Topographic Position Index (TPI)
An ArcView 3.x Tool for Analyzing the Shape of the Landscape
Based on Ideas and Methods described by Andrew Weiss

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Introduction

Andrew Weiss presented a very interesting and useful poster at the 2001 ESRI International User Conference describing the concept of Topographic Position Index (TPI) and how it could be calculated. Using this TPI at different scales, plus slope, users can classify the landscape into both slope position (i.e. ridge top, valley bottom, mid-slope, etc.) and landform category (i.e. steep narrow canyons, gentle valleys, plains, open slopes, mesas, etc.).
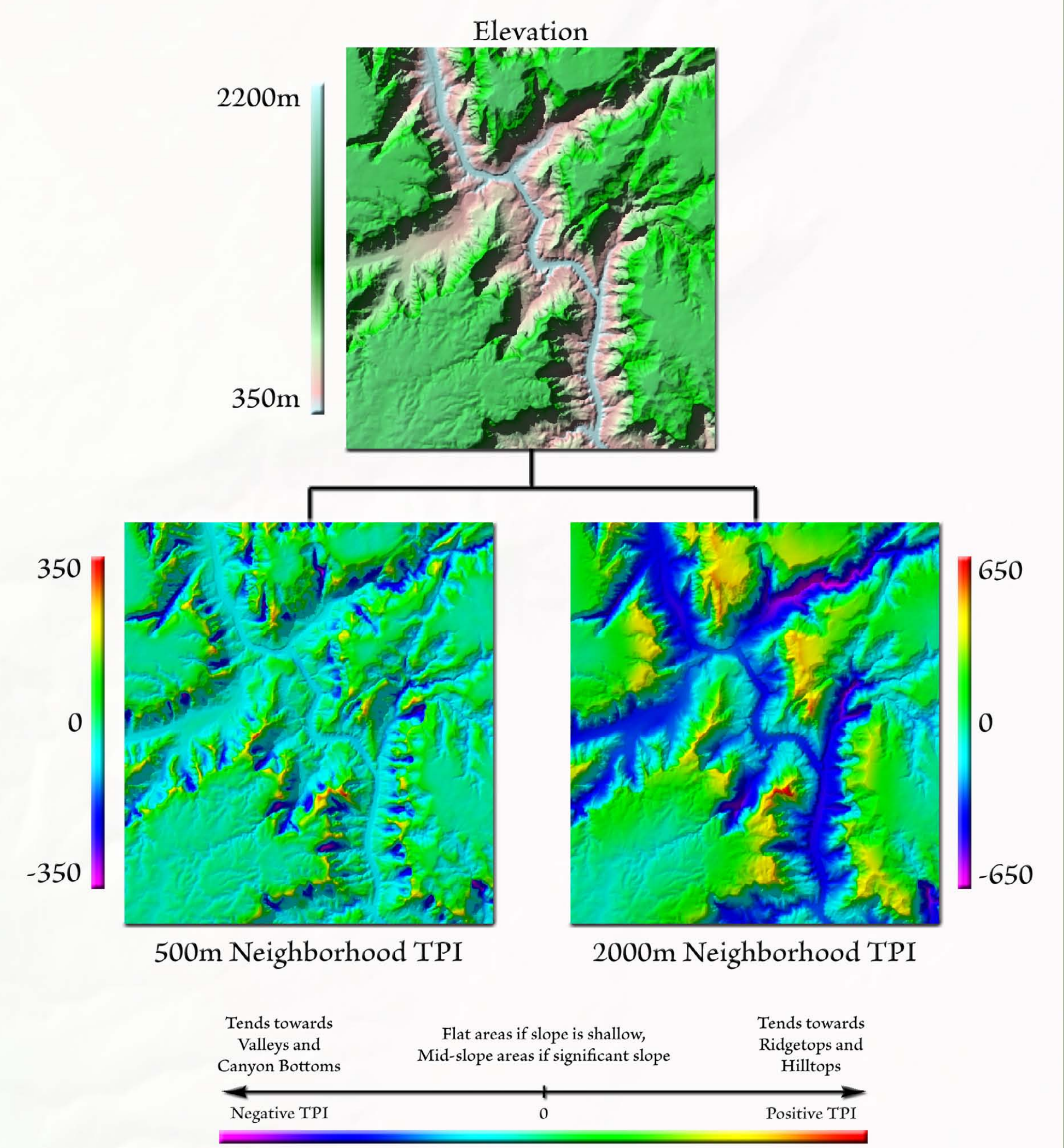
The algorithms are clever and fairly simple. The TPI is the basis of the classification system and is simply the difference between a cell elevation value and the average elevation of the neighborhood around that cell. Positive values mean the cell is higher than its surroundings while negative values mean it is lower.

