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Tornadoes In Mississippi: A County by County Community Risk Assessment

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TORNADOES IN MISSISSIPPI: A COUNTY BY COUNTY COMMUNITY RISK ASSESSMENT

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Mississippi leads the nation in tornado deaths per unit area. Previous risk assessment studies have indicated a connection between housing type and fatalities but have focused only on a national scale. The purpose of this study was to provide a local scale risk assessment for Mississippi. Each county's individual tornado risks were combined with US Census county housing data for each decade from 1960-2000. The study found that the comparable risk to life and property is highest in Harrison County and Hinds County, but with proper shelters and community planning this risk would be mitigated.

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CHAPTER I

INTRODUCTION

From 1950-1995 Mississippi held the dubious honor of having the highest average tornado occurrence per unit area in the United States. Mississippi also led the nation in the number of deaths per unit area between 1953 and 1998 (Table 1) (Grazulis 2001). Tornadoes are a risk factor to people and property in the United States, and specifically to Mississippi, that cannot be ignored. This risk assessment project for Mississippi aims to determine areas within the state where there is a greater threat to housing due to the prevalence of tornadoes, tornado days, and the associated housing communities.

Tornadoes, and the supercell storms that spawn them, are complex fluid structures that, after decades of study, are still not fully understood. It is still not known why the same storm system on a given day can produce both a tornado that does no damage and one that wreaks havoc along its path. It is not known why one tornado may travel for 20 miles over rugged terrain while another remains on the ground for a mere mile over flat grassland. In tornado forecasting, there are very few, if any, absolutes.

Perhaps this unknown is responsible for the number of myths that surround tornadoes. One of the most persistent is the belief that mobile homes are “magnets” for tornadoes. Although mainly disproved within the scientific community the public continues to hold to this idea. Ironically, however, manufactured home sales have increased over the past twenty years in states known for frequent tornadic activity (Manufactured Home Association of Mississippi 2002).

The Oklahoma tornadoes of May 3, 1999 provided a unique opportunity for a wide range of case studies including one on fatalities. The *Journal of Weather and Forecasting* for June 2002 was devoted to the research these storms.

Brooks and Doswell (2002) highlighted the importance of safety and risk assessment within housing communities. Although the Moore, OK F5 tornado of 1999 damaged several thousand permanent homes with less than 100 mobile homes damaged, according to Brooks and Doswell (2002) the risk to mobile home residents was at least twenty times as great as the risk to permanent home residents.

Nationally, the number of deaths related to mobile homes speaks for itself. Table 2 indicates the number of deaths by type of housing attributed to tornadoes since 1975 (Brooks and Doswell 2002). The percentage of those people who die in mobile homes is substantially greater than those who have perished in permanent structures. Since mobile homes and older permanent homes are at risk from tornadoes because of their light weight or substandard wind resistant construction, the people who shelter within them are also at great risk of injury or death. While national studies have been conducted by Harold Brooks (2003) and also by Jim Belles (2002) of the Memphis National Weather Service on tornado risk assessment, no local studies have been carried out.

Table 1. Tornado fatalities ranked by state (Grazulis 2001)

State	Deaths per 1,000,000 people	Deaths per 10,000 sq. miles	Killer tornadoes per 1,000,000 people	Killer tornadoes per 10,000 sq. miles
Mississippi	166.0 (1)	79.0 (2)	25.0 (2)	12.0 (1)
Arkansas	87.0 (2)	32.0 (7)	30.0 (1)	11.0 (2)
Alabama	79.0 (5)	54.0 (4)	15.0 (4)	10.0 (4)
Oklahoma	81.0 (4)	31.0 (9)	24.0 (3)	9.0 (6)
Indiana	43.0 (6)	62.0 (3)	7.5 (17)	11.0 (3)

Table 2. Number of deaths associated with structure type (Brooks and Doswell 2002)

Year	Total	Mobile	Permanent
1975	60	13	—
1976	44	18	—
1977	43	7	—
1978	53	15	—
1979	84	9	—
1980	28	11	—
1981	24	14	—
1982	64	20	—
1983	34	20	—
1984	122	43	—
1985	94	28	40
1986	15	7	3
1987	59	24	7
1988	32	21	6
1989	48	12	8
1990	53	7	11
1991	39	20	3
1992	39	20	18
1993	33	13	6
1994	68	26	14
1995	30	8	15
1996	25	14	8
1997	67	30	23
1998	130	65	40
1999	93	39	35
2000	40	31	4

CHAPTER II

LITERATURE REVIEW

Tornado Environments

Tornadoes are defined as violently rotating columns of air that are in contact with the ground and a cumulus cloud. Tornadoes can initially form anywhere under the proper synoptic influences. These fundamental conditions have been detailed by a number of studies (e.g. Pryor and Kurzhal 1997, Kessler 1992).

A synthesis of the synoptic conditions begins with a warm, dry air mass that must establish a cap in the atmosphere over cooler, but still warm, moist air. In Mississippi, the prime source region for this moist air is the Gulf of Mexico. A cap prevents the ascension of air parcels allowing energy to be trapped in the planetary boundary layer (PBL). Once the cap is forcefully broken by a synoptic mechanism such as a front, the energy is released, enhancing the updraft, and an air parcel's ability to rise rapidly and freely into a developing thunderstorm. (McIlveen 1992) Wind shear in the vertical is necessary for rotation within a column of air. Low level jet streams, or regions of fast moving air (greater than 40 knots) help develop the proper shear environment.

During the fall and winter months the jet stream dips further south bringing the stronger jet streaks across Mississippi and the Southeast. The jet streaks in the upper and mid-level troposphere push cool, dry air into the troposphere and enhance upper level divergence. Low level jet streams help to quickly move heat and moisture into convective regions. The jet streaks create regions of vertical shear that enhance the organization of severe storms (Figure 1) (Verno 1999). However, these conditions alone will not always produce tornadoes.

The Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX) was aimed to shed new light on tornadoes and their environs. It was discovered during VORTEX that boundaries, or leading edges of pools of cool air left behind thunderstorms, are good locations for later tornado formation. These boundaries are "small-scale fronts" that supply the air with horizontal rotation. As a mature storm intersects a boundary, the horizontal rotation can be tilted upward into the updraft and stretched vertically thereby increasing the spin rate of the updraft.

Rasmussen (2002) suggests that strong synoptic scale shear is not necessary in tornado formation. Instead, he offers the hypothesis of three atmospheric ingredients working together. The first ingredient is a long lasting updraft. The second ingredient is sufficient storm relative helicity (SRH) in the 0-1 km layer. The third ingredient is a strong, concentrated rear-flank downdraft.

Supercell Storms

There are three different classifications of supercells, the storms most likely to have tornadic activity in the environment detailed above: 1) Low Precipitation (LP)

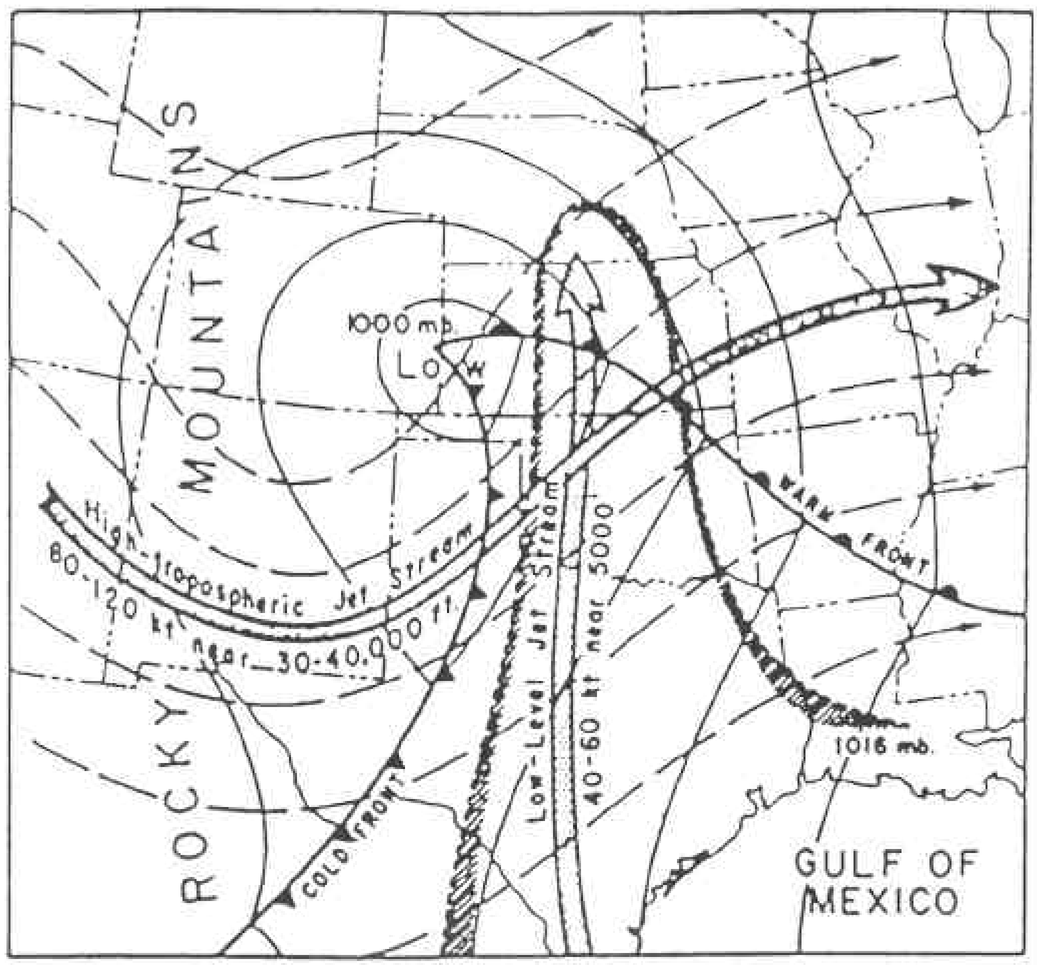

Figure 1. A model of a typical tornadic cell environment. (Kessler 1992)

supercells mainly develop over the Western Great Plains and, in general, produce weak tornadoes, 2) Classic Supercells are most common over the Central Great Plains and, 3) High Precipitation (HP) supercells, which are common in the Southeast and are often responsible for flash floods as well as tornadoes (Ahrens 2000).

In Mississippi, the most common supercell type is the HP storm. This storm is commonly associated with Mesoscale Convective Systems (MCS) (Maddox 1980). Kessler (1992) found that these storms often produce the most violent tornadoes.

Risk and Damage Assessment

The most widely used measurement for damage created by tornadoes is the Fujita Scale. The Fujita Scale works on a rating system of F0 to F5 where F5 is the strongest possible tornado. These ratings are based on the character of damage effected on structures in the tornado’s path. (Table 3) Significant tornadoes are defined as F-scale ratings of F2 or greater.

Until recently there was no effective way to measure the exact wind speed within and around tornado vortices. Even with the technological advancements of the Doppler radar and the Doppler on Wheels (DOW) it is a dangerous undertaking to move instruments within a usable range. Additionally, there is very little opportunity to have a DOW in the right place every time a tornado occurs.

Table 3. Fujita Scale of Tornado Intensity (Fujita and Pearson 1973)

Rating	Estimated Wind Speed	Character of Damage
F0	40- 72 mph	Damage to signs, large tree branches
F1	73-112 mph	Roof damage, mobile homes removed from foundations, cars blown off road
F2	113-157 mph	Roofs torn away, mobile homes destroyed, large tree trunks snapped off
F3	158-206 mph	Roofs and walls torn away from well constructed buildings, railroad trains overturned, large numbers of trees uprooted
F4	207-260 mph	Well constructed residences completely destroyed, cars tossed about like toys
F5	261-318 mph	Well constructed commercial buildings disintegrated, cars carried distances of over 100 yards

Thomas Grazulis (1992) directed one of the largest independent studies on historical tornadoes as part of the Tornado Project. Grazulis only considered those storms he evaluated as significant tornadoes, however. As seen in Figure 2, he did find a minimum of significant tornadoes stretching from Calhoun County, MS to Attala County, MS from 1880 to 1989 that did not seem to be related to low population and reporting biases. (Grazulis 1992).

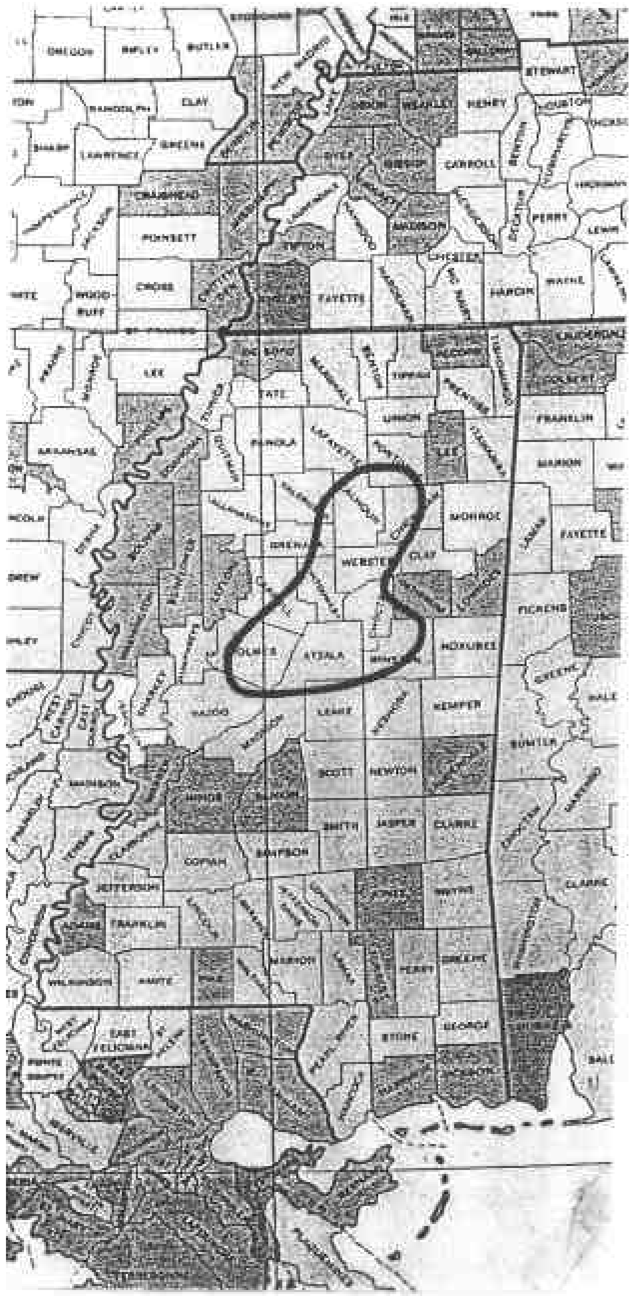

Figure 2. Mississippi Counties with Minima of Significant Tornadoes (Grazulis 1992)

Even with the tornado minima factored in, Mississippi is still ranked number one for tornado deaths by population, a statistic that according to Grazulis (1992) truly demonstrates the relative state-to-state risk to life from tornadoes.

Hinds County, MS and Rankin County, MS, which include the Jackson metropolitan area, are two areas of concern for high damage and injury in the autumn and winter seasons. This assessment was because of high numbers of tornadoes occurring near the relatively high population densities within these two counties. Mississippi, in general, shows a prevalence of very strong tornadoes with a relatively large number of long-track tornadoes (Garinger and Knupp 1993).

Brooks et al. (2001) and Concannon et al. (2000) also indicated southern Mississippi as a region of maximum tornado occurrence when studying national tornado climatology. Brooks et al. (2001) found that the risk of a significant tornado event across the United States can be determined by utilizing a hazard model. The hazard model, named the Monte Carlo, produced results of 10 million extrapolated tornado events that were statistically comparable to the raw data. A high risk was found to be in central Oklahoma and the surrounding area, extending eastward into Alabama.

A long-term tornado climatology that Brooks et al. (2001) compiled suggests Mississippi is at risk of significant tornadoes that have the potential to cause numerous deaths and considerable damage. Compounding this risk is the number of structures built with poor wind resistance. Situations arise where there are simply no safe places for people to seek protection from a severe windstorm (McDonald 1993). People believe the risk of being hit by a tornado is too low to invest in the proper tornado protection. Yet, the most common cause of death in a tornado is from flying projectiles. These might include pieces of wood, metal pipes, or even cars. The tornado does not have to pass directly over a house to cause injury or damage. According to Marshall (1993) small missiles can penetrate walls with single sheathing at speeds as little as 32 mph.

Other than the Tornado Project (Grazulis 2002) and the compilation of papers that were presented in 1993, there have been few recent tornado risk analyses performed. But, when ten percent of all US households will experience a tornado that involves injury to household members and/or damage to real or personal property of the household or its members (Rossi, et. al, 1983) the matter deserves further study, especially at the county level. Since mobile homes that are not properly anchored can be overturned by a tornado with 70 mph winds (F1), all tornadoes from F0 through F5 should be considered a real threat. The amount of property damage continues to increase each year, reaching a level where insurance alone cannot recoup the losses (McDonald 1993). Zoning and building codes are determined on a county or state wide basis. In order to implement changes, a sense of urgency must be instilled on this local level. Determining the Mississippi counties that would benefit from installing interior or exterior storm shelters or building houses that are more wind resistant would, in turn, prevent Mississippi from suffering the economic losses inherent in tornado damage.

CHAPTER III

OBJECTIVES AND HYPOTHESES

The primary objectives of this study are:

1) to determine the locations of greatest risk to human lives from tornadoes in Mississippi;

2) to determine the extent of the spatial relationship that exists between tornadoes and housing structures in Mississippi on a county level;

3) to determine if the areas of greatest risk have changed between 1960 and 2000;

4) to provide emergency management with a detailed risk assessment of tornadoes and property damage of Mississippi counties

This study hypothesizes that due to the economic costs of providing protective areas and the belief that no structure can withstand significant tornado damage:

1) the primary risk areas within Mississippi have changed from 1960-2001 due to changes in lifestyle and housing;

2) mobile home locations have remained relatively stationary, but have increased in number of units with little regard to tornado risk assessment

CHAPTER IV

DATA AND METHODS

Study Period

The time period utilized for this study is January 1, 1960 to December 31, 2001. This time frame was chosen because of the limited availability of housing data prior to 1960. Tornado data was available from the National Climate Data Center (NCDC) from the 1950s through 2001. However, the risk comparisons offered in this study are in relation to the housing data. The 42 year period is long enough to allow for an analysis of decadal risk change.

Housing Data

The housing data was obtained from United States Census Bureau compilations from 1960 to 2000 (Tables 4a-4e). These data were broken down by county, structure type, and approximate year of construction (U.S. Census Bureau 2002). Data were restricted to information that could be found on every one of the last five Census Long Form Summary Files. The year of construction of a structure provides information on

Table 4a. 1960 Census Housing Data (US Census Bureau 1960)

COUNTY	TOTAL HOUSING UNITS	1929 OR EARLIER	1930-1939	1940-1949	1950-March 1960	MOBILE HOMES
ADAMS	11,109	4705	1152	2318	2934	67
ALCORN	8107	3400	1307	1561	1839	37
AMITE	4352	1575	862	1179	736	20
ATTALA	6393	2661	1243	1402	1087	40
BENTON	2190	735	429	396	630	4
BOLIVAR	15508	6864	3613	2874	2157	79
CALHOUN	4670	1524	1014	1239	893	16
CARROLL	3184	1983	281	433	487	8
CHICKASAW	4902	1918	937	972	1075	8
CHOCTAW	2591	1121	584	550	336	12
CLAIBORNE	2862	1200	625	525	512	22
CLARKE	5005	1912	768	1309	1016	21
CLAY	5433	2100	780	877	1676	33
COAHOMA	13087	6653	2235	2084	2115	37
COPIAH	7691	3279	1294	1696	1422	53
COVINGTON	4048	1350	686	1038	974	20
DE SOTO	6253	2126	1348	1249	1530	96
FORREST	15958	4061	2420	5112	4365	124
FRANKLIN	2909	1212	386	698	613	12
GEORGE	3084	787	504	804	989	45
GREENE	2252	766	408	554	524	9
GRENADA	5592	1787	914	1394	1497	28
HANCOCK	6413	1774	824	1431	2384	37
HARRISON	35227	8858	3898	9164	13307	1418
HINDS	N/A	N/A	N/A	N/A	N/A	N/A
HOLMES	7673	4064	1329	1290	990	21

Table 4a. Continued

COUNTY	TOTAL HOUSING UNITS	1929 OR EARLIER	1930-1939	1940-1949	1950-March 1960	MOBILE HOMES
HUMPHREYS	5103	2287	1293	914	609	28
ISSAQUENA	1155	601	168	228	158	0
ITAWAMBA	4703	1401	783	1205	1314	22
JACKSON	16226	2942	1330	4789	7165	823
JASPER	4512	1421	800	1170	1121	59
JEFFERSON	2843	1366	450	421	606	21
JEFFERSON DAVIS	3561	1293	584	859	825	46
JONES	16840	5849	3000	3894	4097	156
KEMPER	3308	1643	503	550	612	7
LAFAYETTE	5681	2309	768	1050	1554	30
LAMAR	4092	1222	670	1059	1141	40
LAUDERDALE	20803	9204	2407	4142	5050	128
LAWRENCE	2999	1057	682	621	639	28
LEAKE	5335	1707	1121	1325	1182	17
LEE	12260	3252	2938	2506	3564	73
LEFLORE	13370	6764	1566	2156	1884	51
LINCOLN	7897	2925	1091	1891	1990	94
LOWNDES	12732	4360	1974	2089	4309	491
MADISON	7945	3659	1362	1370	1554	49
MARION	6838	1895	1225	1941	1777	52
MARSHALL	5772	2631	896	915	1330	17
MONROE	10173	3557	1917	2103	2596	51
MONTGOMERY	3955	1474	797	886	798	16
NESHOBA	6700	2281	1476	1503	1440	21
NEWTON	5859	2242	984	1304	1329	32
NOXUBEE	4456	1737	1145	825	749	0
OKTIBBEHA	6448	1981	1067	1587	1813	94
PANOLA	8329	3288	1798	1575	1668	56

Table 4a. Continued

COUNTY	TOTAL HOUSING UNITS	1929 OR EARLIER	1930-1939	1940-1949	1950-March 1960	MOBILE HOMES
PEARL RIVER	6633	1734	1342	1788	1769	75
PERRY	2486	750	417	725	594	4
PIKE	10291	4619	1527	1869	2276	165
PONTOTOC	5463	2070	872	1313	1208	16
PRENTISS	5583	1919	902	1431	1331	24
QUITMAN	5567	2134	1469	1153	811	13
RANKIN	8482	1518	1193	2032	3739	124
SCOTT	5890	1932	1090	1376	1492	29
SHARKEY	3093	1717	768	279	329	8
SIMPSON	5755	1958	1036	1436	1325	71
SMITH	4250	1330	860	975	1085	28
STONE	1986	603	210	542	631	40
SUNFLOWER	11818	6250	2310	1820	1438	46
TALLAHATCHIE	6872	3688	1451	974	759	20
TATE	4765	1780	796	1171	1018	12
TIPPAH	4549	1816	903	951	879	8
TISHOMINGO	4857	1801	603	1004	1449	28
TUNICA	5130	2232	1502	889	507	26
UNION	5992	2483	1135	1095	1279	20
WALTHALL	3931	1370	777	897	887	17
WARREN	13311	7326	1745	1612	2628	144
WASHINGTON	23030	8710	4589	4141	5590	287
WAYNE	4512	1265	903	1148	1196	27
WEBSTER	3185	1196	554	779	656	32
WILKINSON	3473	1380	589	883	621	4
WINSTON	5350	1592	1054	1555	1149	28
YALOBUSHA	3893	2106	505	640	642	26
YAZOO	8797	3678	1940	1723	1456	49

Table 4b. 1970 Census Housing Data (US Census Bureau 1970)

COUNTY	TOTAL HOUSING UNITS	1939 OR EARLIER	1940-1949	1950-1959	1960-March 1970	MOBILE HOMES
ADAMS	11949	4255	2099	3173	2422	224
ALCORN	9372	3710	1398	1715	2549	342
AMITE	4329	1691	951	588	1099	180
ATTALA	6564	2721	1422	978	1443	223
BENTON	2631	1013	380	442	796	99
BOLIVAR	13793	6233	2569	1985	3006	297
CALHOUN	4885	1948	889	779	1269	140
CARROLL	2982	1519	369	327	767	108
CHICKASAW	5342	2270	687	879	1506	413
CHOCTAW	2849	1332	520	372	625	55
CLAIBORNE	3032	1369	442	475	746	66
CLARKE	5072	2023	908	801	1340	156
CLAY	5651	1993	865	1371	1422	252
COAHOMA	12693	6309	2734	1755	1895	254
COPIAH	7646	3070	1344	1421	1811	261
COVINGTON	4245	1367	660	844	1374	231
DE SOTO	10052	2413	1125	1121	5393	894
FORREST	18939	5205	4102	4416	5216	535
FRANKLIN	2776	1120	495	533	628	132
GEORGE	3895	778	725	892	1500	293
GREENE	2718	869	471	572	806	116
GRENADA	6504	2133	1350	1329	1692	225
HANCOCK	7196	1461	1033	1346	3356	560
HARRISON	41548	8685	6919	9185	16759	3544
HINDS	67235	14321	12372	20306	20236	702
HOLMES	7083	3580	1180	989	1334	117

