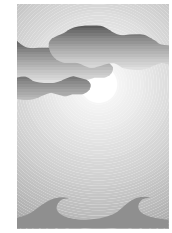
Impacts of 1997–98 El Niño–Generated Weather in the United States



Stanley A. Changnon
Changnon Climatologist, Mahomet, Illinois

ABSTRACT

This paper assesses the major impacts on human lives and the economy of the United States resulting from weather events attributed to El Niño 1997–98. Southern states and California were plagued by storms, whereas the northern half of the nation experienced much above normal cold season temperatures and below normal precipitation and snowfall. Losses included 189 lives, many due to tornadoes, and the major economic losses were property and crop damages from storms, loss of business by the recreation industry and by snow removal equipment/supplies manufacturers and sales firms, and government relief costs. Benefits included an estimated saving of 850 lives because of the lack of bad winter weather. Areas of major economic benefits (primarily in the nation's northern sections) included major reductions in expenditures (and costs) for natural gas and heating oil, record seasonal sales of retail products and homes, lack of spring flood damages, record construction levels, and savings in highway-based and airline transportation. Further, the nation experienced no losses from major Atlantic hurricanes. The net economic effect was surprisingly positive and less government relief was needed than in prior winters without El Niño influences. The estimated direct losses nationally were about $4 billion and the benefits were approximately $19 billion. The highly accurate long-range predictions issued by the Climate Prediction Center in the summer of 1997 for the winter conditions led to some major benefits. For example, the predictions led California to conduct major mitigation efforts and the results suggest these led to a major reduction in losses. Several utilities in the northern United States used the winter forecasts to alter their strategy for purchasing natural gas, leading to major savings to their customers.

1. Introduction

The societal, economic, and environmental impacts of weather events and climate conditions in the United States normally vary spatially across the nation, and for any given period such as a season or year, the impacts reveal a mix of regional winners and losers. This was certainly true with the impacts resulting from El Niño-generated weather during 1997–98.

The early official predictions of more storms in parts of the nation and heavy precipitation for the South and Far West (Climate Prediction Center August 1997) created concerns about damaging impacts. The Federal Emergency Management Agency (FEMA) (1997a,b) issued warnings to promote mitigative activities, and with the help of considerable media hype (Glantz 1998), a nationwide perception developed that all "El Niño weather" was going to be damaging. For example, FEMA (1997c) releases and the *Financial Times* (1997) tied the strong El Niño 1997–98 conditions to the huge U.S. losses from the equally strong El Niño of 1982–83, with 161 killed and losses of $2.2 billion (1983 dollars). Such citations likely resulted from El Niño forecasts that included comparisons of the strong (warm) El Niño of 1997–98 to the magnitude of the 1982–83 event [Climate Prediction Center (CPC) 1997]. California newspapers focused on the 1982–83 losses in California, which included 14 killed and $265 million in damages (*San Francisco Chronicle,* 1997; *Sacramento Bee,* 1997). This helped lead to considerable concern and launched major mitigation endeavors in California where storm and rain predictions were ominous.

Corresponding author address: Dr. Stanley A. Changnon, Chief Emeritus and Principal Scientist, Changnon Climatologist, 801 Buckthorn Circle, Mahomet, IL 61853.
In final form 8 April 1999.

The resulting 1997–98 mitigative activities in California reduced losses and were a beneficial impact of the long-range predictions.

The potential impacts resulting from the official predictions issued by the CPC of a fall–winter–early spring period of above normal temperatures and below normal precipitation for the northern sections of the United States were largely ignored by the media—these conditions were not seen as creating negative impacts and were thus of little interest. However, a few scientists did identify some possible benefits such as fewer Atlantic hurricanes and lower energy prices in the Northeast (Hall 1997).

The role of some members of the scientific community in focusing on negative, as opposed to positive impacts from El Niño weather has also been identified as an important part of the "bad outcome" theme surrounding El Niño found in the news media during 1997 (Glantz 1998). For example, a scientific report prepared in October for the insurance industry predicted several bad El Niño outcomes including excessive flooding in the U.S. west, south, east coast, and central plains (Skinner et al. 1997). The director of the U.S. Geological Survey, in testimony before Congress in October, predicted more flooding and increased water quality problems because of El Niño but failed to recognize any positive outcomes of additional water in the arid west (Shaefer 1997). A report that reviewed the El Niño 1997–98 winter weather conditions and their impacts reflected the widely held perspective that the winter impacts were bad as had been expected. The report states, "The winter of 1997–1998 was marked by a record-breaking El Niño event and unusual extremes in parts of the country. Overall, the winter was the second warmest and seventh wettest since 1895. Severe weather events included flooding in the southeast, an ice storm in the northeast, flooding in California, and tornadoes in Florida. The winter was dominated by an El Niño-influenced weather pattern, with wetter than normal conditions across much of the southern third of the country and warmer than normal conditions across much of the northern two-thirds of the country" (Ross et al. 1998). The report contained no mention of the positive outcomes from the winter weather conditions in the north.

