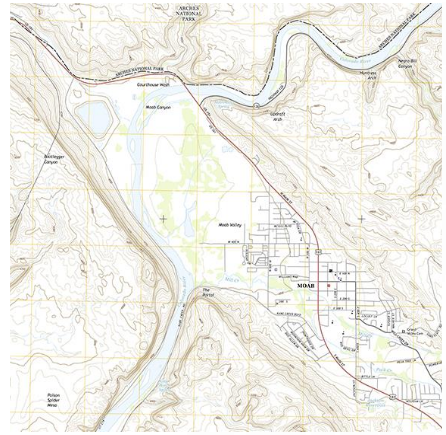
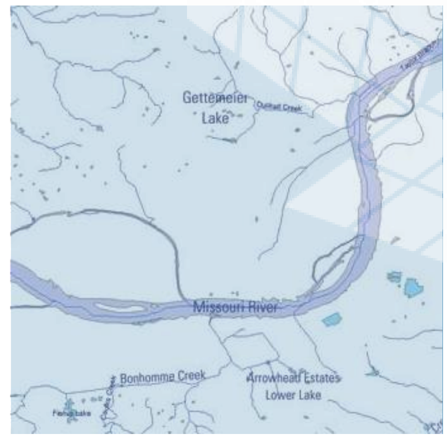
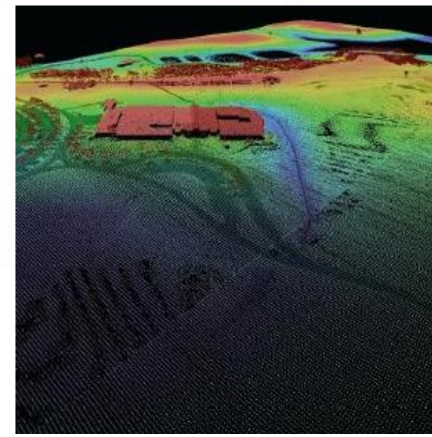
USGS National Hydrography Dataset (NHD) and NHDPlus







Al Rea
USGS National Geospatial Program

Western States Water Council
August 1, 2018

USGS science for a changing world

The National Map
Your Source for Topographic Information

USGS National Hydrography Datasets

Hydrologic networks, units, catchments, and more…

National Hydrography Dataset (NHD)

- The drainage network with features such as rivers, streams, canals, lakes, ponds, and stream gages

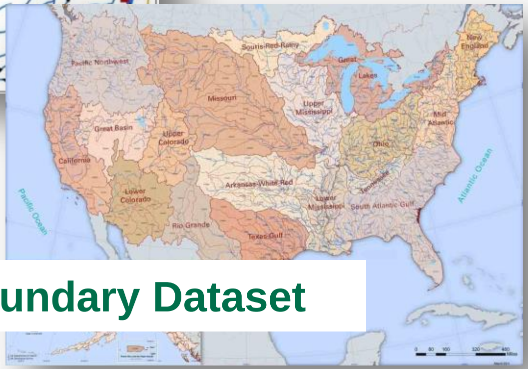
Watershed Boundary Dataset (WBD)

- The drainage basins at 8 scales of a nested hierarchy; defines the areal extent of surface water drainage to a point

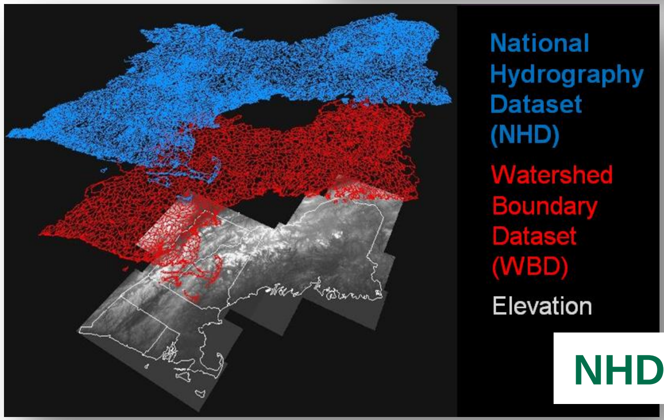
NHDPlus

- Incorporates features of the NHD, WBD and 3DEP elevation data to create a networked hydrography framework that incorporates the entire landscape

National Hydrography Dataset



Watershed Boundary Dataset



NHDPlus

USGS science for a changing world

The National Map Your Source for Topographic Information

The Evolution of NHD and NHDPlus

EPA/USGS-W
Reach File Version 1 (RF1)
(1:500,000)

1982

EPA/USGS-W/USGS-G
Medium Res NHD
(1:100,000)

2000

EPA/USGS-W
Medium Res NHD*Plus*
(1:100,000)

2006, 2012

USGS-G
High Res NHD
(1:24,000 or better)

2007

USGS-G
High Res NHD*Plus*
(1:24,000 or better
with generalization)

~2020

The blue boxes identify the Framework versions used to estimate stream flow volume and velocity.

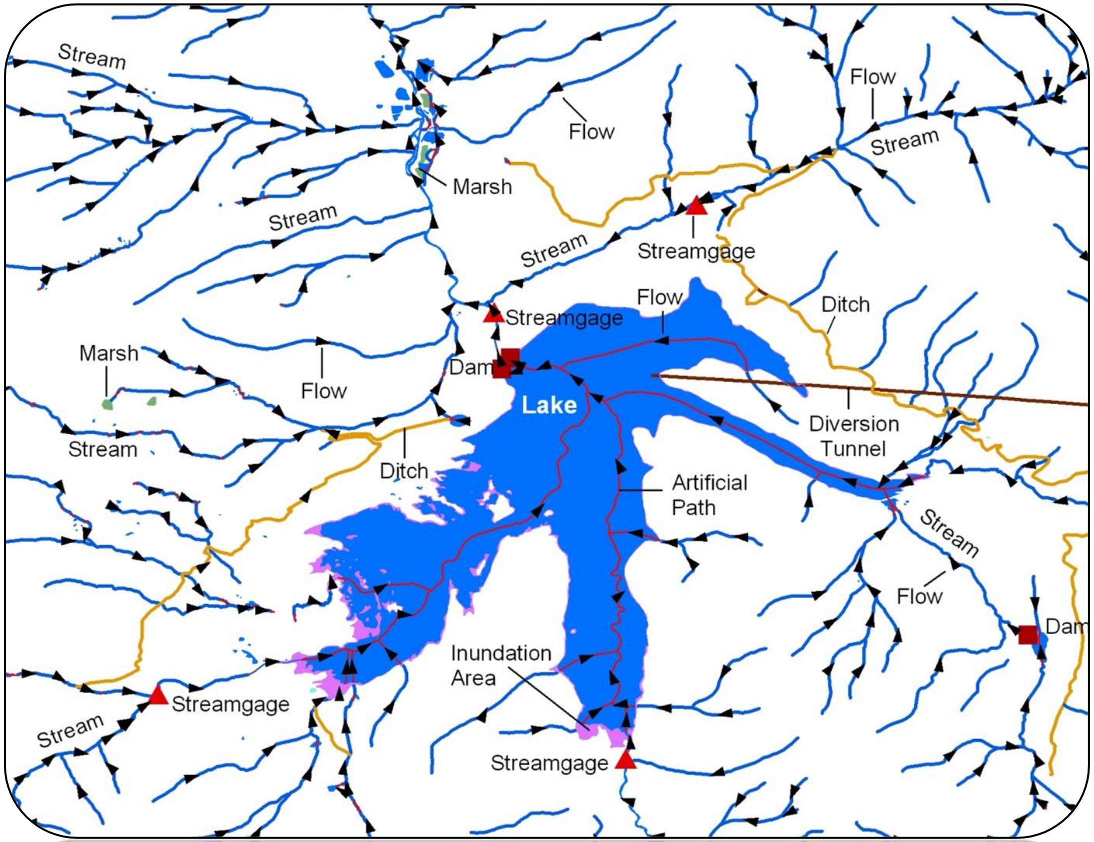
Slide: Tommy Dewald (USEPA)

USGS science for a changing world
The National Map
Your Source for Topographic Information

National Hydrography Dataset

Water network for mapping and modeling

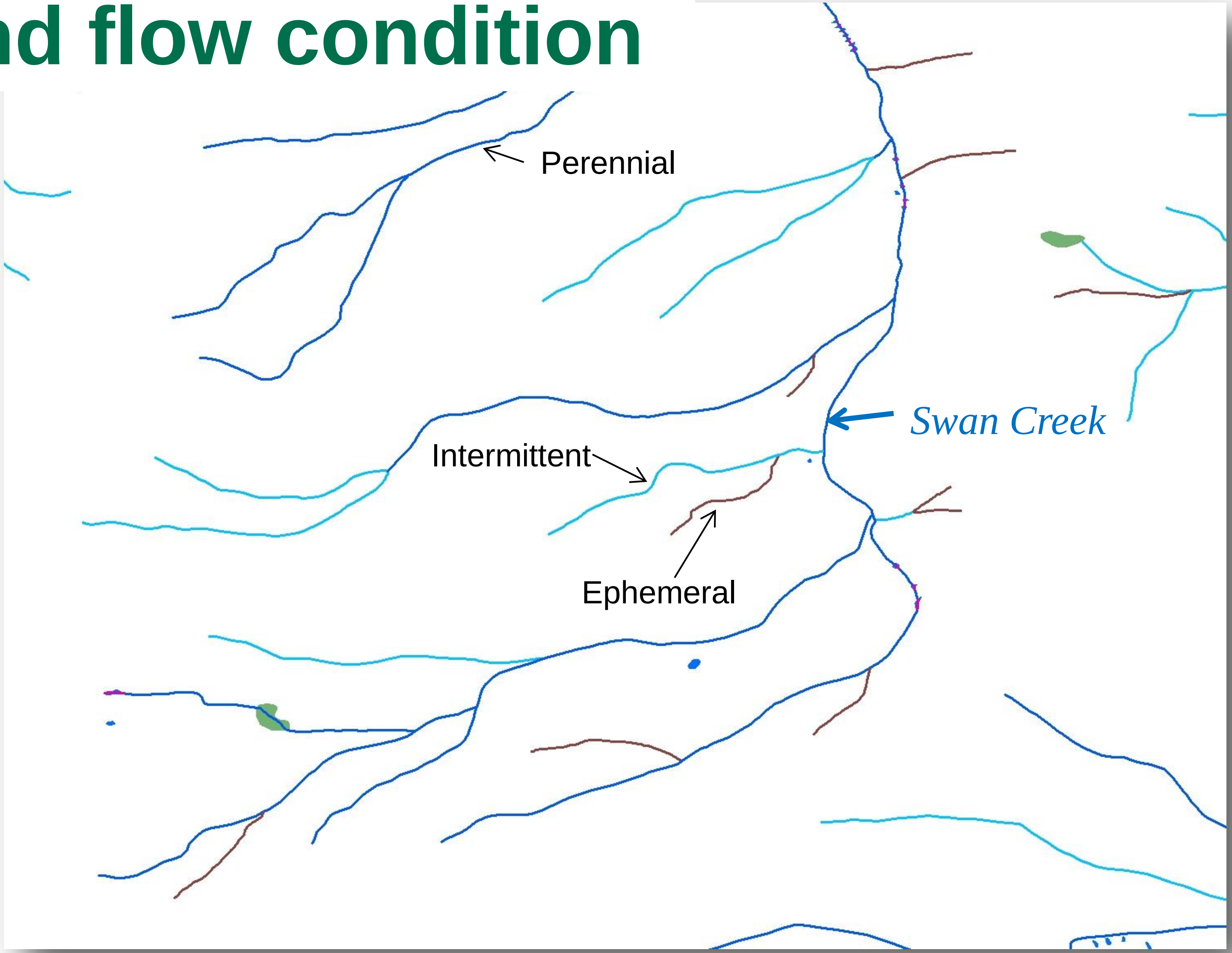
- National drainage network of streams and lakes, plus other hydro info, in a GIS format
- Currently 1:24K or better (1:63K – 1:24K in AK)
- Shapefile and GDB downloads, plus web-based map services



USGS science for a changing world

The National Map
Your Source for Topographic Information

Attributes: Names and flow condition

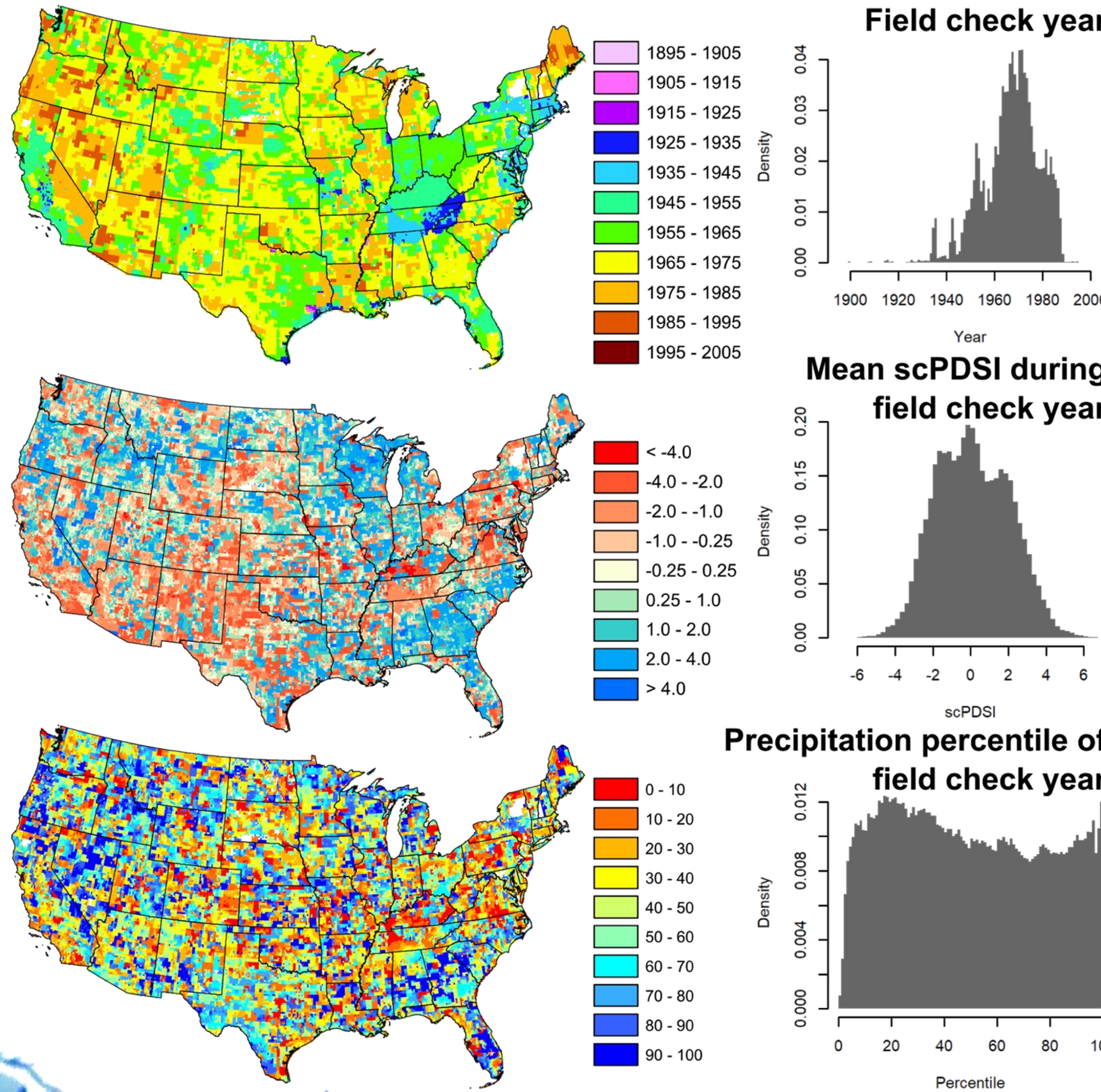


However

- Original topo maps were made over many decades, with somewhat changing standards, and different source materials
- Sometimes they didn't finish the maps and published provisional "P-maps"
- Since 2007 many updates
  - Correcting errors
  - Different interpretation by stewards
  - Densification of networks using higher resolution sources like lidar

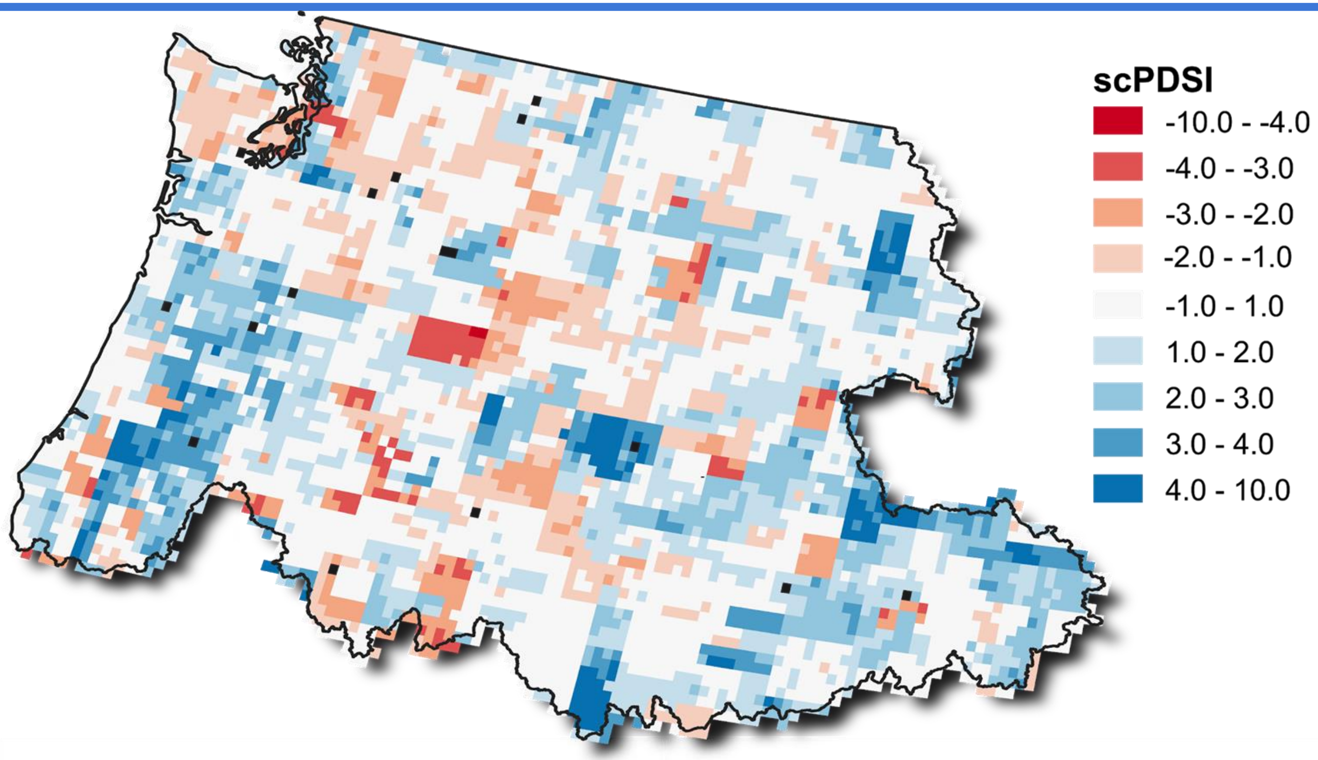
A Hypothesis for classification differences

