



Public Storm Shelters: A Plan for Norman, Oklahoma

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Statement of Purpose

In recent years public storm shelters have come under a lot of scrutiny, and many have come to the conclusion they do more harm than good. However, since not all residents have access to suitable shelter, and safety should be a basic right, it is in the interest of municipalities to look into all possible sheltering options. This idea motivates this planning study to determine the cost and benefit of a public storm shelter network in the city of Norman, Oklahoma.

Background

- In 2013, Norman, Oklahoma closed down all its public shelters citing the following concerns:
 - Greater risk while travelling
 - Integrity of shelters against 200+ mph winds.
 - Overcrowding
 - Health concerns regarding pets
- Norman is located in a high risk area for tornadoes (see Figure 1) and has a vulnerable population (Cutter et al., 2003; see Figure 2)
- Community shelters may be the best way to keep the population safe
- It is possible to answer most of the concerns regarding public shelters:
 - Shelters can be placed within 400 m of all buildings (5 min walk)
 - Shelter capacity can be matched to the surrounding population
 - Most modern shelters are capable of withstanding 200+ mph winds

Proposed Shelters for Norman, Oklahoma

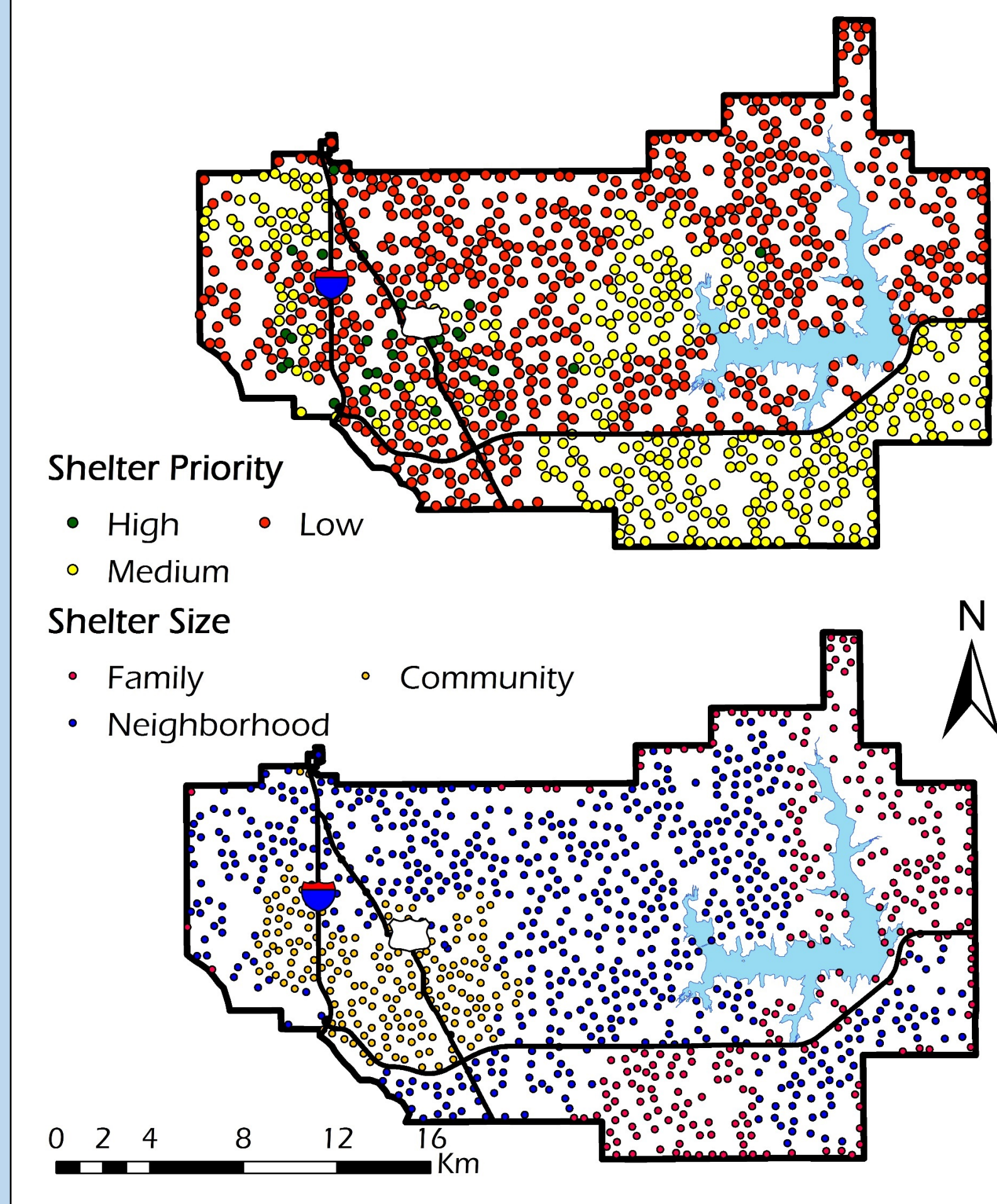


Figure 3. Proposed shelter locations by priority (top) and size (bottom)

Table 1. Shelter sizes and market cost.

Size	Capacity	Cost Per Person
Personal/Family	up to 16	\$ 600.00
Neighborhood	16 to 200+	\$ 700.00
Community	200 - 1500+	\$ 1,000.00