Table 4b. Continued

COUNTY	TOTAL HOUSING UNITS	1939 OR EARLIER	1940-1949	1950-1959	1960-March 1970	MOBILE HOMES
HUMPHREYS	4150	1861	853	677	759	93
ISSAQUENA	860	345	161	159	195	81
ITAWAMBA	5612	1495	998	1042	2077	335
JACKSON	27513	3726	3648	5905	14234	2268
JASPER	4961	1703	846	1058	1354	237
JEFFERSON	2648	1142	402	449	655	56
JEFFERSON DAVIS	3883	1230	809	713	1131	149
JONES	18171	6370	3907	3654	4240	895
KEMPER	3143	1743	339	428	633	91
LAFAYETTE	7194	1876	1183	1547	2588	549
LAMAR	4892	1322	766	1123	1681	404
LAUDERDALE	22677	8214	4354	4614	5495	1004
LAWRENCE	3582	1286	474	545	1277	248
LEAKE	5741	1879	1000	1109	1753	275
LEE	15362	4258	2510	3324	5270	769
LEFLORE	12944	5758	3111	1762	2313	265
LINCOLN	8646	2934	1705	1777	2230	492
LOWNDES	15385	4884	2170	3235	5096	923
MADISON	8184	3047	1568	1304	2265	243
MARION	7343	2567	1572	1354	1850	244
MARSHALL	6537	2412	955	1051	2119	544
MONROE	11140	3844	1792	2322	3182	505
MONTGOMERY	4235	1768	755	787	925	94
NESHOBA	7041	2408	1379	1346	1908	291
NEWTON	6530	2651	1092	1222	1565	266
NOXUBEE	4373	2146	622	628	977	118
OKTIBBEHA	8000	2426	932	1598	3044	678
PANOLA	7933	2929	1359	1393	2252	387

Table 4b. Continued

COUNTY	TOTAL HOUSING UNITS	1939 OR EARLIER	1940-1949	1950-1959	1960-March 1970	MOBILE HOMES
PEARL RIVER	8815	2267	1440	1649	3459	508
PERRY	2852	916	556	523	857	177
PIKE	10591	4779	1722	1965	2125	306
PONTOTOC	5898	2147	1042	1076	1633	264
PRENTISS	6758	2032	1391	1204	2131	219
QUITMAN	4876	2257	973	808	838	182
RANKIN	12091	1729	1381	3056	5925	1011
SCOTT	6634	1813	1182	1590	2049	276
SHARKEY	2459	1505	330	281	343	79
SIMPSON	6419	1985	1018	1401	2015	359
SMITH	4424	1455	672	851	1446	269
STONE	2447	572	496	547	832	165
SUNFLOWER	10107	4531	2205	1499	1872	186
TALLAHATCHIE	6159	3459	992	720	988	220
TATE	5204	1699	937	738	1830	283
TIPPAH	5562	2139	891	958	1574	220
TISHOMINGO	5400	2090	723	1005	1582	276
TUNICA	3861	1905	835	538	583	83
UNION	6705	2297	1168	1269	1971	356
WALTHALL	4011	1406	856	683	1066	100
WARREN	14990	6107	2137	2735	5011	534
WASHINGTON	21006	7102	4852	5084	3968	384
WAYNE	5088	1455	825	1246	1562	308
WEBSTER	3391	1185	629	575	1002	127
WILKINSON	3322	1220	648	603	851	137
WINSTON	5822	1988	1110	1142	1582	225
YALOBUSHA	4110	1809	510	584	1207	176
YAZOO	8608	3552	1697	1576	1783	228

Table 4c. 1980 Census Housing Data (US Census Bureau 1980)

COUNTY	TOTAL HOUSING UNITS	1939 OR EARLIER	1940-1949	1950-1959	1960-1969	1970-March 1980	MOBILE HOMES
ADAMS	13541	2519	1820	3056	3019	3127	645
ALCORN	12805	2411	1635	1827	2602	4330	1297
AMITE	5232	1213	824	583	1141	1471	545
ATTALA	7580	2020	1103	1039	1332	2086	604
BENTON	2822	447	324	419	744	888	232
BOLIVAR	14546	2587	2087	2647	3581	3644	550
CALHOUN	5958	1244	915	695	1322	1782	409
CARROLL	3548	740	369	518	742	1179	434
CHICKASAW	6341	1262	676	939	1452	2012	609
CHOCTAW	3352	853	422	342	711	1024	278
CLAIBORNE	4213	688	492	784	919	1330	580
CLARKE	6425	1281	928	1111	1103	2002	690
CLAY	7291	1232	688	1357	1471	2543	565
COAHOMA	12760	3415	2326	2403	2249	2367	473
COPIAH	9460	2411	1193	1448	1875	2533	878
COVINGTON	5683	887	651	744	1287	2114	608
DE SOTO	17075	1395	828	1314	4901	8637	1515
FORREST	24981	3752	3469	4649	5708	7403	1415
FRANKLIN	3344	811	521	565	549	898	245
GEORGE	5707	682	585	694	1398	2348	761
GREENE	3404	577	437	479	646	1265	421
GRENADA	7535	1112	1142	1440	1749	2092	451
HANCOCK	11623	1265	793	1506	3480	4579	837
HARRISON	57624	6728	5904	10024	16817	18151	3617
HINDS	91542	8285	11033	20220	24771	27233	2302
HOLMES	7717	1988	1145	1181	1529	1874	656

Table 4c. Continued

COUNTY	TOTAL HOUSING UNITS	1939 OR EARLIER	1940-1949	1950-1959	1960-1969	1970-March 1980	MOBILE HOMES
HUMPHREYS	4718	1071	899	763	765	1220	292
ISSAQUENA	871	122	136	130	189	294	80
ITAWAMBA	7626	914	978	1145	1848	2741	575
JACKSON	41966	2596	2932	5822	13323	17293	3156
JASPER	6177	1043	842	947	1255	2090	950
JEFFERSON	3098	654	367	500	682	895	273
JEFFERSON DAVIS	4782	747	490	732	1128	1685	388
JONES	23803	4289	3477	4247	5045	6745	2013
KEMPER	3546	826	371	521	821	1007	361
LAFAYETTE	10788	1369	865	1567	2681	4306	1621
LAMAR	8590	861	766	1077	1810	4076	1064
LAUDERDALE	28999	6051	3895	5374	5969	7710	2467
LAWRENCE	4599	716	357	666	939	1921	511
LEAKE	7085	1023	1080	1098	1597	2287	688
LEE	21308	2505	2354	3232	5498	7719	1881
LEFLORE	13665	3322	2525	2426	2605	2787	547
LINCOLN	11003	2158	1429	1722	2338	3356	1241
LOWNDES	19862	2696	2073	3364	5005	6724	1755
MADISON	13942	2093	1245	1844	2921	5839	997
MARION	9433	1539	1536	1640	2015	2703	796
MARSHALL	9272	1285	774	1217	2145	3851	1600
MONROE	13218	2645	1641	2235	3227	3470	1043
MONTGOMERY	4960	1272	606	786	1198	1098	234
NESHOBA	8838	1511	1263	1166	1984	2914	928
NEWTON	7757	1564	1144	1299	1671	2079	691
NOXUBEE	4316	914	539	580	976	1307	456
OKTIBBEHA	11772	1098	1009	1716	3020	4929	1370
PANOLA	9638	1791	1155	1406	1986	3300	1311

Table 4c. Continued

COUNTY	TOTAL HOUSING UNITS	1939 OR EARLIER	1940-1949	1950-1959	1960-1969	1970-March 1980	MOBILE HOMES
PEARL RIVER	12695	1484	1039	2106	3353	4713	1486
PERRY	3490	604	438	507	724	1217	399
PIKE	13303	3327	1990	2178	2336	3472	968
PONTOTOC	8148	1441	1126	1193	1571	2817	683
PRENTISS	8896	1143	1212	1444	2200	2897	692
QUITMAN	4281	914	957	793	804	813	221
RANKIN	23866	1104	1097	2849	5878	12938	3933
SCOTT	8802	1267	862	1542	2080	3051	1200
SHARKEY	2499	504	378	341	454	822	165
SIMPSON	8710	1548	961	1249	2221	2731	1041
SMITH	5712	871	675	810	1395	1961	754
STONE	3387	495	478	383	1022	1009	364
SUNFLOWER	10229	2212	1639	1705	1990	2683	374
TALLAHATCHIE	5770	1251	876	949	986	1708	409
TATE	6332	1018	708	872	1545	2189	714
TIPPAH	7108	1304	775	917	1821	2291	723
TISHOMINGO	7476	1159	852	1035	1609	2821	985
TUNICA	3041	922	438	400	490	791	173
UNION	8265	1793	994	1326	1667	2485	686
WALTHALL	4905	1106	577	765	913	1544	462
WARREN	19218	3594	2093	2832	4187	6512	2150
WASHINGTON	24154	4339	3974	5160	4749	5932	1062
WAYNE	6792	702	765	1066	1309	2950	906
WEBSTER	3898	785	639	564	852	1058	291
WILKINSON	3767	871	494	555	848	999	379
WINSTON	7171	1220	1000	967	1575	2409	588
YALOBUSHA	5416	1408	556	637	1112	1703	762
YAZOO	9451	2141	1472	1738	1753	2347	713

Table 4d. 1990 Census Housing Data (US Census Bureau 1990)

COUNTY	Total	Mobile home or trailer	1989 to March 1990	1985 to 1988	1980 to 1984	1970 to 1979	1960 to 1969	1950 to 1959	1940 to 1949	1939 or earlier
ADAMS	14,715	1,432	201	720	1,375	3,463	2,470	2,894	1,541	2,051
ALCORN	13,704	1,805	284	1,178	1,522	3,993	2,450	1,610	1,315	1,352
AMITE	5,695	1,202	130	476	771	1,327	969	676	525	821
ATTALA	7,674	1,042	105	562	730	2,110	1,395	1,032	806	934
BENTON	3,379	580	78	329	347	954	872	375	194	230
BOLIVAR	14,514	1,178	327	1,120	1,498	3,739	3,023	1,947	1,404	1,456
CALHOUN	6,260	807	134	554	717	1,764	1,148	768	526	649
CARROLL	3,948	889	102	480	465	1,221	700	328	272	380
CHICKASAW	6,997	1,284	132	650	940	1,824	1,355	947	472	677
CHOCTAW	3,539	480	128	386	449	886	610	363	268	449
CLAIBORNE	4,099	898	116	351	553	1,234	763	474	298	310
CLARKE	7,065	1,379	167	1,017	1,092	1,940	973	672	523	681
CLAY	7,737	1,029	169	851	795	2,292	1,418	1,043	424	745
COAHOMA	11,495	724	189	395	1,007	2,779	2,307	2,201	1,440	1,177
COPIAH	10,260	1,981	211	1,105	1,125	2,234	1,773	1,251	1,041	1,520
COVINGTON	6,535	1,219	197	711	1,005	2,034	966	592	520	510
DE SOTO	24,472	2,627	1,951	4,656	2,674	7,616	4,983	1,274	651	667
FORREST	27,740	2,422	431	1,443	3,490	7,515	5,200	3,870	2,831	2,960
FRANKLIN	3,555	598	20	304	519	1,039	506	513	298	356
GEORGE	6,663	1,237	169	682	988	2,112	1,200	641	403	468
GREENE	3,864	920	136	356	476	1,196	615	352	340	393
GRENADA	8,712	1,100	191	1,123	947	1,968	1,692	1,402	807	582
HANCOCK	16,561	2,204	341	2,362	2,801	4,532	2,992	1,484	867	1,182
HARRISON	67,813	6,494	981	6,674	7,674	18,324	14,895	9,129	5,305	4,831
HINDS	99,860	3,631	1,491	7,894	8,603	25,420	21,502	18,457	9,698	6,795
HOLMES	7,972	1,472	407	646	963	1,836	1,389	1,070	652	1,009

Table 4d. Continued

COUNTY	Total	Mobile home or trailer	1989 to March 1990	1985 to 1988	1980 to 1984	1970 to 1979	1960 to 1969	1950 to 1959	1940 to 1949	1939 or earlier
HUMPHREYS	4,231	534	86	244	281	1,213	783	598	498	528
ISSAQUENA	698	142	5	48	80	219	98	77	107	64
ITAWAMBA	8,116	1,202	158	777	841	2,243	1,699	1,033	751	614
JACKSON	45,542	4,510	499	3,038	3,934	16,817	11,440	4,924	2,991	1,899
JASPER	6,700	1,450	209	634	886	1,917	1,242	845	627	340
JEFFERSON	3,167	706	39	376	575	918	583	180	173	323
JEFFERSON DAVIS	5,336	737	131	437	884	1,611	940	574	332	427
JONES	25,044	3,833	342	2,060	2,780	6,582	4,309	3,429	2,770	2,772
KEMPER	4,151	766	69	530	805	1,074	564	454	230	425
LAFAYETTE	12,478	2,307	460	1,356	1,752	3,995	1,982	1,489	625	819
LAMAR	11,849	1,838	345	1,729	2,022	4,078	1,614	746	566	749
LAUDERDALE	31,232	4,553	474	3,133	3,778	7,024	5,404	5,149	3,098	3,172
LAWRENCE	5,160	748	90	531	951	1,562	995	370	261	400
LEAKE	7,614	1,177	164	937	991	2,254	1,323	758	561	626
LEE	25,971	3,447	774	3,120	3,185	7,103	4,840	3,337	1,763	1,849
LEFLORE	13,799	968	175	858	1,305	3,410	2,768	1,732	1,781	1,770
LINCOLN	12,133	2,339	324	1,388	1,479	2,955	2,013	1,321	1,346	1,307
LOWNDES	23,117	2,674	448	2,312	2,975	6,828	4,074	2,771	1,672	2,037
MADISON	20,761	1,749	754	4,324	3,998	6,080	2,434	1,390	748	1,033
MARION	10,132	1,554	174	837	1,566	2,487	1,739	1,359	761	1,209
MARSHALL	10,984	2,758	413	1,472	1,652	3,401	1,757	1,057	470	762
MONROE	14,285	2,020	414	1,209	1,403	3,584	2,764	2,248	1,340	1,323
MONTGOMERY	4,987	523	107	340	468	979	936	802	646	709
NESHOBA	9,770	1,438	302	1,015	1,094	2,692	1,724	1,118	822	1,003
NEWTON	8,095	1,409	193	1,004	1,130	1,886	1,356	963	625	938
NOXUBEE	4,645	929	35	353	593	1,170	1,002	579	349	564
OKTIBBEHA	13,861	1,687	279	1,671	2,023	3,944	2,416	1,713	721	1,094
PANOLA	11,482	2,915	387	1,195	1,461	3,140	1,921	1,500	790	1,088

Table 4d. Continued

COUNTY	Total	Mobile home or trailer	1989 to March 1990	1985 to 1988	1980 to 1984	1970 to 1979	1960 to 1969	1950 to 1959	1940 to 1949	1939 or earlier
PEARL RIVER	15,793	3,030	274	1,751	2,788	4,446	2,951	1,615	922	1,046
PERRY	4,292	1,093	156	473	627	1,236	629	422	331	418
PIKE	14,995	2,149	186	1,374	1,901	3,482	2,371	1,885	1,481	2,315
PONTOTOC	9,001	1,687	253	1,112	1,088	2,688	1,412	1,116	678	654
PRENTISS	9,155	1,207	207	841	1,115	2,566	1,850	1,096	799	681
QUITMAN	3,880	360	51	199	220	1,008	716	682	497	507
RANKIN	31,872	6,252	931	5,449	5,331	10,169	5,319	2,764	1,056	853
SCOTT	9,488	1,974	189	944	1,009	2,642	1,991	1,363	686	664
SHARKEY	2,290	333	29	188	211	774	443	185	201	259
SIMPSON	9,374	1,969	222	870	1,324	2,383	1,766	1,103	781	925
SMITH	5,850	1,268	120	541	596	1,793	1,134	678	440	548
STONE	4,148	719	86	324	673	1,229	684	497	358	297
SUNFLOWER	10,167	574	167	758	1,150	2,688	1,708	1,522	1,229	945
TALLAHATCHIE	5,492	1,043	73	460	506	1,531	891	743	626	662
TATE	7,474	1,350	178	1,060	851	2,031	1,379	1,004	437	534
TIPPAH	7,846	1,274	171	883	979	2,351	1,392	658	615	797
TISHOMINGO	8,455	1,186	287	586	1,021	2,330	1,918	1,000	528	785
TUNICA	2,990	657	38	341	273	714	630	344	300	350
UNION	9,104	1,192	154	1,019	973	2,455	1,683	1,158	580	1,082
WALTHALL	5,643	1,073	225	613	743	1,359	981	635	341	746
WARREN	19,512	2,533	369	1,411	1,933	5,486	3,734	2,603	1,405	2,571
WASHINGTON	24,567	1,731	412	2,087	2,065	5,687	4,960	4,748	2,423	2,185
WAYNE	7,723	2,034	194	768	953	2,433	1,412	950	542	471
WEBSTER	4,326	440	125	301	430	1,075	815	601	456	523
WILKINSON	4,242	904	108	449	661	1,045	680	517	259	523
WINSTON	7,613	759	167	782	793	2,077	1,564	854	717	659
YALOBUSHA	5,414	1,065	165	517	747	1,447	949	551	370	668
YAZOO	9,549	1,252	259	714	841	2,231	1,867	1,552	891	1,194

Table 4e. 2000 Census Housing Data (US Census Bureau 2000)

COUNTY	Total	Mobile home	1999 to March 2000	1995 to 1998	1990 to 1994	1980 to 1989	1970 to 1979	1960 to 1969	1950 to 1959	1940 to 1949	1939 or earlier
ADAMS	15,175	1,613	245	546	871	2,393	3,192	2,458	2,413	1,058	1,999
ALCORN	15,818	2,425	364	1,216	1,272	2,697	3,717	2,609	1,660	1,010	1,273
AMITE	6,446	1,880	181	588	510	1,258	1,403	847	464	398	797
ATTALA	8,639	1,698	287	815	605	1,355	1,741	1,275	841	775	945
BENTON	3,456	709	31	290	264	680	966	607	237	135	246
BOLIVAR	14,939	1,867	319	804	976	2,468	3,884	2,832	1,728	955	973
CALHOUN	6,902	1,172	137	561	546	1,354	1,562	1,025	721	526	470
CARROLL	4,888	1,407	93	567	404	999	1,129	674	456	174	392
CHICKASAW	7,981	2,095	160	797	752	1,475	1,787	1,063	927	407	613
CHOCTAW	4,249	813	147	372	355	917	925	581	353	260	339
CLAIBORNE	4,252	1,272	156	430	307	752	953	731	403	220	300
CLARKE	8,100	2,248	158	730	605	1,769	1,912	1,024	647	635	620
CLAY	8,810	1,491	164	808	759	1,633	2,002	1,467	980	397	600
COAHOMA	11,490	996	155	619	661	1,258	2,708	2,444	1,773	887	985
COPIAH	11,101	2,487	376	766	904	2,046	2,369	1,640	1,040	757	1,203
COVINGTON	8,083	2,456	305	1,161	843	1,540	1,724	943	554	488	525
DE SOTO	40,795	2,995	3,173	9,442	6,770	7,546	7,738	4,098	885	572	571
FORREST	29,913	3,050	730	2,436	1,788	5,315	7,173	4,609	3,665	2,125	2,072
FRANKLIN	4,119	1,146	170	364	368	726	939	454	366	253	479
GEORGE	7,513	1,862	251	892	877	1,488	1,870	799	609	423	304
GREENE	4,947	1,529	185	496	429	991	1,113	681	417	277	358
GRENADA	9,973	1,459	133	824	775	1,982	2,047	1,630	1,506	561	515
HANCOCK	21,072	3,953	794	2,421	2,207	4,888	4,375	2,776	1,469	758	1,384
HARRISON	79,636	9,843	2,689	8,782	5,966	13,053	17,939	14,144	8,620	4,345	4,098
HINDS	100,287	3,954	1,646	5,282	5,430	15,762	25,162	21,866	14,469	6,585	4,085
HOLMES	8,439	2,265	207	746	661	1,546	1,880	1,278	775	483	863

Table 4e. Continued

COUNTY	Total	Mobile home	1999 to March 2000	1995 to 1998	1990 to 1994	1980 to 1989	1970 to 1979	1960 to 1969	1950 to 1959	1940 to 1949	1939 or earlier
HUMPHREYS	4,138	514	9	204	345	625	1,060	602	513	387	393
ISSAQUENA	877	265	17	60	79	201	202	111	75	73	59
ITAWAMBA	9,804	2,116	261	1,092	809	1,771	2,210	1,690	948	434	589
JACKSON	51,678	6,572	1,835	4,600	3,501	7,563	15,094	10,590	4,472	2,124	1,899
JASPER	7,671	2,143	224	644	806	1,621	1,570	1,087	686	472	561
JEFFERSON	3,819	1,257	109	326	393	886	928	442	333	182	220
JEFFERSON DAVIS	5,891	1,321	167	549	347	1,271	1,575	820	436	280	446
JONES	26,921	5,607	728	2,437	1,666	4,814	5,249	4,286	3,280	2,311	2,150
KEMPER	4,533	1,191	130	511	519	1,081	1,047	484	304	183	274
LAFAYETTE	16,587	3,058	1,327	2,149	2,111	3,292	3,499	1,779	1,077	587	766
LAMAR	15,433	2,456	686	2,966	1,985	3,283	3,022	1,354	914	537	686
LAUDERDALE	33,418	5,187	725	2,540	2,392	5,981	6,818	5,410	4,146	2,510	2,896
LAWRENCE	5,688	1,413	165	514	401	1,293	1,592	895	294	206	328
LEAKE	8,585	1,827	209	839	802	1,718	1,896	1,314	722	537	548
LEE	31,887	4,667	967	3,870	3,560	6,458	7,079	4,229	2,747	1,453	1,524
LEFLORE	14,097	1,252	186	735	732	1,942	3,757	2,785	1,848	1,050	1,062
LINCOLN	14,052	3,327	424	1,310	1,123	2,674	2,839	1,931	1,635	743	1,373
LOWNDES	25,104	3,527	491	2,199	2,063	5,442	6,065	3,304	2,797	1,063	1,680
MADISON	28,781	2,140	732	5,165	5,259	7,662	4,640	2,633	1,109	721	860
MARION	10,395	2,077	303	902	804	2,035	2,069	1,514	1,082	677	1,009
MARSHALL	13,252	3,573	388	1,403	1,258	3,300	3,198	1,827	792	367	719
MONROE	16,236	3,239	459	1,471	1,358	2,497	3,620	2,736	1,945	1,089	1,061
MONTGOMERY	5,402	813	71	401	358	855	1,005	1,034	539	509	630
NESHOBA	11,980	2,608	329	1,374	1,236	1,994	2,778	1,688	1,006	613	962
NEWTON	9,259	2,152	256	860	865	1,661	1,825	1,357	975	566	894
NOXUBEE	5,228	1,457	164	649	567	781	1,221	697	502	191	456
OKTIBBEHA	17,344	2,876	921	2,105	1,676	3,525	4,178	2,283	1,320	650	686
PANOLA	13,736	4,343	558	1,760	1,389	2,668	3,186	1,742	1,020	675	738

Table 4e. Continued

COUNTY	Total	Mobile home	1999 to March 2000	1995 to 1998	1990 to 1994	1980 to 1989	1970 to 1979	1960 to 1969	1950 to 1959	1940 to 1949	1939 or earlier
PEARL RIVER	20,610	4,902	917	2,617	2,013	4,737	4,271	2,771	1,414	767	1,103
PERRY	5,107	1,655	220	717	405	1,195	1,076	590	423	208	273
PIKE	16,720	3,302	587	1,402	979	2,910	3,332	2,216	1,854	1,484	1,956
PONTOTOC	10,816	2,363	286	1,424	1,138	2,071	2,219	1,304	1,112	520	742
PRENTISS	10,681	1,670	290	1,102	875	1,696	2,349	1,922	1,042	722	683
QUITMAN	3,923	614	63	286	292	482	776	716	568	342	398
RANKIN	45,070	8,820	2,285	8,263	5,989	10,296	9,765	4,707	2,089	907	769
SCOTT	11,116	3,160	417	1,161	965	2,001	2,565	1,710	943	752	602
SHARKEY	2,416	547	32	194	120	348	774	323	262	120	243
SIMPSON	11,307	3,080	425	1,014	1,200	2,181	2,395	1,781	788	780	743
SMITH	7,005	2,024	233	816	539	1,418	1,517	1,049	650	347	436
STONE	5,343	1,207	238	547	592	1,023	1,249	652	317	192	533
SUNFLOWER	10,338	751	178	437	646	2,098	2,603	1,893	1,051	633	799
TALLAHATCHIE	5,711	1,375	189	546	374	1,009	1,439	722	635	341	456
TATE	9,354	2,033	459	1,209	1,048	1,816	1,825	1,295	761	432	509
TIPPAH	8,868	1,681	195	920	893	1,673	1,931	1,332	773	526	625
TISHOMINGO	9,553	1,621	177	805	1,116	1,544	2,269	1,480	952	563	647
TUNICA	3,705	826	302	648	342	585	775	413	326	135	179
UNION	10,693	1,961	325	1,084	839	2,148	2,266	1,517	986	737	791
WALTHALL	6,418	1,692	193	630	655	1,298	1,231	970	546	397	498
WARREN	20,789	3,329	475	1,710	1,571	3,534	4,683	3,480	2,304	1,270	1,762
WASHINGTON	24,381	2,102	428	1,056	1,162	3,434	5,757	5,082	4,019	1,709	1,734
WAYNE	9,049	2,983	302	1,096	669	1,979	2,184	1,217	718	398	486
WEBSTER	4,344	716	58	449	330	851	820	650	444	348	394
WILKINSON	5,106	1,776	156	385	427	1,499	1,069	583	362	226	399
WINSTON	8,472	1,353	169	771	597	1,516	2,102	1,428	715	521	653
YALOBUSHA	6,224	1,689	190	578	502	1,252	1,496	860	530	255	561
YAZOO	10,015	1,854	219	688	678	1,486	2,339	1,647	1,346	683	929

which federal building codes were in effect when a structure was erected. Structure type was divided into permanent housing and mobile homes.

