Isarithmic Maps

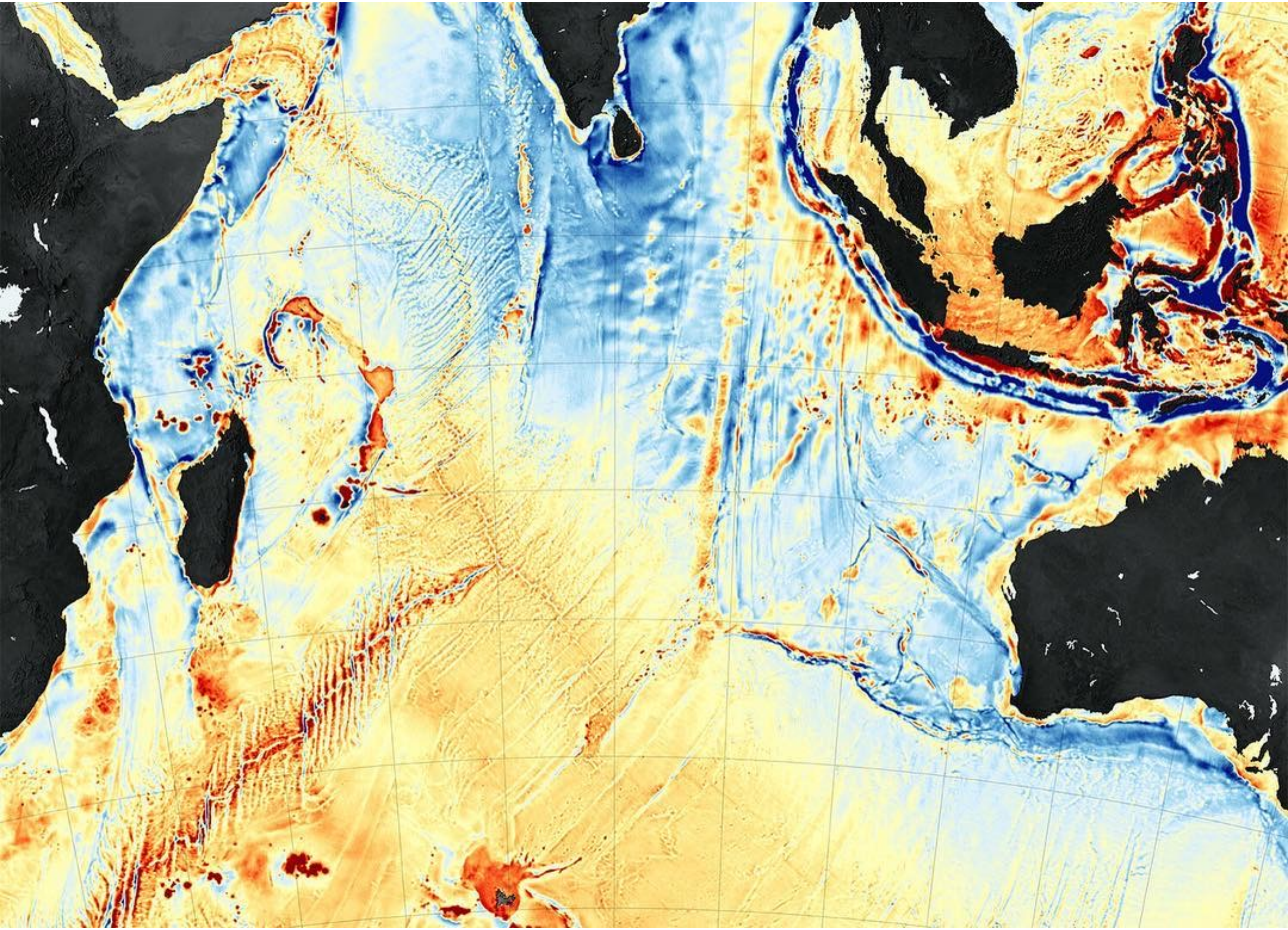
An Iso is a line of equal value. Isarithmic maps are extrapolated and interpolated surfaces, usually derived from point data.

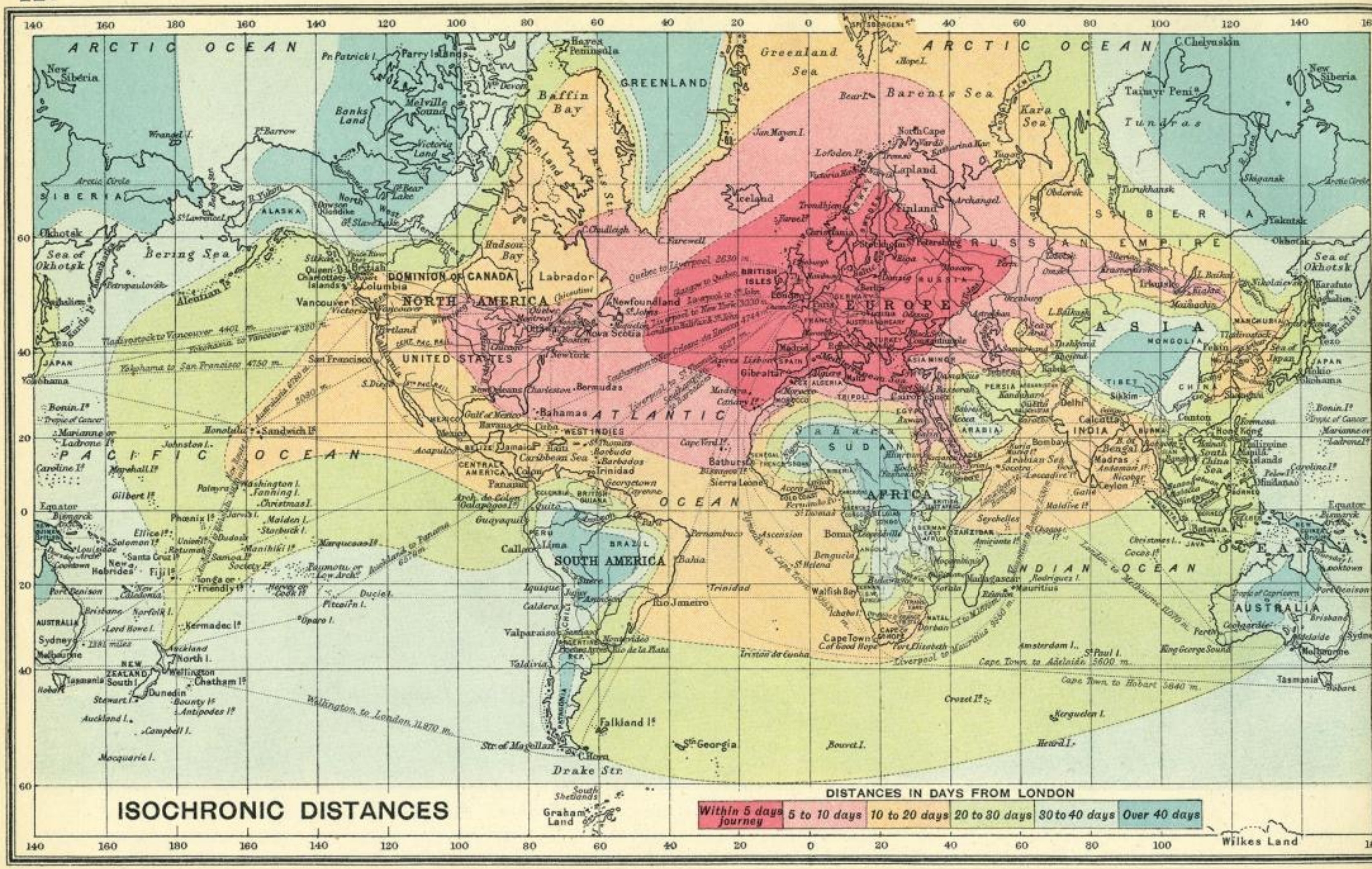
The First Law of Geography, according to Waldo Tobler

"Everything is related to everything else, but near things are more related than distant things"

Isobath	Depth below a datum (for example, mean sea level)
Isogonic line	Magnetic declination
Isocline	Magnetic dip (inclination) or angle of slope
Isohypse (contour)	Elevation above a datum (for example, mean sea level)
Isodynamic line	Intensity of the magnetic field
Isotherm	Temperature (usually average)
Isobar	Atmospheric pressure (usually average)
Isochrone	Time
Isohyet	Precipitation
Isobront	Occurrence of thunderstorms
Isanther	Time of flowering of plants
Isoceph	Cranial indices
Isochalaz	Frequency of hailstorms
Isogene	Density of a genus
Isospecie	Density of a species
Isodyn	Economic attraction
Isohydrodynam	Potential water power
Isostalak	Intensity of plankton precipitation
Isovapor	Vapor content in the air
Isodynam	Traffic tension
Isophot	Intensity of light on a surface
Isoneph	Degree of cloudiness
Isochrone	Travel time from a given point
Isophene	Date of beginning of a plant species entering a certain phenological phase
Isopectic	Time of ice formation
Isotac	Time of thawing
Isobase	Vertical earth movement
Isohemeric line	Minimum time (freight transportation)
Isohel	Average duration of sunshine in a specified time
Isodopane	Cost of travel time