The degree to which it is higher or lower, plus the slope of the cell, can be used to classify the cell into slope position. If it is significantly higher than the surrounding neighborhood, then it is likely to be at or near the top of a hill or ridge. Significantly low values suggest the cell is at or near the bottom of a valley. TPI values near zero could mean either a flat area or a mid-slope area, so the cell slope can be used to distinguish between the two.
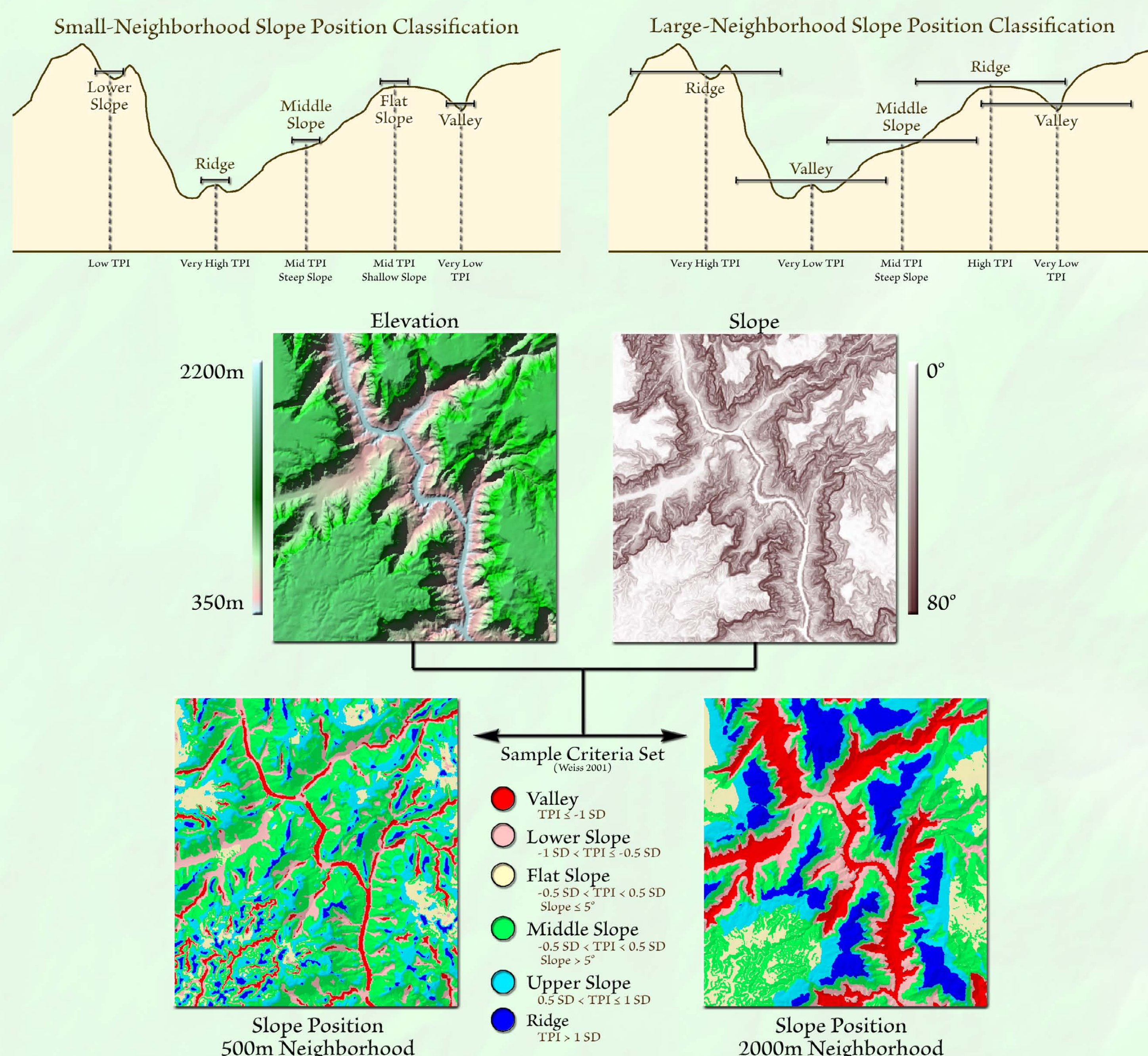

