The Cost of Red Imported Fire Ant Infestation: The Case of the Texas Cattle Industry

Steve Teal
Eduardo Segarra
Department of Agricultural and Applied Economics, Texas Tech University, Lubbock, TX 79409-2132
Charles Barr
Texas Agricultural Extension Service, Bryan, TX 77806
Bart Drees
Department of Entomology, Texas A&M University, College Station, TX 77843-2475

ABSTRACT

The spatial economic impacts of the red imported fire ant (RIFA) on the Texas cattle industry were estimated using regression analysis. Data from a survey of Texas cattle producers were used in conjunction with Agricultural Census data to estimate economic impacts statewide, and on a per county and per acre basis. The statewide economic impacts on the cattle industry were estimated to be approximately $255 million annually. A 95% confidence interval was also calculated, having a lower bound of $28 million and an upper bound of $573 million. Estimates were also calculated for each county to evaluate the spatial properties of RIFA impacts. Per county estimates highlight those counties with relatively large damages associated with RIFA. Per acre damages highlight "hot spots" of RIFA infestation within the state.

KEYWORDS: RIFA, Economic Impacts, Texas Cattle Industry.

The red imported fire ant (RIFA), *Solenopsis invicta* Buren, was introduced into the United States approximately 70 years ago. It is believed that RIFA entered the United States through Mobile, Alabama during the 1930s from South America. From Alabama it has spread and infested Texas, Louisiana, Mississippi, Arkansas, Georgia, Florida, and North and South Carolina. Approximately 275 million acres were estimated to be infested with RIFA in the United States in 1996 (Barr and Drees, 1996) and it continues to infest surrounding states at a steady rate. RIFA was first observed in Texas in 1953 (Culpepper, 1953). Since that time RIFA has continued to spread south and west in the state. Figure 1 depicts the geographical spread of RIFA in the state over time. In 1989, RIFA's infestation range in Texas was estimated to be approximately 50 million acres, representing about 29 percent of the state (Cockendolper and Phillips, 1989). As of 1996, Barr and Drees (1996) estimate that RIFA's infestation range in the state is at 56 million acres of pasture and rangeland, a 10 percent increase over the 1989 estimate.

Temperature and moisture limit the distribution of RIFA because of its dependence on these factors for mound building and foraging. Therefore, RIFA's main direction of expansion has been towards the southern and western parts of Texas in diverse environments. Currently, RIFA infests portions of the state that possess annual rainfall averages ranging from 52 inches in southeast Texas to 24 inches along the entire western edge of

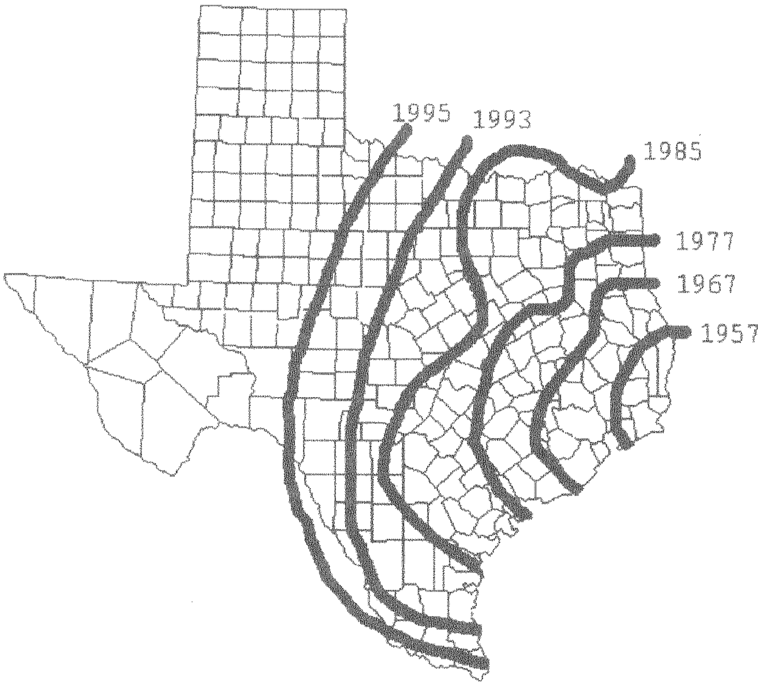

Figure 1. RIFA Infestation and Historical Spread

the infested area. Soils range from sand to heavy clay, and frost-free seasons range from over 300 to less than 225 days per year. Vegetation ranges from pine and hardwood forests in the east, to open prairie and semi-arid rangeland along the southern and western edges of the state (Barr and Drees, 1994).

