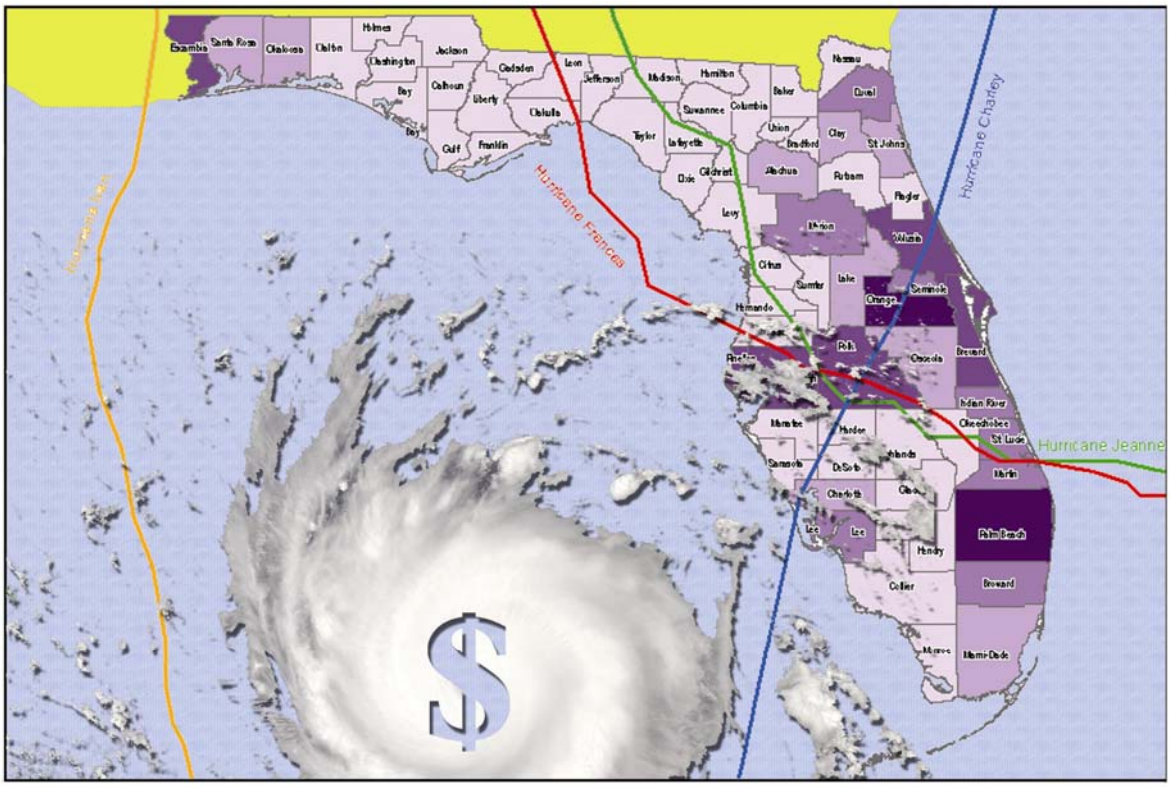

An Estimate of Lost Earnings Due to Electric Supply Disruption

The Case of Florida's 2004 Hurricane Season

FEMA Mitigation – Technical Services Branch

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"If it weren't for electricity we'd all be watching television by candlelight"
George Gobal, Comedian

I. INTRODUCTION

Four hurricanes hit Florida in 2004, each time causing power outages affecting thousands of businesses. Consequently, these businesses were unable to resume normal operations resulting in lost earnings (wages and benefits) for employees. Additional studies by Kliesen (1994), The National Research Council (1999) and Webb, Tierney, and Dahlhamer (2000) support this idea. Lost wages and benefits for hourly workers in Florida were calculated based on data from the Florida Public Service Commission (FPSC). With the exception of Monroe County, businesses in all Florida's counties lost power in at least one storm. In some cases data was limited resulting in several simplifying assumptions as identified in this paper. As illustrated, power failures resulted in an estimated $748.6 million in lost wages and benefits for Florida's workforce (See Table 1). Maps in the appendix illustrate losses by county.

Table 1. Hurricane Losses

Hurricane	Loss
Charley	$108.4
Frances	$382.7
Ivan	$59.9
Jeanne	$197.7
Total	**$748.6**[1]

Lost earnings disrupt lives and, in some cases, cause serious financial hardship for workers. These losses provide an opportunity for businesses to reduce damages from future storms. Using generators, businesses could remain in operation, maintain a steady flow of income for workers and thereby reduce the risk of employee turnover. For the community, the loss of wages and benefits is socially undesirable. Replacing wood utility poles with spun concrete poles is another way to potentially reduce future damages. A third suggestion involves switching from copper conductors to aluminum conductor steel reinforced. Putting existing power lines underground is another potential measure. Each of these is discussed later in the report.

Are these projects cost effective? Three attempts are made to answer this question: two hypothetical benefit-cost analyses of storm damage and an estimate of benefits (reduced lost earnings) from each of three mitigation projects. None of the three are definitive answers to the question.

[1] Sum of Losses May Not Equal Total Due to Rounding

Reports of Lost Wages

Kliesen writes "…calamities have cost the economy dearly in terms of lost wages and output…." The National Research Council adds, "…employees of firms affected by the power outage have reduced incomes…the key impact is not unemployment per se but reduced work and income that does not qualify for (federal) program assistance." Workers temporarily laid off because of power outages, however, are eligible for unemployment compensation in the State of Florida (Chuck Brown, personal communication, January 12, 2005). Webb, Tierney and Dahlhamer (2000) wrote, "…when asked for reasons why they experienced business interruption, businesses were most likely to cite disruptions to water, electric power, and sewer and wastewater services."

Assumptions

The following assumptions were made:[2]

- Businesses that were out of power one day were out the whole day
- If some electric customers were without power, then at least some businesses were without power
- Government workers did not lose earnings after the storms
- The number of firms without power is the ratio of firms to electric customers times the number electric customers without power
- Workers labored four hours of overtime between October 1 and in October 31 to recover lost earnings
- The number of employees per firm per county is the number of employees in a county divided by the number of firms in that county
- All workers earn the mean wage
- Hourly workers work a 40-hour week
- Workers labor eight hours per day

[2] Some of these assumptions were made because of the lack of available data. Others were made to reflect a typical practice in an industry or among workers.

II. METHODOLOGY

To determine the total loss from all hurricanes, the loss from each hurricane was calculated and summed together (see Table 1). To estimate the loss from each hurricane, the following methodology was employed.

Net lost wages and benefits (earnings) were calculated. Net lost earnings (NLE) is defined as:

$$NLE = \sum_{i=1}^{n} GLE_i - RE$$

where i = a specific day without power
GLE = gross lost earnings
RE = recovered earnings

NLE was estimated for each day that businesses were without power and each county where customers lost power. The estimate for each county was summed together to estimate total lost earnings from each individual hurricane. According to data from the FPSC, the number of days that customers were without power is listed below:

- Eight days after Hurricane Charley (n = 8)
- Nine days after Hurricane Frances (n = 9)
- Ten days after Hurricane Ivan (n = 10)
- Six days after Hurricane Jeanne (n = 6)

It was assumed that if some customers were without power, then at least some businesses were without power as well. Most businesses get power restored when residential customers do—not before.

GLE is defined as:

GLE = (b firms)(c workers per firm)(d dollars)(8 hours)(1.231)

where b = the number of firms without power
c = the number of workers per firm
d = the mean wage in dollars
1.231 = a factor for fringe benefits

Eight hours reflect the length of one average workday. Based on data from the U.S. Department of Labor, fringe benefits were assumed to be 23.1 percent of wages. An example calculation of gross lost earnings per day for one county is illustrated in Table 2.

RE are earnings workers recouped by working overtime after power was restored and after they resumed a normal 40-hour workweek. Data from AWI's Current Employment Statistics database, suggest that workers in each county worked four hours of overtime in the month of October to make up

Table 2. Calculation of Gross Lost Earnings for One Day by County

County	# of Firms Without Power (b)	Workers Per Firm (c)	Mean Wage (d)	Length of a Workday in Hours	Fringe Benefit Factor	Gross Lost Earnings (GLE)
Alachua	1,386	9.3	$17.72	8	1.231	$2,249,355
Brevard	5,645	8.4	$17.03	8	1.231	$7,952,541

for lost wages. For example, if workers in Brevard County lost wages after Hurricane Charley, Hurricane Frances and Hurricane Jeanne, they worked a total of four hours to make up wages from all three hurricanes. They did not work fours hours of overtime per hurricane. Recovered earnings were subtracted from gross lost earnings of the hurricane that caused the most damage in that county.

