U.S. Motorcycle Fatalities '94-'09: GIS Analysis & Solutions

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Motorcycle History 101

- Multiple designs appeared simultaneously across Europe during the late 19th century
- Became reasonably affordable means of personal transport around 1930
- Europe and Asia embrace motorcycles first, establishing manufacturing dominance
- Finally see wide adoption in the U.S. after WWII, but rarely as primary means of transport
Early Motorcycles

- Unique low-power engine designs, ranging from steam power to radial internal combustion
- Rarely suspended, exceedingly heavy, poor range and performance
- Prohibitively expensive to purchase, ride and maintain

Modern Motorcycles

- Three common high-power internal combustion engine designs predominate
- High technology materials and construction throughout, obscene performance
- Affordable to purchase, ride and maintain
**Current U.S. Usage**

- Nearly 7 million registered motorcycles, but only 5% are used year round
- Approximately 250,000 motorcycle commuters on an average weekday
- Accounted for approximately 1.5% of all personal vehicle miles traveled in 2009
- Expected to account for 15% of all personal vehicle miles traveled by 2030

**Motorcycle Accidents**

**Early Accidents**
- Common causes
  - low performance characteristics
  - mechanical failure
  - road conditions
  - Usually involved other traffic
  - Slow speeds, rarely fatal

**Modern Accidents**
- Common causes
  - high performance characteristics
  - operator error
  - road conditions
  - Often single vehicle incidents
  - High speeds, often fatal
GIS Fatality Analysis

Last year over 5000 motorcyclists died on roads in the U.S. Why?

• Collect data on fatal accidents and possible contributing factors
• Integrate tabular data into GIS database for spatial analysis
• Mine historical fatality trends for factor weights using advanced statistics software
• Predict future fatality trends and recommend specific states for educational and regulatory focus

Changes in Fatality Rates

Between '94-'09 **NO** states showed reduced motorcycle fatality rates

• Best: Hawaii, +67% fatalities per MVM
• Worst: North Dakota, +486% fatalities per MVM
• Mean Change: +191% fatalities per MVM

Between '94-'09 **ALL** states showed reduced overall vehicle fatality rates

• Best: Washington D.C., -53% fatalities per MVM
• Worst: North Dakota, -5% fatalities per MVM
• Mean Change: -27% fatalities per MVM
Changes in Fatality Rates

Motorcycle Fatalities
Frequency Increase '94-'08
- 0% - 20%
- 20% - 30%
- 40% - 80%

Moran's I & Getis-Ord

Spatial Autocorrelation (Global Moran's I)

High/Low Clustering (Getis-Ord General I)

While somewhat clustered, the pattern may be due to random chance.

No apparent clustering is detected at this scale.
Factors Evaluated

16 factors considered
- Weather averages and fluctuations
- Land cover and vegetation
- Helmet and insurance mandates
- Road maintenance budgets

Temperature Fluctuations

[Map showing annual temperature fluctuations across the United States with color codes for different temperature ranges]
Deciduous Forests

Coniferous Forests
**Mixed Forests**

**Federal Highway Funds**
Factor Weights

- Over 300 trillion formulas were tested using Cornell University's free Eureqa computation engine.
- The following equation correctly forecasts 77% of observed increases:
  \[ q = -\ln(a)*((b+3.2c+d+.08e/f)/g) + 26.57h + \cos(3.29i) + (6.14j/k-1.57)^{(.04l-m)} + (2.6m^{.05o/p}) \]
  
  - a=% increase in miles, b=win avg temp, c=spr avg temp, d=sum avg temp, e=fal avg temp, f=win-sum temp diff, 
  - g=win precip, h=spr precip, i=sum precip, j=fal precip, k=clear days, l=helmet mandate, m=federal highway $, n=% decid coverage, o=% conif coverage, p=% mix coverage, 
  - q=% increase in motorcycle fatalities

Future Predictions

- Observed trends will likely continue in the absence of serious regulatory and educational reform.
- Top five states to watch: Virginia, Ohio, Utah, South Carolina, Kansas.
- Suggest federal funding of Motorcycle Safety Foundation or equivalent courses for all new riders, as well as tying federal highway funds to reduced motorcycle fatalities.
Data Sources

- Fatalities: NHTSA (nhtsa.gov)
- Helmet Laws: NHTSA (nhtsa.gov)
- Weather: NOAA (noaa.gov)
- Vegetation: USFS (fs.fed.us)
- Highway Subsidies: PEW (subsidyscope.com)
- U.S. Basemap: ESRI (esri.com)
- Expert Knowledge: Me (10+ bikes, 100k+ miles)
- Photos: Wikimedia (commons.wikimedia.org)