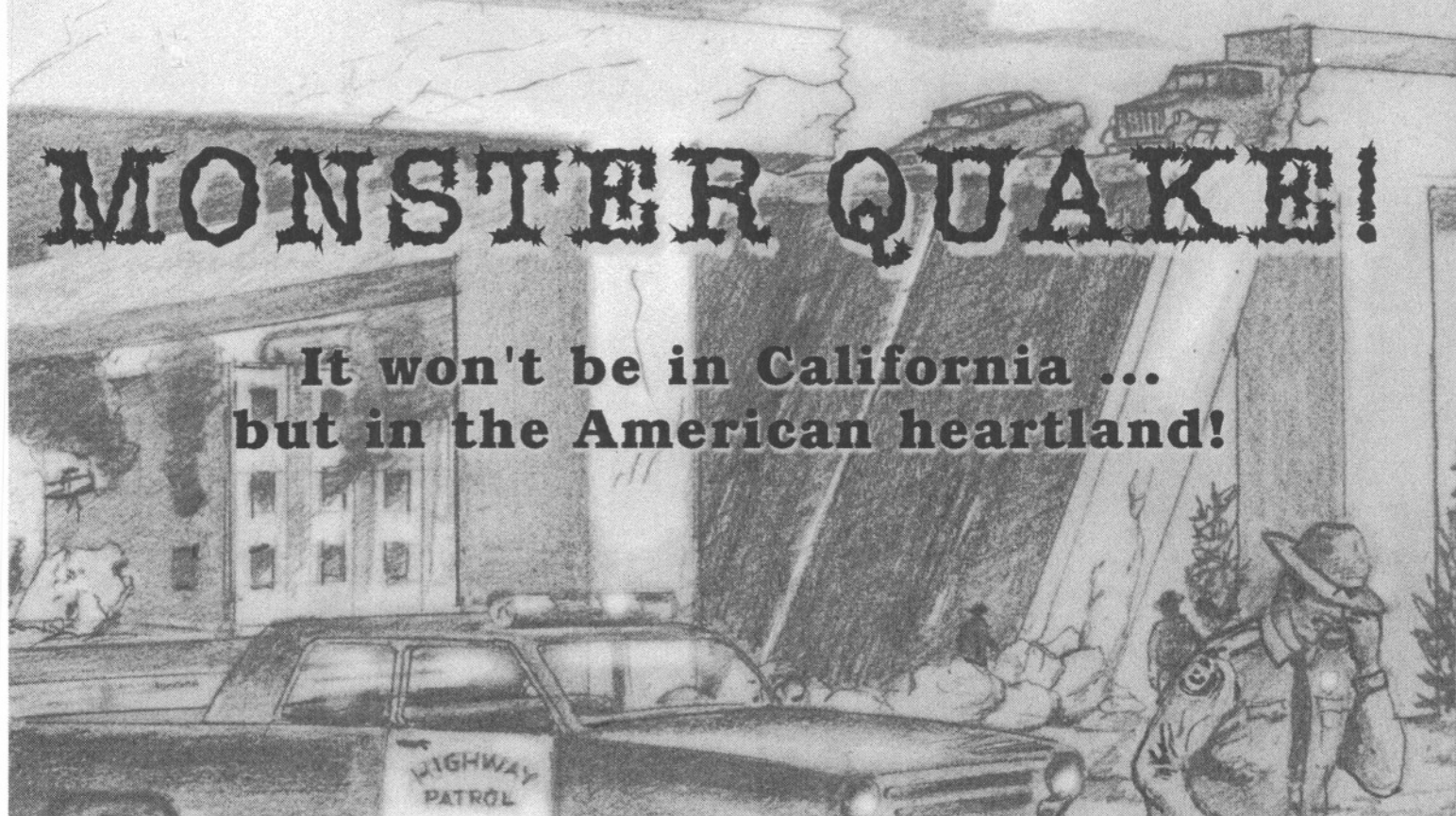


MONSTER QUAKE!

**It won't be in California ...
but in the American heartland!**



By John Silveira

Where's the scariest place to be in the lower 48 states if you're concerned about a massive earthquake that could snuff out you and everything around you in a few moments of violent shaking? Hint: It's not California!