Firms in the equation below reflect all the firms that were without power immediately after the storm hit. Because power has been restored, those firms are assumed to be operating again. Otherwise, the variables in the equation below are the same as the equation above, except for the number of hours worked. RE can be stated as:

$$RE = (b\ firms)(c\ workers\ per\ firm)(d\ dollars)(4\ hours)(1.231)$$

The Florida Public Service Commission provided estimates of the number of customers without power. Mean wages by county were available from AWI through the Florida Research and Economic Database (FRED).

To calculate the number of firms without power and the number of workers per firm, data on the number of firms per county and the number of workers per county were used, respectively. The number of agricultural firms and agricultural workers were available from FRED. The number of all other firms and all other workers, excluding public entities and public service workers, were available from the U.S. Census Bureau (2004).

Based on data from the Bureau of Labor Statistics, 59.7 percent of Florida workers are hourly (Michael Machtinger, personal communication, January 4 2005). Sixty percent was multiplied by the number of workers per firm to estimate the number of hourly workers in each county.

Limitations

The estimate provided here is conservative. Charley came ashore Friday, Frances came ashore Saturday and Jeanne came ashore Saturday. Estimated losses would have been greater if calculations started on Saturday or Sunday when the most people were without power. However, estimating began Monday following the storms. Estimates were made for each day of the regular workweek, and a 40-hour week was assumed.

There is limited data to estimate the amount of overtime workers labored to recover lost earnings. The data is statewide for the manufacturing industry only. If data were based on all industries at the county or regional level, estimates would be more precise. The 60 percent figure used to calculate the number of hourly workers is a statewide figure. If a county level figure was available, the estimate of the number of hourly workers by county would also be more precise.

III. RESULTS

Table 3 shows net lost earnings for the counties most impacted, except for Charlotte County which was included due to its proximity to Hurricane Charley's landfall. Palm Beach County workers lost a net $132 million—more than any other county. Workers in Martin County, where Hurricanes Frances and Jeanne made landfall, lost a net $21.5 million. Workers in Escambia County, hit by the right front quadrant of Hurricane Ivan, lost a net $38.5 million. Workers had the potential to earn a certain amount when the power was out.

Lost earnings are a certain percentage of that potential. This is an interesting way to look at lost earnings. For example, total lost earnings of nearly $750 million (See Table 1) are eight percent of total potential earnings. Among the selected counties shown below, the total loss of $606.4 million is 10 percent of potential earnings. Workers in Indian River County lost 44 percent of potential earnings; Martin County workers lost 34 percent, Escambia County 41 percent and Palm Beach County 19 percent. (See Table 3).

Table 3. NLE for Selected Counties

County	NLE	Potential Earnings	% of Potential Earnings[3]
Brevard	$51,255,792	$387,410,408	13%
Broward	$18,657,354	$562,637,520	3%
Charlotte	$9,122,235	$65,803,915	14%
Duval	$26,204,286	$595,997,127	4%
Escambia	$38,541,293	$93,355,813	41%
Hillsborough	$41,318,954	$760,921,005	5%
Indian River	$22,822,570	$52,069,279	44%
Lee	$17,856,550	$246,459,737	7%
Martin	$21,484,843	$63,680,142	34%
Orange	$76,942,667	$1,207,670,614	6%
Palm Beach	$131,968,805	$708,389,381	19%
Pinellas	$38,509,652	$571,934,363	7%
Polk	$31,972,582	$325,596,506	10%
Seminole	$25,697,637	$304,514,170	8%
St. Lucie	$20,792,194	$58,671,043	35%
Volusia	$33,284,590	$271,021,429	12%
Total	**$606,432,003**	**$6,276,132,451**	**10%**

[3] The following formula was used to estimate this percentage:

$$\text{Percent of potential earnings by county)} = \sum_{i=1}^{4} NLE_i \,/\, \sum_{i=1}^{4} PE_i$$

where NLE = Net Lost Earnings
PE = Potential Earnings
i = each hurricane (Charley = 1, Frances = 2, Ivan = 3, Jeanne = 4)

IV. DISCUSSION

The losses estimated above could possibly be used to identify the cost-effectiveness of various mitigation projects. Determining cost-effectiveness is done via a benefit-cost analysis (BCA). As the name suggests, a BCA compares the benefits of a potential mitigation project with the costs of that project. Benefits are losses or damages avoided. For example, the benefits of raising a home out of the flood plane are the reduced or avoided damages to the house should another flood occur. The BCA would compare these benefits with the costs of raising the house. Such costs would at least include the labor and materials required to raise the first floor above the flood plane.

A common suggested mitigation measure is putting existing overhead power lines underground. There is a consensus, however, that this is cost prohibitive (Becky Harrison, personal communication, January 26, 2005). Other mitigation measures include complying with construction standards and cutting trees close to power lines. A bill before the Florida Senate would establish an Electric Utility Task Force to do three things:

- examine the feasibility of upgrading and protecting the current electric infrastructure
- determine the cost-effectiveness of requiring underground installation of new lines
- determine the cost of putting existing overhead lines underground

Another potential mitigation measure is the replacement of wooden electric poles with spun concrete poles. Concrete poles are three to four times stronger than wood poles; however, rural cooperative electric utilities continue to use wood.

Major utilities, such as Florida Power & Light, and all the municipal utilities have gone to concrete. An important step in implementing this measure is making arrangements for mitigation with the coop before a storm threatens. Coops would then have a plan to replace downed poles with spun concrete immediately after the storm.

In addition to concrete poles, rural coops could also mitigate their systems with conductors known as aluminum conductor steel reinforced (ACSR). These conductors, with strands of steel at the core for strength and aluminum outside as the conduit, are stronger than current copper conductors that coops are using now. Virtually none of the ACSR's installed failed during last year's hurricane season, except when a tree fell on the line. Even when the pole fell, the ACSR usually stayed intact. This is another measure to discuss with coops before a storm threatens.

Back-up generators for businesses are another potential mitigation measure. These should be strong enough to handle the essential load. For example, some hospitals had a generator(s) to handle lights and the operating room but lacked enough power for air-conditioning. This can be a serious problem for sealed structures. Good maintenance, a good and secure fuel supply and adequate reserve for an emergency are also effective mitigation measures. Natural gas is a good source of fuel for generators because there were no widespread outages after the hurricanes. When there was an outage, service was restored in hours. In addition, businesses should use quality generators.

Generators would keep hourly workers employed, which is beneficial to workers and employers. Workers are able to maintain a steady flow of income resulting in a lower risk of turnover for owners.

Benefit-Cost Analysis (BCA)

Two example benefit-cost analyses are given below. Each compares the benefits of mitigation with the cost of three different projects.

Example1: The first example involves a home improvement warehouse similar to a Home Depot or Lowe's. In this example, the warehouse is in Choctawhatchee Electric Cooperative's (CHELCO) service area. The warehouse has 200 hourly employees, with operating hours from 7 a.m. to 7 p.m. The 200 hourly employees earn wages of either $6.00 per hour, $12.00 per hour or $18.00 per hour. Twenty-five employees earn $6.00 per hour, 50 employees earn $12.00 per hour and 25 earn $18.00 per hour. During Hurricane Ivan, winds in the area served by CHELCO ranged from 45 mph to 66 mph (Hurricane Research Division, 2005). In this example, we assume that the power is out for one day after Hurricane Ivan. The store needs 60 person-hours to run cash registers at $6.00 per hour, 60 person-hours to supervise other employees at $18.00 per hour, 120 person-hours to help customers choose products at $12.00 per hour. This yields lost wages of $2,880 for one day.

Society loses less than $2,880 though. Lost wages are the number of hours worked times the wage. If a worker does not work one hour, the worker loses an hour's worth of wages. This would be the loss to society if the worker did nothing else with the time off from work. Because leisure time has a value, the loss to society is an hour's worth of wages minus the value of leisure time. For example, suppose a worker gets paid $12 per hour. Also assume the worker values leisure time at $10 per hour. Society loses $12 when the worker does not work, but gains $10 because the worker is benefiting and therefore society is benefiting when the worker engages in leisure. The net loss to society is $2.

In this BCA example, the benefits of protecting the home center from a power outage are something called consumer surplus. This is the difference between what consumers are willing to pay for goods and services and the purchase price. When the purchase price is less than what consumers are willing to pay, the difference is the benefit of having a market or store. If the store does not open because of the storm, the benefit is lost. Not all consumers would be willing to pay more than the purchase price, but some would. If consumers purchase $100,000 worth of goods on an average day, the benefits may be $70,000.

But, in this example, there are four reasons why the benefits would be less than $70,000: 1) stores that are open can supply goods and services 2) the store may recoup some of these sales when it opens 3) some materials may be supplied by state, local or federal recovery operations 4) consumers may get materials from their neighbors. In this example, this may reduce the benefits to $50,000.

Additional benefits may accrue for two reasons: 1) by improving the reliability of power, consumers will benefit when there is a power loss of shorter duration. A thunderstorm could cause such an outage; 2) consumers will benefit when the next hurricane strikes. A larger storm will provide greater benefits. These benefits may be $10,000 or more, yielding $60,000 in total benefits.