This division is necessary because mobile homes are more susceptible to damage from high winds since they are built to only sustain maximum winds of 110 mph, equivalent to a strong F1 on the Fujita Scale (U.S. Department of Housing and Urban Development 1997). Additionally, county area was utilized to normalize the housing and tornado data in certain map sets. In this way, counties with greater land area would not result in a greater risk area simply due to size.

Tornado Data

Tornado information and descriptions from the Tornado Project (www.tornadoproject.com/alltorns/mstorn.htm) and from the National Climate Data Center (www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms) were used to find touchdown sites, path locations, exact dates, and F-scale damage ratings of all Mississippi tornadoes over the forty-two year period. Tables 5a-5d offer a decadal breakdown of these data into tornado days per county, total number of tornadoes per county, number of tornadoes rated F2 or greater, and number of tornadoes rated F4 or F5.

These tornado archives, while invaluable to historical tornado research, do have some weaknesses. Data collection prior to the advent of technical advancements, like Doppler warning systems, was a hit and miss venture. For a tornado to be reported someone must realize that it occurred in the first place. In sparsely populated agricultural

Table 5a. Tornado Days Per County by Decade

	1960s	1970s	1980s	1990s	2000 - 2001
Adams	0	4	3	0	0
Alcorn	2	4	3	1	1
Amite	2	4	7	3	0
Attala	3	6	3	4	1
Benton	0	2	1	1	1
Bolivar	4	7	9	2	3
Calhoun	1	5	1	3	1
Carroll	0	2	2	5	1
Chickasaw	1	1	3	2	0
Choctaw	1	1	1	2	0
Claiborne	0	3	2	5	0
Clarke	1	5	5	3	2
Clay	1	1	3	0	0
Coahoma	3	6	3	2	1
Copiah	4	6	6	5	1
Covington	1	1	2	6	0
De Soto	6	2	2	2	1
Forrest	3	3	2	6	1
Franklin	0	1	3	0	1
George	1	4	2	2	1
Greene	0	5	1	1	1
Grenada	4	5	0	1	3
Hancock	2	7	7	8	3
Harrison	7	9	9	4	4
Hinds	11	13	7	5	2
Holmes	2	3	3	7	1
Humphreys	3	4	3	6	2
Issaquena	0	3	1	1	0
Itawamba	0	3	0	2	0
Jackson	5	13	6	7	4
Jasper	2	3	4	5	1
Jefferson	2	1	2	2	0
Jefferson Davis	1	4	1	3	1
Jones	4	9	9	3	3
Kemper	0	1	5	3	0
Lafayette	1	7	2	1	1
Lamar	2	3	1	4	4

Table 5a. Continued

Lawrence	2	4	1	4	0
Leake	2	6	3	3	1
Lee	2	4	2	4	1
Leflore	3	6	5	6	2
Lincoln	2	5	7	8	1
Lowndes	2	5	3	4	2
Madison	2	8	6	6	2
Marion	2	3	4	0	3
Marshall	1	2	3	4	1
Monroe	2	3	8	1	0
Montgomery	0	3	2	3	0
Neshoba	2	7	5	2	1
Newton	2	3	6	1	2
Noxubee	0	2	2	2	1
Oktibbeha	3	1	3	0	1
Panola	1	5	3	1	1
Pearl River	3	7	3	7	3
Perry	0	3	2	2	1
Pike	2	3	5	4	1
Pontotoc	1	2	2	5	1
Prentiss	3	4	3	2	2
Quitman	2	2	0	0	1
Rankin	8	7	6	5	2
Scott	5	1	5	5	0
Sharkey	0	3	5	6	0
Simpson	8	8	3	7	0
Smith	5	7	3	3	0
Stone	4	1	2	0	1
Sunflower	3	2	3	2	1
Tallahatchie	1	2	7	1	0
Tate	2	2	3	1	1
Tippah	2	3	2	2	0
Tishomingo	2	2	4	0	0
Tunica	1	2	3	0	0
Union	1	3	3	1	2
Walthall	4	1	3	4	1
Warren	7	4	4	7	1
Washington	3	7	2	3	2
Wayne	1	2	2	3	0
Webster	0	3	1	2	0
Wilkinson	1	1	4	2	1
Winston	0	2	1	1	0
Yalobusha	0	2	2	1	2
Yazoo	0	2	6	8	1

Table 5b. Total Tornadoes Per County By Decade

	1960s	1970s	1980s	1990s	2000 - 2001
Adams	0	4	3	0	0
Alcorn	2	4	3	1	1
Amite	2	4	7	3	0
Attala	3	6	4	4	1
Benton	0	2	1	1	1
Bolivar	4	7	10	6	5
Calhoun	1	5	1	4	1
Carroll	0	2	2	5	1
Chickasaw	1	1	5	4	0
Choctaw	1	1	1	2	0
Claiborne	0	3	2	5	0
Clarke	1	8	6	4	3
Clay	1	1	3	0	0
Coahoma	4	6	4	2	1
Copiah	5	6	7	8	1
Covington	2	1	2	6	0
De Soto	6	4	2	2	1
Forrest	3	5	2	7	1
Franklin	0	1	5	0	1
George	1	6	2	2	1
Greene	0	5	1	2	1
Grenada	5	5	0	3	3
Hancock	2	7	9	8	4
Harrison	7	16	15	4	6
Hinds	11	13	10	7	3
Holmes	2	3	4	8	1
Humphreys	3	5	4	6	2
Issaquena	0	4	1	1	0
Itawamba	0	3	0	2	0
Jackson	5	15	7	8	4
Jasper	2	3	5	6	1
Jefferson	2	1	2	2	0
Jefferson Davis	2	4	1	3	1
Jones	4	10	9	3	4
Kemper	0	1	6	4	0
Lafayette	1	7	3	1	1
Lamar	2	3	1	4	4
Lauderdale	0	5	5	12	2

Table 5b. Continued

Leake	2	7	3	3	1
Lee	3	4	2	4	1
Leflore	3	8	6	6	2
Lincoln	3	5	8	10	1
Lowndes	2	6	3	4	2
Madison	2	8	8	7	2
Marion	2	3	4	1	6
Marshall	1	2	3	7	1
Monroe	2	3	9	1	0
Montgomery	0	3	3	3	0
Neshoba	2	8	6	2	1
Newton	2	3	6	2	2
Noxubee	0	2	2	3	1
Oktibbeha	3	1	3	0	1
Panola	1	5	3	1	1
Pearl River	4	8	3	8	4
Perry	0	3	2	3	1
Pike	2	3	5	5	1
Pontotoc	1	2	2	8	1
Prentiss	3	5	5	3	2
Quitman	2	2	0	0	1
Rankin	8	8	10	5	3
Scott	6	1	5	5	0
Sharkey	0	4	5	6	0
Simpson	9	9	3	7	0
Smith	6	7	3	5	0
Stone	4	1	2	0	2
Sunflower	3	4	3	5	1
Tallahatchie	1	3	9	1	0
Tate	2	2	3	1	1
Tippah	2	3	2	2	0
Tishomingo	2	2	6	0	0
Tunica	1	2	5	0	0
Union	1	3	3	1	2
Walthall	4	1	3	4	1
Warren	7	4	4	7	1
Washington	3	7	2	4	2
Wayne	1	2	2	5	0
Webster	0	3	1	2	0
Wilkinson	1	1	4	2	1
Winston	0	2	1	1	0
Yalobusha	0	2	3	1	2
Yazoo	0	2	10	11	1

Table 5c. F2-F5 Tornadoes Per County By Decade

	1960s	1970s	1980s	1990s	2000 - 2001
Adams	0	1	1	0	0
Alcorn	2	3	1	0	0
Amite	0	2	1	0	0
Attala	1	1	1	1	0
Benton	0	1	0	1	0
Bolivar	1	4	1	0	2
Calhoun	1	3	0	1	1
Carroll	0	1	2	1	0
Chickasaw	0	1	1	0	0
Choctaw	1	1	0	1	0
Claiborne	0	2	1	0	0
Clarke	1	3	2	0	0
Clay	0	1	1	0	0
Coahoma	2	3	0	0	0
Copiah	2	5	1	2	0
Covington	1	1	1	3	0
De Soto	4	2	1	0	1
Forrest	0	3	1	0	0
Franklin	0	1	1	0	0
George	1	4	1	0	0
Greene	0	3	1	1	0
Grenada	3	5	0	1	0
Hancock	0	4	4	0	0
Harrison	2	5	7	1	0
Hinds	2	5	4	0	0
Holmes	1	2	1	2	1
Humphreys	1	5	4	1	1
Issaquena	0	4	0	0	0
Itawamba	0	2	0	0	0
Jackson	1	3	4	0	0
Jasper	0	2	2	2	1
Jefferson	1	1	0	0	0
Jefferson Davis	2	4	1	1	0
Jones	1	9	5	1	0
Kemper	0	1	2	2	0
Lafayette	1	3	1	1	1
Lamar	0	1	1	0	0
Lauderdale	0	3	2	1	1
Lawrence	3	3	1	1	0
Leake	2	5	2	2	0

Table 5c. Continued

Lincoln	1	5	4	2	0
Lowndes	2	4	1	2	0
Madison	1	3	5	2	1
Marion	2	2	1	0	0
Marshall	0	1	1	0	0
Monroe	2	2	3	0	0
Montgomery	0	2	1	0	0
Neshoba	0	6	3	0	0
Newton	1	3	2	1	0
Noxubee	0	1	0	2	0
Oktibbeha	2	1	0	0	0
Panola	0	3	0	0	1
Pearl River	4	3	2	1	0
Perry	0	0	1	0	0
Pike	2	2	2	0	0
Pontotoc	1	1	1	1	1
Prentiss	2	3	2	0	1
Quitman	1	2	0	0	1
Rankin	2	4	3	2	0
Scott	3	0	1	3	0
Sharkey	0	4	1	2	0
Simpson	2	7	2	3	0
Smith	2	3	2	2	0
Stone	1	0	0	0	0
Sunflower	1	3	3	1	0
Tallahatchie	1	3	5	0	0
Tate	0	1	1	0	1
Tippah	1	3	0	1	0
Tishomingo	1	2	3	0	0
Tunica	1	1	1	0	0
Union	1	3	1	1	2
Walthall	2	0	1	0	0
Warren	3	2	1	2	0
Washington	1	5	1	1	1
Wayne	0	1	2	0	0
Webster	0	2	0	0	0
Wilkinson	0	0	1	1	0
Winston	0	2	1	1	0
Yalobusha	0	1	3	0	1
Yazoo	0	2	5	1	0

Table 5d. F4 - F5 Tornadoes Per County By Decade

County	1960s	1970s	1980s	1990s	2000-2001
Adams	0	0	0	0	0
Alcorn	0	1	0	0	0
Amite	0	0	0	0	0
Attala	1	0	1	1	0
Benton	0	0	0	0	0
Bolivar	0	0	0	0	1
Calhoun	0	0	0	0	0
Carroll	0	0	0	0	0
Chickasaw	0	0	0	0	0
Choctaw	1	0	0	1	0
Claiborne	0	0	0	0	0
Clarke	0	0	1	0	0
Clay	0	0	0	0	0
Coahoma	0	0	0	0	0
Copiah	1	1	0	1	0
Covington	0	0	0	0	0
De Soto	0	0	0	0	0
Forrest	0	0	0	0	0
Franklin	0	0	0	0	0
George	0	0	0	0	0
Greene	0	0	0	0	0
Grenada	0	1	0	0	0
Hancock	0	0	0	0	0
Harrison	0	0	0	0	0
Hinds	1	0	0	0	0
Holmes	0	1	0	0	0
Humphreys	0	2	0	1	0
Issaquena	0	2	0	0	0
Itawamba	0	0	0	0	0
Jackson	0	0	0	0	0
Jasper	0	0	0	1	0
Jefferson	1	0	0	0	0
Jefferson Davis	0	1	0	0	0
Jones	0	0	1	0	0
Kemper	0	0	1	0	0
Lafayette	0	0	0	0	0
Lamar	0	0	0	0	0
Lauderdale	0	1	1	0	0
Lawrence	0	2	0	0	0
Leake	1	0	0	1	0
Lee	1	0	0	0	0

Table 5d. Continued

Leflore	0	2	0	0	0
Lincoln	0	1	0	0	0
Lowndes	0	0	0	0	0
Madison	0	1	0	0	1
Marion	0	0	0	0	0
Marshall	0	1	0	0	0
Monroe	0	0	0	0	0
Montgomery	0	0	0	0	0
Neshoba	0	0	0	0	0
Newton	0	1	0	1	0
Noxubee	0	0	0	0	0
Oktibbeha	1	0	0	0	0
Panola	0	0	0	0	0
Pearl River	0	0	0	0	0
Perry	0	0	0	0	0
Pike	0	1	0	0	0
Pontotoc	0	0	0	0	0
Prentiss	0	0	0	0	0
Quitman	0	0	0	0	0
Rankin	2	1	0	1	0
Scott	2	0	0	1	0
Sharkey	0	2	0	1	0
Simpson	1	3	0	1	0
Smith	1	1	0	1	0
Stone	0	0	0	0	0
Sunflower	0	2	0	0	0
Tallahatchie	0	0	0	0	0
Tate	0	0	0	0	0
Tippah	0	1	0	0	0
Tishomingo	0	0	0	0	0
Tunica	0	0	0	0	0
Union	0	0	0	0	0
Walthall	0	0	0	0	0
Warren	0	1	0	0	0
Washington	0	2	0	1	1
Wayne	0	0	1	0	0
Webster	0	0	0	0	0
Wilkinson	0	0	0	0	0
Winston	0	1	0	0	0
Yalobusha	0	0	0	0	0
Yazoo	0	1	0	0	0

areas like the Mississippi Delta or in nature reserves there are likely to be few reports of any tornadoes that did not significantly alter the landscape. If a tornado does hit a farmer's property, but does not encounter any well-built structure, this may result in the tornado being classified much lower on the Fujita damage scale than what the wind speeds actually could have been. In contrast, over highly populated areas like the Gulf Coast, every tornado is likely to be seen and reported. Each event is also likely to encounter a house, boat, trailer, or other building, thereby producing more damage and resulting in higher average F-scale ratings. These factors were taken into account when designing subsequent analysis maps.

The tornado paths for each decade in each county of Mississippi (Appendix A) were plotted using Severe Plot 2.0 from the Storm Prediction Center (2002). Housing structure density data was then plotted on GIS ArcView 3.3 on a county wide basis. These maps provide a visual representation of each county's risk where "risk" is defined as the threat to life and property.

Data and Database Organization

After gathering the housing data, the author entered each decade's information into a database. The data was separated by county and listed as follows: total number of housing structures, total number of mobile homes, number of homes built before 1939, between 1940 and March 1950, between 1950 and March 1960, between 1960 and March 1970, and so on.

The total number of housing structures provides a more accurate view of the population's potential effect on tornado reports, in the author's opinion, than a general county population statistic. People are more likely to group together in a neighborhood than to spread out across the entire county individually.

Although not directly used to produce the risk maps in this study, the year of construction was also included to further characterize tornado risk. As stated previously, the year of construction of a building structure indicates the federal requirements to which the structure was required to adhere. Houses built before the updated HUD standards were enacted are, generally, more susceptible to wind damage. Therefore, any county with larger percentages of such housing might choose to increase its average assumed risk.

This study is the first to combine housing and tornado data at a county level. The visual representation produced within GIS aids in understanding the patterns of risk more easily than with a spreadsheet.

Determining Risk

For each decade, comparisons between counties were performed on the following: tornado based risks, housing based risks, and a combination of tornado and housing based risks. A numerical average was established of these risks to create a decadal risk category. The decadal averages were subsequently average again to determine an overall risk for Mississippi counties. Each county's risk was classified as low, low-moderate, moderate, moderate-high, or high. The author allowed GIS to create the breaks between the categories in order to establish a comparative pattern of risk. Even when the numerical values differ greatly from decade to decade, the patterns of comparative county risk remain relatively constant. Obviously these are general classifications, and do not preclude the occurrence of anomalies in tornado occurrence. The numerical values remain on the maps for the reader to observe.

Tornado Based Risk

The first set of maps is based on tornado density where the number of F0-F5 tornadoes per county was divided by the county's land area. The majority of studies have been completed using only significant tornado (F2 or F3 and greater) data. Since Mississippi has many agricultural areas where little damage may occur the "non-significant" ratings were included, as well.

The equation for the second set of maps was: (total tornadoes)*(total housing / county land area). These maps normalized the tornado density for population where High Risk areas were expected to coincide with large population centers (ie. Biloxi, Columbus, Jackson, Hattiesburg, Tupelo). If a tornado hits, the risk would be greater where there is a higher population density. Total housing was used because the author believes it reflects the risk more accurately than population density. People tend to group in smaller areas as opposed to spreading out individually.

Mobile Home Based Risk

The number of mobile homes per county was divided by county land area to create a density map. Counties with greater mobile home densities are at greater risk of damage if a severe wind storm occurs.

Combined Risk

The mobile home data and the tornado data were combined in two ways. First, mobile home density was multiplied by tornado days per county. Counties where mobile homes would possibly interact more frequently with tornadoes, as determined by the number of tornado days, were considered to be under a higher risk.

Second, mobile home density per county was multiplied by the number of F2-F5 tornadoes experienced by the county. If a particular county experienced more tornadoes rated F2 or greater on the Fujita scale than another county and combined this risk with a prevalence of mobile homes that could potentially be destroyed at such wind speeds, the county was concluded to be at higher risk.

Decadal Change

Combining all of these stated risk factors by averaging the numerical values obtained in the previous map sets, allowed for an average county risk to be established. The decadal risks offer the opportunity to observe if any county’s assumed risk has changed significantly over the studied time period. This change may have occurred due to a shift in tornado tracks or a lifestyle shift in housing or population.

CHAPTER V

RESULTS AND DISCUSSION

Thirty-one graphical representations of Mississippi's county-by-county risk were produced on GIS. Each decade is color-coded for easy comparison. The 1960s are presented in yellow, the 1970s in purple, the 1980s in red, the 1990s in blue, and 2000-2001 in green.

Tornado Based Risk

Figures 3a-3e provide tornado density information. The 1960s data (Figure 3a) classified De Soto, Harrison, Warren, Hinds, and Simpson as High Risk in this category. Ten others were considered Moderate-High Risk.

During the 1970s (Figure 3b) the High Risk category, which included Harrison, Jackson, Hancock, Jones, Simpson, and Hinds counties, shifted south. Fourteen counties classified as Moderate-High Risk. Although one might assume the increased activity was partially due to the significant tornado outbreak of 1974, this was found not to be the case. In fact, according to the historical data, tornadic activity in Mississippi was minimal during that entire year.

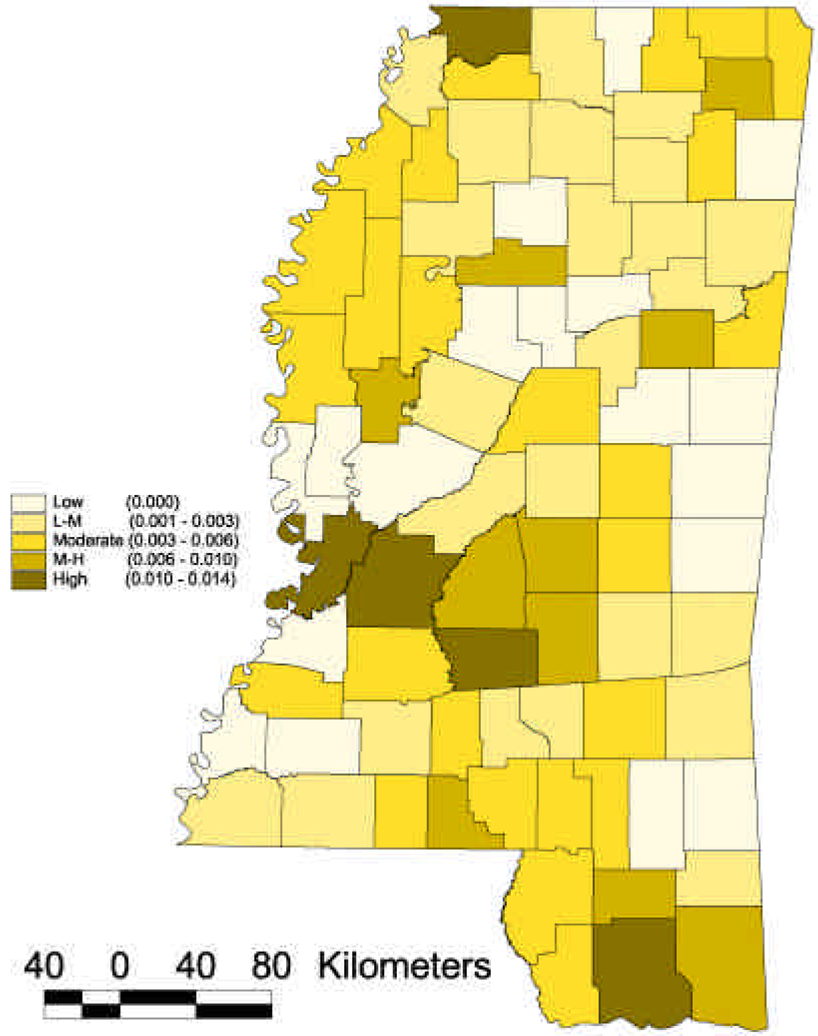

Figure 3a. Tornado Density Per County (F0-F5) from 1960-1969

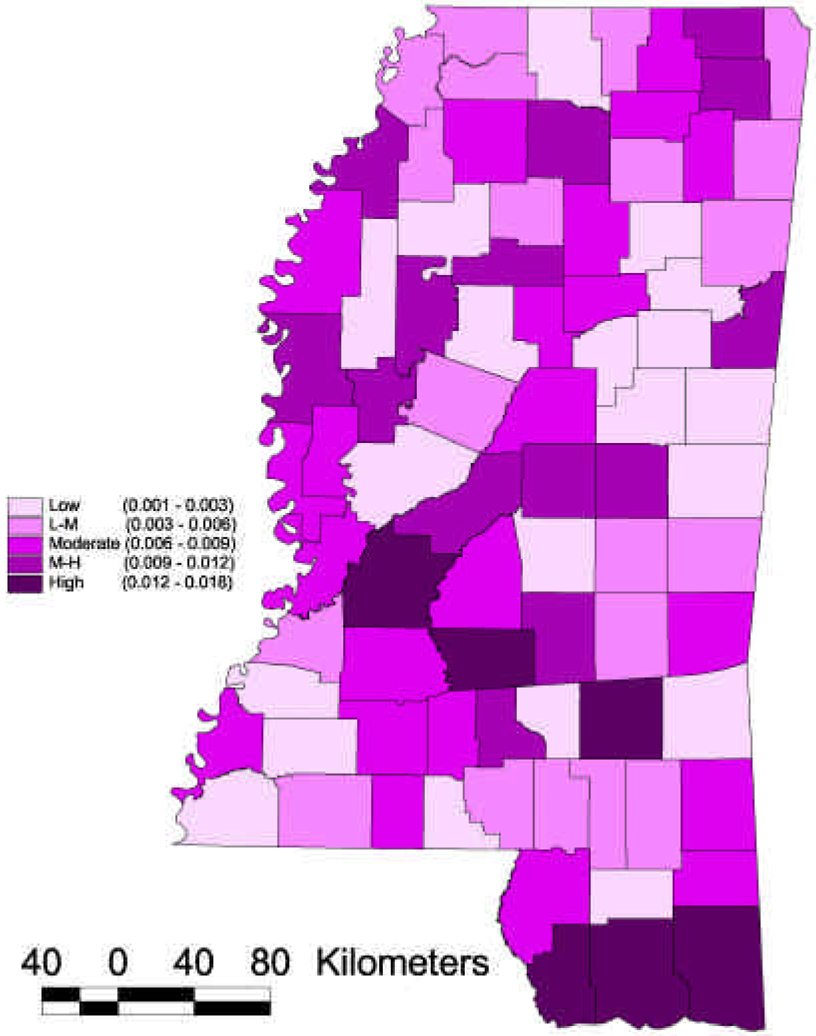

Figure 3b. Tornado Density Per County (F0-F5) from 1970-1979

Figure 3c shows a more widespread High Risk group for the 1980s including Tallahatchie, Monroe, Sharkey, Pike, Lincoln, Jones, Harrison, and Hancock. Thirteen counties fell into the Moderate-High Risk category.

The 1990s, illustrated in Figure 3d, provided an increase in the number of High Risk areas than in the other decades. A total of nine counties belong in this grouping, including Humphreys, Sharkey, Warren, Lauderdale, Hancock, Forrest, Covington, Simpson, and Lincoln. An increase to sixteen counties was also seen in the Moderate-High Risk category.

Illustrating the risks for 2000-2001 (Figure 3e) admittedly does not offer the best comparison to the other decades with a complete ten years of accumulated tornado data. However, the reason for including these years is to be able to look back at the end of the decade to see if the trends continued or drastically altered. Keeping that reasoning in mind, Harrison, Hancock, Lamar, Marion, and Grenada counties are considered High Risk for this period.

Over the study period, tornado densities shifted with every decade. However, Harrison County and Hancock County offered an interesting pattern, as they both appeared in the High Risk category almost every decade. Since other counties with major population centers did not adhere to such a pattern, this can be considered significant.