It's in what is called the New Madrid seismic zone (NMSZ), which is in the central United States. Never heard of it? Most people haven't. The NMSZ is right in the heart of America. It weaves its way through five states: Arkansas, Tennessee, Missouri, Kentucky, and Illinois. It crosses under the Mississippi River in at least three places and beneath the Ohio River in two.

Though largely unknown to most of the world, every once in a while it stirs and reminds people it's there. Otherwise, we rarely think about it. The last earthquake of significance to take place in the NMSZ, an estimated 6.8 on the Richter scale, occurred in 1895 and is known as the Charleston, Missouri, earthquake.

But according to the United States Geological Survey (USGS), in the winter of 1811-12 at least three of the four biggest recorded earthquakes to take place in the lower 48 took place there, dead in the American heartland.

No one knows exactly how big those quakes were. Despite all the science and technology available to us, it's difficult for two seismic stations to get the same measurements on an earthquake if it happens *today*, never mind trying to estimate how large earthquakes were that took place decades before there was any meaningful way to measure them. A century after San Francisco's 1906 earthquake, there's still no consensus as to how big that one was because it, too, occurred before the first modern seismographs were built. Most estimates put it at around 7.8 while others say it *may* have been as large as an 8.25.

But many seismologists are sure that three and perhaps as many as five 8.0 or bigger earthquakes took place in the NMSZ during the winter of 1811-12. And they took place in just

over seven weeks. Jared Brooks, who lived in Louisville, Kentucky, when the quakes occurred, recorded that from December 16, 1811 to March 15, 1812, he counted 1,874 shocks, eight of which were violent, 10 very severe, and 35 that were moderate. There were other reports that at least 18 of the quakes, which on the modern Richter scale would doubtlessly be classed as 6.0s or greater, were felt all the way to the Atlantic Coast, some 600 miles away.

Most of these quakes took place in a span of less than 90 days. This many earthquakes, of such severity, over so short an interval of time, have not occurred at any other time in recorded history.

Though named for a Missouri town, the actual epicenters of the quakes were in northwestern Arkansas, very near the Missouri border. But since, in that day, the closest white settlement of note, and the largest between St. Louis and Natchez, was New Madrid, the New Madrid name was pinned on them and the whole area has become known as the New Madrid seismic zone.

To understand the danger the NMSZ poses today, you should know what happened during the earthquakes that took place there from December 1811 to March of 1812, because one of the best predictors of future quakes in any area are the past quakes that occurred there.

