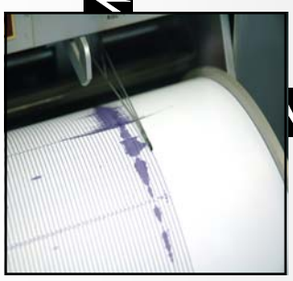
GEORGIA EARTHQUAKE AWARENESS GUIDE



For Local Emergency Management Agency Directors

April 2011

FEMA

GEMA

Geophysics @ Georgia Institute of Technology
School of Earth and Atmospheric Sciences

Ready.Georgia

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This publication is a project of the Georgia Emergency Management Agency (GEMA)/Homeland Security in cooperation with the Georgia Institute of Technology-School of Earth & Atmospheric Science, the Federal Emergency Management Agency (FEMA) National Earthquake Hazards Reduction Program (NEHRP) and the Ready Georgia Campaign. A downloadable guide is available at:

www.gema.ga.gov
www.ready.ga.gov
http://geophysics.eas.gatech.edu

For additional information, please contact GEMA or Georgia Institute of Technology, School of Earth & Atmospheric Sciences.

Agency	Website	Address	Phone Number
Georgia Emergency Management Agency/Homeland Security **Ready Georgia Campaign**	www.gema.ga.gov www.ready.ga.gov	P.O. Box 18055 Atlanta, Georgia 30316	1-800-TRY-GEMA
Georgia Institute of Technology-School of Earth & Atmospheric Sciences	http://www.eas.gatech.edu/schoo	311 Ferst Drive Atlanta, GA 30332-0340	404-894-3893
April 2011			

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Descriptive Comparisons of Earthquake Magnitude with Observed Effects

Modified-Mercalli Intensity Scale of 1931

GEORGIA AND EARTHQUAKES

According to Georgia Tech's School of Earth and Atmospheric Sciences, 15 percent of the world's earthquakes are scattered over areas like Georgia that lack clearly defined active faults. These earthquakes usually start with a jolt, build rapidly in amplitude within a couple of seconds, and then decay.

The total felt duration of the typical small Georgia earthquake is usually less than 10 seconds, and it sounds like a muffled dynamite explosion. Although earthquakes in Georgia are comparatively rare, scattered earthquakes have caused significant damage and can be an important consideration for homeowners (Source: www.ready.ga.gov).

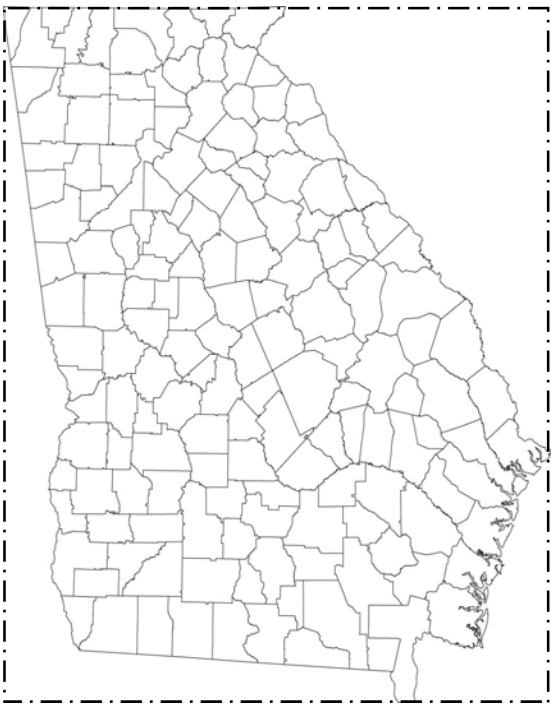
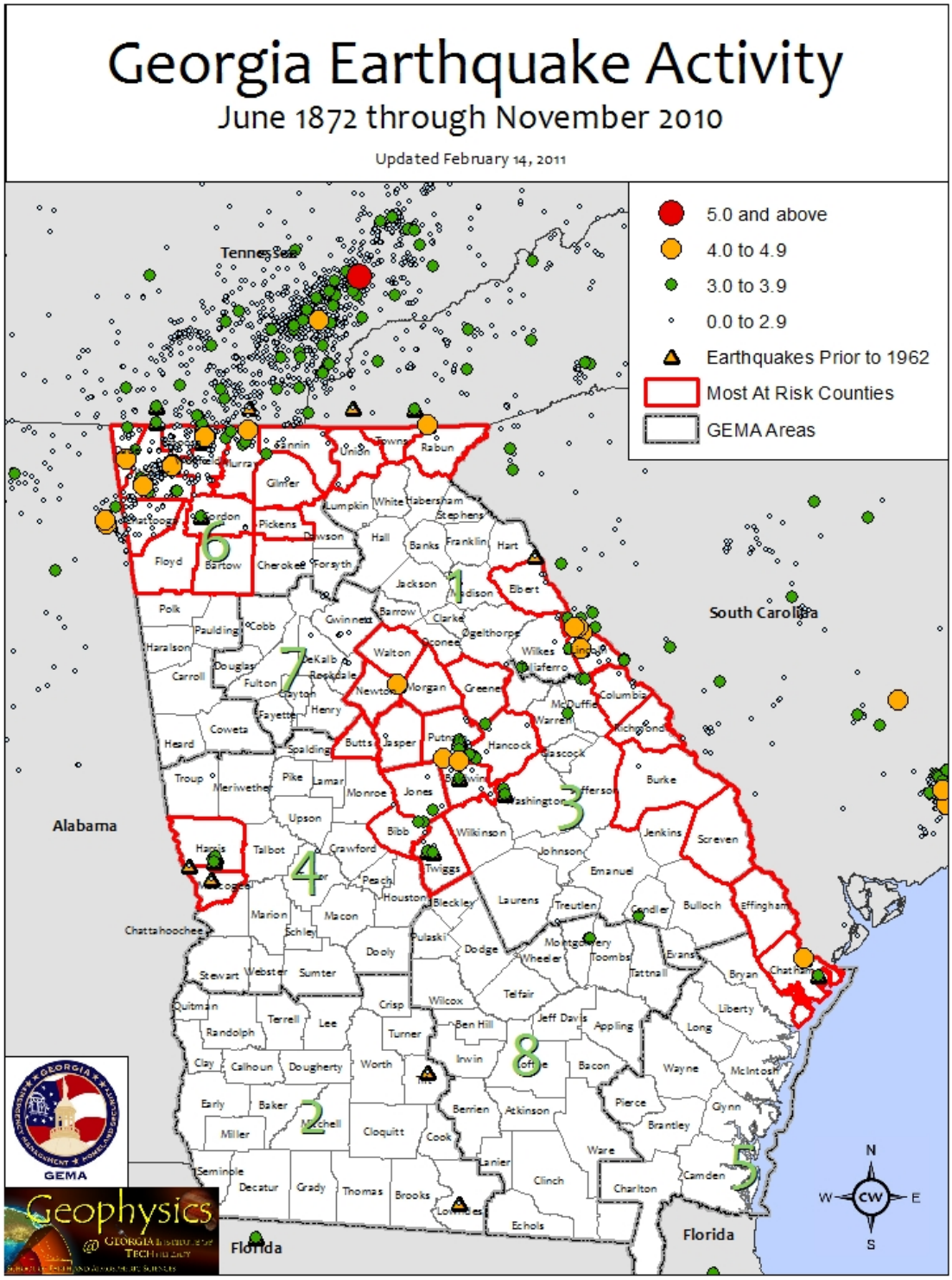