Population is considered an important factor in the number of storm reports each year. If a tornado occurs near a major population center there are plenty of people who

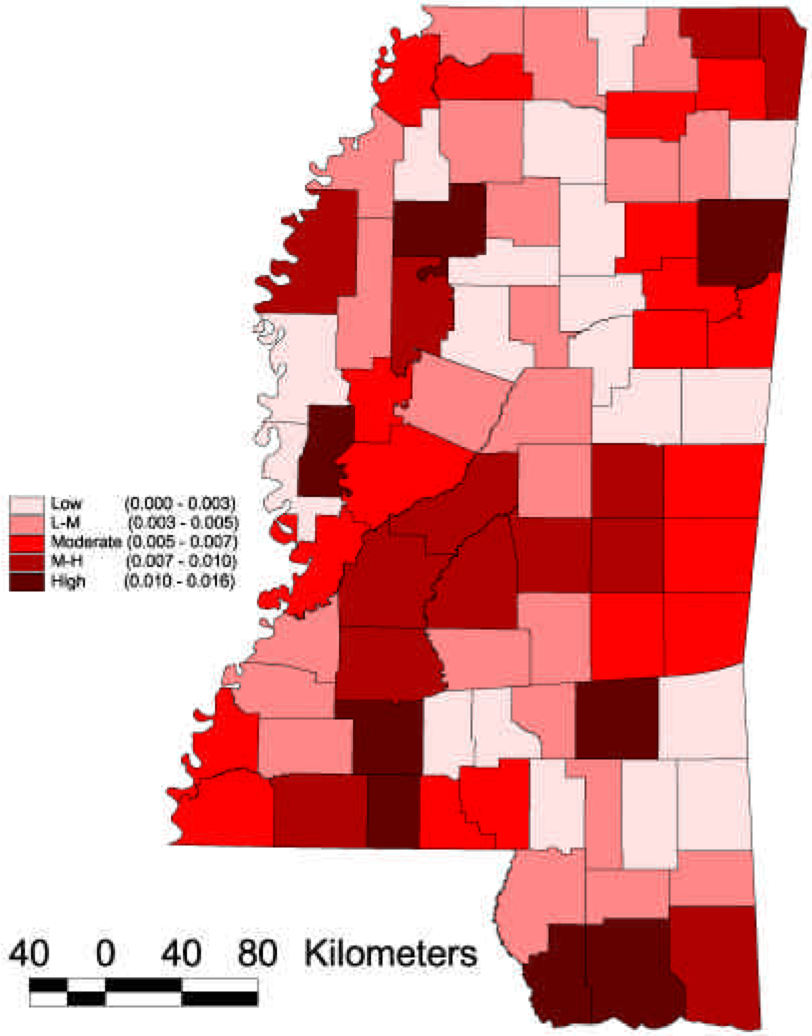

Figure 3c. Tornado Density Per County (F0-F5) from 1980-1989

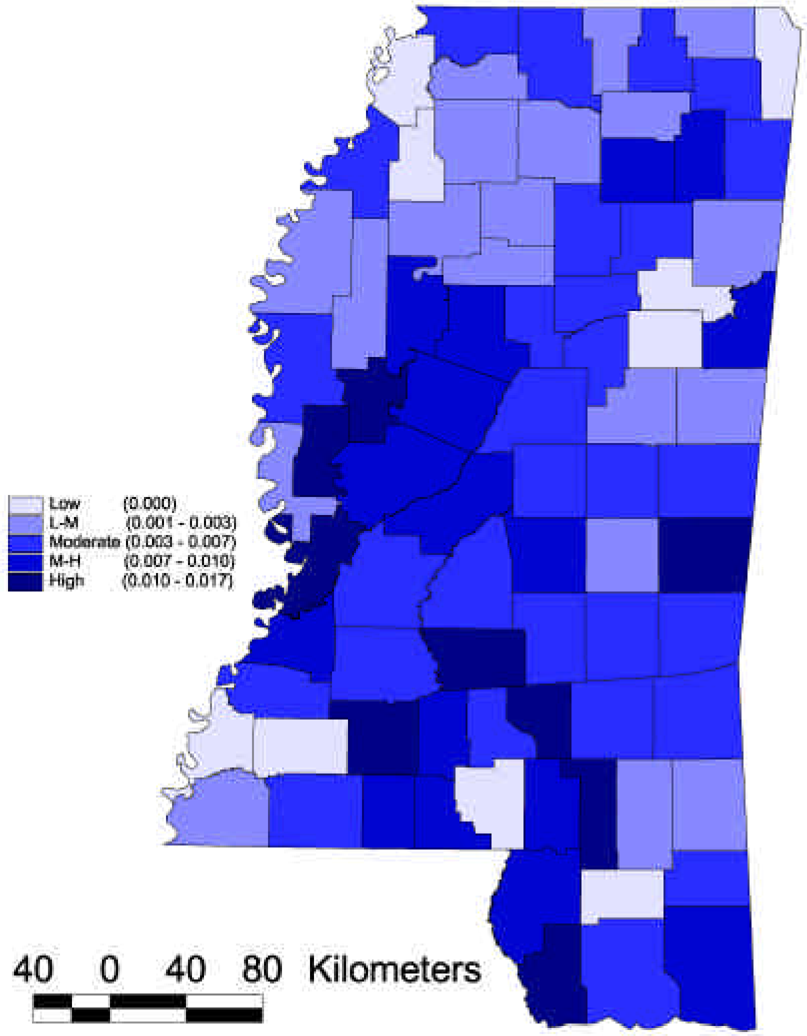

Figure 3d. Tornado Density Per County (F0-F5) from 1990-1999

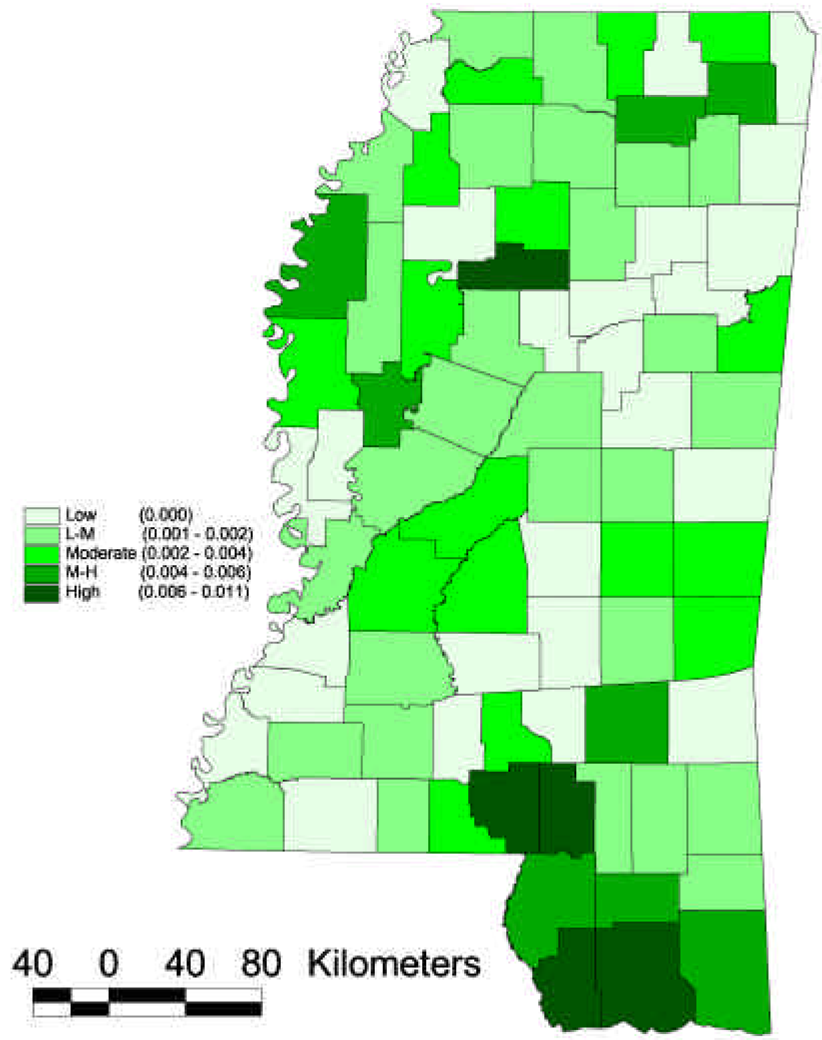

Figure 3e. Tornado Density Per County (F0-F5) from 2000-2001

will see it and then report the event. If one occurs in an open field, and does not cause considerable damage to anyone or anything, chances are the event will go unreported. Therefore, in an attempt to normalize for population, Figures 4a-4e were calculated by taking the total number of housing units divided by county land area and multiplying that by the total number of tornado reports (F0 to F5). It should be noted that there was no available housing data given for Hinds County in the 1960 Census.

Only Harrison County classified as High Risk in the 1960s in this set of maps (Figure 4a). Ten counties were found to be Moderate-High Risk and fifteen counties were areas of Moderate Risk.

The 1970s (Figure 4b) added Hinds County to Harrison County in the High Risk category. Nine other counties were considered Moderate to Moderate-High Risk.

The 1980s show a similar trend with Harrison and Hinds Counties the sole occupants of the High Risk category (Figure 4c). Three counties fell under Moderate-High Risk and nine counties under Moderate Risk.

In the 1990s (Figure 4d) the High Risk category expanded to include Lauderdale, Jackson, Forrest, Hinds and Harrison Counties. Moderate-High Risk encompassed eight counties and fifteen counties were Moderate Risk.

Figure 4e shows that the years following 2000-2001 might form a similar pattern. Harrison County is considered to be High Risk for this period, with ten counties found in the Moderate Risk to Moderate-High Risk categories.

Counties with high population densities, like Harrison and Hinds Counties, would be expected to dominate the High Risk category for this set of maps and, therefore,

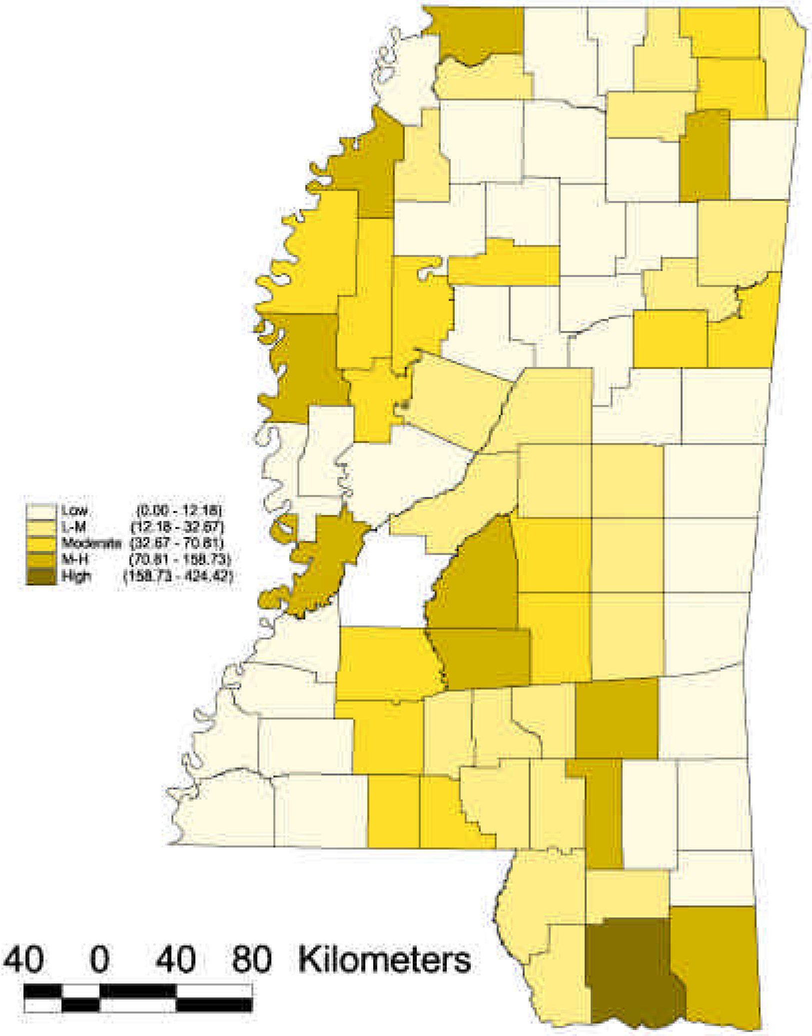

Figure 4a. Total Tornadoes Per County (1960-1969) Normalized for Housing Density

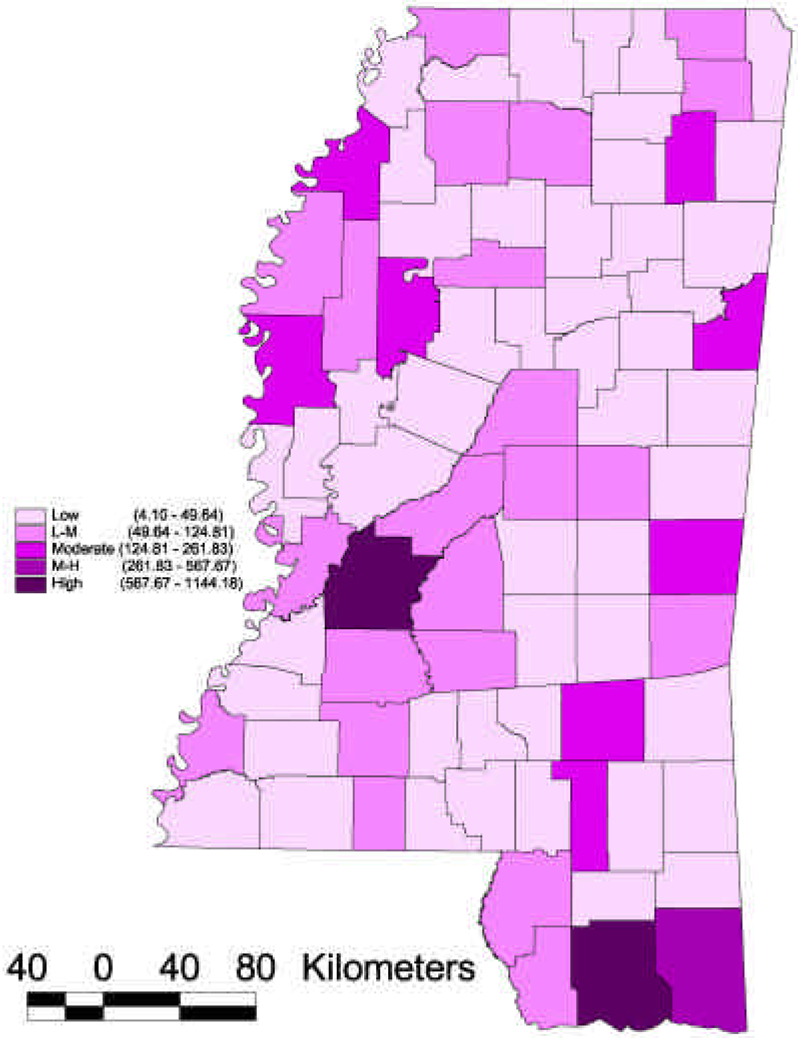

Figure 4b. Total Tornadoes Per County (1970-1979) Normalized for Housing Density

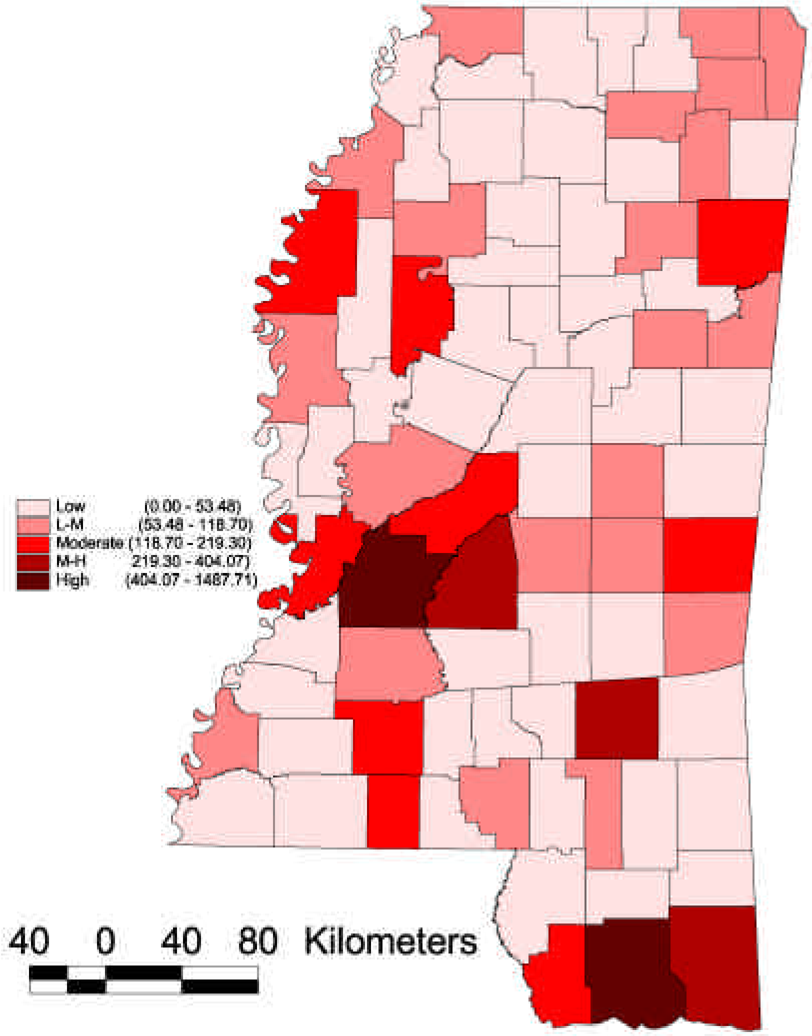

Figure 4c. Total Tornadoes Per County (1980-1989) Normalized for Housing Density

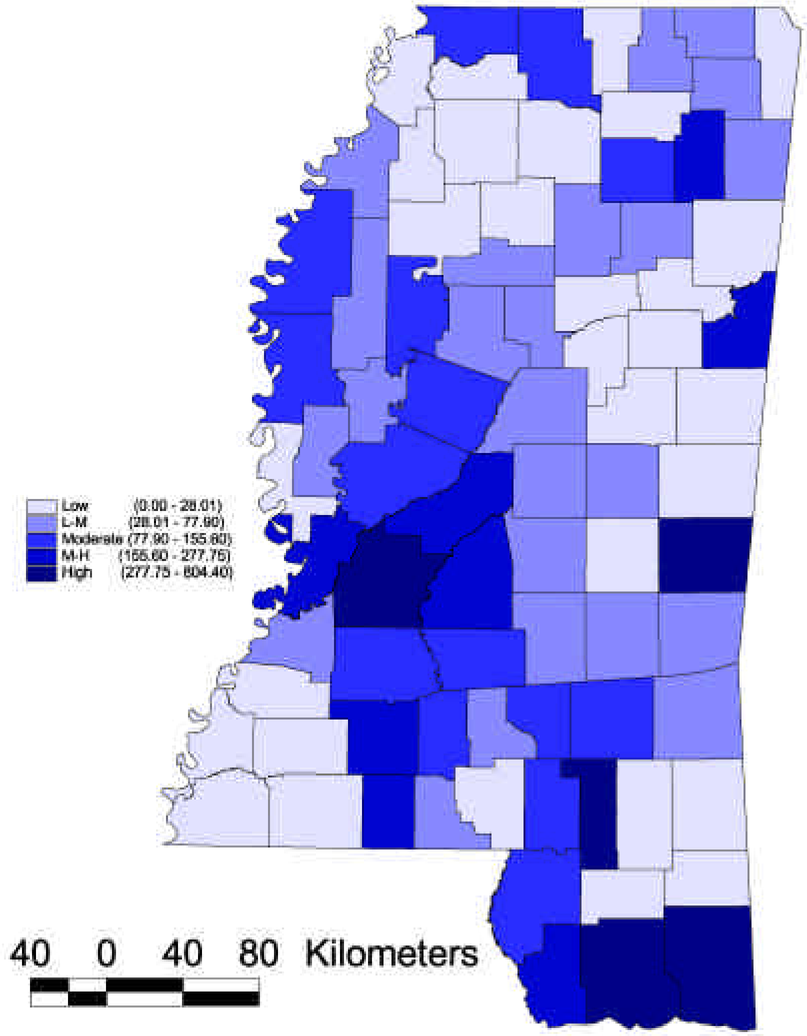

Figure 4d. Total Tornadoes Per County (1990-1999) Normalized for Housing Density

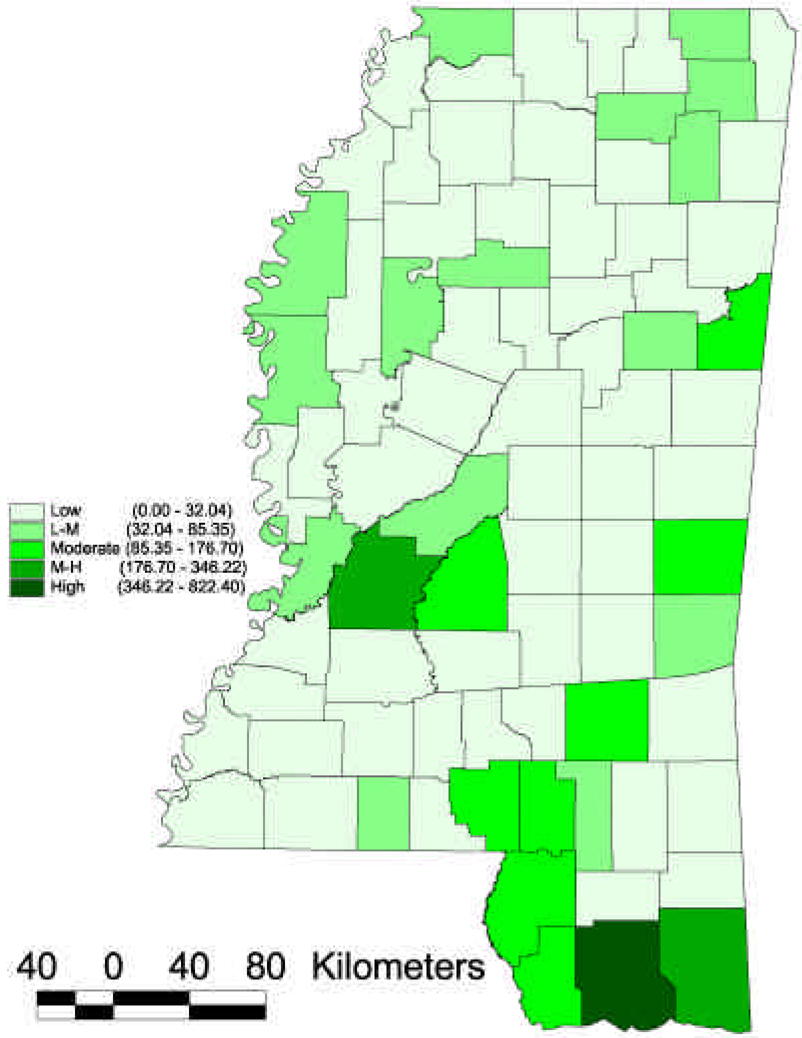

Figure 4e. Total Tornadoes Per County (2000-2001) Normalized for Housing Density

offered no surprises. However, counties in the Delta appeared in the Moderate Risk to Moderate-High Risk categories with remarkable frequency considering the lack of populated land area. Also, counties with higher population densities such as Oktibbeha County did not rank Moderate Risk or higher as often as would be expected.

Mobile Home Based Risk

As stated in earlier chapters, one type of housing at highest risk from tornadoes is manufactured housing or mobile homes. Although currently designed to withstand maximum wind speeds of 110 mph as required by 1997 HUD standards, housing census data indicates that a large percentage of each county's housing structures were built prior to the 1990s. The next three sets of maps were created with that in mind. Figures 5a-5e provide a risk assessment simply based on the density of mobile homes. Figures 6a-6e suggest the risk afforded by each county's possibility of seeing a tornado day combined with the number of mobile homes. Figures 7a-7e take this possibility one step further and combine the risk of mobile homes encountering a tornado of F2 or greater.

Harrison County once again is the sole occupant in the High Risk category for 1960 (Figure 5a). Nine counties were considered to have Moderate-High Risk housing community density.

