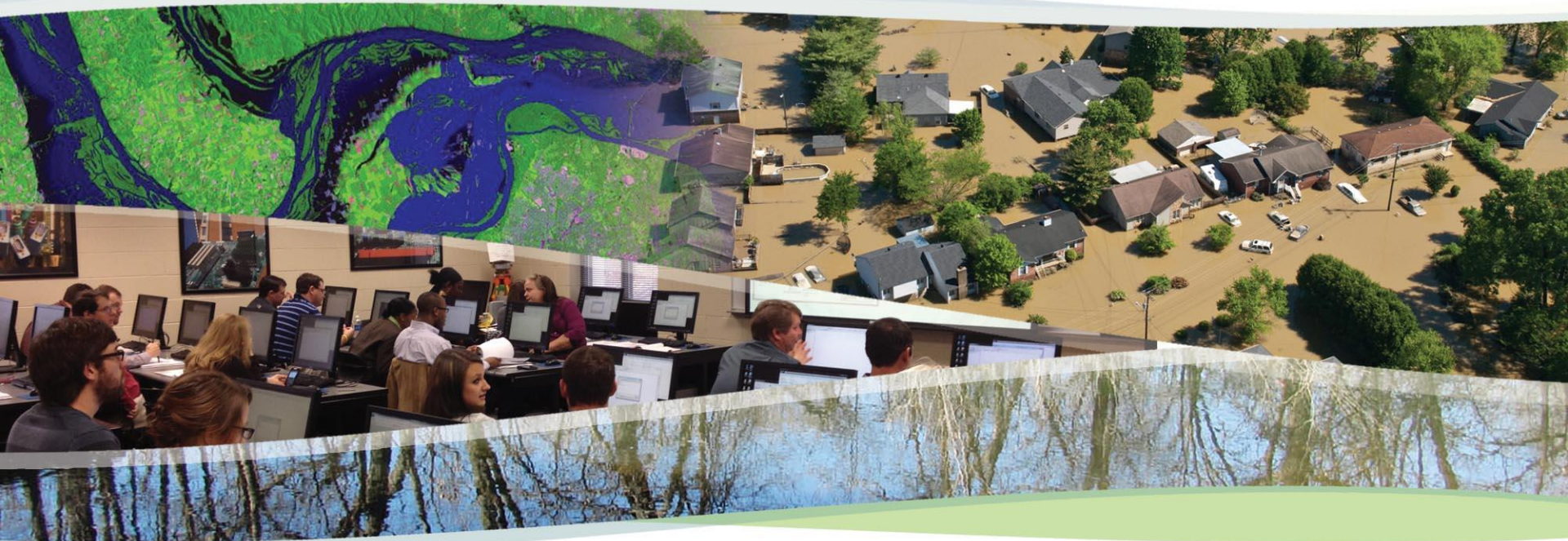


# Natural Hazards Risks in Kentucky



KAMM Regional Training

# Floodplain 101

- ✓ Kentucky has approximately 92,000 linear miles of streams and rivers
  - Approximately 31,000 linear miles have mapped flood hazards



# Mitigation 101

Did you know...?

*Since 1953, Kentucky has experienced 67 federally-declared disasters, 32 of which have occurred since 2000.*



# What is Risk?

- ✓ Risk is the potential that a chosen action or activity (including the choice of inaction) will lead to a loss (an undesirable outcome). Potential losses themselves may also be called "risks".
- ✓ Risk can also be defined as future issues that can be avoided or mitigated, rather than present problems that must be immediately addressed.
- ✓ Most events resulting in significant harm to people (aside from accidents and self-inflicted injuries) fall into one of three categories:
  - Natural Disasters
  - Criminal violence
  - Terrorism



# Perception of Risk Severity

- ✓ Risk is perceived in two ways:
  - Dread risk
  - Unknown risk
- ✓ Perception may lead people to view criminal activity and terrorism as higher risk than natural disasters
- ✓ Natural disasters are seen as unavoidable and catastrophic, but are often misjudged
- ✓ Misperceptions may lead people to over or underestimate the seriousness of risk and inappropriately respond to such risks



# What is a Vulnerability?

- ✓ Vulnerability refers to the susceptibility of a person, group, society or system to physical or emotional injury or attack
- ✓ It's also the extent to which changes could harm a system, or to which a community can be affected by the impact of a hazard
- ✓ With regards to natural disasters, vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of the hazard



# High Risk vs. Low Risk Areas

- ✓ It is generally accepted that High Risk areas have the most potential for negative effects
  - Urban areas within a floodplain, along a seismic fault, in a hurricane-prone coastal area
- ✓ Low risk areas do not have as much potential for negative effects.
  - Rural areas have fewer structures
  - Structures built out of the floodplain, away from faults, inland vs. coastal



# Kentucky Risk Assessment

- ✓ The risk assessment in the Kentucky State Hazard Mitigation plan includes an overview of the types ... of all natural hazards that can affect the state.
- ✓ Due to its diversified geology and geographical setting, the state of Kentucky is vulnerable to a wide array of natural hazards which threaten life and property.
- ✓ Through research of the historic impacts, thirteen hazards are emphasized in the KY State Hazard Mitigation Plan

- Dam Failure
- Drought
- Earthquake
- Extreme Heat
- Flood
- Hailstorm
- Karst

- Land Subsidence
- Landslide
- Severe Storm
- Severe Winter Storm
- Tornado
- Wildfire





# Kentucky HMP Risk Assessment

Hazard: Profile Risk Table	
<b>Period of occurrence:</b>	When does this hazard occur?
<b>Number of events: (Year - Year)</b>	Number of hazard events in Kentucky based on county occurrences for each hazard. So you could have one state event count as 50 county-level events within this data capture.
<b>Annual Rate of Occurrence:</b>	Expected annual number of state-wide occurrences per year based on county-level occurrence data.
<b>Warning time:</b>	Average warning time for this type of hazard.
<b>Potential impacts:</b>	The potential impacts this hazard could produce.
<b>Recorded losses:</b>	Amount of damages captured within Kentucky for each hazard (This data is very diverse).
<b>Annualized Loss:</b>	The expected annual loss state-wide per year from each hazard.
<b>Extent:</b>	Worst case scenario based on historic data.

**Hazard Identification:** Anything which either threatens the residents of a community or the things that they value

**Exposure:** A community's assets: people, property, essential facilities, and infrastructure potentially exposed to a hazard