The area served by CHELCO is

hurricane-prone. The home improvement center would want to reduce lost earnings, reduce lost profit and provide needed goods to community citizens by doing one of two mitigation projects. It could bury the power line from the utility pole to the store or purchase a generator for backup power. In addition, CHELCO could replace the wood utility poles with spun concrete poles between the store and the substation.

The cost of burying a power line is anywhere from $360,200 to $1 million per mile, according to Johnson (2004). In this example, the length of line from the pole to the store is one-eighth of a mile. Thus the total cost of burying the line would probably be between $45,000 and $125,000. Comparing benefits with costs, the project is cost-effective when the costs are $60,000 or below. The benefit-cost ratio, or benefits divided by costs, is equal to 1.33, if the project costs $45,000.

The cost of replacing one wooden pole with a spun concrete pole, including installation, is $1000 (Matthew Avery, personal communication, March 25, 2005). Replacing one pole will likely reduce damages in the next storm, but damages also depend on trees near the poles and the distance of the store to the utility's substation. At $1,000 per pole, 60 poles could be replaced and the project would still be cost-effective. Given the possibility that the utility has more than one way to route power to the store, 60 poles may be enough to reduce most of the damages from the next hurricane.

A generator for a store like this is estimated to be approximately $42,000 (Steve Iverson, personal communication, February 21, 2005). Installation costs would be about $3,500 (Get-A-Quote.net, 2005). Thus, the total cost of the generator, excluding wiring, is $45,500. This reflects the cost of a 250 kW generator. At $45,500, the benefits of the project ($60,000) outweigh the costs. Thus the project is cost-effective. The benefit-cost ratio is 1.32.

Table 4. Benefits, Costs and Benefit-Cost Ratios of Mitigation Projects: Home Center

Project	Benefits	Cost	Benefit-Cost Ratio
Burying existing overhead power line	$60,000	$45,000 to $125,000	0.48 to 1.33
Replacing wood poles with spun concrete pole	$60,000	Depends on how many poles are replaced	--
Installing a generator	$60,000	$45,500	1.32

Table 4 shows the benefits and costs of each project. Given these costs and benefits, installing a generator and replacing wooden utility poles with spun concrete poles would be cost-effective projects. Burying the power line to the store would be cost-effective if the cost per mile of burial is $480,000 or less. In this example, lost wages or net business profits alone would not be enough to justify any of the mitigation projects. We assume that after Hurricane Ivan, the power at the firm is out for one day.

Example 2: The second example involves a peanut processing plant in the same geographic area with 500 employees.

The firm operates two shifts, each eight hours long. The average hourly worker earns $30 per hour, including fringe employees work each shift, yielding lost wages of $48,000 per day [(8 hours x 30 per hour x 100 employees) x 2 = $48,000]. As in the previous example, the net loss to society is less than $48,000.

The benefits, called consumer surplus, also apply in this example. If the plant sells $500,000 in peanuts per day, consumer surplus may be $250,000. But there are three reasons why the $250,000 is larger than the actual benefits: 1) it is likely there is another processor or supplier of peanuts 2) the plant in question can make up for lost production by adding another shift or using their excess production capacity to process more peanuts 3) the plant or the caterers may have some inventory. All of this may reduce the benefits to $100,000. In contrast, additional benefits will accrue if any one of the mitigation projects is successful because the plant will also have power during future hurricanes and less severe weather. This may add $15,000 to benefits, bringing total benefits to $115,000.

The rest of the example is essentially the same as the previous with a few exceptions. A generator for a plant this size would cost $174,000 (Steve Iverson, personal communication, February 21, 2005). Installation would cost of $9,000 (Get-A-Quote.net, 2005). In this case, reducing losses via back-up power is not cost-effective. Burying the power line from the utility pole to the plant is cost-effective if the burial cost is $115,000 or below. Burial costs could range as high as $125,000. At the high end of the range, costs would exceed benefits. The benefits, costs and benefit-cost ratios are shown in Table 5. Unlike the previous example, reduced lost earnings are enough to justify burying an existing overhead power line or replacing wood poles with concrete.

Table 5: Benefits, Costs, and Benefit-Cost Ratios for Mitigation Projects: Processing Plant

Project	Benefits	Cost	Benefit-Cost Ratio
Burying existing overhead power line	$115,000	$45,000 to $125,000	2.55 to 0.92
Replacing wood poles with spun concrete pole	$115,000	Depends on how many poles are replaced	--
Installing a generator	$115,000	$183,000	0.63

Benefits of Three Potential Mitigation Projects

In this analysis, just the benefits of three hypothetical mitigation projects were calculated for an area served by CHELCO. Benefits are presented in Table 6 and reflect reduced lost earnings. Lost earnings for individual counties affected by Hurricane Ivan, from which these benefits were derived, were estimated and presented in an earlier part of this paper. Benefits range from $1.8 million and $2.1 million annually, depending on the useful life of the project. The method used to calculate these benefits is described below.

The three projects are: burying existing overhead power lines, replacing wood utility poles with spun concrete poles and providing businesses with generators. Benefits from burying existing overhead power lines are

Table 6. Summary of Project Benefits

Project	Benefits
Burying existing overhead power lines	$2.1 million
Replacing wood utility poles with spun concrete poles	$2.1 million
Providing businesses with generators	$1.8 million

$2.1 million. This reflects a useful life of 50 years for power lines. The Federal Emergency Management Agency standard for public works projects is fifty years. It was assumed that burying existing power lines and replacing wood utility poles with spun concrete poles are quasi public works projects.

Benefits from replacing wood utility poles with spun concrete poles are $2.1 million. This assumes that the project reduces lost earnings after the project to zero. In other words, spun concrete poles eliminate losses from the next storm. Benefits of providing businesses with generators are $1.8 million, assuming the average generator lasts 25 years. FEMA uses 25 years as the standard useful life of machines. This result also assumes the project eliminates losses from the next storm.

To estimate the benefits above, a full-data BCA wind module developed for FEMA was adopted and modified in Microsoft Excel. Estimates of the following factors were used to determine total benefits of the project:

- Functional days of downtime
- Daily lost earnings
- Damages before mitigation
- Annual probability of a storm of that category
- Annual damages before mitigation
- Annual damages after mitigation
- Annual benefits for each category of storm

To arrive at functional days of downtime, the dollar amount of damage the storm did to the utility was divided by the replacement value of the utility (how much it would cost to replace the infrastructure of the utility) and multiplied by 100. For example, CHELCO suffered $3 million in damage due to Hurricane Ivan; the replacement value was $100 million. This yields three functional downtime days [$3 million / $100 million) x 100) = 3]. In addition, CHELCO's replacement value at the time of Hurricane Opal was approximately $41 million (Bill Nall, personal communication, March 3 2005). According to FEMA, the damage to the utility from Hurricane Opal was approximately $2 million. This yields five days of functional downtime. Hurricane Opal were extrapolated and interpolated. This method of calculating functional days of downtime is consistent with the method FEMA uses for buildings, but inconsistent with the method used for utilities. (See FEMA's BCA document titled, *What Is A Benefit?*). Our method, however, seems plausible.

To estimate functional days of downtime for different categories of storms, the functional days of downtime for Hurricane Ivan and Hurricane Opal were extrapolated and interpolated. Using data from the earlier part of this paper, lost earnings per day were service area and includes parts of Okaloosa and Walton counties (Nall, 2005). Daily lost earnings in this area were estimated to be $243,205.

Lost earnings of $243,205 per day reflect a loss from a Category 0 storm because, during Ivan, winds in CHELCO's service area did not reach hurricane strength. To estimate daily lost earnings for storms of other categories, $243,205 was increased by the percentage increase in functional days of

downtime. Daily lost earnings were expected to rise in direct proportion to functional days of downtime. This is shown in Table 7.

For example, the number of functional downtime days in a Category 1 storm increased 29 percent compared with a category zero. Thus, daily lost earnings in a Category 0 storm were increased by 29 percent to yield daily lost earnings in a Category 1 storm: [$312,866 = $243,205 +0.29($243,205)].

Table 7. Increase in Daily Lost Earnings and Functional Downtime Days

Category	Functional Downtime Days (FDD)	Percent Increase in FDD	Daily Lost Earnings
0	3.34		$243,205
1	4.30	29%	$312,866
2	6.08	41%	$442,201
3	7.50	23%	$545,433
4	9.40	25%	$684,039
5	11.69	24%	$850,366

Damages before mitigation were calculated by multiplying the functional days of downtime by daily lost wages for each category of storm. This is shown in Table 8. For example, in this analysis there were 3.34 days of functional downtime after a Category 0 storm (Hurricane Ivan). Workers lost $243,205 in earnings per day. Multiplying these two figures yields $813,010 in lost earnings. In a Category 3 storm, it was estimated that workers lost $545,433 in earnings, and that there were 7.5 days of functional downtime. Multiplying these figures yields $4,089,168 in lost earnings.