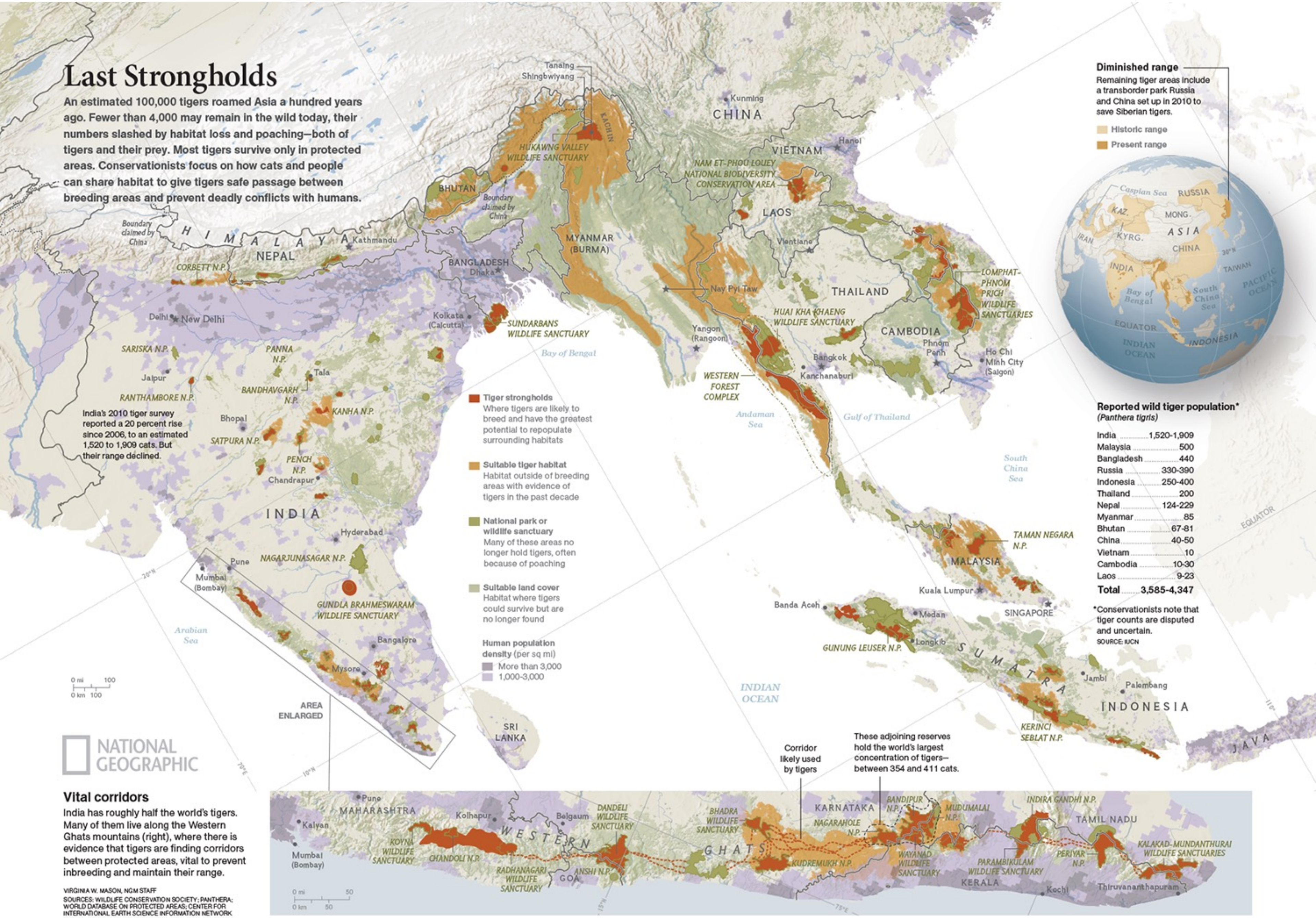
Source: Thrower 1972, Appendix B.




ISOCHRONIC DISTANCES
DISTANCES IN DAYS FROM LONDON
Within 5 days journey
5 to 10 days
10 to 20 days
20 to 30 days
30 to 40 days
Over 40 days
ARCTIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
NORTH AMERICA
DOMINION OF CANADA
UNITED STATES
SOUTH AMERICA
EUROPE
AFRICA
ASIA
AUSTRALIA
OCEANIA
GREENLAND
RUSSIAN EMPIRE
SIBERIA
INDIA
BRITISH ISLES
Quebec to Liverpool 2630 m.
Yokohama to San Francisco 4750 m.
Vladivostock to Vancouver 4401 m.
Wellington to London 11,970 m.
Cape Town to Adelaide 5600 m.
Cape Town to Hobart 5840 m.
Wilkes Land
Drake Str.

Last Strongholds

An estimated 100,000 tigers roamed Asia a hundred years ago. Fewer than 4,000 may remain in the wild today, their numbers slashed by habitat loss and poaching—both of tigers and their prey. Most tigers survive only in protected areas. Conservationists focus on how cats and people can share habitat to give tigers safe passage between breeding areas and prevent deadly conflicts with humans.



Reported wild tiger population*
(Panthera tigris)

India	1,520-1,909
Malaysia	500
Bangladesh	440
Russia	330-390
Indonesia	250-400
Thailand	200
Nepal	124-229
Myanmar	85
Bhutan	67-81
China	40-50
Vietnam	10
Cambodia	10-30
Laos	9-23
Total	**3,585-4,347**

*Conservationists note that tiger counts are disputed and uncertain.
SOURCE: IUCN

NATIONAL GEOGRAPHIC

Vital corridors

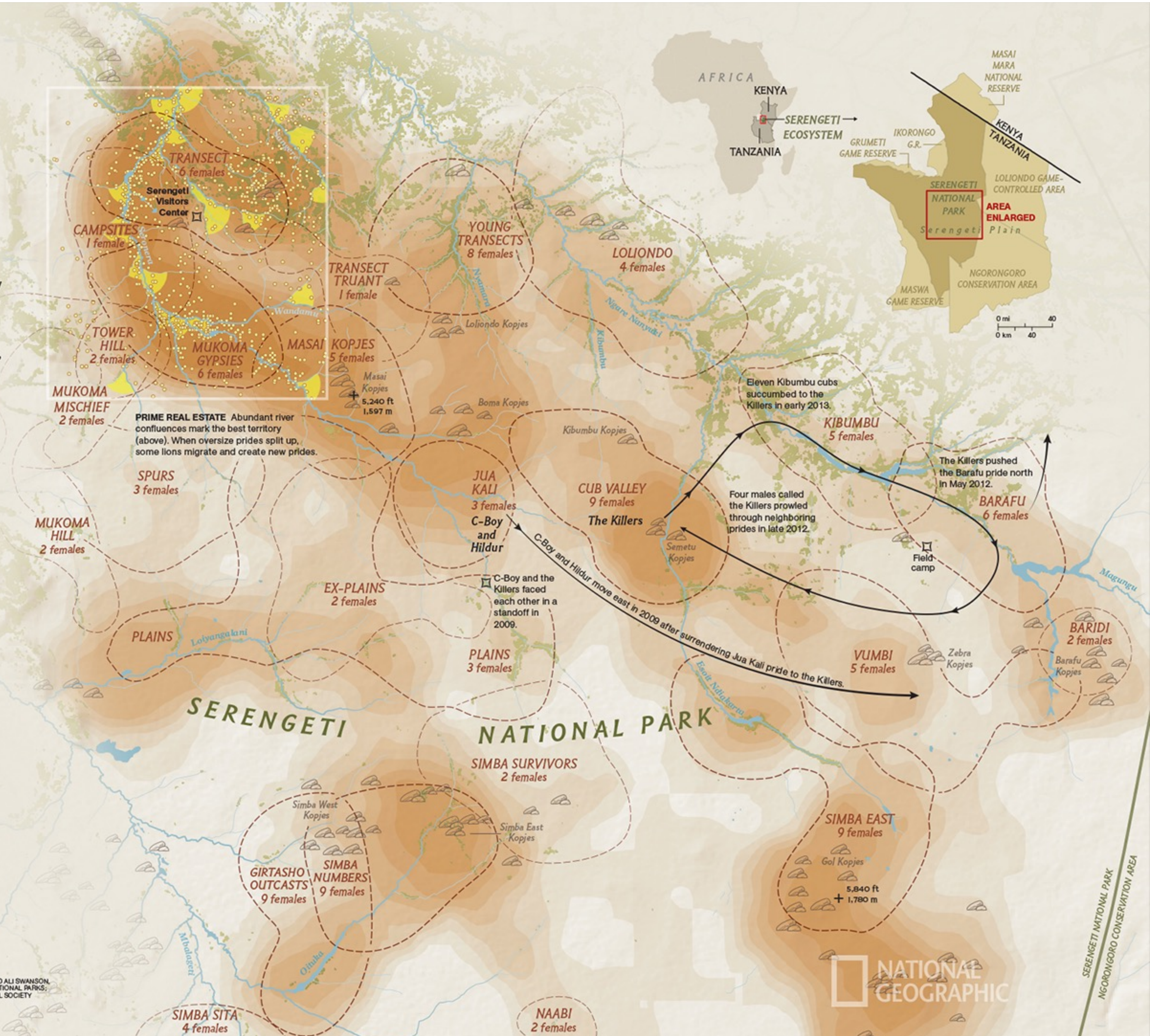
India has roughly half the world's tigers. Many of them live along the Western Ghats mountains (right), where there is evidence that tigers are finding corridors between protected areas, vital to prevent inbreeding and maintain their range.

VIRGINIA W. MASON, NGM STAFF

SOURCES: WILDLIFE CONSERVATION SOCIETY; PANTHERA; WORLD DATABASE ON PROTECTED AREAS; CENTER FOR INTERNATIONAL EARTH SCIENCE INFORMATION NETWORK

TRACKING THE Prides

Location, location, location: High-quality habitat is crucial to a lion pride. Midsize prides generally control the best real estate and do better at holding on to their prime territories. Where rivers join, prey animals such as wildebeests and zebras become concentrated, making it easier for lions to kill them. Prides holding such territories produce more cubs that survive.



WHERE LIONS THRIVE
Prides that control the best territories produce the most cubs.

Reproductive success

High — Low

PRIDE TERRITORIES
Two to six females are optimal for prides on the plains, up to 11 in woodlands.

