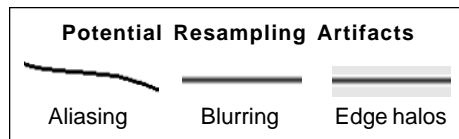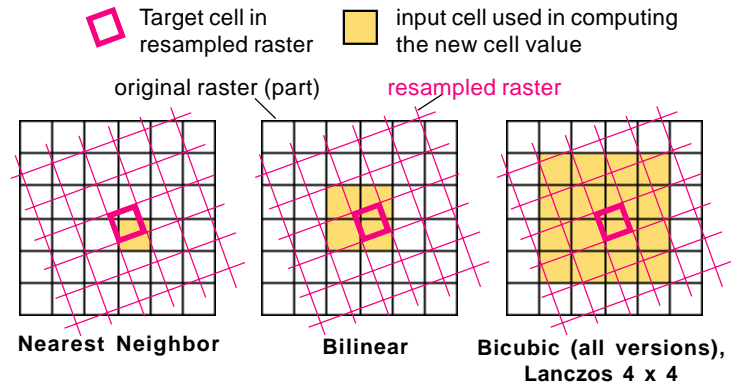# Resampling Methods

Rescaling a raster object or reprojecting it to a different coordinate reference system involves creating a new raster cell grid on a different alignment than the original raster. A value for each cell in the new raster object must be computed by sampling or interpolating over some neighborhood of cells in the corresponding position in the original raster object. This *resampling* procedure is a component of a number of processes in TNTmips, including Automatic Resampling, Auto Mosaic, and Export to Tilesets, among others. These processes offer a number of different *resampling methods* to compute the new raster values.

Resampling inevitably introduces some visual artifacts in the resampled image. The main types of artifacts are most easily seen at sharp edges, and include aliasing (jagged edges), blurring, and edge halos (see illustration below). The various resampling methods used in TNTmips are designed to mitigate one or more of these artifacts. The resampling methods discussed below are shown schematically in the illustration at top right of this page, and examples are shown below and on the reverse.
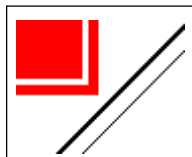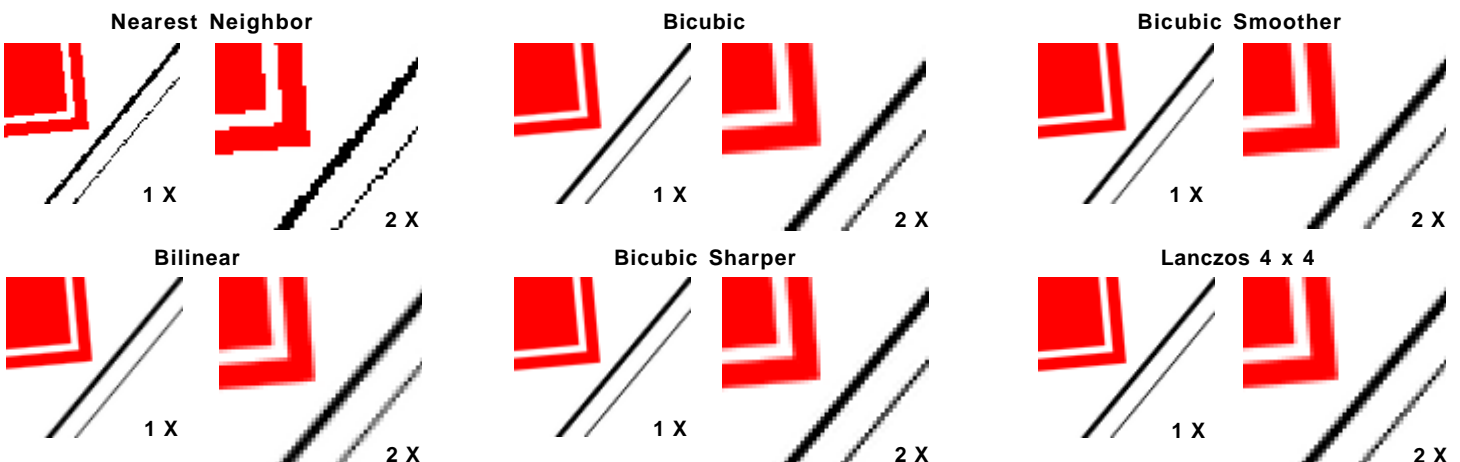
Cell Neighborhoods used in Computing a Resampled Cell Value

Nearest Neighbor   **Bilinear**   **Bicubic (all versions), Lanczos 4 x 4**

Potential Resampling Artifacts

Aliasing   Blurring   Edge halos

Nearest Neighbor: Each cell value in the resampled raster is determined by simply copying the value from the closest input cell. This method is most suitable for reprojecting a raster object (without a change in cell size) when preserving the original cell values for later quantitative analysis is important. When resampling involves rotation, the nearest neighbor method introduces severe aliasing of sharp edges.

Bilinear: In this method the output cell value is the linear distance-weighted average of the four closest input cell values. Bilinear interpolation minimizes aliasing but introduces significant blurring. It is most suitable when resampling to a smaller output cell size (upsampling).

Bicubic (**cubic convolution**): The closest 4 x 4 block of input cells is used to compute each output cell value. The weighting factors for the average of the input cells are computed using a cubic (third-order) function of distance. Bicubic resampling reduces both aliasing and blurring in comparison to the nearest neighbor and bilinear methods. It may introduce edge halos, but these are not likely to be noticeable in typical continuous-value images and surface rasters.

Bicubic Sharper and Bicubic Smoother: These methods are variants of the basic bicubic interpolator that alter the interpolation coefficients slightly to produce mildly sharper or smoother results (respectively). Differences between the three bicubic methods are subtle and may be difficult to see without directly overlaying the results and switching between them. The bicubic smoother method is recommended by some sources for upsampling and the bicubic sharper method for downsampling (resampling to a larger cell size).

Lanczos 4 x 4: This method uses the same 4 x 4 input cell neighborhood as the bicubic methods but a different mathematical combination of the input cell values. It is best suited for downsampling, and produces results very similar to the bicubic and bicubic sharper methods.

Nearest Neighbor

1 X   2 X

Bicubic

1 X   2 X

Bicubic Smoother

1 X   2 X

Bilinear

1 X   2 X

Bicubic Sharper

1 X   2 X

Lanczos 4 x 4

1 X   2 X

Example resampled images using the various resampling methods are shown above at 1 X (1 raster cell per screen pixel) and magnified by a factor of 2 (2X). The simple high-contrast test image is shown to the left. In the example above, this image was reprojected to a different coordinate reference system (involving a modest counter-clockwise rotation), and the cell size was reduced from 2.4 meters to 2.0 meters (increasing resolution, or upsampling).

(over)

At left is a portion of an orthoimage with resolution (cell size) of 1 foot (0.3 meter). Several small buildings and an adjacent parking lot in a community in Pennsylvania (USA) are shown. This image was reprojected (from NAD83 / SPCS83 Pennsylvania South zone to WGS84 / Spherical Web Mercator) and upsampled to a cell size of 0.2 meter. The results using the various resampling methods are shown below at 1 X (1 raster cell per screen pixel, left image for each) and with 2 X magnification of the upper left corner of each image (right image for each). Differences between the resampled images are most evident for the areas circled in yellow in the test image (left), which include a diagonally-striped area of the parking surface and a portion of the building roof.

Nearest Neighbor

Bilinear

Bicubic

Bicubic Smoother

Bicubic Sharper

Lanczos 4 x 4