Figure 1.0: Georgia Counties at the Greatest Risk for Earthquakes

Area	Counties
Northwest Georgia Counties	Bartow, Catoosa, Chattooga, Dade, Fannin, Floyd, Gilmer, Gordon, Murray, Pickens, Rabun, Towns, Union, Walker, Whitfield
South Carolina Border Counties	Burke, Chatham, Columbia, Effingham, Elbert, Lincoln, Richmond, Screven
Central and West Central Georgia Counties	Twiggs, Bibb, Jones, Baldwin, Hancock, Greene, Putnam, Butts, Jasper, Newton, Morgan, Walton, Harris, Mucscogee
Source: **Georgia Tech School of Earth & Atmospheric Sciences, A.V. Newman, C.N. Gammans, 2010.**	


Georgia Earthquake Activity
June 1872 through November 2010
Updated February 14, 2011
5.0 and above
4.0 to 4.9
3.0 to 3.9
0.0 to 2.9
Earthquakes Prior to 1962
Most At Risk Counties
GEMA Areas
Tennessee
South Carolina
Alabama
Florida
Florida
1
2
3
4
5
6
7
8
GEMA
Geophysics
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EARTHQUAKE BASICS OVERVIEW

An earthquake is a sudden shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. Earthquakes can cause buildings and bridges to collapse, telephone and power lines to fall, and cause fires, explosions and landslides. Earthquakes can also cause tsunamis, which can impact coastal areas far away from where earthquake shaking can be felt.

Earthquake Effects

Earthquakes often have significant social and economic impacts on communities, including:

- Disruption of business supply chains;
- Rise in insurance costs for certain types of buildings susceptible to earthquake damage;
- Cancellation of insurance policy after an earthquake;
- Loss of housing options (especially for low-income residents);
- Changes to neighborhoods, as residents often must relocate.

Causes of Earthquakes

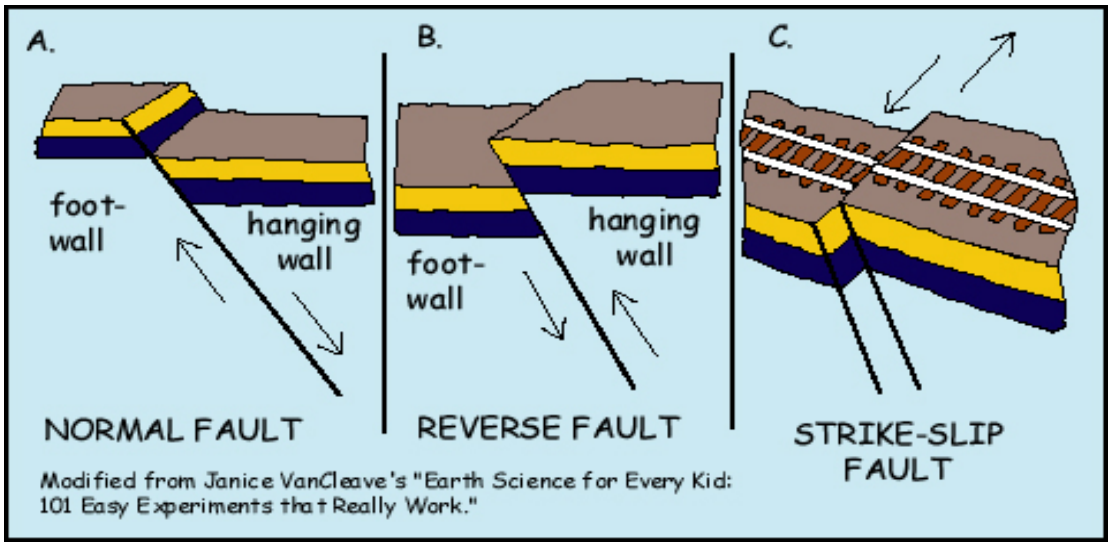
An earthquake is caused by a sudden slip on a fault, which results in a release of energy that travels away from the fault surface as seismic waves. Seismic waves are elastic shocks that travel through the earth. Faults slip to release stress that is created as tectonic plates move around the surface of the earth.

Faults

A fault is a weak zone in the earth's crust where two sections can shift.

- Normal fault movement occurs when the two sides move away from one another as the crust fails in extension.
- Thrust or reverse fault movement occurs when the two sides are pushed together due to compression.
- Strike-slip or lateral fault movement occurs when the pieces move horizontally past one another.

Figure 2.0: Types of Faults



Source: http://www.dnr.sc.gov/geology/earthquake.html

Seismic Waves

Earthquakes release energy that radiates away from the fault in the form of seismic waves.

The two main types of seismic waves are:

- Body waves
- Surface waves

Body Waves

- Travel through the Earth
- Are felt first after an earthquake
- Can be divided into:
    - **Compressional Waves** (also called primary or P waves) are the fastest seismic waves traveling as fast as 30 times the speed of sound in air.
    - **Shear Waves** (or secondary waves) are the second main arrival, traveling at about 60% the speed of P waves.

Surface Waves

- Travel along the Earth's surface
- Travel slower than either type of body wave
- Are larger then body waves for most earthquakes
- Cause most of the damage to buildings

Measuring Earthquakes

Seismographs record and measure vibrations produced by earthquakes as a wavy line called a seismogram. Modern seismographs record earthquakes digitally, rather than on paper allowing for greater research and storage capabilities.

Using the data recorded as seismograms by many recording stations, the following can be determined:

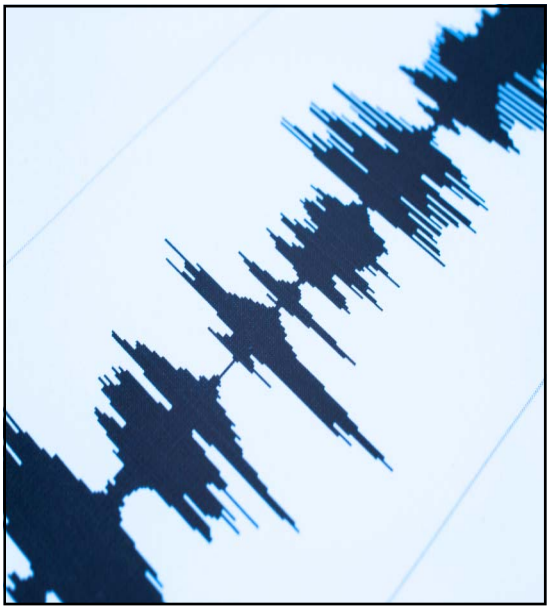
- Time the earthquake started
- Epicenter of the quake (where it started)
- Focal depth
- Amount of energy released (related to the magnitude)
- Fault area

Measuring Severity

Earthquake severity can be measured in two main ways:

- **Magnitude**, based on the amount of shaking or the size of the fault rupture. The Richter and Moment Magnitude Scales are each used to measure magnitude.
- **Intensity**, based on how strong the shock is felt and the damage done at the location of interest. An earthquake has many different intensities. The Modified Mercalli Scale is used to identify these various intensities.