PRIDE NAME
Number of adult females
As of July 2012

LANDSCAPE

River confluences trap prey
Prey carcass (data collected 1966-2005)

Kopje: a small, rocky hill used as a lookout or to hide cubs

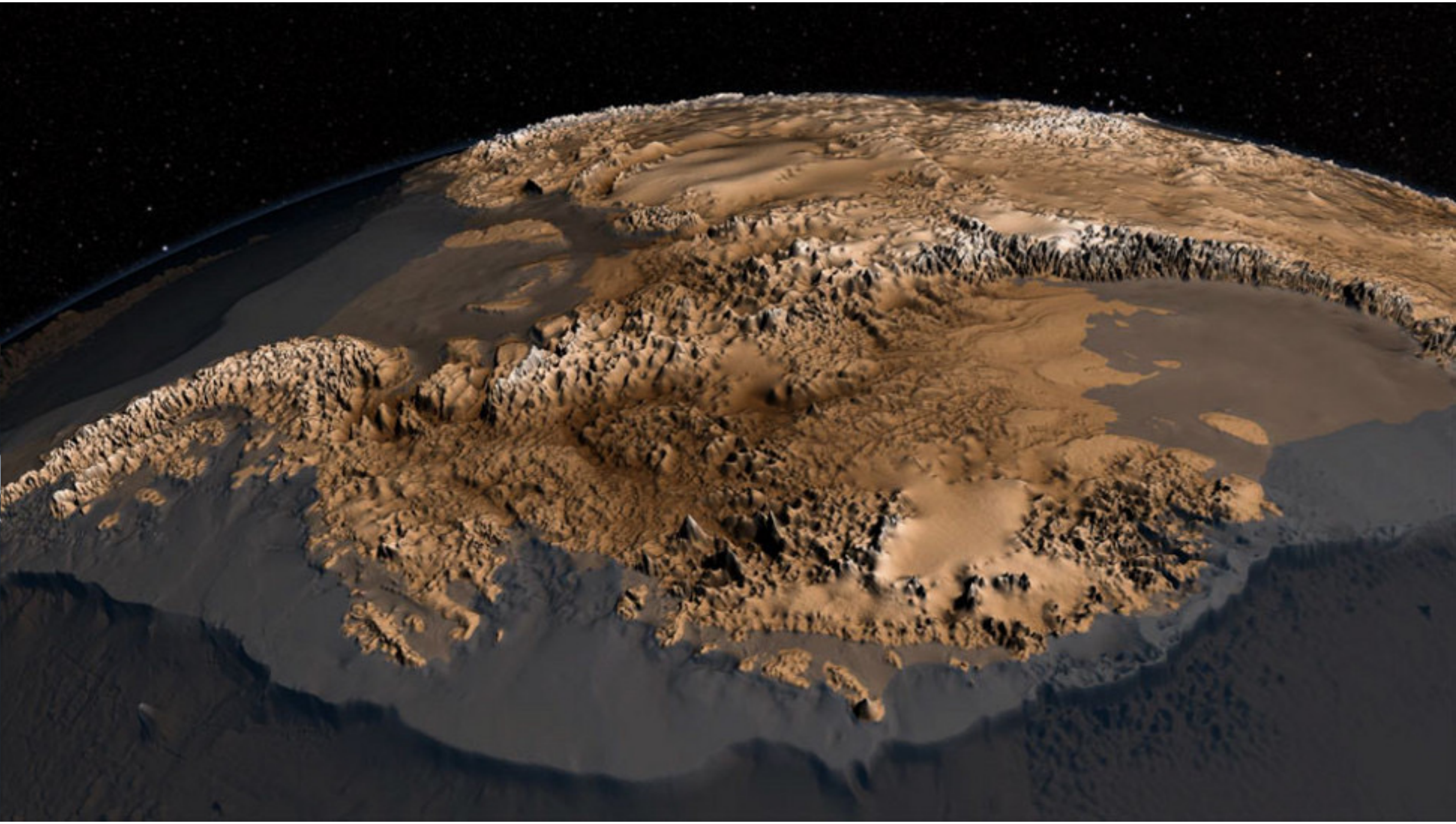
Plains: grassland or shrubland
Open woodland

0 mi 3
0 km 3

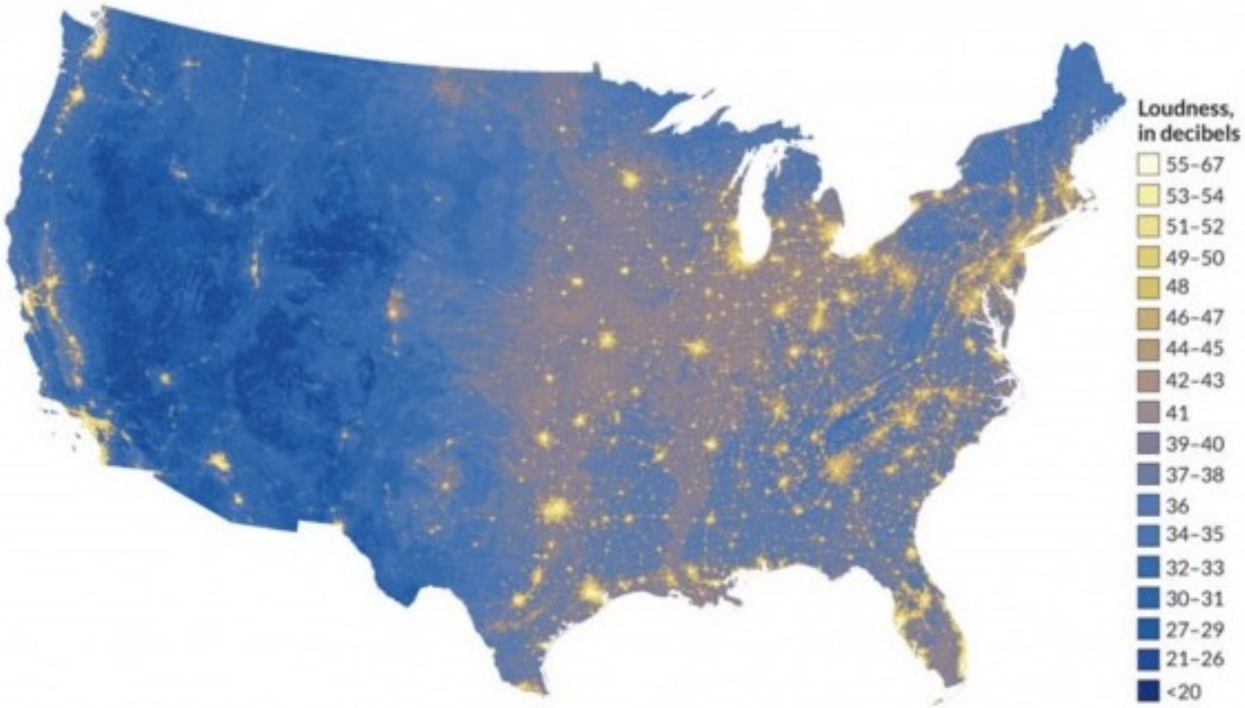
Check out audio, video, and an interactive map on our digital editions.

VIRGINIA W. MASON, NGM STAFF

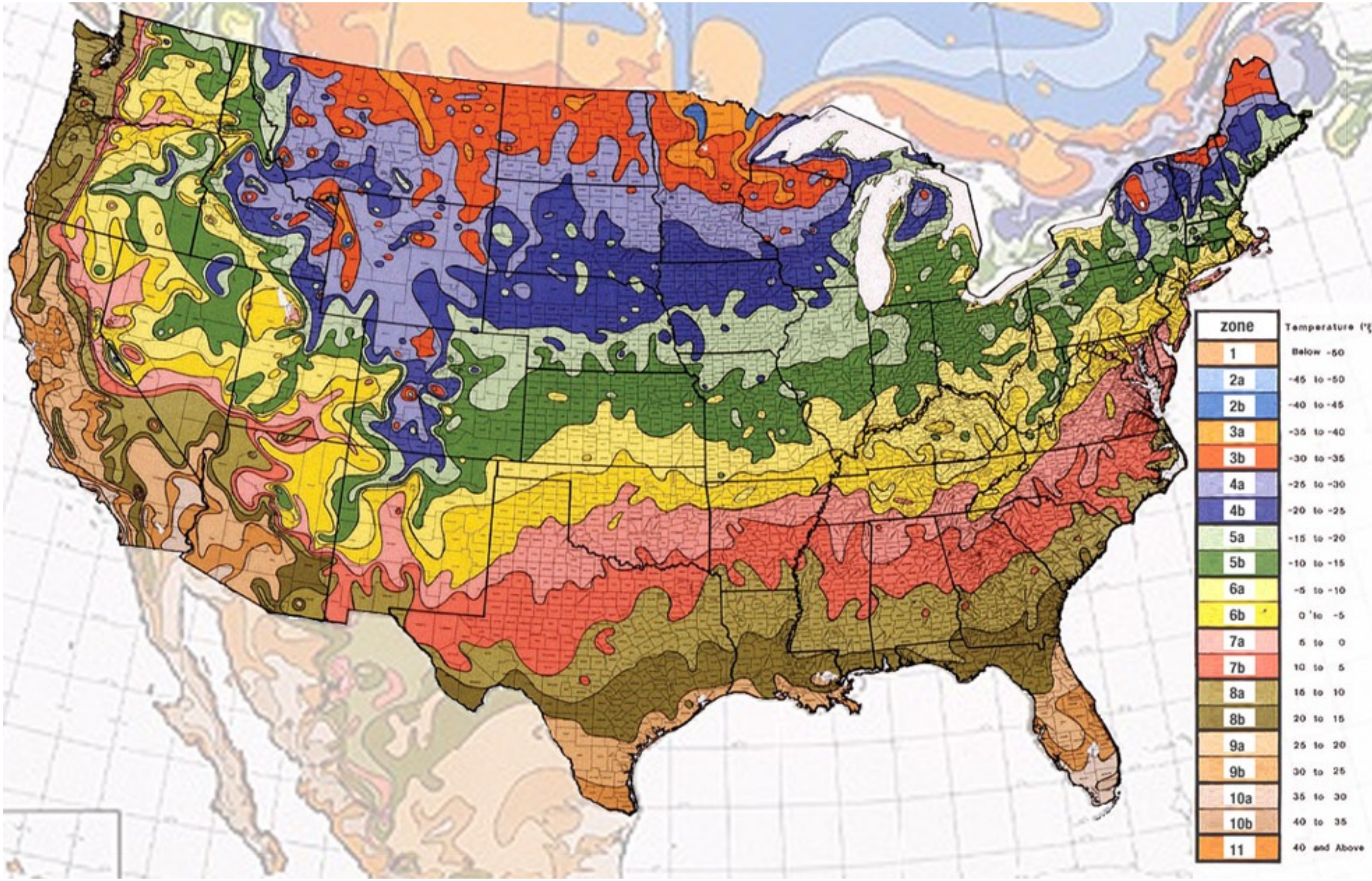
SOURCES: CRAIG PACKER, ANNA MOSSER, DANIEL ROSENGREN, AND ALI SWANSON, LION RESEARCH CENTER, UNIVERSITY OF MINNESOTA; TANZANIA NATIONAL PARKS; TANZANIA WILDLIFE RESEARCH INSTITUTE; FRANKFURT ZOOLOGICAL SOCIETY

