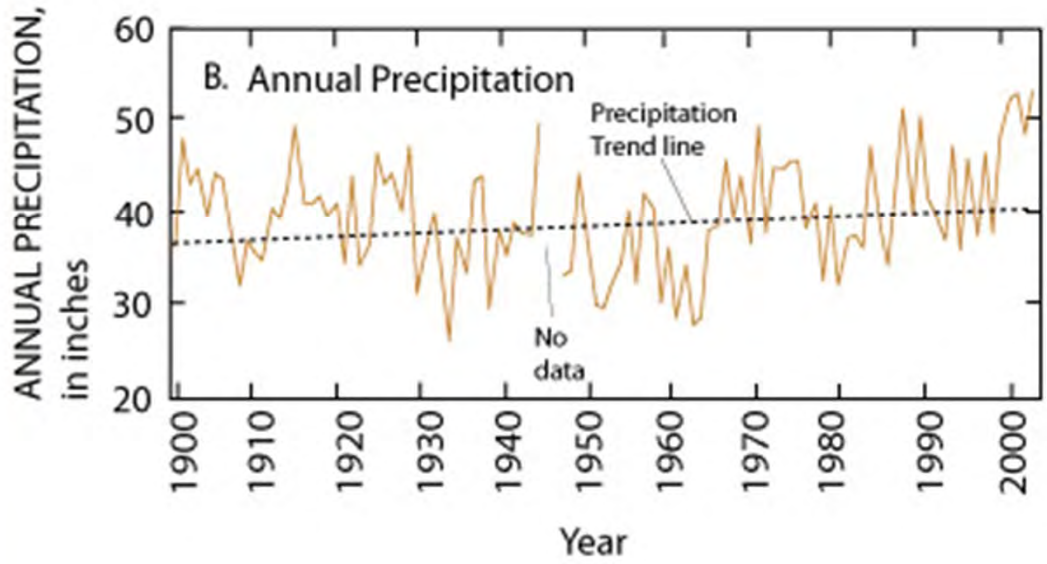

Tree cross-section exhibiting
“eccentric” growth
Uphill side of tree
Downhill side of tree

Increment boring – a pencil-sized core from a tree

2 cores usually taken from each tree – one on the uphill and one on the downhill side of the tree

Annual ring-width difference ratio is then used to determine the year in which an 'event response' occurred, as shown by the eccentric growth.


A. Event Response Curve
Number of samples per year
Event Index
Event Response Trend line
EVENT INDEX, percent of trees showing a response
NUMBER OF SAMPLES PER YEAR
Year
0
10
20
30
40
50
60
0
5
10
15
20
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000


B. Annual Precipitation
Precipitation Trend line
No data
ANNUAL PRECIPITATION, in inches
Year
20
30
40
50
60
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