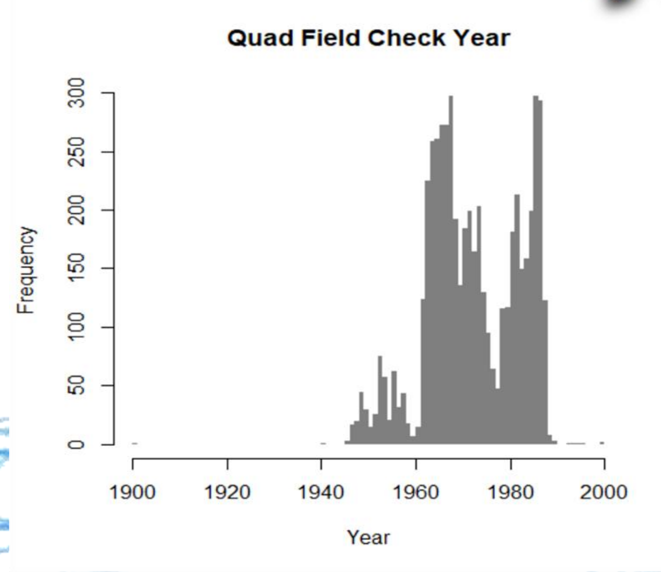
- Differences in climate during field check years of USGS quad maps may affect stream permanence classifications
- Throughout the US, quad maps were field checked across varying climate conditions
- scPDSI and precipitation percentile used as indicators of ‘wetness’

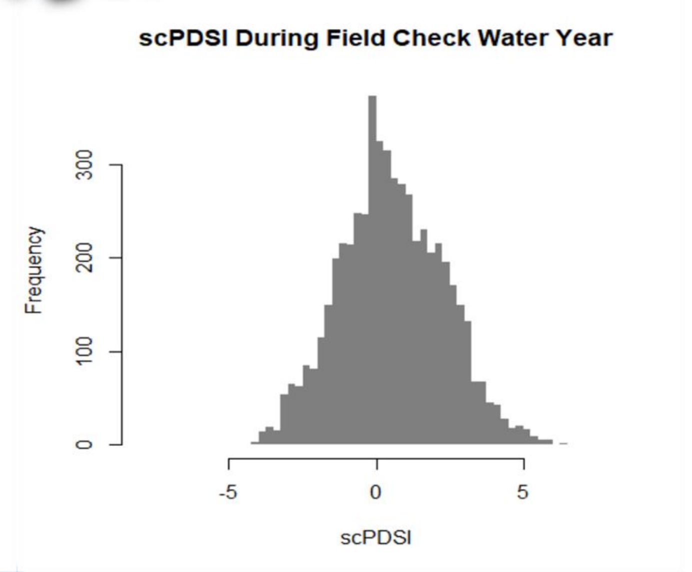


In the CRB

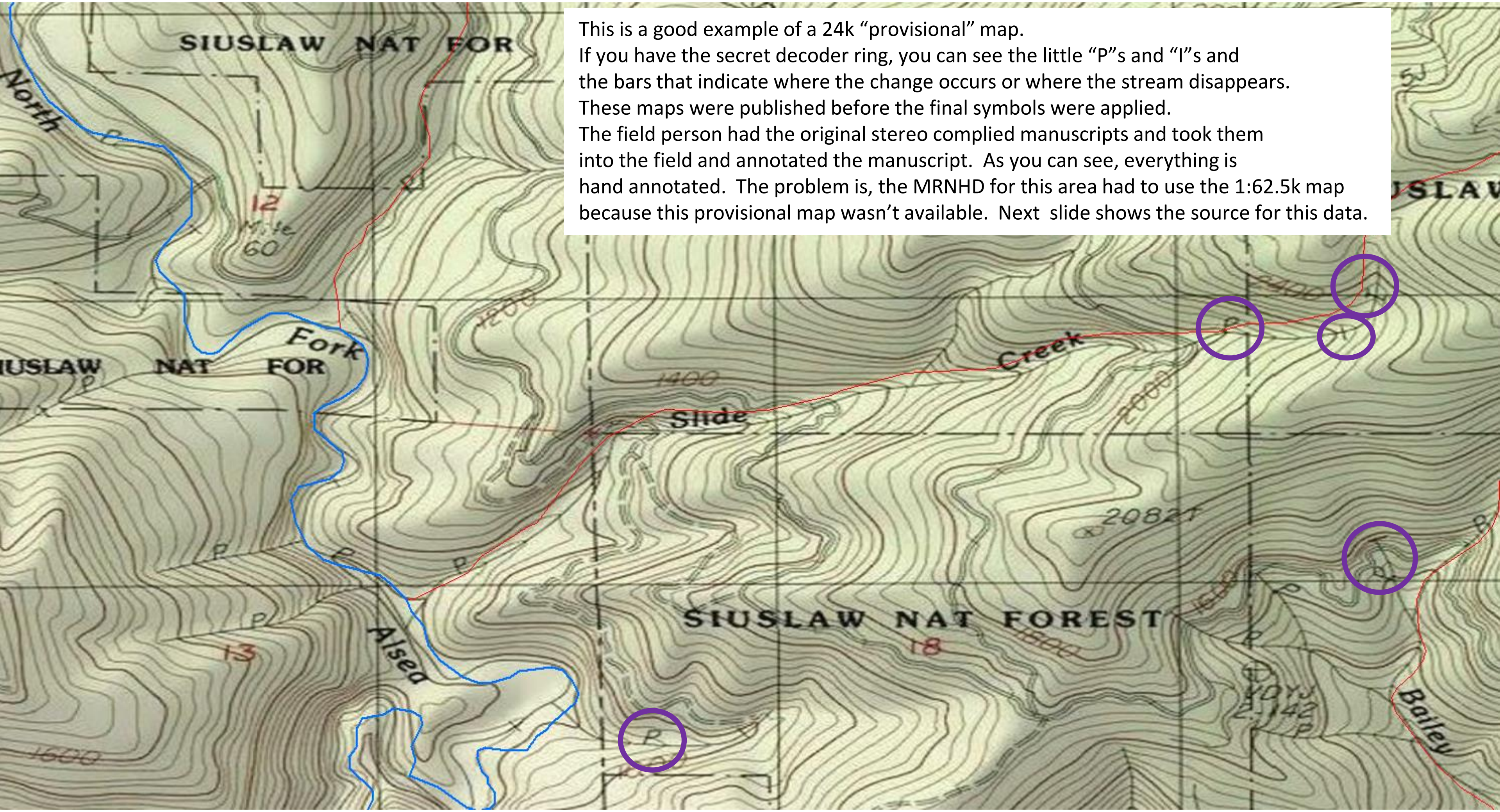
- Majority of topo quads collected 1960-1990
- Conditions during quad collection varied substantially, from extremely wet to extremely dry



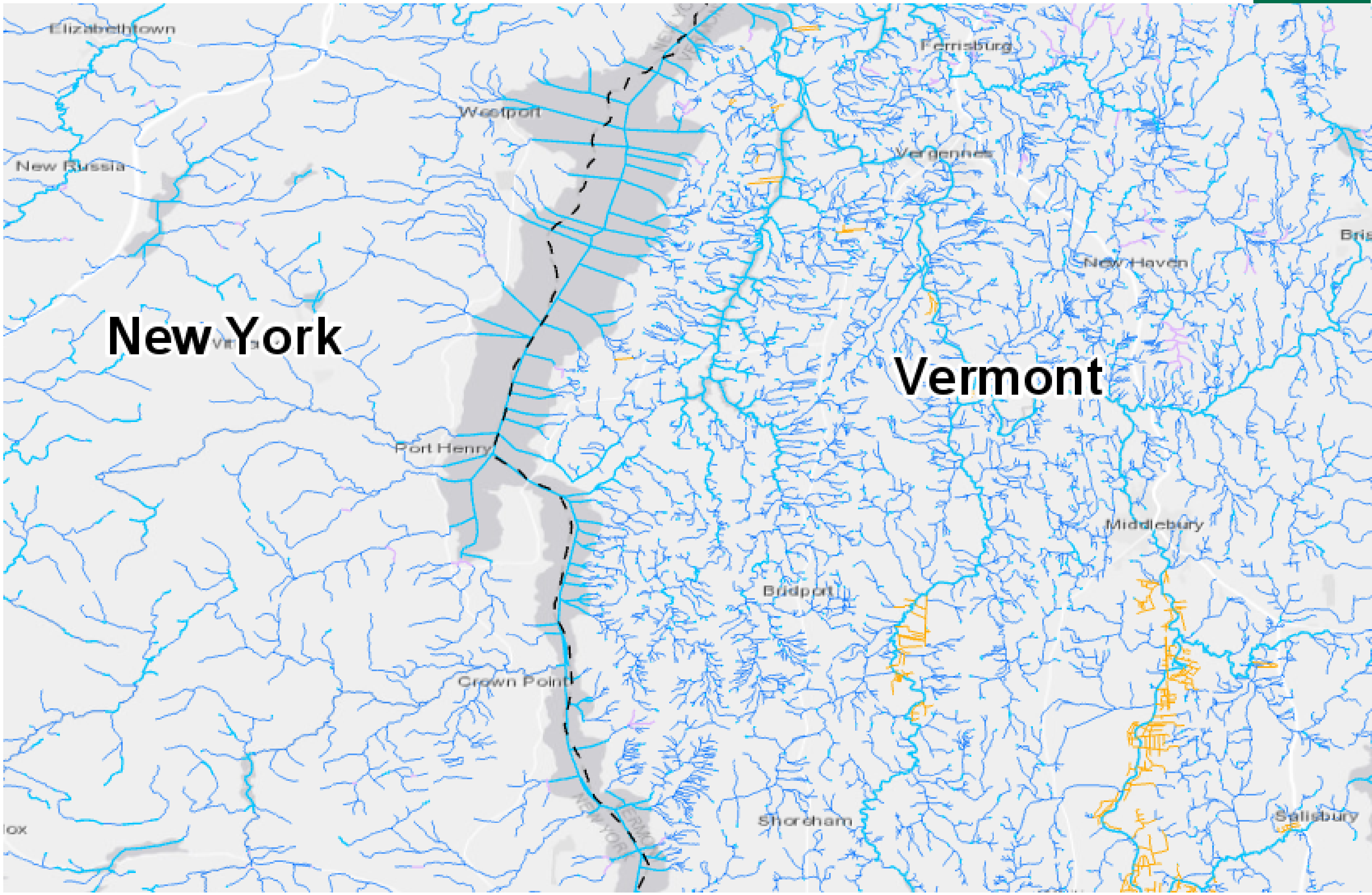




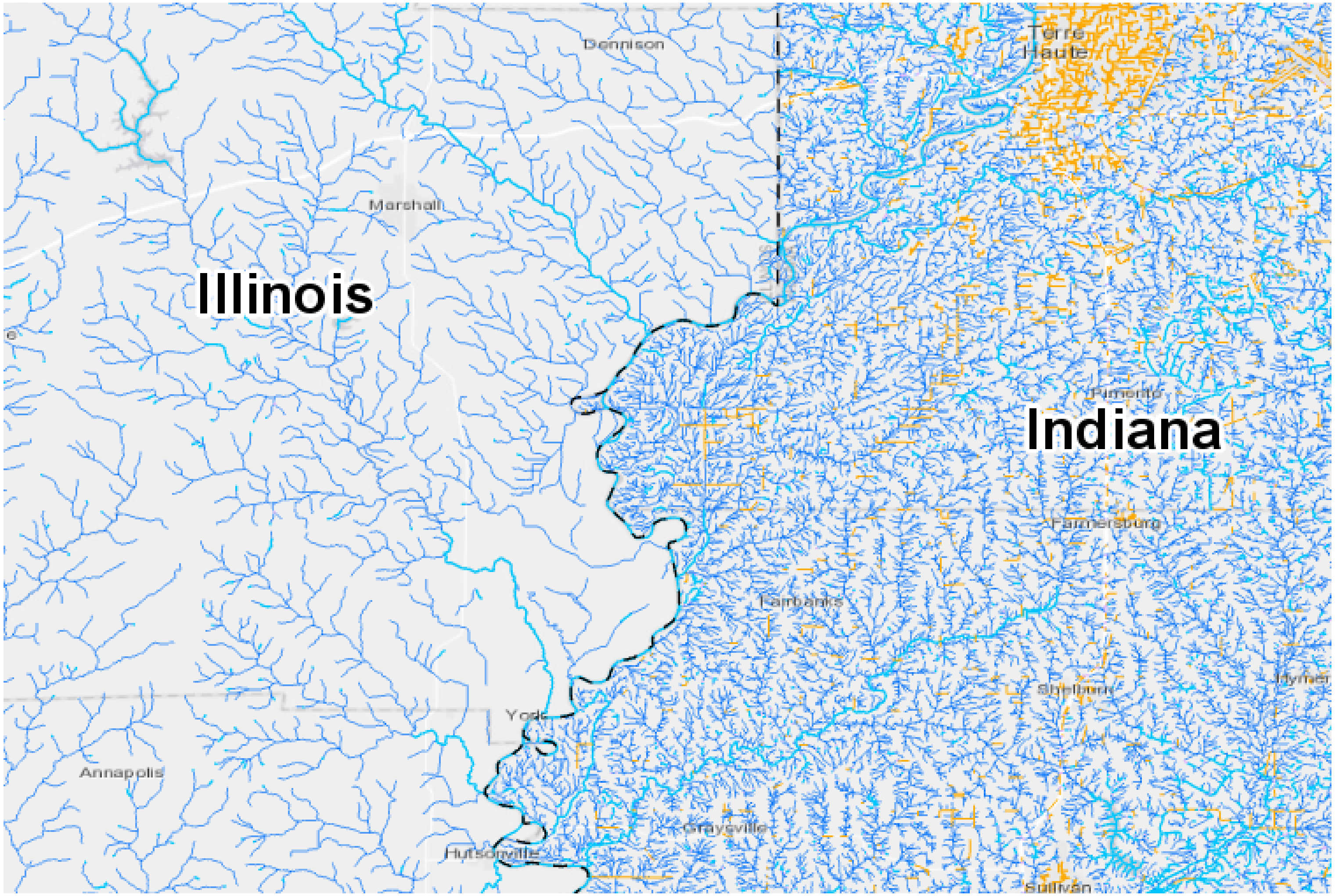
This is a good example of a 24k “provisional” map.
If you have the secret decoder ring, you can see the little “P”s and “I”s and
the bars that indicate where the change occurs or where the stream disappears.
These maps were published before the final symbols were applied.
The field person had the original stereo complied manuscripts and took them
into the field and annotated the manuscript. As you can see, everything is
hand annotated. The problem is, the MRNHD for this area had to use the 1:62.5k map
because this provisional map wasn’t available. Next slide shows the source for this data.