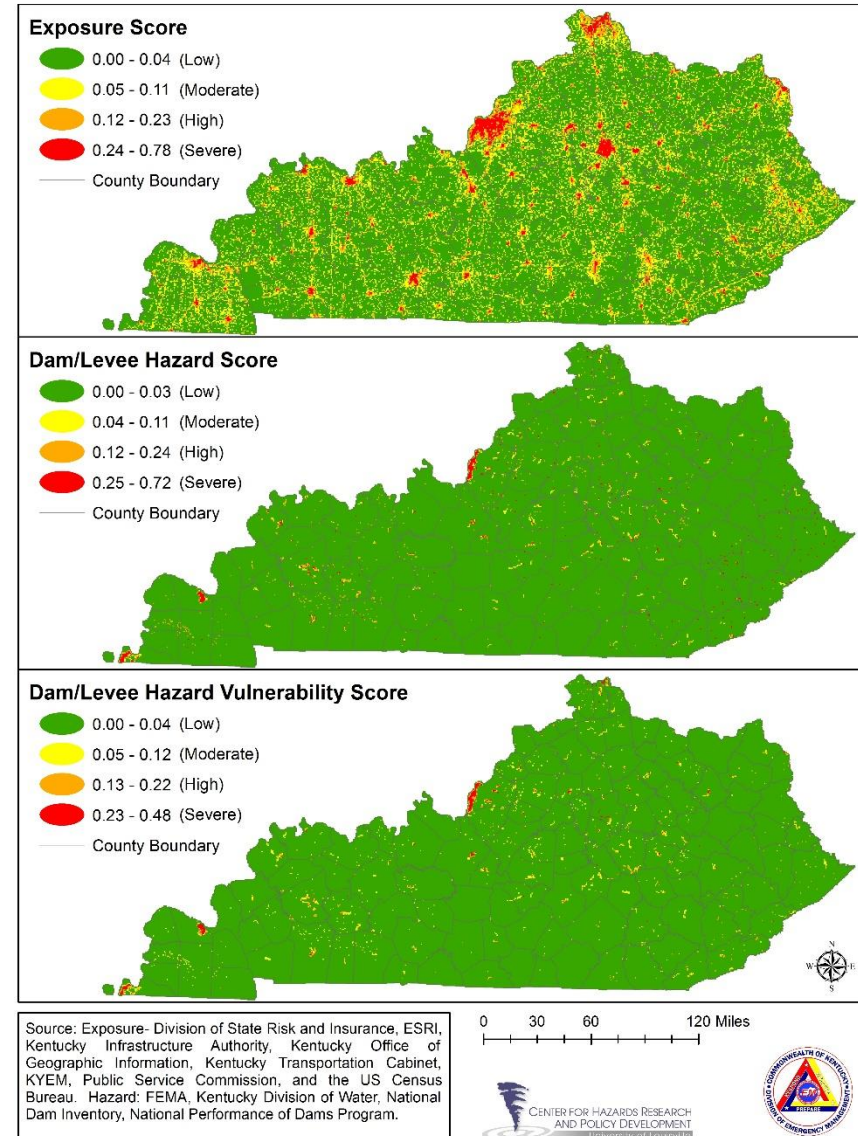
**Vulnerability:** What part of an "exposure" is at "risk" to each "hazard"

$$\text{Hazard Vulnerability Score} = \text{Exposure Score} + \text{Hazard Score}$$

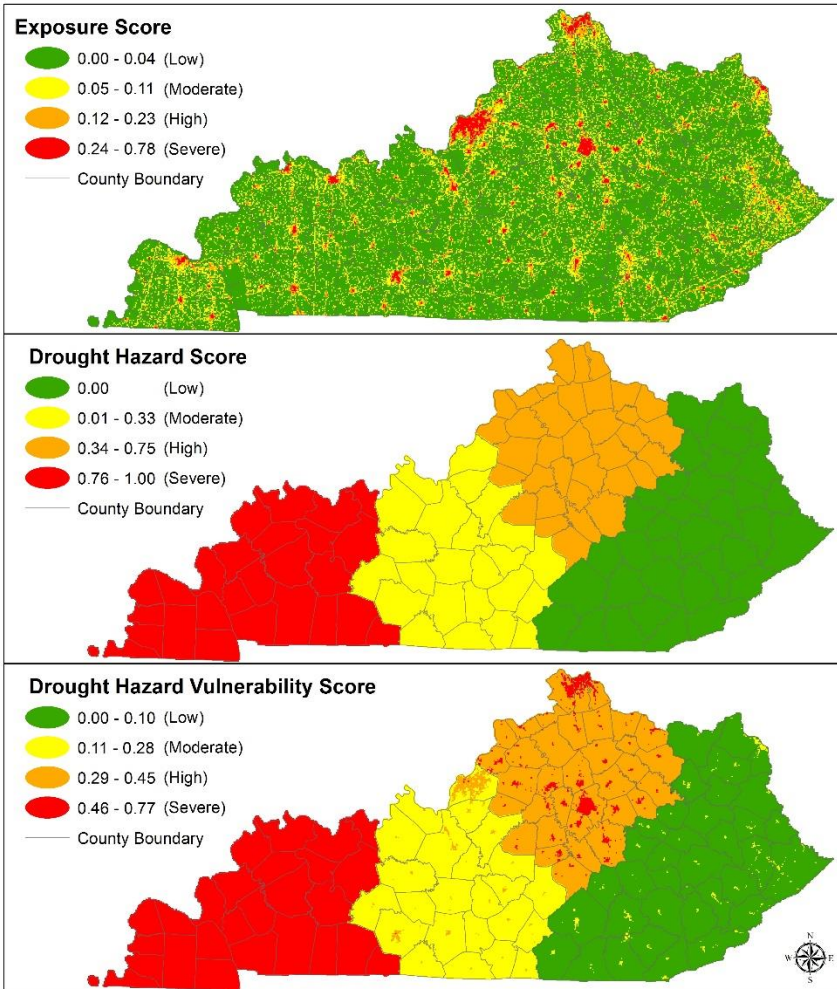


# Dam Failure

DAM FAILURE PROFILE RISK TABLE	
<b>Period of occurrence:</b>	Failure can occur at any time, but is often spurred by other events such as heavy flooding or seismic activity
<b>Number of events: (1973-2013)</b>	13*
<b>Annual Rate of Occurrence:</b>	0.43
<b>Warning time:</b>	Warning time is minimal and can often be directly related to frequency and thoroughness of inspections
<b>Potential impacts:</b>	Impacts on human life and public safety. Economic loss, environmental damage, and disruption of lifeline facilities.
<b>Recorded losses:</b>	Unknown based on lack of data capture
<b>Annualized Loss:</b>	Unknown based on lack of recorded losses
<b>Extent (Date, Damages, Scale/Size):</b>	Years: 1981, 2000 Damage: 1 fatality, 250 million gallons of slurry release.