Even with a major, multiyear costly study, it would not be possible to derive precise measures of the economic and environmental impacts of major nationwide weather conditions like those created by the El Niño-generated weather conditions in 1997–98. A recent study has addressed the difficulties of estimating the losses from natural hazards (NRC 1999). However, by using data in news accounts, business reports, and government reports, coupled with data on insurance losses, useful estimates of the impacts can be and were derived. Based on past studies involving assessments of the economic impacts of major natural hazards, it is likely that the estimates derived for the El Niño 1997–98 impacts are within 30% of the true costs (Guimares et al. 1993; West and Lenze 1994; Changnon 1996).

Assessing the losses and gains caused by El Niño 1997–98 involved decisions as to which weather conditions were caused or enhanced by El Niño's influence on the atmosphere and weather across the United States. Assessment of the comments by many atmospheric scientists on this issue (Changnon 1999a) showed general agreement that the monthly and seasonal temperature and precipitation conditions of the fall, winter, and spring of 1997–98 were attributed to El Niño, but there was debate over storms. Most scientists agreed that the lack of Atlantic hurricanes in 1997 and the numerous coastal storms of the 1997–98 cold season were a result of El Niño. However, there was scientific debate over whether El Niño played a role in a major October snowstorm in the high plains (Pielke 1999), and about the numerous tornadoes that occurred in Florida and other southeastern states during the winter–spring (Changnon 1999a). In this analysis of impacts we included the losses of all events when an atmospheric/oceanic scientist speaking in an official capacity as a NOAA staff member attributed the event(s) to El Niño. This led to the inclusion of all the tornadoes of December–April and the two major winter storms of October 1997 and January 1998. If these events were excluded, El Niño's damage total would be considerably less, reducing the number of deaths by 100 and losses by $1 billion.

2. Losses

An extensive content analysis of 2000 news stories and television programs about El Niño (Wilkins 1999) revealed that in the event's early months (June–September 1997) the El Niño information presented focused on the climate and oceanic forecasts and their scientific uncertainties. However, as El Niño grew to record proportions, FEMA and some scientists translated the official forecasts into warnings of damaging weather ahead, and the press picked up on this new theme that "El Niño 1997–98 would bring death and

destruction" similar to that caused by the massive 1982–83 El Niño. When three damaging Pacific hurricanes occurred just west of Mexico in September–early October, and then a damaging winter storm hit the high plains in October, the press considered the dire predictions verified. Thereafter, the press blamed all weather events on El Niño, and the concept that generally benign weather conditions would exist in the northern United States and be beneficial disappeared from the media stories (Wilkins 1999).

Indeed, El Niño-influenced atmospheric conditions created a considerable amount of damaging weather. In March, a leading NOAA scientist stated that El Niño 1997–98 was "the most damaging ever" (Friday 1998). The series of weather disasters from October 1997 to May 1998 were attributed to the record largest El Niño of 1997–98 Dole 1998), and these weather disasters were noteworthy for their variety and distribution across the nation.

As predicted when El Niño rapidly developed during April–August 1997, California was assaulted by coastal storms and heavy rains causing floods, numerous landslides, and damages to the state's valuable agriculture with losses totaling $1.1 billion statewide (Andrews 1998, personal communication). Florida, Texas, and several other southern states were struck by several severe rainstorms and numerous tornadoes, events not common in winter. Tornadoes led to more than 100 deaths, and El Niño-related property and agricultural losses in Florida ultimately reached $500 million. A record early damaging snowstorm swept across the high plains and upper Midwest in October, and then an extremely severe ice storm struck the Northeast in January, creating losses in excess of $400 million and 28 deaths (Ross et al. 1998). The intensity of both storms was attributed to El Niño (Wolter 1997; Ross et al. 1998).

By the end of May 1998 the national death toll caused by weather conditions related to El Niño was 189. The total included 42 deaths from February tornadoes in Florida, 28 deaths from the January ice storm, 17 in California due to various events during the winter, 2 from a Minnesota tornado, 3 drowned while snowmobiling on thin ice in northern Michigan, 24 dead from an intense February snow and rainstorm across 14 eastern states, 65 dead due to tornadoes during March–April in various southeastern states, and 8 drowned in Texas from a December flood-producing rainstorm. President Clinton visited damaged areas of Florida and California in late February and stated, "The people of California and now Florida are giving

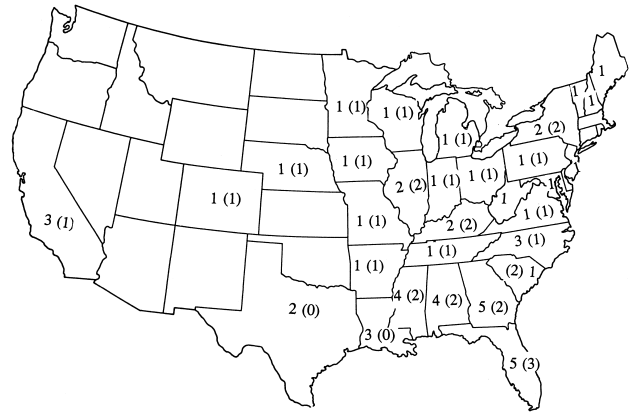


FIG. 1. The number of catastrophes, defined as events causing $25 million or more in insured losses nationally, that caused property losses in each state during September 1997–May 1998. The areal distribution reveals where most of the El Niño-induced weather losses occurred. The values in parenthesis are the number of times each state experienced losses due to catastrophes causing greater than $100 million nationally.

the people of the U.S. some painful examples of the excesses of this El Niño which is apparently the strongest ever in this century" (1998).