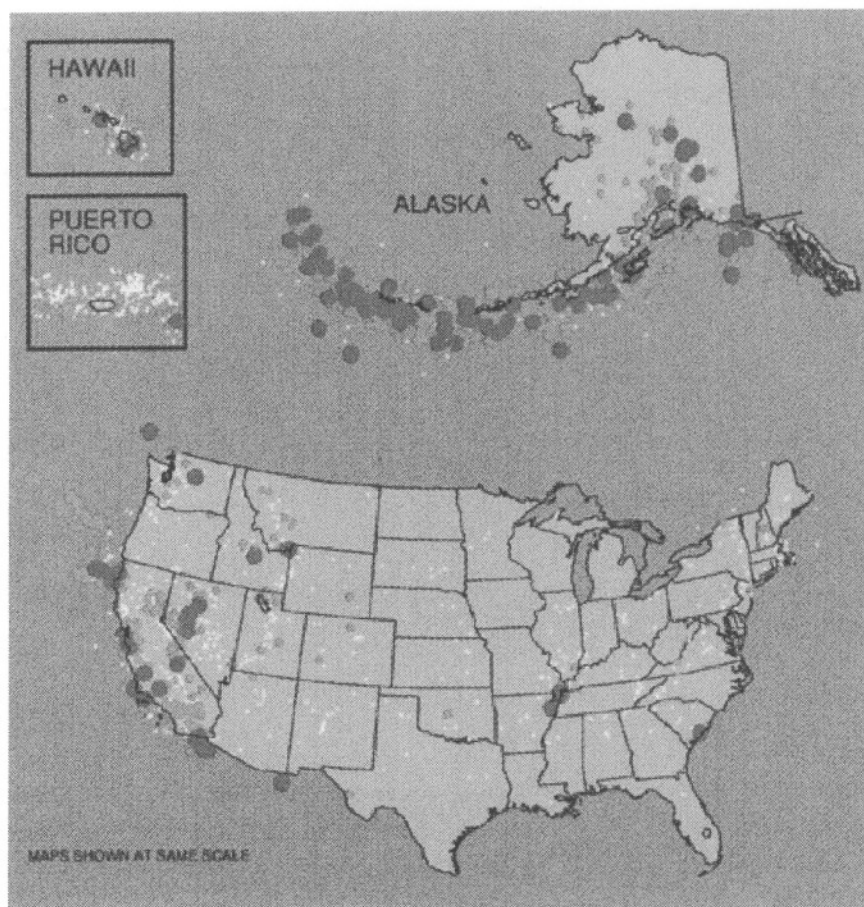
Quakes that rocked a continent

Two centuries ago there were only 20,000 to 30,000 people living in the quarter million square miles most severely affected by the quakes. If you need an appreciation of how large an area that is, it's about equal in size to the state of Texas today. However, the total area over which damage occurred was about one million square miles, roughly one third of today's lower 48 states, and the area over which the quakes were felt was twice that, or about two thirds of those states.

The first of the quakes came without warning just after 2 a.m. on December 16, 1811. People in New Madrid were roused from their beds. Initially, they couldn't even stand up. When they could, many ran from their houses.

Over an area of roughly 50,000 square miles (about equivalent to the size of the state of Alabama) the earth was uplifted in some places and sank in others. Seiches, which are like tsunamis, but on an inland body of water, rose from the Mississippi sinking boats before they raced inland. At many points the banks of the river collapsed. Parts of the river itself flowed backwards for several hours as the topography of the land beneath it was lifted as much as 25 feet in

Each year anywhere from 6 to 24 earthquakes of magnitude 7.0 or greater take place somewhere in the world, with an average of about 18. One of those is likely to be of magnitude 8.0 or greater.



Earthquakes are a widespread hazard in the United States. Map shows magnitudes of historical earthquakes: dark, 5.5 to 7 or greater; light, 4.5 to 5.5. The U.S. Geological Survey operates instruments in many structures in the seismically active areas shown. These instruments measure how structures respond to earthquake shaking. (Photo courtesy USGS, <http://quake.wr.usgs.gov/prepare/factsheets/SaferStructures/USEarthquakes.gif>)

some places and sank by the same amount in others. Whole islands vanished and new ones were born. Even the river's course was permanently changed.

In other places, ponds and lakes disappeared, while a whole new 15,000-acre lake, 10 miles long and 3 miles wide, now called Reelfoot Lake, formed in Tennessee where there had been no lake before. In eastern Arkansas, Lake St. Francis, some 40 miles long and a half mile wide, was one of the many new lakes created.

The ground sank under the town of Big Prairie, in what is now the state of Arkansas, and a lake appeared in

its place. Fifty miles to the north, people in the town of Little Prairie, Missouri, ran from their houses, then watched as embers from damaged fireplaces and overturned stoves caught their homes on fire and burned most of the town to the ground.

The quakes continued off and on for hours, including one at dawn that was more fierce than the initial shock. Then, at around 11 a.m., an even bigger one hit.

For the next five weeks, there were one or more quakes a day. Over thousands of square miles eyewitnesses reported that during the largest of the quakes giant fissures opened and

An Eyewitness report

From the March 21, 1812 edition of the *Louisiana Gazette* (which was in St. Louis but was named for the Louisiana Territory which this section of the country was then called):

We are informed from a respectable source that the old road to the post of Arkansas, by Spring river, is entirely destroyed by the last violent shocks of earthquake. Chasms of great depth and considerable length cross the country in various directions, some swamps have become dry, others deep lakes, and in some places hills have disappeared.

closed, sometimes spewing out water, sometimes sand, gas, or mud, and some even belched out carbonized wood before they abruptly closed up again. Some of the fissures were hundreds of feet long, 50 feet wide, and 25 feet deep. At least one was five miles long. Witnesses also reported that during the largest quakes they could actually see the ground roll in visible waves like water on the ocean.