Madison Elementary, Norman, Oklahoma

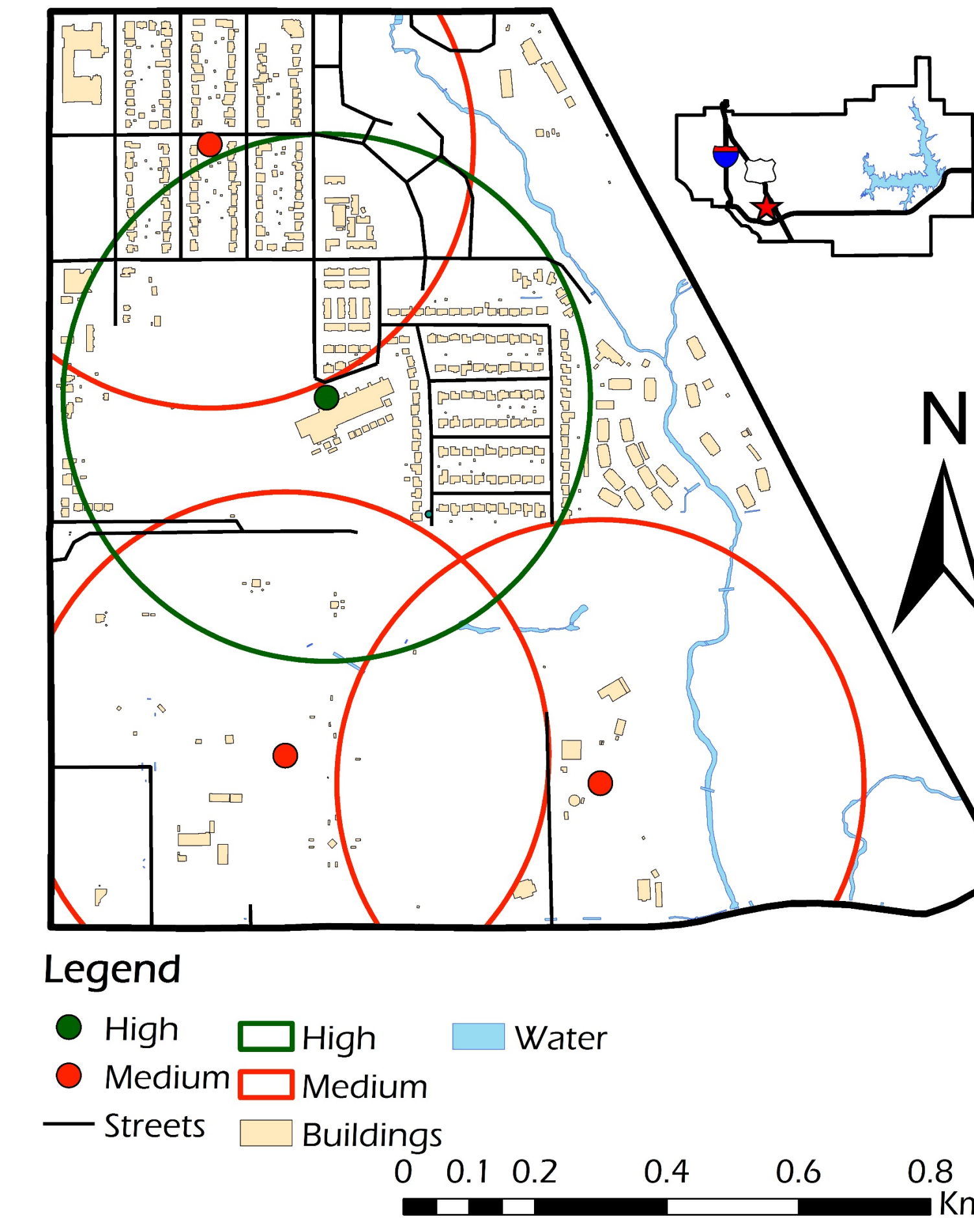


Figure 4. Shelter placement near Madison Elementary in Norman. Circles represent coverage areas for each shelter.

Table 2. Total cost for shelters

Priority	Cost
High	\$ 22,875,000.00
Medium	\$ 43,671,000.00
Low	\$ 136,387,200.00
Total	\$ 202,933,200.00

Results

- Even in a high risk location like Oklahoma the cost of a storm shelter exceeds the value of a statistical life (\$10 million).
 - Shelter locations (Figures 3 & 4) and total cost (Table 2)
- The cost per life saved for storm shelters in Norman:
 - Permanent Home: \$66.4 million
 - Mobile Home: \$16.4 million

Discussion

- Stand alone storm shelters are not economical
- Best practices involve new construction
 - FEMA can cover up to 75% of approved personal or community storm shelter projects under their Hazard Mitigation Grant Program (FEMA, 2016a).
 - It is usually cheaper to build a safe room in a new building than to retrofit an old one (FEMA, 2010).
 - Increased push for better construction should reduce costs through competition (Johnston, 2013).
 - New homes can withstand winds up to 120+ mph with the addition of metal connectors costing about \$0.50 per square foot (FEMA, 2016b)

Tornado Risk in Norman, Oklahoma (1950 - 2015)