# Drought



Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: NOAA

0 30 60 120 Miles

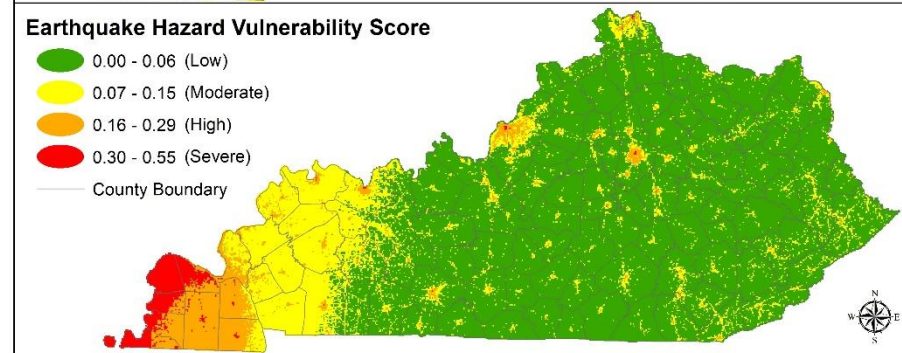
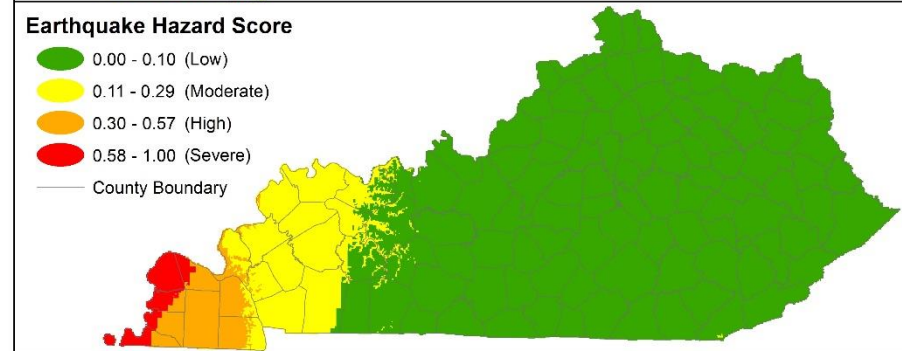
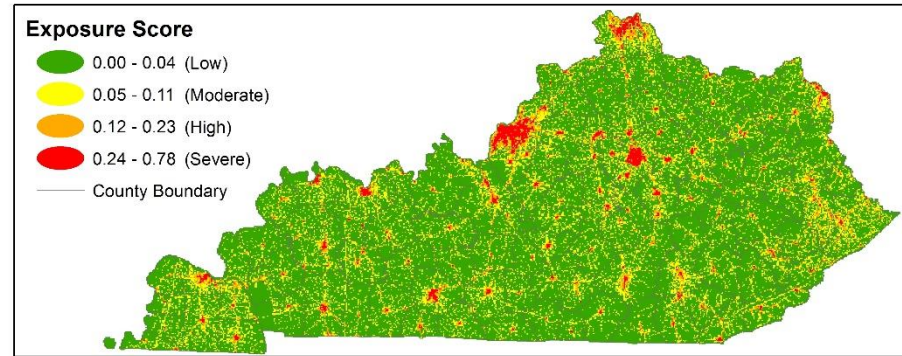


## DROUGHT PROFILE RISK TABLE

<b>Period of occurrence:</b>	Drought can occur at any time of the year in any part of Kentucky
<b>Number of events: (1960-2013)</b>	121*
<b>Annual Rate of Occurrence:</b>	2.28
<b>Warning time:</b>	Warning times for drought are not applicable as they are for severe storms or winter weather. Drought is onset by a period of similar weather and precipitation conditions. Predictability and preparedness is based mostly on the awareness of populations drought conditions are affecting.
<b>Potential impacts:</b>	Impacts to human life, health, and public safety are possible. Utility damage and failure, infrastructure damage (transportation and communication systems), structural damage, potential increase in risk of wild fire, and the possibility of damaged or destroyed critical facilities are additional impacts. Most impacts result from wildfire, extreme dry conditions, or dust storms.
<b>Recorded losses:</b>	\$301,317,375*
<b>Annualized Loss:</b>	\$2,490,226
<b>Extent (Historical &amp; Scale):</b>	Year: 1996 Scale: 1.5 inches of rain measured between July and September Damages: \$155 M in crop losses

# Earthquake


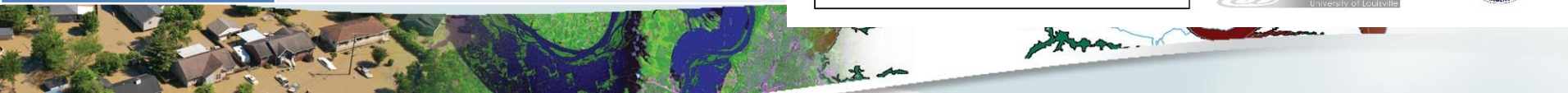
EARTHQUAKE PROFILE RISK TABLE	
Period of occurrence:	Earthquakes can occur year-round, at any time of the day or the night
Number of events: (1960-2013)	1*
Annual Rate of Occurrence:	Currently there are no probability ratios determined for earthquakes because of its unpredictable nature.
Warning time:	Warning time is essentially non-existent, as geologic activity at fault lines in the earth's crust happen sporadically.
Potential impacts:	Earthquakes can heavily impact human life, health, and public safety. Large events can cause infrastructure damage, utility damage, and critical facilities damage. Secondary events often trigger landslides, dam failure/flooding, and may facilitate the release of hazardous materials from containment structures.
Recorded losses:	\$2,763,158*
Annualized Loss:	\$52,135
Extent (Historical & Scale):	Year: 1980 Scale: 5.2 Location: Bath County



Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: Kentucky Geological Survey, USGS.

0 30 60 120 Miles

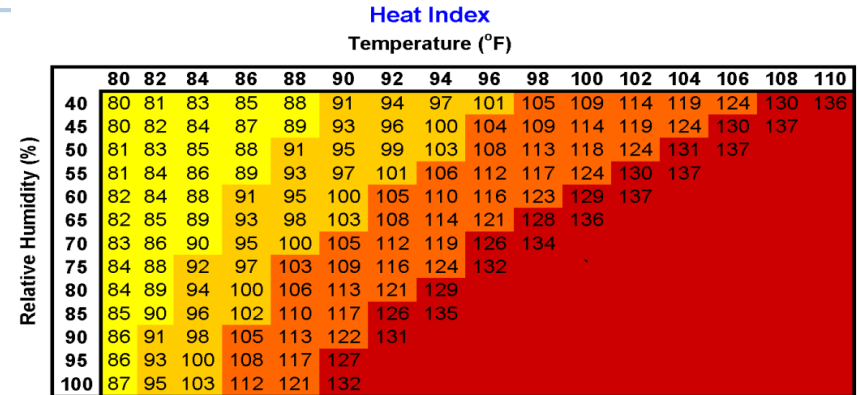
CENTER FOR HAZARDS RESEARCH AND POLICY DEVELOPMENT  
UNIVERSITY OF LOUISVILLE

# Extreme Heat

EXTREME TEMPERATURE PROFILE RISK TABLE	
<b>Period of occurrence:</b>	Extreme heat is most likely to occur in the months of July, August, or September. Extreme heat has been known to occur in May, June, and October. The likelihood of extreme heat occurring outside of these months is extremely small and unheard of December through March. Extreme cold is most likely to occur in the months of December, January or February.
<b>Number of events: (1960-2013)</b>	1,175*
<b>Annual Rate of Occurrence:</b>	22.17
<b>Warning time:</b>	The National Weather Service will initiate alert procedures when the Heat Index is expected to exceed 105° - 110°F (depending on local climate) for at least two consecutive days. Currently, there are no officially warnings for extreme cold. This was tested in 2012 but later dropped.
<b>Potential impacts:</b>	Extreme heat, impacts human life, health, and public safety. Fires due to extremely dry conditions are possible. Can lead to economic losses such as decreased land values and agribusiness losses. Extreme cold, impacts human life, health, and public safety. Rivers and lakes freeze causing transportation issues. Energy consumption goes up and depending on the time of year extreme cold can have large impacts on agriculture. Cold temperatures can also cause ruptured pipes and stressed on engines and motors.
<b>Recorded losses:</b>	\$1,141,306*
<b>Annualized Loss:</b>	\$21,534
<b>Extent (Historical):</b>	Date: 2012 Temperature: 94 degrees Impact: 1 death