The dollar amount of damages after mitigation is unclear. Burying existing overhead power lines may eliminate all damages after mitigation. Providing generators may yield the same result. Replacing wood utility poles with spun concrete is likely to result in some damage even after the replacement is complete. How much that each project eliminated damages depends on other factors such as the number of trees around the poles. No estimate of the improved effectiveness of spun concrete could be found, despite the efforts to contact manufacturers of the poles. Thus, for this report, it was assumed that each project eliminated damages from any future storm.

These calculations are shown in Table 9. The annual number of hurricanes in the area under analysis was estimated by taking the reciprocal of the return interval (i.e. how often a storm of that magnitude will strike that area) for each category of hurricane. For example, the return interval for a Category 0 storm striking CHELCO's service area is 12.64. Taking the reciprocal yields an expected annual number of hurricanes of 0.079. This

Table 8. Estimates of Damages before Mitigation

Category	Daily Lost Earnings	Functional Downtime Days	Damages Before Mitigation
0	$243,205	3.34	$813,010
1	$312,866	4.30	$1,345,453
2	$442,201	6.08	$2,687,762
3	$545,433	7.50	$4,089,168
4	$684,039	9.40	$6,431,517
5	$850,366	11.69	$9,939,477

means 0.079 hurricanes are expected to hit each year. The return intervals for other categories of storms were calculated via linear interpolation.

Therefore, the annual benefits, which are equal to annual damages before mitigation minus annual damages after mitigation, are the annual damages before mitigation. These figures were multiplied by a present value coefficient to yield the present value of annual benefits for each category of storm.[4] Adding the annual benefits from each category of storm together yields the total benefits of the mitigation project. In this analysis the benefits from burying existing overhead power lines and replacing wood utility poles with spun concrete poles are $2.1 million. The benefits of providing businesses with generators are $1.8 million.

Table 9. Estimated Annual Damages before Mitigation

Category	Damages Before Project	Expected Annual Number of Hurricanes	Annual Damages Before Project
0	$813,010	0.07913	$64,336
1	$1,345,453	0.03603	$48,476
2	$2,687,762	0.00836	$22,472
3	$4,089,168	0.00261	$10,654
4	$6,431,517	0.00054	$3,502
5	$9,939,477	0.00008	$827

[4] The present value coefficient is different is different for each project because the life of each project is different. The coefficient changes with the life of the project and the interest rate used. The life of underground power lines is estimated to be 50 years. The interest rate is seven percent, standard for BCA projects. Using 50 years and seven percent yields a present value coefficient of 13.8. The present value coefficient for spun concrete poles is 13.8, and the present value coefficient for generators is 11.7.

V. CONCLUSION

Four hurricanes struck Florida, causing many businesses to lose electricity temporarily. As a result, businesses temporarily laid off of hourly workers, leading to lost wages and fringe benefits. Studies by Kliesen, the National Research Council and Webb, Tierney and Dahlhamer support this assessment. Using data from the Florida Public Service Commission, an estimate of lost earnings was developed. Results indicate that Florida workers lost $748.6 million in earnings in the span of seven and a half weeks. Workers in Palm Beach County alone lost $132 million. Some counties, such as Indian River County, lost 44 percent of their potential earnings if power had remained.

Four potential mitigation measures were discussed. The first involved burying existing overhead power lines. Unfortunately, industry professionals opine that this is cost prohibitive. The second measure entails replacing wooden utility poles with spun concrete poles. This is an option for rural cooperative utilities since larger utilities such as Florida Power & Light have already made the switch. A third involves replacing copper conductors with ACSR, another suggestion for rural coops. Few ACSRs were damaged in last year's hurricane season unless a tree fell on the line.

Generators were the final measure. Generators at businesses would maintain the flow of workers' income, an incentive for workers to stay with the firm. Decreased turnover is a desirable outcome for business owners.

Two benefit-cost analyses examples of storm damage were illustrated to look at the cost-effectiveness of three mitigation projects discussed earlier. The BCAs indicate that one or more of the mitigation projects might be cost-effective. Later, the benefits of these same mitigation projects were calculated for an area serviced by CHELCO. Results indicate that benefits range from $1.8 million to $2.1 million annually. Costs for mitigation projects in this same geographic area are complex to calculate. Therefore, at this time they are beyond the scope of this paper.

Should costs be calculated, additional benefits should be estimated because reduced lost earnings are just one of the benefits of reducing power outages.