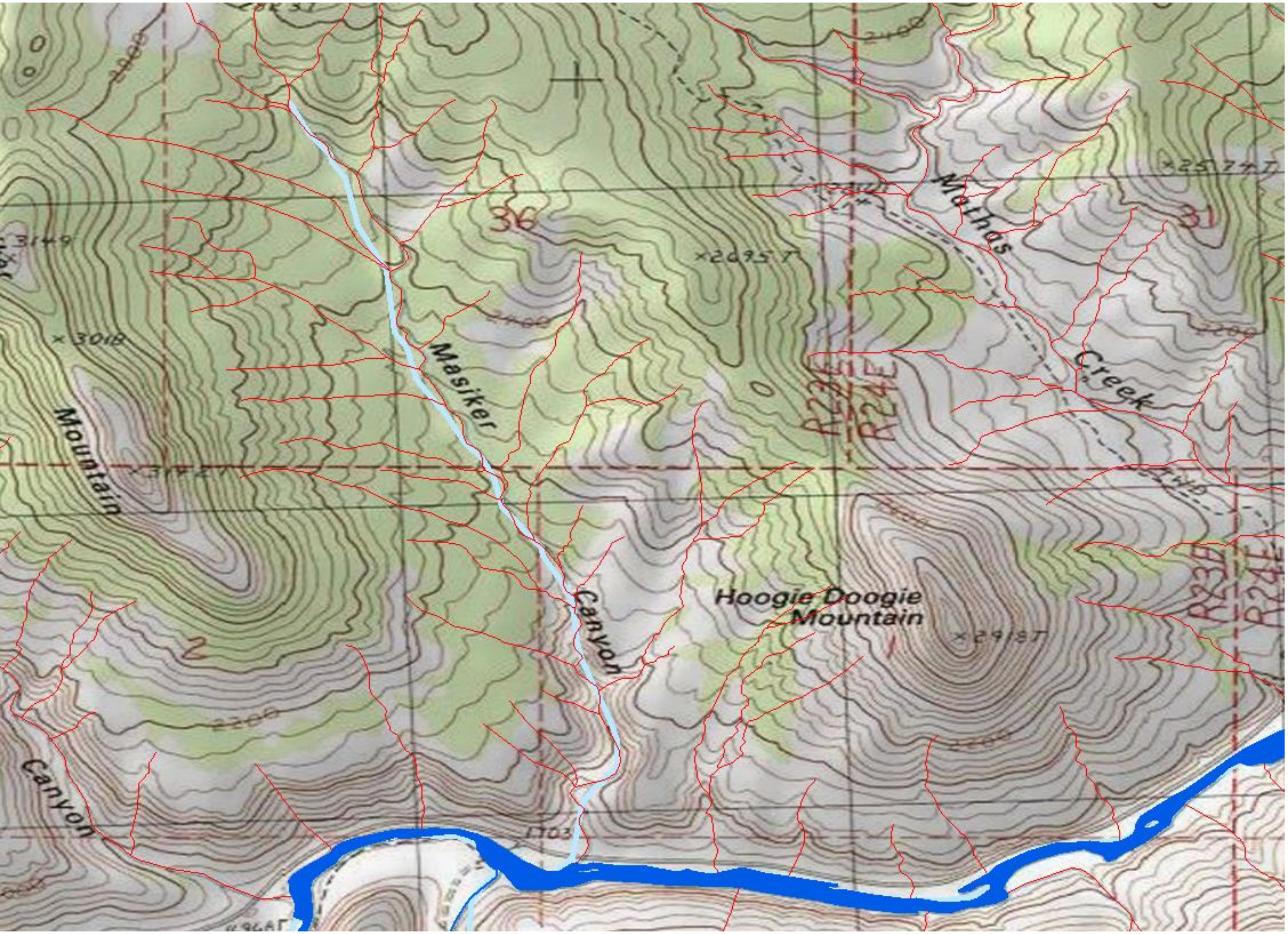


NHD is a multi-scale dataset

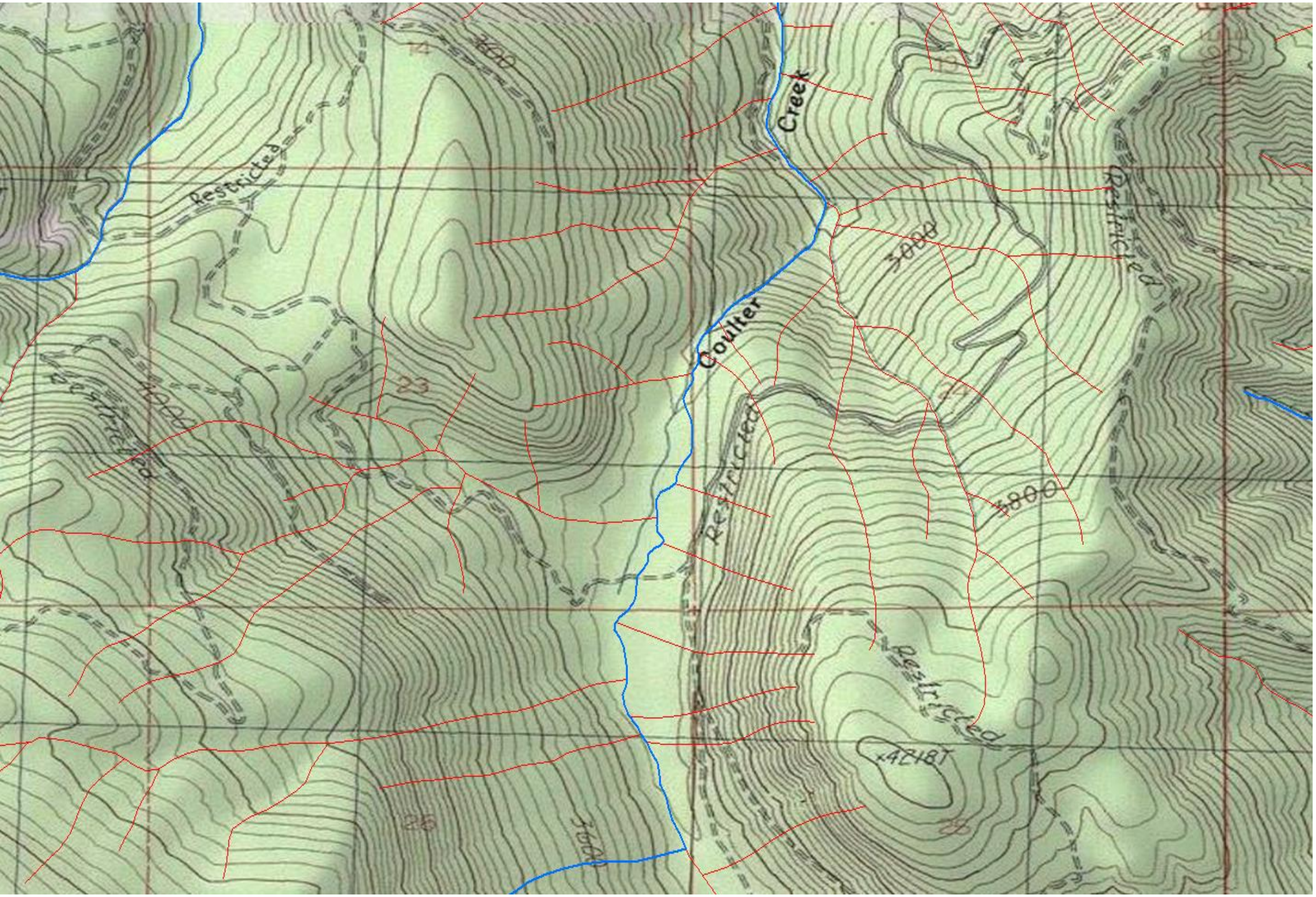


NHD is a multi-scale dataset





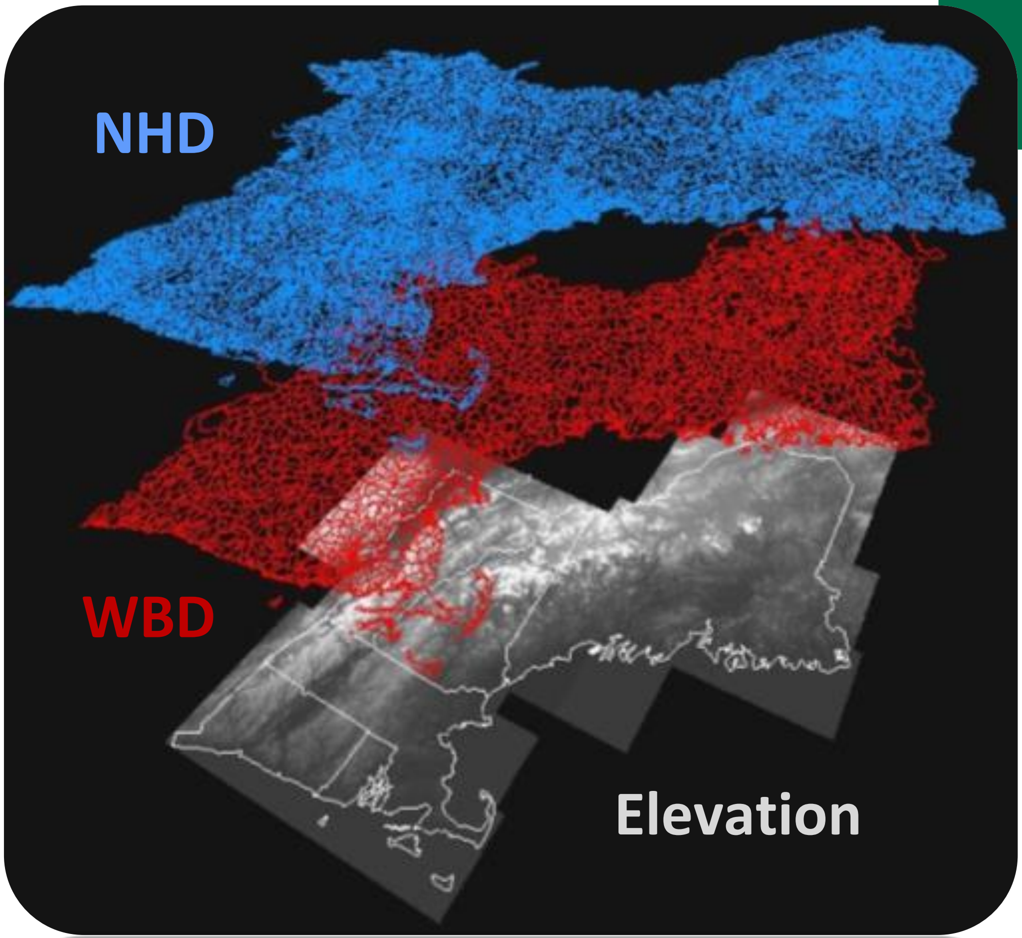
Contour Crenulations added as intermittent



More additions

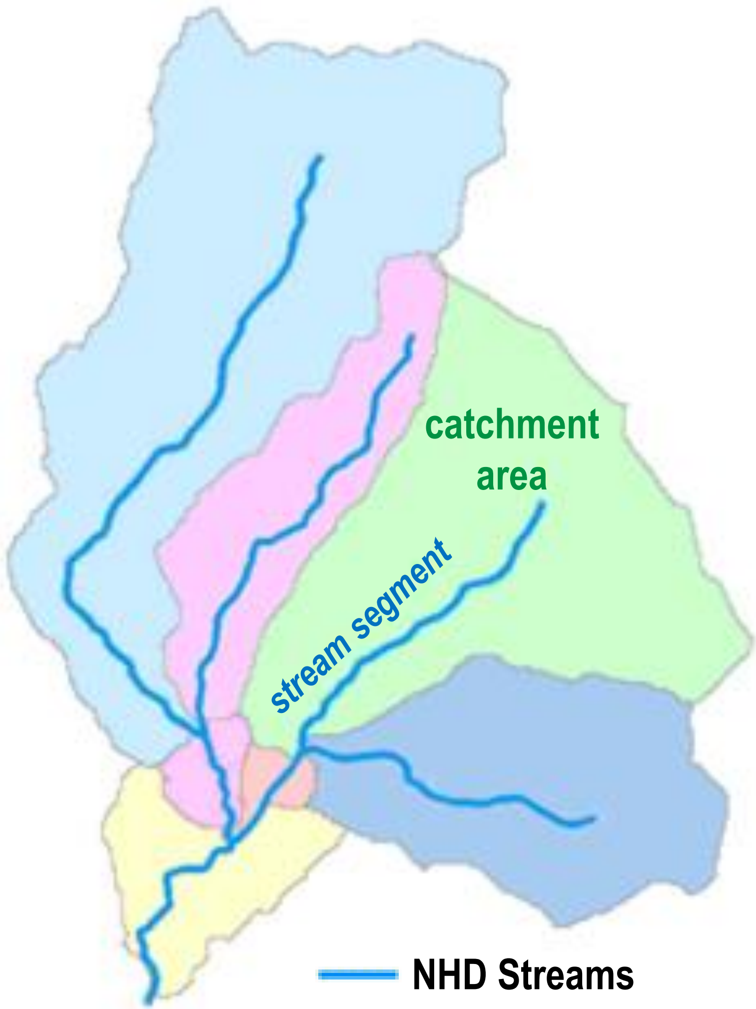
NHDPlus Completes the Framework

- Brings together NHD, WBD and elevation data to incorporate the landscape as a part of the stream network
- Creates a national framework for water-related information and enhance modeling capabilities
- Medium Resolution completed for CONUS (1:100,000)



NHDPlus includes…

- A nationally seamless network of stream reaches
- Value-added attributes for stream network navigation and analysis
- Flow surfaces in raster format
- Elevation-based catchment areas for each stream segment that
  - Create a seamless, scalable hydrologic framework
  - Enable modeling of water flow across the landscape, linking terrestrial characteristics to the stream network



Ariel Bates[1], Jeff Simley[1], Tommy Dewald[2], Tim Bondelid[3]

Natural Stream Flow Estimates for Washington

Using the NHDPlus Unit Runoff Method

Purpose

This map presents the methodology and results of the NHDPlus Unit Runoff Method (UROM) calculations for modeling natural streamflow in Washtington. The map does not represent actual streamflow, but rather modeled streamflow based on the UROM model. The intent of the map is to show the characteristics of Washingtons's drainage network and how the tributary system converges into larger and larger arteries to form the major rivers that drain the state. By reviewing this drainage pattern it is possible to better understand Washington's drainage.

The Map

The stream lines come from NHDPlus, a joint U.S. Environmental Protection Agency (USEPA)-U.S. Geological Survey (USGS) program to develop enhancements to the 1:100,000-scale National Hydrography Dataset. The line weights represent ranges in mean annual streamflow measured in cubic feet per second (cfs). Streams with a UROM streamflow less than 1.0 cfs are not shown. This eliminates approximately half of the 1:100,000-scale streams from being shown and results in good map clarity at the map scale of 1:767,000 (as shown).

NHDPlus

NHDPlus is an integrated suite of application-ready geospatial data sets that incorporates many of the best features of the National Hydrography Dataset (NHD), and National Elevation Dataset (NED). NHDPlus includes a stream network based on the medium resolution NHD, improved networking, name attributes, and "value-added attributes" (VAA's) providing additional flowline characteristics. Flowlines are the basic linear hydrologic features in the NHD, such as streams, rivers, etc. NHDPlus also includes elevation-derived catchments (flowline-based drainage areas) produced using a drainage enforcement technique dubbed "The New-England Method". This technique modifies the National Elevation Dataset (NED) by "burning-in" the 1:100,000-scale NHD, and when available, building "walls" using the national Watershed Boundary Dataset (WBD). The resulting modified Digital Elevation Model (DEM) is used to produce hydrologic derivatives that agree with the NHD and WBD. Over two years an interdisciplinary team from the USGS and USEPA found this method to produce the best quality catchments feasible in a relatively short time frame.

Unit Runoff Method

The UROM stream flow estimates are calculated using flowline catchment areas and unit runoff (cfs/km^2) values from associated 8-digit hydrologic subbasins. The USGS streamgages in the Hydro Climatic Data Network (HCDN) were selected for developing the unit runoff values because they represent relatively natural hydrologic conditions and are not influenced by controlled releases from reservoirs. Further, only gages with a drainage area less than the drainage area of the subbasin where the gage is located were selected so that the discharge data represents runoff for only that subbasin. For example, a gage on the Mississippi River at St. Louis would not be representative of the unit runoff from that subbasin. At the national level, a total of 1,338 HCDN gages were selected for this dataset.

Explanation

▲ Stream Gage

Mean Annual Flow (cfs)

1- 25	5001 - 10000
26 - 50	10001 - 25000
51 - 100	25001 - 50000
101 - 500	50001 - 130000
501 - 1000	130001 - 200000
1001 - 5000	200001 - 300000

Scale 1:767,000
Lambert Conformal Conic Projection
Central Meridian -119.50

0 25 50 100
Miles

N
W E
S

UROM Calculations

Using streamflow data from the selected gages, mean annual and mean summer unit runoffs ($ft^3/sec/km^2$) were calculated for each subbasin. The nearest HCDN gages were identified using a 200-mile maximum search radius from the centroid of a subbasin. In most subbasins, five gages were selected but some had fewer than five within the 200-mile search radius. Mean annual and mean summer unit runoffs for each subbasin were calculated using a weighted-average technique based on the square of the distance of the selected HCDN gages from the centroid of the subbasin. The computations are defined as follows:

$$Q_{CU\_MA} = \Sigma(Q_{HCDN\_MA} \times 1/D^2_{CU\_HCDN})/\Sigma(1/D^2_{CU\_HCDN})$$

Where

Q_{CU_MA} = estimated mean annual unit discharge for the 8-digit Subbasin of interest,

Q_{HCDN_MA} = mean annual unit discharge for the selected HCDN gage,

$D^2_{CU\_HCDN}$ = square of distance from the selected HCDN gage to the centroid of the 8-digit Subbasin of interest.

Flows for each NHDPlus flowline were then calculated as follows:
IncrFlowU is the incremental flow at the bottom of flowline, computed as:

IncrFlowU = A * CU_MA

Where
A = Drainage Area of the catchment (km^2), and
CU_MA = Unit Runoff for the 8-digit Subbasin (cfs/km^2)

The UROM based mean annual flow for each flowline (MAFlowU) is computed as:

$MAFlowU = \sum_{i=1 \text{ to } n} (IncrFlowU_i)$ for each i to n upstream flowline.

UROM Tuning Using Intermittent Flow Adjustment Factors

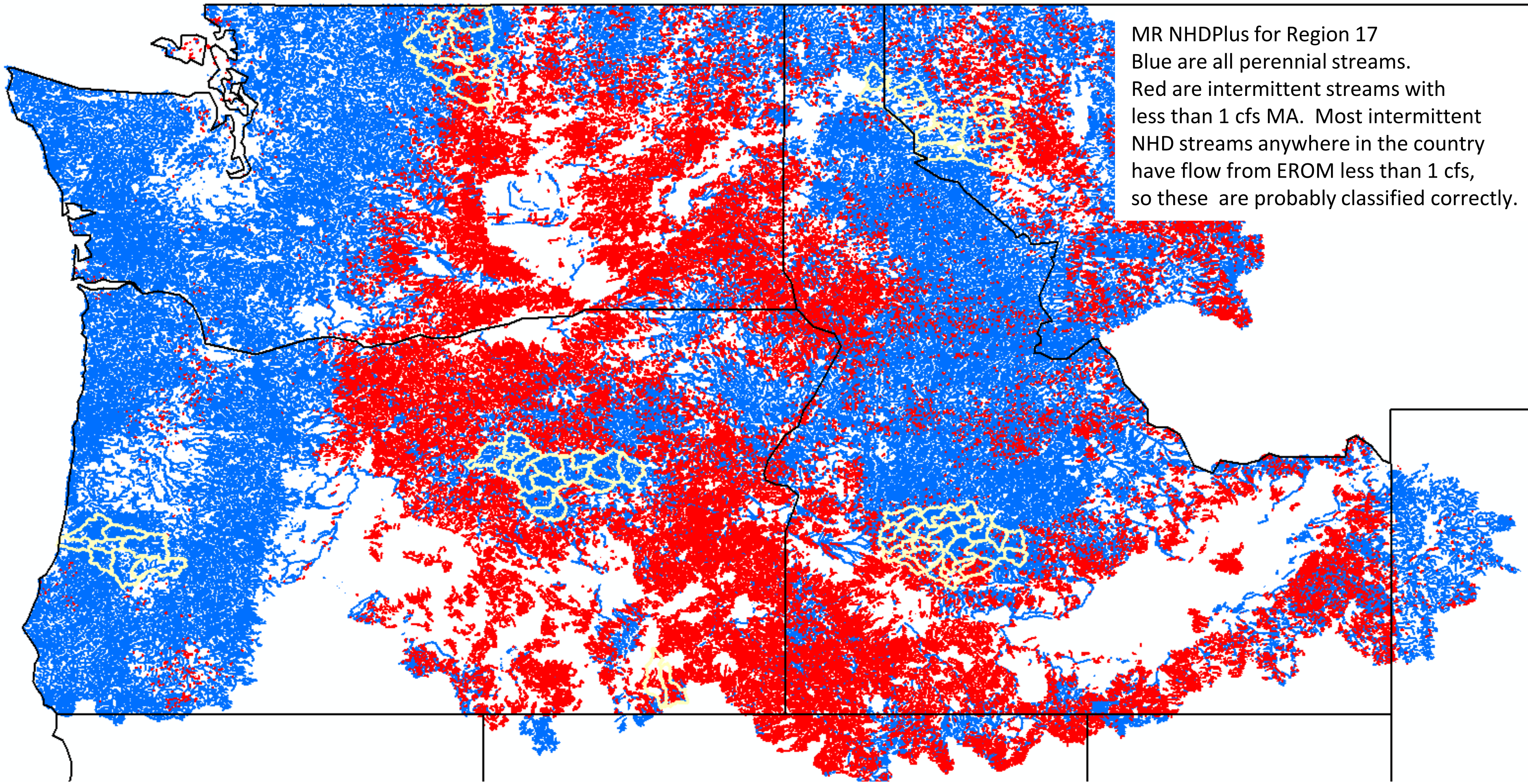
The UROM was developed as part of the National Water Pollution Control Assesment Model (NWPCAM) (Research Triangle Institute, 2001). For hydrologic regions west of the Mississippi, initial UROM estimates of routed discharge generally were observed to be greater than the HCDN gage flow values. Consequently, for the western hydrologic regions, a method was developed to better relate discharge estimates to observed flow data. The discharge estimates were lowered (tuned) by incorporating only a percentage of the reach-specific runoff for intermittent stream reaches. The method calculates discharge estimates assuming various contributions (e.g., 100, 50, 25, 10, and 1 percent) of the unit runoff for intermittent flowlines. The method proved successful in improving the match between actual gage flows and UROM-based flow estimates and it was employed in the western hydrologic regions in NHDPlus. The best fit is selected based on graphical analyses that compare the UROM flow estimates to the HCDN gage flow data.