## NOAA's National Weather Service

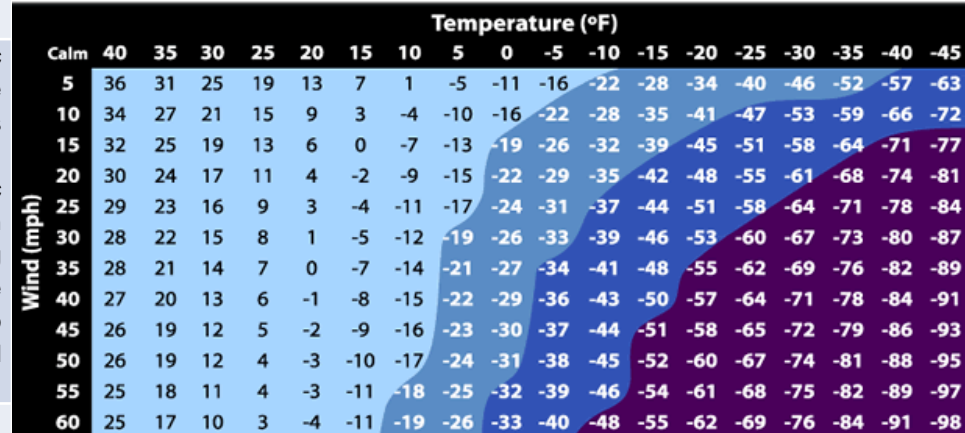


Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution
  Extreme Caution
  Danger
  Extreme Danger



## NWS Windchill Chart



Frostbite Times  30 minutes  10 minutes  5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

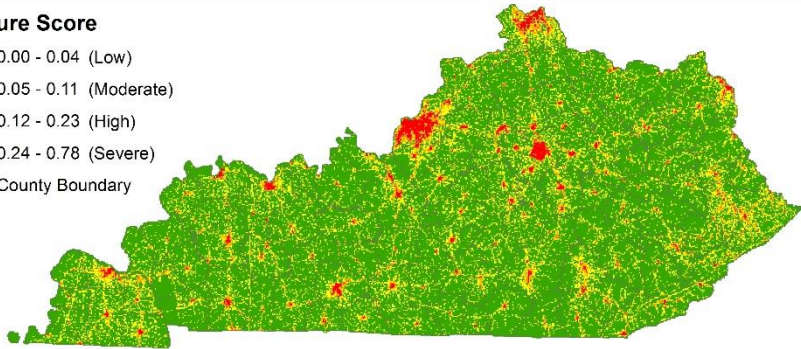
Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

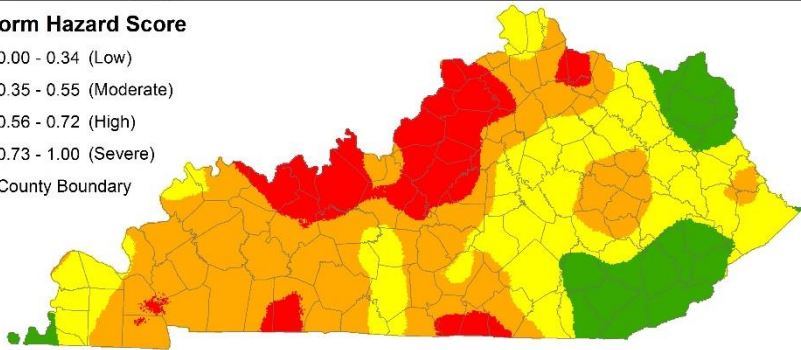


# Hail

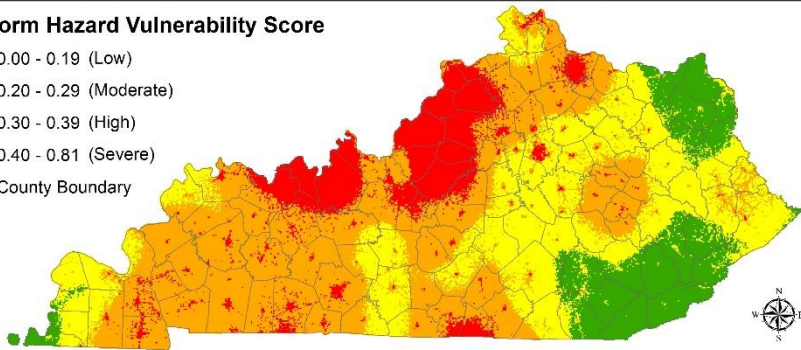
## Exposure Score



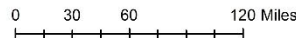
## Hail Storm Hazard Score



## Hail Storm Hazard Vulnerability Score



Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: NOAA



## HAIL STORM PROFILE RISK TABLE

**Period of occurrence:**

Frequented with severe storms which are most prevalent in Kentucky from April to June. Severe storms can occur whenever conditions are favorable however. As such, hail can occur at any time of the year, although it is a rarity in off season months.

**Number of events: (1960-2013)**

4,882\*

**Annual Rate of Occurrence:**

92.11

**Warning time:**

Prediction of hail as a contained event is very difficult. Providing any warning in advance for a threat of hail relies mostly on tracking storm systems which are capable of producing hail. Assuming hail is a possibility, when severe storms are approaching the best warning for hail is this point in time.

**Potential impacts:**

Impacts to human life, health, and public safety are possible. Utility damage and failure, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases are additional impacts.

**Recorded losses:**

\$983,340,017

**Annualized Loss:**

\$18,553,585

**Extent (Historical):**

Date: April 16, 1998  
Size: 2.75 inches  
Damage: \$714 M

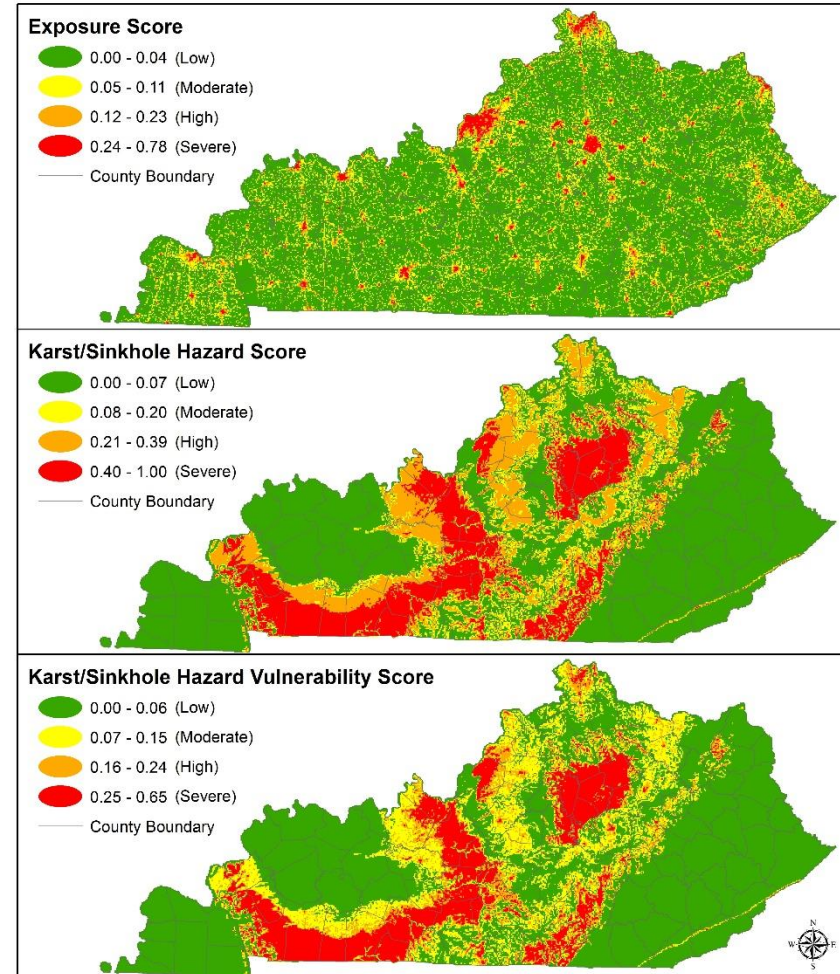


# Karst/ Sinkhole

Karst refers to a terrain with distinctive landforms and hydrology created from the dissolution of soluble rock—such as limestone and other carbonate rocks—and is characterized by springs, caves, sinkholes, and a unique hydrology.