The property insurance industry identified 15 catastrophes, events each causing greater than $25 million in insured losses, during the 8-month period ending by May 1998 (when El Niño's influence on U.S. weather conditions had largely disappeared). The total insured losses by these 15 catastrophes was $1.7 billion (Property Claim Service 1998) and the weather with each had been attributed to El Niño (Changnon 1999b). As shown in Fig. 1, states where insured losses came from three or more catastrophes included Alabama, California, Florida, Georgia, Louisiana, Mississippi, and North Carolina, revealing that the long-range forecasts calling for more storms on the West Coast and in the deep South were correct. Florida experienced losses in 5 of the 15 catastrophes and 3 of these each caused more than $100 million to losses nationally. The single greatest insured storm loss was $305 million caused by heavy rains (flooding), hail, and tornadoes in a storm system on 15–17 April that swept across Arkansas, Missouri, Kentucky, Tennessee, and Illinois (and killed 11). The two major winter storms, one in October and one in January, account for the catastrophe counts found in the states comprising the central high plains, upper Midwest, and New England (Fig. 1).

A severe drought developed in Hawaii as a result of El Niño's influences on the region's weather, depleting water supplies and damaging certain crops. The

much above normal fall and winter precipitation in California and Florida devastated many vegetable crops. National prices for fresh produce rose 7.9% in January, retreated in February, and then rose 5% in March. The floods and storms in California were cited as the main reason for a raise in the price of food of 0.4% in February (Labor Department 1998). Food processors also suffered from a lack of produce and complained about the poor quality of the fresh produce coming from California and Arizona (*Detroit News* 1998). Prices for strawberries doubled, those for cauliflower tripled, and the USDA reassured the public indicating the high prices would retreat to normal levels by June (Peterlin 1998).

The tourist industry dependent on nice winter weather in Florida and the California coastal areas was hurt by a 30% drop in tourists during the winter and early spring, although the skiing industry in California had much above average business (*USA Today* 1998). Many ski resorts in the Midwest and Northeast were hurt by the lack of snow, increasing costs to make artificial snow and with marginal conditions that kept many skiers away. Michigan reported that income at the state's ski resorts was decreased by 50% (Pearce and Smith 1998). Among the businesses most negatively impacted by El Niño-generated weather were (a) providers of natural gas and heating oil (because temperatures were so mild in the northern United States), (b) farmers growing vegetables and fruits in California and Florida and cotton in Arizona where it was too wet, (c) manufacturers of snowmobiles and snow removal equipment including shovels (because of the low snowfall in the northern United States), and (d) producers of salt, victims of low sales due to very little snow and few winter storms (*USA Today* 1998). Retailers in California and Florida reported 3%–5% decreases in sales as a result of cool and wet weather (*Wall Street Journal* 1998a), and retailers in northern states who had developed large stocks of winter clothing suffered some from lack of sales.

Impacts of El Niño's weather in other regions of the world also produced negative impacts in the United States. For example, the drought in Panama led to a lowering of the canal and this reduced shipping loads and increased costs for shipping for five months. Davis (1997) assessed many of these impacts showing how the drought in Central America hurt the quantity and quality of vegetables exported to the United States and caused their prices to raise by 10%. Further, commodity traders dealing with Central American agricultural products did an extensive business. The El Niño-related drought in Southeast Asia cut production of coffee and palm oil, raising prices in the United States (Davis 1997).

Even after the storm activity ended, more El Niño-related damages occurred. Widespread fires broke out in Florida during June, fueled by a heavy growth of underbrush caused by the unusually heavy El Niño-caused winter rains. In Florida and Texas, two states predicted to have above normal rainfall in the spring due to El Niño conditions, spring rainfall was well below normal and drought conditions developed, helping to create the Florida fires in June and to greatly hurt the crops in both states (NOAA 1998).

Federal relief payments for El Niño-caused storm losses reached $289 million by the end of March, but this was lower than relief payments in the prior two winters that were not El Niño related (Bunting 1998). There were 18 presidentially declared disasters made from the fall of 1997 through April 1998, and all were partly attributed to El Niño's influence on the atmosphere (Leetma 1998). El Niño events have become stronger and more frequent since 1980, certainly one reason for the increased losses from weather-related natural disasters over the past 15 years (Changnon et al. 1997).