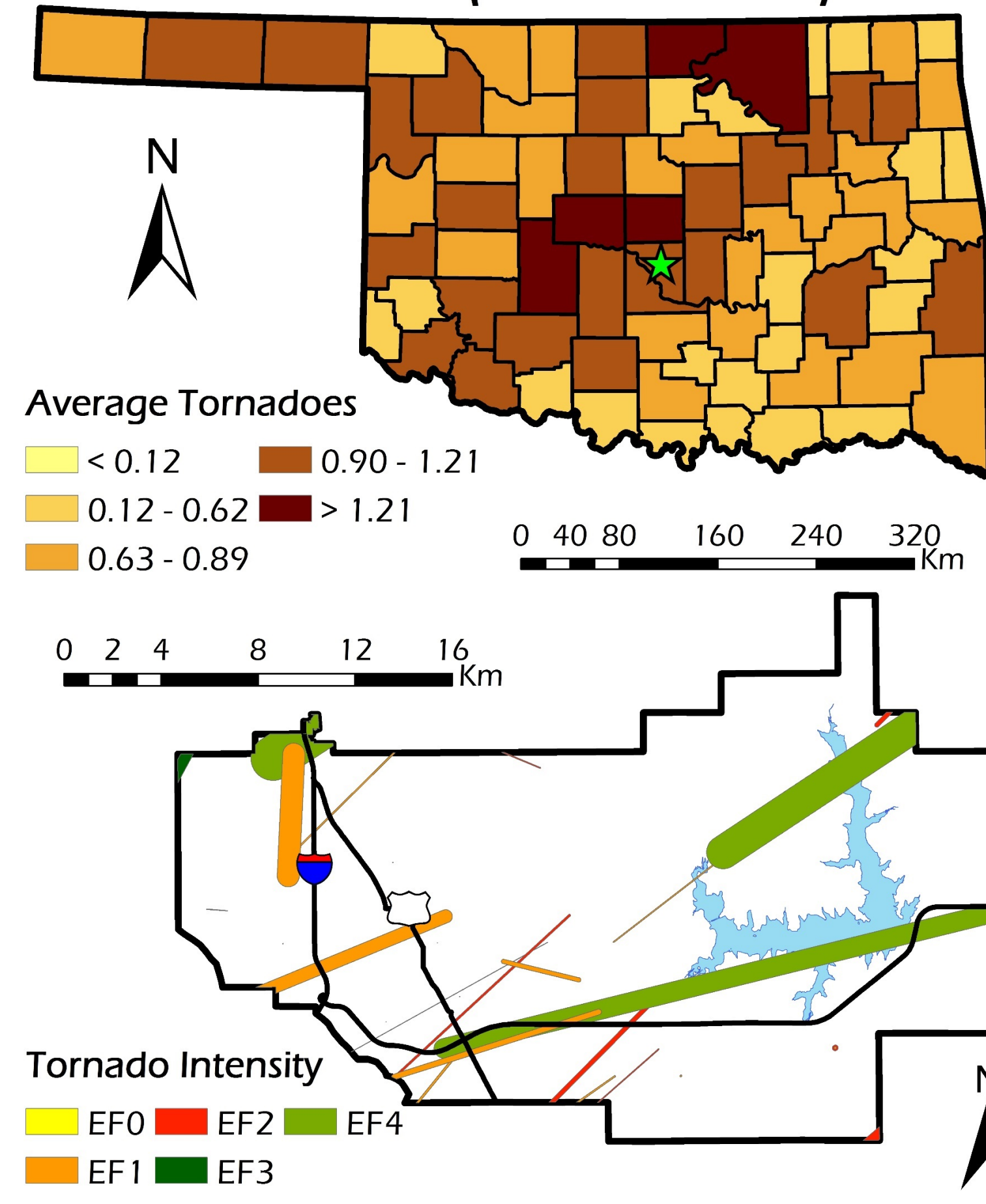


Figure 1. Annual tornado risk (top); Tornado paths by intensity (bottom).