The 1970s brought a shift in housing type (Figure 5b). Although Harrison County was the only High Risk, Moderate Risk and Moderate-High Risk classifications

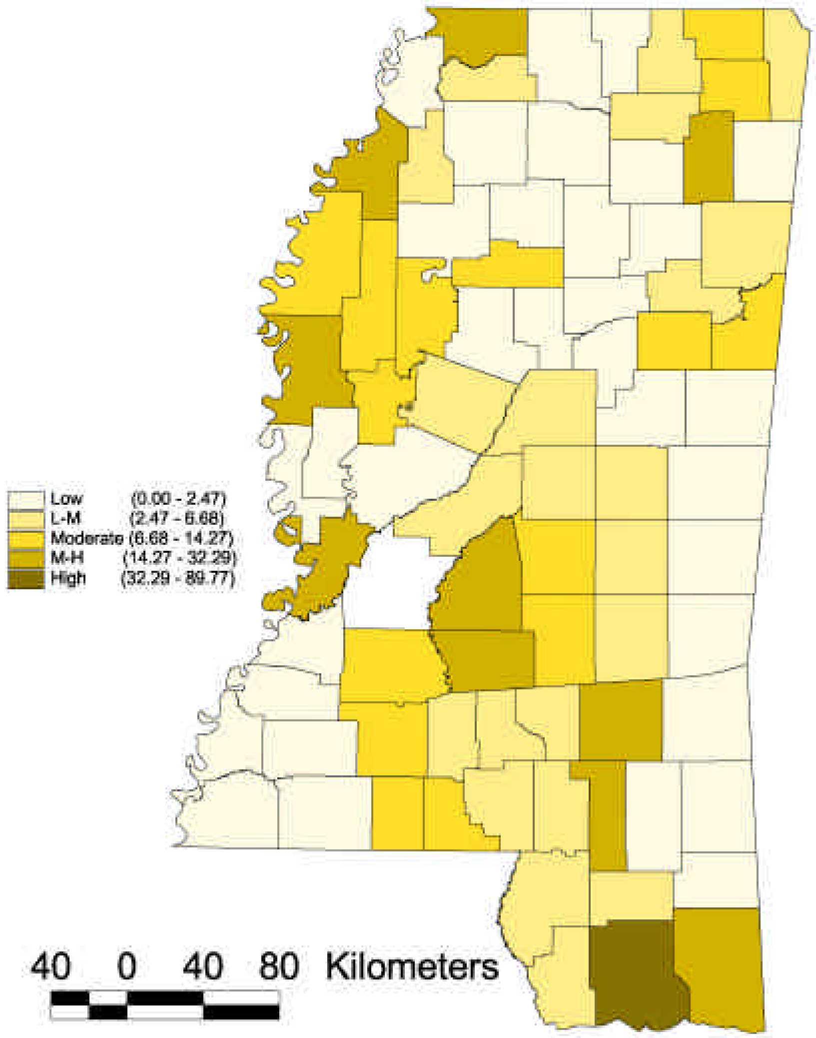

Figure 5a. Mobile Home Density Per County from 1960-1969

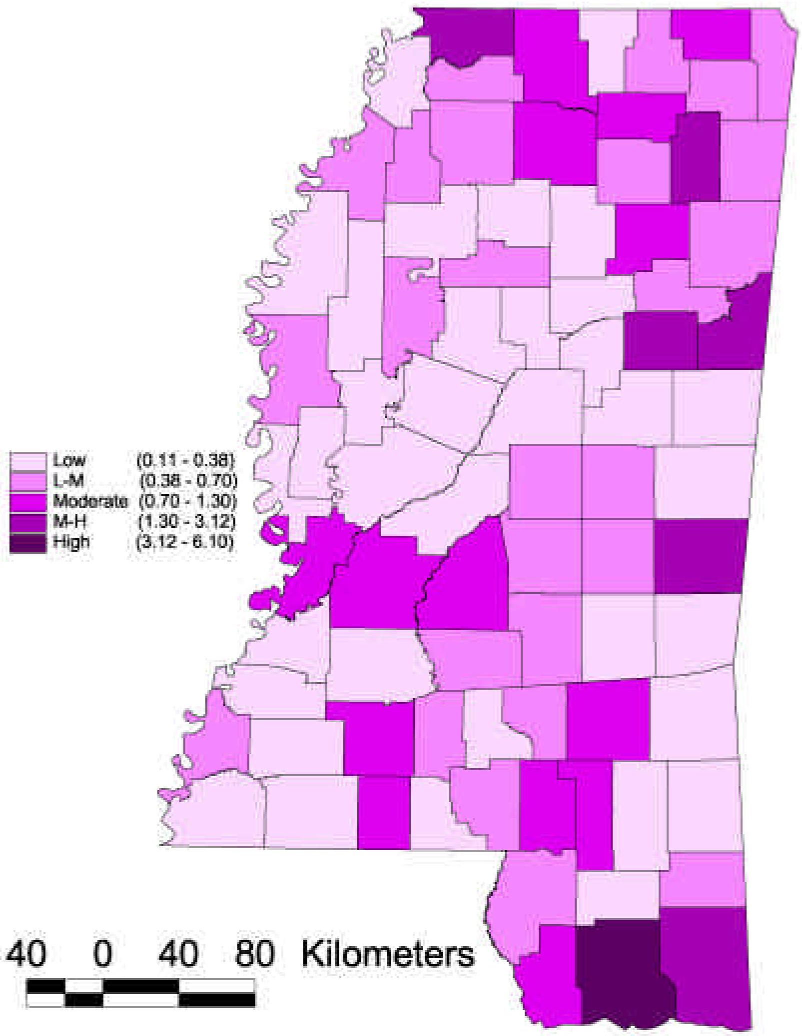

Figure 5b. Mobile Home Density Per County from 1970-1979

represented twenty counties. There was also a distinct increase in mobile home density in the North-Central portion of Mississippi.

In the 1980s, Lee, Harrison, Jackson, and Rankin County qualified as High Risk areas (Figure 5c). An additional ten counties were Moderate-High Risk.

The 1990s (Figure 5d) continued the same trend as the 1980s with Lee, Rankin, and Harrison County considered High Risk. Seven counties were Moderate-High Risk.

The 2000 Census data (Figure 5e) indicates an increased number of mobile homes concentrated within fewer counties. Harrison County is alone in the High Risk category for mobile home density this decade. Fourteen counties were considered to be Moderate Risk or Moderate-High Risk.

Harrison County dominated this category for High Risk incidence. Perhaps more significant is the lack of mobile home density in the Delta, though this may be due to a general lack of population. Another interesting occurrence was the persistence of Low Risk community housing in Benton County even though it was surrounded by counties at potentially higher risk.

Combined Risk

When tornado days are factored into the equation of risk, the trends remain essentially the same with a few minor differences. Harrison County was the only High Risk for the 1960s (Figure 6a). A marked decrease in the number of Moderate-High Risk

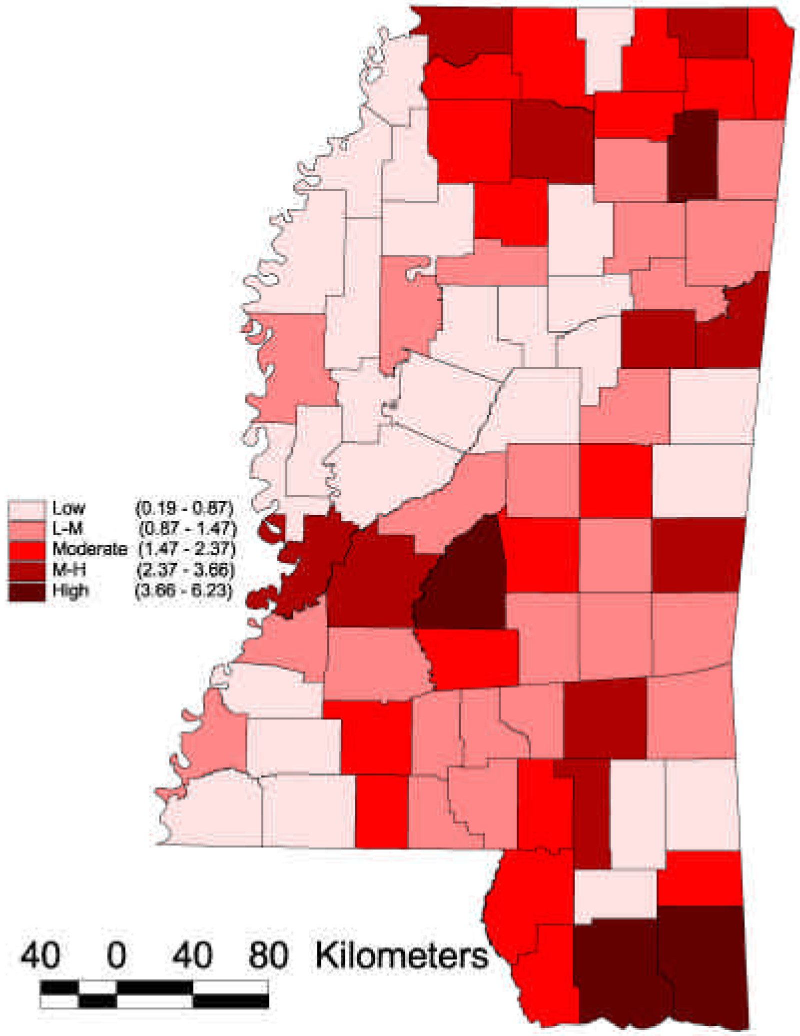

Figure 5c. Mobile Home Density Per County from 1980-1989

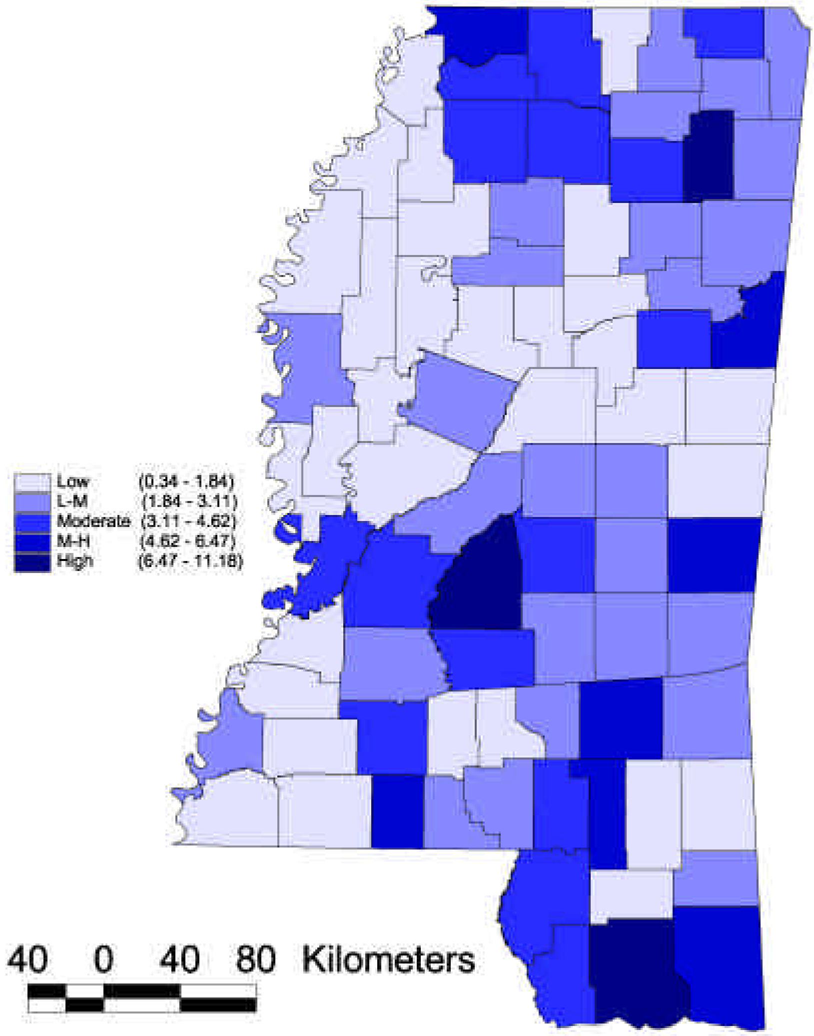

Figure 5d. Mobile Home Density Per County from 1990-1999

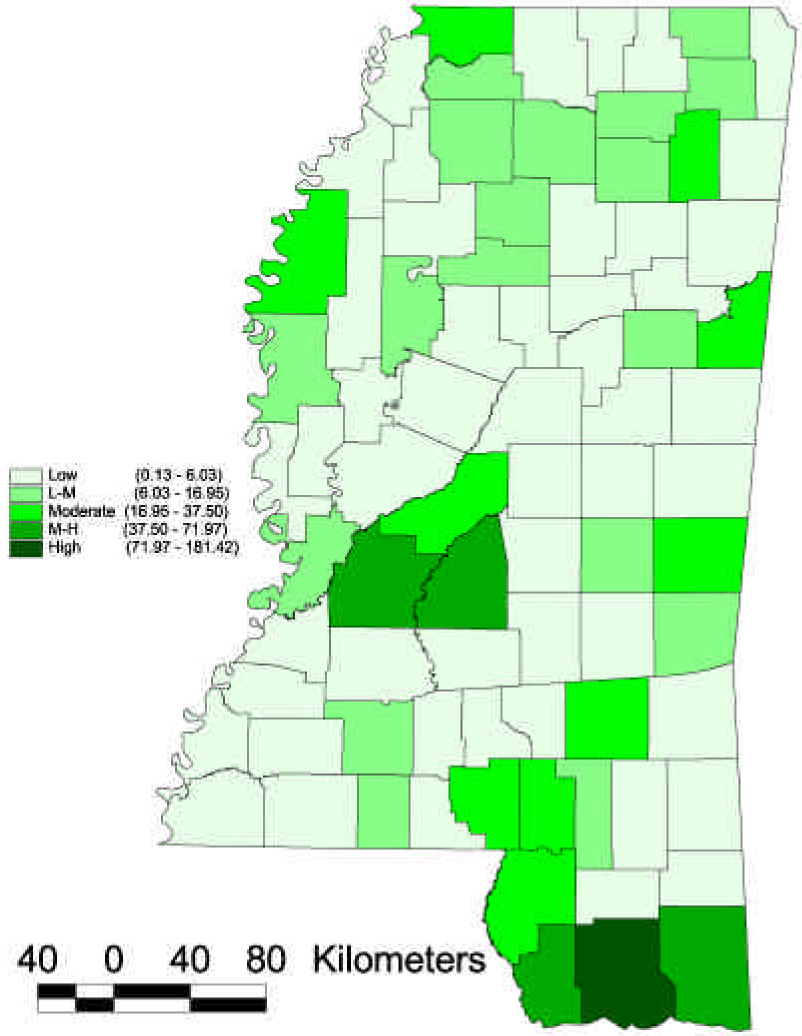

Figure 5e. Mobile Home Density Per County from 2000-2001

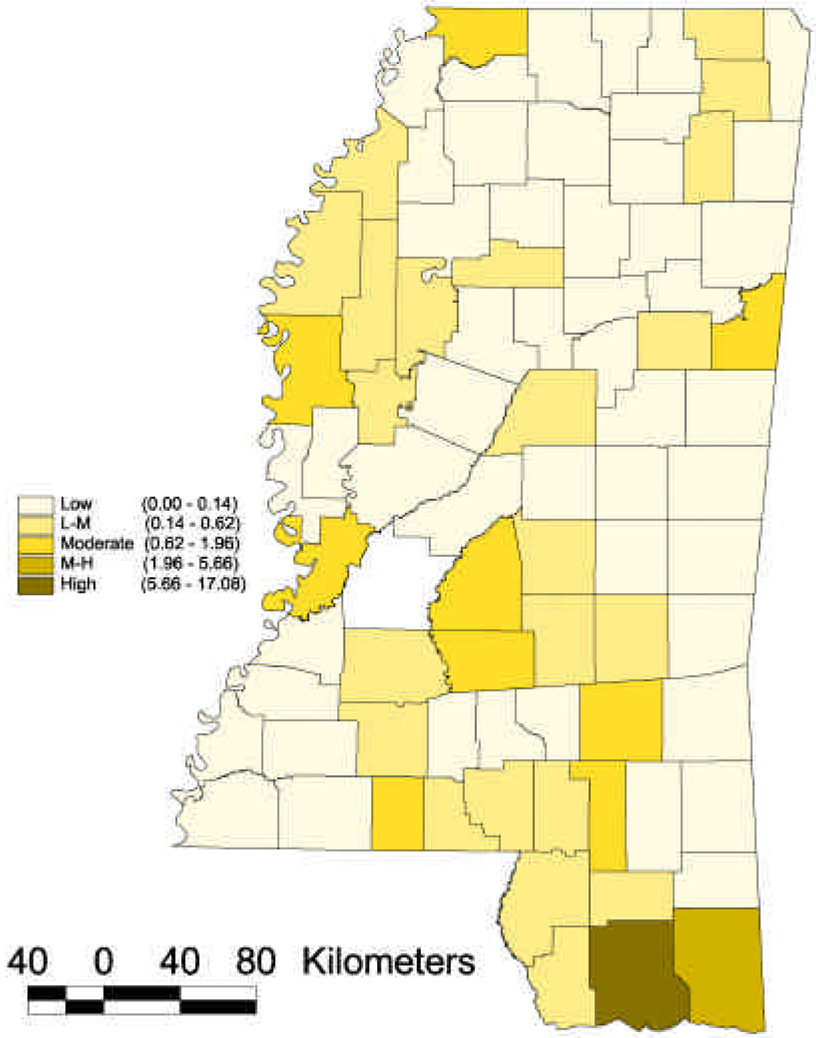

Figure 6a. Mobile Home Density and Tornado Days Per County (1960-1969)

counties occurred in this map set with Jackson County the only one in this category during the 1960s. Nine other counties were considered to be Moderate Risk.

During the 1970s, Harrison County and Jackson County were High Risk communities (Figure 6b). Five counties were Moderate-High Risk and six counties were Moderate Risk.

The 1980s show a general increase in the number of counties under a Moderate to High Risk (Figure 6c). Rankin, Jones, Harrison, and Jackson County were High Risk. Eight counties were Moderate-High Risk.

Risk factors for the 1990s indicate Rankin, Lauderdale, Jackson, Harrison, and Hancock County were High Risk (Figure 6d). In this instance, it could be possible that the positioning of the Gulf Coast counties in this risk group was due to a greater than average occurrence of land falling tropical systems or a predilection to sea-breeze induced tornadic activity. Nine other counties were grouped into the Moderate-High Risk.

The map for 2000-2001 (Figure 6e) is closer to the results from the 1960s to 1980s. Harrison County is currently the only High Risk region, but twenty-eight other counties are Moderate Risk to Moderate-High Risk. The major concern for this decade is the obvious frequency of tornadoes in the Delta over just a two year period. The Moderate Risk attributed to Bolivar County and Washington County is higher than would be expected from the trends in Figures 6a-6d.

The real risk, as stated previously, is the occurrence of tornadoes rated F2 or greater in counties with high densities of mobile home communities. In 1960-1969

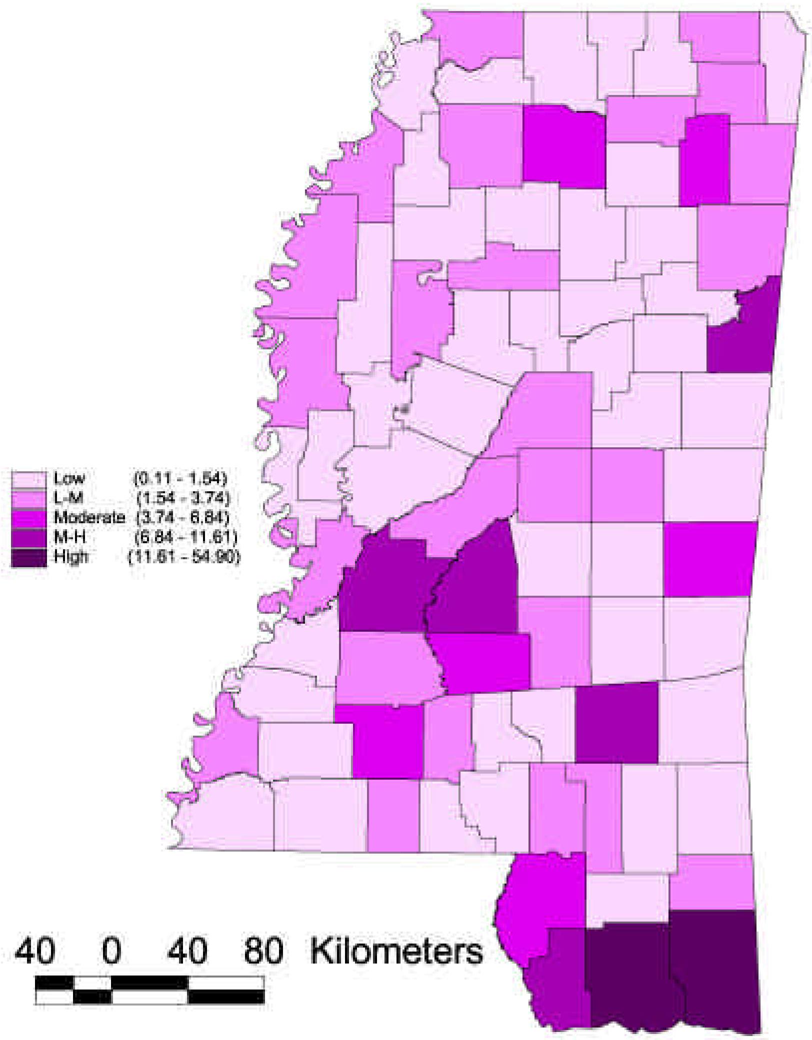

Figure 6b. Mobile Home Density and Tornado Days Per County (1970-1979)

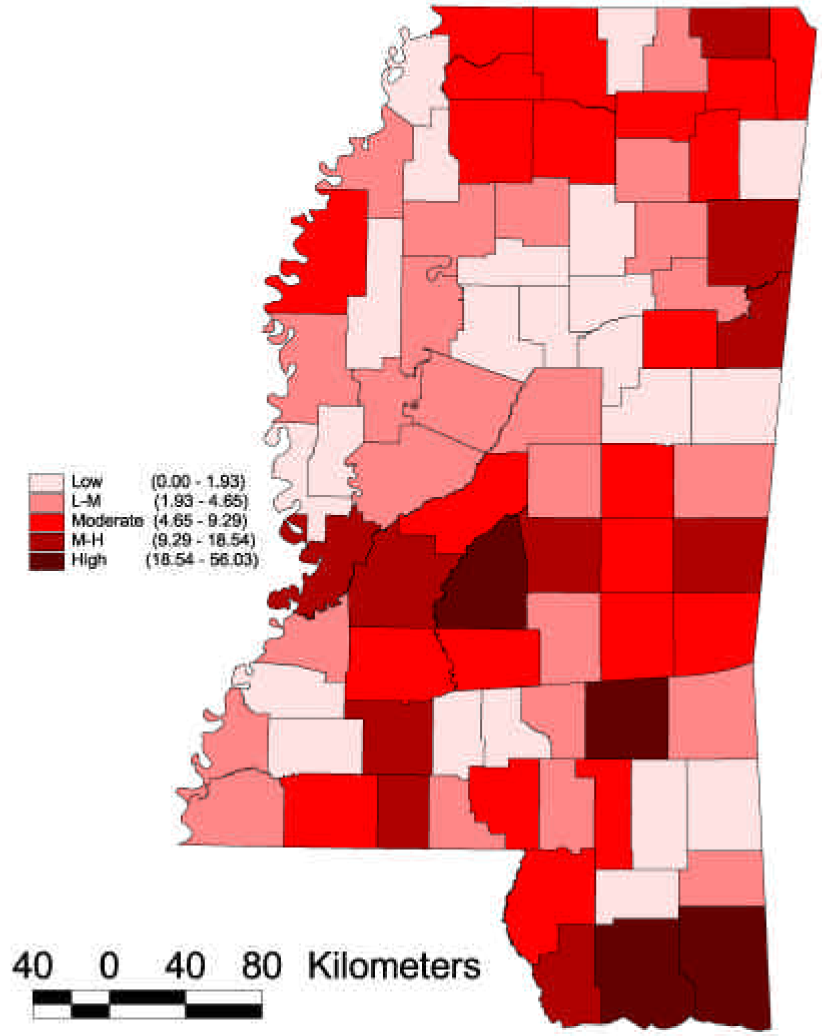

Figure 6c. Mobile Home Density and Tornado Days Per County (1980-1989)

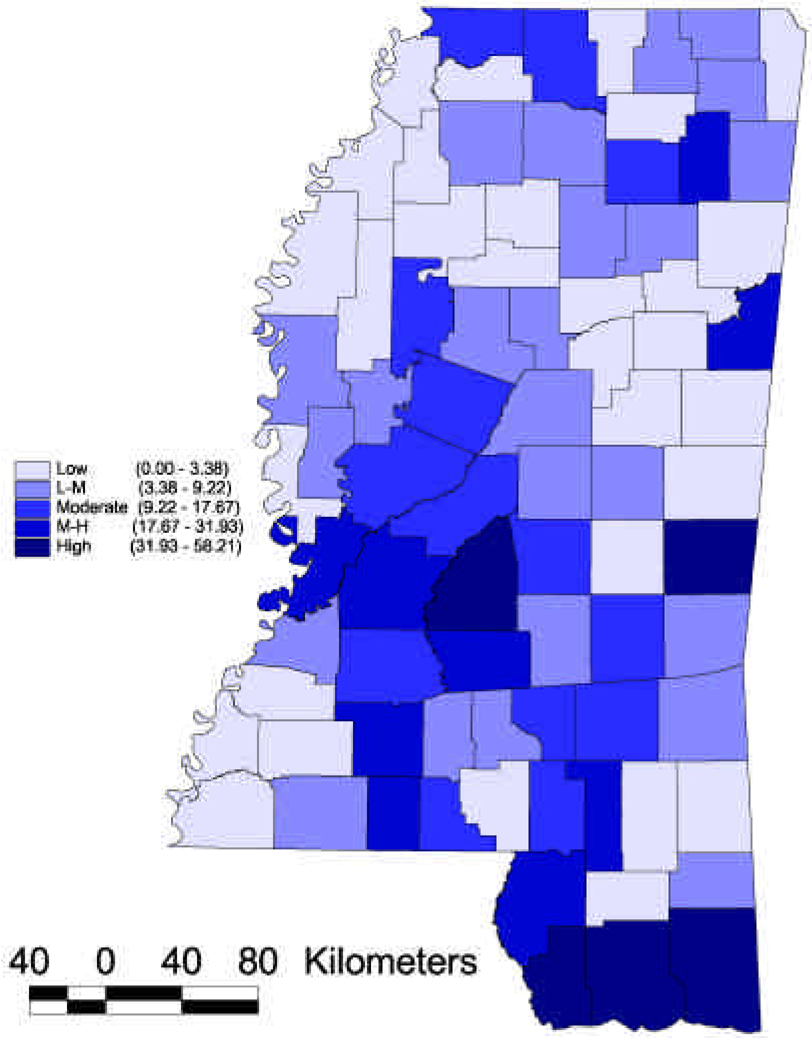

Figure 6d. Mobile Home Density and Tornado Days Per County (1990-1999)

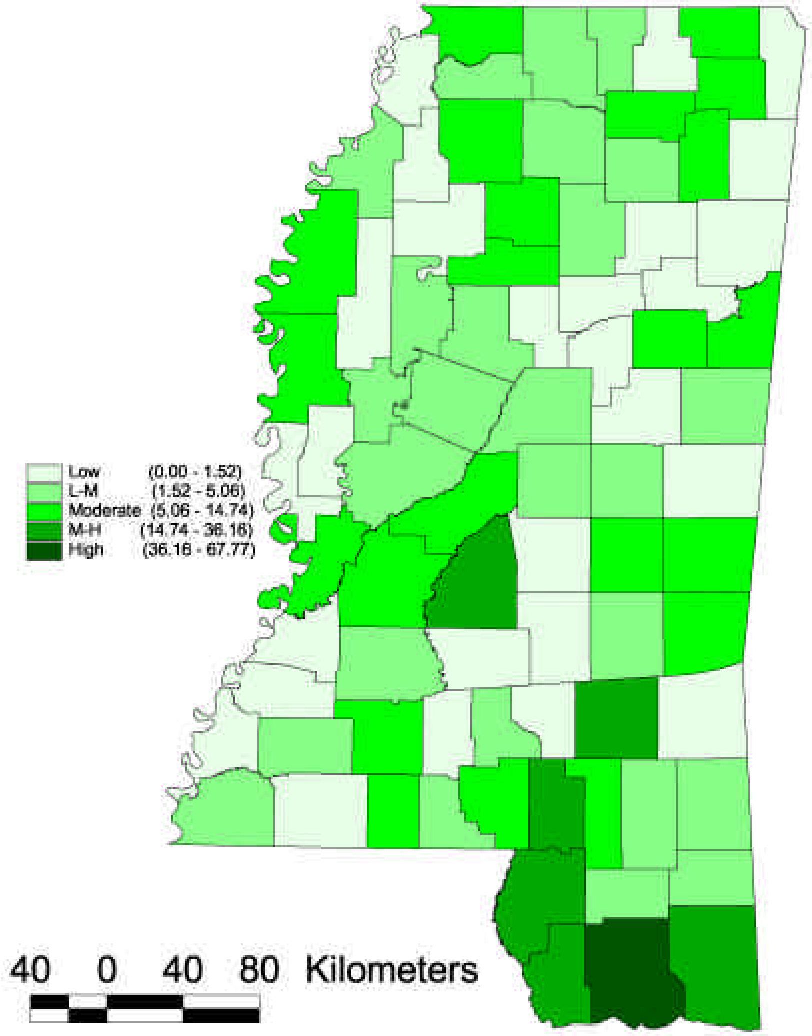

Figure 6e. Mobile Home Density and Tornado Days Per County (2000-2001)

(Figure 7a) Harrison County was the only High Risk area. De Soto, Lowndes, Jackson, Warren, and Pike County were Moderate-High Risk.