TPI Values at 3 Different Scales

$TPI \approx 0$ (A) $TPI > 0$ (B) $TPI < 0$ (C)
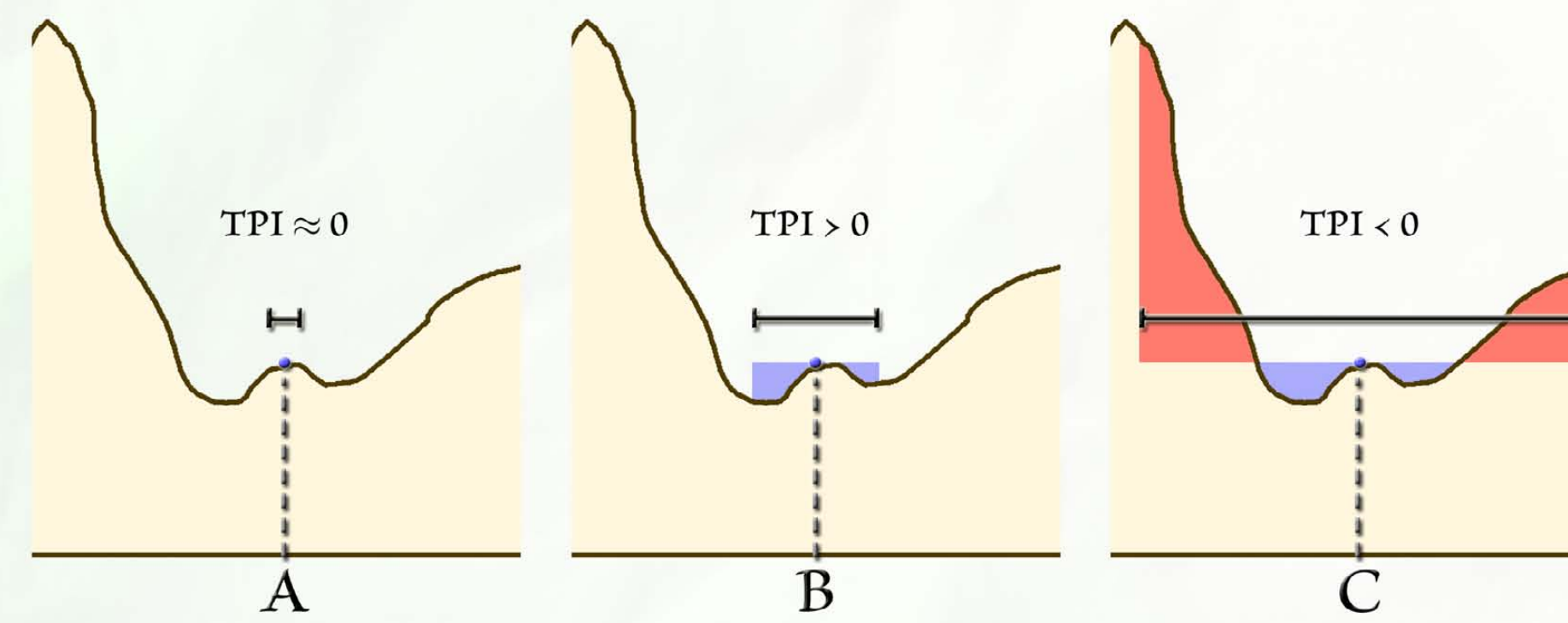
Scales and Neighborhoods: TPI is naturally very scale-dependent. The same point at the crest of a mountain range might be considered a ridgetop to a highway construction crew or a flat plain to a mouse. The classifications produced by this extension depend entirely on the scale you use to analyze the landscape.