Vulnerable Areas in Norman Versus Existing Refuge Areas

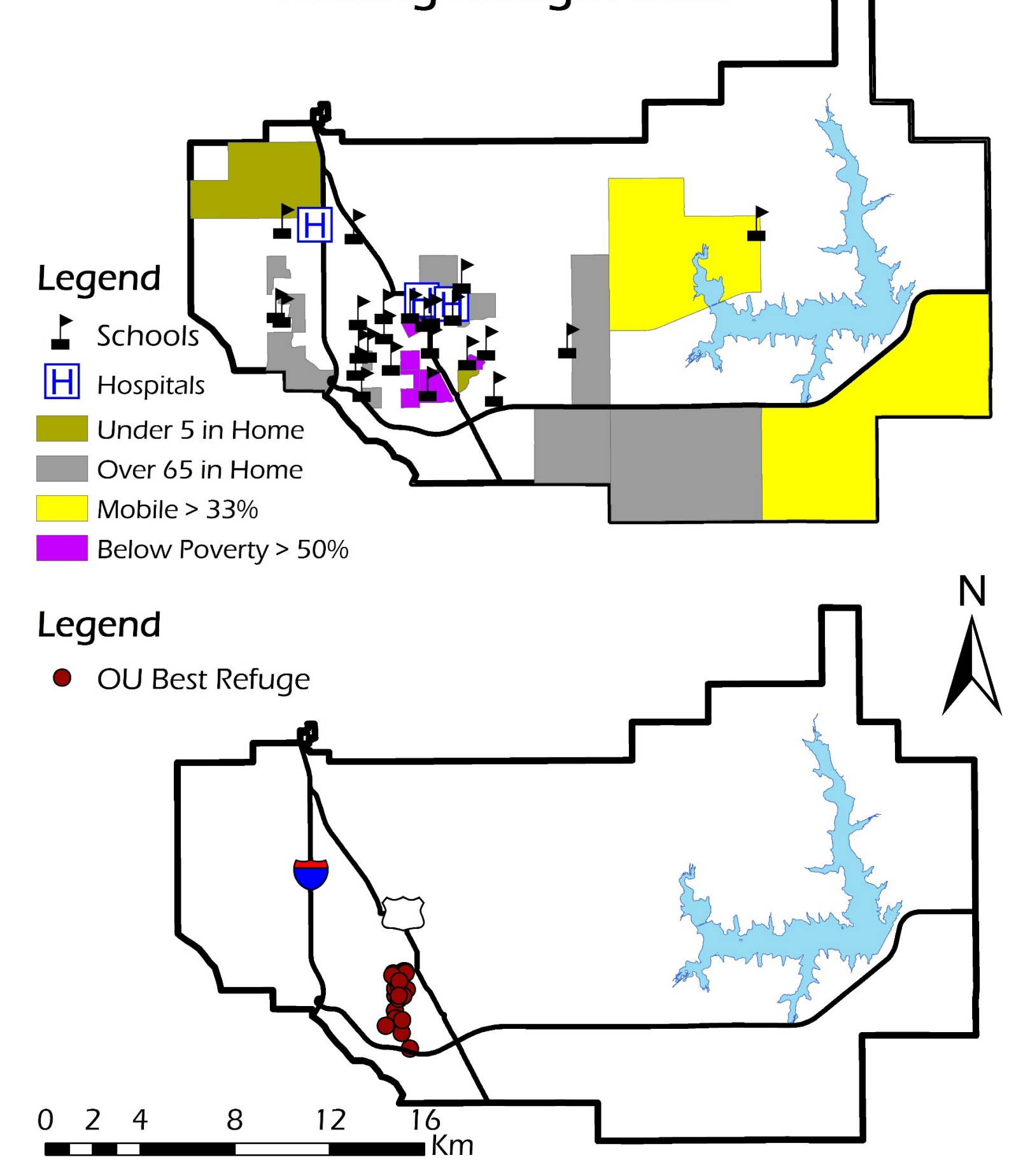


Figure 2. Locations of vulnerable areas in Norman (top); Location of refuge areas at University of Oklahoma (bottom).

Data and Methods

- Data Sources
 - Tornado tracks for 1950 to 2015 (SPC, 2016)
 - Norman Interactive Map data (City of Norman, 2016)
 - Demographic data from the 2010 Census (MPC, 2016)
- Shelter locations
 - First guess was the center of a 800 x 800 m grid placed over Norman
 - Final location was the mean center of the surrounding buildings.
 - Additional shelters were placed at each school and hospital.
- Shelter specifications
 - Capacity was based on the surrounding population
 - Cost was based on capacity using the price estimates in Table 1.
- Priority to build shelters
 - High for schools, hospitals, or mobile home parks
 - Medium for other vulnerable populations
 - Low otherwise
- The cost per life saved for storm shelters was assessed following the method of Simmons and Sutter (2006).