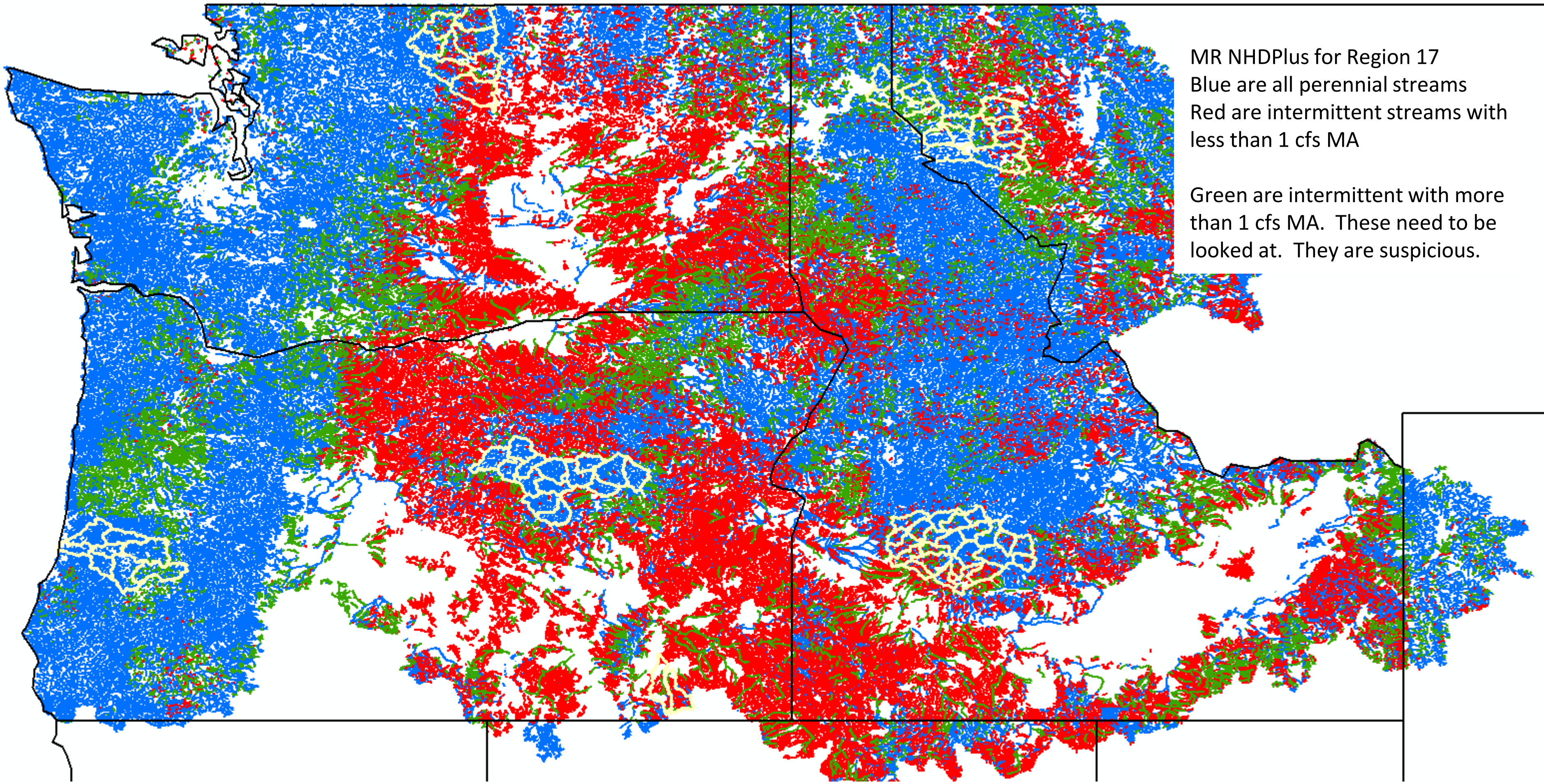
Additional Information:
http://www.epa.gov/WATERS
http://nhd.usgs.gov
http://www.horizon-systems.com/nhdplus/
http://pubs.usgs.gov/of/1992/ofr92-129/

1 U.S. Geological Survey, National Geospatial Programs Office
2 U.S. Environmental Protection Agency, Office of Water
3 U.S. Environmental Protection Agency

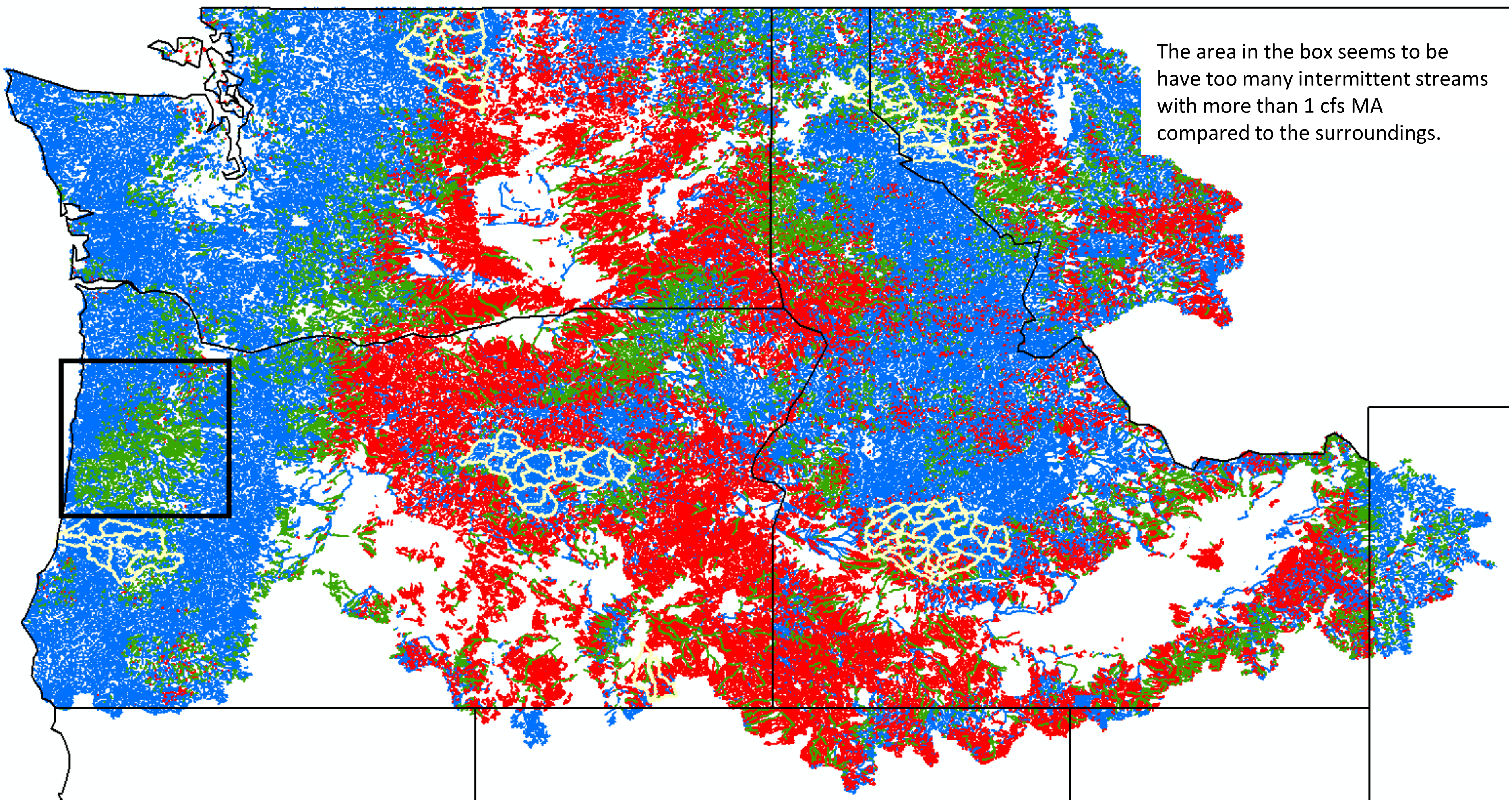
Department of the Interior
U.S. Geological Survey

November 2008

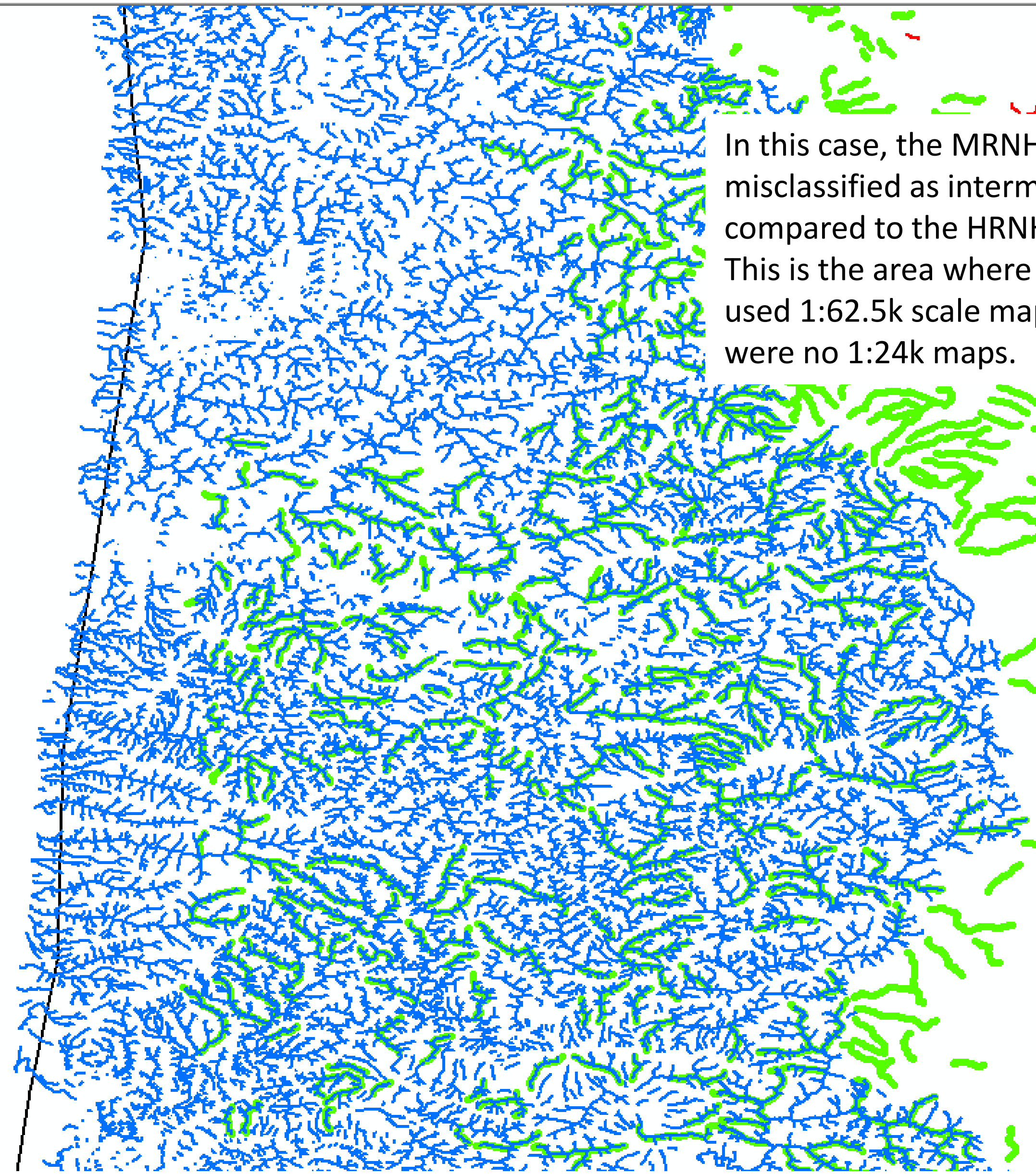

MR NHDPlus for Region 17
Blue are all perennial streams.
Red are intermittent streams with
less than 1 cfs MA. Most intermittent
NHD streams anywhere in the country
have flow from EROM less than 1 cfs,
so these are probably classified correctly.


MR NHDPlus for Region 17
Blue are all perennial streams
Red are intermittent streams with less than 1 cfs MA

Green are intermittent with more than 1 cfs MA. These need to be looked at. They are suspicious.



The area in the box seems to be have too many intermittent streams with more than 1 cfs MA compared to the surroundings.



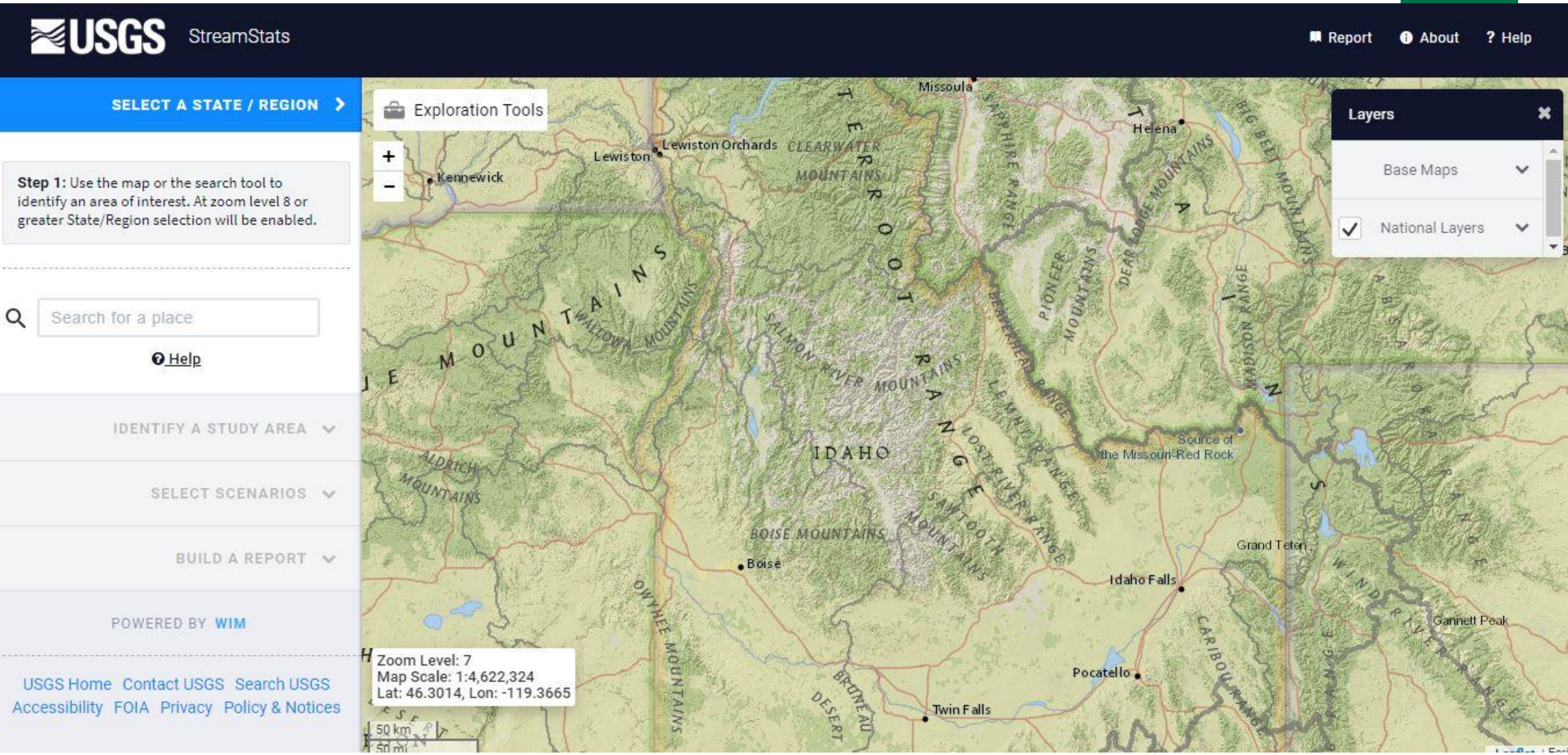
In this case, the MRNHD (green) is misclassified as intermittent compared to the HRNHD (blue). This is the area where the 100K maps used 1:62.5k scale maps because there were no 1:24k maps.

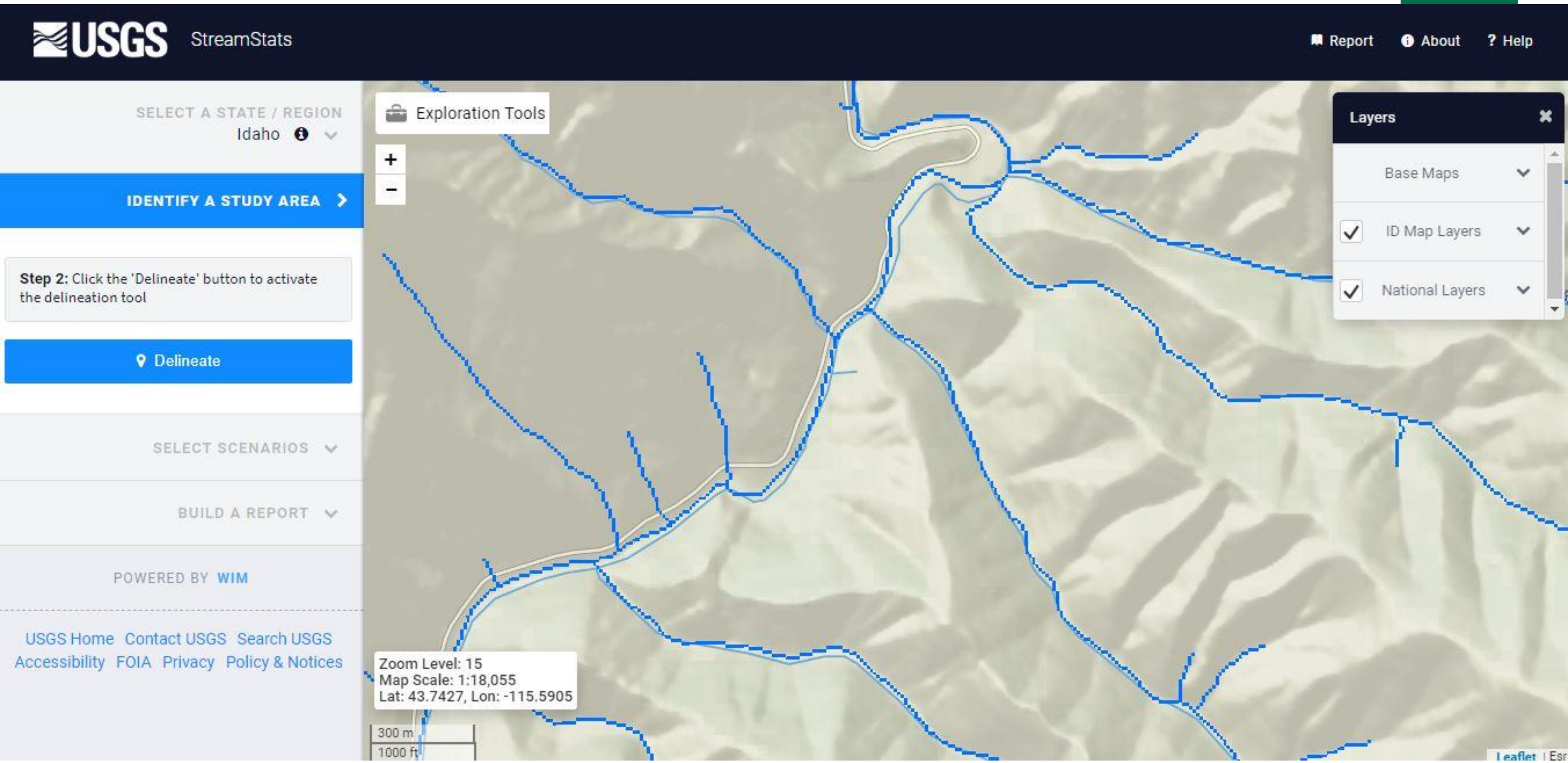
Bottom Line

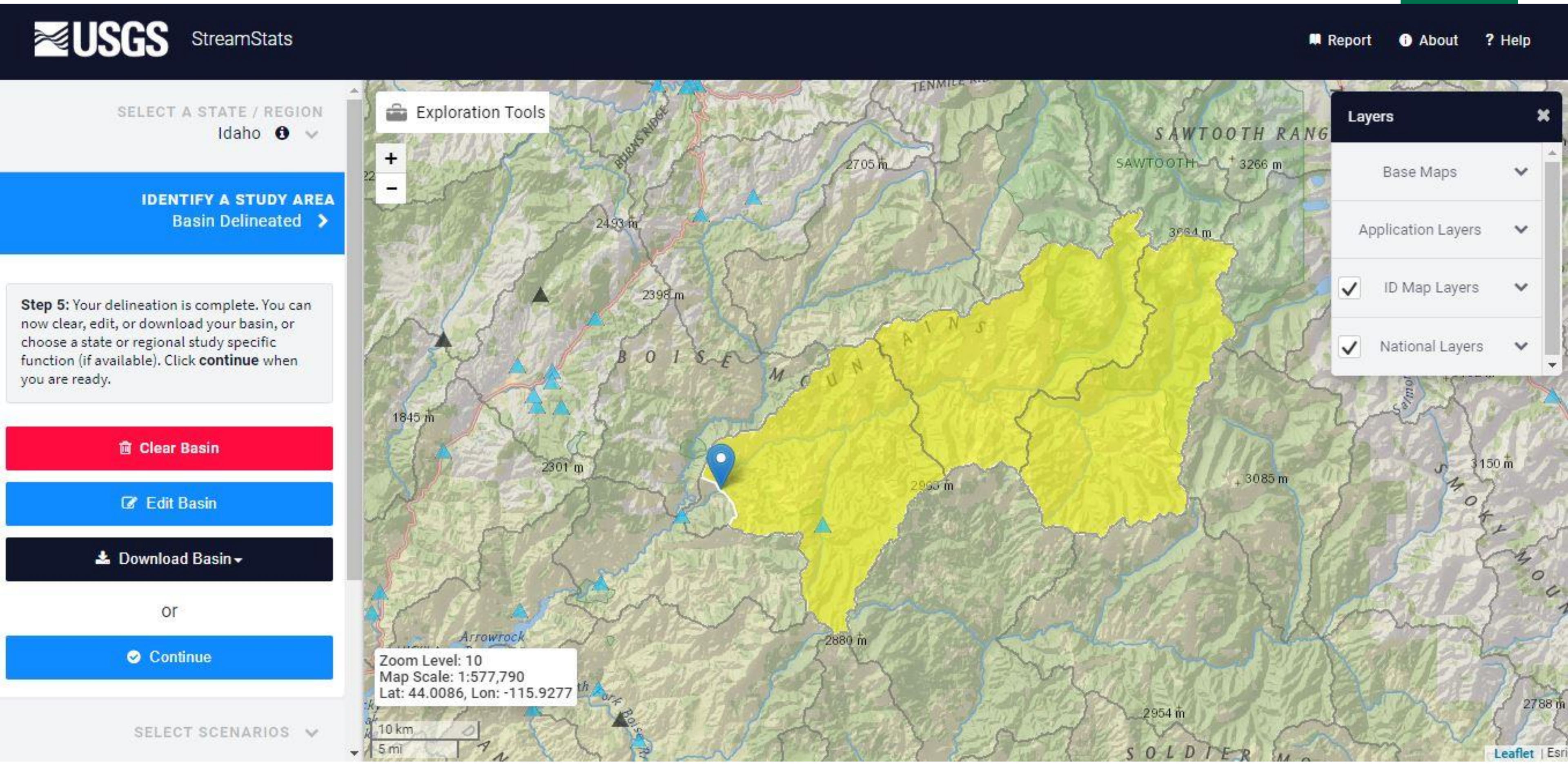
- NHD has a lot of valuable information
- However, it is something of a “mixed bag”
- NHDPlus has even more valuable information, including simple modeled flow estimates that may help counter the “mixed bag” issue
- NHDPlus also provides data used in other models, including SPARROW, StreamStats, and PROSPER