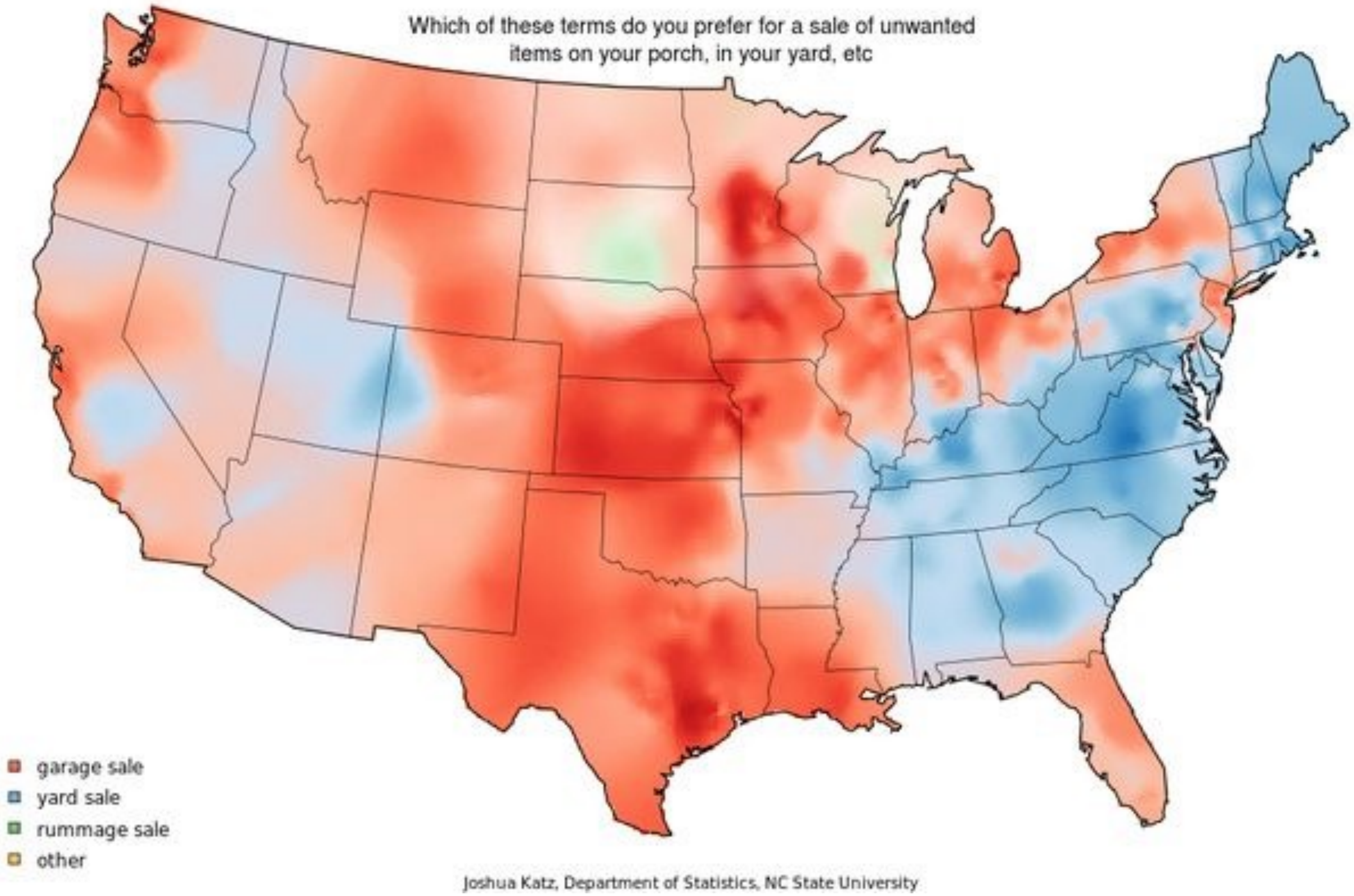


Noise in the USA



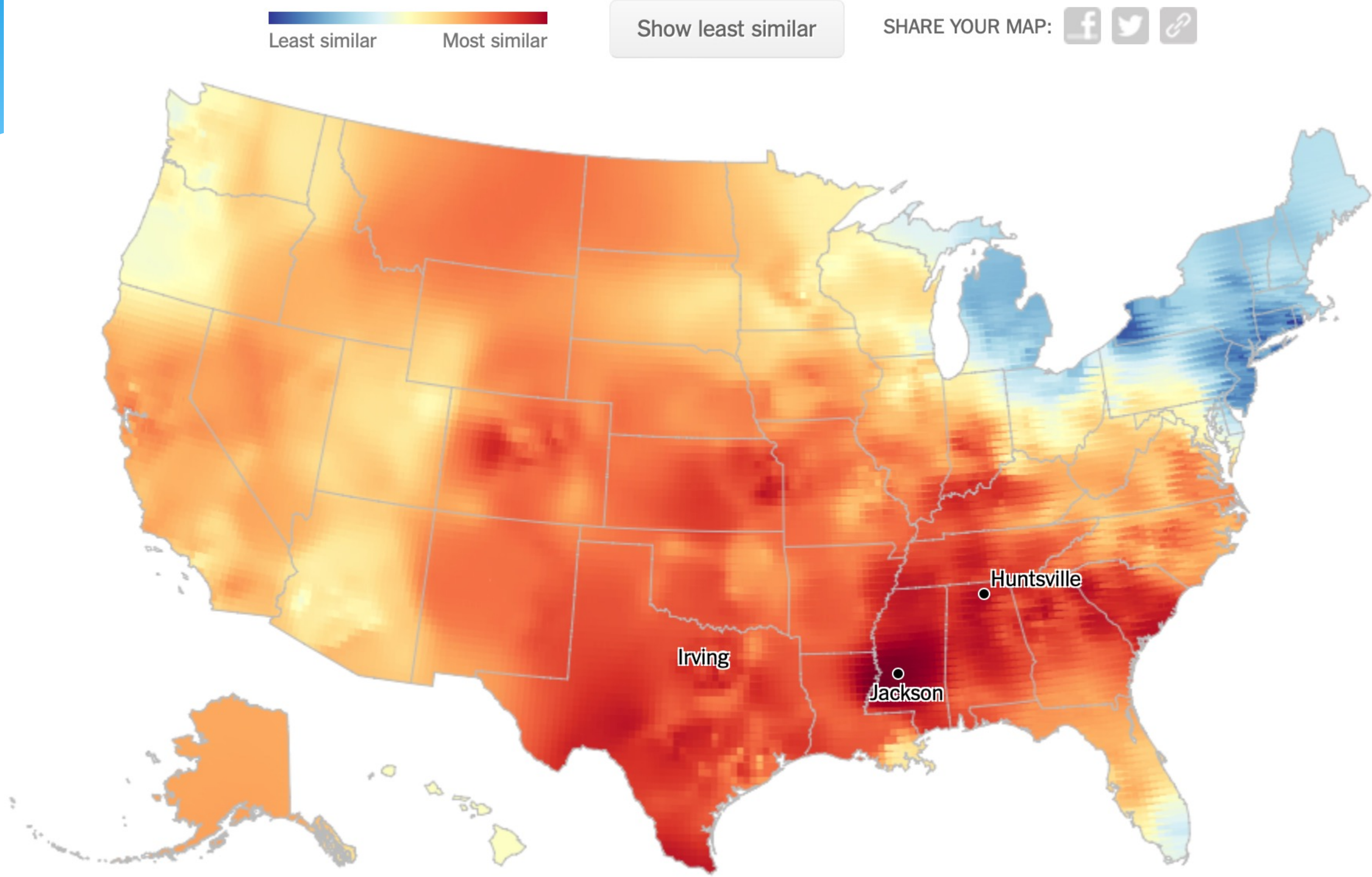
Hardiness Zones




Which of these terms do you prefer for a sale of unwanted
items on your porch, in your yard, etc
garage sale
yard sale
rummage sale
other
Joshua Katz, Department of Statistics, NC State University

Your Map

See the pattern of your dialect in the map below. Three of the most similar cities are shown.