Elevation (2200m – 350m)

500m Neighborhood TPI (350 / 0 / -350) 2000m Neighborhood TPI (650 / 0 / -650)

Tends towards Valleys and Canyon Bottoms — Flat areas if slope is shallow, Mid-slope areas if significant slope — Tends towards Ridgetops and Hilltops
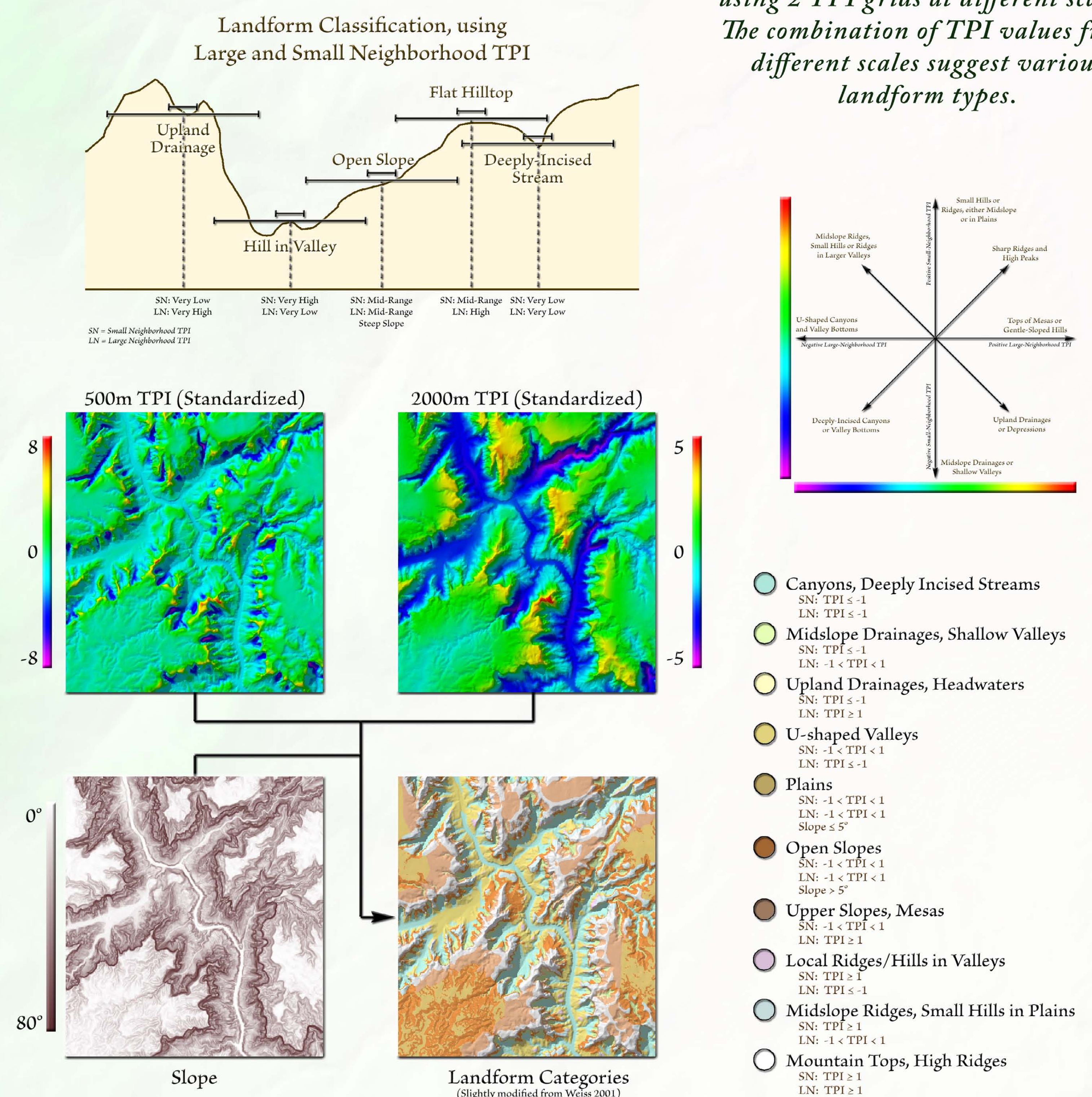
Negative TPI — 0 — Positive TPI