Given RIFA's ability to successfully adapt to various environments, it has become a significant urban and rural economic pest. Many of RIFA's damages to agricultural crops and livestock production, human health, electrical equipment and urban landscape are well documented. Glancey, Coley, and Killebrew (1979) reported a 63.4 percent loss in potential corn yield due to RIFA. Lonfgren and Adams (1981) reported losses of 14.5 percent of soybean yield because of RIFA. Adams (1983) estimated a 50 percent loss in eggplant yields. Smitttle, et. al. (1988) estimated damages to young citrus trees to be $750 per hectare. A study by Brinkley (1989) estimated RIFA's annual damages in terms of medical expenses, wildlife losses, electrical equipment related expenses and negative impacts on golf courses in Texas to be $52.8 million dollars annually. Using this information, Ervin et. al. (1990) conducted a benefit-cost analysis for controlling RIFA in Texas. They determined that RIFA could be considered an economically damaging pest.

It is estimated that current losses due to RIFA in the state are significantly higher than in the past. Control costs of RIFA, structural repairs, human medical expenses, and other costs are estimated to be $93.2 million dollars annually in urban areas of Texas (Frisbie, 1997). A survey of cattle producers was conducted in 1995 to estimate the economic impact of RIFA on cattle production. Estimates based on that survey placed losses to the cattle industry in Texas at about $67 million dollars annually (Barr and

Drees, 1996). An overall estimate of the current annual economic loss due to RIFA on all economic sectors in Texas is $300 million dollars (Frisbie, 1997).

Livestock production in the state of Texas is a significant industry in the state's economy. It accounts for over $7 billion annually and contributes more than 50 percent of the total estimated value of agricultural production in the state (USDA, 1996).

Given that RIFA continues to spread and that its spreading is a function of climatic and geographical factors, it is desirable to develop methods and procedures to estimate possible ex-ante impacts of its infestation. In particular, the objective of this study is to revisit Barr and Drees' estimated impacts of RIFA on the Texas cattle industry based on climatic and geographical factors, and focus on the spatial impacts of RIFA on the cattle industry in Texas.

METHODS AND PROCEDURES

Data from the cattle producers' survey conducted by Barr and Drees (1996) were used to re-analyze the economic impact of RIFA on the Texas cattle industry on a spatial basis. Barr and Drees' information was used to estimate RIFA damages as a function of the number of cattle per operation, size of operation, location, and spatial weather characteristics.

Total loss with respect to cattle injuries as well as damages to hay production for those who produce their own feed was used as the dependent variable in the regression model estimated. Several independent variables were considered. Some of the independent variables that were suspected of affecting total loss were: climatic related factors, geographical location, number of cattle, number of acres, and length of time a particular region had been infested with RIFA. The survey provided data for the county in which the respondent lived, and the number of acres and cattle on their ranches. The other independent variables were introduced by using dummy variables.

Several qualitative variables were examined using dummy variables as both intercept and slope shifting variables. These included variables for the amount of annual rainfall, the annual number of frost-free days, and the amount of time RIFA has been in the area. The rainfall variable was chosen because RIFA population tends to thrive in areas with greater amounts of rainfall. This variable was determined by the amount of rainfall that each respondent's county received during an average year. The variables included less than 20 inches, 20-34 inches, 35-48 inches and 49 inches or more of rainfall per year.

Another variable considered was related to the number of frost-free days per year for particular counties. This variable was included because the greater the number of frost-free days usually result in higher RIFA populations. This variable was used as a dummy variable to separate counties into two categories: those with less than 290 frost-free days and those with more than 290 frost-free days.

