Motivation and Objectives
Despite the proven advantages of Terrestrial Laser Scanning (TLS) for detailed geomorphic research, raw TLS data demonstrate multiple trade-offs that make them poorly suited for immediate use in geomorphologic modeling. Most notably, the high density of survey points acquired by TLS results in characteristically large and computationally burdensome datasets, which tend to strain most software programs used for terrain analysis (Buskey et al. 2008; Hetherington 2009). Therefore, we sought to develop a novel filtering method for raw TLS data that (1) reduces dataset size by eliminating data redundancy; (2) produces a less heterogeneously spaced dataset; and (3) eliminates erroneous measurements.

In order to enable researchers to achieve greater efficiencies and accuracy in modeling terrain using TLS, we sought to develop a novel filtering method for raw TLS data that: (1) reduces dataset size by eliminating data redundancy; (2) produces a less heterogeneously spaced dataset; and (3) eliminates erroneous measurements.

Methods
CONCEPT
The developed method consists of local aggregation of raw TLS data using geometrical modeling of expected random errors in the data. TLS point measurements are subject to random error from two sources: the TLS scanner and the procedure used for georeferencing independent scans. Random error associated with the scanner can be manifested in all three dimensions (x, y, and z) and at approximately 2 cm total displacement (two sigma at 100 m range) (RIEGL Laser Measurement Systems 2009). Geometrically, this error is modeled with the sphere of radius \( r \) around each TLS point (Figure 4). The location of each scatter point, however, may also be subject to horizontal error of approximately \( \pm 0.021 \) m (Buckley et al. 2008). Despite the proven advantages of Terrestrial Laser Scanning (TLS) for detailed geomorphic research, raw TLS datasets are typically heterogeneous in point distribution and density (Figure 2) (Buskey et al. 2008). Closer than average point spacing is common in areas where multiple scans overlap and in areas immediately surrounding individual scan positions (Buskey et al. 2008). A final concern with raw TLS data relates to their accuracy, likely involving reduced signal-to-noise ratio and total signal accuracy and precision (RIEGL Laser Measurement Systems 2009). Hedges et al. (2006) showed that for a single TLS scan, the expected error (two sigma) at a range of 100 m or larger magnitude (Hetherington and Hetherington 2007) or, alternatively, may represent a moderate (2 cm) or low (0.25 cm) error. Despite these concerns, the data presented on this poster represent an initial investigation into TLS data reduction methods, and at the scale of the entire study area (Figure 12a and 12b) suggest that the implemented method correctly filters TLS data while retaining georeferencing independent scans. Random error associated with the scanner can be manifested in all three dimensions (x, y, and z) and at approximately 2 cm total displacement (two sigma at 100 m range) (RIEGL Laser Measurement Systems 2009). Geometrically, this error is modeled with the sphere of radius \( r \) around each TLS point (Figure 4). The location of each scatter point, however, may also be subject to horizontal error of approximately \( \pm 0.021 \) m (Buckley et al. 2008). Despite the proven advantages of Terrestrial Laser Scanning (TLS) for detailed geomorphic research, raw TLS datasets are typically heterogeneous in point distribution and density (Figure 2) (Buskey et al. 2008). Closer than average point spacing is common in areas where multiple scans overlap and in areas immediately surrounding individual scan positions (Buskey et al. 2008). A final concern with raw TLS data relates to their accuracy, likely involving reduced signal-to-noise ratio and total signal accuracy and precision (RIEGL Laser Measurement Systems 2009). Hedges et al. (2006) showed that for a single TLS scan, the expected error (two sigma) at a range of 100 m or larger magnitude (Hetherington and Hetherington 2007) or, alternatively, may represent a moderate (2 cm) or low (0.25 cm) error. Despite these concerns, the data presented on this poster represent an initial investigation into TLS data reduction methods, and at the scale of the entire study area (Figure 12a and 12b) suggest that the implemented method correctly filters TLS data while retaining TLS point density and quality, raw TLS dataset. Hedges et al. (2006) showed that for a single TLS scan, the expected error (two sigma) at a range of 100 m or larger magnitude (Hetherington and Hetherington 2007) or, alternatively, may represent a moderate (2 cm) or low (0.25 cm) error. Despite these concerns, the data presented on this poster represent an initial investigation into TLS data reduction methods, and at the scale of the entire study area (Figure 12a and 12b) suggest that the implemented method correctly filters TLS data while retaining TLS point density and quality, raw TLS dataset.

IMPLEMENTATION
The data reduction method was implemented as a Python script using QGis/OGRE. The method operates directly on ESRI shapefiles; however, efficiency is readily improved by using quadratic spatial indexing, an OGR data structure (qps).

Preliminary Results
The results presented on this poster are preliminary and expected to be complete by May 2012. This evaluation seeks to address three research questions:

1. How effective is the developed filter at addressing each of the three critical objectives: (a) data reduction, greater homogeneity of point distribution, and elimination of erroneous measurements?
2. How does the filter affect the spatial dependence structure and terrain characteristics?
3. How does the filter affect the spatial dependence structure and terrain characteristics?

The results presented on this poster represent an initial investigation into TLS data reduction methods, and at the scale of the entire study area (Figure 12a and 12b) suggest that the implemented method correctly filters TLS data while retaining TLS point density and quality, raw TLS dataset. Hedges et al. (2006) showed that for a single TLS scan, the expected error (two sigma) at a range of 100 m or larger magnitude (Hetherington and Hetherington 2007) or, alternatively, may represent a moderate (2 cm) or low (0.25 cm) error. Despite these concerns, the data presented on this poster represent an initial investigation into TLS data reduction methods, and at the scale of the entire study area (Figure 12a and 12b) suggest that the implemented method correctly filters TLS data while retaining TLS point density and quality, raw TLS dataset.

References