In many places the alluvial soil, deposited over the centuries by the Mississippi, liquefied under the shaking and objects sunk into the earth like they were sitting on quicksand. Along the riverbanks entire settlements vanished into the water as the ground below them sank.

One eyewitness reported his wagon simply sank up to its axles on a dirt road that became unstable.

If widespread liquefaction were to take place in that area today, the ground in many places will behave like quicksand. Some buildings will slide off their foundations while others will simply topple over. For thousands of other buildings, sinking even a few feet will result in damage that may be best corrected by demolition.

Hundreds of square miles of forest were either toppled by the quakes or ruined because the soil was shaken from the roots of the trees. And land near the epicenter was so broken up that farming was impossible there for years.

Four hundred miles away, the quakes shook down chimneys in Cincinnati, and dislodged chimney

bricks in Georgia and South Carolina. Seven hundred miles away, people in Washington, DC, were scared from their beds and ran into the streets. The quakes were felt strongly in Pennsylvania and they buckled sidewalks in Baltimore. And 1100 miles away they rang church bells in Boston.

At least three of the quakes were felt as far north as Canada and as far south as Mexico and Cuba, and east and west from the Atlantic seaboard to the Rocky Mountains.

World coming to an end

A little over five weeks later, on January 23, 1812, another huge one hit that was at least as big as those of December 16 and shook the continent again. The cycle of smaller daily quakes continued until another, an 8.0 monster, struck once more on February 7.

Lesser quakes, usually once a week but sometimes three or four times a day, continued over the next few years including two good jolts in the winter of 1815-16.

Though it ranks as one of the greatest earthquakes in history, there wasn't much property damage because there were so few people in that area in those days. There were deaths from the sinking of boats and landslides along the Mississippi River, but there was only one reported death in New Madrid itself.

Almost all the buildings there were log cabins, a type of architecture peculiarly suited to withstanding earthquakes. But the cabins did not stand for long. Damaged by the almost incessant quakes that seemed to follow, one after another, day after day, from the initial quake on December 16, through the rest of December, then through January and into early February, most of the cabins still standing collapsed. The last big one hit on February 7, but frequent aftershocks continued through mid-March, and sporadic aftershocks continued for another two years.

To those who lived through them, it seemed like the world was coming to an end. It's only because New Madrid was at the edge of the western frontier, and all of the states and territories that now make up America's Midwest were so thinly settled, that

An Eyewitness report

From the February 14, 1812 edition of the *Pittsburgh Gazette* this excerpt from an account by a Mr. James Fletcher, and dated January 21, was recorded. He provided eyewitness accounts of his own and others who saw fissures 8 to 10 feet wide and fountains of water that burst 12 feet into the air, the stench of sulphur filling the air, and small rivers and lakes that disappeared. The entire topography was changed, impeding travel. He wrote:

A gentleman attempting to pass from Cape Girardeau to the pass of St. Francis, found the earth so much cracked and broke, that it was impossible to get along. The course must be about 50 miles back of the Little Prairie. Others have experienced the same difficulty in getting along, and at times had to go miles out of their way to shun those chasms.

the quakes did not become a national disaster. If they happened again today, they would constitute the greatest disaster the United States has ever suffered. Greater than any of the great hurricanes, the great floods and fires, or any of the previous earthquakes. If it happened at the worst of times, when the Mississippi is at flood stage, it could be more destructive than *all* of the previous natural disasters combined. And here's the scary part: seismologists expect another monster there. They just don't know when it, or they, will happen.

A midwest quake today?

Today there are more than 11 million people living in the same quarter-million-square-mile area that suffered most severely during the quakes of 1811-12. They live in cities like Little Rock, St. Louis, Memphis, Nashville, Indianapolis, and Frankfort—all within the destructive range of a major NMSZ earthquake. And they also live in numerous smaller cities and towns, including many along the banks of the Mississippi. But in spite of the potential for calamity greater than the predicted consequences of an earthquake in California, the Midwest is unprepared for a major earthquake. Compared to California, the buildings are substandard.

According to the USGS, more earthquakes occur in the NMSZ than

Energy release and the Richter Scale

An increase of 1.0 on the Richter scale, e.g., from 5.0 to 6.0 or from 5.2 to 6.2 represents an increase in magnitude of 10. But the amount of energy released is actually about 31.6 times greater.