Richter Magnitude Scale



The Richter Magnitude Scale expresses earthquake size as a magnitude in a numeric scale. The Richter Magnitude Scale is logarithmic, where each increase in whole numbers represents a tenfold increase in shaking and an increase in energy of 32 times.

Earthquakes with a magnitude of 2.0 or less (microearthquakes) are generally too small to be felt. According to the United States Geological Survey, microearthquakes are very common; approximately 8,000 occur worldwide each day. Large earthquakes that have caused significant damage have measured 7.0 or larger. In the United States, a magnitude of 5.5 or greater is capable of causing building and infrastructure damage. However, the Richter Magnitude Scale measures energy release, not damage.

Moment Magnitude Scale

The Moment Magnitude Scale supersedes the Richter Magnitude Scale and other magnitude scales to evaluate the size of the fault rupture. The Moment Magnitude Scale gives the most reliable estimate of earthquake size when the earthquakes exceed 6.0 on the Richter Magnitude Scale or are very distant from recording devices. The Moment Magnitude Scale is the preferred magnitude scale.

Modified-Mercalli Intensity Scale

The Modified Mercalli Intensity Scale is a measure of the strength of shaking of an earthquake at a specific location. It can also be described as the local effect of an earthquake as felt by people and resulting damage on the earth's surface. It is normally represented in Roman numerals.

Each earthquake has several intensities over the impacted area. Under this system, an area with an intensity of I is felt by a very few people, while a XII will cause total damage.

The Modified Mercalli Intensity Scale quantifies the results of an earthquake at various locations. It is not a measurement of an earthquake or any of its characteristics.

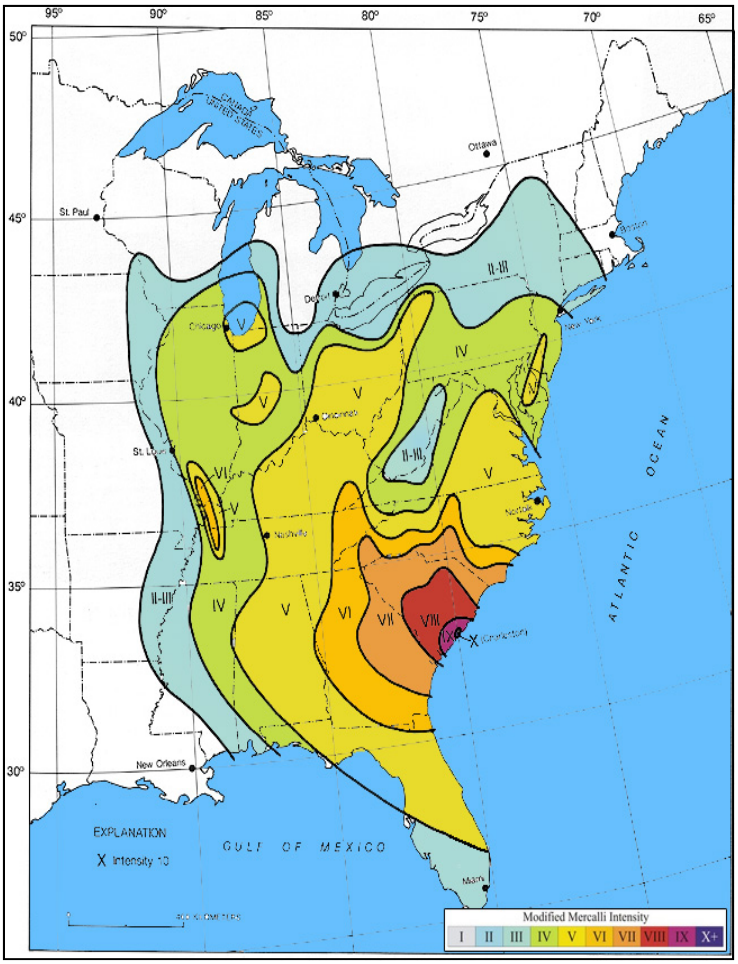


Figure 3.0:

Modified -Mercalli Intensity Map for the shaking and damage associated with the 1886 Charleston, South Carolina earthquake. A few chimneys fell even in Atlanta, and shaking was felt as far away as Chicago (McKinley, 1887). The precise magnitude of this event is unknown because seismometers did not yet exist, however, it is estimated to be between magnitude 6.6 and 7.3. (Image from Stover and Coffman, 1993.)

U.S. SEISMICITY

While earthquakes have occurred in nearly all of the 50 states and territories, there are areas of heightened earthquake activity. Some areas of the U.S. experience moderate to severe earthquakes every 30 to 50 years, while other areas may experience these size earthquakes approximately every 200 or more years.