In the 1970s Harrison County remained the only county at High Risk (Figure 7b). Lowndes, Jackson, and Jones County were Moderate-High Risk.

The 1980s continued Harrison County's trend as the distinctive dweller in the High Risk category (Figure 7c). Rankin, Jones, and Jackson County were Moderate-High Risk and six other counties were grouped as Moderate Risk.

A pattern shift occurred in the 1990s to include more central Mississippi counties in the higher risk categories (Figure 7d). The exception to this was, of course, Harrison County which remained along with Rankin, Scott, Simpson, Covington, Warren, and Lowndes counties in the High Risk region. High-Moderate Risk encompassed five counties in the central portion of the state.

So far this decade, the tendency has been for more severe tornadoes to occur in northern Mississippi (Figure 7e). This data would skew more towards the southern part of the state, presumably, if the outbreak of November 2002 had been included in the data set. As of 2001, Union County and Lee County were the only ones in the High Risk category. Nine other counties fell under a Moderate-High Risk.

The interesting aspect of this map set is the absence of Harrison County in the High Risk category for the beginning of the 2000-2009 decade. The assumption could be made that this oversight will rectify itself over the remainder of the decade if the previous patterns hold. Or, perhaps it is a continuation of the 1990s drift away from the extreme southern counties.

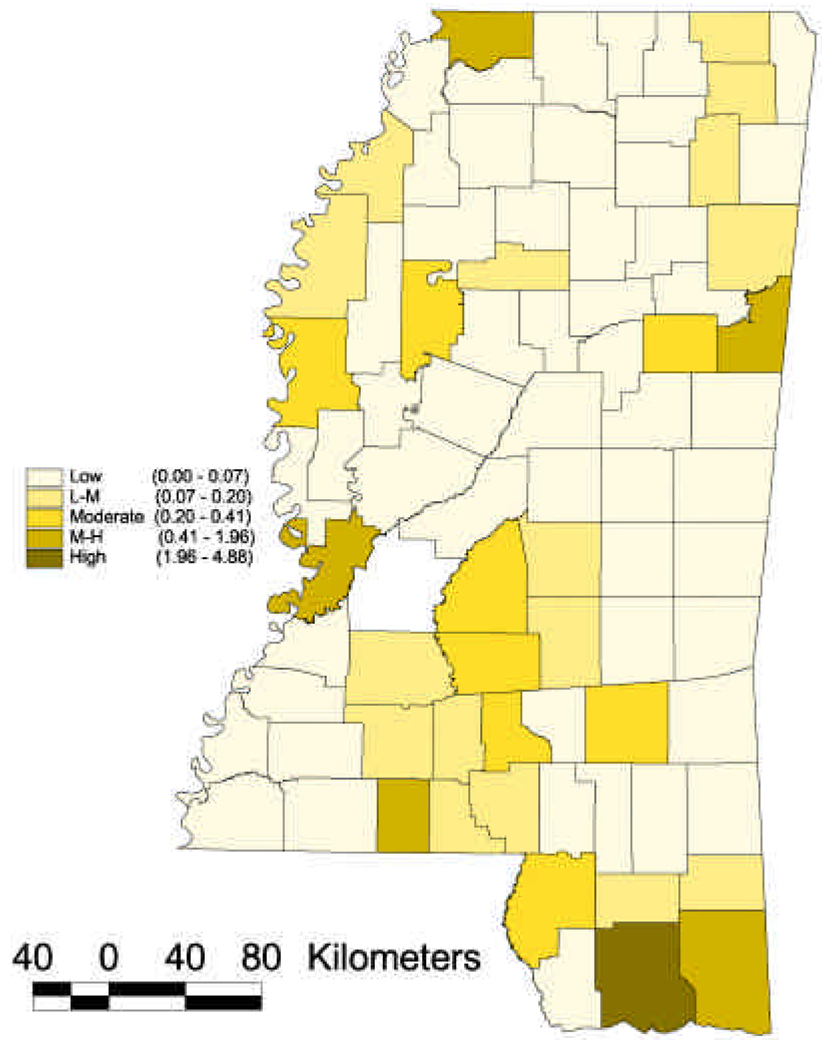

Figure 7a. Mobile Home Density and F2-F5 Tornadoes Per County (1960-1969)

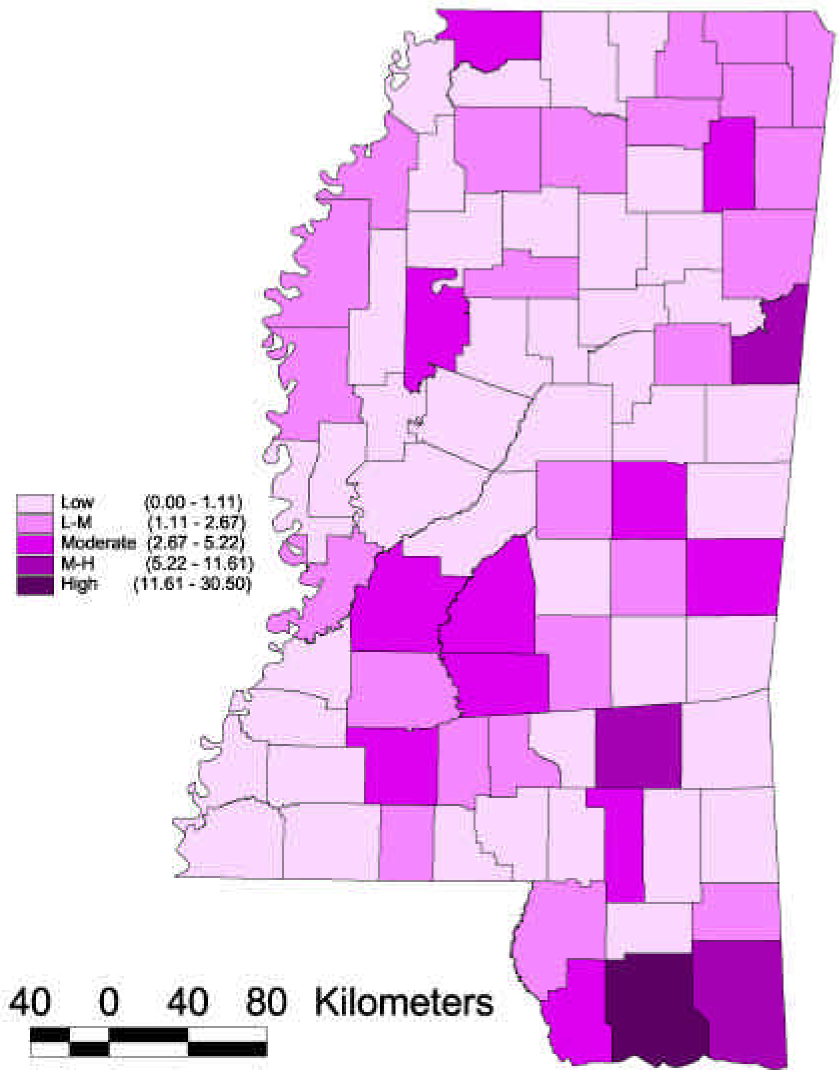

Figure 7b. Mobile Home Density and F2-F5 Tornadoes Per County (1970-1979)

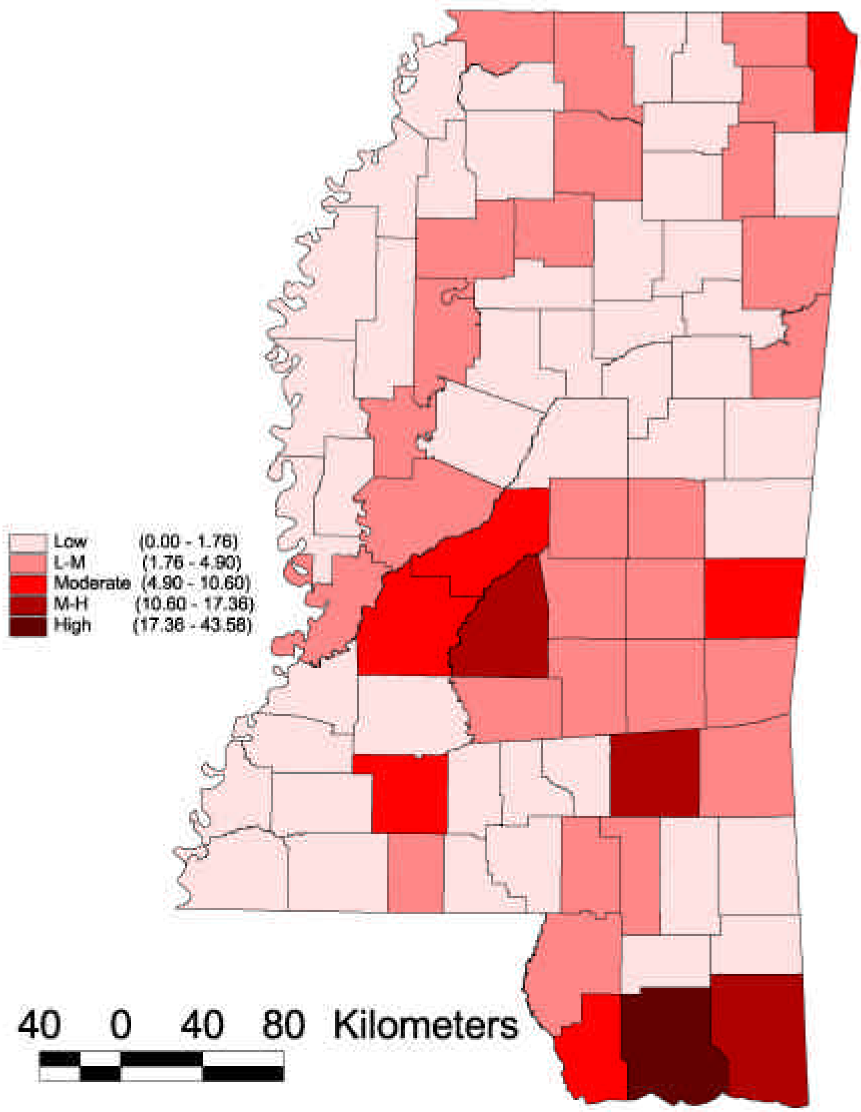

Figure 7c. Mobile Home Density and F2-F5 Tornadoes Per County (1980-1989)

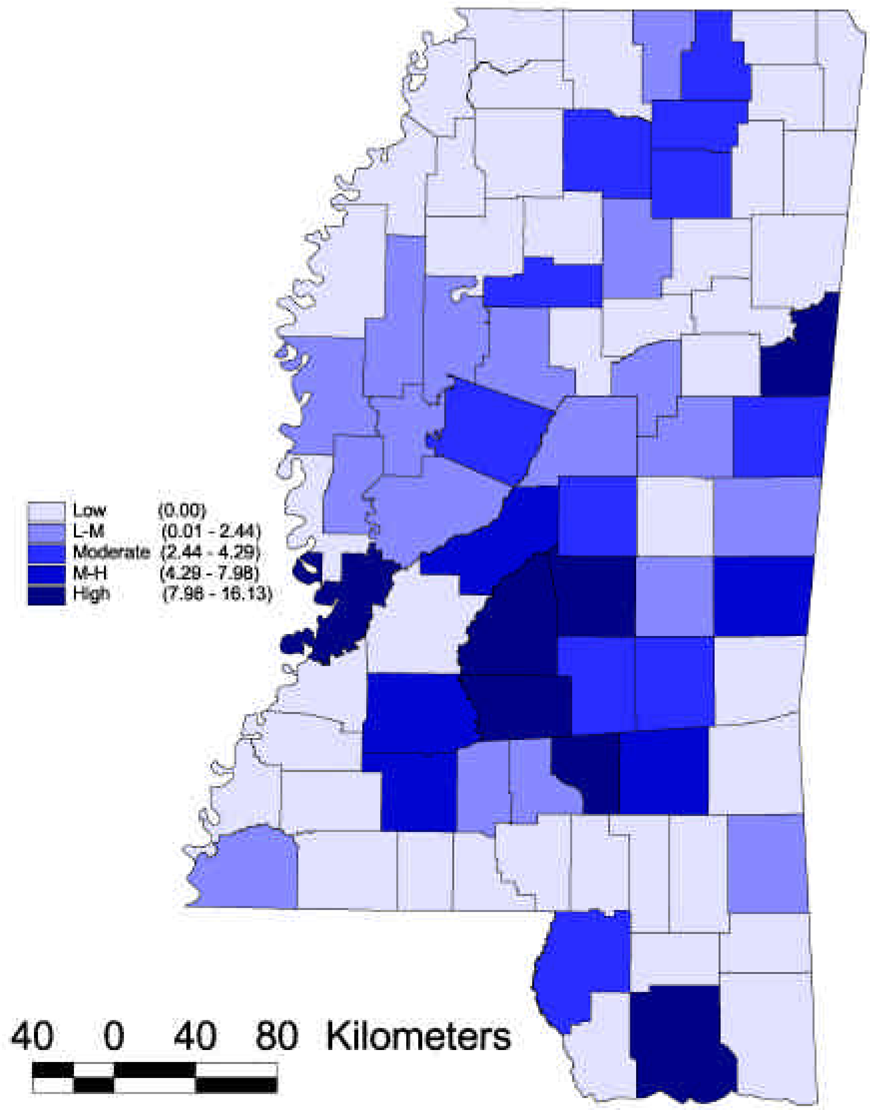

Figure 7d. Mobile Home Density and F2-F5 Tornadoes Per County (1990-1999)

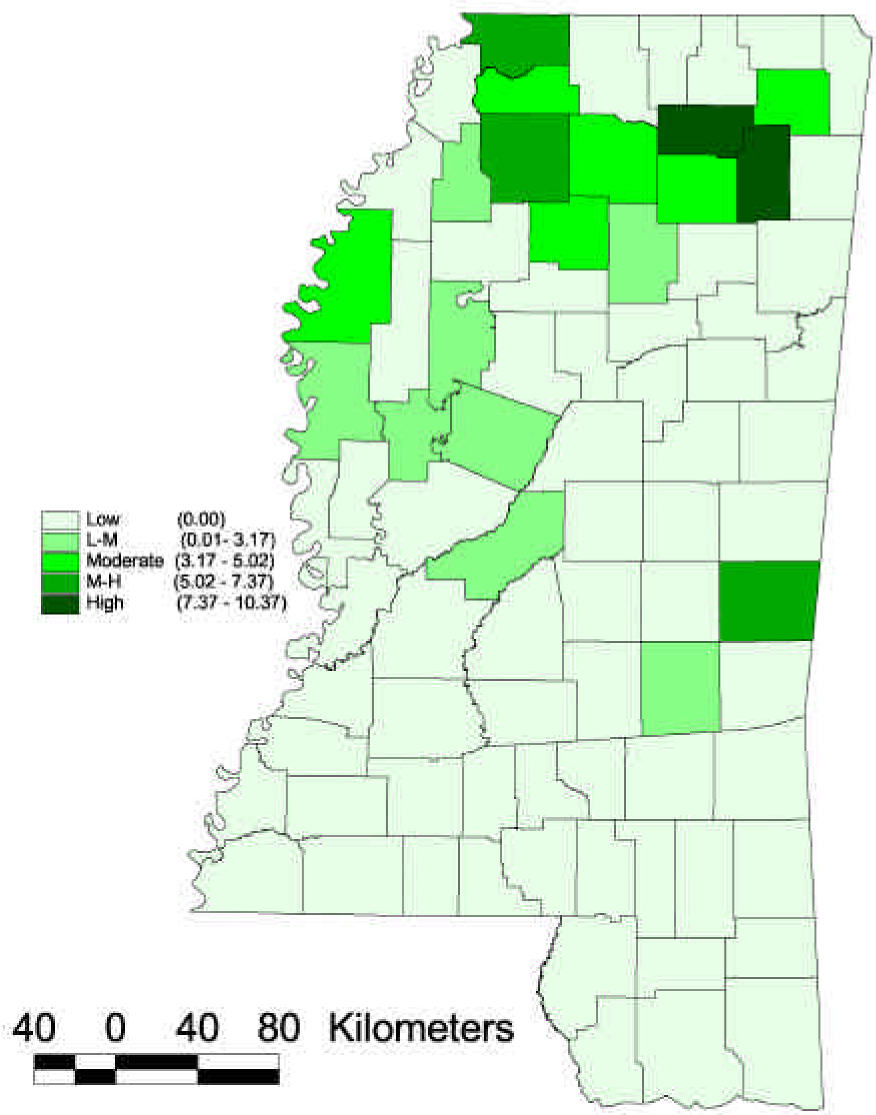

Figure 7e. Mobile Home Density and F2-F5 Tornadoes Per County (2000-2001)

Another factor that must be brought to the reader's attention is the prevalence of strong tornadoes in the Delta. Even though the mobile home densities for counties in the Delta are known to be low, these same counties were most often found in the Low-Moderate Risk or Moderate Risk categories indicating a relatively significant occurrence of F2 or greater tornadoes in a sparsely populated region.

Decadal Change

When all of these data sets are taken into consideration, a decade by decade average risk can be established. The maps in figures 8a-8e offer these initial risk assessments.

On average, Harrison County was the only High Risk area in Mississippi in the 1960s (Figure 8a). De Soto, Lee, Coahoma, Washington, Rankin, Simpson, Warren, Jones, Forrest, and Jackson counties were grouped as Moderate-High Risk. If Hinds County data had been available for this time period it is likely that it, too, would have been included in the Moderate-High Risk.

The 1970s saw the inclusion of Hinds County and Harrison County in the High Risk group (Figure 8b). Rankin, Jackson, Jones, Forrest, Lauderdale, Lowndes, Lee, Washington, Coahoma, and Leflore counties rounded out the Moderate Risk to Moderate-High Risk groups.

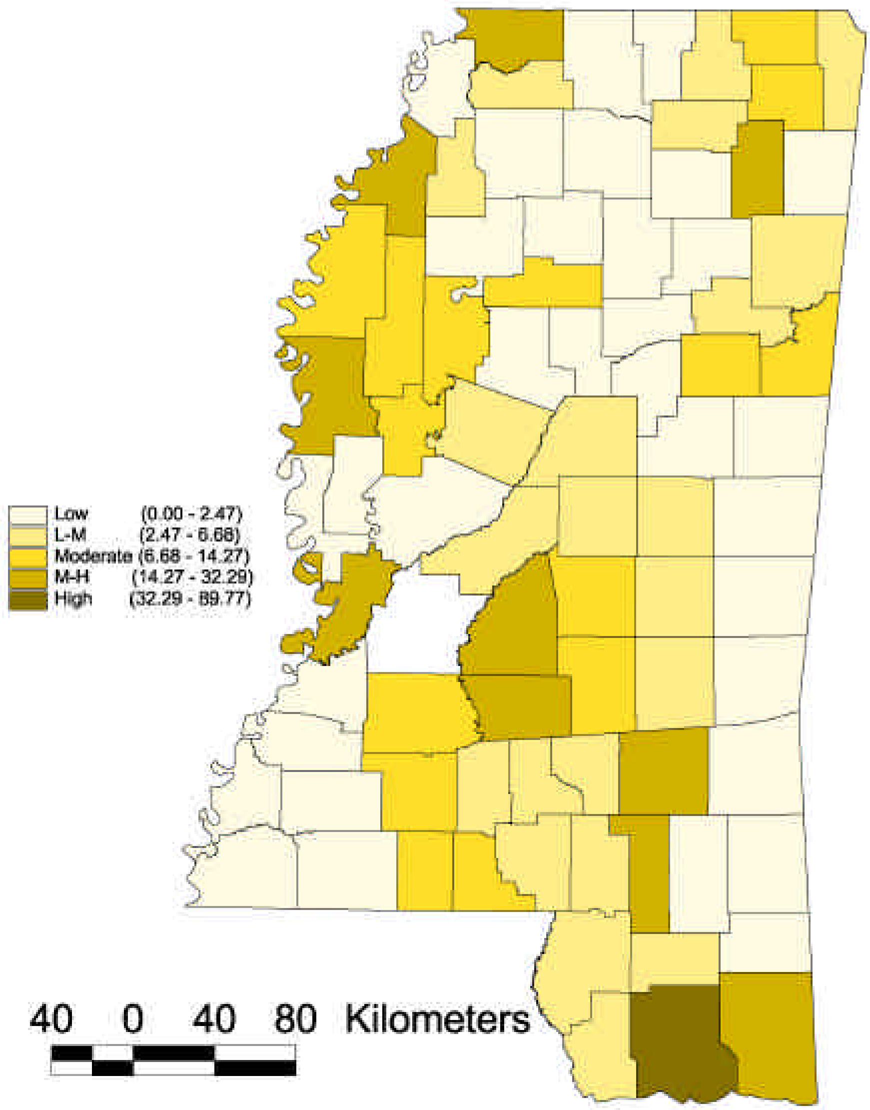

Figure 8a. Average County Risk for 1960-1969

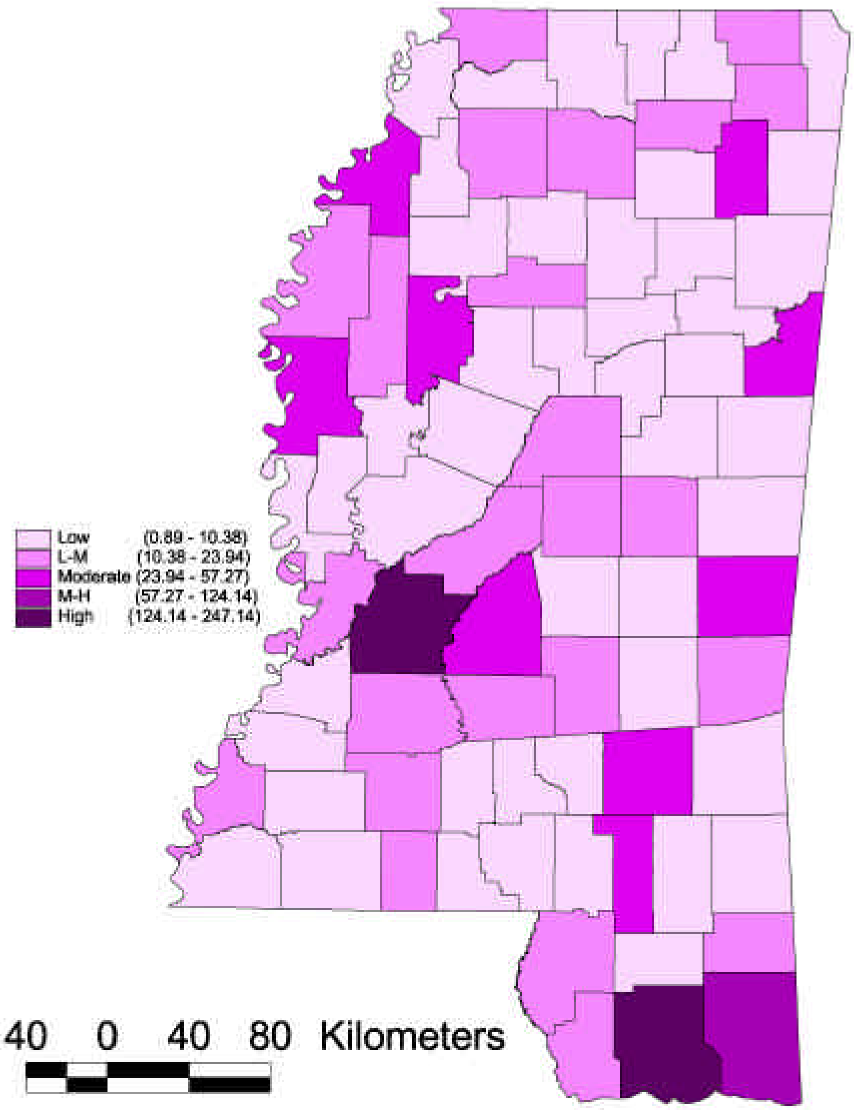

Figure 8b. Average County Risk for 1970-1979

In the 1980s, average community High Risk was located in Harrison County and Hinds County (Figure 8c). Moderate-High Risk counties included Jackson, Jones, and Rankin.