Slope Position

TPI values near 0 mean only that the elevation is close to the mean elevation of the neighborhood cells, and this could happen if that cell is in a flat area or if it is mid-slope somewhere. An easy way to distinguish between these 2 possibilities is to check the slope at that point. If the slope is near 0, then the point is probably on a flat area. A high slope value implies that the point is mid-slope somewhere. In his poster, Weiss demonstrates one possible classification process using both TPI and slope to generate a 6-category Slope Position grid.

Small-Neighborhood Slope Position Classification

Large-Neighborhood Slope Position Classification

Elevation (2200m – 350m) Slope (0° – 80°)

Sample Criteria Set (Weiss 2001)

- Valley — TPI ≤ -1 SD
- Lower Slope — -1 SD < TPI ≤ -0.5 SD
- Flat Slope — -0.5 SD < TPI < 0.5 SD, Slope ≤ 5°
- Middle Slope — -0.5 SD < TPI < 0.5 SD, Slope > 5°
- Upper Slope — 0.5 SD < TPI ≤ 1 SD
- Ridge — TPI > 1 SD

Slope Position 500m Neighborhood Slope Position 2000m Neighborhood

Landform Delineation

Landform category can be determined by classifying the landscape using 2 TPI grids at different scales. The combination of TPI values from different scales suggest various landform types.

Landform Classification, using Large and Small Neighborhood TPI

SN = Small Neighborhood TPI
LN = Large Neighborhood TPI

500m TPI (Standardized) (8 / 0 / -8) 2000m TPI (Standardized) (5 / 0 / -5)

Slope (0° – 80°) Landform Categories (Slightly modified from Weiss 2001)

- Canyons, Deeply Incised Streams — SN: TPI ≤ -1, LN: TPI ≤ -1
- Midslope Drainages, Shallow Valleys — SN: TPI ≤ -1, LN: -1 < TPI < 1
- Upland Drainages, Headwaters — SN: TPI ≤ -1, LN: TPI ≥ 1
- U-shaped Valleys — SN: -1 < TPI < 1, LN: TPI ≤ -1
- Plains — SN: -1 < TPI < 1, LN: -1 < TPI < 1, Slope ≤ 5°
- Open Slopes — SN: -1 < TPI < 1, LN: -1 < TPI < 1, Slope > 5°
- Upper Slopes, Mesas — SN: -1 < TPI < 1, LN: TPI ≥ 1
- Local Ridges/Hills in Valleys — SN: TPI ≥ 1, LN: TPI ≤ -1
- Midslope Ridges, Small Hills in Plains — SN: TPI ≥ 1, LN: -1 < TPI < 1
- Mountain Tops, High Ridges — SN: TPI ≥ 1, LN: TPI ≥ 1

Additional Functions

1) Save, reuse and share criteria sets, making it simple to replicate sophisticated classifications and to try variations.

2) General grid classification tools.

3) Advanced neighborhood statistics tools, with options for multiple statistics and multiple neighborhoods. This function also includes a tool to generate your own custom neighborhood.

4) Tools for general grid statistics, describing characteristics of individual grids.

5) Tools for standardizing grids, such that cell values in the new grid represent the number of standard deviations from the original grid mean.

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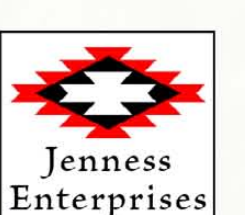
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