Figure 4.0: U.S Earthquake Facts & Statistics

Number of Earthquakes in the United States 2000-2010

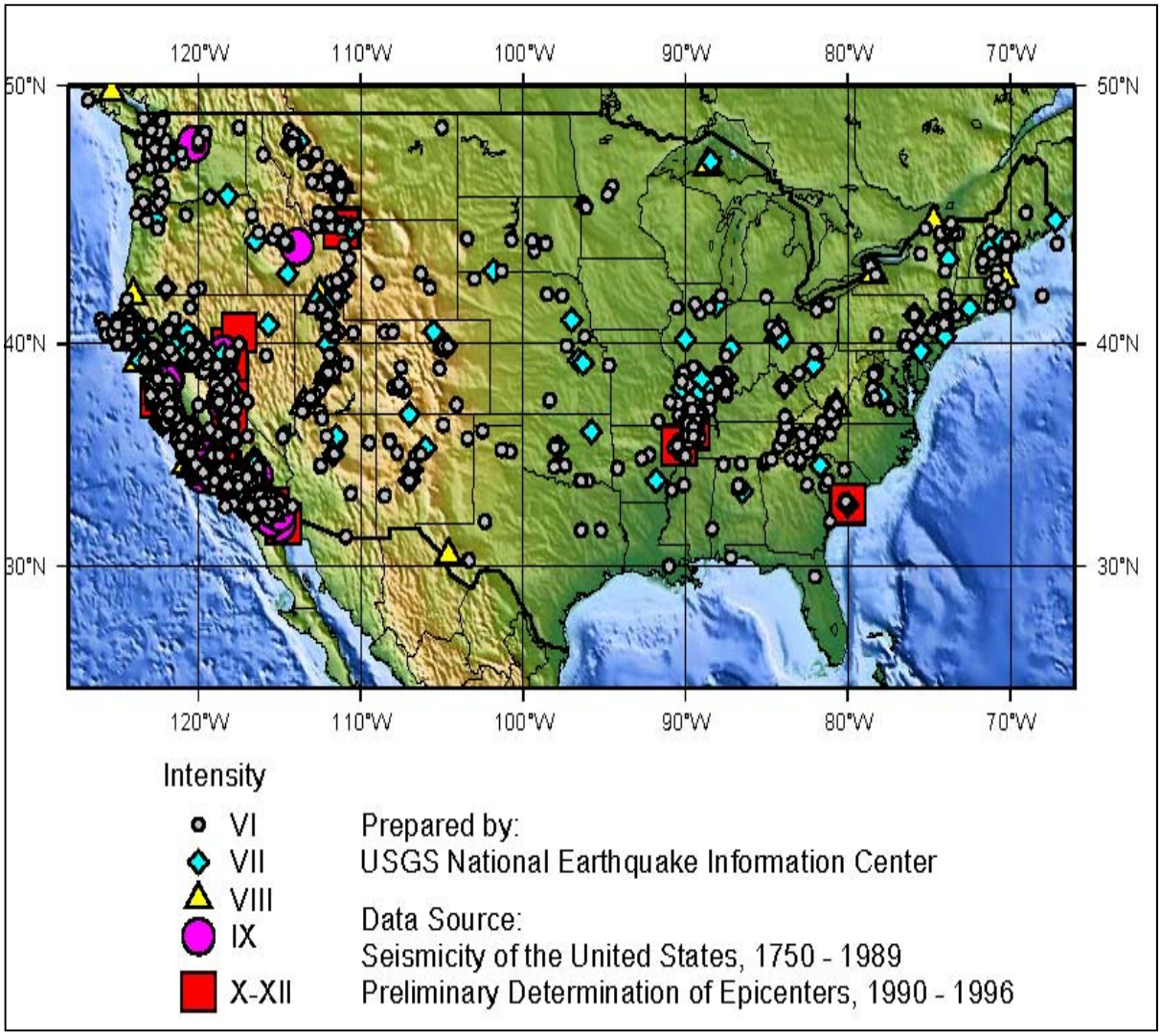
Magnitude	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
8.0 to 9.9	0	0	0	0	0	0	0	0	0	0	0
7.0 to 7.9	0	1	1	2	0	1	0	1	0	0	1
6.0 to 6.9	6	5	4	7	2	4	7	9	9	4	7
5.0 to 5.9	63	41	63	54	25	47	51	72	85	59	52
4.0 to 4.9	281	290	536	541	284	345	346	366	432	288	523
3.0 to 3.9	917	842	1535	1303	1362	1475	1213	1137	1486	1492	2962
2.0 to 2.9	660	646	1228	704	1336	1738	1145	1173	1573	2378	3091
1.0 to 1.9	0	2	2	2	1	2	7	11	13	26	23
0.1 to 0.9	0	0	0	0	0	0	1	0	0	1	0
No Magnitude	415	434	507	333	540	73	13	22	20	14	13
Total	2342	2261	3876	2946	3550	3685	2783	2791	3618	* 4262	* 6672
Estimated Deaths	0	0	0	2	0	0	0	0	0	0	0

Source: http://earthquake.usgs.gov/earthquakes/eqarchives/year/eqstats.php. Located by the US Geological Survey National Earthquake Information Center (***As of November 1, 2010**)

LARGEST U.S. EARTHQUAKES

Alaska experiences the majority of the earthquakes in the United States and is one of the most seismically active regions of the world. To date, the largest earthquake recorded in the United States was in 1964, when measured at a magnitude of 9.2 and occurred in Prince William Sound, Alaska. In addition, a series of large earthquakes occurred in 1811 and 1812 in New Madrid, Missouri, the largest of which is estimated between 7.4 and 7.8 magnitude. Below is a map that depicts where the most significant earthquakes occurred in the United States over the years.

Figure 5.0: US Earthquakes Causing Damage 1750-1996 , Modified-Mercalli Intensity VI-XII.



GEORGIA EARTHQUAKE HISTORY

The first notable earthquakes felt in Georgia were the great New Madrid series of 1811 - 1812. These shocks were felt over almost all of the eastern United States. In Georgia, that series of shocks reportedly shook some bricks from chimneys. Besides those initial earthquake rumblings between 1811-1812, Georgia was also impacted by the large Charleston, South Carolina Earthquake of 1886.; it caused severe shaking throughout the state. Georgians heard a low rumble then began feeling earthquake tremors on August 31 at 9:25 p.m.. The shock waves reached Savannah. The shaking was so significant that people had difficulty remaining standing, and one woman even died of fright as the shaking cracked walls, felled chimneys, and broke windows. Panic at a revival service left two injured and two more were injured when they leapt from upper story windows. Several more were injured by falling bricks. Ten buildings in Savannah were damaged beyond repair, and at least 240 chimneys were reported damaged. People spent the night outside. At the Tybee Island light station the 134-foot lighthouse was cracked near the middle where the walls were six feet thick, and the 1-ton lens moved an inch and a half to the northeast.

In Augusta, the shaking was the most severe (VIII on the Modified Mercalli Intensity Scale) in the state. An estimated 1,000 chimneys and many buildings were damaged. Businesses and social life was paralyzed for two days.

An earthquake on June 17, 1872, in Milledgeville had an intensity of at least V on the Modified Mercalli Intensity Scale, the lowest intensity in which some damage may occur. It was reported as a sharp shock, jarring brick buildings and rattling windows.

On November 1, 1875, at 9:55 p.m., an intensity VI earthquake occurred near the South Carolina border. It was felt from Sparatansburg and Columbia, South Carolina, to Atlanta and Macon, Georgia, from Gainesville to Augusta. The earthquake was felt over an area of 2,500 square miles.

A more local event occurred on October 18, 1902, with a sharp shock felt along the east face of Rocky Face Mountain west of Dalton with intensity VI and at La Fayette with intensity V. The felt area was about 1,500 square miles and included Chattanooga, Tennessee.

The Savannah area was shaken by an intensity VI earthquake on January 23, 1903. Centering near Tybee Island, it was felt over an area of 10,000 square miles including Savannah (intensity VI), Augusta (intensity III), Charleston (intensity IV-V), and Columbia (intensity III-IV). Houses were strongly shaken. Another shock was felt on June 20, 1912, in Savannah with intensity V.

On March 5, 1916, an earthquake centered 30 miles southeast of Atlanta was felt over an area of 5,000 square miles, as far as Cherokee County, North Carolina, by several people in Raleigh, and in parts of Alabama and Tennessee.

An earthquake of intensity V or over occurred on March 12, 1964, near Haddock, less than 20 miles northeast of Macon. Intensity V was recorded at Haddock, while shaking was felt in four counties over a 400 square miles.