https://www.nytimes.com/interactive/2014/upshot/dialect-quiz-map.html

Spatial Interpolation & Extrapolation

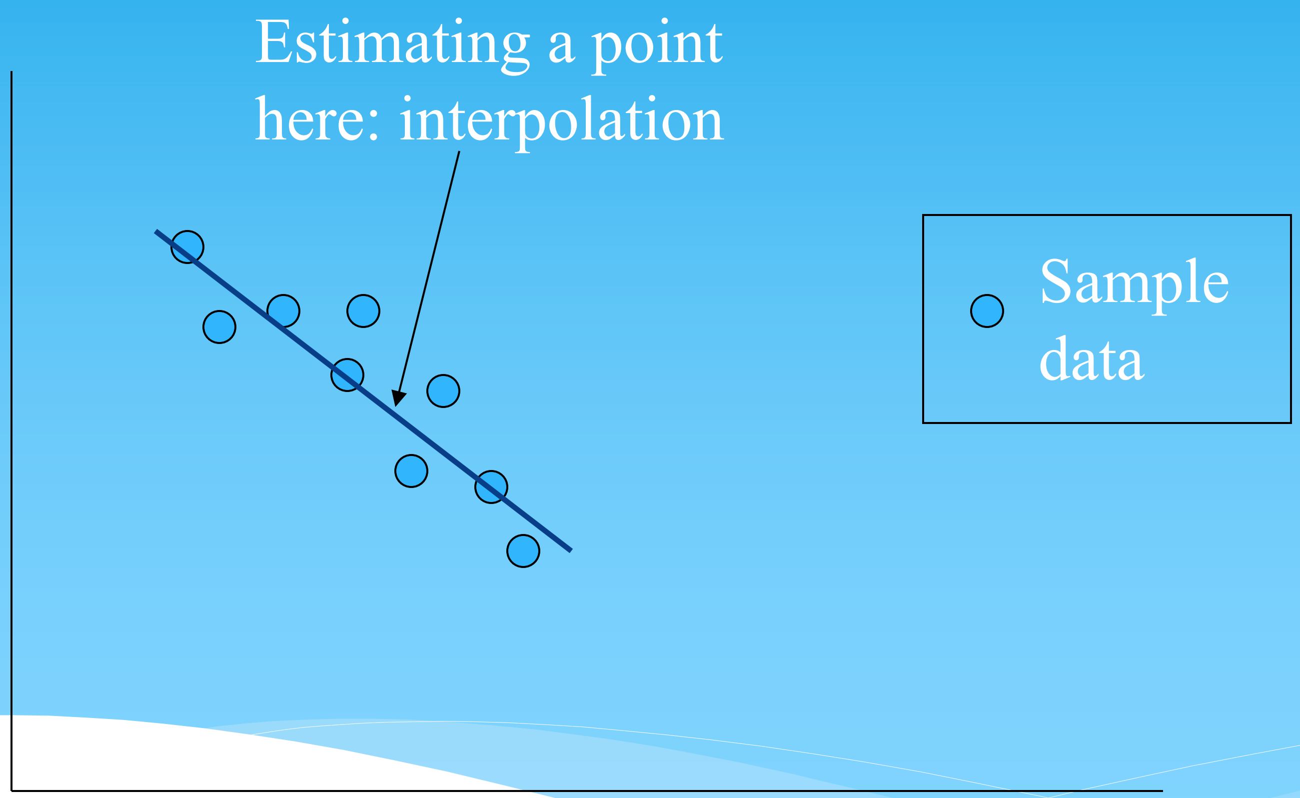
- Deterministic
  - Deterministic interpolation techniques create surfaces from measured points, based on either the extent of similarity (Inverse Distance Weighted) or the degree of smoothing (Radial Basis Functions)
  - **IDW**, **Spline**, Voronoi / TP / Delaunay

- Geostatistical
  - Create surfaces incorporating the statistical properties of the measured data (for example trend).
  - These techniques produce not only prediction surfaces but also error or uncertainty surfaces, giving you an indication of how good the predictions are.
  - **Kriging** (Simple, Co, Ordinary, etc.)

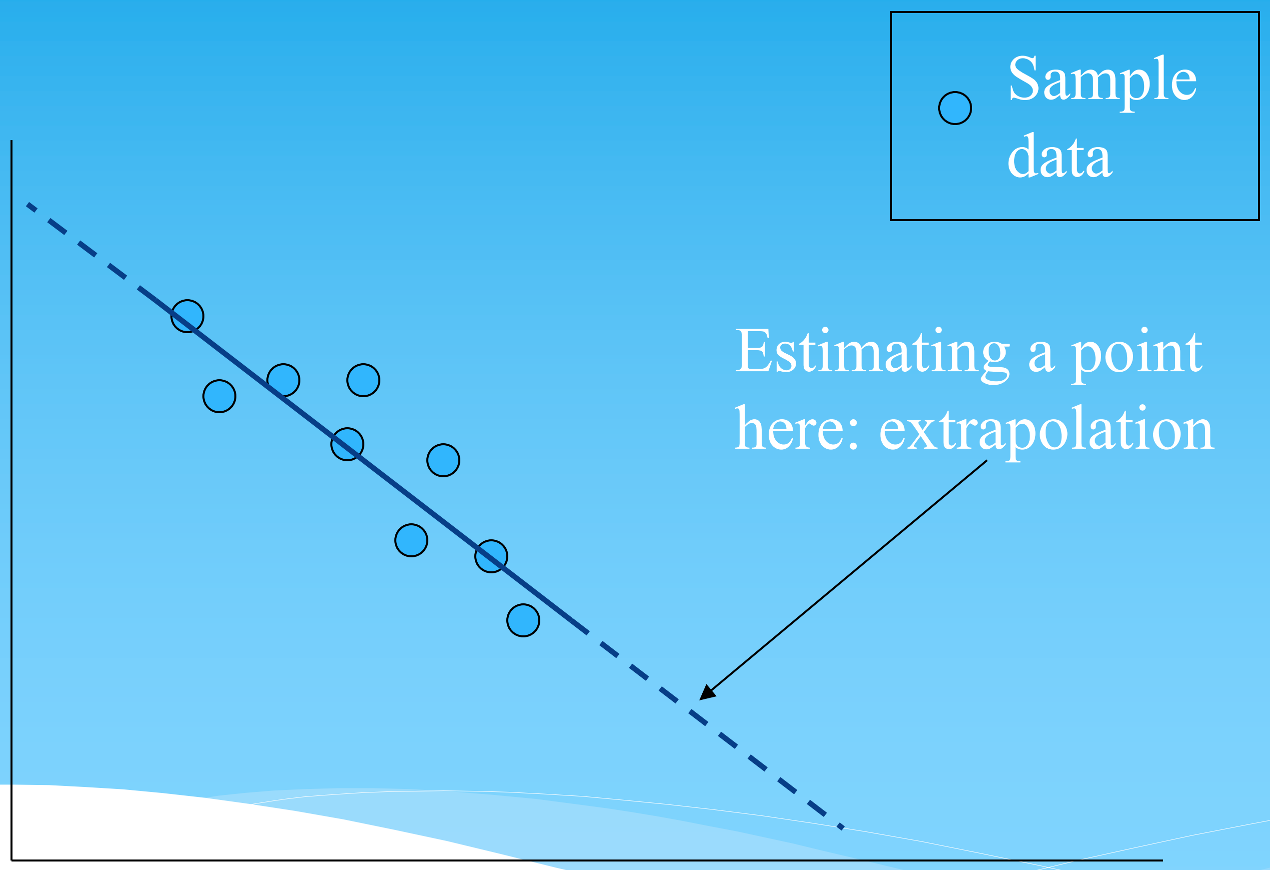
Interpolation vs Extrapolation

- Interpolation
  - Estimating the attribute values of locations that are within the range of available data using known data values
- Extrapolation
  - Estimating the attribute values of locations outside the range of available data using known data values