USGS StreamStats

1. Web application provides access to an assortment of Geographic Information Systems (GIS) analytical tools
2. Map-based user delineates drainage areas for user-selected sites on streams and calculates basin characteristics for any selected drainage
3. Estimates flow statistics for the selected sites anywhere this functionality is available.
4. Incorporates relational data base that contains information for data-collection stations and regression equations
5. Application and mapping functionality exist for most of our western states


USGS
StreamStats
Report
About
? Help
SELECT A STATE / REGION
Step 1: Use the map or the search tool to identify an area of interest. At zoom level 8 or greater State/Region selection will be enabled.
Search for a place
Help
IDENTIFY A STUDY AREA
SELECT SCENARIOS
BUILD A REPORT
POWERED BY WIM
USGS Home Contact USGS Search USGS
Accessibility FOIA Privacy Policy & Notices
Exploration Tools
Layers
Base Maps
National Layers
Zoom Level: 7
Map Scale: 1:4,622,324
Lat: 46.3014, Lon: -119.3665
50 km
50 mi
Missoula
Helena
Lewiston Orchards
Lewiston
Kennewick
IDAHO
Boise
Idaho Falls
Pocatello
Twin Falls
Grand Teton
Gannett Peak
Source of the Missouri-Red Rock
SALMON RIVER MOUNTAINS
BOISE MOUNTAINS
SAWTOOTH MOUNTAINS
CLEARWATER MOUNTAINS
OWYHEE MOUNTAINS
BRUNEAU DESERT


USGS StreamStats
Report
About
Help
SELECT A STATE / REGION
Idaho
IDENTIFY A STUDY AREA
Step 2: Click the 'Delineate' button to activate the delineation tool
Delineate
SELECT SCENARIOS
BUILD A REPORT
POWERED BY WIM
USGS Home Contact USGS Search USGS
Accessibility FOIA Privacy Policy & Notices
Exploration Tools
Layers
Base Maps
ID Map Layers
National Layers
Zoom Level: 15
Map Scale: 1:18,055
Lat: 43.7427, Lon: -115.5905
300 m
1000 ft
Leaflet


USGS StreamStats
Report
About
? Help
SELECT A STATE / REGION
Idaho
IDENTIFY A STUDY AREA
Basin Delineated
Step 5: Your delineation is complete. You can now clear, edit, or download your basin, or choose a state or regional study specific function (if available). Click continue when you are ready.
Clear Basin
Edit Basin
Download Basin
or
Continue
SELECT SCENARIOS
Exploration Tools
Layers
Base Maps
Application Layers
ID Map Layers
National Layers
Zoom Level: 10
Map Scale: 1:577,790
Lat: 44.0086, Lon: -115.9277
10 km
5 mi
SAWTOOTH RANG
BOISE MOUNTAINS
Arrowrock
Leaflet | Esri

USGS StreamStats

SELECT SCENARIOS

BUILD A REPORT — Report Built

Step 1: You can modify computed basin characteristics here, then select the types of reports you wish to generate. Then click the "Build Report" button

Show Basin Characteristics

Select available reports to display:

- Basin Characteristics Report
- Scenario Flow Reports

Continue

POWERED BY WIM

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	373.49	square miles
VOLCANIC	Percent of drainage area as surficial volcanic rocks as defined in SIR 2006-5035	78.5	percent

Low-Flow Statistics Parameters [100 Percent (374 square miles) Low Flow Region 5 2006 5053]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	373.49	square miles	19.3	12228
VOLCANIC	Percent Volcanic	78.5	percent	27.1	100

Low-Flow Statistics Flow Report [100 Percent (374 square miles) Low Flow Region 5 2006 5053]

PII: Prediction Interval-Lower, Plu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

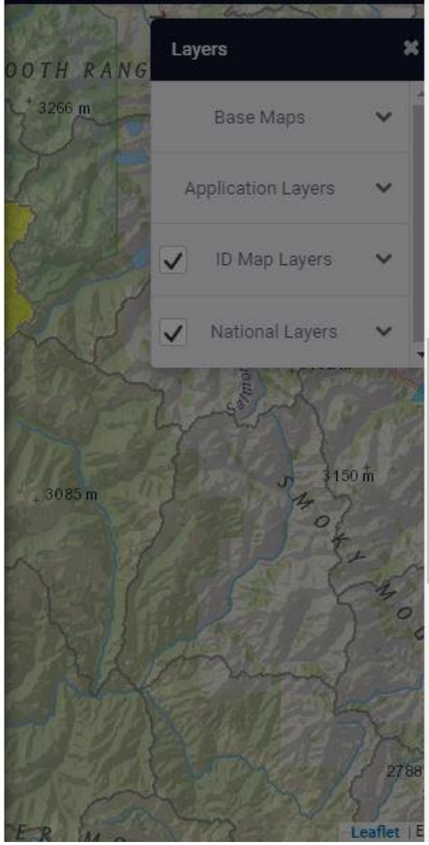
Statistic	Value	Unit	SE	SEp
1 Day 10 Year Low Flow	81.5	ft^3/s	113	124
7 Day 2 Year Low Flow	159	ft^3/s	25	25
7 Day 10 Year Low Flow	102	ft^3/s	99	107
30 Day 5 Year Low Flow	128	ft^3/s	63	65

Low-Flow Statistics Citations

Report · About · Help

Layers

- Base Maps
- Application Layers
- ID Map Layers
- National Layers

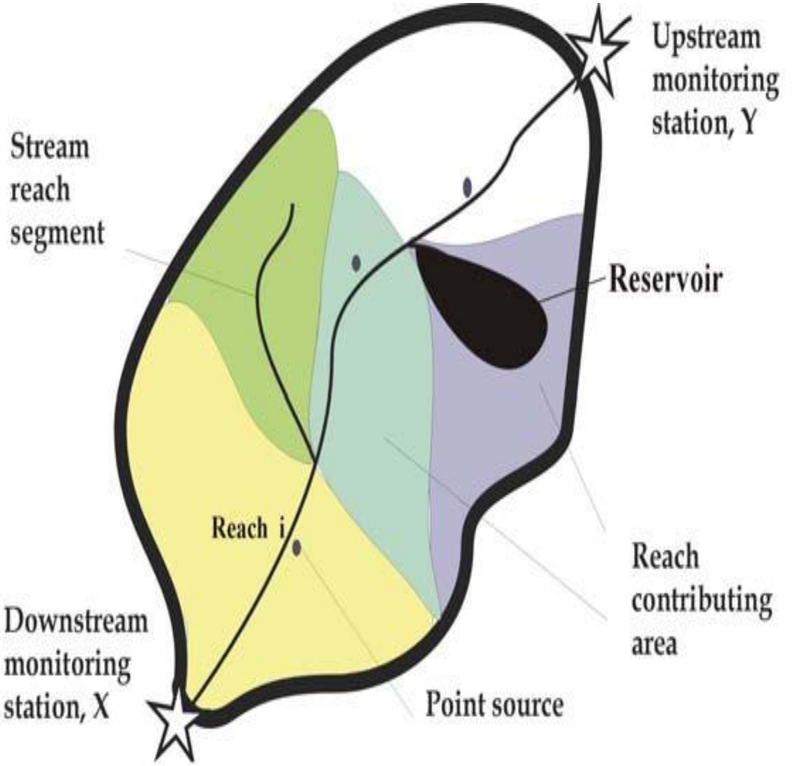


USGS science for a changing world · The National Map — Your Source for Topographic Information

+ USGS SPARROW Model (SPAtially Referenced Regressions On Watershed attributes)

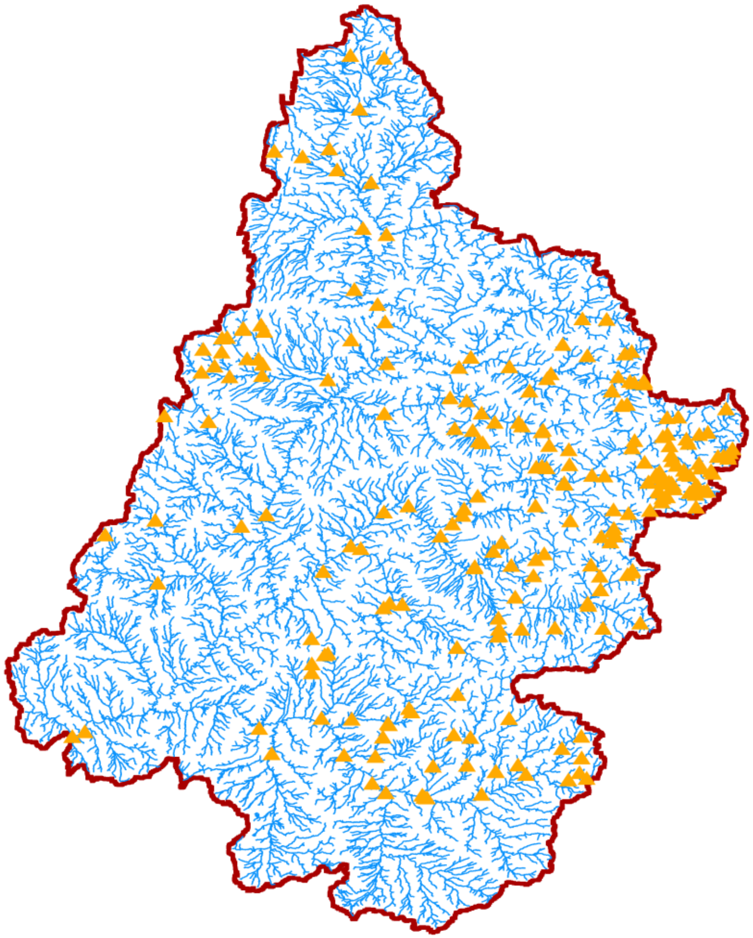
- Estimates water quality and water quantity attributes by linking monitoring data with information on watershed characteristics and contaminant sources.
- Can be used to explore relations between human activities, natural processes, and contaminant transport using interactive Mappers.
- Could be used to explore flow attributes and sources such as the groundwater component of flow (baseflow) at a given point of interest

A non-linear regression model that relates measured transport at monitoring stations to upland catchment attributes including upstream reaches



USGS science for a changing world
The National Map
Your Source for Topographic Information

Upper Colorado River Basin SPARROW



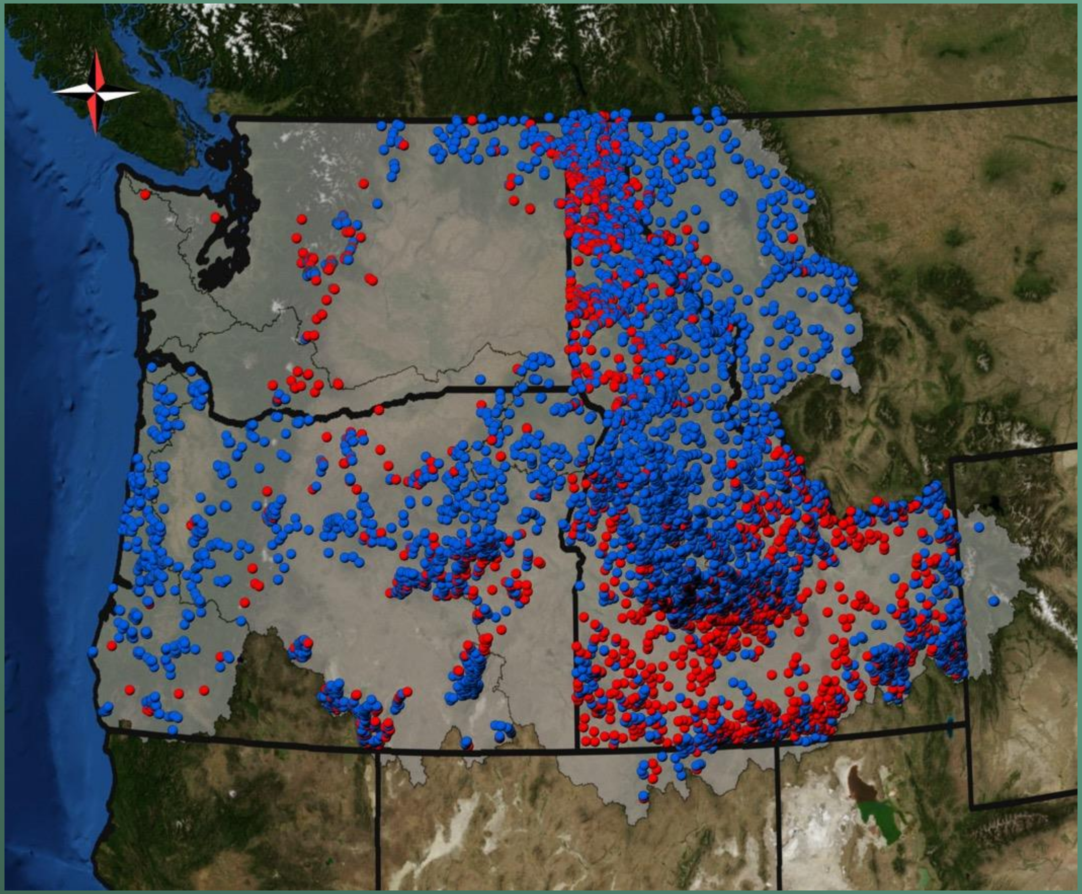
- Stream network:
  - NHD
    - 10,813 unique reaches/catchments
    - 1 to 78 mi^2
    - 218 monitoring sites- calibration reaches

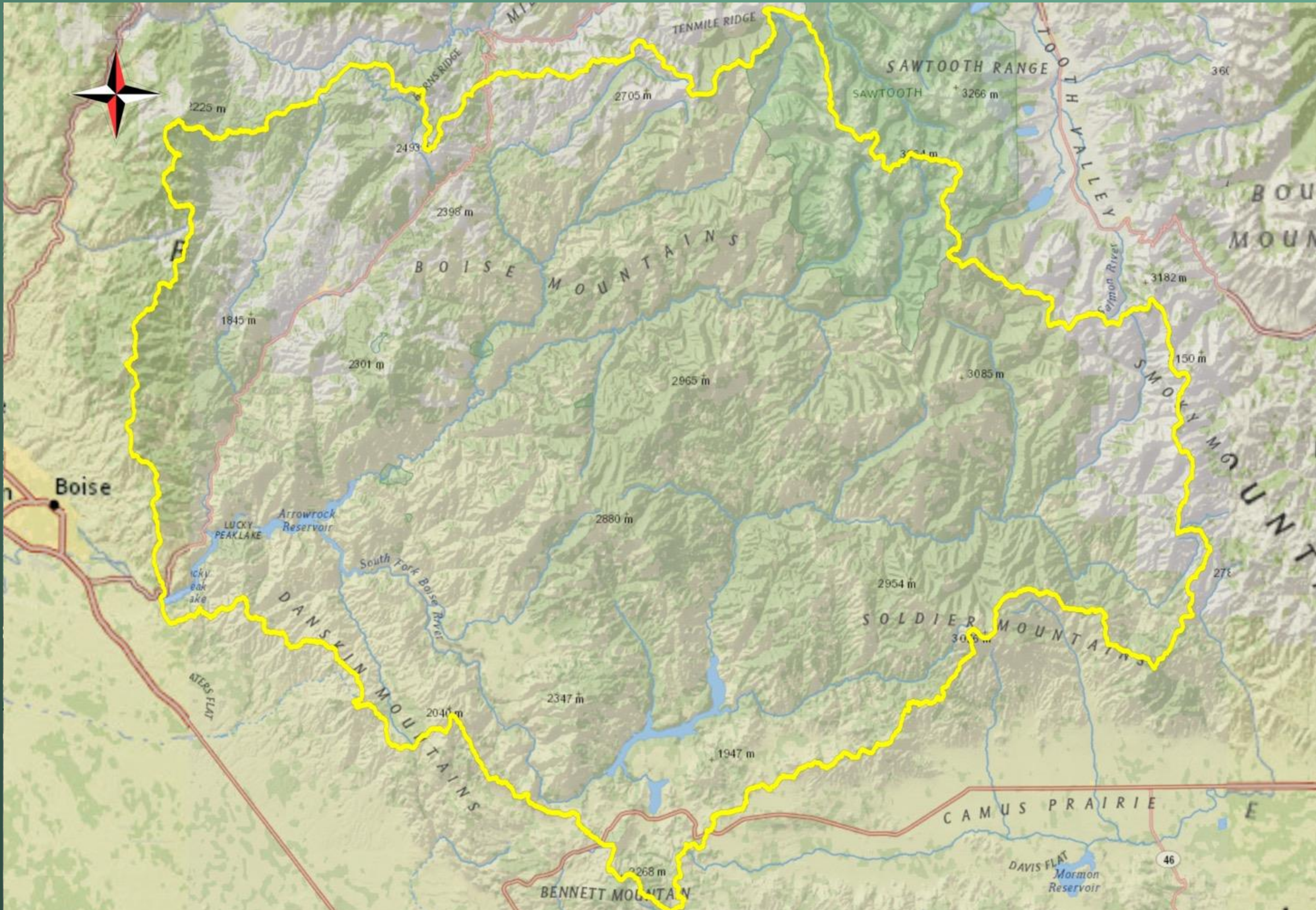
Example of Streamflow Permanence Model in the Boise River Basin