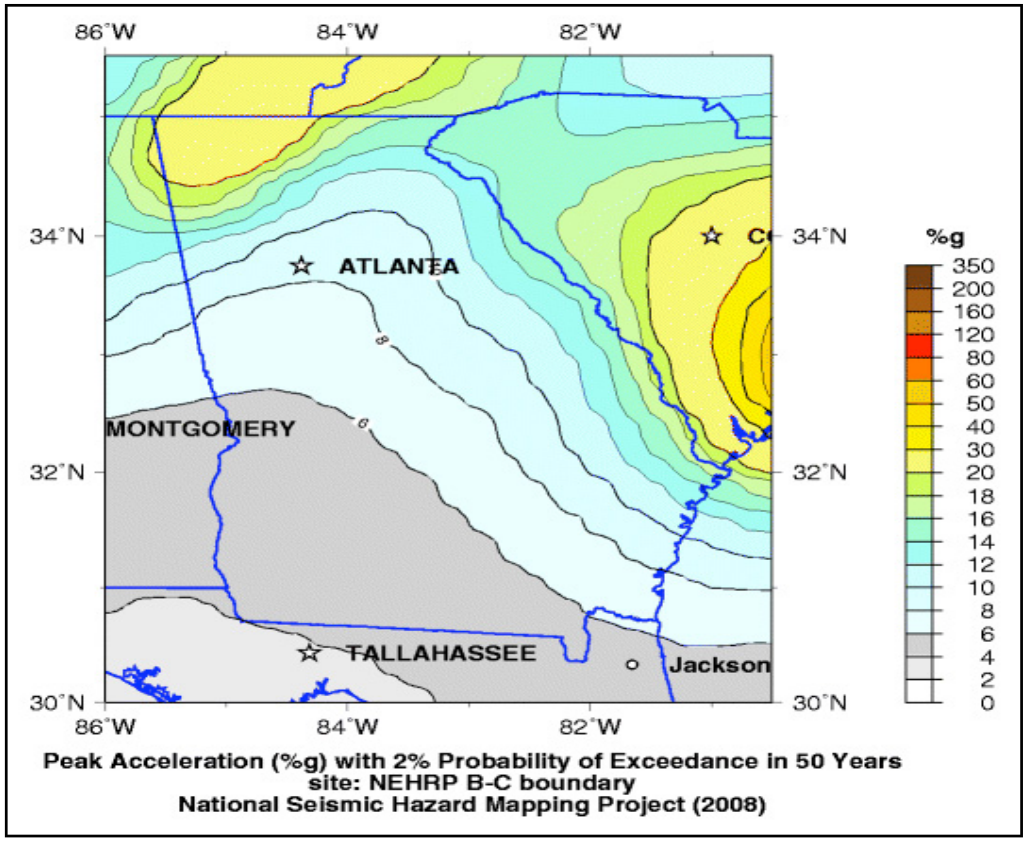


Figure 6.0: USGS estimated seismic hazards in and around Georgia. The map shows the low probability (2% in 50 years) of reaching a certain level of shaking. Only the northwestern section of the state is expected has more than a 1/50 chance of accelerations greater than 20% g (yellow region) in the next 50 years. (Source: USGS Hazard, 2010).

GEORGIA EARTHQUAKE RISK

Earthquakes are much less common in the eastern United States than in California, with most events imperceptible by the public. This leads to a dangerous complacency that may be unwarranted. Most Georgians are largely unaware of the last large event that struck Charleston, South Carolina in 1886, killing almost 60 people and causing complete devastation to the city. Unfortunately, earthquakes in the eastern United States are very efficient at transmitting seismic energy over large distances, such that the damage area of a magnitude 6.0 here is comparable to a magnitude 7.0 in the western United States.

Earthquakes may be felt in any area of Georgia, but northwestern Georgia has experienced the most earthquakes in recent history. Earthquakes large enough to cause damage could be felt in most, if not all, of Georgia's counties. Based on current and historical seismicity, three zones of somewhat distinct seismic activity are apparent in Georgia (Figure 1). The least active area extends from the Coastal Plain of South Georgia through Columbus and on past Montgomery Alabama, where almost no seismic activity is observed, besides a magnitude 3.6 earthquake that occurred near Jacksonville in 1900.

The northern half of Georgia is more seismically active, with earthquakes occurring primarily along two distinct bands. The most prominent is the Eastern Tennessee Seismic Zone. The second band is less active but extends along the Fall Line from Macon to the South Carolina border, just north of Augusta. The threat of a large earthquake from the Tennessee Valley Seismic Zone and a potential repeat of the Charleston earthquake pose the greatest risk to Georgia (Figure 7.0).

Earthquakes in Northwest Georgia occur primarily along the Eastern Tennessee Seismic Zone (ETSZ), which runs along the western Appalachian Mountains and extends from West Virginia down to the Alabama-Mississippi border. In the eastern United States, the ETSZ is second only to the New Madrid Seismic Zone in terms of seismic activity. Earthquakes here typically occur between approximately 3 km-25 km below the surface and outline a very long (200 miles or more) roughly linear active zone. These similarities between the ETSZ and the New Madrid suggest that ETSZ could sustain an event similar to the devastating 1811-1812 earthquakes. This area currently experiences about one magnitude 4.0 earthquake about every 5 to 10 years. Such an event is generally perceived as a startling vibration that may rock objects off shelves and may cause some cracking of plaster.

Earthquakes in Central and South Georgia are more scattered than in the ETSZ and do not define any convincing faults. Some large faults including the Brevard Fault that run through Atlanta, however these known faults are not considered to be active and show no ongoing microseismicity (small earthquakes). Instead, most of these events may be failing smaller faults that are buried beneath soil and can be affected by changes in reservoirs levels. Many of these earthquakes are very small but occur within 3 km of the surface making them more easily felt and heard. They often occur in an earthquake swarm, which may be felt for one to three months. In the Piedmont, they are most common in areas of weakly fractured granitic rock. The Piedmont may experience about one magnitude 4 event every 10 to 20 years, this will likely be both felt and heard, potentially with many foreshocks and aftershocks. In the immediate epicentral zone, plaster and cement block walls will be cracked, merchandise will fall off store shelves, and minor structural damage will occur in buildings not designed to withstand earthquake forces. Earthquakes in the Coastal Plain of Southern Georgia are too sparsely distributed to define a pattern but pose the second largest long-term risk to Georgians. This risk is dominated by the repeat of the 1886 Charleston earthquake. While scientists do not know the likelihood of such a repeat near or along coastal Georgia, the potential can not be entirely discounted.

Earthquakes outside Georgia's borders are a considerable threat to Georgians. The Charleston earthquake of 1886 and the New Madrid Earthquakes of 1811-1812 caused as much damage in Georgia as earthquakes that occurred within the borders. Current models for earthquake risk suggest that these distant earthquakes provide the greatest threat. In most of Georgia, the Charleston earthquake of August 1886, knocked over chimneys, broke windows and cracked plaster. The Charleston earthquake is estimated to have been between magnitude 6.6 and 7.3. This magnitude is similar in size to the "World Series," or Loma Prieta earthquake of October 18, 1989 (magnitude 6.9). A repeat of this event today would likely be far more devastating due to population growth. Such an earthquake would be felt far beyond Charleston, and possibly cause damage to unreinforced structures as far away as Atlanta. Though the precise magnitudes of the 1811-1812 New Madrid Earthquakes may never be known, many reports suggest that at least one of the four large earthquakes in the sequence was among the strongest felt intraplate earthquakes in the world. Magnitude estimated for the largest of these events is between 7.0 and 8.3, with newer estimates trending smaller. In any case, the events were devastating and caused massive changes to the landscape that are still visible today. The Mississippi River changed its course, the land surface sunk to form new lakes and violent shaking snapped off trees. At the time, the log cabin settlements were sparsely populated and the loss of life was minimal. However, if a similar event were to occur today, extensive damage would be expected throughout a large region, and, because population density is now significantly higher, the loss of life is likely to be