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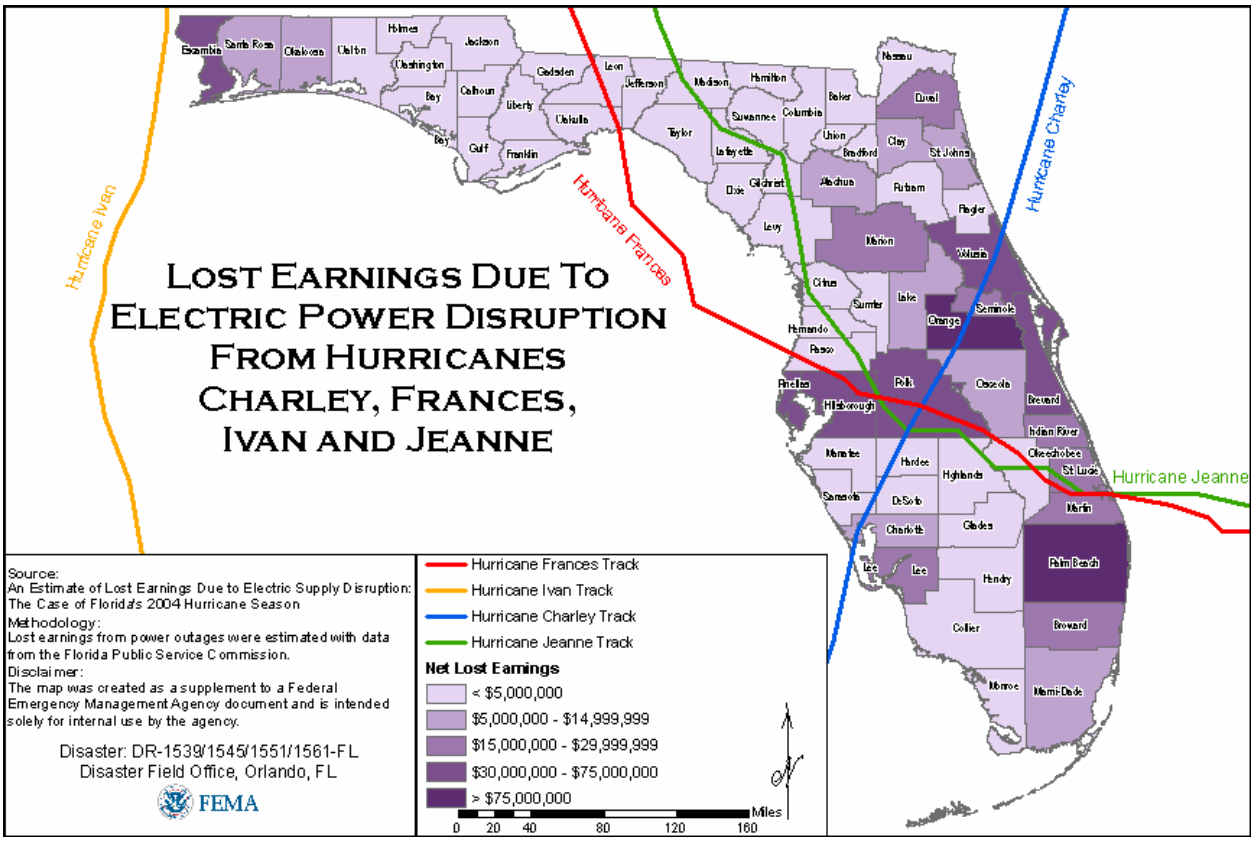
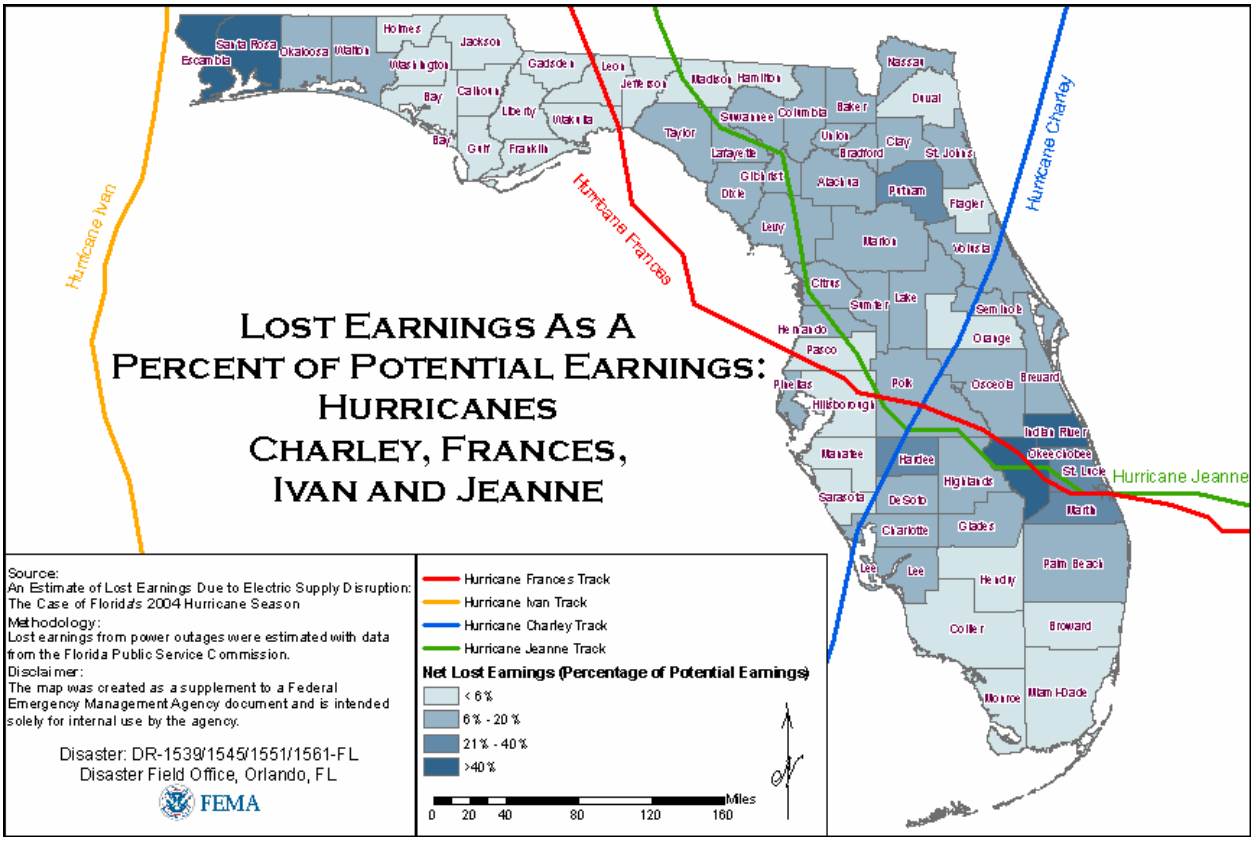
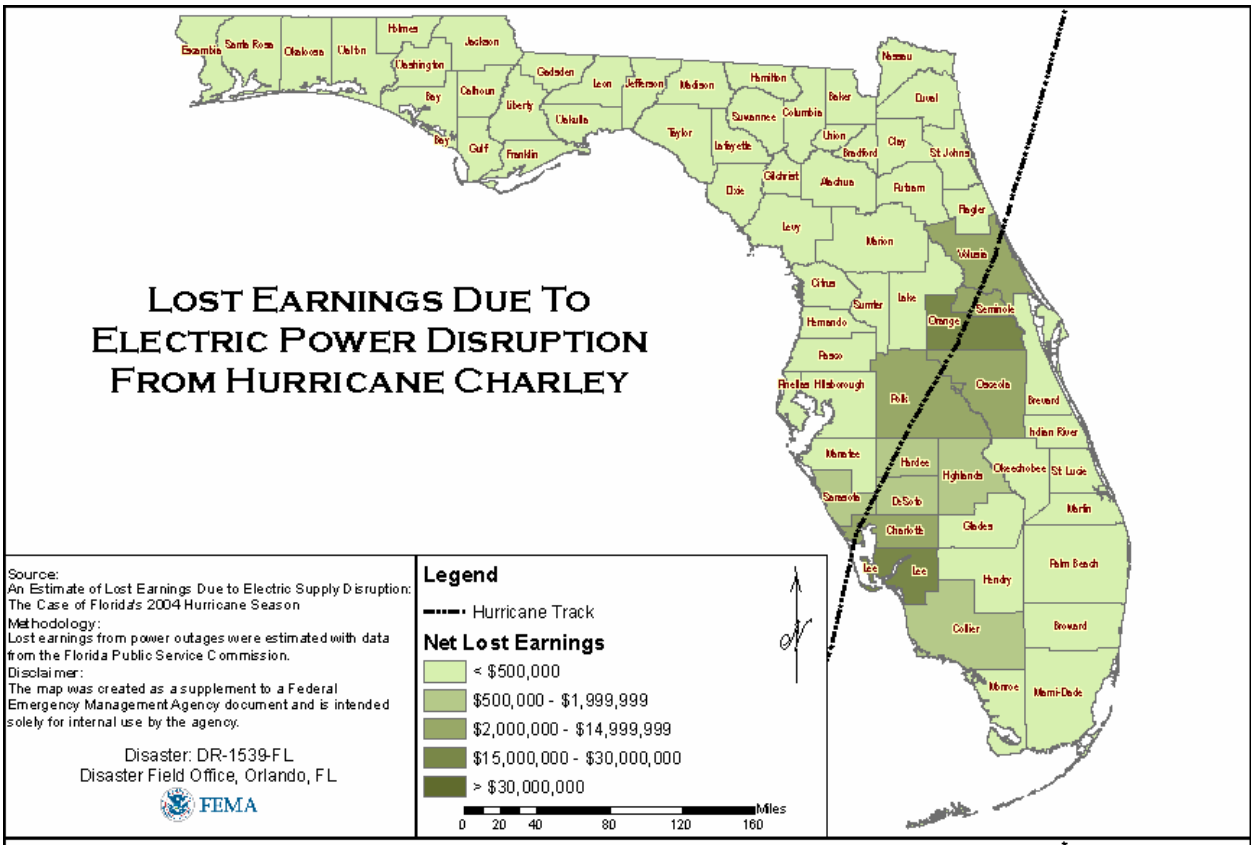
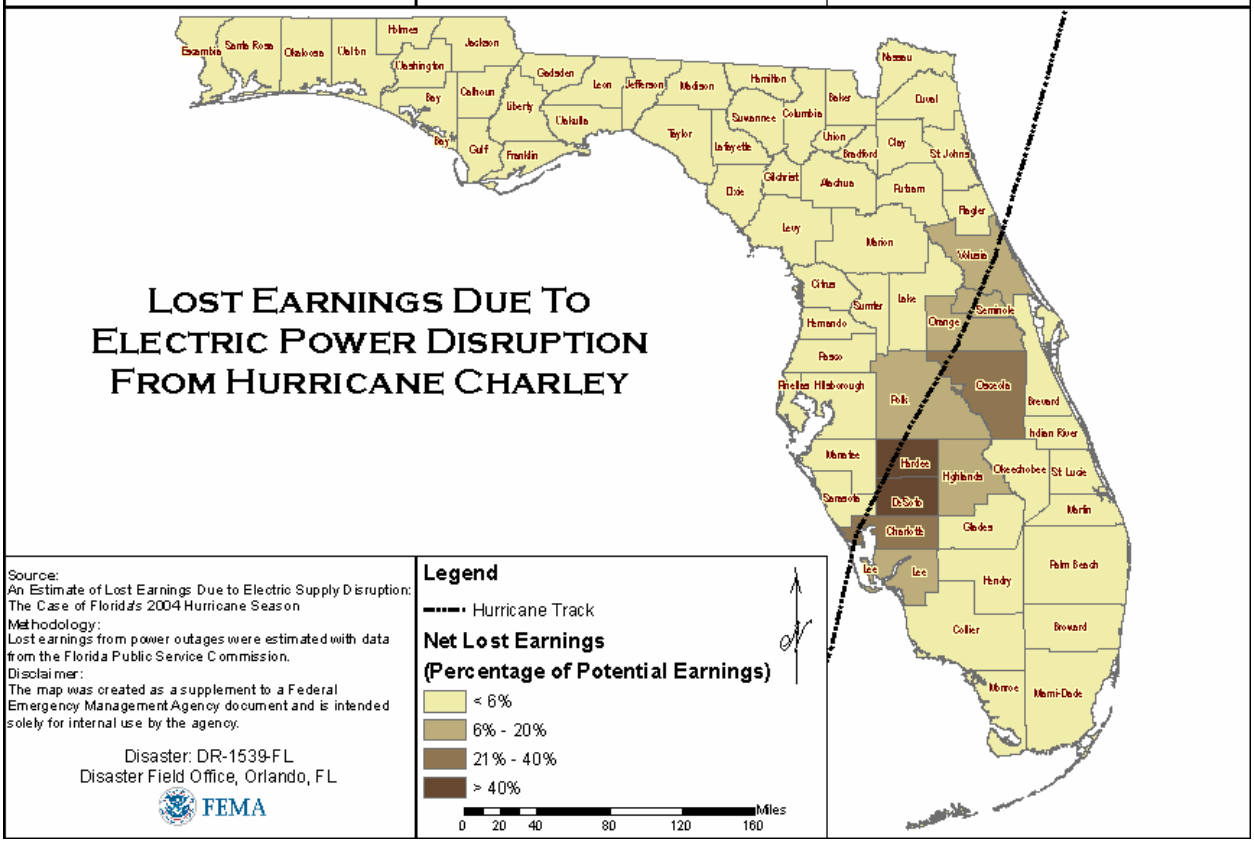
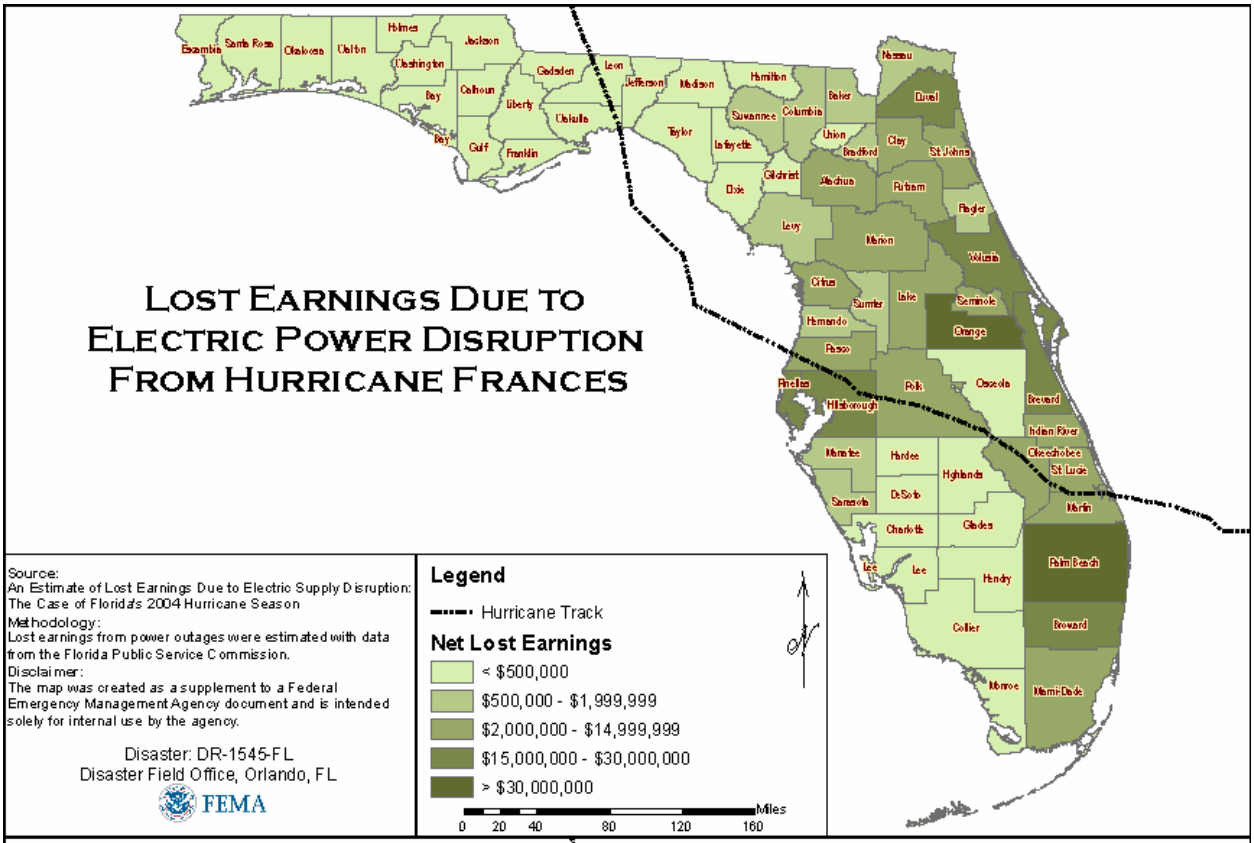
Appendix