Probability of annual streamflow permanence for 2004-2016

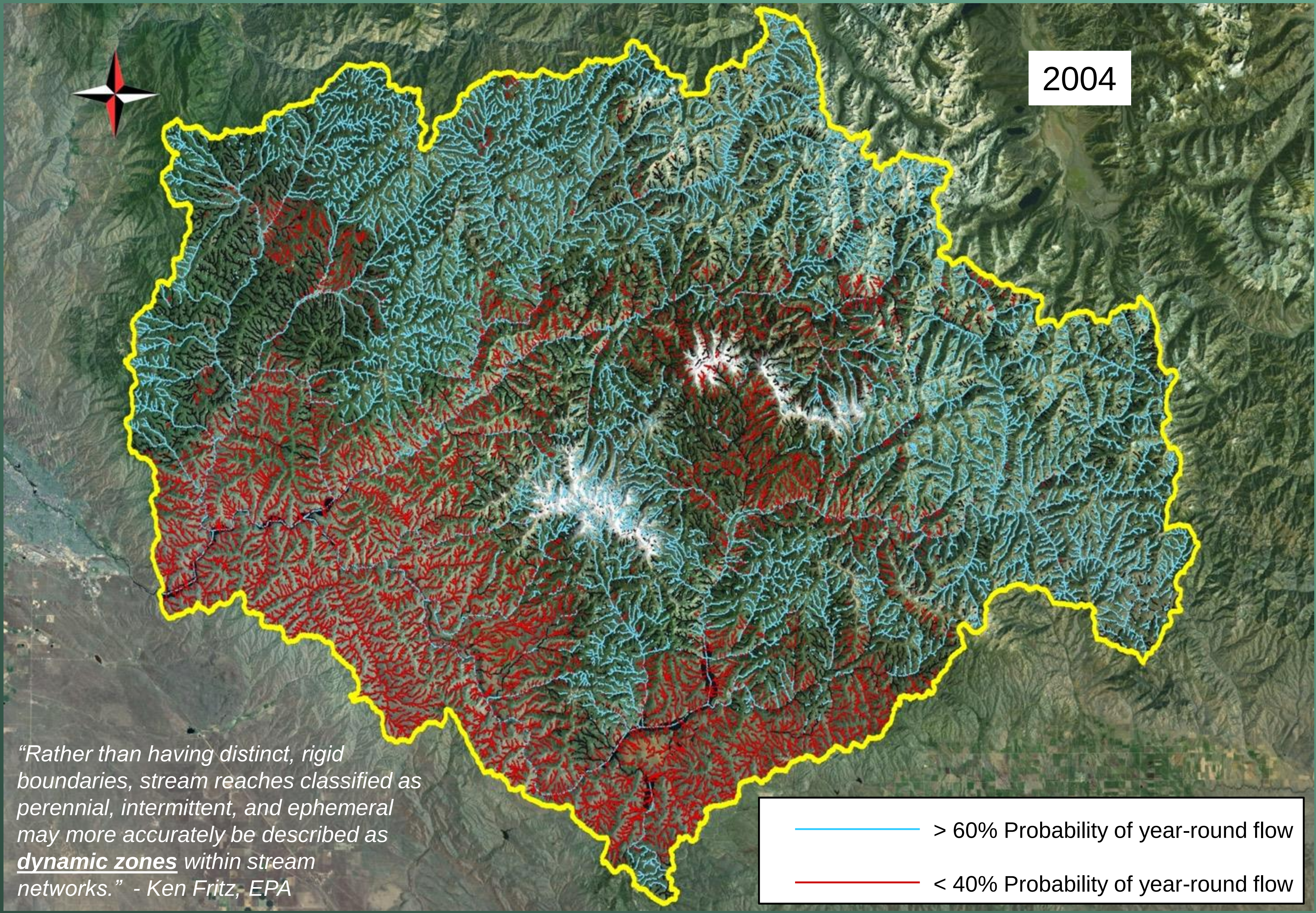
25,000 observations of wet and dry streams in the headwaters

Used to calibrate a streamflow permanence model using geographic and climatic variables



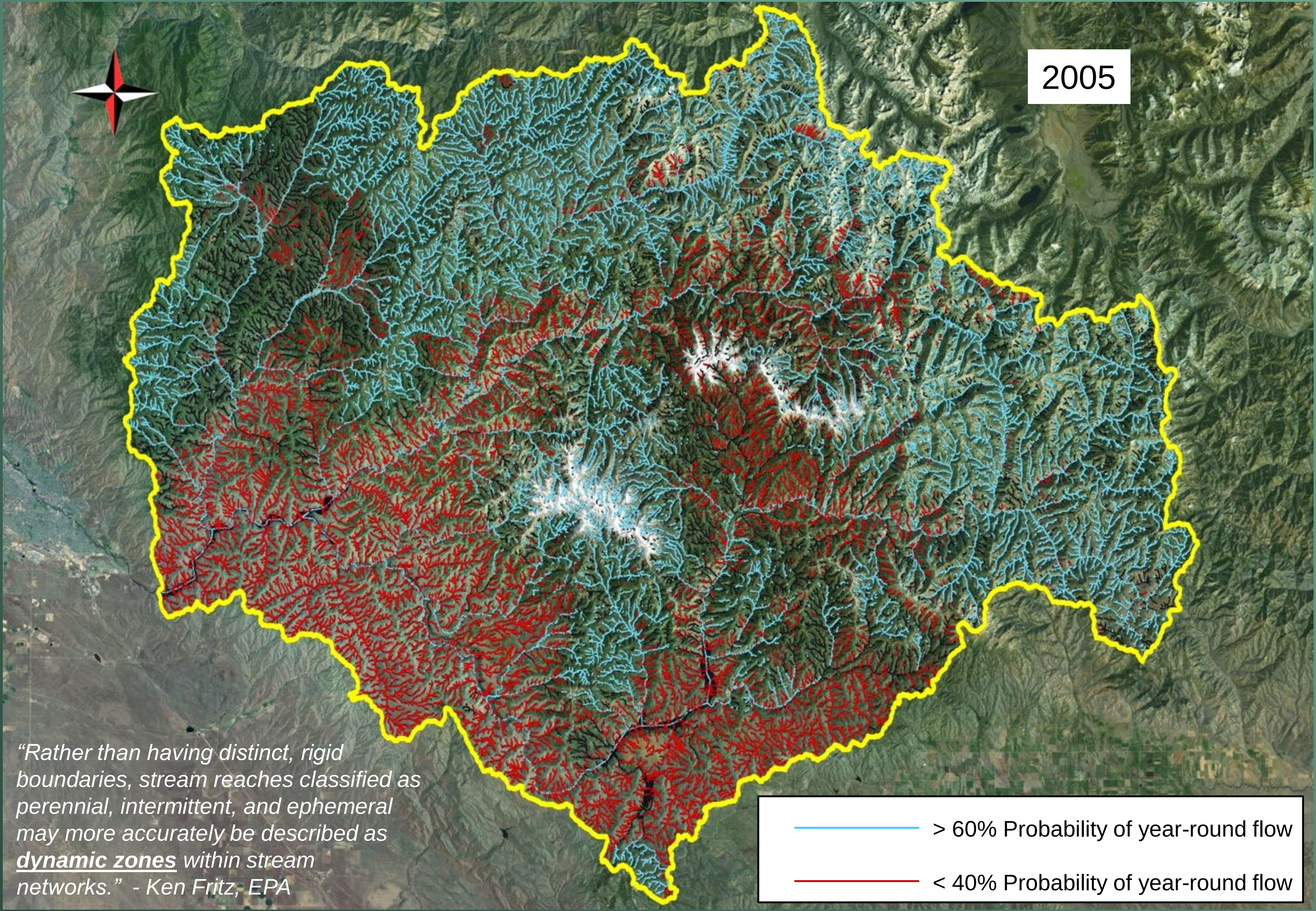


Provisional data



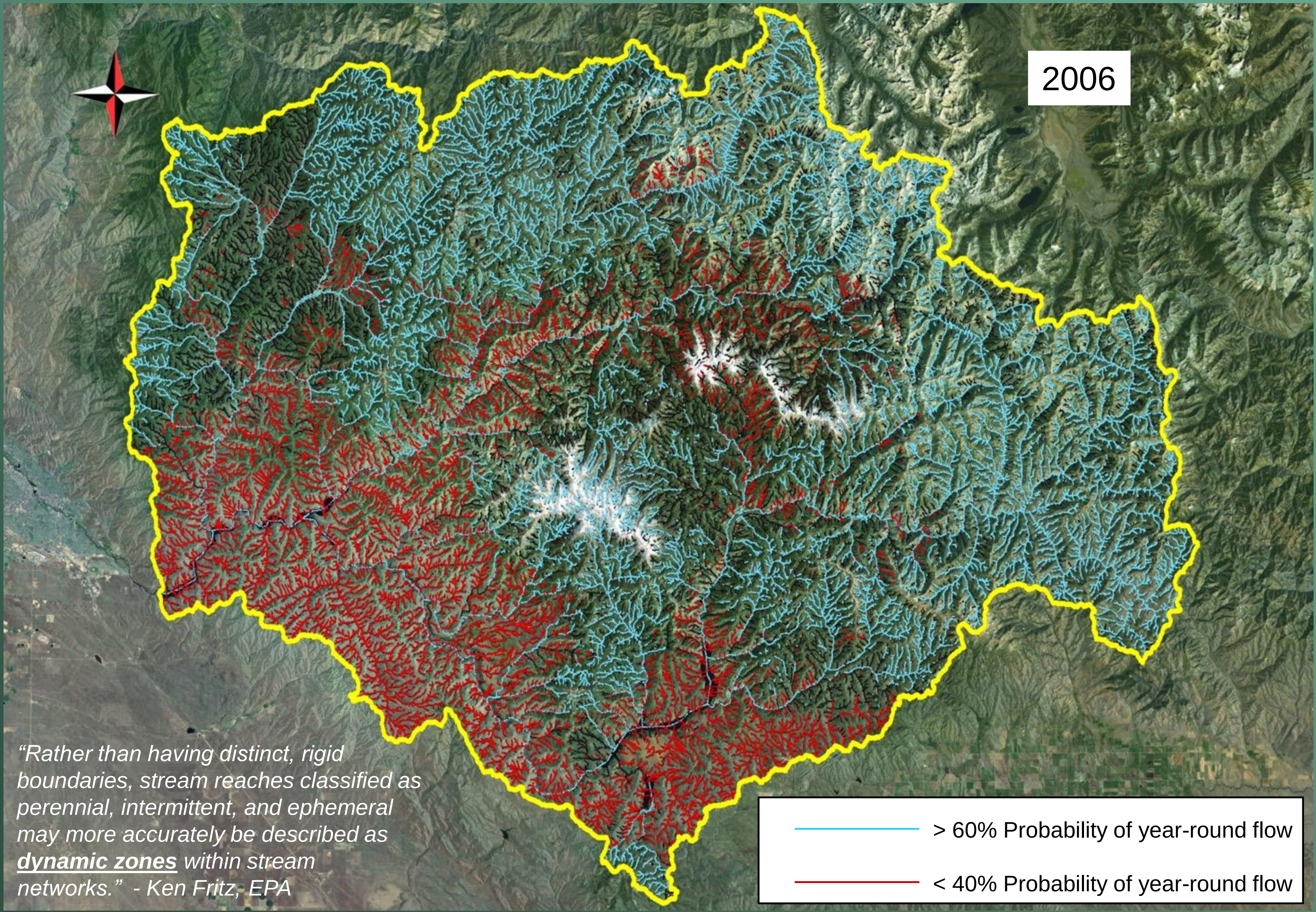
“Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as ***dynamic zones*** *within stream networks.” - Ken Fritz, EPA*

Provisional data



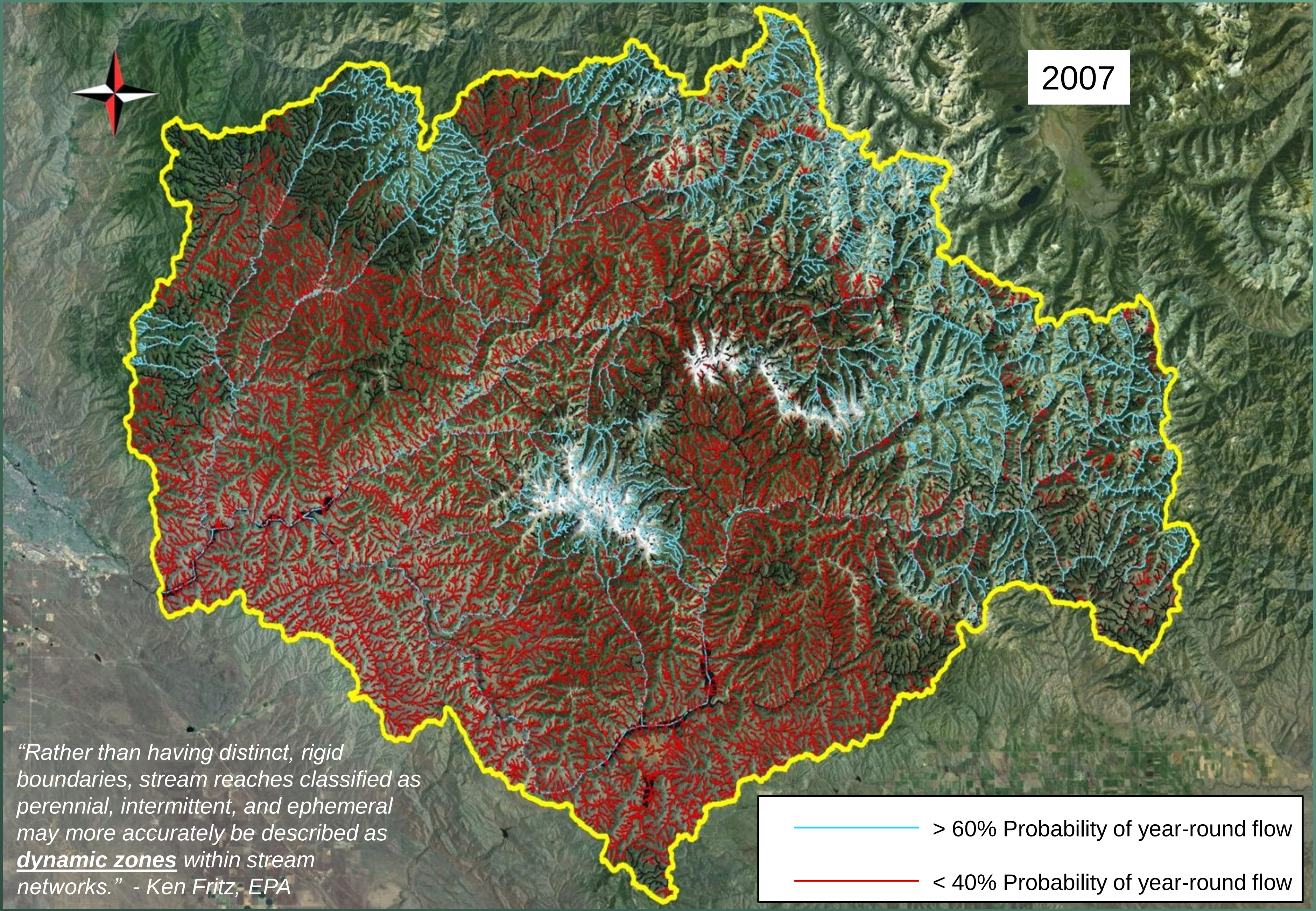
*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks." - Ken Fritz, EPA*

Provisional data



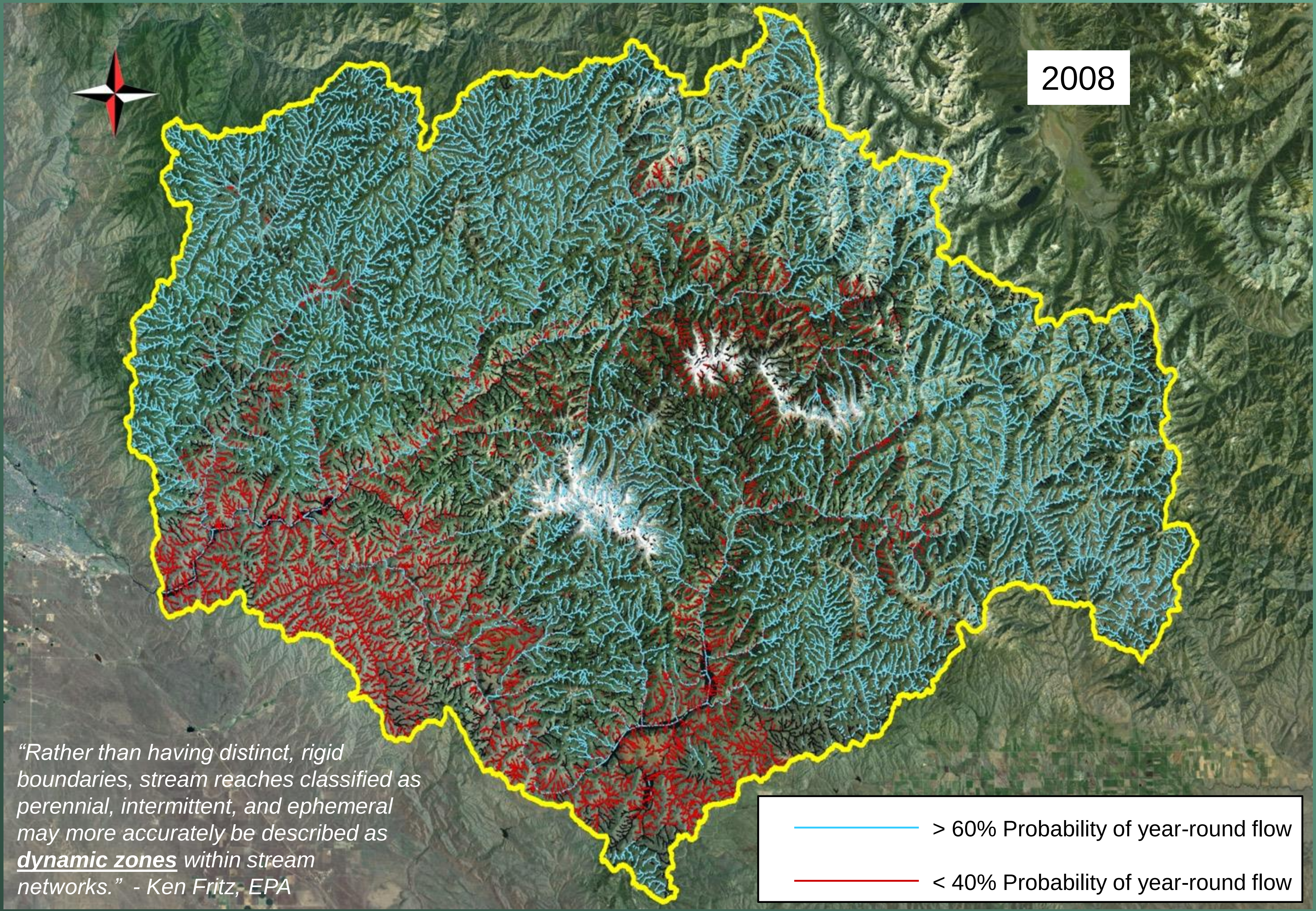
"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as ***dynamic zones*** *within stream networks." - Ken Fritz, EPA*