On that basis, going from 5.0 to 7.0 represents about 1,000 times more energy released and an increase of two-tenths on the scale, such as from 5.2 to 5.4 represents a doubling in the amount of energy released.

What causes earthquakes?

Earthquakes were once thought to be the wrath of God, and Aristotle thought they were caused by winds beneath the earth's surface.

As late as the 19th century they were believed to be caused by volcanos—and sometimes they are. But today we know most earthquakes are caused because of the movement of the tectonic plates that float on the plastic layer of near-molten rock below the earth's surface.

Imagine the surface of the earth being like a soft boiled egg whose shell is rife with cracks. Some of the pieces of the shell are big while others are small. But unlike an egg, where the pieces stick to the egg, the earth's shell—the tectonic plates—floats on top of nearly molten rock deep inside the earth. In some places, the pieces float past each other like barges floating on a river, but in other places they crash head-on, with one trying to go under the other.

Earthquakes occur because all the plates, whether they're moving hori-

zontally against each other or trying to move over and under each other, tend to "stick" along their edges. Meanwhile, the motion of the nearly molten rock beneath tries to keep them moving. When they're not moving the forces that are trying to propel them along start to accumulate. Eventually, those forces get so strong that something has to give, and the fault literally breaks, and when that energy is released, that's your earthquake. This is why some 90 percent of earthquakes take place at the edges of the plates.

However, earthquakes in the NMSZ occur in the middle of a plate, not at its edge. It's thought that these quakes are the result of faults created half a billion years ago when movements of the earth's crust tried to tear the North American plate apart. Now, new motions in the crust are compressing those ancient faults and creating the earthquakes we experience today.

any other part of the United States east of the Rockies. Here are USGS estimates of seismic activity in the zone:

A quake of **4.0 or greater** occurs about every 18 months. These are usually felt but rarely cause much damage.

A quake of **5.0 or greater** occurs roughly once every 10 years. The larger of these can do considerable damage and are felt over several states.

A quake of **6.0 or greater** occurs about every 80 years. One of these will cause serious damage to masonry buildings and other buildings from St. Louis to Memphis. Estimates are that there is a 25 to 50 percent chance of one happening in the Mississippi Valley in the next 50 years. However, there are scientists who believe a quake this size is overdue and that the

chances of a 6.0 or greater quake in the next 50 years exceeds 90 percent.

A quake of **7.5 or greater** occurs every 200 to 300 years, with the last one happening almost 200 years ago. There's as much as a 25 percent chance one will occur there in the next 40 years. It was a quake of this magnitude that leveled much of San Francisco in 1906.

If a quake of 7.5 or greater occurs in the NMSZ today it will be felt over one half to two thirds of the lower 48 states and cause damage in 20 states. In quakes of this magnitude, ground acceleration will be so great you won't even be able to stand on your feet until it's over. The damage will be extensive.

What will the death rate and damage rates be during such a large earthquake today? It depends on how close the epicenter is, but one study con-



Saturated soils are soils in which the space between individual particles is completely filled with water. Much of the soil in the Mississippi Valley is saturated. Normally, such soil can support the weight of buildings, bridges, roads, dams, hillsides, etc., that rest on it. However, intense shaking from an earthquake can cause the water pressure in the soil to increase until the soil particles can move readily with respect to each other. This is called "liquefaction" and, when it occurs, the ability of the soil to support anything resting on it decreases. Buildings and bridges begin to sink into the ground or they can slide and even topple. In the photo are apartment buildings in Niigata, Japan, that toppled as the result of liquefaction of the soil beneath them during a magnitude-7.5 earthquake in 1964. Remarkably, only 28 people died. Liquefaction can also cause soil around dams to give way leading to dam collapses and flooding. It can destroy roads and airports.

(Photo courtesy National Geophysical Data Center.)

cerning a major earthquake near St. Louis put the estimated number of dead as high as 4,300, with at least another 65,000 injured. More than 179,000 homes will be destroyed, one million households left without water service, and 500 highway and railroad bridges destroyed.