While these events are most likely to occur along zones of active seismicity (including the New Madrid, Eastern Tennessee and Charleston regions), it is possible that the next large event may occur outside of one of these zones. Again, residents of Georgia are fortunate that such devastating earthquakes are rare in the eastern United States. Major events like Charleston and New Madrid have occurred about once every 100 years in all of the eastern United States. The probability that such an event could cause at least some damage in Georgia within the next year is only about one in a thousand. The damage would be much like that experienced in Georgia during the 1886 Charleston earthquake if the event occurred in a neighboring state. However, near the epicenter of the large event, the damage would be like that experienced in Charleston or in the San Francisco Bay area on October 18, 1989. For such a major earthquake, the zone of extreme damage, Modified Mercalli Intensity VIII and higher, could be in excess of 100 miles in radius (See Appendix III).

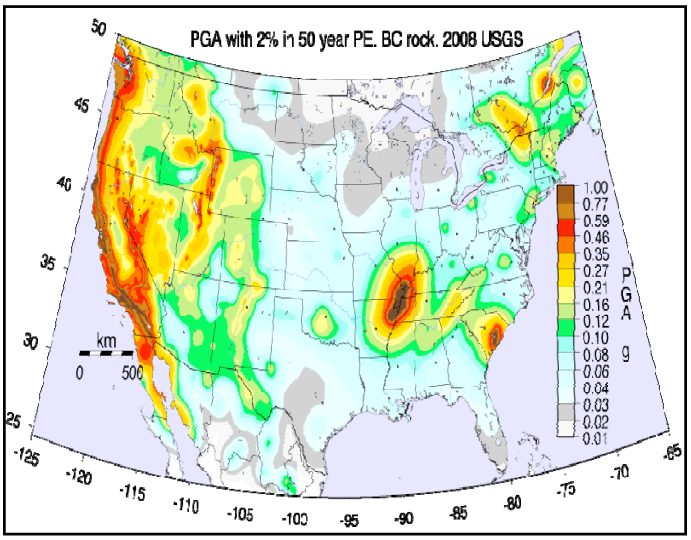


Figure 7.0: The National Seismic Hazard map defining the level of shaking that has a 2% probability of occurring in 50 years around the United States (the expected shaking an area might feel once every 2500 years).

Seismic Hazard Mapping is used to evaluate the long-term probability of risk from strong ground shaking any area may sustain. This is the only non-speculative means available to assess hazards. Hazard maps rely heavily on the historical and ongoing measurements of seismicity, though in some parts of the western United States new information about fault motions are now also being included. Because such fault motions are too small to be observed in the eastern United States, only prior earthquake information is used. In these maps, "hazard" is expressed in terms of the probability of experiencing a given level of shaking and are reported in terms of acceleration relative to the gravity, *g* (this is the same as the G-Force described during flight). earthquakes are also considered.

Seismic hazards are obviously greater in areas of higher seismic activity, but the effects of large distant earthquakes are taken into consideration. In a statistical sense, this is the level of vibration one should expect to experience once every 2,500 years. The United States Geological Survey seismic hazard maps are frequently being updated due to improved understanding of earthquake behavior and recent versions are used by the Building Seismic Safety Council to revise the seismic hazard maps used in building codes. The seismic hazard indicated by these maps is greatest in northwest Georgia if decreases in the Piedmont and is minimal in the Coastal Plain. Predicted seismic hazard is again greater toward and in South Carolina, showing the influence of the continuing activity near Charleston, South Carolina.

PLANNING FOR EARTHQUAKES

Emergency Response to Earthquakes can be divided into response efforts for those for small, moderate, strong, large and great earthquakes. In all cases, the first task is to determine the size and location of the event because these parameters will determine the extent and location of emergency services that will be needed. Unlike hurricanes and other weather-related disasters, there will be no opportunity for advanced preparation or mobilization. Following is an outline of potential impacts to communities based on estimated size variations of earthquake events.

Small earthquakes are of magnitude less than 2.5. These are typically felt only within 15 km of the epicenter and typically contained within one or two counties. These could generate calls to emergency response agencies, particularly in central Georgia where these events occur closer to the surface and are felt more strongly. If the event is part of a typical Piedmont earthquake swarm, such as in the Norris Lake Community swarm of 1993, the continuing occurrence of minor seismicity may cause alarm. Actions, such as town meetings, may be needed to explain the events to the population.

Also, the time following an earthquake or during a swarm provides a good opportunity to instruct the population in methods to minimize damage and injury during earthquakes, particularly because earthquake swarms are often followed by isolated events as large as the largest event in the swarm. Swarms are very rarely indicators of coming larger earthquakes.

Moderate earthquakes are those with magnitudes between 3 and 5. These will be noticed by almost everyone in the epicentral area and will be felt up to 200 miles away. The local 9-1-1 centers are likely to become swamped with calls, but the news media will usually be quick to distribute information on the identity and size of these earthquakes. Some weak structures may experience minor damage, such as cracked plaster and falling objects. In addition, in rare incidences, there may be some minor structural damage such as brick facade falling off buildings. Life threatening situations would be rare for these moderate events, and any associated emergencies should be easily handled as routine events.

Strong earthquakes are those with magnitudes between 5 and 6. These will be widely noticed and will cause widespread minor damage in well-built structures. A few structures will suffer major damage that could require safety inspections, but these will be rare. Again, life-threatening situations would be restricted to the immediate epicentral zone and to weak structures with poor foundation. These events will be felt up to 600 miles away. As with moderate earthquakes, the news media will distribute information. Traffic control may be needed in damaged areas. In rare cases, a bridge or road structure may be damaged. Fires are also a strong possibility following an earthquake. In the eastern United States, water heaters and furnaces are not routinely protected against falling over, which could start fires.

Large earthquakes are those with magnitude 6.5 and larger, such as the Charleston, 1886, and New Madrid, 1811-1812, earthquakes. Expect extensive damage and loss of life in a radius of 10 to 30 miles from the epicenter. Outside the epicentral zone of major damage, the effects, to 150 miles, will be like those of the large earthquakes. Safety inspections will need to be conducted because these large earthquakes may have aftershocks that cause more damage, particularly to weakened structures. Many people will be displaced from their homes, and field or tent communities will need to be established up to two months. Transportation may be interrupted by broken rail lines and

and bridges. Furthermore, clutter from buildings in the intensely damaged areas could inhibit rescue efforts. A systematic search for survivors of collapsed buildings will have to be conducted. The probability for the repeat of an event like Charleston, 1886, somewhere in the eastern United States is about 2.5 percent in the next 25 years. (one chance in 1,000 per year in Georgia). Such an event near any large metropolitan area in the southeastern United States and outside of Atlanta would likely see a rapid temporary to long-term influx of evacuees to Atlanta.