Provisional data



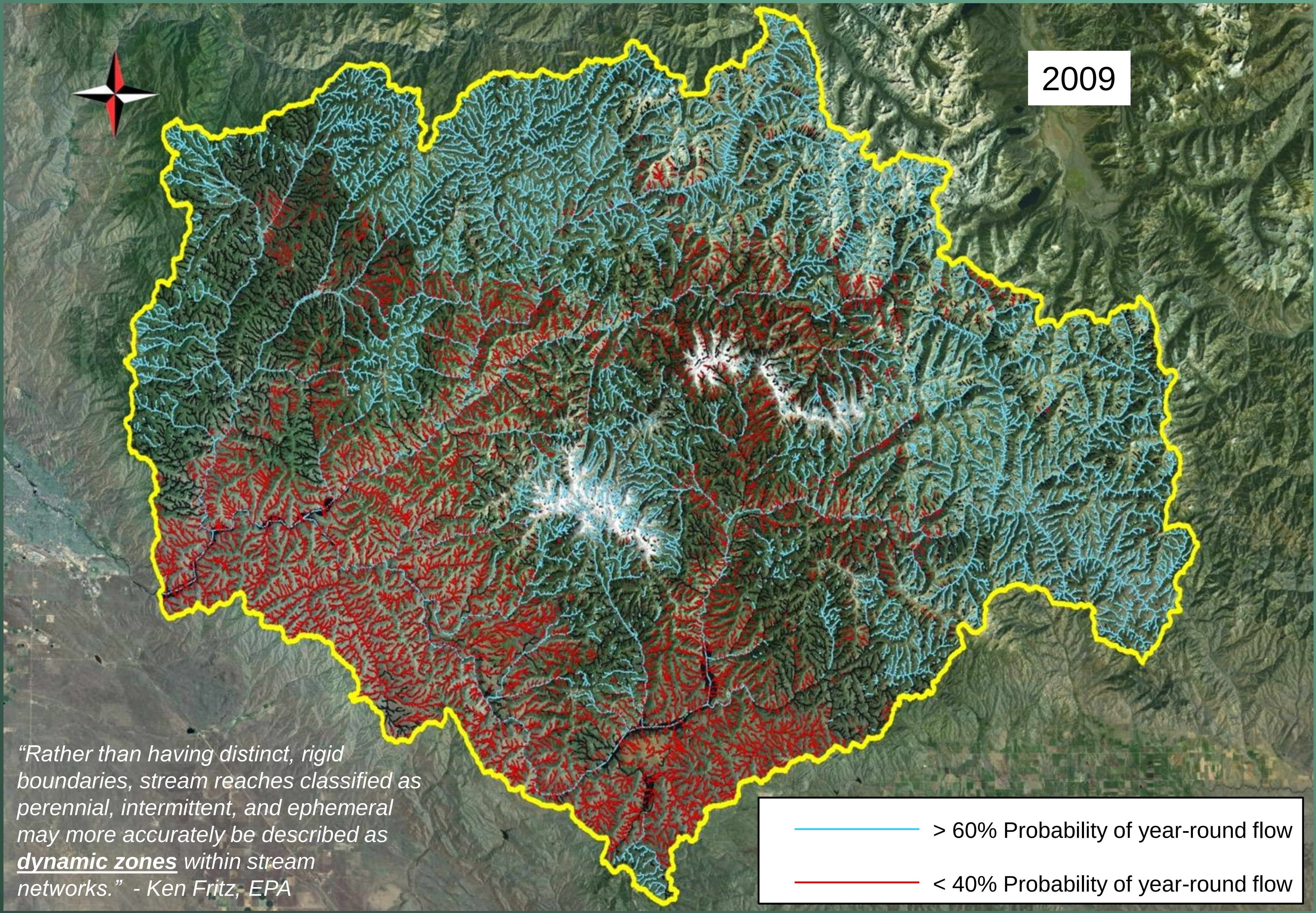
*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks."* - Ken Fritz, EPA

Provisional data



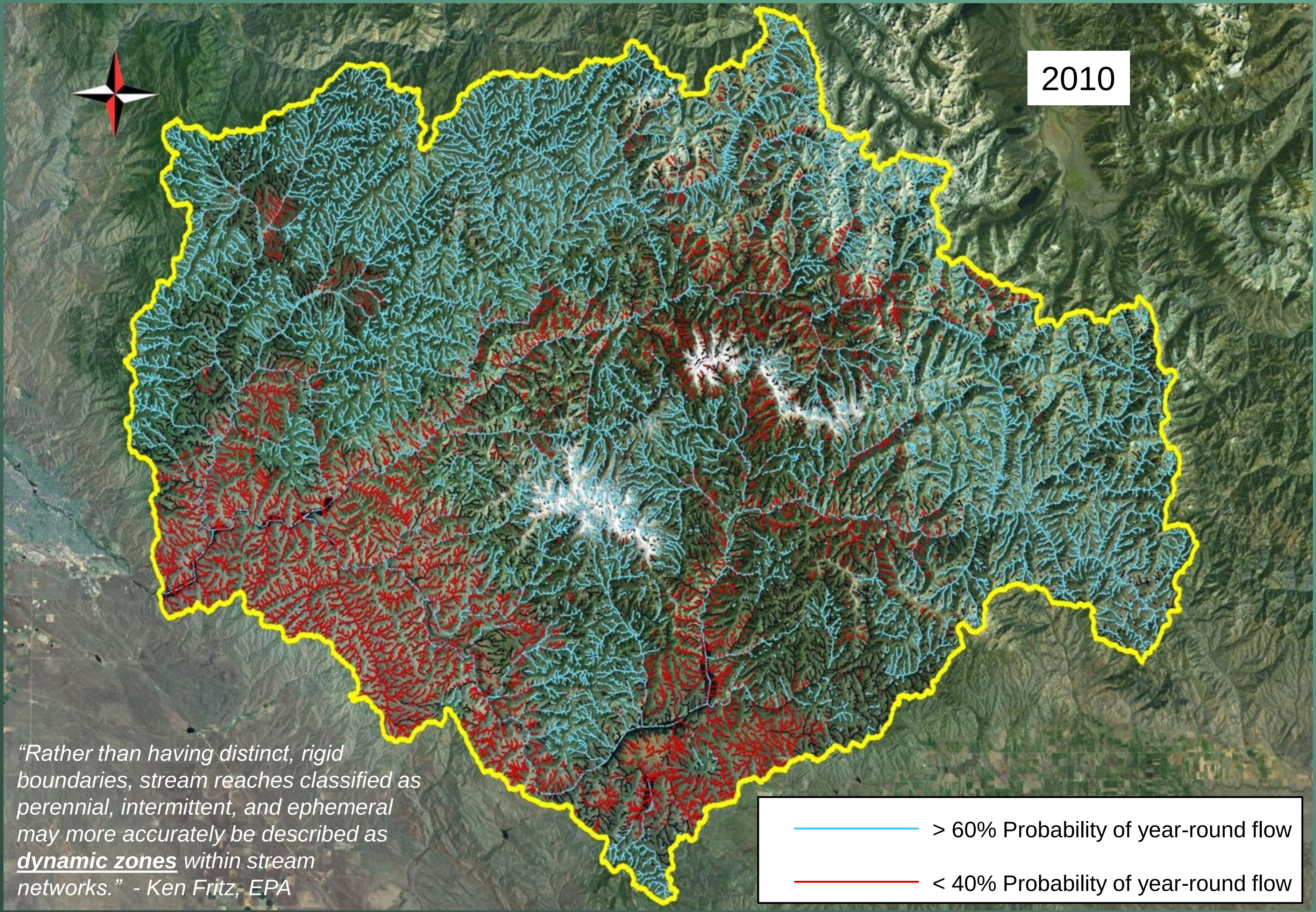
"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as ***dynamic zones*** *within stream networks." - Ken Fritz, EPA*

Provisional data



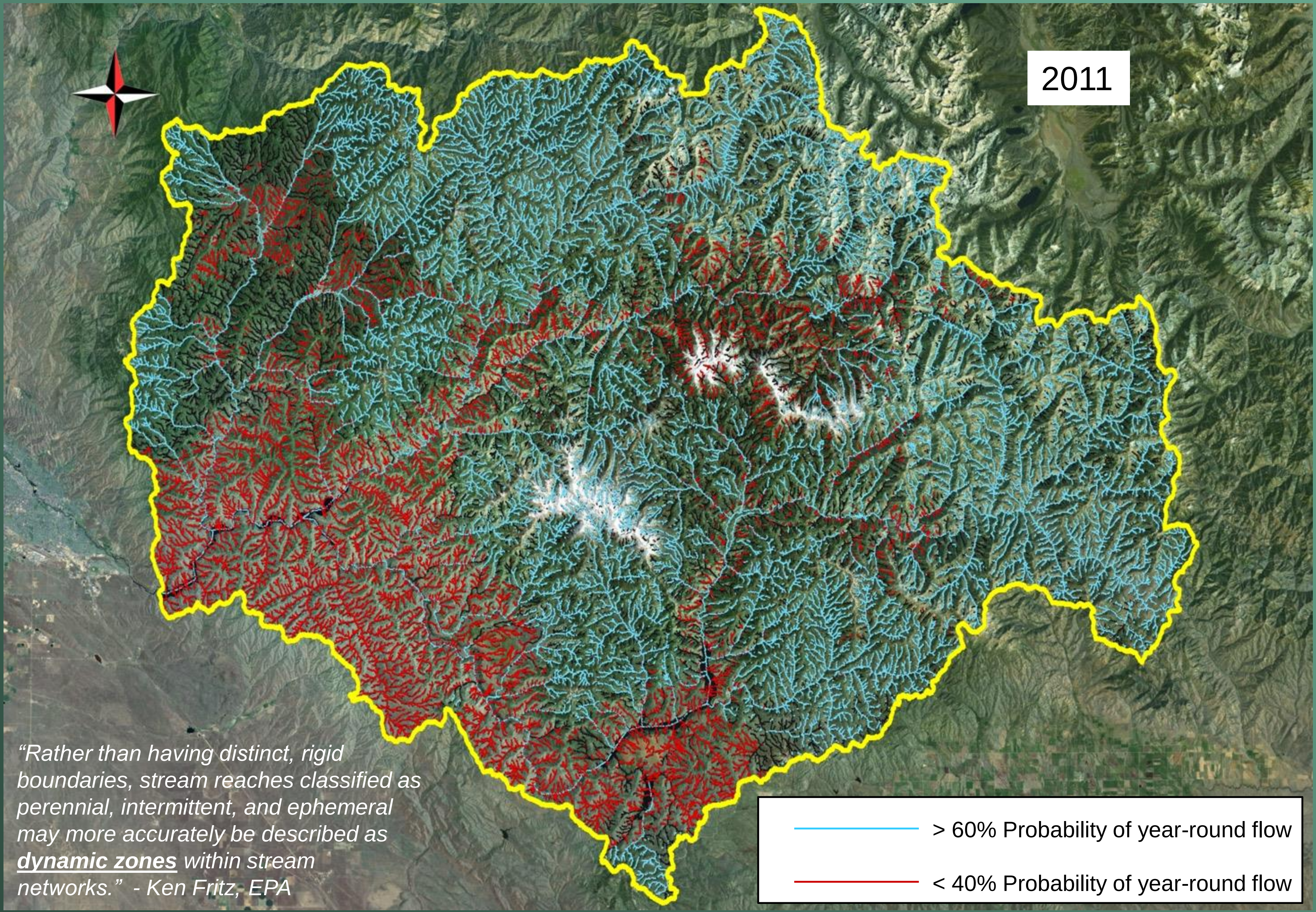
*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks." - Ken Fritz, EPA*

Provisional data



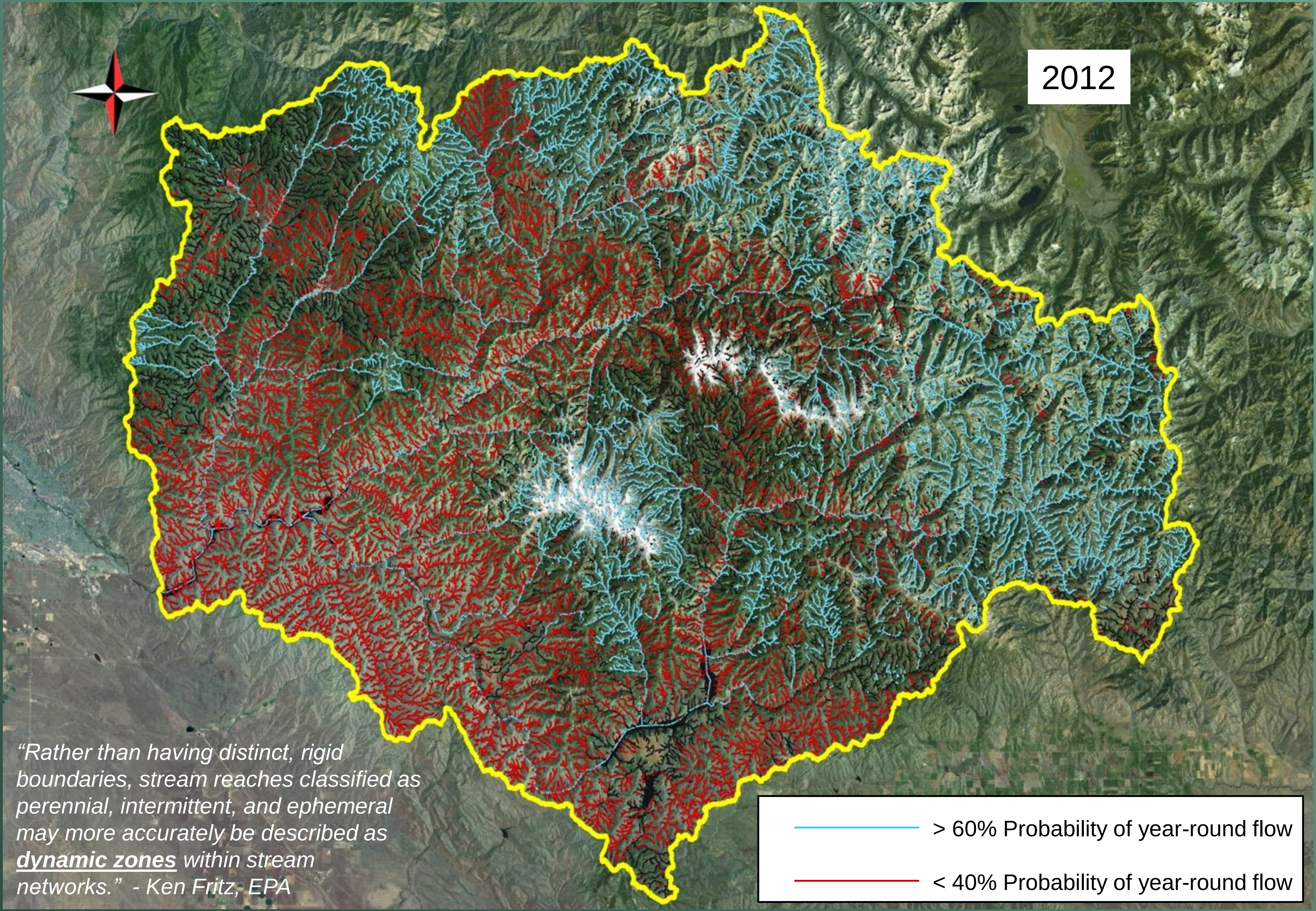
*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks." - Ken Fritz, EPA*

Provisional data



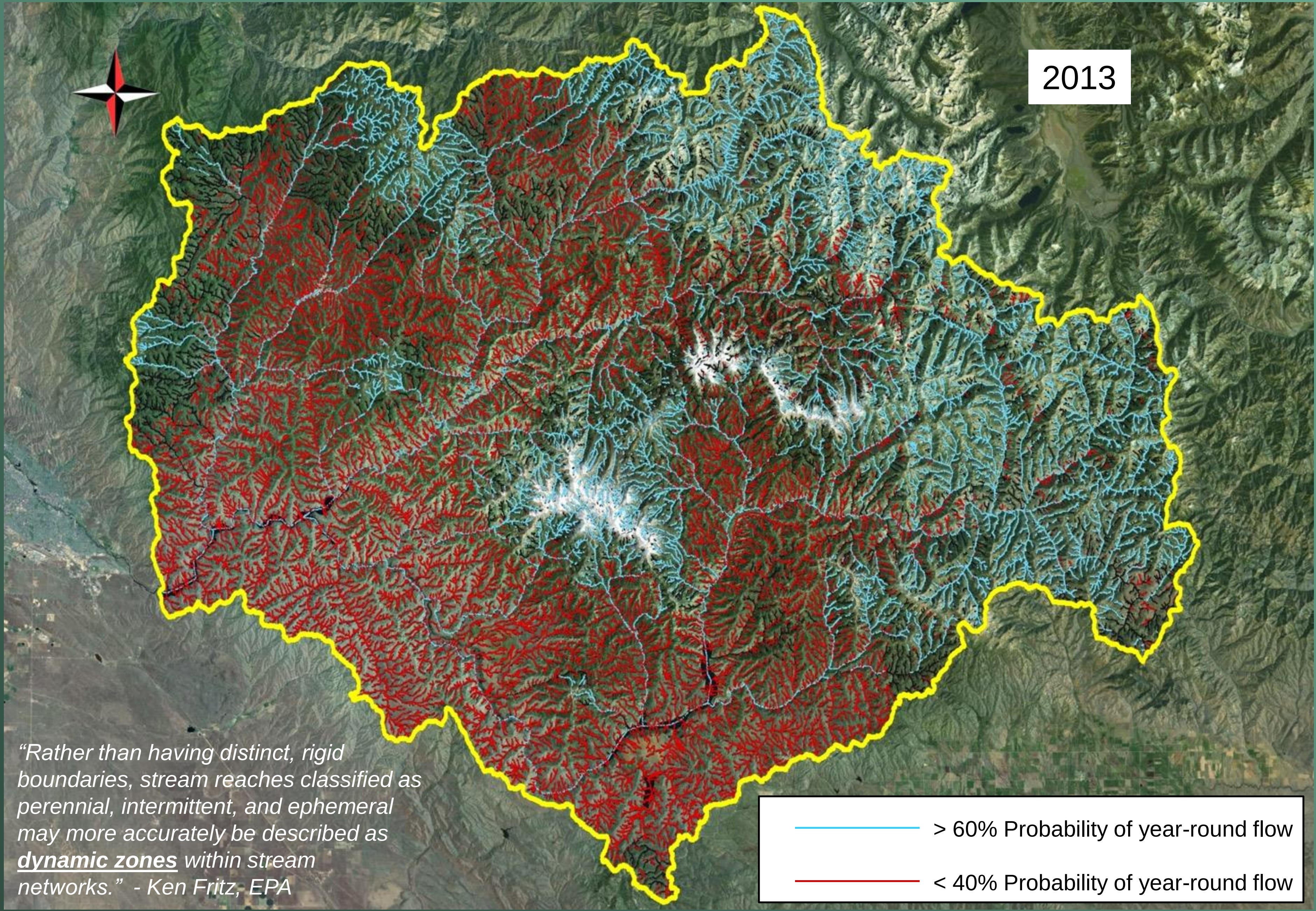
*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks." - Ken Fritz, EPA*