A quake of **8.0 or greater**, which is the size of the largest of the earthquakes of 1811-12, occurs on the average about every 400 to 1100 years. When they happen again, we can expect repeats of the phenomena that accompanied the quakes of two centuries ago. That is, fissures opening and closing in the ground, liquefaction of the soil, sinking of vast areas of ground in some places that will result in flooding, and huge areas

rising at other places. Expect seiches on the river that will look and act like tsunamis.

There is evidence in the geologic record that there have been earthquakes of this magnitude in the NMSZ many times in the past. Seismologists currently feel there's a 7-10 percent chance of an earthquake this large happening in any given 50-year period.

Even more bad news

Additionally, earthquakes in the center of the country have an inherently greater range over which they create damage. A quake in the NMSZ will wreak its havoc over 20 times the area of a typical California quake. The reason for this is in the underly-

ing geology of the two areas. The shock waves beneath California are more readily absorbed by the earth while those in the Midwestern states will travel further without losing energy. (See map on the next page.)

If a big one (7.5 or greater) does hit the NMSZ, there will be enormous damage and chaos. For example:

- Impassable roads, destroyed railway beds, river bridges gone, highway overpasses fallen
- Gas stations closed with no deliveries for awhile
- Airports closed with damaged runways
- River traffic halted with piers on the Mississippi and possibly the Ohio River destroyed
- Fires from gas and oil pipeline leaks
- Fires everywhere with emergency services taxed to the breaking point
- Water service and electricity interrupted, especially in the cities
- Most stores closed or unable to restock their shelves
- Medical services stretched beyond the breaking point
- Hundreds or thousands killed, and tens or hundreds of thousands homeless
- Looting, much of it by people just trying to stay alive
- Lastly, no homeowners insurance to pick up the tab for damages when it's over. **Most homeowners**

The first seismograph, the device used to measure earthquakes, was built in Japan in the 1880s — by three Englishmen who worked at the Imperial College in Tokyo.

er's policies do not cover earthquake damage. If you want coverage, you'll have to have it added on now.

If the quakes match the intensity of the 1811-12 events, and they come one after another, day after day, for several months, the problems listed above will be multiplied. If an epic quake or series of quakes hits when the Mississippi is at flood stage, levees all along the river might be destroyed. In this case the flooding will be catastrophic and as much as a quarter of Arkansas could be under water. If this happens, some predict the loss of life could go over 100,000. The economic damage will be unimaginable.

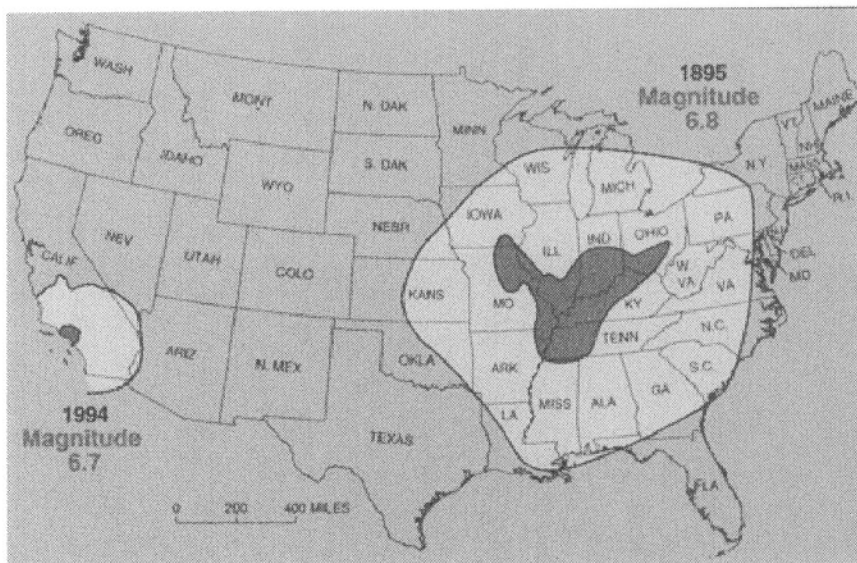
Government help?

The Federal Emergency Management Agency (FEMA) had been perceived as the first line of defense in the event of a disaster. But that agency couldn't properly respond to Hurricane Katrina even though it had days of advanced warning. Try to imagine how it will respond when there is no warning and the devastation and loss of life may be 10 to 100 times worse.