In summary, the national economic losses that could be estimated include the following:

- property losses = $2.8 billion [insured losses were $1.7 billion, and uninsured losses were estimated as $1.1 billion based on the fact that insured storm losses normally represent 65% of all structural losses from storms (NRC 1999; Pielke 1995)];
- federal government relief = $400 million;
- state assistance costs = $125 million;
- agricultural losses = $650 to $700 million;
- lost sales in snow-removal equipment = $60–$80 million; and
- losses in the tourist industry = $180 to $200 million.

3. Benefits

Weather conditions across the United States for any given month, season, or year produce losers and winners. The mild, almost snow-free winter in the northern United States produced by El Niño's influence on the atmospheric circulation over North America resulted in several major beneficial gains and some losses. Many fewer lives were lost due to bad winter conditions (bad roads, low temperatures, etc.)

than normally occur. Estimates from various parts of the northern United States indicated a national drop from an average of 850 winter deaths to less than 100 lives lost to winter conditions during 1997–98 (Pearce and Smith 1998). The mild, near record high winter temperatures of 1997–98 meant few exceptionally cold temperatures and this greatly reduced the lives lost to extreme low temperatures. Lives lost to extreme cold nationally totaled 13 (Parrish 1999, personal communication) compared to the annual average of 770 (Adams 1997), a reduction amounting to 757 lives. Winter snow and ice storms, fewer than normal, led to 33 deaths nationally (National Weather Service 1997–98) which is 14 less than average (Kocin 1997). Vehicular injuries and deaths due to winter season accidents were also decreased (Pearce and Smith 1998), and the December 1997–March 1998 total nationally was 64 deaths (National Highway Traffic Safety Administration 1999). This is 57 fewer deaths than the average based on the prior two winters (National Safety Council 1999). In sum, these national reductions sum to 828 fewer deaths than in an average U.S. winter.

El Niño's influence on the atmosphere led to the elimination of major Atlantic hurricanes during 1997 (CPC 1997; Gray 1997), and annual hurricane damages in the United States have been averaging $5 billion per year in the 1990s (Pielke and Landsea 1998). This lack of hurricanes meant an enormous savings to home and business owners, the government, and to insurers. It further meant no lives lost to hurricanes, which have produced an average of 20 deaths per year since 1986. Thus, one can estimate a total savings of 850 lives as a result of El Niño.

The abnormal warmth led to major reductions in heating costs with less use of natural gas and heating oil. Nationally, the energy savings were 10% (Ross et al. 1998) and this translates to a savings of $6.7 billion. One could postulate that this consumer gain was also a loss to the natural gas, fuel oil, and electric power industries. One could further argue that the damages to houses and businesses counted as losses were also gains to the construction industry involved in the repair and rebuilding of damaged structures. What has been counted as losses and gains herein are the "direct" losses and gains, involving those that initially bear the loss or experience the gain. The secondary, often delayed, financial effects resulting from either direct gains or losses are not accounted for herein because there is great difficulty in acquiring meaningful estimates and these effects represent a major dilemma in assessing *all* the impacts of natural disasters (NRC 1999).

Utilities using the predictions also bought natural gas and heating oil at much lower prices during the winter, rather than sign costlier early-season contracts, and this also further reduced heating costs to consumers. The major reduction in use of natural gas and heating oil was sufficiently sizable to have an effect on global oil prices, and El Niño's influence that brought abnormally warm winters to North America and Europe was cited as one of the three factors that led to a major reduction in gasoline prices that began in March 1998 (Stamper 1998).

Not only were many fewer persons killed because of the mild, storm-free winter weather, but many people changed their normal winter behavioral patterns. Thousands went out of doors more, millions went shopping, many altered their types of recreation, and most everyone enjoyed better health than in normal winters. There were notably fewer airline and highway transportation delays normally due to inclement weather, bringing less stress and increased profits, estimated at 3%–8%, to the airlines and trucking industry (Changnon 1999b).

The lack of winter snowfall and freezing rain led to major reductions in the use of salt on highways and streets saving money and minimizing environmental impacts. This also reduced normal overtime payments to street crews for snow removal, and collectively these actions brought major savings to state and local governments. For example, the savings reported in the Chicago metropolitan area totaled $21 million (Fonda 1998).

The generally good weather in the Midwest and Northeast, with little precipitation and temperatures averaging 7°C above normal, also had a major influence on construction, retail shopping, and home sales. Many retail chains reported record high sales for January–March, and record high sales of homes occurred during December–March (National Association of Realtors 1998). The Department of Commerce reported (March 1998) that construction of new homes in February was up 6% from January, the highest monthly increase since November 1987, and that income and employment in the construction industry from December through February had increased 25%, representing an increase of $350 million above the income in normal recent winters. Most major retailers reported healthy gains as their sales, and stock prices, rose as a result of the warm winter weather. Sales gains above 1997 values were 4.9% in January

(*Wall Street Journal* 1998b), 5.7% in February (*Wall Street Journal* 1998c), and 3.4% in March (*Wall Street Journal* 1998d). The record seasonal sales of goods and homes brought sizable added incomes to retailers, relators, and homeowners, and summation of the various reported increases yielded a national total estimated at $5.6 billion. Of course, this also occurred during a period when the nation's economy was quite robust, likely enabling added purchases.