Provisional data



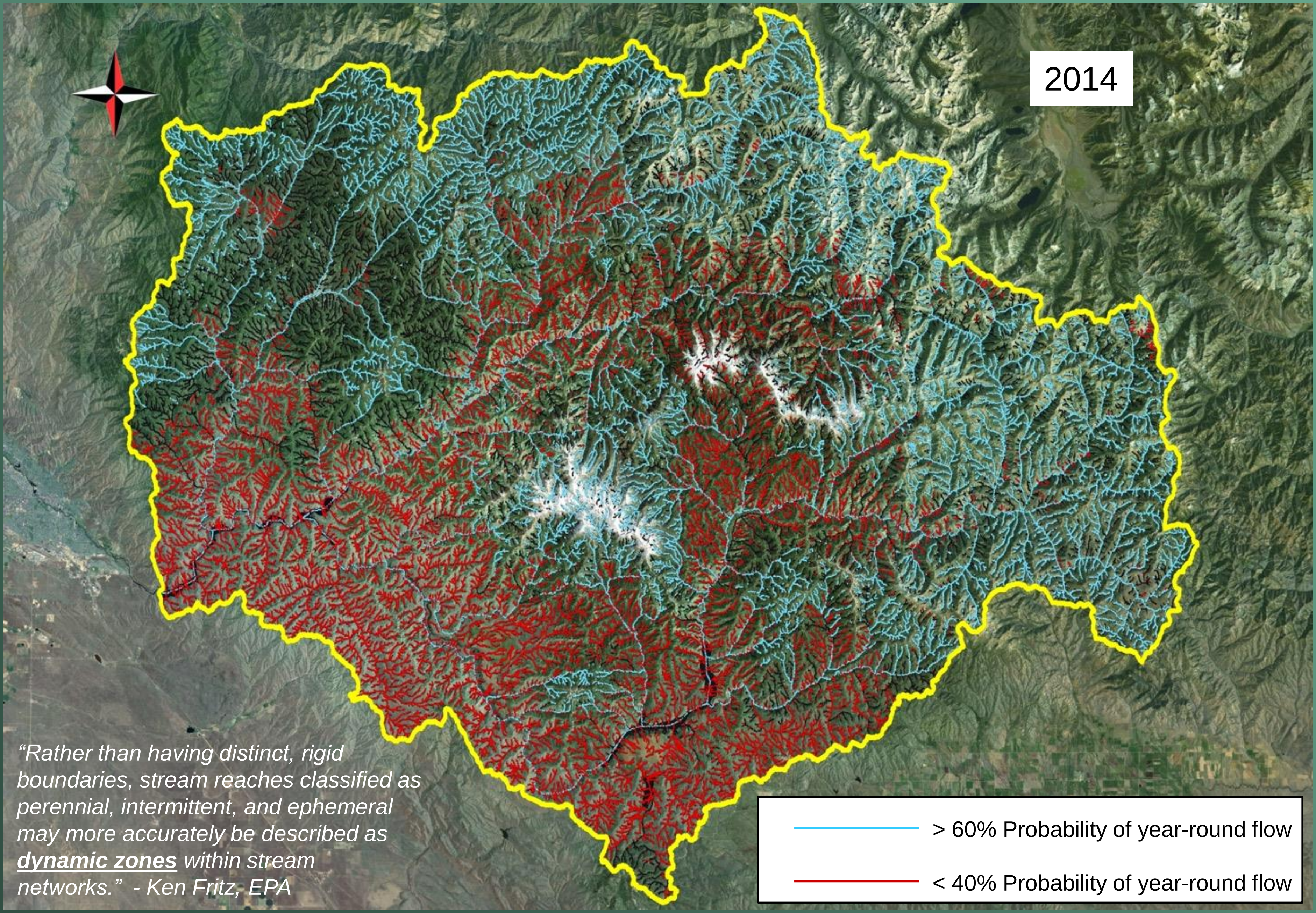
*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks." - Ken Fritz, EPA*

Provisional data



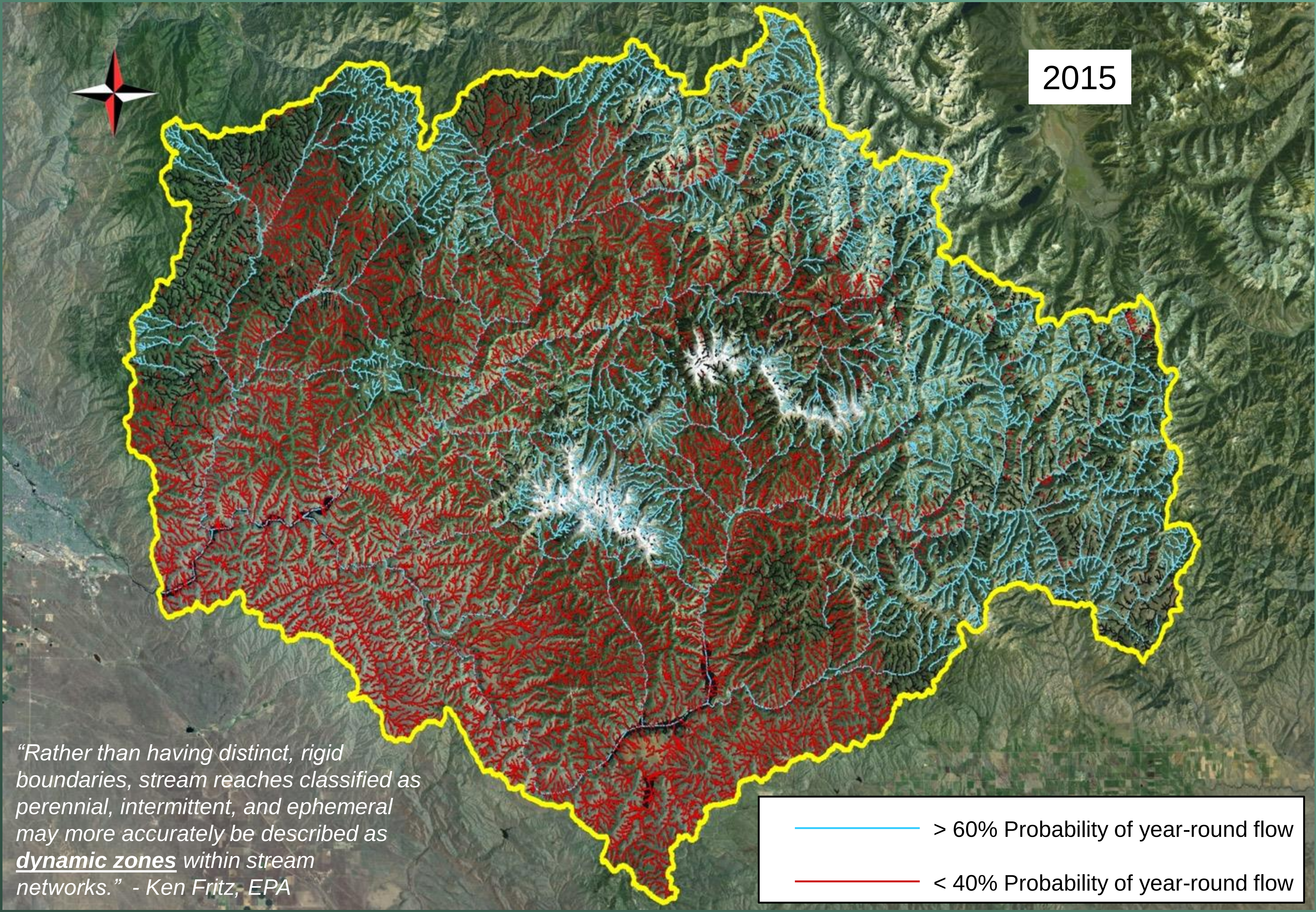
*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks." - Ken Fritz, EPA*

Provisional data



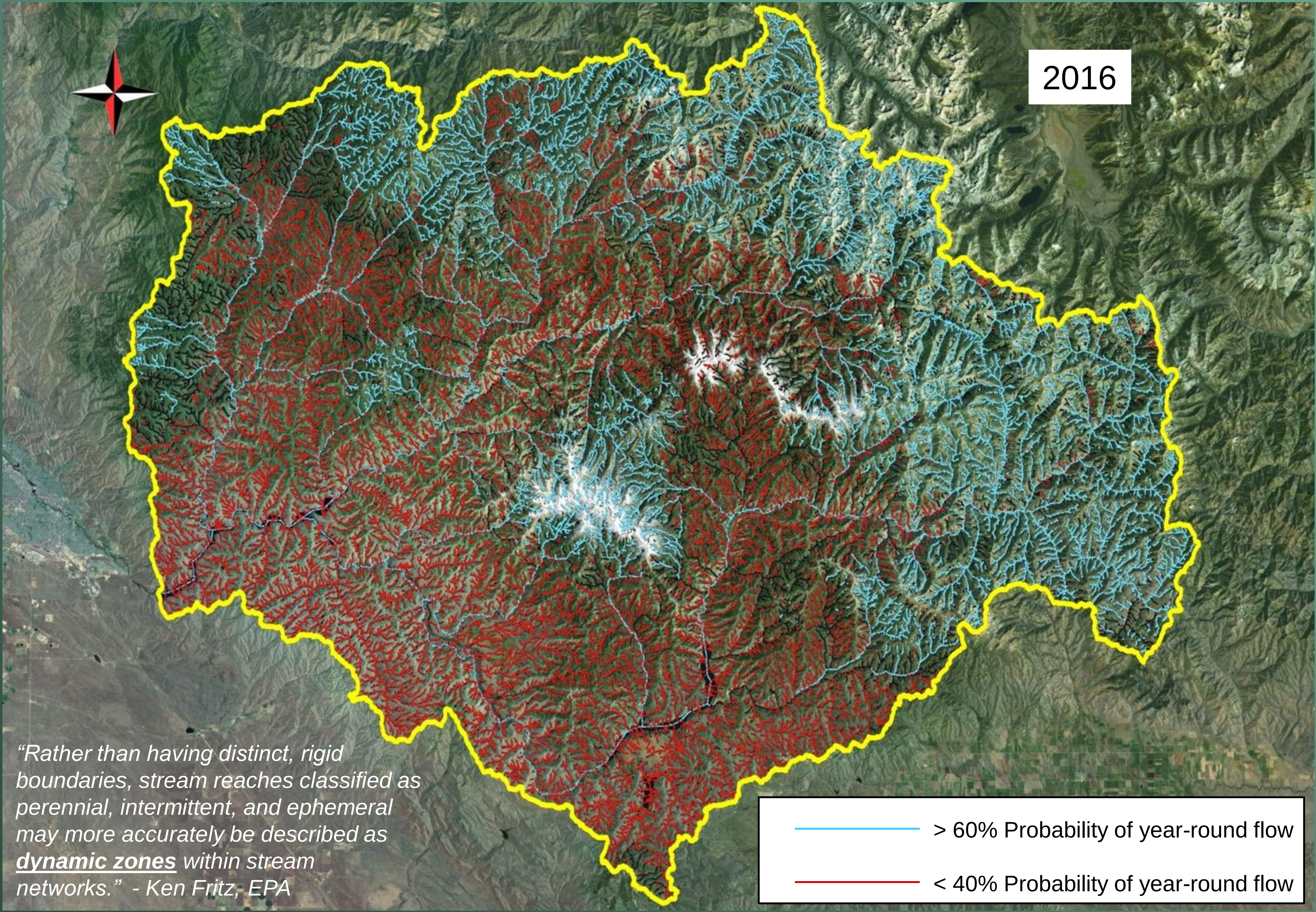
*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as __**dynamic zones**__ within stream networks." - Ken Fritz, EPA*

Provisional data

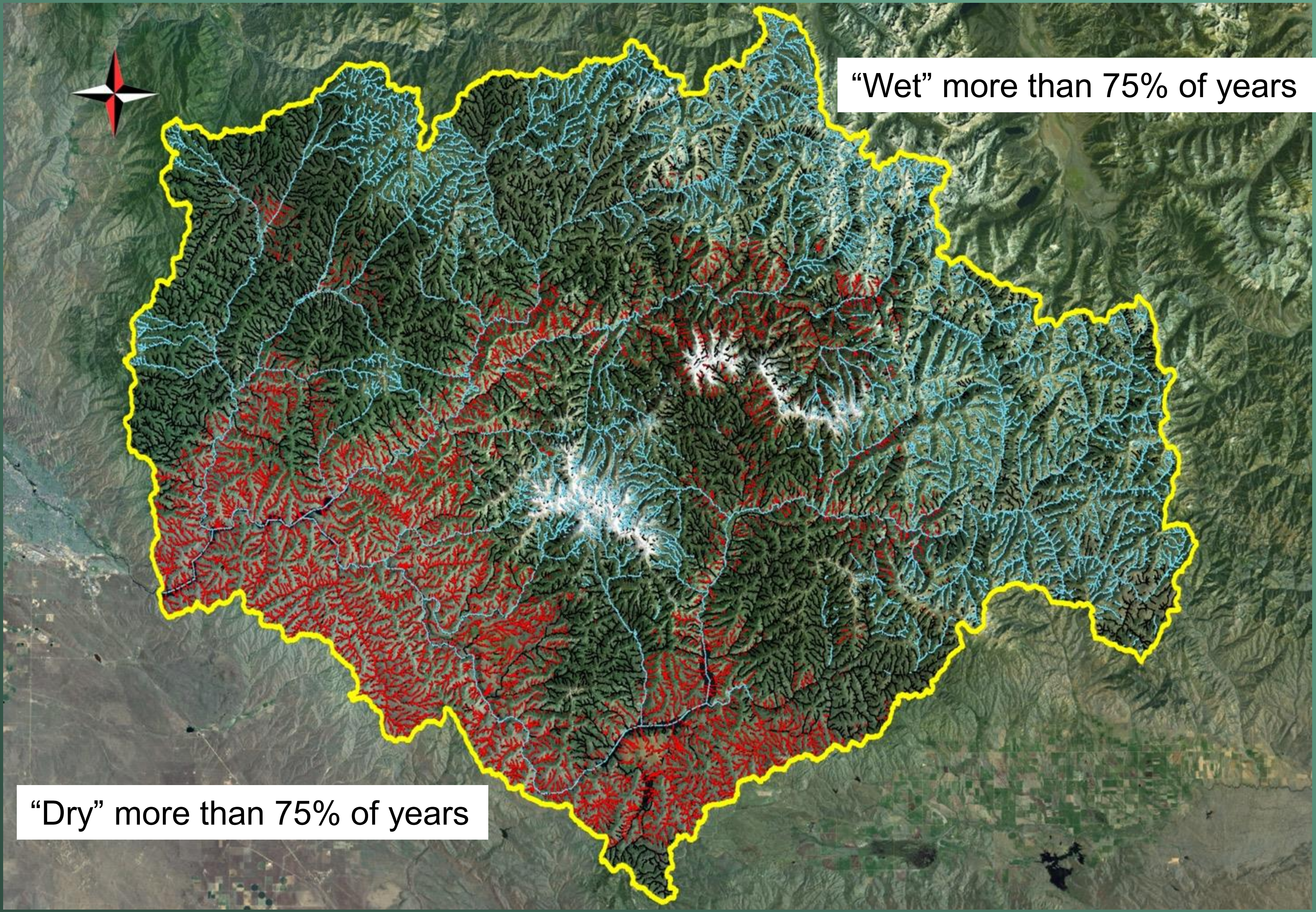


*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks." - Ken Fritz, EPA*

Provisional data



*"Rather than having distinct, rigid boundaries, stream reaches classified as perennial, intermittent, and ephemeral may more accurately be described as **dynamic zones** within stream networks."* *- Ken Fritz, EPA*



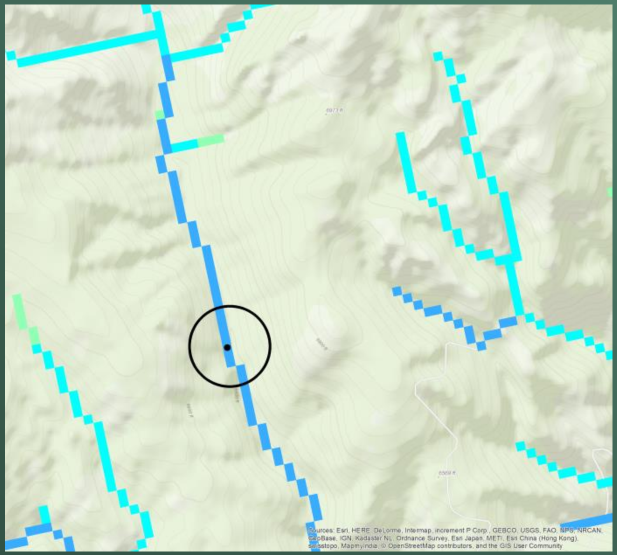
Provisional data

StreamStats (www.streamstats.usgs.gov)

For location-based PROSPER data

- For each location:
  - Select years for which you want data
    - For each year selected:
      - Raw Probabilities
      - Categorical Classifications
      - Warnings

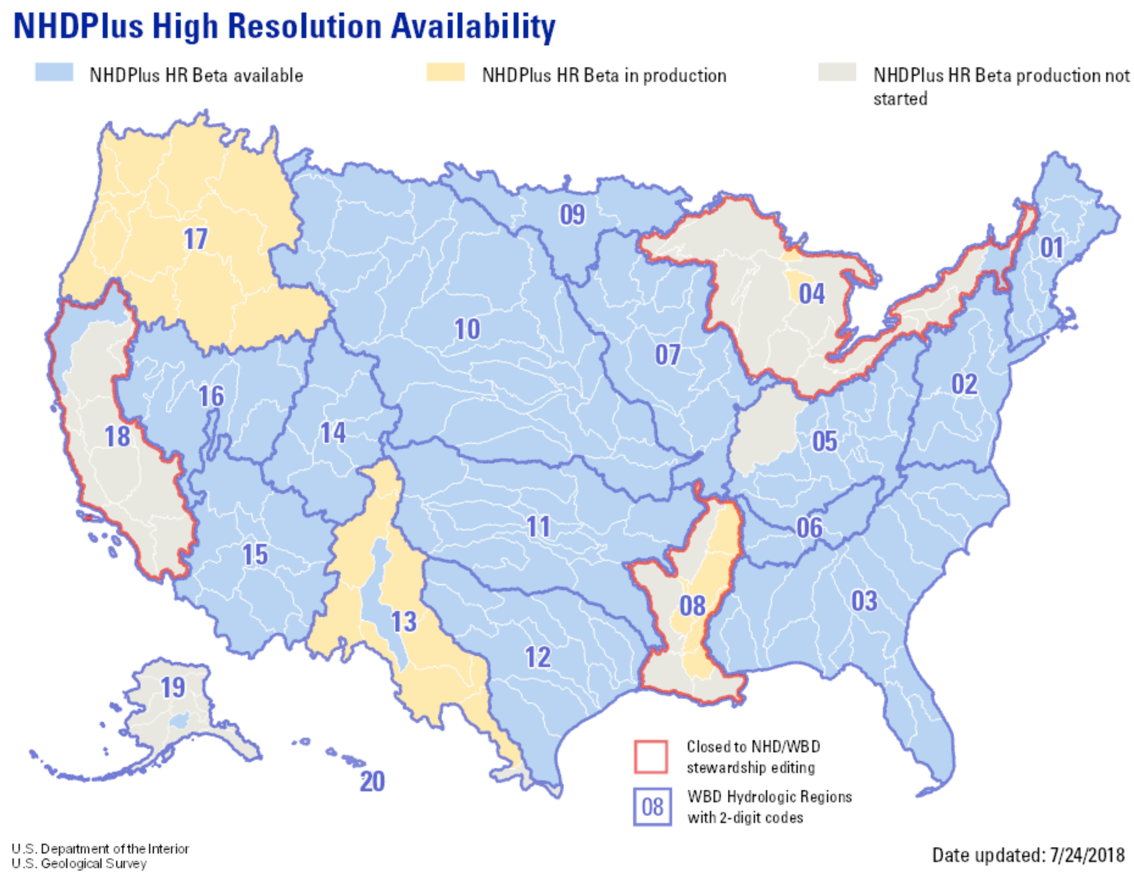
Year	Raw Probability	Categorical Stream Status	Warnings
2004	0.84	5	0
2005	0.76	3	0
2006	0.74	2	0
2007	0.73	2	0
2008	0.71	1	0
2009	0.87	5	0
2010	0.84	5	0
2011	0.75	3	0
2012	0.74	2	0
2013	0.8	5	0
2014	0.72	1	0
2015	0.83	5	0
2016	0.66	-3	0
Mean	0.77	3	0



NHDPlus HR Status

First datasets released in April, 2017

- NHDPlus HR Beta will be completed in 2019 for the conterminous U.S., followed by AK, HI, and territories in later years
- Users are invited to review and provide feedback to the Beta version datasets
- Feedback will be used to update and improve the refreshed data release, beginning in 2019



USGS science for a changing world
The National Map
Your Source for Topographic Information

Questions?

Al Rea

USGS National
Hydrography Co-Lead

ahrea@usgs.gov