Interpolation

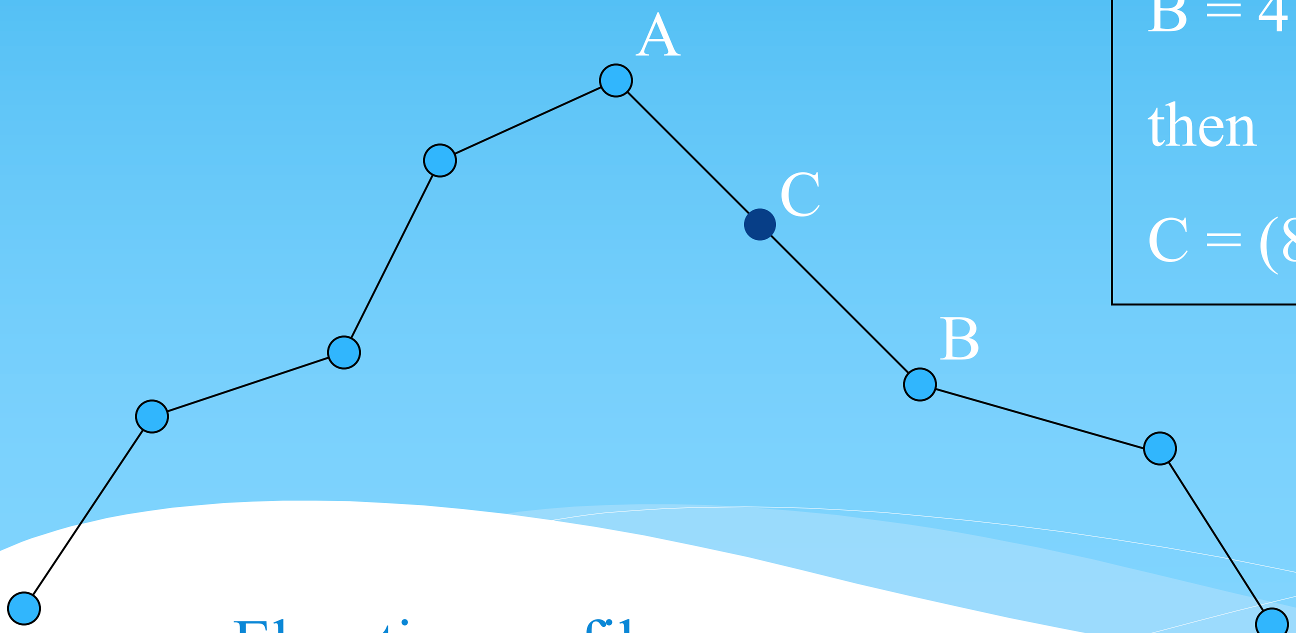


Extrapolation



Linear Interpolation

Sample elevation data



Elevation profile

If

A = 8 feet and

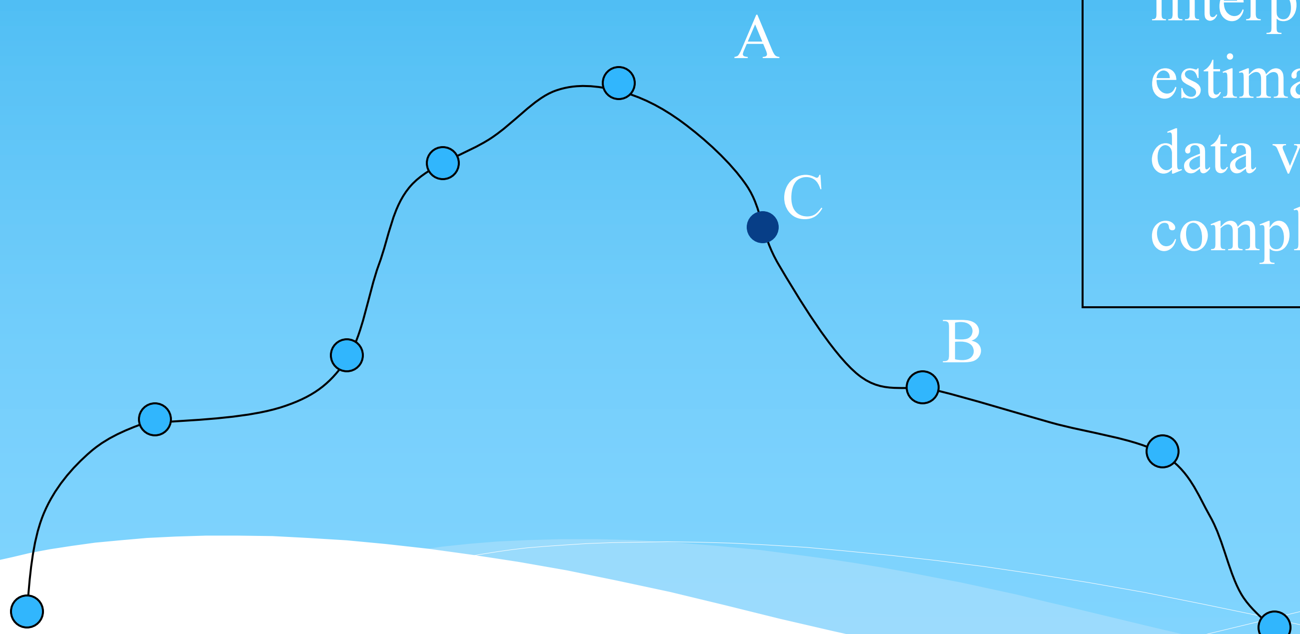
B = 4 feet

then

C = (8 + 4) / 2 = 6 feet

Non-Linear Interpolation

Sample elevation data



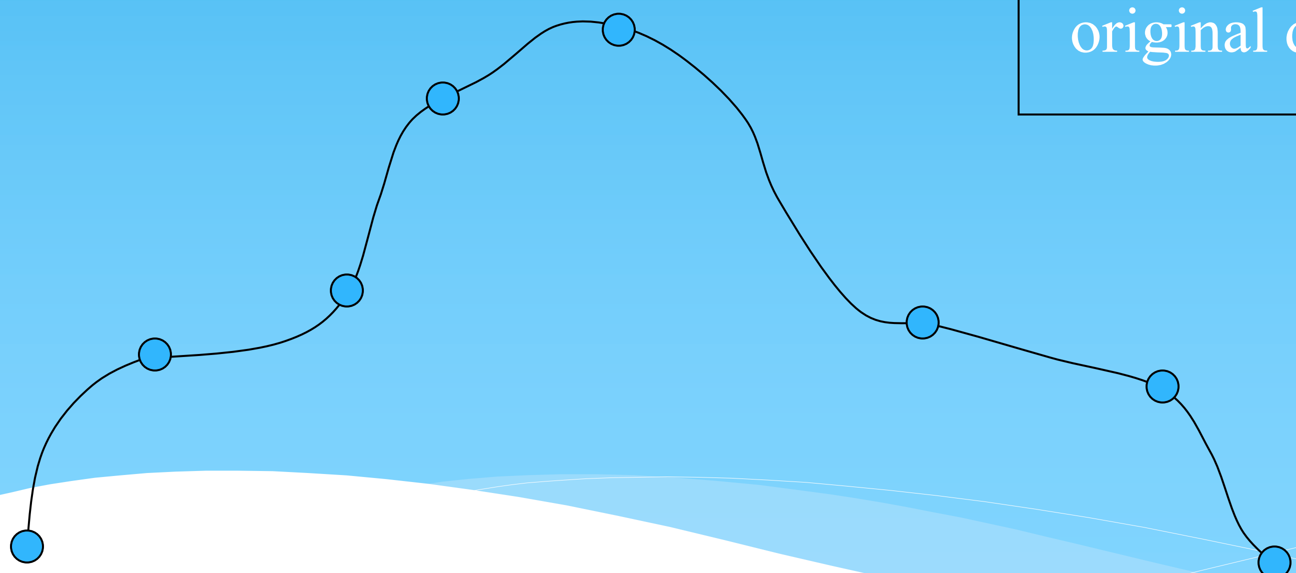
Often results in a more realistic interpolation but estimating missing data values is more complex