The early fears about bad weather brought economic predictions of instability in the commodity markets (*Detroit News* 1997). As a result, many brokers did a brisk business during the fall and winter of 1997 (Fig. 2). Economists reported that the lack of Atlantic hurricanes and attendant losses were a major boon to insurers, affecting investors who increased their purchases of stocks (Stread and Thomason 1998). The lack of losses from hurricanes and those normally due to spring snowmelt floods benefitted the federal government, which normally faces large relief costs related to hurricane and flood damages (NRC 1999). Spring snowmelt floods in the nation's northern states normally produce $1.9 billion in losses (Changnon 1999b).

> The El Niño weather pattern is here, and it's bigger than ever. No one is sure, however, where it will do the most damage, if any. The only thing we can compare it to is the last major El Niño in 1983 which triggered $9.00 a bushel soybeans.
>
> Since damage can occur anywhere in the world, a general strategy is to buy food commodities such as sugar, cocoa, coffee, corn and soybeans and maintain long positions throughout 1998.
>
> Since timing the major impact of El Niño is too difficult, the best strategy is to maintain these long positions in the form of call options. Look to buy call options in the coming months which allow you to take advantage of the El Niño situation. For example, El Niño is expected to have its strong influence on the U.S. soybean crop in early summer. The best option to trade to take advantage of this event would be the November soybean options.
>
> Finally, even if El Niño does not result in great crop damage, commodity markets are still likely to experience strong volatility due to "El Niño nervousness."

FIG. 2. An excerpt from an advertisement of a brokerage firm in October 1997.

California, as a result of severe floods earlier in 1997, was already in the process of instigating major mitigative activities when the El Niño predictions of a bad 1997–98 cold season were issued. The state spent an additional $7.5 million to aid in preparedness and to alert the public (Andrews 1998), and several communities spent their funds on local projects. No cost figures exist to measure the benefits of the mitigative activities done in California, but the state suffered less loss in the 1997–98 winter, a total of $1.1 billion, than in the comparably severe 1982–83 El Niño (approximately $2 billion in losses adjusted to 1998 dollars). California roofing companies and home repair companies had major increases in business beginning in September 1997 and reported $125 million in added income as a result of El Niño-related mitigation activities (Labor Department 1998). There also should have been benefits in western water systems since the director of the U.S. Geological Survey reported to Congress in October 1997 that government water managers in the Survey and Bureau of Reclamation had been instructed to plan their management strategies using the El Niño-based long-range forecasts calling for heavy precipitation (Shaefer 1997). The Secretary of Commerce pointed to the correctness of NOAA's El Niño predictions, reflecting on the numerous national benefits resulting from their use (Daley 1997). NOAA Administrator Baker (1997), in presenting congressional testimony, claimed the value of the El Niño predictions to U.S. agriculture was $275 million.

The net effect on the nation's economy from these varied benefits was detectable. For example, the Federal Reserve Board announced in February 1998 that the warm January caused a 4% drop in production at the nation's electric and gas utilities, ending a run of months with production increases that economists had expected to be +0.3% in January (Federal Reserve Board 1998). El Niño's net influence and the Asian financial crisis combined in February to eliminate inflation in the prices paid by wholesalers, as food processors and manufacturers charged wholesalers 0.1% less than in January for finished goods (Labor Department 1998). Inflation was held to zero during January–March for the first time in 10 years, and the Consumer Price Index went unchanged due to the falling energy prices (Department of Commerce 1998).

Other outcomes partially attributed to El Niño-created conditions are difficult to quantify. For example, gasoline prices in the United States fell to record lows in early March 1998, and oil experts indi-

cated that one part of the cause was the warmer-than-usual winter in the United States that greatly reduced demand for oil, and also partly the result of the Asian financial crisis and the bickering over sales quotas by the world's oil producers (*USA Today* 1998). This gas price reduction, averaging $0.25 per gallon below pre-El Niño costs continued through 1998, represented an enormous saving to drivers. With 260 million autos and trucks operating and using an estimated 10 gallons of gasoline per week, the savings for March–May 1998 amounted to $7.5 billion, but how much of this can be attributed to an El Niño-caused warm winter? Even if only a small amount of this saving was attributable to El Niño, then very large benefits accrued across the nation with gasoline prices remaining low throughout 1998. The head of the Energy Information Administration stated that the decrease in gasoline prices was largely due to the winter's warmth (Stampler 1998), which suggests that some of the consumer benefits from these savings could be counted but they were not included in the list below.

The national economic gains due to El Niño weather that could be estimated are as follows:

- reduced heating costs = $6.7 billion;
- increased sales of merchandise, homes, and other goods = $5.6 billion;
- reductions in costs of street/highway removal of ice and snow = $350–$400 million;
- reductions in normal losses due to absence of snowmelt floods and no Atlantic hurricanes = $6.9 billion;
- income from increased construction and related employment = $450–$500 million; and
- reduced operating costs to airlines and trucking industry = $160–$175 million.