Today, to its credit, FEMA has announced that it has *no* assets. That is, it's without evacuation vehicles, emergency supplies, or medical help. What FEMA is is a coordinating agency. What this means to you is that for all practical purposes *all* practical help will be local and the first line of defense will be *you*.

And don't expect the government to pick up the tab when it's over. After any major disaster, there may be federal loans available, but that's all they'll be, loans. There may be some grant money, but it will be only to meet your basic needs, not to replace your belongings. You're better off looking into insurance coverage.

However, it's hoped that research, an increase in the public's awareness of the dangers the NMSZ poses, and



The map shows the contrast in how far ranging earthquakes are in the New Madrid seismic zone as compared to similar quakes on the West Coast. The Charleston, Missouri, quake of 1895 was similar in intensity to the Northridge, California quake of 1994, but the extent over which each of the earthquakes caused damage (dark) and over which each was felt (light) is vastly different. While the Northridge quake was felt in Nevada, Arizona, and parts of Mexico, the Charleston quake was felt over 23 states and parts of Canada. The area of damage in the New Madrid seismic zone will typically be 20 times greater than that of California because of the differences in the geology of the earth beneath the two areas. The 1811-12 New Madrid earthquakes were of even greater intensity than the 1895 quake and were felt over the entire United States east of the Rockies and well up into Canada. (Map from <http://quake.wr.usgs.gov/prepare/factsheets/NewMadrid/>)

better emergency preparedness can substantially decrease the losses expected to accompany a major earthquake in the central states.

To this end, in 1983 the Central United States Earthquake Consortium (CUSEC) was formed by the states of Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, and Tennessee. The purpose of CUSEC is to deal with earthquake preparedness and foster study of the New Madrid seismic zone.

Their site is one of the best places to begin earthquake preparation even if you live in other earthquake-prone zones. It is one of the best earthquake preparation sites on the Web. If you don't have access to the Internet, go to your local library and check their site out.

Will there be a warning?

Given the current state of seismology, it's highly unlikely we'll know when the next big one is going to hit. Unlike Hurricanes Katrina and Rita, there will be no anticipatory evacuation. Everyone will be caught with their pants down. And once it hits most traffic into and out of the most devastated areas will stop for days or even weeks. What supplies are available when the quake strikes will dwindle fast. Those who make no preparations will covet your cup-

How close you are to the epicenter of an earthquake will determine how you feel it. If it's a rolling motion, you're probably quite far away from it. If you feel it as a jolt—well, you're there.

Earthquakes and Alaska

It's easy, when we think of earthquakes, to think "California." To many California is the earthquake center of the world, though, in reality, it's not even the earthquake center of the United States. That dubious distinction belongs to Alaska.

According to the United States Geological Survey (USGS), Alaska experiences more earthquakes each year than *all* the other 49 states combined. It averages an earthquake of magnitude 7.0 or greater just about once a year. California, on the other hand, experiences a 7.0 or greater earthquake about every 12 years or so (though there were four of them in the '90s).

Alaska also experiences bigger earthquakes. Some of the biggest in the world take place there. There were eight of magnitude 8.0 or greater, in Alaska, between 1899 and 1969. In that same time, there were *none* in any of the other 49 states (with the possible exception of the 1906 San Francisco earthquake which may or may not have been an 8.0+; it depends on who's doing the estimating). But Alaska is so large and so scarcely populated that, other than being detected by seismographs, four of those 8.0-or-greater monsters went largely unnoticed by the rest of the world.

Also, during the 20th century, three of Alaska's earthquakes were among the eight largest to take place *anywhere* in the world.

So, if you live in America and earthquakes scare you, neither Alaska nor California are where you want to live. Florida and North Dakota, on the other hand, have the fewest. But you'll never entirely get away from earthquakes no matter where you go.

boards, your fuel, and your Honda generator.

If you'll recall the bridge connecting Gretna, Louisiana, to New Orleans, where authorities would not allow refugees to cross, expect a lot more of that because there will be a lot more refugees. They will not be just the urban poor as were the majority with Hurricane Katrina. They'll also be people who currently have respectable standards of living: the dentist living down the street, the office manager next door, and the cop across the alley who will not be prepared, or who will lose everything when the quaking, fires, and flooding start.