Seismic monitoring of significant earthquakes in the United States is coordinated by the United States Geological Survey (https://www.usgs.gov). This includes most earthquakes larger than magnitude 3.5 and those that are felt widely. For small local earthquakes, it is generally necessary to rely on data from a nearby regional network. In Georgia, Georgia Institute of Technology maintains a small network, including station ATL just south of Atlanta, and a distributed Educational Seismic Network (http://geophysics.eas.gatech.edu/GTEQ-see Figure 8.0). The University of Tennessee, University of North Carolina at Chapel Hill, and the University of South Carolina maintain seismic stations surrounding Georgia. In addition, the Center for Earthquake Research and Information at Memphis State University maintains a Southern Appalachian Regional Network. These networks generally record events of magnitude greater than 1.5 and routinely distribute information on these events directly to the public or over the Internet.

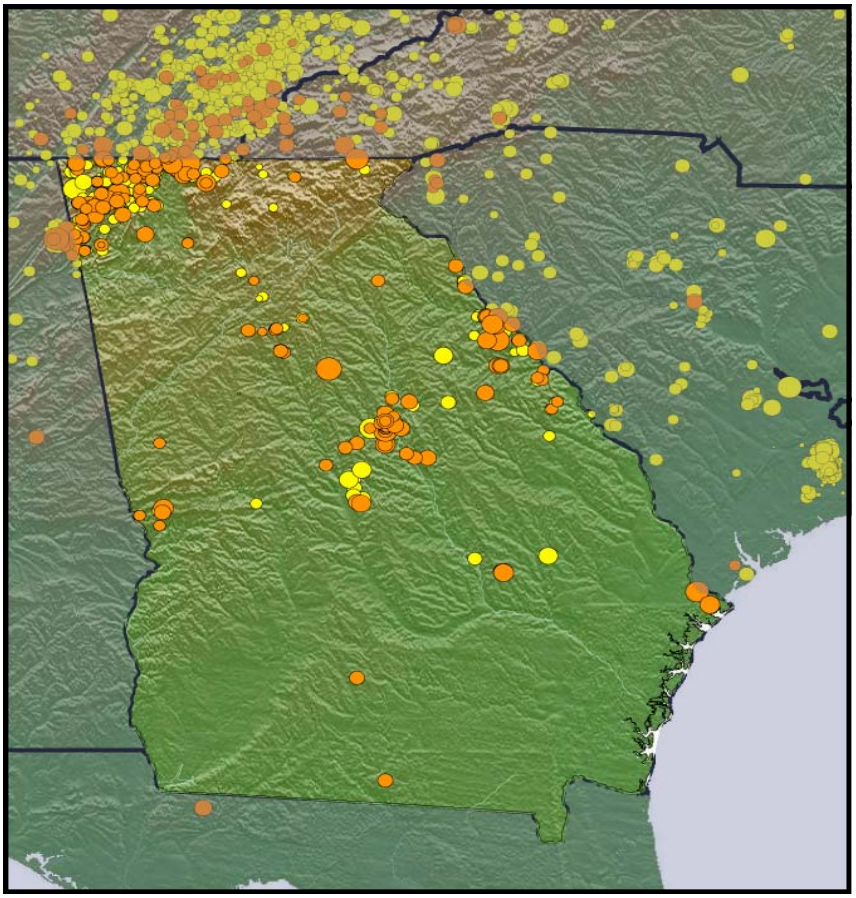


Figure 8.0: Earthquake activity in and around Georgia. Yellow events are those recorded since 1962 and reported in the global composite catalog (ANSS, 2010), Orange events are historic and locally recorded earthquakes. A continuously updated version of this map is available at: http://geophysics.eas.gatech.edu/GTEQ. Most events are between magnitude 2 and 3.

For more information on real-time seismic monitoring, please contact the Georgia Institute of Technology, School of Earth and Atmospheric Sciences-

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Additional Resources

- **Descriptive Comparisons of Earthquake Magnitude with Observed Effects**
- **Modified-Mercalli Intensity Scale of 1931**
- **Glossary of Terms**
- **Information Sources**

DESCRIPTIVE COMPARISON OF EARTHQUAKE MAGNITUDES WITH OBSERVED EFFECTS

The rate at which earthquakes have occurred in Georgia is shown in Figure 7.0. We experience a magnitude 3.0 every year or two and a magnitude 4.0 every 8 years. The best way to estimate the area of potential damage is to use the observed relation between magnitude and area of intensity VII. Modified Mercalli Intensity VII is the lowest level of shaking at which damage requiring some emergency response would be expected. The relation for the eastern United States is approximately, Log10 (AVII) = M - 2. The intensity VII area for a magnitude 4.0 is 100 square kilometer (a radius of 5.6 km or 3.5 mile) and a magnitude 6.0 is 10,000 square kilometer (a radius of 56 km or 35 mile).

MAGNITUDE:

0.0: Earthquakes that occur at shallow depths in the Piedmont are occasionally heard by people when they are within a few miles of the epicenter. Their sounds are like a distant cannon. These are usually ignored.

1.0: Earthquakes that occur at shallow depths in the Piedmont are usually heard by people when they are within a few miles of the epicenter. These and smaller earthquakes are rarely reported by people in areas of northwest Georgia where the earthquake focus is deeper.

2.0: (e.g. Norris Lake Community, Georgia, summer 1993) Earthquakes are typically described as a large quarry blast by residents in the Piedmont. Vibrations are felt near the epicenter. People in northwest Georgia occasionally report vibrations from events of this size.

3.0: (e.g. Heard County, Georgia, February 10, 1997, or the largest Norris Lake Community earthquakes) Earthquakes are maximum intensity III in northwest Georgia and V in the Piedmont. Vibrations are like a heavy truck. Their sounds and vibrations are like an explosion. Sometimes two shakes are felt, with the first a higher frequency vibration and the second following within a few seconds a rocking vibration. In the Piedmont, they sound like a cannon. The vibration decays with time.

4.0: Earthquakes (e.g. Clarks Hill Reservoir, Georgia, August 2, 1974) have maximum intensities in the VI to VII range. These events are just large enough to cause some minor damage in the epicenter area and groceries may off shelves. Felt over many counties, typically out to a distance of 100 miles.

5.0: Earthquakes (e.g. Sharpsburg, Kentucky, July 27, 1980) are noted for widespread damage. The Sharpsburg earthquake was particularly noted for damage to chimneys. Intensity VI and higher within a radius of 30 miles. Felt over many states, a radius of over 300 miles.

6.0: Earthquakes (e.g. Massena, New York, September 5, 1944) are characterized by intensity VIII and higher near the epicenter. The Massena earthquake was felt from Canada south to Maryland and from Maine west to Indiana. It caused property damage estimated at $2 million. Many chimneys required rebuilding, and several structures were unsafe for occupancy until repaired. Residents of St. Lawrence County reported that many water wells went dry. At Massena, 90 percent of the chimneys were destroyed or damaged and house foundations, plumbing, and masonry were damaged severely. Cracks formed in the ground and brick-masonry and concrete structures were damaged.