Cost Per Life Saved: Permanent Versus Mobile Homes

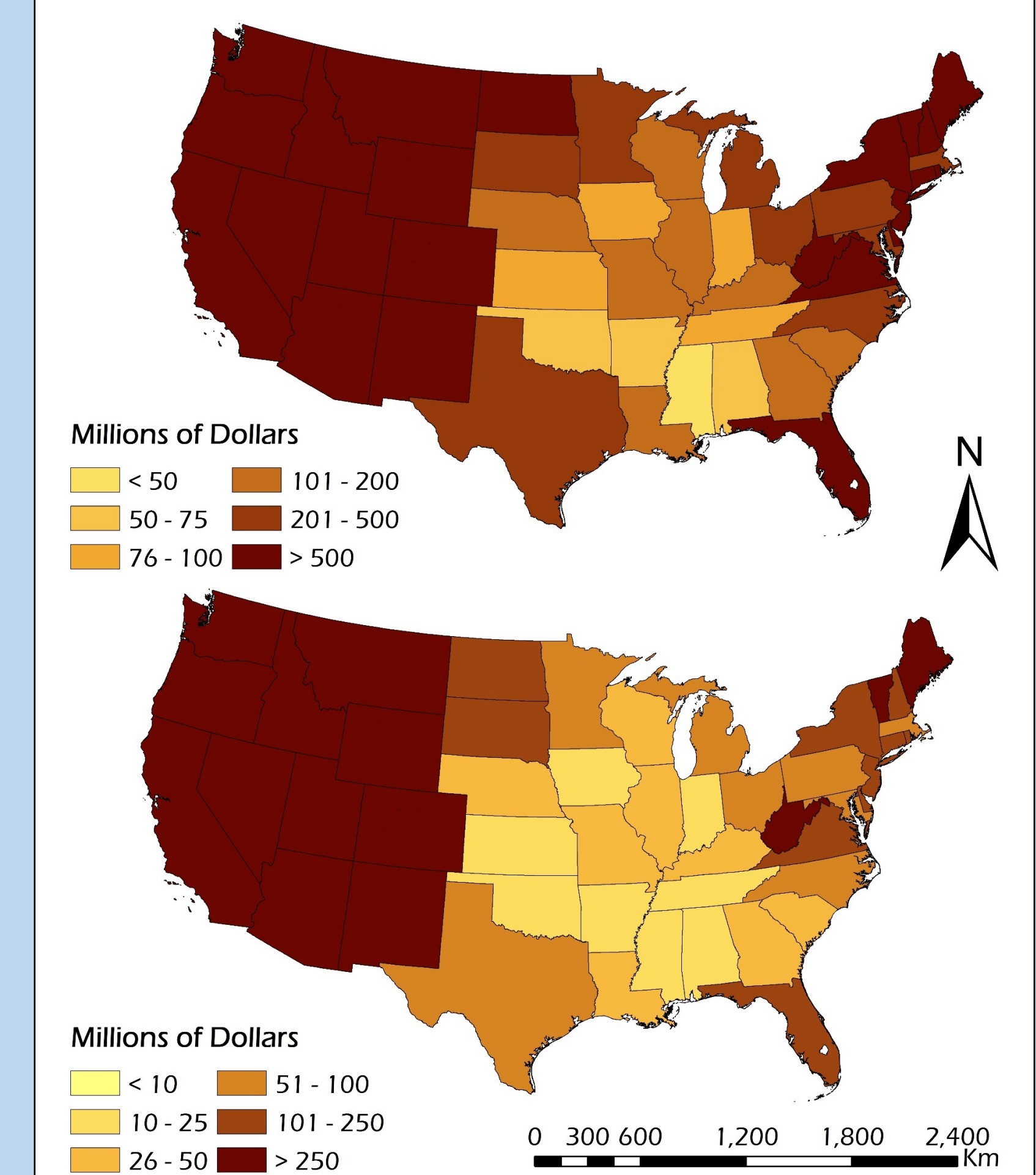


Figure 5. Cost per life saved in millions of dollars for permanent homes (top) and mobile homes (bottom)

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