What to do when the shaking starts

When an earthquake starts, if you're indoors, stay indoors. If you're outside, stay outside. Many people are injured or killed by falling debris—chimney, gutters, broken glass, walls, etc.—just outside of buildings.

If you're indoors, take cover underneath something sturdy like a desk. Stay away from windows, mirrors, and furniture that might fall over such as overloaded bookshelves, dressers, entertainment centers, etc.

If you're outside, stay away from walls, chimneys, power lines, and trees with dangerously heavy dead limbs. Wherever you are, protect your head.

If you are driving, pull over to the side of the road, stop, and set the parking brake. Do not stop on or under an overpass or bridge. Avoid power lines, signs, trees, and other things that might collapse or fall onto your vehicle. Stay inside until the shaking is over. If a power line falls on your vehicle, stay inside until a trained person removes the hazard.

A survival kit

You should have a survival kit for all kinds of emergencies. (*BHM* has run several excellent articles on this

After an earthquake

Wear shoes at all times.

First thing to do is check for injuries and account for everyone you possibly can. Provide first aid when necessary.

Turn off the gas. Check for gas leaks.

Check for electrical shorts in your house.

Check for downed power lines. Mark and avoid them, particularly those outside. Even dead lines can be a hazard if, for some reason, power comes back on. Turn the electricity off.

Look for plumbing, including sewage breaks.

Inspect building damage and potential problems that can occur when there are aftershocks.

Clean up dangerous spills. This is particularly important if you are storing heating oil.

Turn on your radio and listen for instructions.

Beware of aftershocks. Structure, already weakened by the first quake, will become major hazards. And aftershocks can even exceed the power of the first shocks.

in past issues, and our *Emergency Preparedness and Survival Guide* has detailed instructions for kits.) Make sure any survival kit is accessible. After an earthquake, things are going to be a mess. Your kit(s) should be stored in easy to find locations. You should also know the following:

- Learn your building's dangerous areas: near windows, near shelves, near bookcases, etc. Never place heavy objects such as large pictures, TVs, etc., over beds, and you should try to keep any heavy objects, including large planters, lower than the head height of the shortest family members.

- Learn the main utility shutoffs.

- Learn your building's safe areas: inside corner of building, under sturdy furniture, in supported doorways.

- Heavy objects such as bookcases, entertainment centers, large dressers, mirrors, cabinets, filing cabinets, etc., should be anchored to the walls. Strap your water heater to wall studs.

- As with any emergency planning, have family emergency procedures, including plans for reuniting your family.

- Post emergency telephone numbers such as doctors, hospitals, 911, etc. and make sure family members are aware of where these numbers are kept.

- Personal protection? (See sidebar on survival kits). Experience with Katrina was that there was looting. The further you got away from metropolitan areas, the less there was. Armed people and those who banded together did best.

- If you already own a home go to the CUSEC website and see how to inspect it. Determine if it will stand up to an earthquake. If not, and you can either afford it or you have the ability to bring it up to "earthquake code" yourself, do so. Otherwise, consider selling it. If you're in the market to buy, I'd make an earthquake inspection a criteria while selecting a place. If you're building, build with the idea that you want the roof over your head to stay where it is when the big one hits.

- Last, if you're in a seismically active zone, neither buy nor build in flood zones.

No one knows when the next earthquake or series of quakes will occur in the NMSZ or anywhere else, but history shows us that those who are prepared will fare much better than those who rely on others to help them in the aftermath. Δ

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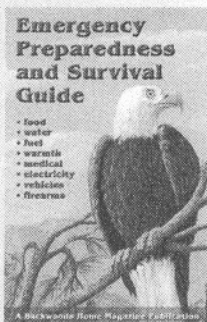
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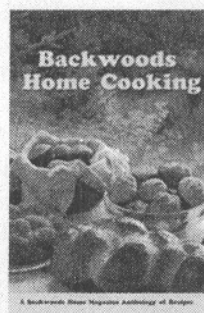
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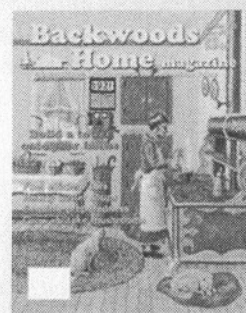
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