The last dummy variable dealt with the rate at which RIFA has spread over the state of Texas. RIFA was first observed in Texas in 1953, but it is believed to have been established in 1957. RIFA has continued to spread south and west through the state as shown in Figure 1. Each respondent was assigned to a group based on their geographical location in that map. Because of the small number of respondents in the first two groups (1957 and 1967), these two areas were combined into Group 1. Group 2 corresponded to the areas infested between 1967 and 1977. Group 3 corresponded to the areas infested between 1977 and 1985. Group 4 corresponded to the areas infested between 1985 and 1993. And Group 5 corresponded to the areas located west of the areas infested by 1995.

After establishing these dummy variables, a considerable number of alternative regressions using several combinations of the independent variables were ran. Several functional forms such as linear, quadratic, and semi-log were considered. These regressions were ran to determine which functional form provided the best fit of the data. Using the best model would allow the prediction of RIFA damages on a per county basis. That is, given a county in a certain geographical location in the state, a total cost or damage estimate can be determined for that county depending on the average number of cattle operations, and the number of cattle and acres per cattle operation in that county.

The model that best fit the data took the following functional form:

$$TC = f(G1, G2, G3, Cat, Cat^2, G1Acre, G2Acre, FFD1),$$

where: TC represents the total damage to cattle and hay production caused by RIFA; G1 to G3 are dummy variables based on the length of RIFA establishment; Cat represents the number of cattle per operation; Cat^2 represents the number of cattle per operation squared; G1Acre is a slope shifting dummy variable relating Group 1 of infestation and the number of acres per operation; G2Acre is another slope shifting dummy variable for Group 2; and FFD1 is the first category of frost-free days. There were a total of 1,415 observations in the data set used.

Once a regression equation depicting the total cost of RIFA to cattle and hay production was determined, this equation was used to extrapolate the RIFA impact on a per county basis. The procedures used to accomplish this included the use of 1992 census data to derive the average number of acres per cattle operation on a per county basis (Agriculture Census, 1992). This information along with the geographical and climatic characteristics of a particular county, were substituted in the regression equation to derive a per cattle operation RIFA damage estimate. After this was done, these levels of damages were multiplied by the number of cattle operations in a particular county to determine the total damage on a per county basis.

RESULTS

As mentioned previously, several functional forms and combinations of the variables relating to RIFA damages and number of acres per operation, number of cattle per operation, dummy variables for the spread of RIFA, dummy variables for annual rainfall, and dummy variables for the number of annual frost-free days were examined. The estimated model was:

$$\begin{array}{l} TC = 933.800 + 1023.300 * R1 + 1092.700 * R2 + 1639.200 * R3 + 2.3068 * CAT - \\ \quad (2.1818) + (2.6047) \quad (3.9088) \quad (6.2515) \quad (5.9400) \\ 0.000299 * CAT^2 + 0.8998 * R1ACRE + 0.50803 * R2ACRE - 778.640 * FFD1 \\ (-6.2228) \quad (3.1944) \quad (4.9591) \quad (-1.9064), \end{array}$$

where the variables are defined as before, and the numbers in parenthesis below the coefficients depict their associated t-values. All estimated coefficients had the expected signs and were significant at the 95 percent confidence level, except for the dummy variable for the number of frost-free days, which was significant at the 90 percent confidence level. The coefficient for the dummy variable of region one has a positive sign, indicating a direct relationship with RIFA damage. The same is true about the coefficients for the dummy variables for regions two and three. In short, the regional location was a significant determinant of total RIFA damage. The coefficient for the number of cattle variable was found to have a direct relationship with RIFA damage. The number of cattle squared coefficient is negative, indicating an indirect relationship with RIFA damage. Thus, it is expected that after a certain number of cattle RIFA damage begins to decline. Specifically, it was found that the number of cattle before the damage begins to decline is approximately 3,950 cattle.