Elevation profile

Exact Interpolation

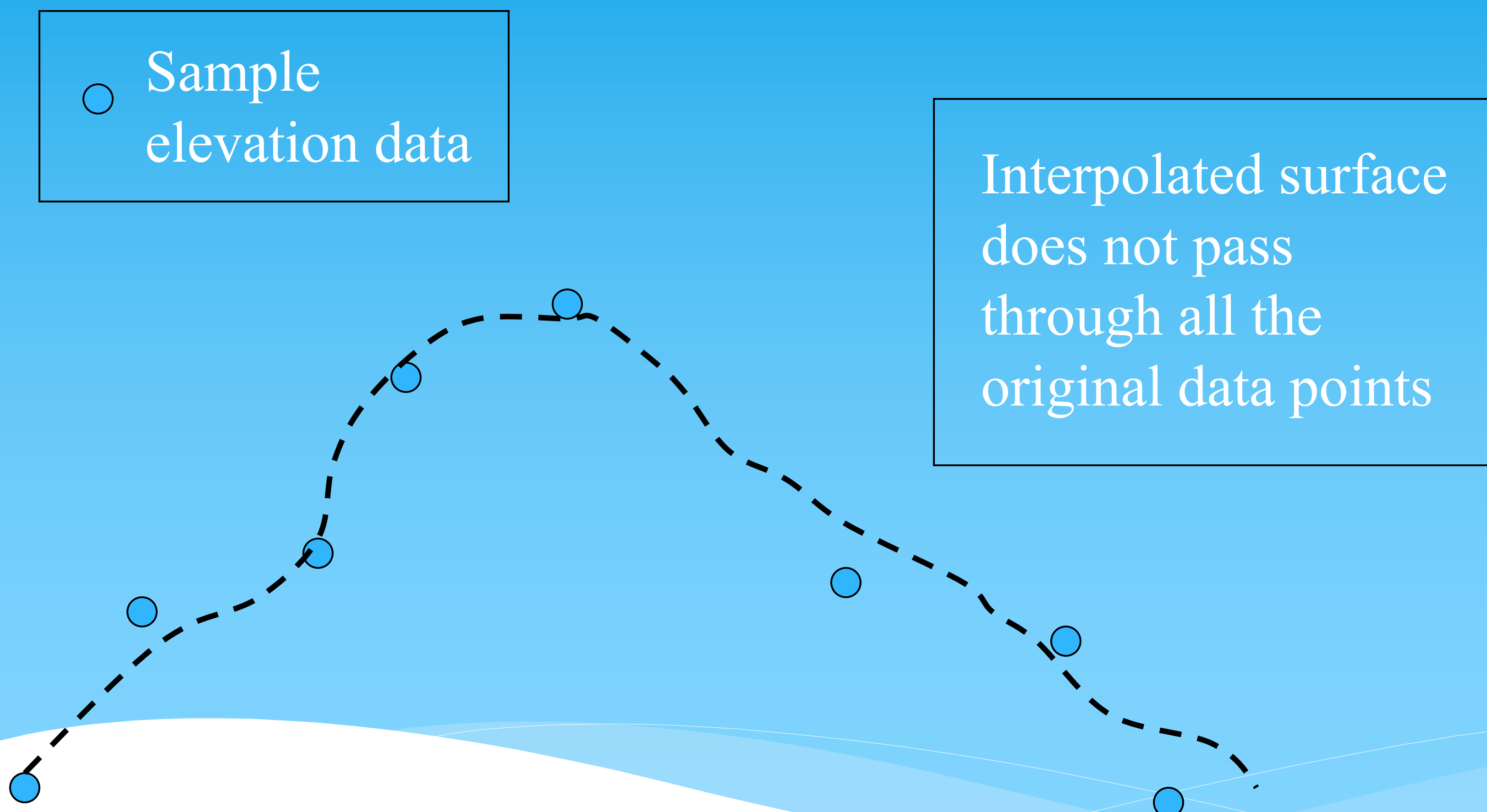
Sample elevation data

Interpolated surface passes through the original data points



Elevation profile

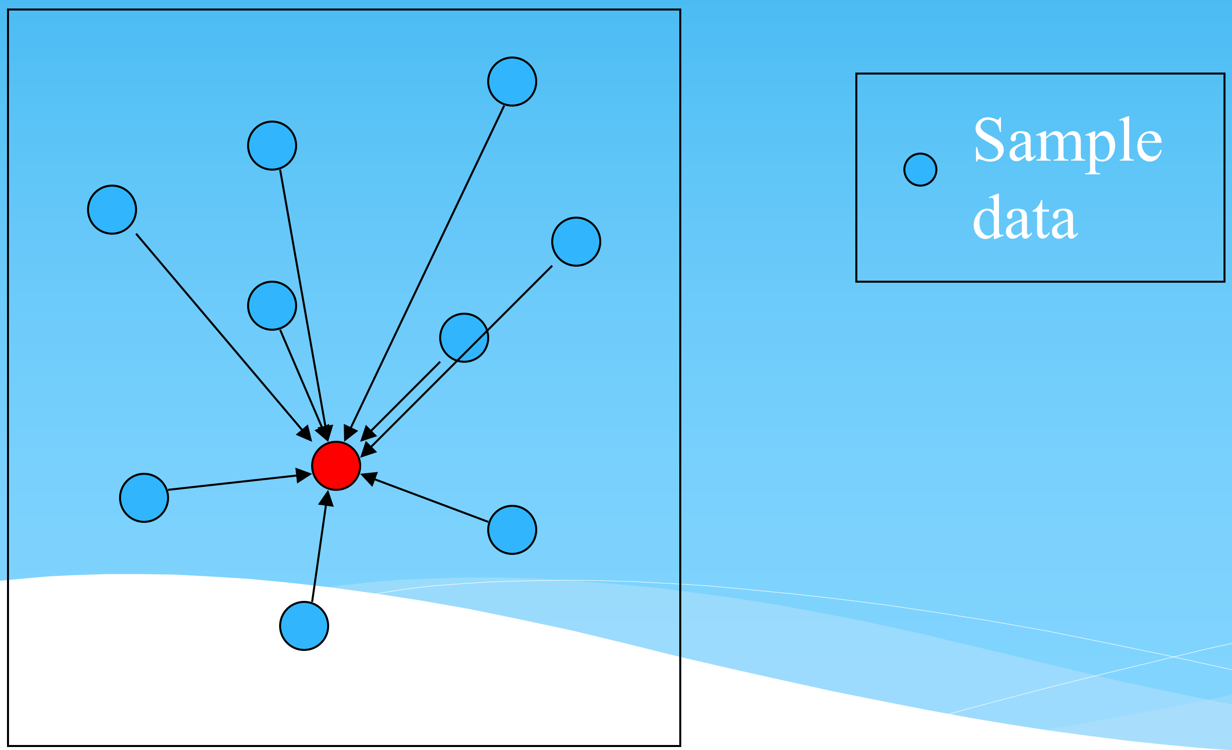
Inexact Interpolation



Elevation profile

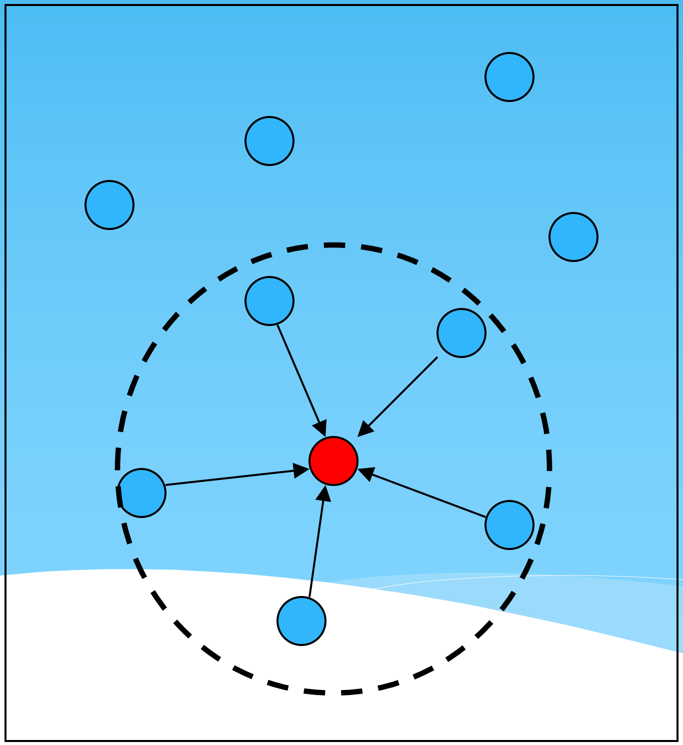
Global Interpolation

Uses all known sample points to estimate a value at an unsampled location



Local Interpolation

Uses a neighborhood of sample points to estimate a value at an unsampled location



Uses a local neighborhood to estimate value, i.e. closest *n* number of points, or within a given search radius

Inverse Distance Weighted (IDW)

- IDW
  - The IDW (Inverse Distance Weighted) tool uses a method of interpolation that estimates cell values by averaging the values of sample data points in the neighborhood of each processing cell.
  - Because IDW is a weighted distance average, the average cannot be greater than the highest or less than the lowest input. Therefore, it cannot create ridges or valleys if these extremes have not already been sampled.
  - The best results from IDW are obtained when sampling is sufficiently dense with regard to the local variation you are attempting to simulate.

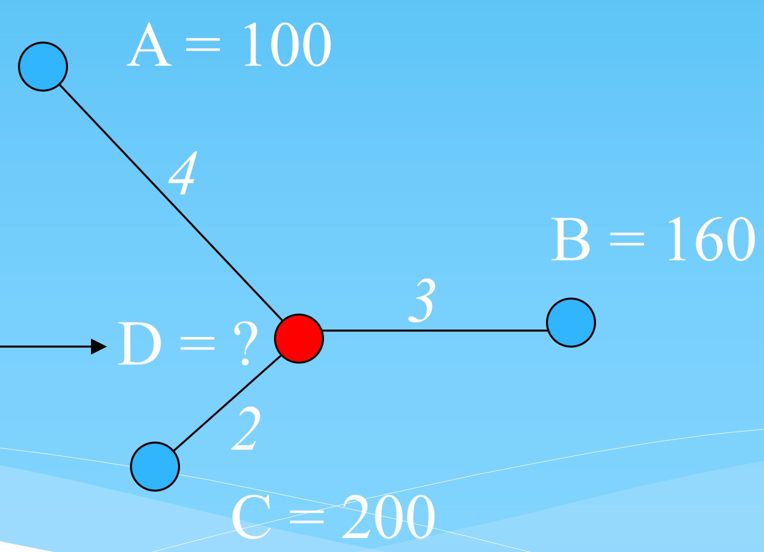
  - Use IDW with a dense sample of randomly spaced points that are closely related.

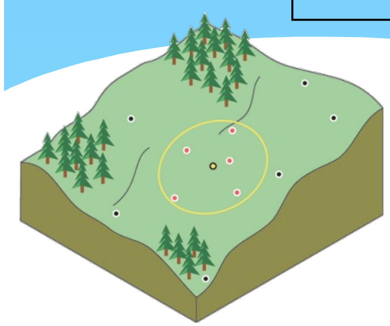
Inverse Distance Weighted (IDW): Example

	Weights	Adjusted Weights	Adjusted Values
A	$1 / (4^2) = .0625$	$.0625 / .4236 = .15$	$100 \text{ x } .15 = 15$
B	$1 / (3^2) = .1111$	$.1111 / .4236 = .26$	$160 \text{ x } .26 = 42$
C	$1 / (2^2) = .2500$	$.2500 / .4236 = .59$	$200 \text{ x } .59 = 118$

Total = .4236

$15 + 42 + 118 = \mathbf{175}$



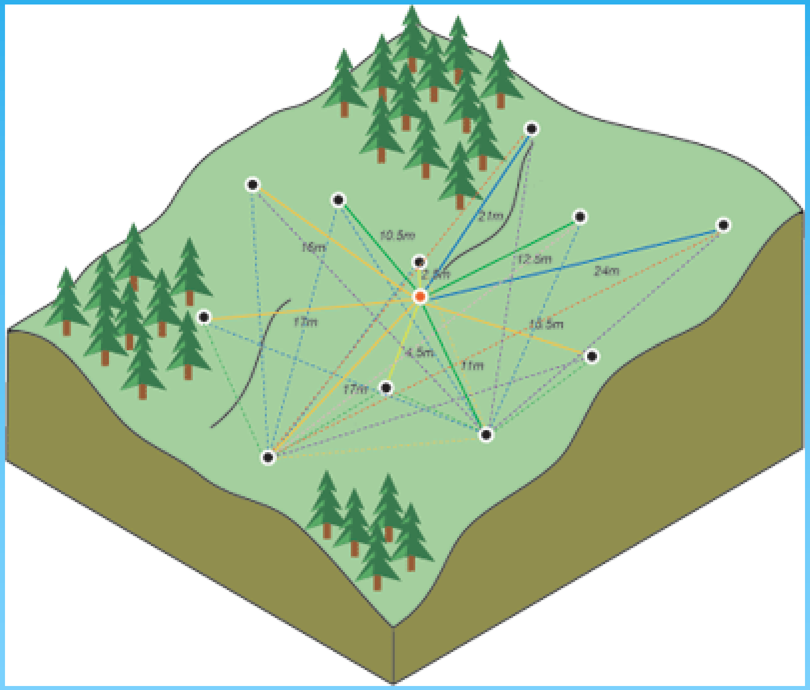


Kriging

* Kriging:
  * Kriging is an advanced geostatistical procedure that generates an estimated surface from a scattered set of points with z-values.
  * The Universal kriging types assume that there is a structural component present and that the local trend varies from one location to another.
  * Low values within the optional output variance of prediction raster indicate a high degree of confidence in the predicted value. High values may indicate a need for more data points.

* Use Kriging on scattered points with a structure that varies with location.

Kriging



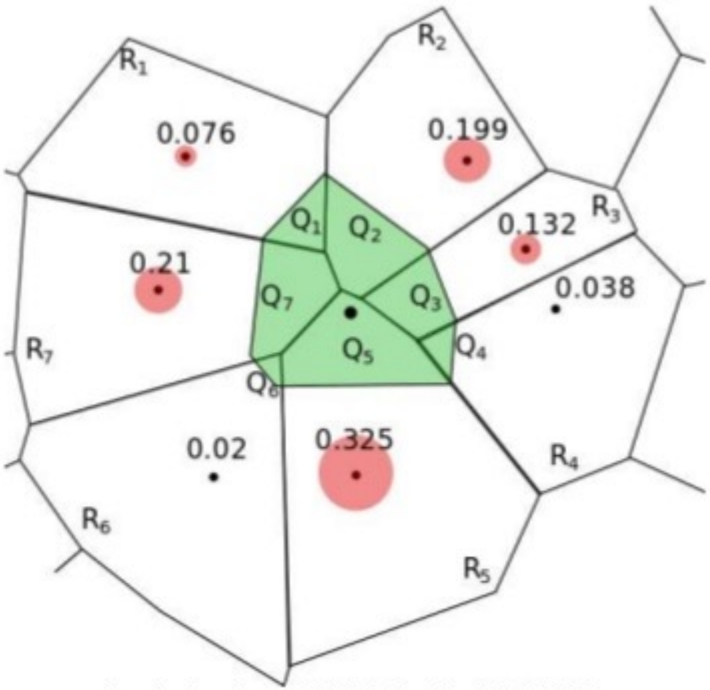
Natural Neighbor

- Natural Neighbor:
  - Natural Neighbor interpolation finds the closest subset of input samples to a query point and applies weights to them based on proportionate areas to interpolate a value.
  - It is also known as Sibson or "area-stealing" interpolation.
  - It is recommended that the input data be in a projected coordinate system rather than in a geographic coordinate system.

- Use Natural Neighbor on data that was collected in areal enumeration units.