4. Summary

Various sources of data were employed to derive estimates of many of the direct financial losses as well effects on human lives from weather conditions attributed to El Niño 1997–98. However, other nonfinancial impacts as well as delayed economic effects were not well measured nor estimated at this time. For example, the environmental impacts resulting from El Niño 1997-98 are not well defined but we know that some were negative and others positive. The enhanced precipitation in the arid west certainly improved water supplies. The western rains filled the reservoirs and also reduced energy costs since hydroelectric plants could operate at full capacity. Many envisioned that the mild winter would lead to increased insect pests in 1998, but little evidence that this occurred could be found.

The many impacts resulting from use of the El Niño-based predictions for fall, winter, and early spring weather also represent another group of positive but largely unmeasured outcomes. One example is the benefits derived from the widespread mitigation activities in California. The difference in the California losses between similar El Niños was sizable; $2 billion in 1982–83 (adjusted to 1998 dollars) versus $1.1 billion in 1997–98, suggesting the extensive mitigation activities were extremely beneficial. Utilities that used the forecasts and waited to purchase their natural gas supplies on the spot market during the winter, as prices rapidly fell, also reaped sizable benefits for their customers. One Iowa-based utility saved its customers $39 million from use of the predictions (Waetke 1998), and two utilities in Michigan reported savings of $48 million and $147 million during March 1998 (Bishop 1998). Another impact resulting from the unusual weather of 1997–98 related to the evolving weather derivatives business that reportedly increased its sales (Zeng 1999). Most impacts identified and estimated fell in the category of direct losses and benefits and do not include many of the secondary, often delayed effects occurring after El Niño ended. One example of the delayed effects is the Florida fires in June 1998 that damaged orange groves. This damage ultimately led to a 20% increase in orange juice prices that began in October 1998 (Cornell 1998). Another example of delayed impacts relates to the low use of natural gas in the northern states during the warm winter of 1997–98. This led utilities to buy natural gas at low prices and to fill their gas storage fields, resulting in abundant supplies for the 1998–99 winter. As a result, natural gas prices in 1998–99 became 20%–30% lower than in normal winters (*Wall Street Journal* 1998a). Some events claimed as El Niño-related were not. For example, the summer 1998 drought in Texas, which developed during the very dry spring in 1998, was an outcome in direct contrast to the El Niño-faced forecasts for wet conditions in Texas, and was not attributed to El Niño-related conditions.

A summary of the national impacts, both losses and benefits, appears in Table 1. These reveal that the benefits realized greatly outweighed the losses, both in terms of the lives lost and in damages. Michaels (1998) made an early estimate that accounted for national benefits of $15 billion versus losses of $2 billion. One

TABLE 1. National tally of impacts from weather conditions attributed to El Niño, 1997–98.

LOSSES	
Human lives lost	189
Economic losses and costs	$4.2–$4.5 billion
BENEFITS	
Human lives saved	850
Economic gains	$19.6–$19.9 billion

must realize that the dollar values in Table 1 are based on estimates that may be in error by up to 30%; thus, the losses could range from $3 billion to $6 billion and the benefits from $14 billion up to $25 billion.

The sizable and unexpected benefits from El Niño conditions were noted by the press. One news article stated, "Effects of El Niño are mostly a positive outcome" (*Reuters* 1998). This net positive outcome led another assessor of the impacts to contrast and question this outcome against the climatologists' predictions in 1997, which called for major losses (*Cincinnati Enquirer* 1998). This assessment concluded that this prediction of "bad impacts" raised major doubts about the scientists' predictions of negative outcomes apt to result from global warming.

One lesson for atmospheric scientists and government agencies acting on climate forecasts is the need to focus on both the good and bad impacts of predicted weather conditions. The media tends to focus only on the negative outcomes. Another lesson revealed in the study was that when weather conditions or climate events become "national news," news and science writers tend to approach "local" experts for interpretations of the events and conditions. This situation often results in widely different interpretations such as what tornadoes to attribute to El Niño or whether global warming has begun.

An important third lesson is that all weather conditions produce winners and losers, and in general, less is known about the winners than about the losers. Although hard to realize, major storms like hurricanes and tornadoes result in certain losses which, in turn, become gains in the form of replaced aged property and infrastructures, discovery that building codes or other laws have not been followed, and rebuilding for the construction industry. The fourth lesson shown from analysis of El Niño's impacts is that predicting future impacts on lives and the economy due to expected weather is likely as difficult as making accurate long-range weather predictions.

Acknowledgments. This research was supported by a subcontract with the University Corporation for Atmospheric Research, based on funding from the Climate Prediction Center of NOAA. The views expressed herein are those of the author and do not necessarily reflect the views of NOAA or UCAR.