Region one multiplied by the number of acres was found to have a direct relationship with the dependent variable. This is a slope shifter dummy variable. As the number of acres change within this region, RIFA damages increase. Region two multiplied by the number of acres was found to also have a similar effect on expected RIFA damages, but at a slightly lower level.

The last independent variable included in the model was the dummy variable associated with the annual number of frost-free days. This variable was found to have a direct relationship with the dependent variable. That is, the fewer frost-free days at a given location, the lower the RIFA damages.

The coefficient of determination, or R^2, of the estimated equation was 0.0923. Due to the fact that the regression model uses cross-sectional data and that the variation in the dependent variable is large, this causes the model to have a low R^2. However, because the R^2 is lower than what would be desired, a confidence interval of the estimated damages on a per county basis was calculated at the 95% confidence level. This provides upper and lower bounds of damages.

Per County Damages

Using the estimated equation, census information, climatic, and geographic information, a point estimate of the aggregate annual damage of RIFA to the state's cattle industry was found to be $254.847 million. In Figure 2, the point estimate of damages is shown on a per county basis. As shown in that figure, the highest annual levels of RIFA damages on the cattle industry are expected to take place in 16 counties in which the levels of annual damages are estimated to be between $3 and $5.56 million. The county with the highest level of estimated damage was Lavaca, located in south central Texas. Generally speaking, the counties expected to experience the greatest losses are surrounded by counties that are expected to experience the second highest levels of damages, between $2 and $3 million per year, due to RIFA.

Given that the overall fit of the estimated equation, on which the above estimates of damages are based, is not as good as desired, the reliability of the estimate of damages discussed above is questionable. For this reason, in Figures 3 and 4 the lower bound and upper bound estimates of damages at the 95% confidence level are depicted, respectively. At the 95% confidence level, the lower bound of the annual aggregate estimate of RIFA damages on the Texas cattle industry is $27.870 million and the upper bound of the damage is $572.904 million. The spread of these bounds reflects the less than desirable goodness of fit of the overall equation. However, given the statistical significance of the variables included in the regression model, it is felt that, while the estimated levels of damages on a per county basis and for the state as a whole might not be as accurate as desired, the relative magnitude of the damages from county to county provide valuable insight in identifying counties in which RIFA damages are expected to be highest.

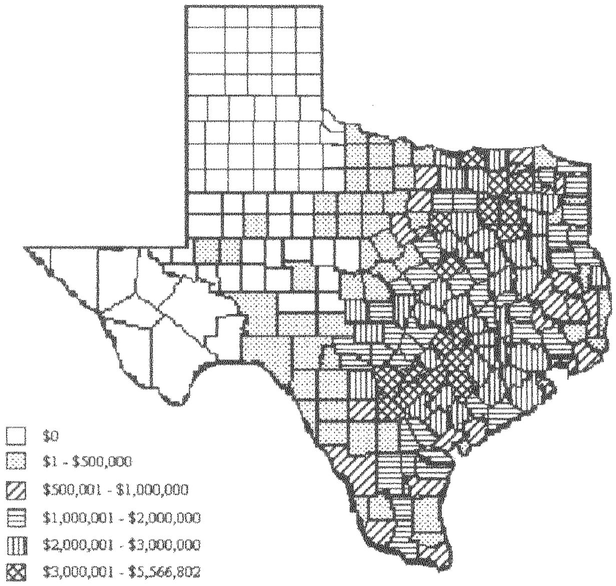

Figure 2. Spatial Economic Impacts of RIFA on the Texas Cattle Industry, 1995.