Natural Neighbor

Natural Neighbor Interpolation Method



$$G(x,y) = \sum_{i=1}^{N} w_i f(x_i, y_i)$$

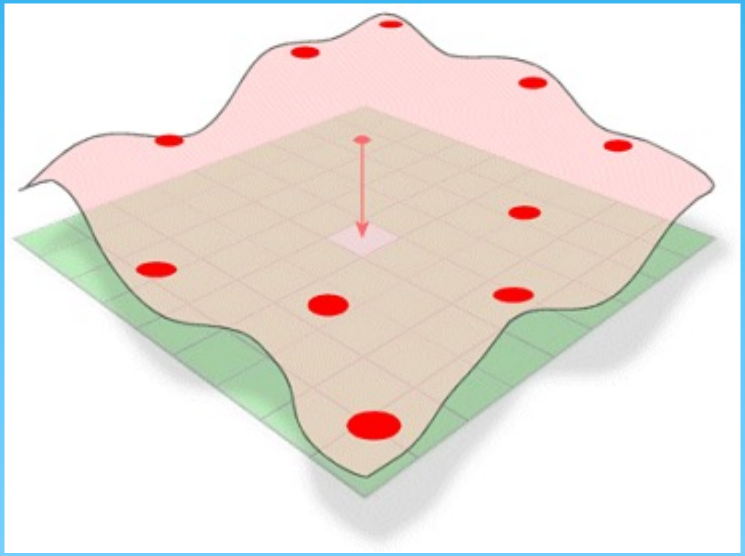
$f(x_i, y_i)$ is the measured (initial) value in point (x_i, y_i)

$w_i = \frac{Q_k}{R_k}$ is ratio of "stolen" area

Spline

* Spline:
  * The Spline tool uses an interpolation method that estimates values using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points.
  * The REGULARIZED option of Spline type usually produces smoother surfaces than those created with the TENSION option.
    * With the REGULARIZED option, higher values used for the weight parameter produce smoother surfaces. The values entered for this parameter must be equal to or greater than zero. Typical values used are 0, 0.001, 0.01, 0.1, and 0.5.
    * With the TENSION option, higher values entered for the weight parameter result in somewhat coarser surfaces, but surfaces that closely conform to the control points. The values entered must be equal to or greater than zero. Typical values are 0, 1, 5, and 10.
  * Use Spline on points that are evenly spaced samples of extrapolated data.

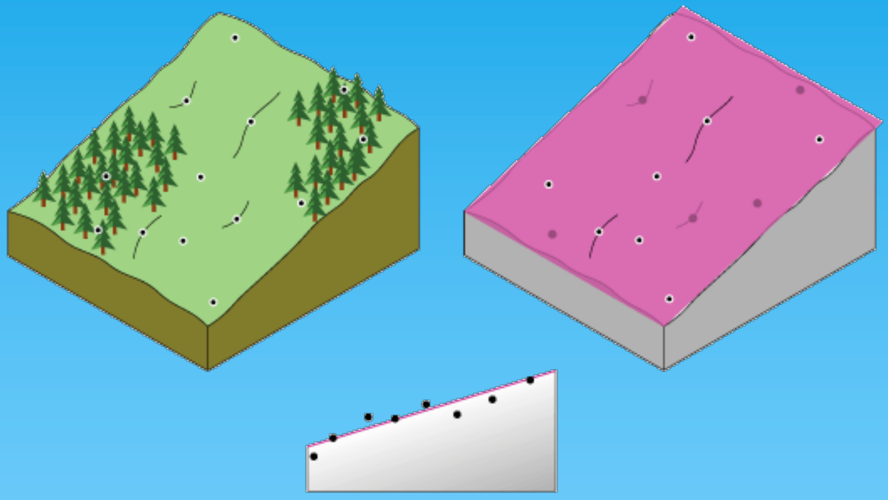
Spline

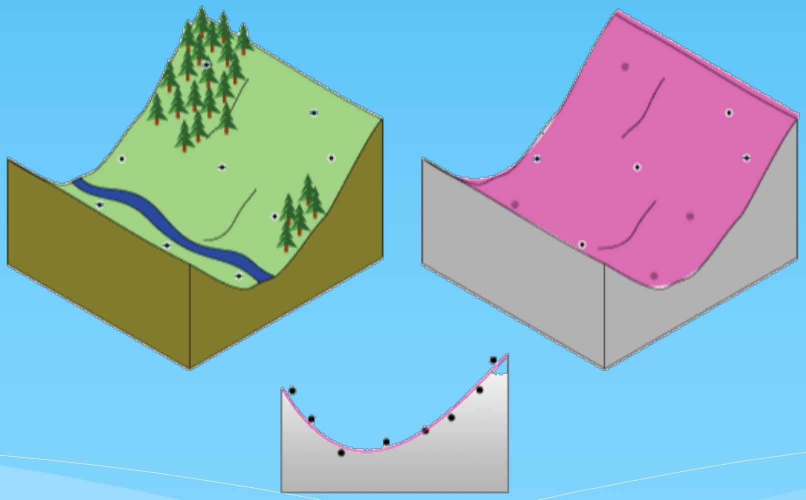


Trend

- Trend:
  - Trend is a global polynomial interpolation that fits a smooth surface defined by a mathematical function (a polynomial) to the input sample points. The trend surface changes gradually and captures coarse-scale patterns in the data.
  - As the order of the polynomial is increased, the surface being fitted becomes progressively more complex. A higher-order polynomial will not always generate the most accurate surface; it is dependent on the data.
  - The optional RMS file output contains information on the RMS error of the interpolation. This information can be used to determine the best value to use for the polynomial order, by changing the order value until you get the lowest RMS error.
  - Use Trend when the data has a linear relationship that is well fit to regression.

Trend



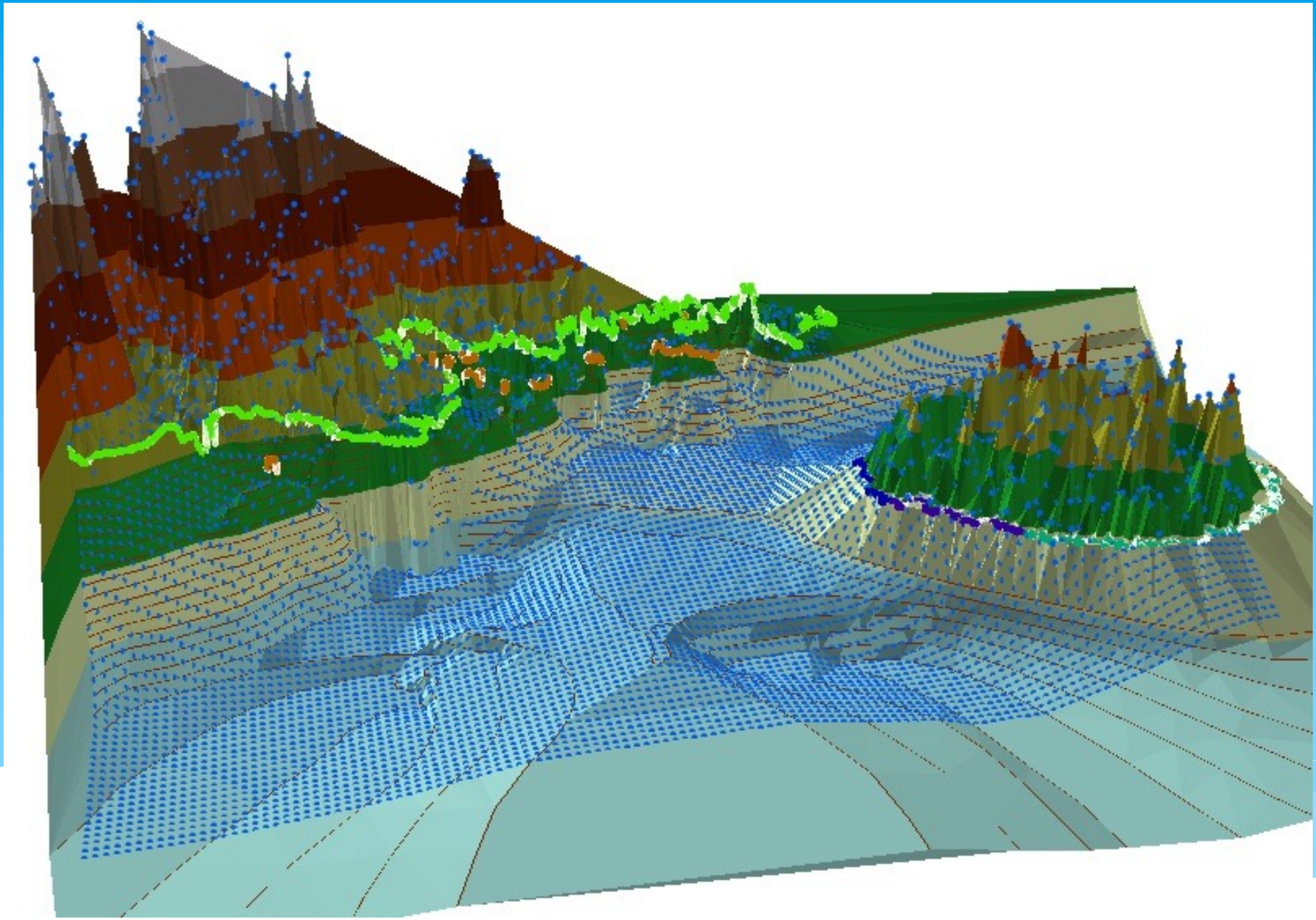


Topo to Raster

- Topo to Raster:
  - The Topo to Raster and Topo to Raster by File tools use an interpolation technique specifically designed to create a surface that more closely represents a natural drainage surface and better preserves both ridgelines and stream networks from input contour data.
  - The best results will be obtained if all input data is stored in the same planar coordinate system and has the same ZUNITS. Unprojected data (latitude–longitude) can be used; however, the results may not be as accurate, particularly at high latitudes.
  - Topo to Raster will only use four input data points for the interpolation of each output cell. All additional points are ignored. If too many points are encountered by the algorithm, an error may occur, indicating the point dataset has too many points.
  - When the input feature type is CONTOUR, the algorithm first generates a generalized morphology of the surface based on the curvature of the contours. Contours are best suited for large-scale data where the contours and corners are reliable indicators of streams and ridges.

  - Use Topo to Raster when points are generated from digitizing contours.

Topo To Raster



Isarithmic Best Practices

- Use **IDW** with a dense sample of randomly spaced points that are closely related.
- Use **Kriging** on scattered points with a structure that varies with location.
- Use **Natural Neighbor** on data that was collected in areal enumeration units.
- Use **Spline** on points that are evenly spaced samples of extrapolated data.
- Use **Trend** when the data has a linear relationship that is well fit to regression.
- Use **Topo to Raster** when points are generated from digitizing contours.