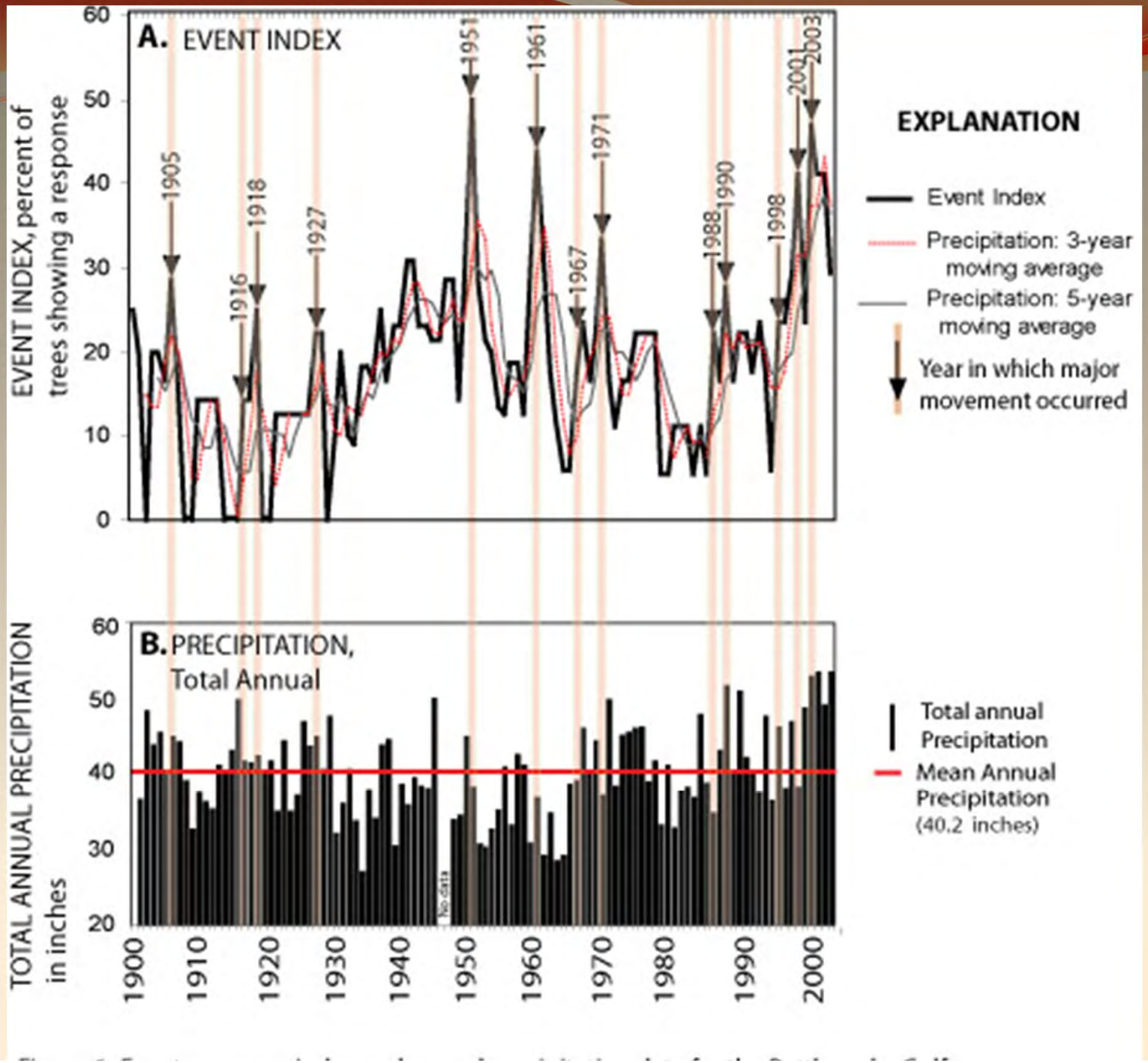
Event response curve indicates years of ‘significant’ slope movement corresponding to eccentric ring response in a number of trees.

What caused the event response was the next part of the study –

Above normal precipitation in a single year?

Three- or five year moving average precipitation?

Dry periods followed by wet periods?


A. EVENT INDEX
EVENT INDEX, percent of trees showing a response
1905
1916
1918
1927
1951
1961
1967
1971
1988
1990
1998
2001
2003
EXPLANATION
Event Index
Precipitation: 3-year moving average
Precipitation: 5-year moving average
Year in which major movement occurred
B. PRECIPITATION, Total Annual
TOTAL ANNUAL PRECIPITATION in inches
No data
Total annual Precipitation
Mean Annual Precipitation (40.2 inches)

Results of the response-curve assessment:

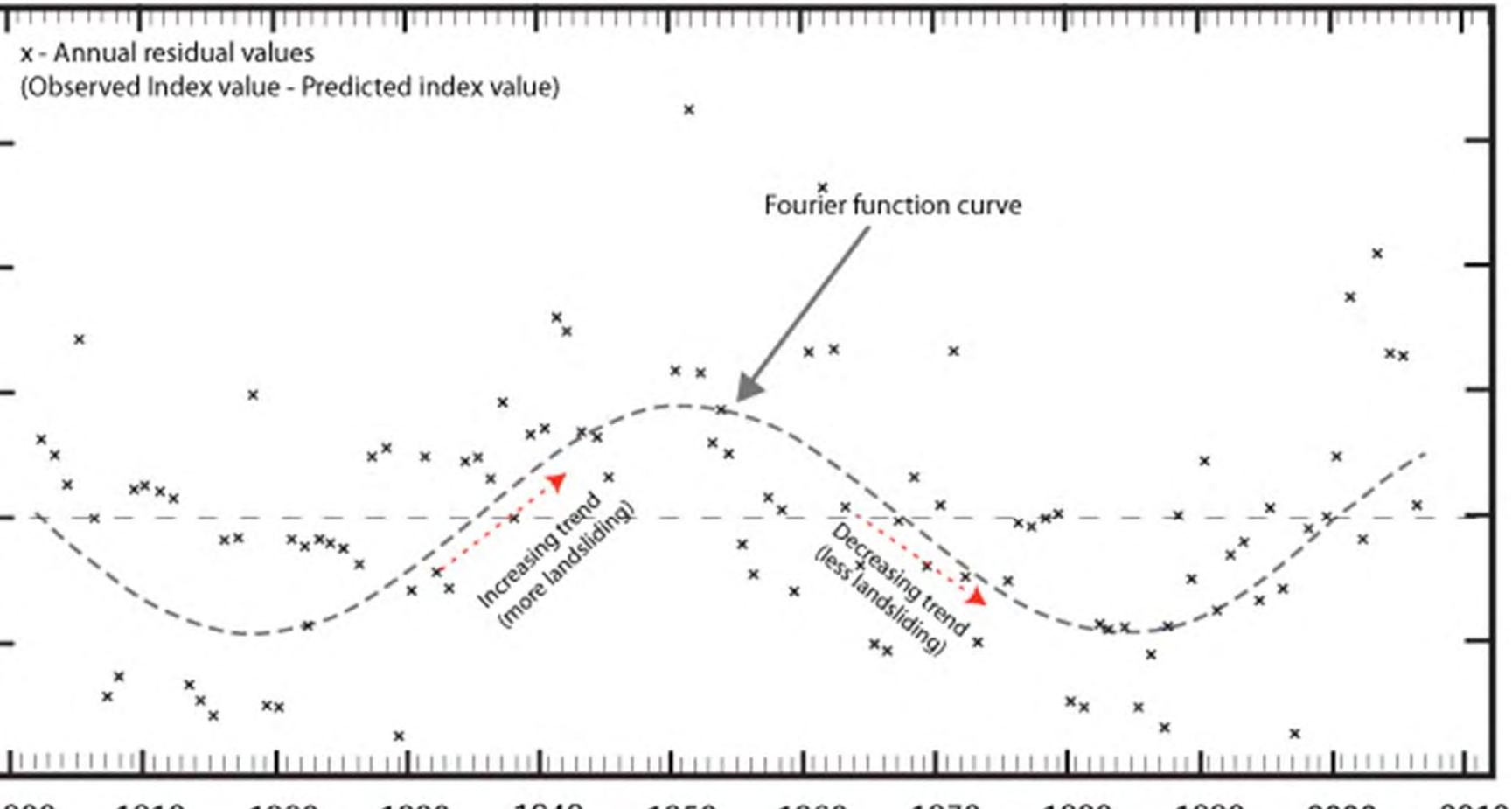
Above normal annual or event based precipitation - Not significant

3-year and 5-year moving average precipitation - Sometimes significant

Dry years followed by above-normal precipitation - Often times significant

Is there something else? Yes, there always is.....

Linear Regression - Residual Values Analysis



esidual values from linear regression showed a periodic nature –

30-year +/- increase in landslide activity followed by a similar period of declining landslide activity.

So……

Could it be a long-term response to slope failure propagating uphill followed by a period of general slope stability?

Could it be related to tree stand maturity and(or) timber harvesting?