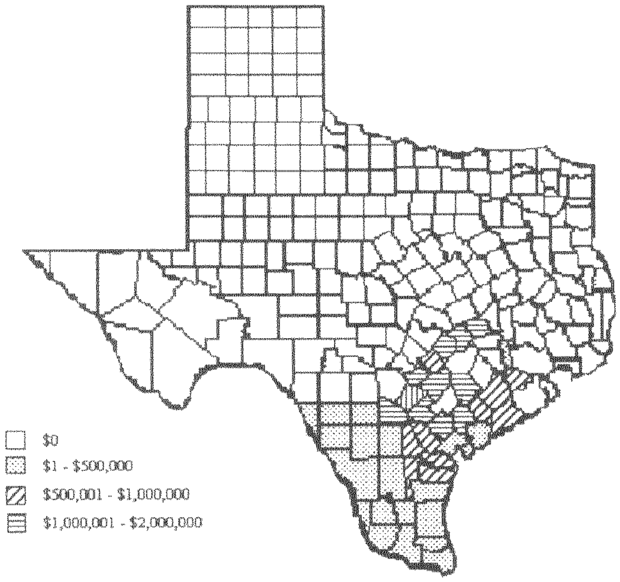

Figure 3. Spatial Economic Impacts of RIFA, 1995: 95% Confidence Level - Lower Bound.

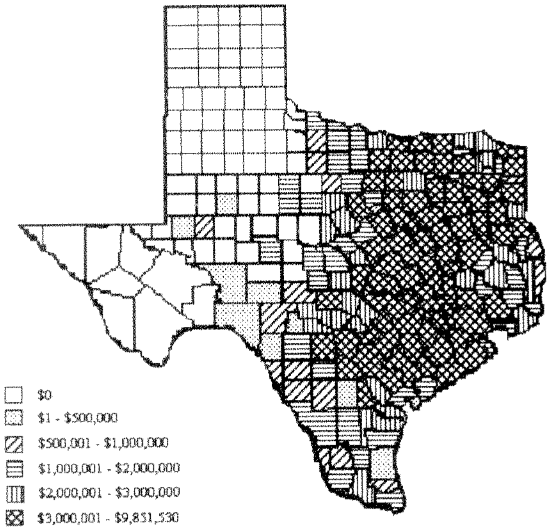

Figure 4. Spatial Economic Impacts of RIFA, 1995: 95% Confidence Level - Upper Bound.

Per Acre Damages

County-wide estimates are useful in determining which regions of the state are expected to be experience the highest levels of damages due to RIFA infestation. However, counties which include large urban areas generally do not have large damage estimates because of the small numbers of cattle within these counties. For this reason, RIFA damages were also estimated on a per acre basis.

Per acre damages were calculated in a similar fashion as the estimates on a per county basis. The estimated equation was used along with census data to determine the damage to the cattle industry on a per operation basis. This damage estimate was then divided by the operations' average size per county. Figure 5 presents the annual damages per acre, per county.

As can be seen in Figure 5, most of the counties that were considered "hot spots" for RIFA infestation on a per county basis, only have moderate damages on a per acre basis. Because these counties have more acres devoted to cattle production, the overall damage estimates are higher than other counties with higher per acre estimates. The highest per acre damage estimate was for Hunt County at $28.06 per year. The per acre damage estimates show those regions of the state which are being affected most by the presence of RIFA.

Again, because of the low R^2 of the estimated equation, 95% confidence intervals were calculated on a per acre basis. Figures 6 and 7 show the upper and lower bounds of the annual per acre damage estimates, respectively.

SUMMARY AND CONCLUSIONS

Given an interest in identifying the spatial impacts of RIFA on the Texas cattle industry, hypothesized relationships between RIFA damages, and characteristics and