References

Adams, C. R., 1997: Impacts of temperature extremes. *Proc. Workshop on the Societal and Economic Impacts of Weather*, Boulder, CO, NCAR, 11–16.

Baker, D. J., 1997: *Testimony Subcommittee on Science, Technology and Space.* U.S. Senate Committee on Commerce, Science and Transportation, 15 May 1997, 6 pp.

Bishop, D., 1998: El Niño led to lower gas bills. *Detroit News,* 12 March 1998, B.1.

Bunting, V., 1998: Winter damage from El Niño bad but not the worst. *Champaign–Urbana News Gazette,* April 1998, 11 pp.

Changnon, S. A., 1996: Losers and winners: A summary of the flood's impacts. *The Great Flood of 1993,* S. Changnon, Ed., Westview Press, 276–299.

——, 1999a: The scientific issues associated with El Niño 1997–98. *El Niño 1997–98.* S. Changnon, Ed., Oxford University Press, in press.

——, 1999b: Impacts of El Niño's weather. *El Niño 1997–1998.* S. Changnon, Ed., Oxford University Press, in press.

——, D. Changnon, E. Fosse, R. Hoganson, R. Roth, and J. Tosch, 1997: Effects of recent extremes on the insurance industry: Major implications for the atmospheric sciences, *Bull. Amer. Meteor. Soc.,* **78,** 425–435.

Cincinnati Enquirer, 1998: El Niño prediction uncertain—Lots more known, but not the "why?" *Cincinnati Enquirer.,* 26 March 1998, A.15.

Clinton, W. J., 1998: It keeps going and going. *ABC News,* 1 March 1998. [Available online at www.abcnews.com].

Cornell, B., 1998: Tropicana squeezing up oj price. *Chicago Tribune,* 29 October 1998, C.1.

CPC, 1997: *ENSO Advisory.* NWS, NOAA, 13 August 1997, 6 pp.

——, 1997: *Special Climate Summary, 97/3.* NWS, NOAA, November 1997, 14 pp.

Daley, W. M., 1997: El Niño still going strong: Impacts felt around the country. NOAA, 13 February 1997, 4 pp.

Davis, J., 1997: There is no shortage of misconceptions associated with El Niño: Loose talk is influencing consumer behavior and businesses in quaint ways. *Minneapolis Star Tribune,* 17 November 1997, 1.D.

Department of Commerce, 1998: *Construction of New Homes in February.* Dept. of Commerce, 17 March 1998, 2 pp.

——, 1998: Inflation barely detected in first quarter. *Detroit News,* April 1998, B.3.

Detroit News, 1998: Local produce buyers say El Niño is hurting crops. *Detroit News,* 3 March 1998.

Dole, R. M., 1998: Effect of the 1997–98 El Niño on major U.S. weather events. *EOS, Trans. Amer. Geophys. Union,* **79,** F.27.

Federal Reserve Board, 1998: U.S. industrial output turns flat in January: El Niño gets the blame because warmer than normal weather hurt production at gas and electric utilities. *Minneapolis Star Tribune,* 18 February 1998, 4.D.

FEMA, 1997a: *Strong El Niño Could Disrupt U.S. Winter Weather Patterns.* FEMA, 12 August 1997, 2 pp.

——, 1997b: *U.S. Residents Urged to Prepare in Advance for Potentially Heavy Rains and Flooding Expected to Accompany this Year's Powerful El Niño.* FEMA, 12 September 1997, 3 pp.

——, 1997c: *El Niño of 1997–98 Could Resemble the Destructive 1982–83 Event.* FEMA, 5 September 1997, 2 pp.

Financial Times, 1997: Losses from El Niño 1982–1983. *Financial Times,* 28 July 1997, 1 pp.

Fonda, R., 1998: Mild winter helps salt away funds. *Chicago Tribune,* 1 April 1998, 1 pp.

Friday, E. W., 1998: It keeps going and going. *ABC News,* 1 March 1998. [Available online at www.abcnews.com].

Glantz, M. H., 1998: El Niño forecasts: Hype or Hope? *Network Newsletter,* Vol. 13, 1 pp.

Gray, W., November 29, 1997: Hurricane season oddly quiet in 1997. *Champaign–Urbana News Gazette,* 29 November 1997, 5 pp.

Guimares, R., F. L. Hefner, and D. P. Woodward, 1993: Wealth and income effects of natural disasters: An econometric analysis of Hurricane Hugo. *Review of Regional Studies,* **23,** 97–114.

Hall, J. M., 1997: *Testimony Subcommittee on Energy and Environment.* Committee on Science, 11 September 1997, 12 pp.

Kocin, P. J., 1997: Some thoughts on the societal and economic impacts of winter storms. *Proc. Workshop on Societal and Economic Impacts of Weather,* Boulder, CO, NCAR, 55–60.

Labor Department, 1998: Mild weather helps to build job growth. *Chicago Tribune,* 7 March 1998, 1 pp.

Labor Department, 1998: Wholesale prices not up for fifth month in a row: Asian Crisis and El Niño force producers to charge less for goods. *Associated Press,* 14 March 1998, 2 pp.