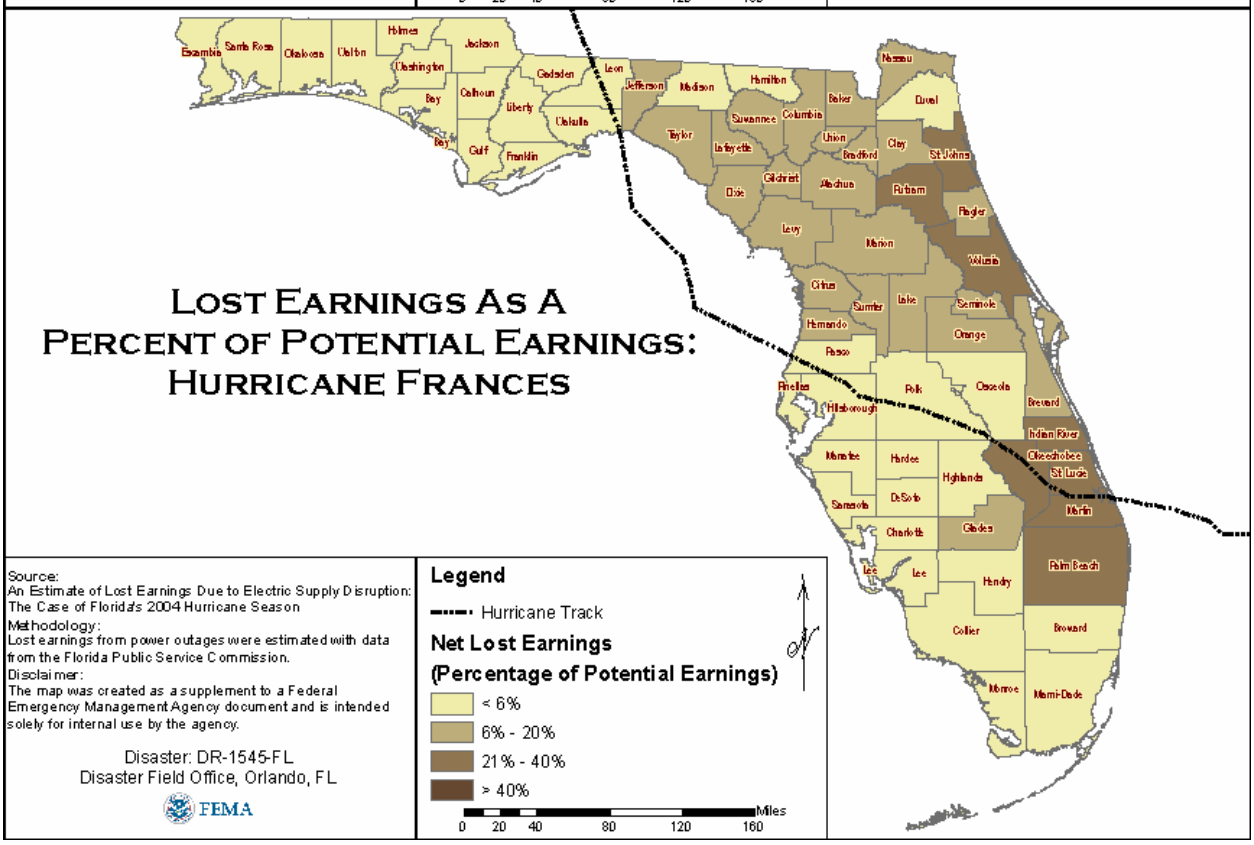

Lost Earnings Due To Electric Power Disruption From Hurricanes Charley, Frances, Ivan and Jeanne
Hurricane Ivan
Hurricane Frances
Hurricane Charley
Hurricane Jeanne
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1539/1545/1551/1561-FL
Disaster Field Office, Orlando, FL
FEMA
Hurricane Frances Track
Hurricane Ivan Track
Hurricane Charley Track
Hurricane Jeanne Track
Net Lost Earnings
< $5,000,000
$5,000,000 - $14,999,999
$15,000,000 - $29,999,999
$30,000,000 - $75,000,000
> $75,000,000
Miles
0 20 40 80 120 160