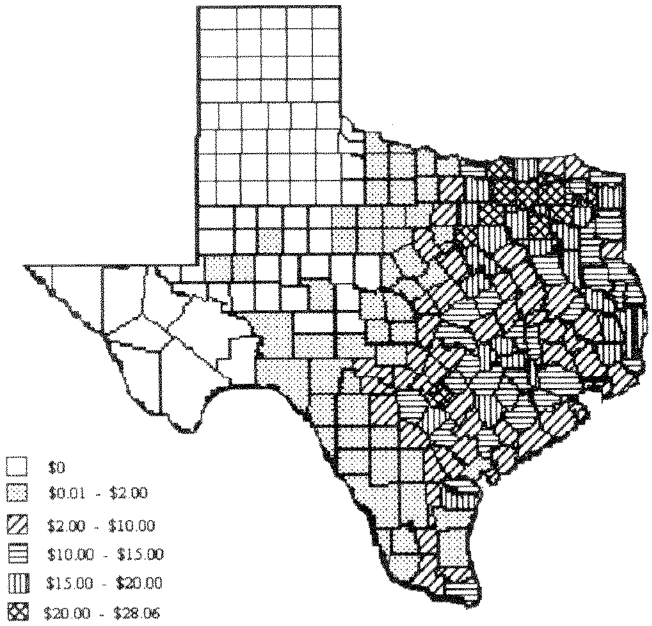

Figure 5. Spatial Per Acre Economic Impacts of RIFA, 1995.

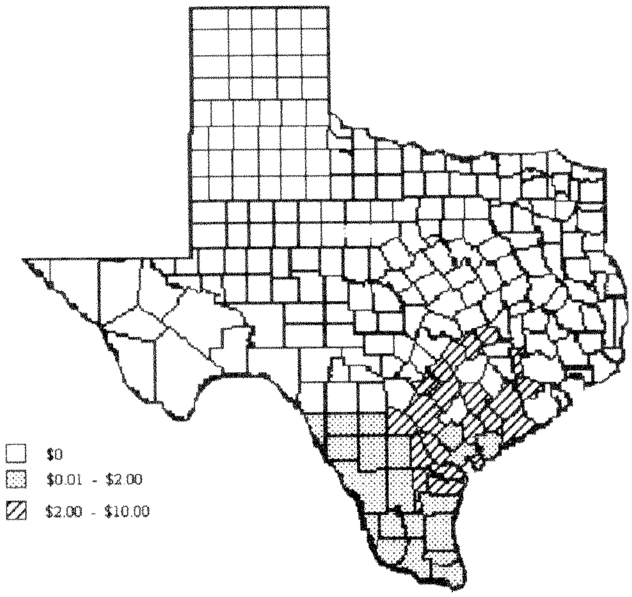

Figure 6. Spatial Per Acre Impacts of RIFA, 1995: 95% Confidence Level - Lower Bound.

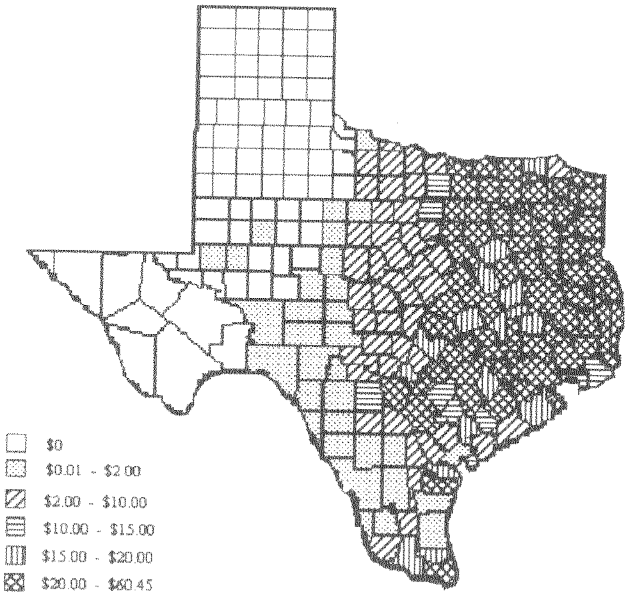

Figure 7. Spatial Per Acre Impacts of RIFA, 1995: 95% Confidence Level - Upper Bound.

location of cattle operations were tested using regression analysis. The data used in this study were a cross-sectional sample consisting of 1,415 survey responses from cattle producers regarding their personal costs of RIFA infestation on their cattle operations. These data came from a survey conducted by Barr and Drees in 1995. A model relating RIFA damages as a function of characteristics and location of cattle operations was estimated, and then used to derive annual county and state level estimates of RIFA damages on the Texas cattle industry.