Both cases are a possibility, possibly in tandem, but we do not have enough

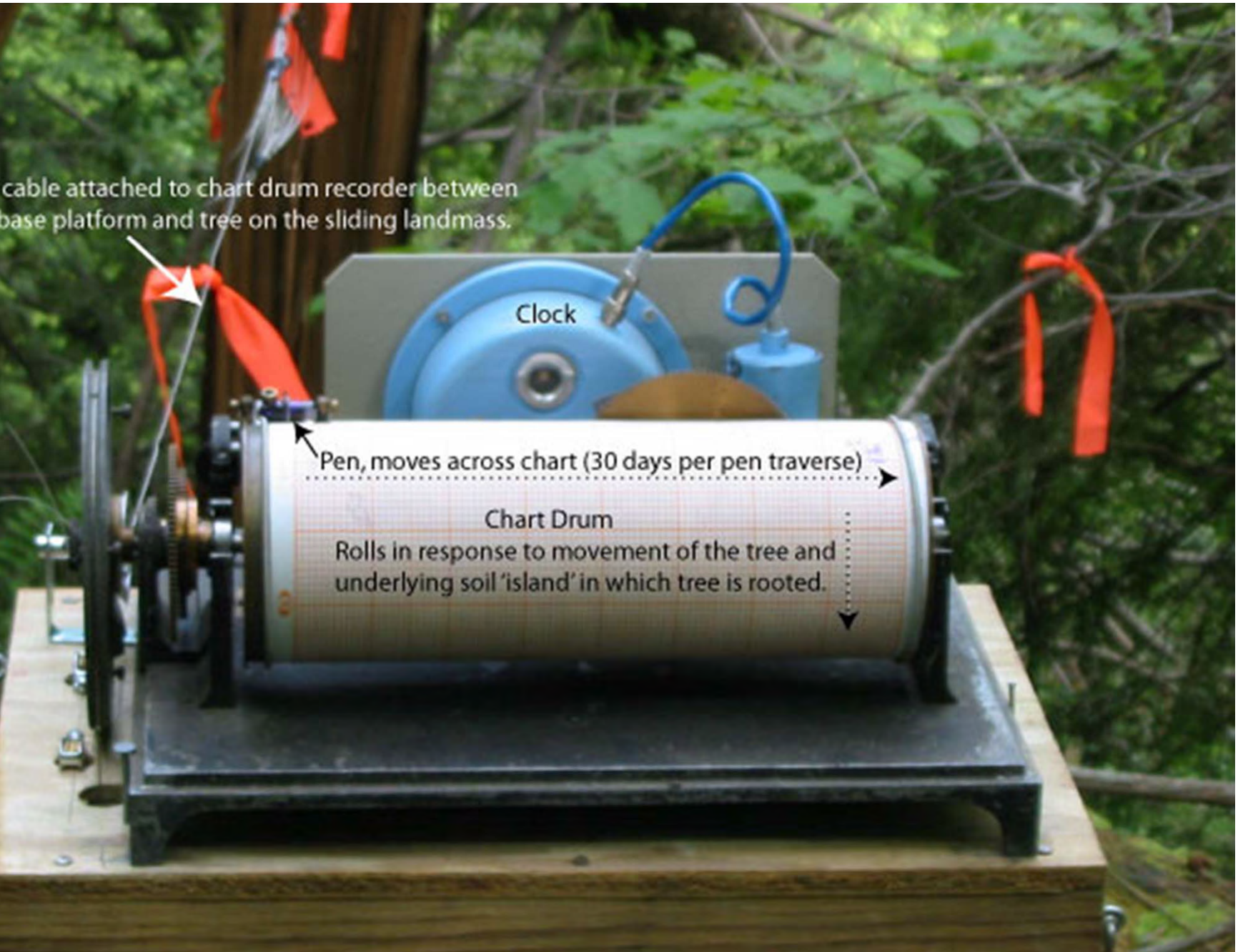
Bottom Line --

ment of slope stability involves understanding the geologic nature of the slope, characteristics, vegetation, climatic conditions and trends, and how the slope enced by natural and anthropogenic change.

ndrogeomorphology is a useful tool to determine the stability and nature of ep slopes, and provides a “forensic” record of slope stability when no other oric record of stability is available.

he presence of ‘jayed’ trees, when viewed with the character of the slope (as utlined above) can be a simple, but good indicator of slope instability.