## KARST/SINKHOLE PROFILE RISK TABLE

<b>Period of occurrence:</b>	At any time
<b>Number of events: (Unknown)</b>	101,632 Identified Sinkholes*
<b>Annual Rate of Occurrence:</b>	Unknown due to lack of start and end dates
<b>Warning time:</b>	Weeks to months, depending on monitoring and maintenance
<b>Potential impacts:</b>	Economic losses such as decreased property value and agribusiness losses, and may cause minimal to severe property damage and destruction, may cause geological movement, causing infrastructure damages.
<b>Recorded losses:</b>	Unknown
<b>Annualized Loss:</b>	Unknown due to lack loss data captured on Karst/Sinkhole events
<b>Extent (Statistical):</b>	Location: 55% of State with rocks susceptible to developing karst terrain Size: On average 7 ft. in diameter



Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: Kentucky Geological Survey

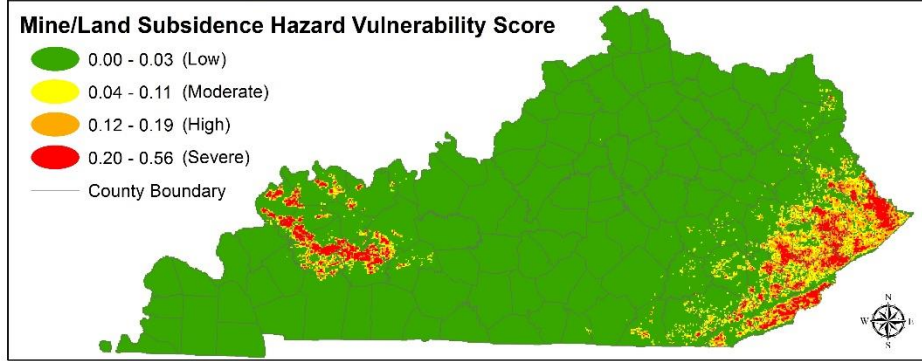
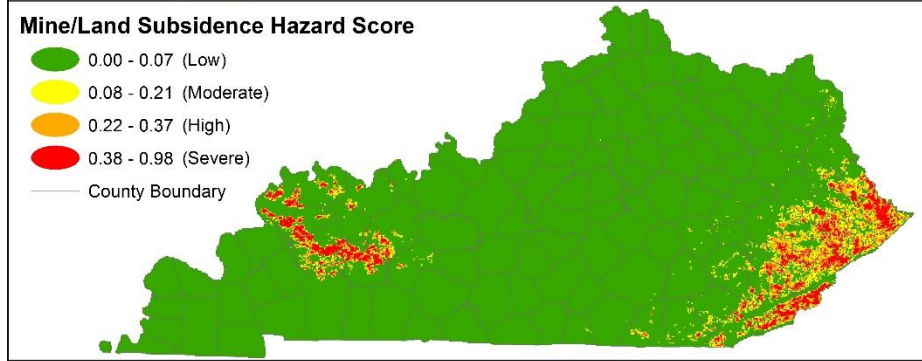
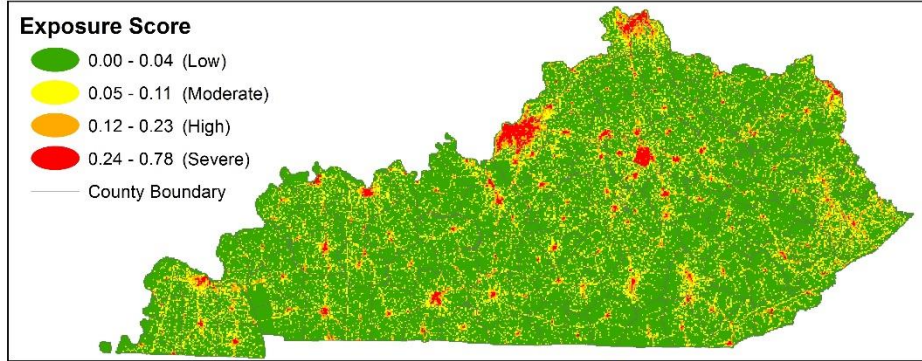
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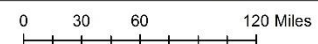
# Mine Subsidence

## MINE/LAND SUBSIDENCE PROFILE RISK TABLE

<b>Period of occurrence:</b>	At any time. Chance of occurrence increases after heavy rainfall, snow melt, or construction and mining activity.
<b>Number of events: (1981-2013)</b>	133*
<b>Annual Rate of Occurrence:</b>	4.16
<b>Warning time:</b>	Warning times vary greatly and are often dependent upon inspection for weaknesses in rock and soil. Most subsidence problems move slowly and cause damage gradually; however some events can move very quickly.
<b>Potential impacts:</b>	Economic losses such as decreased land values, agribusiness losses, disruption of utility and transportation systems, and costs for any litigation. May cause geological movement, causing infrastructure damages ranging from minimal to severe. May cause injury or death and shut down critical facilities for days or weeks.
<b>Recorded losses:</b>	\$5,550,000*
<b>Annualized Loss:</b>	\$173,438
<b>Extent:</b>	Deaths: Multiple per year Damage/Reclamation Costs: \$13.5-14 M in mine reclamation grant dollars over a 3 year period: Some go up into the millions of dollars