Labor Department, 1998: Inflation barely detected in first quarter. *Detroit News,* 15 April 1998, B.3.

Leetma, A., 1998: El Niño's winter no more costly than others. *USA Today,* 25 March 1998, 1 pp.

Michaels, P., 1998: Beware: Was El Niño combined with global warming? No! *Los Angeles Times,* 19 April 1998, 5.A.

National Association of Realtors, 1998: *Home Sales Set New Records for the Winter.* National Association of Realtors, 6 pp.

National Highway Traffic Safety Administration, 1999: *Data on Vehicular Deaths.* U.S. Department of Transportation, 7 pp.

National Safety Council, 1999: *Road Safety Statistics.* [Available online at http://www.national-safety-council.ie/road/state].

NOAA, 1998: Information on Florida's weather that led to fires. NOAA, June 1998, 1 pp.

——, 1998: January and February warmest and wettest on record. NOAA, March 1998, 1 pp.

NRC, 1999: *The Costs of Disasters: A Framework for Loss Estimation.* National Academy of Sciences Press, 68 pp.

National Weather Service, 1997–1998: *Storm Data.* December 1997, January 1998, February 1998, March 1998, Government Printing Office, 271 pp.

Pearce, J., and J. Smith, 1998: Farewell to winter that wasn't: Warmth hurt businesses that depend on snow, but it helped consumers and environment. *Detroit News,* 20 March 1998, E.1.

Peterlin, A., 1998: Weather and Food Prices. *Detroit News,* 15 April 1998, C.1.

Pielke, R. A., 1995: *Hurricane Andrew in Southern Florida: Mesoscale Weather and Societal Responses.* NCAR, 187 pp.

——, 1999: Responses to El Niño 1997–98. *El Niño 1997–1998,* Oxford University Press, in press.

Pielke, R., and C. W. Landsea, 1998: Normalized hurricane damages in the U.S. 1925–1995. *J. Wea. Analysis Forecasting,* 387–398.

Property Claim Service, 1998: *Catastrophe Record by Year 1998.* New York, NY, October 1998, 3 pp.

Reuters News Service, 1998: Effects of El Niño. *Reuters News Services,* 17 March 1998, 2 pp.

Ross, T., N. Lott, S. McCown, and D. Quinn, 1998: *The El Niño Winter of '97–'98.* NCDC Tech. Rep. 98-02, 12 pp.

Sacramento Bee, 1997: L.A. summit seeks joint approach to El Niño. *Sacramento Bee,* 15 October 1997, 1 pp.

San Francisco Chronicle, 1997: Devastating El Niño forecast. *San Francisco Chronicle,* 14 August 1997, 1 pp.

Shaefer, M., 1997: *Testimony Subcommittee on Water and Power.* Committee on Resources, 30 October 1997, 6 pp.

Skinner, B., P. Lamb, M. Richman, and J. Snow, 1997: *The 1997–1998 El Niño—Possible Impacts on the Property Insurance Industry.* Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, 23 pp.

Stamper, J., 1998: Gasoline Prices Decrease. *Seattle Times,* 7 March 1998, 4 pp.

Stread, R., and E. Thomason, 1998: Some stocks and investors weather El Niño. *St. Louis Post-Dispatch,* 6 March 1998, C.15.

USA Today, 1998: El Niño has absolutely crazy effect on business. *USA Today,* 2 March 1998, B.1.

——, 1998: Gas prices plunge to historic low. *USA Today,* 10 March 1998, 1 pp.

Waetke, K., 1998: El Niño produces $39 million windfall for MAE consumers. *Des Moines Register,* 23 February 1998, 2 pp.

Wall Street Journal, 1998a: Slide in energy prices may not be done. *Wall Street Journal,* 7 December 1998, C.1.

——, 1998b: Retailers say sales in January rose strongly. *Wall Street Journal,* 6 February 1998, B.4.

——, 1998c: Retailers top forecasts for sales in February. *Wall Street Journal,* 6 March 1998, B.4.

——, 1998d: Retailers post modest March sales gains. *Wall Street Journal,* 10 April 1998, B.4.

West, C. T., and D. C. Lenze, 1994: Modeling the regional impact of natural disasters and recovery: A general framework and application to hurricane Andrew. *Int. Reg. Sci. Rev.,* 17, 121–150.

Wilkins, L., 1999: Was El Niño a weather metaphor: A signal for global warming? *El Niño 1997–1998,* Oxford University Press, in press.

Wilson, W. T., 1998: Investing: Markets reacting to any old noise: El Niño among other things seen as latest threat to stability, *Detroit News,* 22 September 1998, F.9.

Wolter, K., 1997: El Niño gave blizzard much of its strength. *USA Today,* 28 October 1997, 4 pp.

Zeng, L., 1999: Pricing and portfolio management of weather derivatives and weather insurance: Theoretical framework, methodology, and applications. *J. Risk Insurance,* in press.