-Tree" Photo Sequence
il 2006 – September 2007


cable attached to chart drum recorder between
base platform and tree on the sliding landmass.
Clock
Pen, moves across chart (30 days per pen traverse)
Chart Drum
Rolls in response to movement of the tree and
underlying soil 'island' in which tree is rooted.

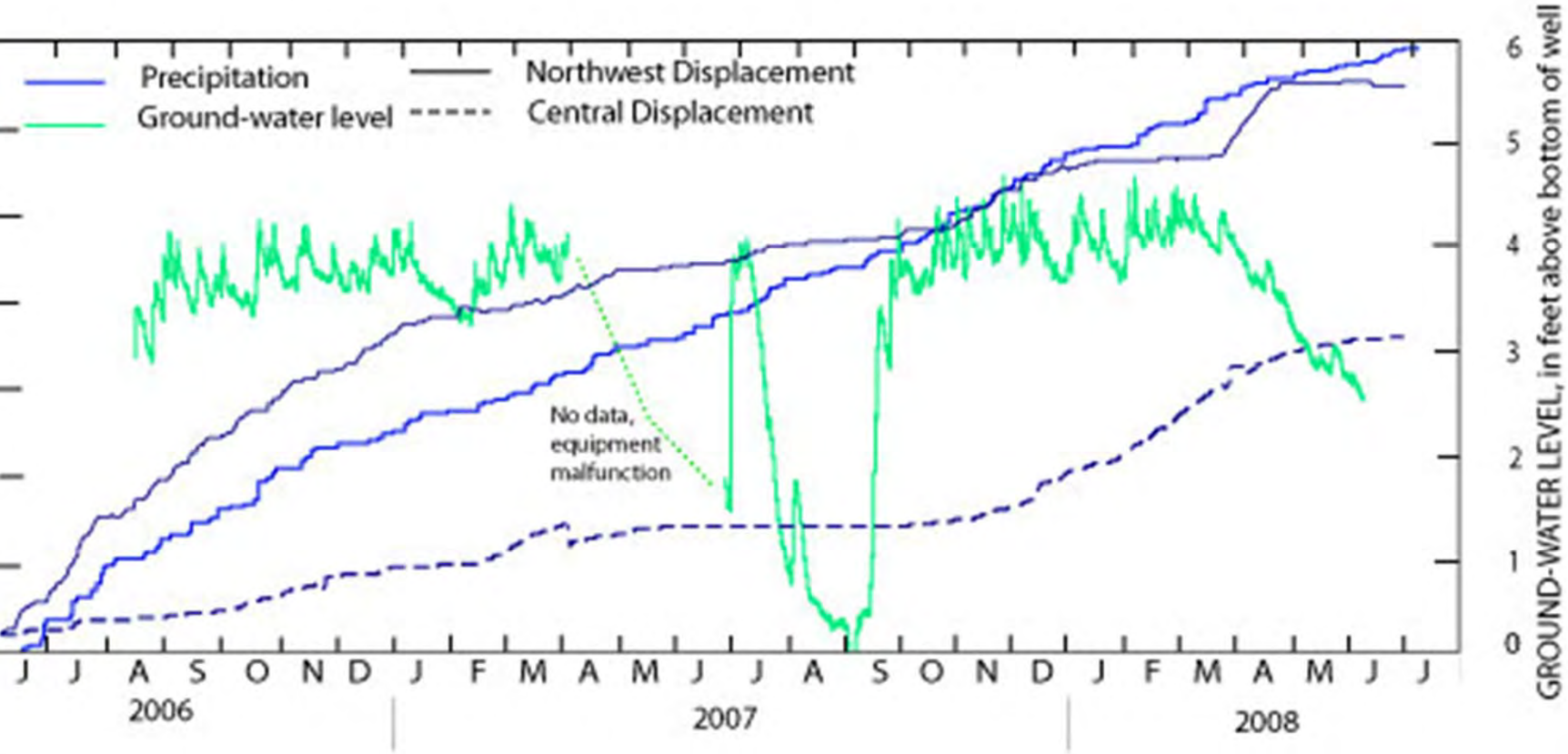
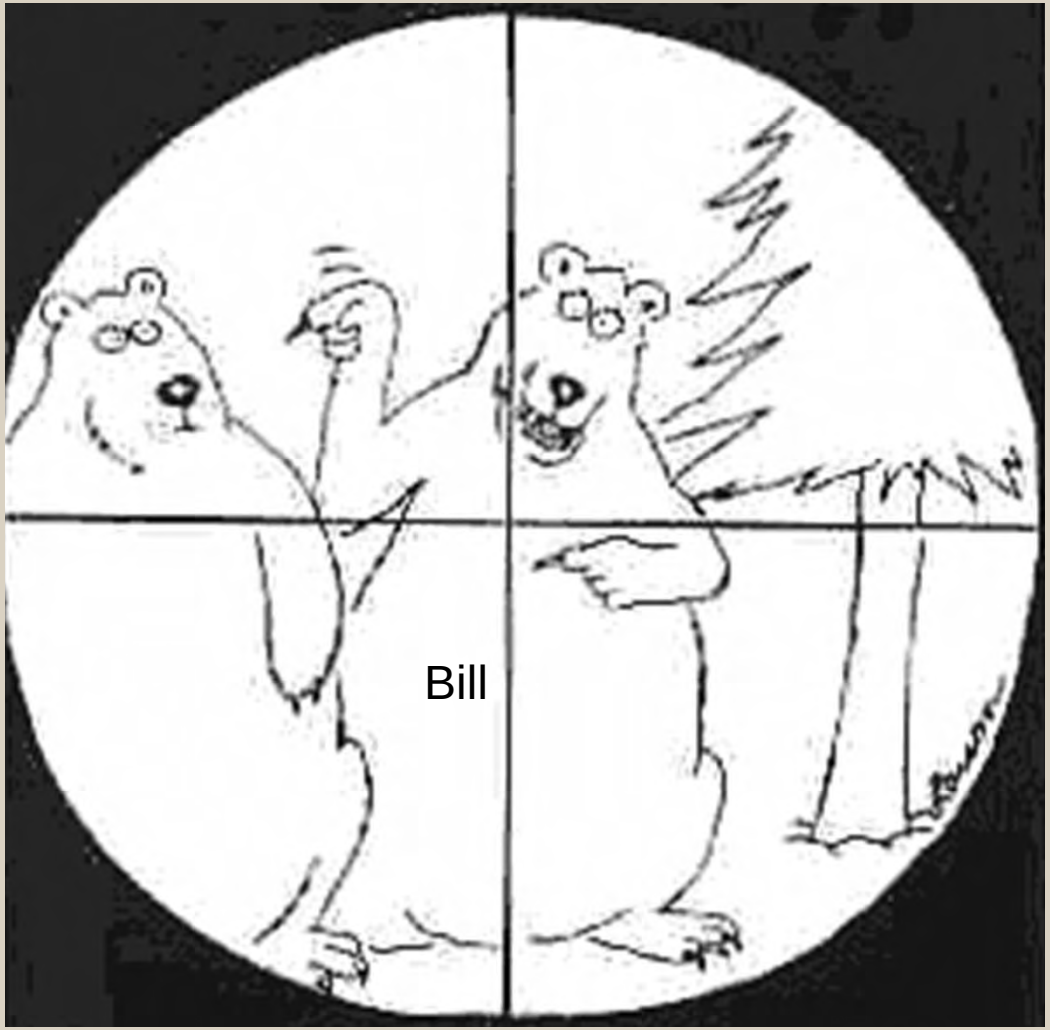


Figure 3.--Cumulative creepmeter displacement and precipitation in relation to ground-water level within the Rattlesnake Gulf landslide area from June 2006 through June 2008 (Location shown in fig. 2.)

Questions?



Gary Larsen, 1981