7.0: Earthquakes (Charleston, South Carolina, August 2, 1886) generate intensities of IX and above. Effects in the epicentral region include more than 1,300 square kilometers of extensive cratering and fissuring. Damage to railroad tracks, about 6 kilometers northwest of Charleston, included lateral and vertical displacements, formation of S-shaped curves and longitudinal movement. Strong alarming vibrations are felt. Many building will sustain damage, a few will fall or be rendered useless. Some lives will be lost in collapsed buildings or in fires following the earthquake. Communications and transportation will be interrupted significantly.

MODIFIED-MERCALLI INTENSITY SCALE	
Intensity	**What to Expect**
I.	Not felt except by a very few under especially favorable circumstances.
II.	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing
III.	Felt quite noticeably indoors, especially on upper floors of buildings, but most people do not recognize it as an earthquake. Standing motorcars rock slightly. Vibration like passing truck. Duration estimated.
IV.	During the day, felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, and doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.
V.	Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
VI.	Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
VII.	Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving motorcars.
VIII.	Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed.
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
XI.	Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
XII.	Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

GLOSSARY OF TERMS

Acceleration: Rate of change in velocity with time. In earthquake ground shaking, acceleration is measured relative to the acceleration of gravity (g).

Active Fault or Active Seismic Zone: A fault that has exhibited movement in recent time and that is expected to move in the future. The movement may be indicated by earthquakes in a seismic zone or by displacements within the last 10,000 years of young soil or other deposits along a fault trace.

Aftershocks: Smaller earthquakes following a large event and occurring in the same fault zone. Generally, aftershocks decrease in magnitude and frequency-of-occurrence with time.

Aseismic Region: A region lacking earthquakes and also assumed to lack a potential for future earthquakes.

Capable Fault: A fault that is considered active for seismic hazard computations.

Creep: Slow slip along a fault without producing earthquakes.

Crust of the Earth: The top 30 km of the Earth that is brittle and the area of occurrence of most earthquakes. Mid-crustal depths represent the strongest part of the Earth's crust and are at depths of 10km to 20 km.

Duration: The duration of strong shaking is the time interval between the first and last peaks of strong (usually felt) ground motion.

Eastern United States: All states in the continental United States east of the Rocky Mountain Front, approximately Longitude 105° west.

Earthquake: The sudden release of stress along a fault and the resulting vibrations of the earth. The vibrations propagate away from the epicenter.

Earthquake Prediction: An earthquake prediction is a qualified determination of the magnitude, location, and time of a future earthquake. Such qualifications must be beyond the expectations from ongoing background activity. Predictions can be broken down into short-term (hours to days), intermediate-term (weeks to months), or long-term forecasts (years to decades).

Earthquake Swarm: An earthquake swarm is a prolonged series of small events. In a swarm, earthquake activity usually increases until the largest event occurs.

Epicenter: The location on the earth's surface directly above the focus (or hypocenter) for an earthquake.

GLOSSARY OF TERMS

Fault: (or Fault Zone) a zone of weakness or fractures in the earth along which the two sides have been displaced relative to each other parallel to the fracture. The total fault offset may range from centimeters to kilometers.
Focal Depth: The depth below the surface of the hypocenter, the point where an earthquake initiates movement.
Focal Plane: The area of movement on a fault during an earthquake. The Focus may be any place on the focal plane.
Focus: (or hypocenter) The place at which rock failure commences in an earthquake.
Foreshocks: Smaller earthquakes preceding a large event and occurring in the same fault zone.
Hazard Map: A map showing locations of areas where a defined level of vibration is expected to be felt in a given time period. For example, areas where an acceleration of 0.1 g or greater would be expected once every 450 years.
Hypocenter: see Focus.
Intraplate Earthquake: Earthquake that occurs in the interior of recognized tectonic plates, often not associated with major active fault zones. All eastern United States earthquakes are intraplate earthquakes.
Intensity: A measure of ground shaking obtained from the damage done to structures built by man, changes in the earth's surface and felt reports. The Modified Mercalli Intensity Scale measures intensity in Roman numeral units from I (felt slightly) to XII (total damage).
Isoseismal: Lines that surround zones in which an earthquake generated a given intensity.
Magnitude: Earthquake magnitude is an instrumental determination of the relative size of an earthquake. The Richter Magnitude was the first commonly used measure of earthquake size. All subsequent magnitude scales are tied to the Richter magnitude scale. Magnitudes released in news reports are often referred to as Richter Magnitude, although that term can only be applied strictly to southern California earthquakes.
Microseism: Weak, almost continuous seismic waves or earth noise; often caused by surf, ocean waves, wind, or industrial activity.
New Madrid Seismic Zone: An area of continuing seismic activity along the Mississippi River in Tennessee and Missouri. Also, the location of the epicenters of the four largest New Madrid earthquakes of 1811-1812.

GLOSSARY OF TERMS

P-wave: The primary or fastest wave traveling away from a seismic event through the earth and consisting of a train of compressions and dilatations of the material.

Plate Tectonics: The Earth's crust consists of many rigid plates, such as the North American Plate. Plate Tectonics is the description of plate movement and interaction that explains earthquakes, volcanoes, and mountain building as consequences of horizontal surface motions of rigid portions of the Earth's crust.

San Andrea fault zone: A zone of movement between the North American Plate and the Pacific Plate, extending through southern California.

S wave: The secondary, or shear, seismic wave, traveling more slowly than the P wave, and consisting of elastic vibrations that are transverse to the direction of travel. It cannot travel in a fluid.

Surface Waves: Seismic waves that are confined to the earth's surface. Surface wave velocities are less than S-wave velocities.

Seismicity: Generally, the occurrence of earthquakes in space and time. Usually given as the number of earthquakes of a given magnitude in a specified time, such as the number of zero magnitude events per year.

Seismogram: The record of an earthquake written by a seismograph.

Seismograph: An instrument for recording the motions of the Earth's surface.

Seismologist: Scientist trained in interpreting ground motion from earthquakes and in using the waves from explosions to determine the structure of the Earth. Seismologists are found in major universities and in the oil industry.

Seismology: The study of earthquakes, seismic sources, and wave propagation through the Earth.

Seismometer: The sensor part of the seismograph.

Tectonic Earthquakes: Earthquakes resulting from sudden release of energy stored by deformation of the Earth's tectonic plates.

INFORMATION SOURCES

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USGS Hazard (2010). USGS National Seismic Hazards Mapping Project, Earthquake Hazard Program, http://earthquake.usgs.gov/hazards/ (last visited 13 Sept 2010).

Web Resources

National Earthquake Hazard Reduction Program
http://www.fema.gov/plan/prevent/earthquake/nehrp.shtm

The Great Central US Shake-Out
http://www.shakeoout.org/centralus/

Disaster Assistance Website
www.disasterassistance.gov

Ready Georgia
www.ready.ga.gov

Federal Emergency Management Agency
www.fema.gov

United States Geological Survey
www.earthquake.usgs.gov/prepare/

Prepare Now
www.preparenow.org

Seven Steps on the Road to Earthquake Safety
http://www.earthquakecountry.info/roots/steps.html