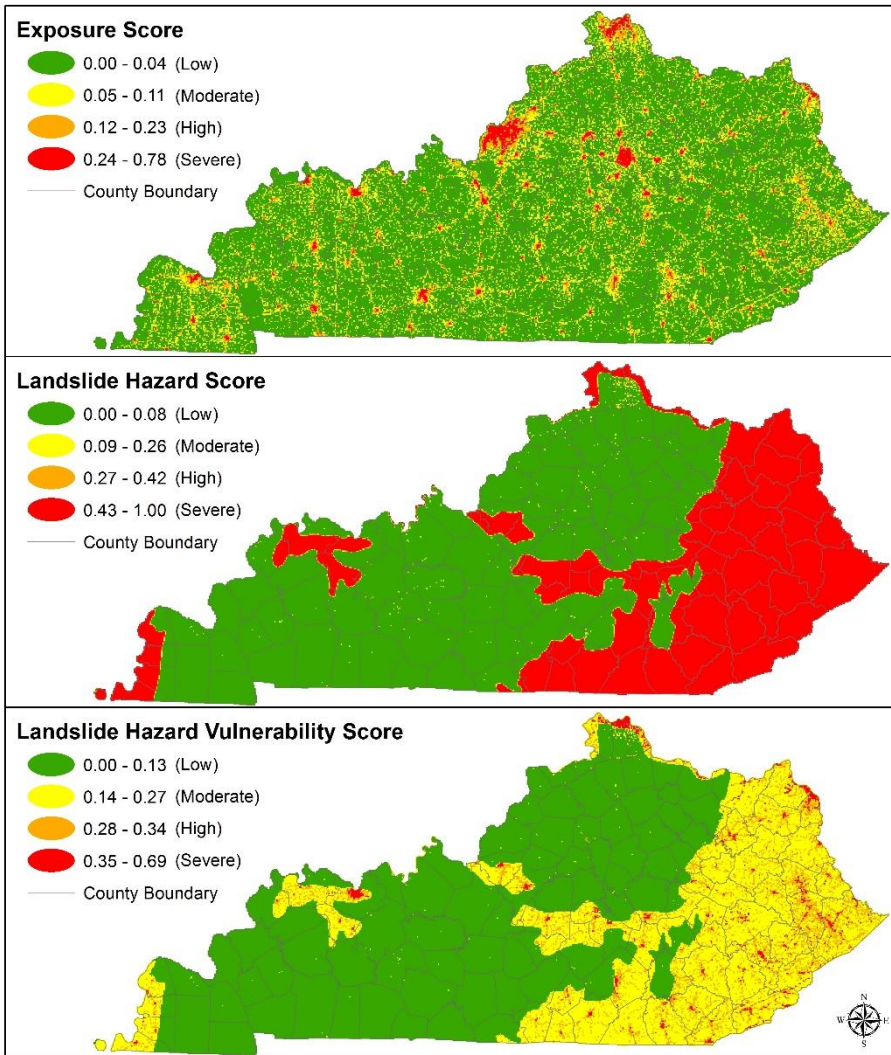


Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: Division of Abandoned Mine Lands, Kentucky Geological Survey.

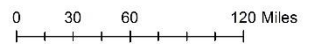




# Landslide

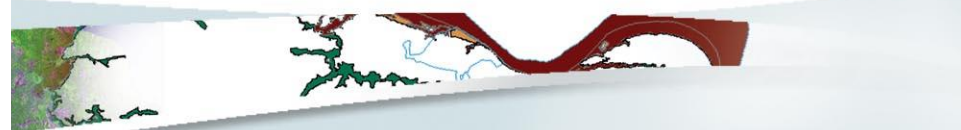


Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: Kentucky Geological Survey, USGS.



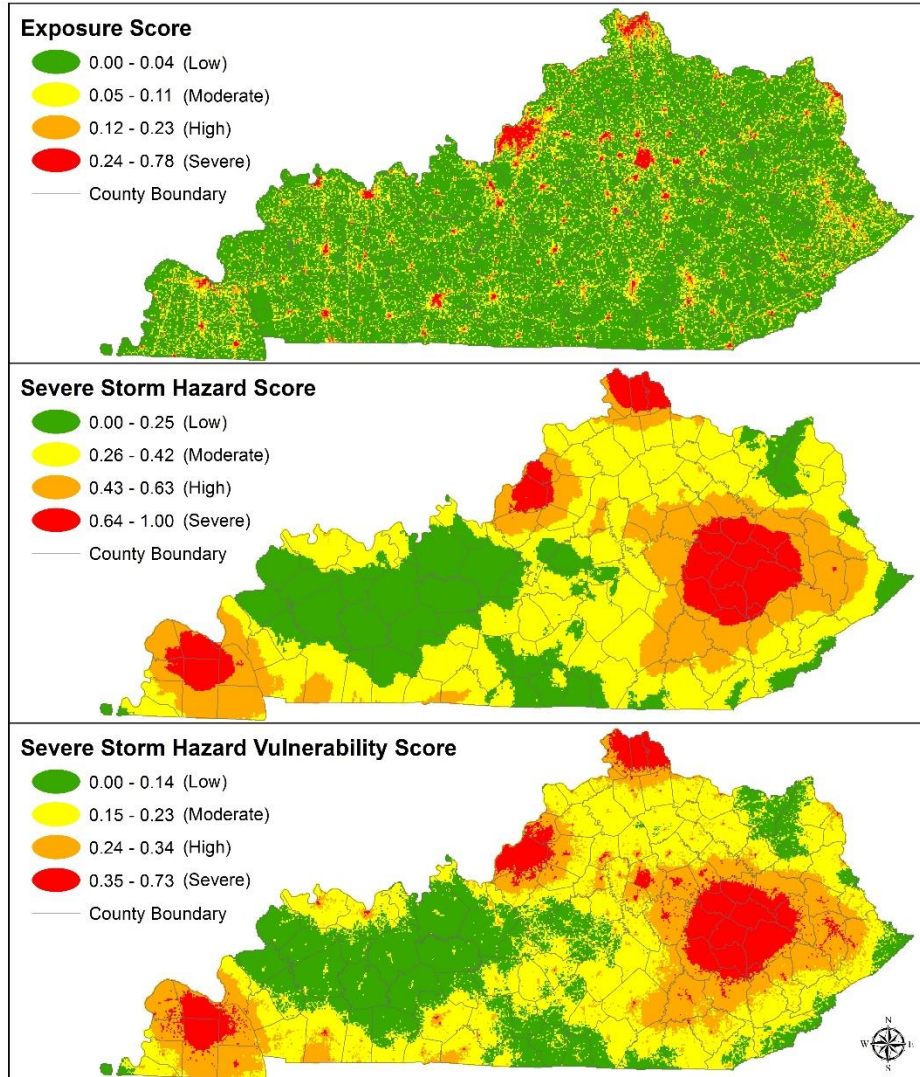
## LANDSLIDE PROFILE RISK TABLE

<b>Period of occurrence:</b>	At any time. Chance of occurrence increases after heavy rainfall, snow melt, or construction and mining activities.
<b>Number of events: (1975-2013)</b>	1,393*
<b>Annual Rate of Occurrence:</b>	36.66
<b>Warning time:</b>	Days to months, depends on inspection for weakness in rock and soil.
<b>Potential impacts:</b>	Economic losses such as decreased land values, infrastructure damage, and agrobusiness losses. May cause minimal to severe property damage and destruction.
<b>Recorded losses:</b>	\$28,365,706*
<b>Annualized Loss:</b>	\$746,466
<b>Extent:</b>	Damage: \$2 million to repair annually Location: Statewide Data Currently Unavailable related to a physical standard by which to compare landslide hazard events

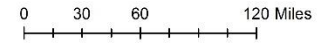


# Severe Storm

SEVERE STORM PROFILE RISK TABLE	
Period of occurrence:	Spring, Summer, and Fall
Number of events: (1960-2013)	21,481*
Annual Rate of Occurrence:	405.30
Warning time:	Minutes to hours
Potential impacts:	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Impacts human life, health, and public safety.
Recorded losses:	\$898,499,257*
Annualized Loss:	\$16,952,816
Extent (Historical):	Date: September 14, 2008 Scale: 68 knots (kts.) Damages: \$168 M property, \$69 M crop, 1 death, 46 injuries



Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: NOAA



# Severe Winter Storm

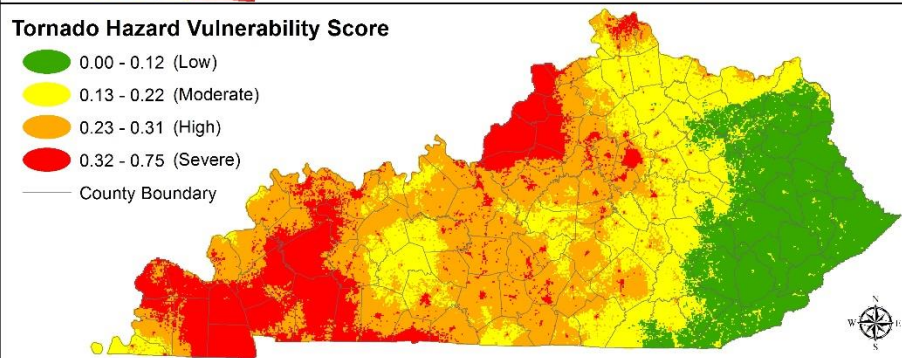
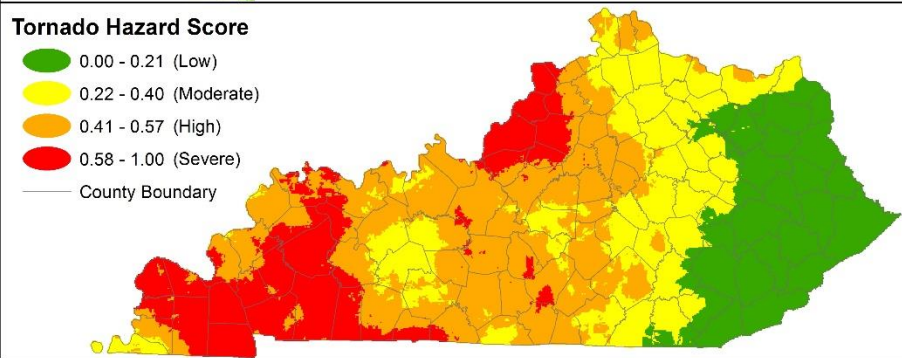
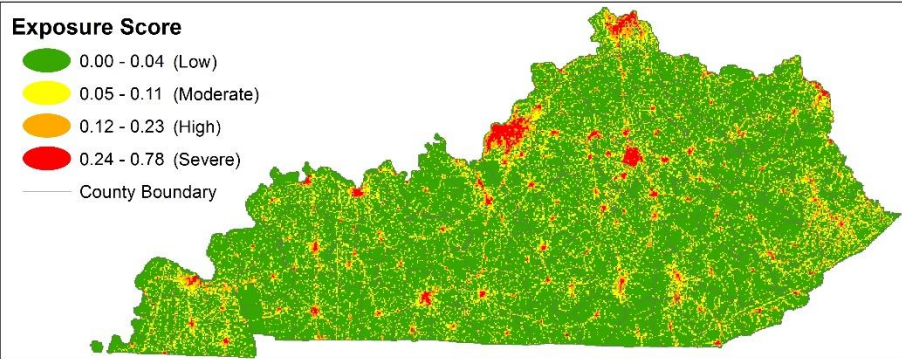
1818	1-28-2009	Severe Winter Storm
1578	2-8-2005	Severe Winter Storm Record Snow
1454	3-14-2003	Severe Winter Storm
1207	3-3-1998	Severe Winter Storm
1089	1-13-1996	Blizzard
1018	3-16-1994	Severe Winter Storm (Precipitation, high winds)
3104	3-16-1993	Severe Winter Storms

## SEVERE WINTER STORM PROFILE RISK TABLE

<b>Period of occurrence:</b>	Winter
<b>Number of events: (1960-2013)</b>	3,951*
<b>Annual Rate of Occurrence:</b>	74.55
<b>Warning time:</b>	Days for Snow Minutes to hours for ice
<b>Potential impacts:</b>	Power outages, which results in loss of electrical power and potentially loss of heat, and human life. Extreme cold temperatures may lead to frozen water mains and pipes, damaged car engines, and prolonged exposure to cold resulting in frostbite
<b>Recorded losses:</b>	\$435,706,556*
<b>Annualized Loss:</b>	\$8,220,878
<b>Extent (Historical):</b>	Date: January 26 – February 13, 2009 Damages: \$307 M, multiple injuries and 36 fatalities Scale: 1.5 inches of ice



# Tornado



Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: NOAA

0 30 60 120 Miles



## TORNADO PROFILE RISK TABLE

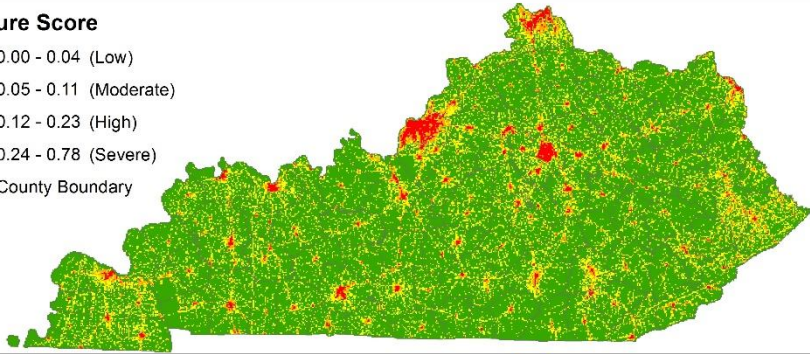
<b>Period of occurrence:</b>	Spring, Summer, and Fall
<b>Number of events: (1960-2013)</b>	1,136*
<b>Annual Rate of Occurrence:</b>	21.43
<b>Warning time:</b>	Minutes to hours
<b>Potential impacts:</b>	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Impacts human life, health, and public safety.
<b>Recorded losses:</b>	\$1,020,237,467*
<b>Annualized Loss:</b>	\$19,249,764
<b>Extent (Scale):</b>	Date: March 2-3, 2012 Scale: EF4 Damages: \$33.5 M, 23 deaths, 207 injuries



# Forest Fire

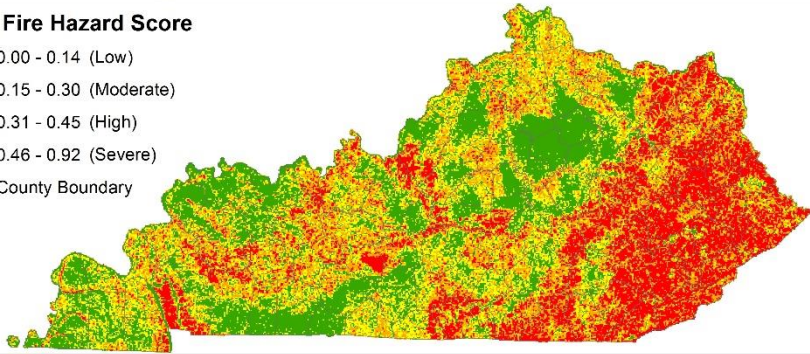
## Exposure Score

- 0.00 - 0.04 (Low)
- 0.05 - 0.11 (Moderate)
- 0.12 - 0.23 (High)
- 0.24 - 0.78 (Severe)
- County Boundary



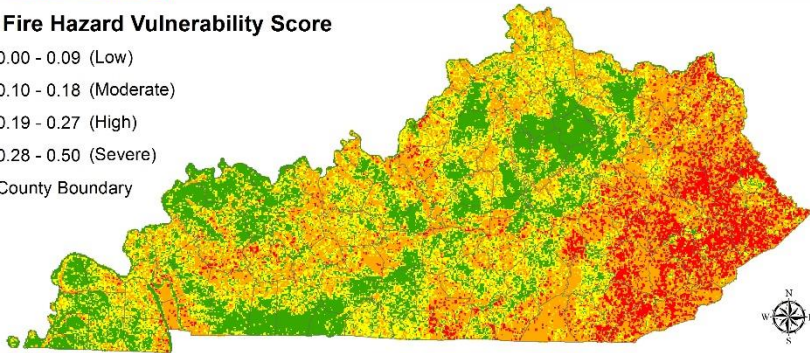
## Forest Fire Hazard Score

- 0.00 - 0.14 (Low)
- 0.15 - 0.30 (Moderate)
- 0.31 - 0.45 (High)
- 0.46 - 0.92 (Severe)
- County Boundary