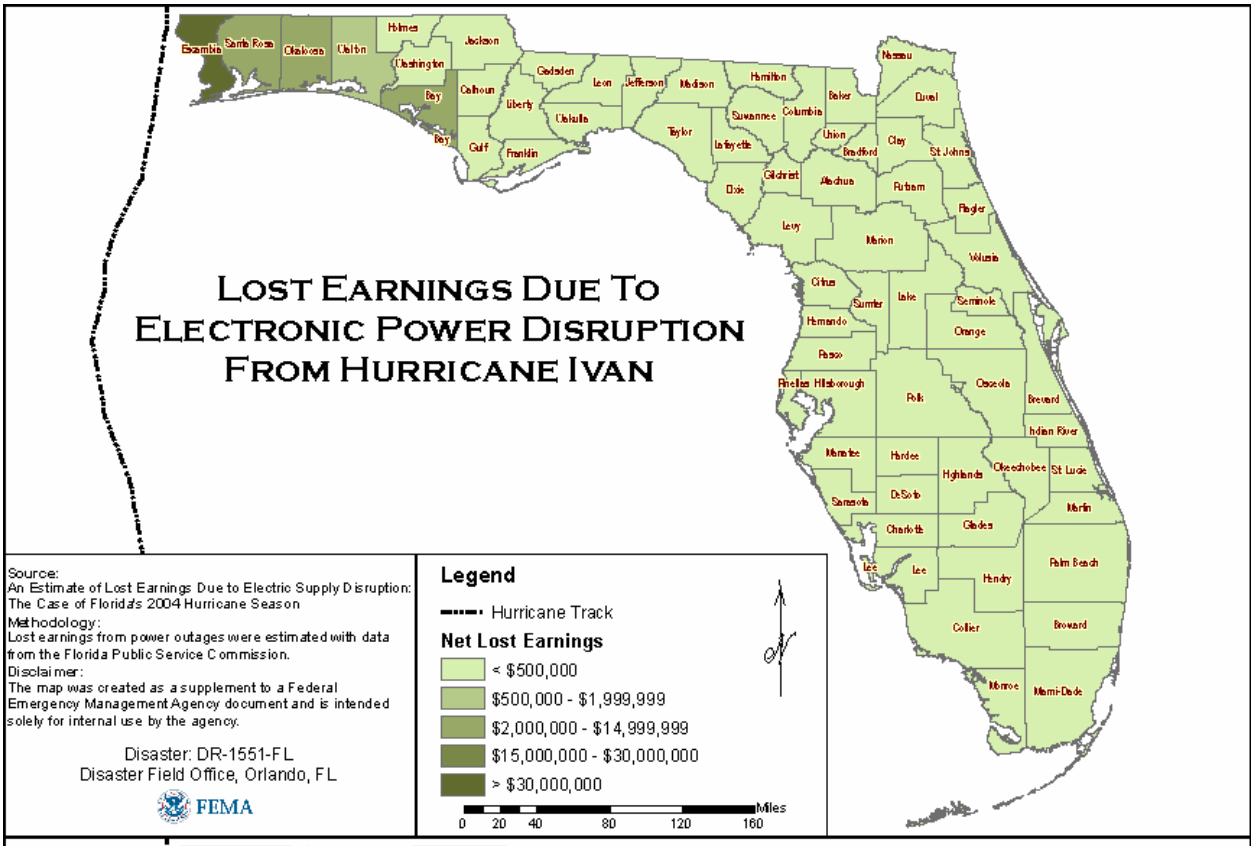

Lost Earnings As A Percent of Potential Earnings: Hurricanes Charley, Frances, Ivan and Jeanne
Hurricane Ivan
Hurricane Frances
Hurricane Charley
Hurricane Jeanne
Santa Rosa
Escambia
Okaloosa
Walton
Holmes
Jackson
Washington
Bay
Calhoun
Gadsden
Leon
Liberty
Wakulla
Franklin
Gulf
Jefferson
Madison
Hamilton
Taylor
Suwannee
Columbia
Baker
Nassau
Duval
Union
Clay
Bradford
St. Johns
Lafayette
Gilchrist
Alachua
Putnam
Flagler
Dixie
Levy
Marion
Volusia
Citrus
Sumter
Lake
Seminole
Hernando
Orange
Pasco
Pinellas
Polk
Osceola
Brevard
Hillsborough
Indian River
Manatee
Hardee
Okeechobee
St. Lucie
Highlands
Sarasota
DeSoto
Martin
Charlotte
Glades
Lee
Lee
Hendry
Palm Beach
Collier
Broward
Monroe
Miami-Dade
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1539/1545/1551/1561-FL
Disaster Field Office, Orlando, FL
FEMA
Hurricane Frances Track
Hurricane Ivan Track
Hurricane Charley Track
Hurricane Jeanne Track
Net Lost Earnings (Percentage of Potential Earnings)
< 6%
6% - 20%
21% - 40%
>40%
Miles
0 20 40 80 120 160

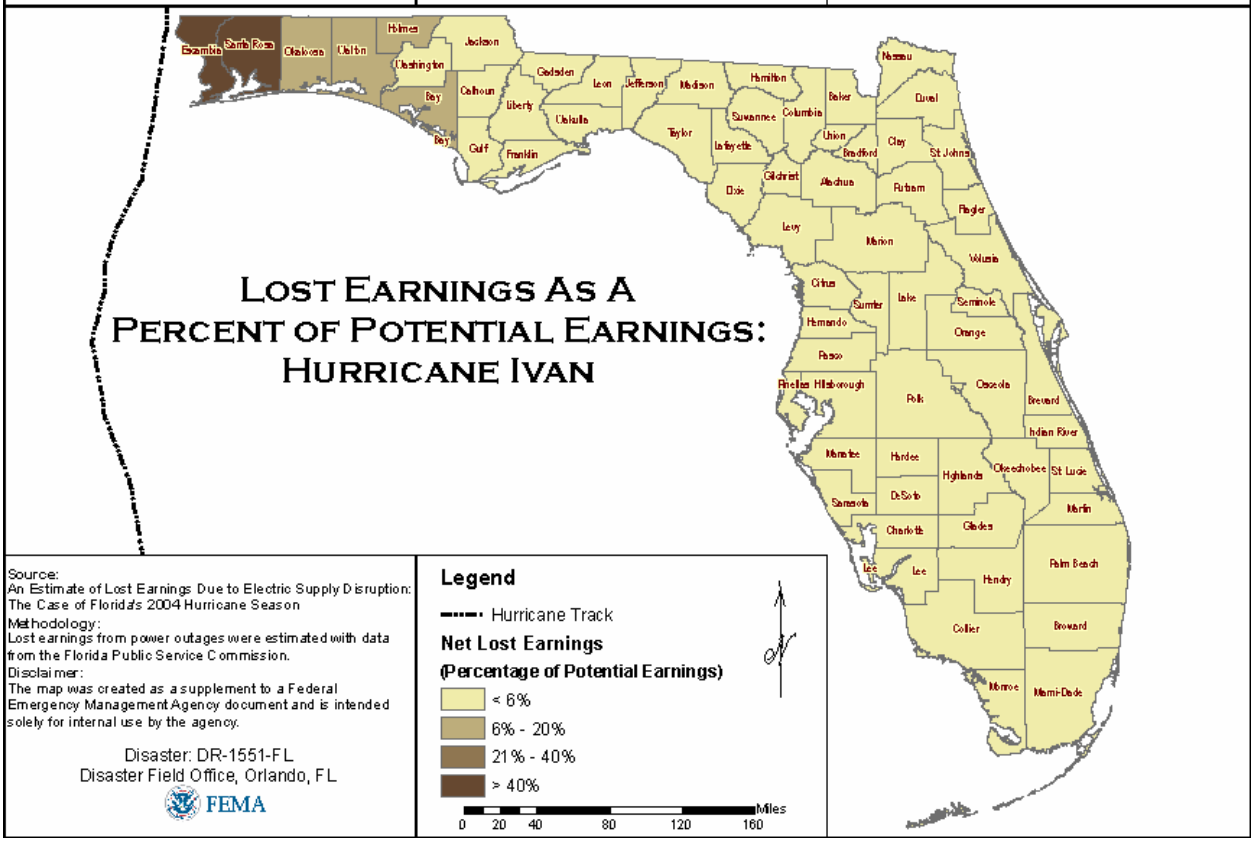

LOST EARNINGS DUE TO
ELECTRIC POWER DISRUPTION
FROM HURRICANE CHARLEY
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1539-FL
Disaster Field Office, Orlando, FL
FEMA
Legend
Hurricane Track
Net Lost Earnings
< $500,000
$500,000 - $1,999,999
$2,000,000 - $14,999,999
$15,000,000 - $30,000,000
> $30,000,000
Miles
0 20 40 80 120 160