Figure 8d provides a more expansive High Risk group for the 1990s including Harrison, Jackson, Forrest, Hinds, and Lauderdale counties. Moderate-High Risk included Hancock, Pike, Lincoln, Rankin, Madison, Warren, Lee, and Lowndes counties. For this time period, Lowndes County is grouped in a surprisingly high risk category considering that it is completely surrounded by Low Risk counties. Population statistics do not adequately explain this difference.

Harrison County is so far the only site under High Risk for this decade (Figure 8e). To date, the average increased community risk this decade has centered on counties with larger populations. This is in part because of the minimal tornado data over the two year period as opposed to census housing data weighted over the entire decade. The major exception to this is Bolivar County which is already considered Moderate Risk.

Overall County by County Risk

The overall risk map for Mississippi (Figure 9) indicates that Hinds County and Harrison County are the two areas of greatest community risk from tornadoes in the state. Jackson, Rankin, Jones, and Lauderdale counties are considered to be areas of Moderate-High risk based on the factors reviewed in this study. Counties of Moderate Risk include:

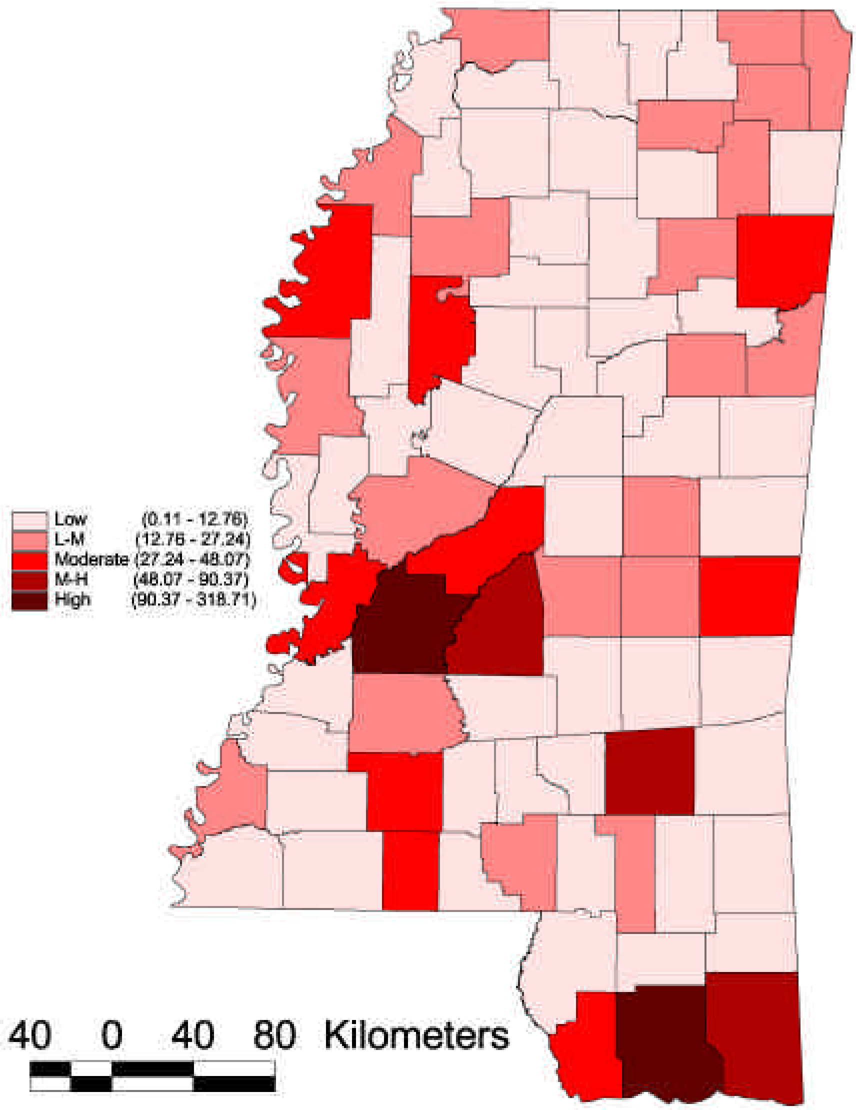

Figure 8c. Average County Risk for 1980-1989

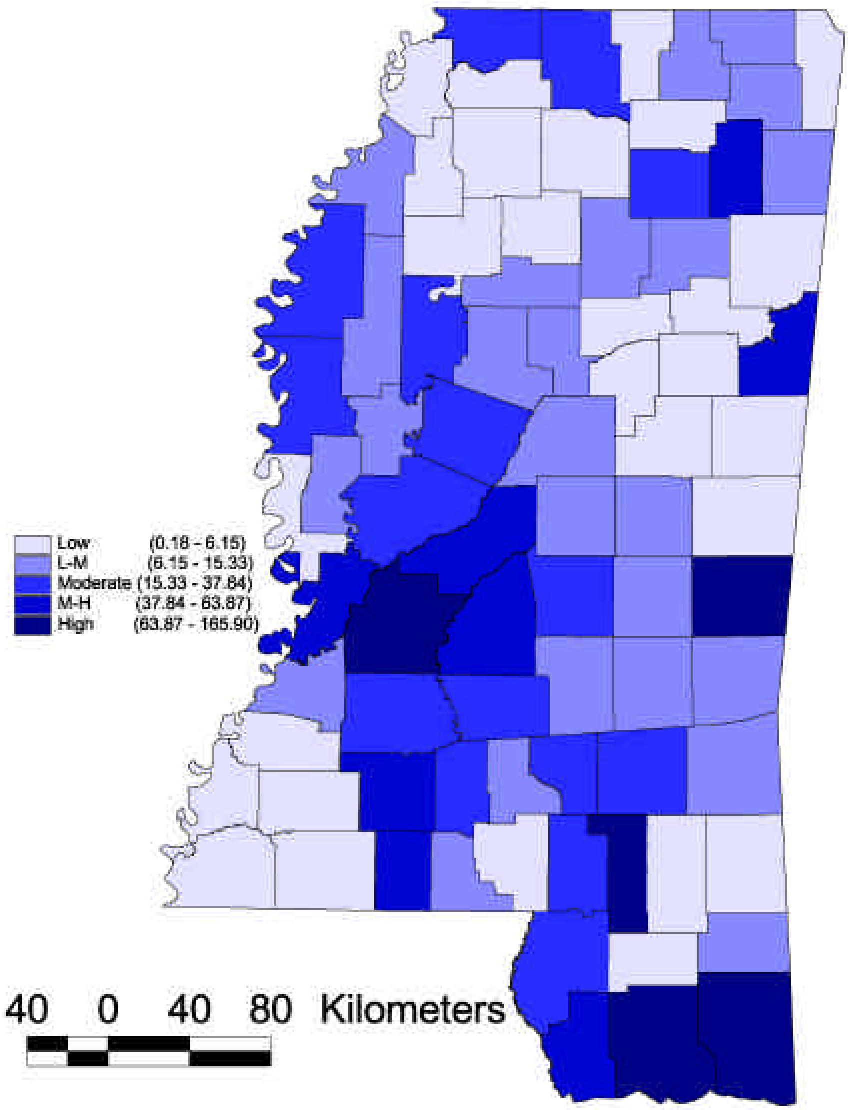

Figure 8d. Average County Risk for 1990-1999

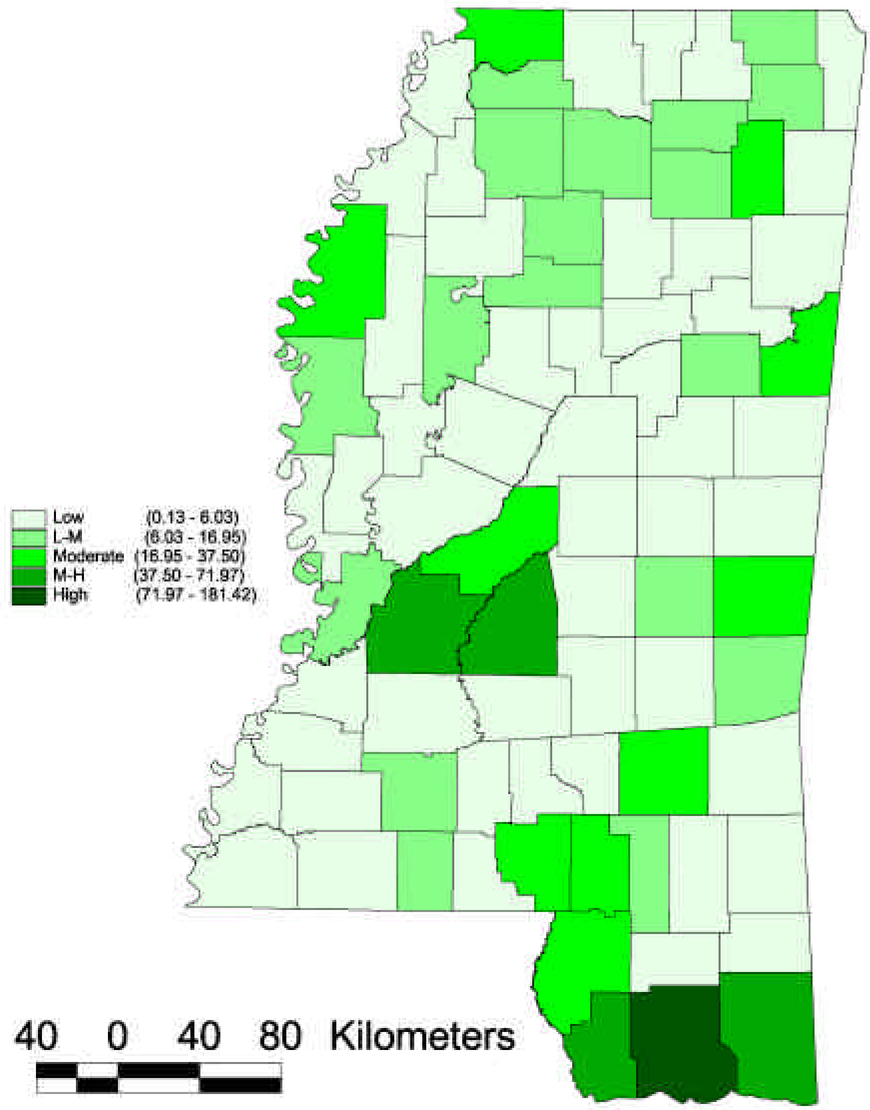

Figure 8e. Average County Risk for 2000-2001

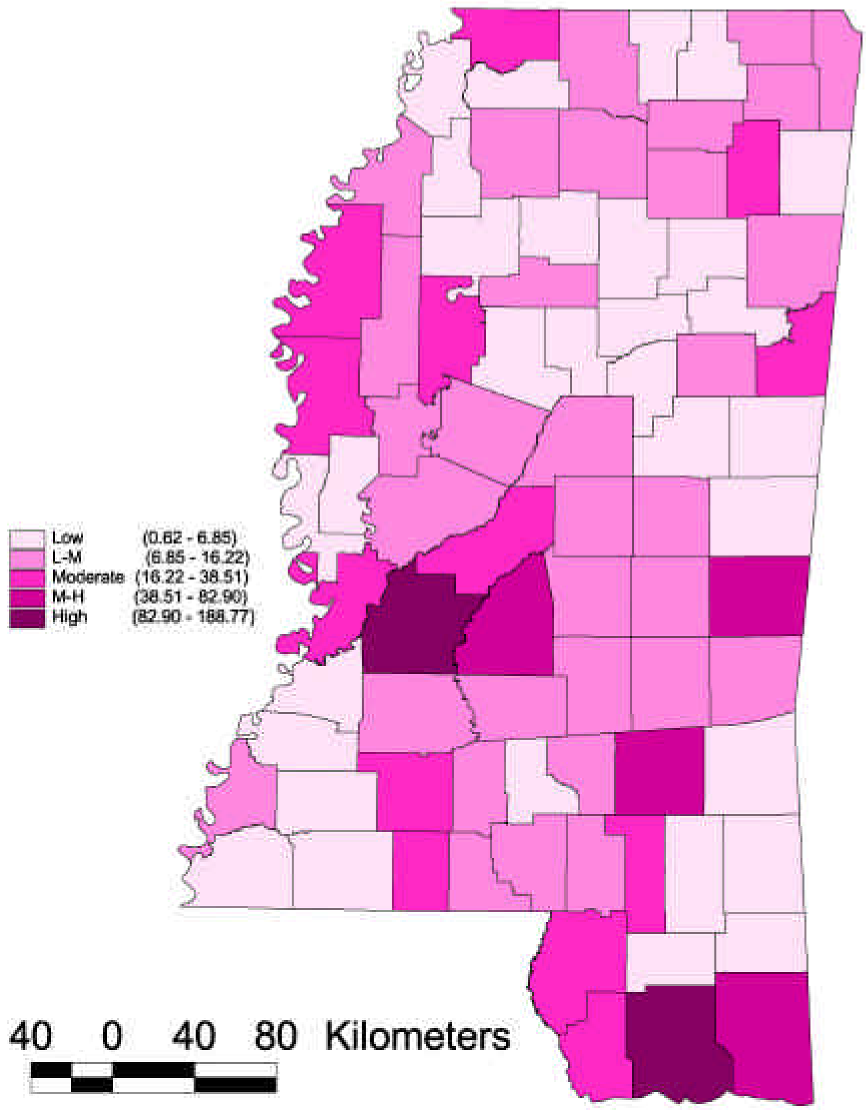

Figure 9. Overall Risk for Mississippi Counties

Lowndes, Lee, De Soto, Bolivar, Washington, Leflore, Warren, Madison, Lincoln, Pike, Hancock, Pearl River, and Forrest.

Counties classified as Low-Moderate Risk are: Marshall, Alcorn, Prentiss, Tishomingo, Union, Pontotoc, Lafayette, Panola, Coahoma, Sunflower, Grenada, Monroe, Oktibbeha, Humphreys, Holmes, Yazoo, Attala, Leake, Neshoba, Scott, Newton, Smith, Jasper, Clarke, Simpson, Copiah, Lawrence, Covington, Walthall, Marion, Lamar, and Adams.

Low Risk counties are as follows: Benton, Tippah, Tunica, Tate, Quitman, Tallahatchie, Yalobusha, Calhoun, Chickasaw, Itawamba, Clay, Webster, Montgomery, Carroll, Choctaw, Winston, Noxubee, Kemper, Sharkey, Issaquena, Claiborne, Jefferson, Franklin, Amite, Wilkinson, Jefferson Davis, Wayne, Perry, Greene, George, and Stone.

The extreme southwestern and northeastern portions of the state as well as north central counties of Mississippi generally exhibit themselves as Low Risk neighborhoods. On the other hand, even with a minimum housing population, the Delta is still considered an area of Moderate Risk. This risk would undoubtedly rise with any increase in population density.

CHAPTER VI

CONCLUSION

This study intended to identify the counties in Mississippi at greatest risk to life and property from the threat of tornadoes. If the risk changed greatly from decade to decade this study would not be valuable with regards to emergency risk management personnel and pre-planning for disasters. However, areas of High Risk were relatively constant. Although there will always be exceptions to the general categories of risk, the study provides a base from which to work.

Mobile home statistics were used as a guide to high risk housing. Obviously, there are many other types of structures that are considered to be at risk if they are not built to proper wind specifications. But, in terms of human geography, studying the spatial relationship of tornadoes and mobile homes is important because it offers the opportunity to serve as a warning for a growing housing industry. In counties where correlations were found between frequency of tornado occurrence and large numbers of mobile homes, manufacturers may have to set new standards for construction or redesign the existing frames. If this is improbable, the state of Mississippi may need to set stricter guidelines for manufactured home zoning or mandate the building of protective areas in counties that were found to be High Risk. No one should use the excuse that there is no refuge from a violent tornado. Other studies (Marshall 1993, McDonald 1993) have shown that protective areas are effective for wind speeds up to and including an F3, possibly even an F4 rating when built properly. Data indicate that the occurrence of F5 tornadoes in Mississippi has been extremely rare over the past 42 years with one in 1966 and another in 1971. Not one has been recorded since the Fujita Scale was developed. Effectively, any person in Mississippi with easy access to a protective area should be safe from becoming a fatality statistic.

The author also hopes this study provided a gateway of knowledge for the risk management community. Knowing which counties are at greatest risk allows for more efficient division of personnel and equipment during periods of severe weather.

Separating the risk areas by county allows for better division of economic resources. Counties should be equipped to decide on a local level that building codes are sufficient for their assessed risk.

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APPENDIX

TORNADO PATHS IN MISSISSIPPI

Figure 10a. 1960-1969 F0-F5 Tornado Paths (Hart 2002)

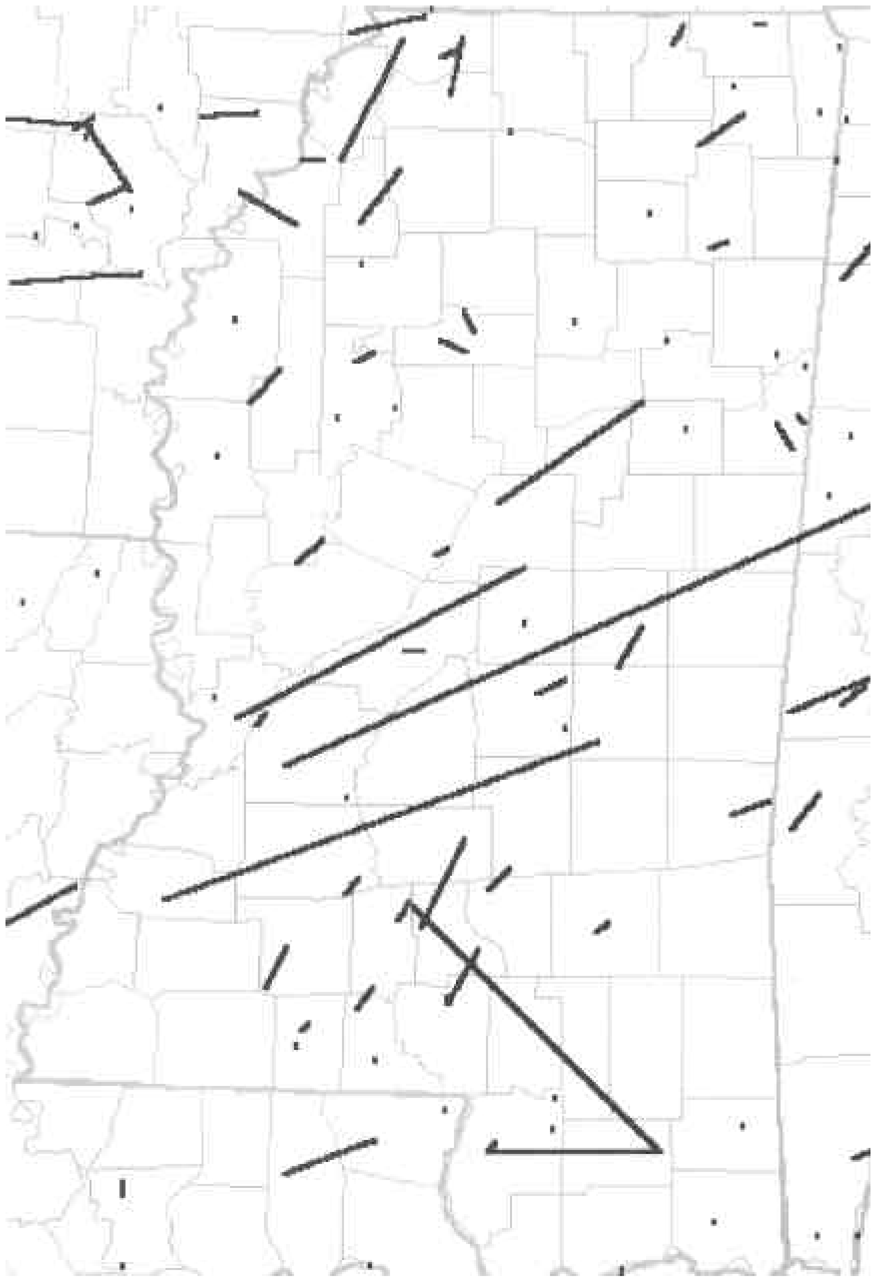

Figure 10b. 1960-1969 F2-F5 Tornado Paths (Hart 2002)

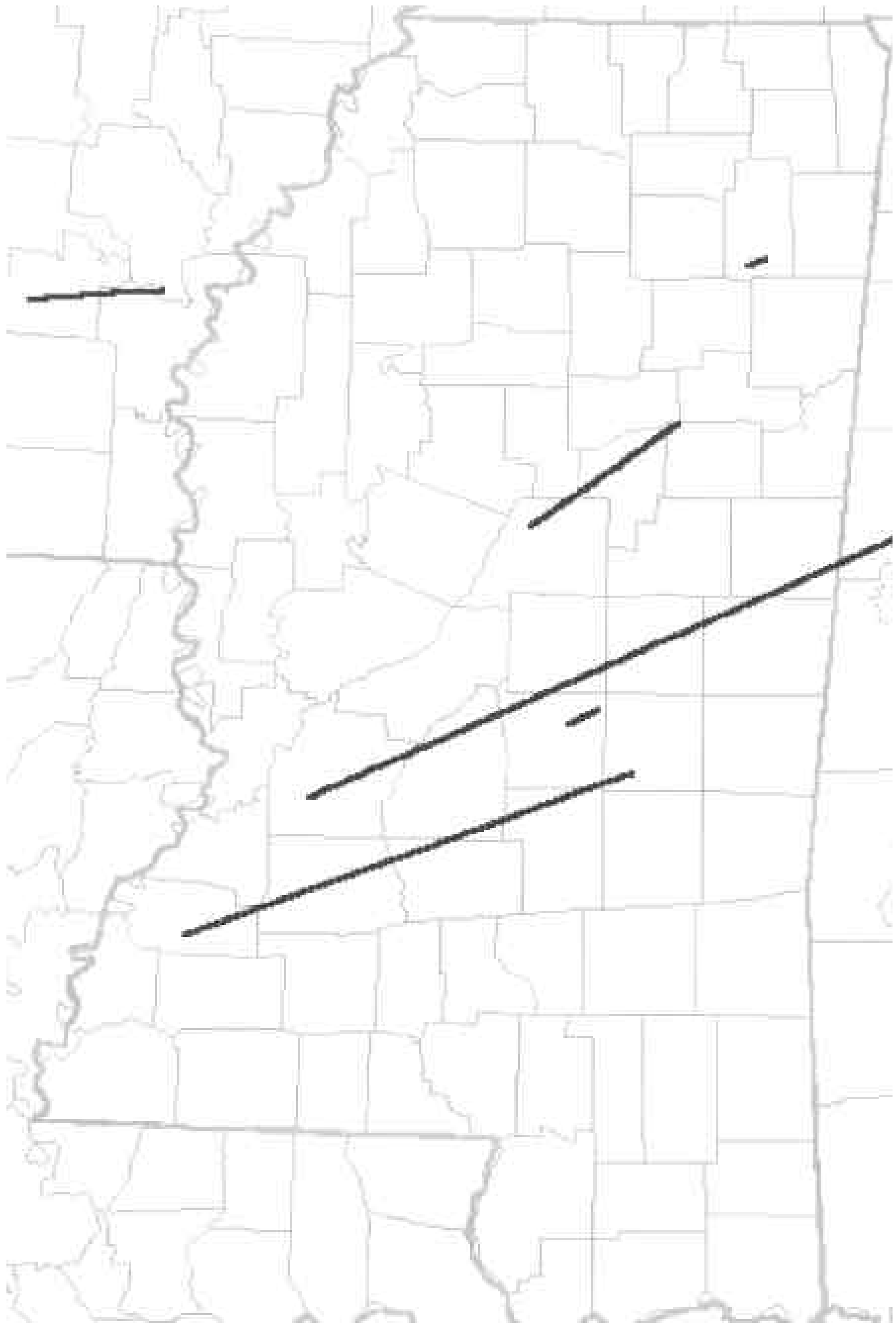

Figure 10c. 1960-1969 F4-F5 Tornado Paths (Hart 2002)

Figure 11a. 1970-1979 F0-F5 Tornado Paths (Hart 2002)

Figure 11b. 1970-1979 F2-F5 Tornado Paths (Hart 2002)