Using the estimated equation, census information, climatic, and geographical information, a point estimate of the aggregate annual state damage of RIFA to the cattle industry was found to be $254.847 million. Given that the overall fit of the estimated equation on which this estimate of damages is based is not as good as would be desired, the reliability of the estimate of damages is questionable. For this reason, lower bound and upper bound estimates of damages at the 95% confidence level were derived. The lower bound of the annual aggregate estimate of RIFA damages on the Texas cattle industry was found to be $27.870 million, and the upper bound of the damage was found to be $572.904 million. The spread of these bounds reflects the less than desirable goodness of fit of the overall equation. However, given the statistical significance of the variables included in the regression model, it is felt that the relative magnitude of the damages from county to county provides valuable insight in identifying counties expected to experience significant RIFA damages.

Damage estimates were also determined on a per acre basis. Per acre damage estimates show those counties which may not have a high damage estimate for the county as a whole, but could be considered "hot spots" in RIFA infestation none the less.

It was difficult to come up with a statistically sound model that fit the data well, but significant variables affecting RIFA damages on the cattle industry were identified. The major obstacles in the statistical estimation were that the information represents a cross-sectional sample and that the variability of the RIFA damages reported from respondent to respondent was large. Overall, the statistical power of the estimated equation was not as good as would be desired, however some of the independent variables that have an impact on RIFA populations were found to be significant in explaining the economic damages of RIFA on the Texas cattle industry. It is felt that, given the way in which RIFA infestations and associated damages on the cattle industry take place, it would be difficult to improve on the estimation of the economic impacts of RIFA on the cattle industry derived in this study.

REFERENCES

Adams, C.T. 1983. Destruction of Eggplants in Marion County, Florida by Red Imported Fire Ant. Florida Entomologist, 66: 518-520.

Agriculture Census Data, 1992. http://govinfo.kerr.orst.edu.

Barr, C. L. and B.M. Drees, 1996. "Texas Cattle Producers' Survey: Impact of Red Imported Fire Ants on the Texas Cattle Industry. Final Report." Texas Agricultural Extension Service, The Texas A&M University System.

Barr, Charles L., and Bastiaan M. Drees, 1994. "Results from the Texas Veterinarian Survey: Impact of Red Imported Fire Ant on Animal Health" Proceedings of the 1994 Imported Fire Ant Conference.

Brinkley, C.K. 1989. Economic Impact of the Red Imported Fire Ant, Solenopisi invicta (Buren), in Texas. M.S. Thesis, Texas Tech University, Lubbock, Texas.

Cockendolpher, J.C., and S.A. Phillips, Jr. 1989. "Rate of Spread of the Red Imported Fire Ant, Solenopsis invicta (Hymenoptera: Formicidae)", in Texas. Southwestern Naturalist.

Culpepper, G.H. 1953. "Status of the Imported Fire Ant in Southern States in July 1953." Entomol. Plant Quar. USDA, Bur. Entomol. Plant Quar. E-867.

Ervin, R.T., C.K. Brinkley, D.E. Ethridge, E. Segarra, P. Zhang, and H.G. Thorvilson. 1990. "Economic Impact of Red Imported Fire Ant with Uncertainty Considerations." Working Paper, Department of Agricultural Economics, Texas Tech University, Lubbock, Texas.

Frisbie, R., 1997. "Texas Imported Fire Ant Control Management Plan Summary." World Wide Web posting at: http://fireant.tamu.edu/summary.htm.

Glancey, B.M., J.D. Coley, and F. Killebrew. 1979. "Damage to Corn by the Red Imported Fire Ant". Journal of the Georgia Entomological Society, 14: 198-201.

Lofgren, C.S., and C.T. Adams. 1981. "Reduced Yield of Soybeans in Fields Infested with Red Imported Fire Ants, Solenopsis invicta Buren". Florida Entomologist, 64: 199-202.

Smittle, B.J., C.T. Adams, W.A. Banks, and C.S. Logren. 1988. "Red Imported Fire Ant: Feeding on Radiolabeled Citrus Trees". Journal of Economic Entomology, 81: 1019-1021.

United States Department of Agriculture, Texas Agricultural Statistics Service, 1996. "Texas Agricultural Statistics."