## Forest Fire Hazard Vulnerability Score

- 0.00 - 0.09 (Low)
- 0.10 - 0.18 (Moderate)
- 0.19 - 0.27 (High)
- 0.28 - 0.50 (Severe)
- County Boundary



Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: Kentucky Division of Forestry, USGS

0 30 60 120 Miles



## FOREST FIRE PROFILE RISK TABLE

<b>Period of occurrence:</b>	Spring Forest Fire Hazard Season: Feb. 15 through April 30 Fall Forest Fire Hazard Season: Oct. 1 through Dec. 15
<b>Number of events: (1997-2012)</b>	22,467*
<b>Annual Rate of Occurrence:</b>	898.68
<b>Warning time:</b>	None, unless associated with drought
<b>Potential impacts:</b>	Utility damage and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases.
<b>Recorded losses:</b>	\$41,250**
<b>Annualized Loss:</b>	\$1,650
<b>Extent (Scale):</b>	Year: 2010 Scale: 54,577 acres burned



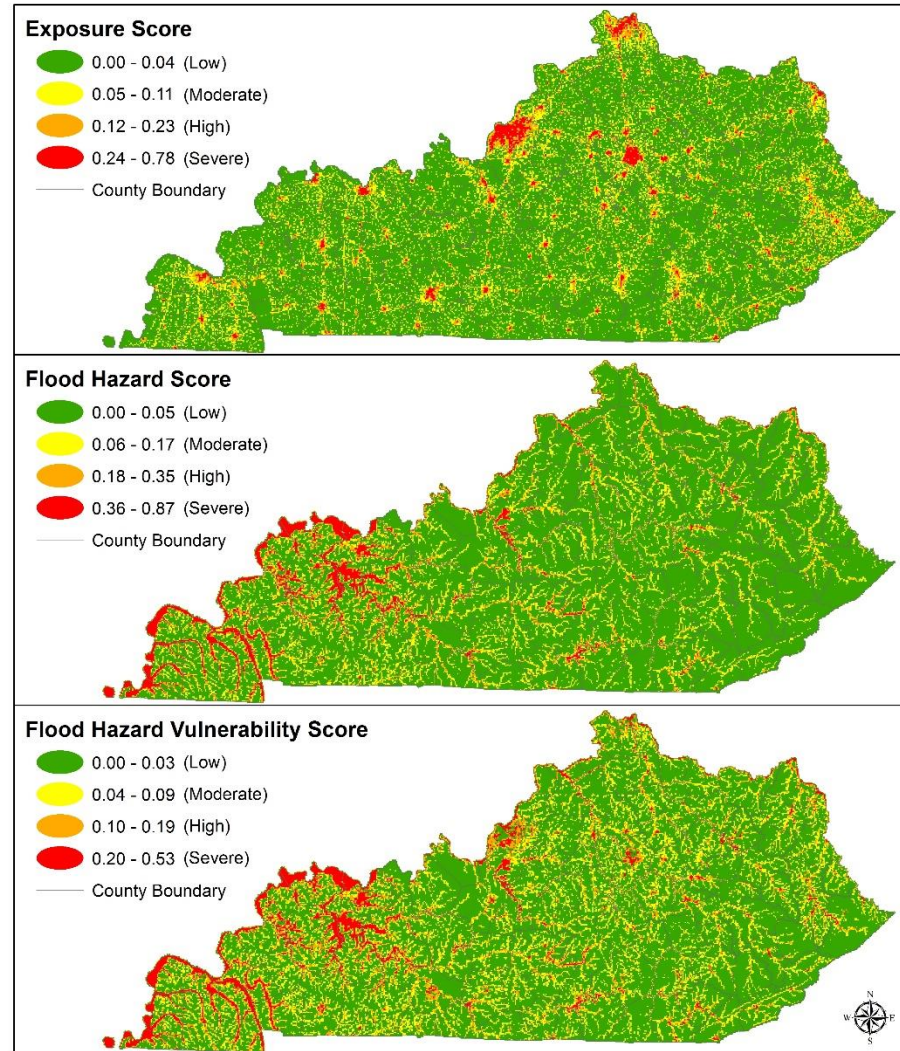
# Flooding

FLOOD PROFILE RISK TABLE	
<b>Period of occurrence:</b>	For river flooding - January through May For flash flooding - Anytime, but primarily during summer rains
<b>Number of events: (1960-2013)</b>	5,934*
<b>Annual Rate of Occurrence:</b>	112
<b>Warning time:</b>	River flooding - 3-5 days Flash flooding - minutes to several hours Out-of-bank flooding - several hours/days
<b>Potential impacts:</b>	Impacts human life, health, and public safety. Utility damages and outages, infrastructure damage (transportation and communication systems), structural damage, fire, damaged or destroyed critical facilities, and hazardous material releases. Can lead to economic losses such as unemployment, decreased land values, and agribusiness losses. Floodwaters are a public safety issue due to contaminants and pollutants.
<b>Recorded losses:</b>	\$2,301,445,697*
<b>Annualized Loss:</b>	\$43,423,504
<b>Extent (Historical):</b>	Date: March 1997 Damage: \$400 M Location: 100 counties/statewide

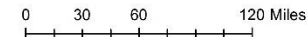


# What Causes Flooding

- ✓ Flash Floods
- ✓ Flood After Fire
- ✓ Heavy Rains
- ✓ Ice Jams
- ✓ La Nina
- ✓ Levees
- ✓ Mudflows
- ✓ New Development
- ✓ Snowmelt
- ✓ Spring Thaw
- ✓ Tropical Storms and Hurricanes



Source: Exposure- Division of State Risk and Insurance, ESRI, Kentucky Infrastructure Authority, Kentucky Office of Geographic Information, Kentucky Transportation Cabinet, KYEM, Public Service Commission, and the US Census Bureau. Hazard: FEMA, Kentucky Division of Water.



# Defining Flood Risks

- ✓ Understanding Flood Areas
  - To help communities understand their risk, flood maps ([Flood Insurance Rate Maps, FIRMs](#)) have been created to show the locations of high-risk, moderate-to-low risk, and undetermined-risk areas.
    - High-risk areas (Special Flood Hazard Area or SFHA - Zone AE or A)
    - Moderate-to-low risk areas (Shaded Zone X or Zone X)
    - Undetermined-risk areas
- ✓ Determining the Risk
  - Flood Insurance Study
  - Flood Hazard maps
  - Repetitive Loss areas
- ✓ Understanding Your Area
  - Understand your map to make informed decisions





# Flood Risk Scenarios

[http://www.floodsmart.gov/floodsmart/pages/flooding\\_flood\\_risks/flood\\_scenarios.jsp](http://www.floodsmart.gov/floodsmart/pages/flooding_flood_risks/flood_scenarios.jsp)

What are your chances of experiencing a flood?  
These animated scenarios demonstrate how various factors impact different neighborhoods.