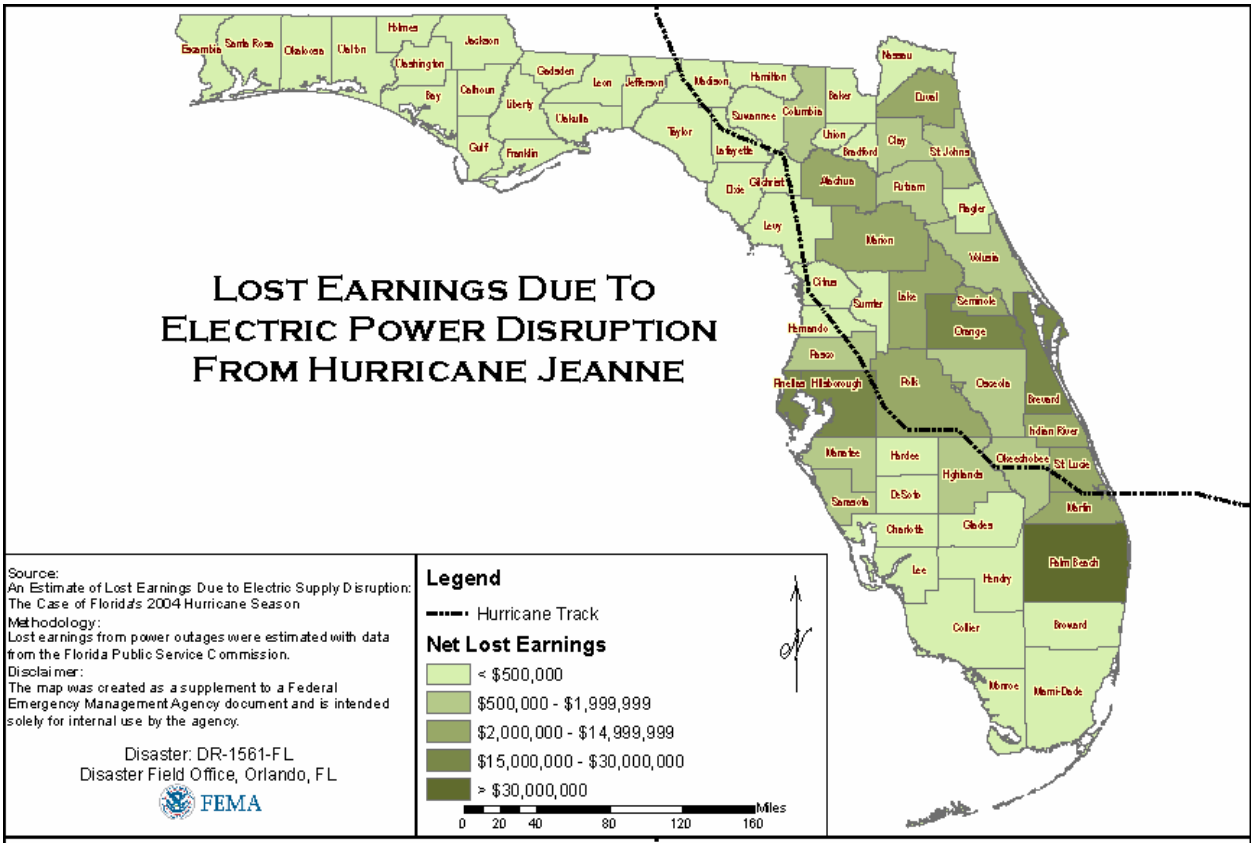

LOST EARNINGS DUE TO
ELECTRIC POWER DISRUPTION
FROM HURRICANE CHARLEY
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1539-FL
Disaster Field Office, Orlando, FL
FEMA
Legend
Hurricane Track
Net Lost Earnings
(Percentage of Potential Earnings)
< 6%
6% - 20%
21% - 40%
> 40%
Miles
0 20 40 80 120 160

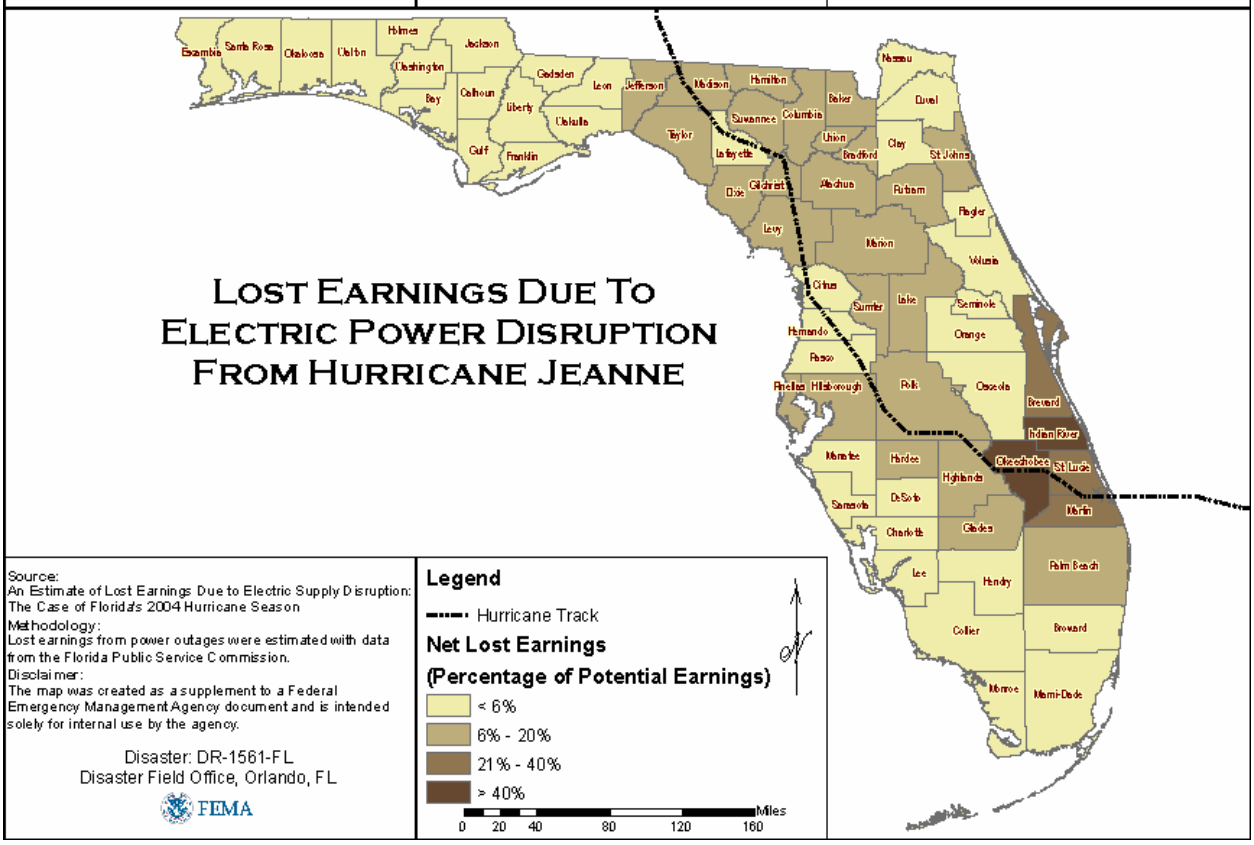

Lost Earnings Due to Electric Power Disruption From Hurricane Frances
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1545-FL
Disaster Field Office, Orlando, FL
FEMA
Legend
Hurricane Track
Net Lost Earnings
< $500,000
$500,000 - $1,999,999
$2,000,000 - $14,999,999
$15,000,000 - $30,000,000
> $30,000,000
Miles
0 20 40 80 120 160


Lost Earnings As A Percent of Potential Earnings: Hurricane Frances
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1545-FL
Disaster Field Office, Orlando, FL
FEMA
Legend
Hurricane Track
Net Lost Earnings
(Percentage of Potential Earnings)
< 6%
6% - 20%
21% - 40%
> 40%
Miles
0 20 40 80 120 160


Lost Earnings Due To
Electronic Power Disruption
From Hurricane Ivan
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1551-FL
Disaster Field Office, Orlando, FL
FEMA
Legend
Hurricane Track
Net Lost Earnings
< $500,000
$500,000 - $1,999,999
$2,000,000 - $14,999,999
$15,000,000 - $30,000,000
> $30,000,000
0 20 40 80 120 160 Miles


Lost Earnings As A
Percent of Potential Earnings:
Hurricane Ivan
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1551-FL
Disaster Field Office, Orlando, FL
FEMA
Legend
Hurricane Track
Net Lost Earnings
(Percentage of Potential Earnings)
< 6%
6% - 20%
21% - 40%
> 40%
0 20 40 80 120 160 Miles


Lost Earnings Due To
Electric Power Disruption
From Hurricane Jeanne
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1561-FL
Disaster Field Office, Orlando, FL
FEMA
Legend
Hurricane Track
Net Lost Earnings
< $500,000
$500,000 - $1,999,999
$2,000,000 - $14,999,999
$15,000,000 - $30,000,000
> $30,000,000
Miles
0 20 40 80 120 160


Lost Earnings Due To
Electric Power Disruption
From Hurricane Jeanne
Source:
An Estimate of Lost Earnings Due to Electric Supply Disruption: The Case of Florida's 2004 Hurricane Season
Methodology:
Lost earnings from power outages were estimated with data from the Florida Public Service Commission.
Disclaimer:
The map was created as a supplement to a Federal Emergency Management Agency document and is intended solely for internal use by the agency.
Disaster: DR-1561-FL
Disaster Field Office, Orlando, FL
FEMA
Legend
Hurricane Track
Net Lost Earnings
(Percentage of Potential Earnings)
< 6%
6% - 20%
21% - 40%
> 40%
Miles
0 20 40 80 120 160