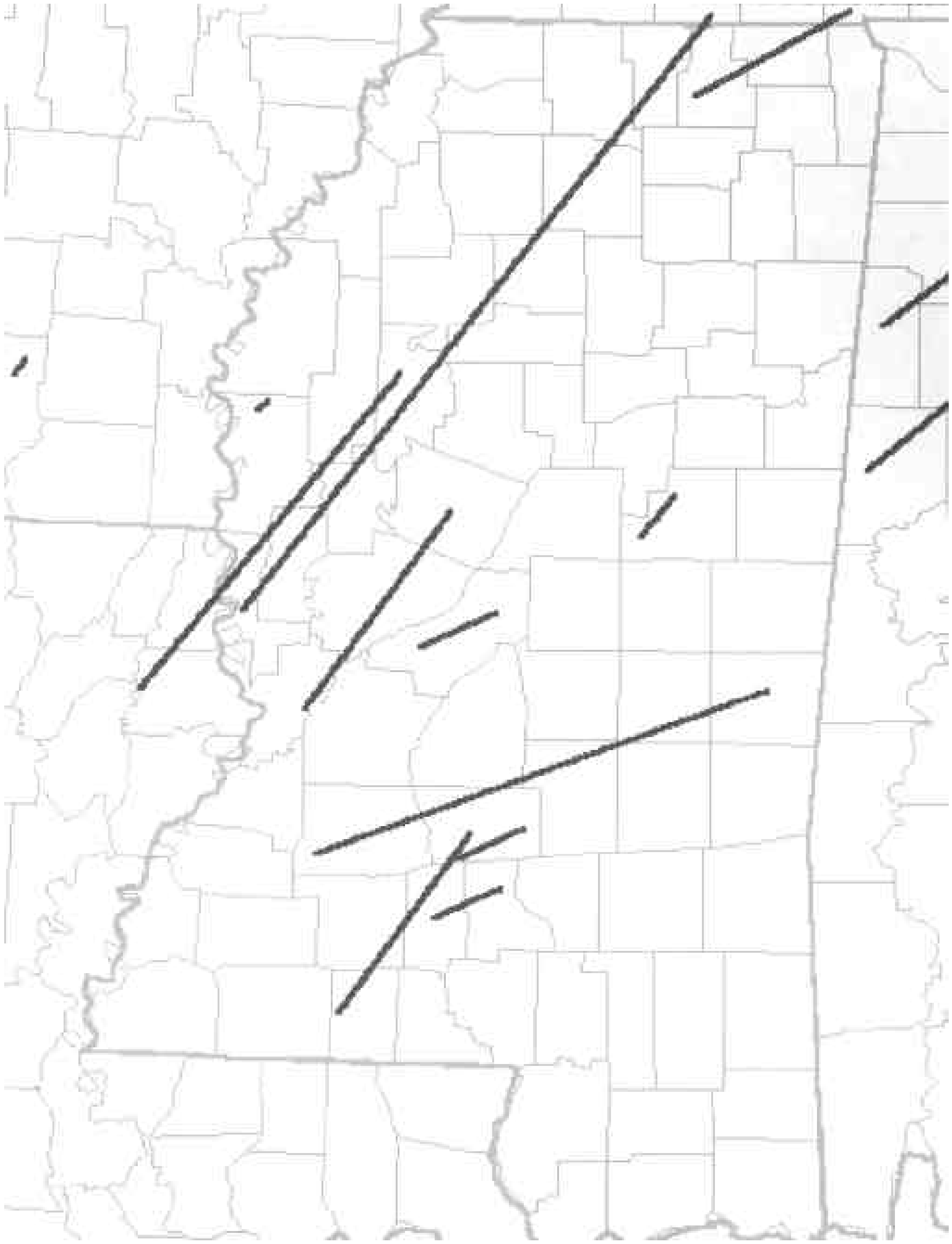

Figure 11c. 1970-1979 F4-F5 Tornado Paths (Hart 2002)

Figure 12a. 1980-1989 F0-F5 Tornado Paths (Hart 2002)

Figure 12b. 1980-1989 F2-F5 Tornado Paths (Hart 2002)

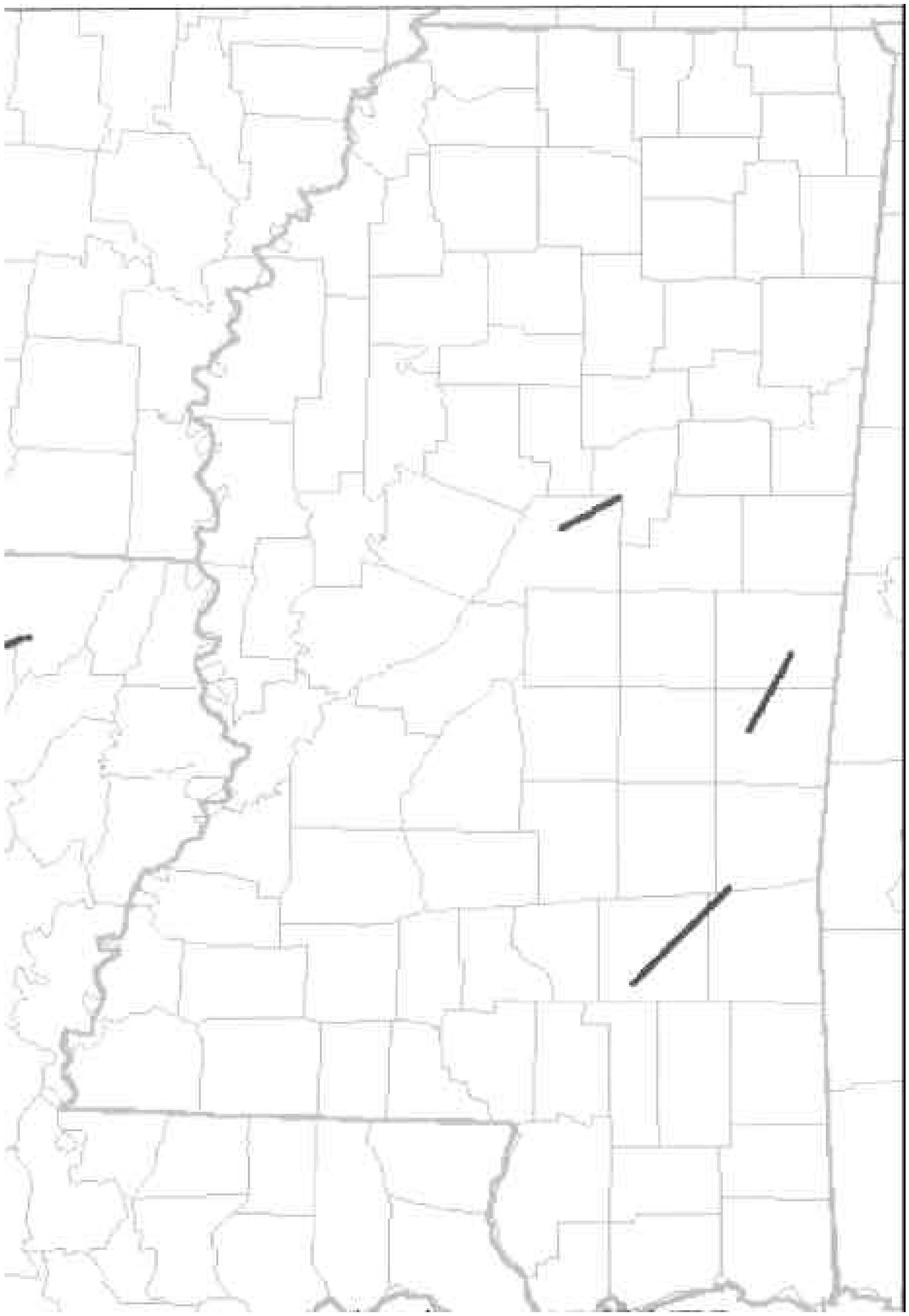

Figure 12c. 1980-1989 F4-F5 Tornado Paths (Hart 2002)

Figure 13a. 1990-1999 F0-F5 Tornado Paths (Hart 2002)

Figure 13b. 1990-1999 F2-F5 Tornado Paths (Hart 2002)

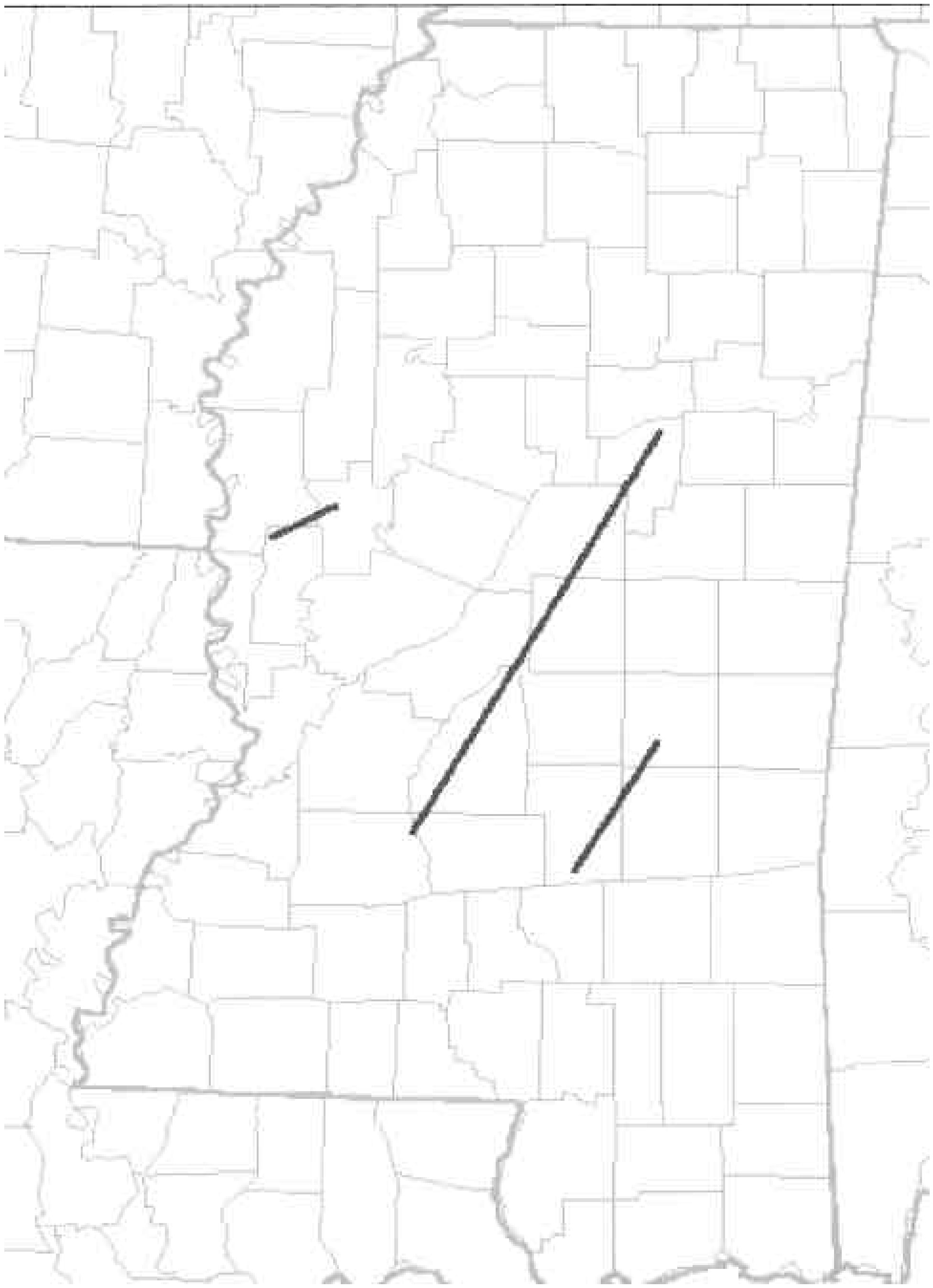

Figure 13c. 1990-1999 F4-F5 Tornado Paths (Hart 2002)

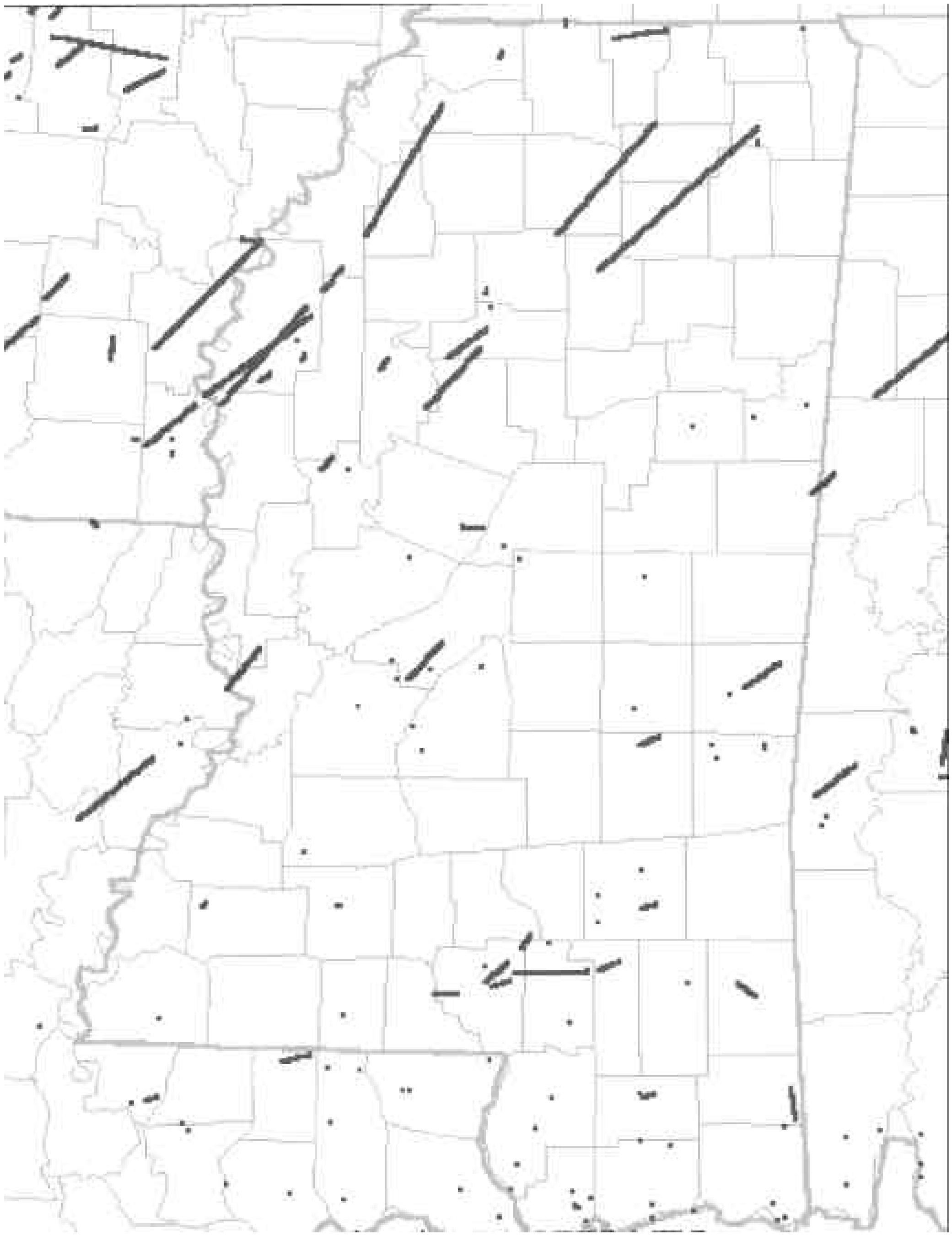

Figure 14a. 2000-2001 F0-F5 Tornado Paths (Hart 2002)

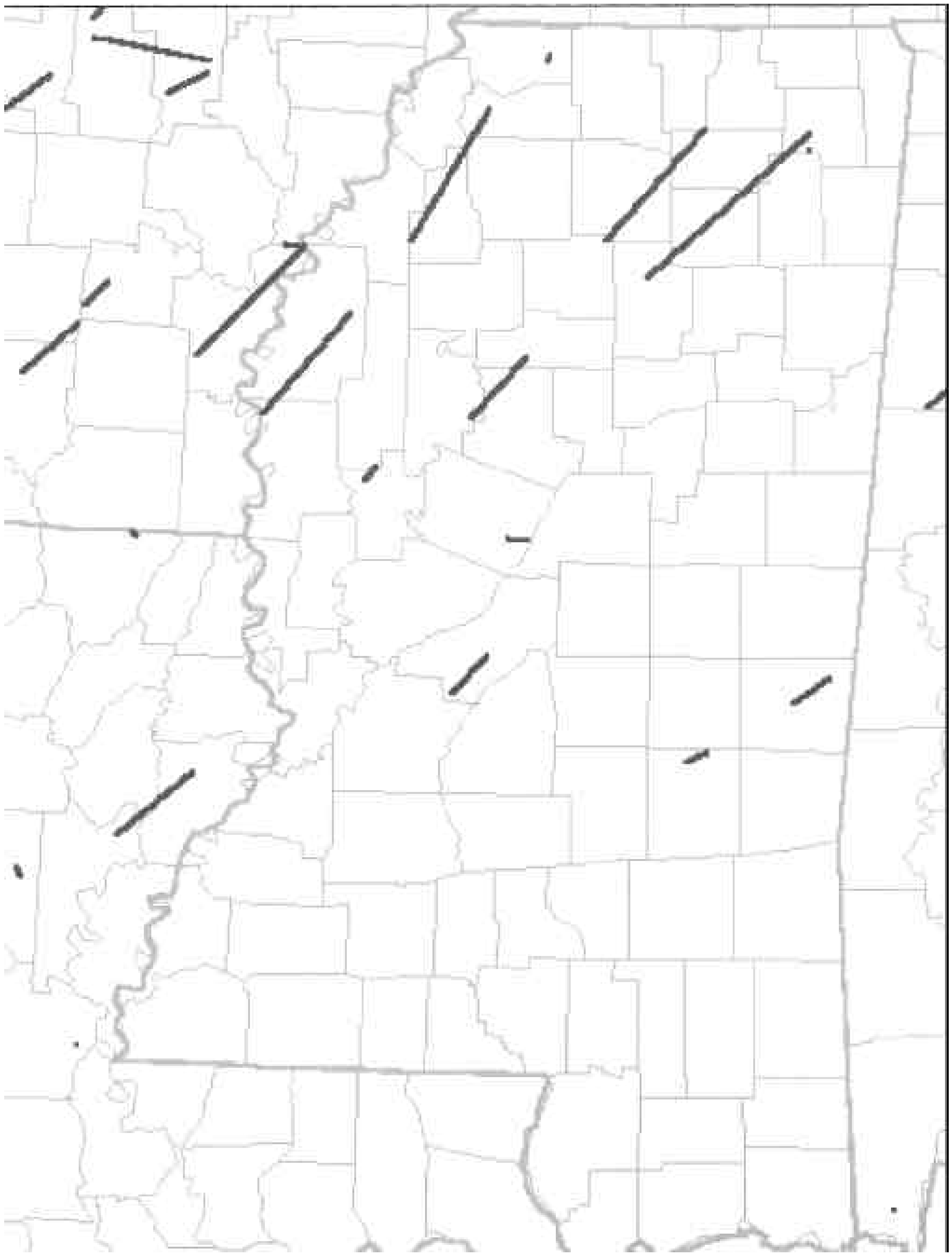

Figure 14b. 2000-2001 F2-F5 Tornado Paths (Hart 2002)

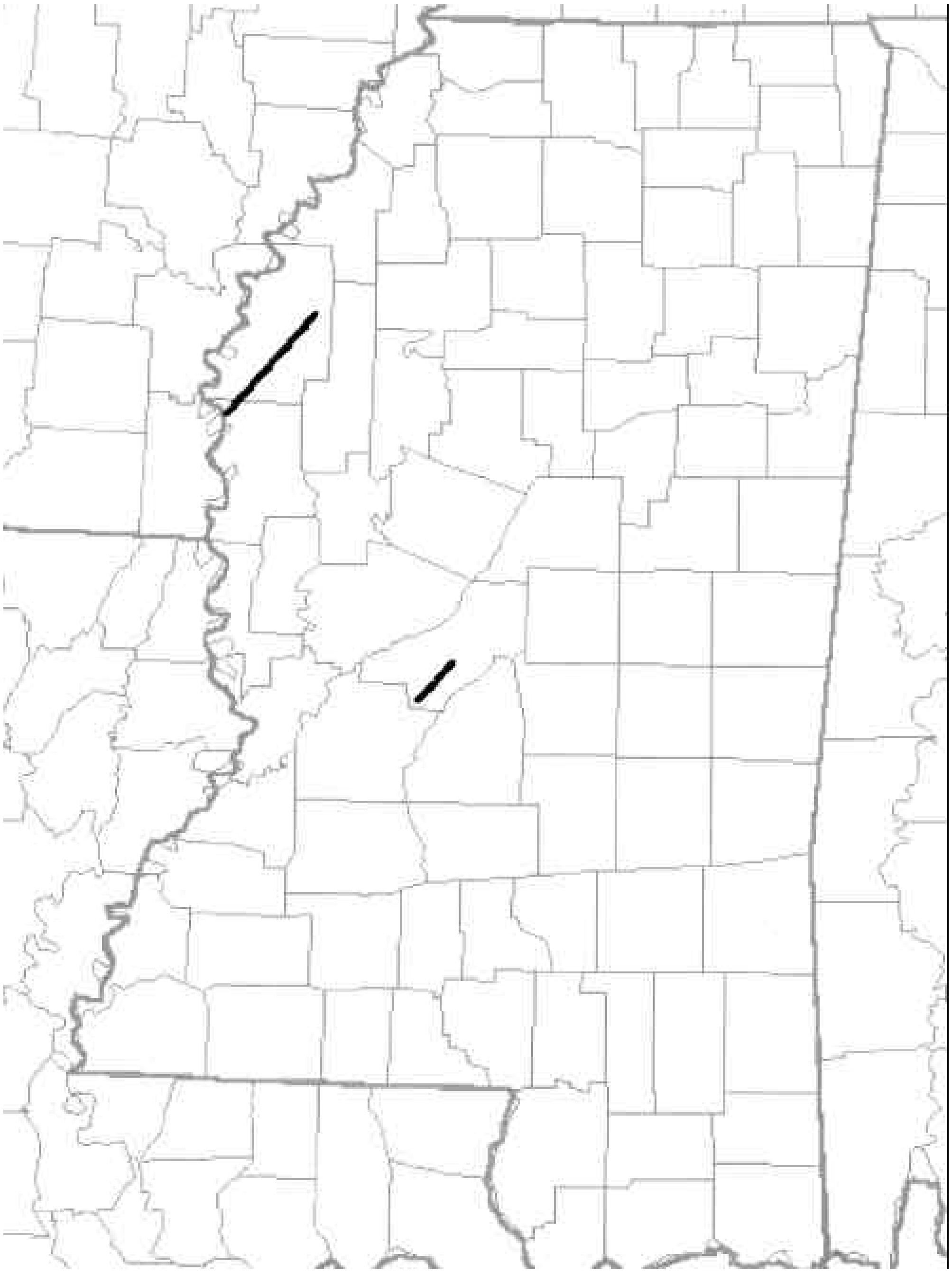

Figure 14c. 2000-2001 F4-F5 Tornado Paths (Hart 2002)

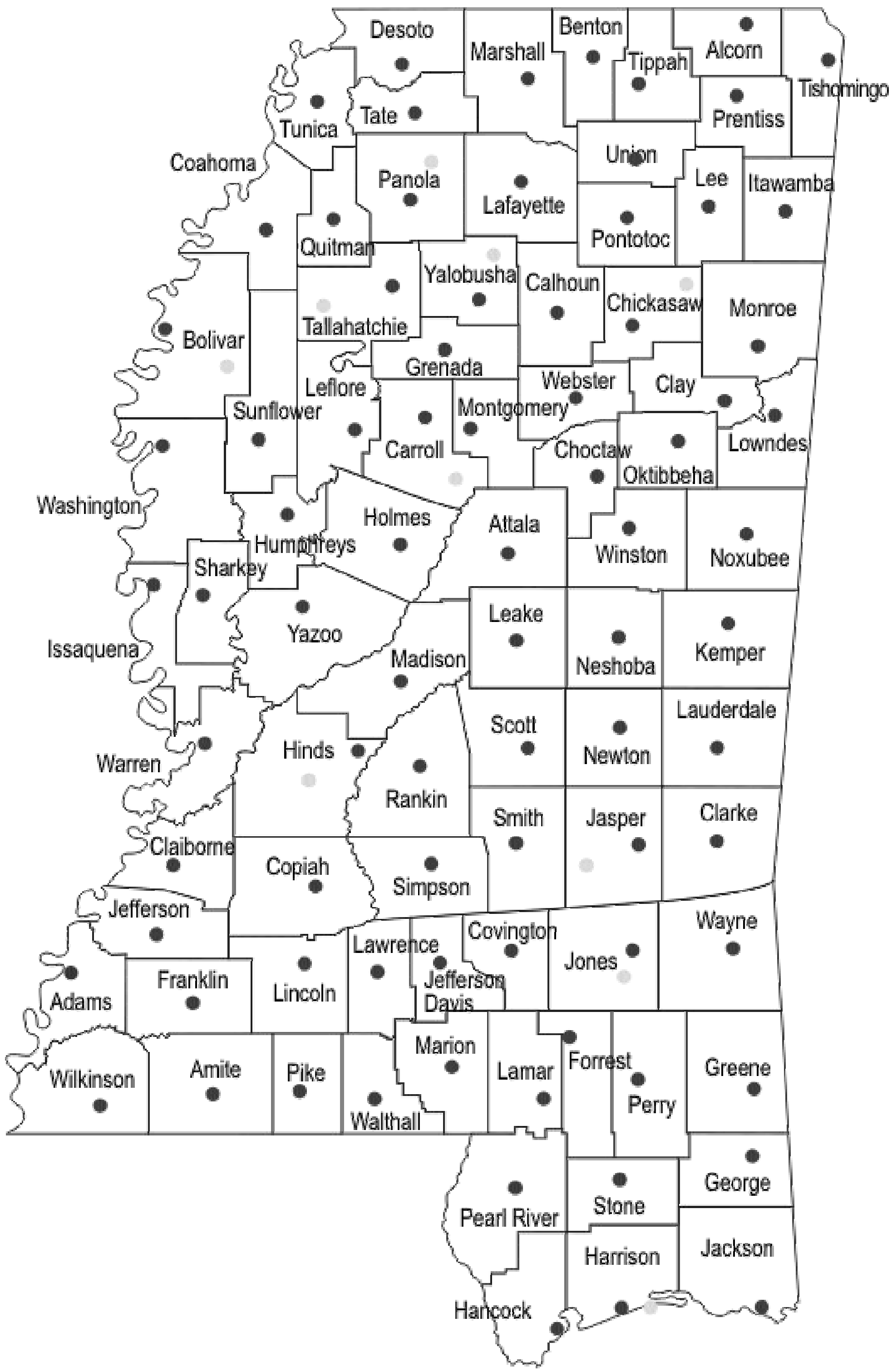

Figure 15. Mississippi Counties