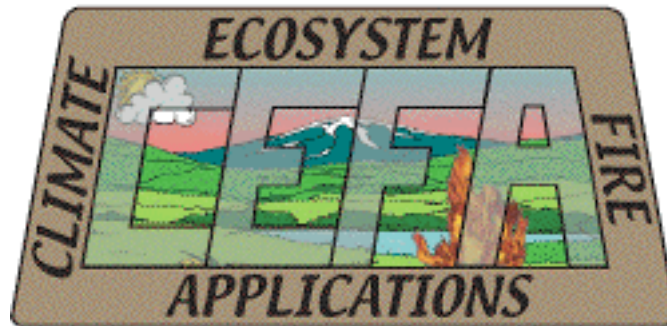


*Program for Climate, Ecosystem and Fire Applications*



# **Development of Historic Fire Weather Data and Wildland Fire Occurrence Data for the New York Division of Protection and Fire Management**

*Final Report*

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Division of Atmospheric Sciences

**Final report on Development of Historic Fire Weather Data and Wildland Fire Occurrence Data for the New York Division of Protection and Fire Management**

by

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## EXECUTIVE SUMMARY

The National Fire Danger Rating System (NFDRS) is the National standard for fire danger rating in the United States, and is the accepted standard for the New York Division of Environmental Conservation Wildland Fire Management Program. NFDRS calculates daily fire danger indices and components based on weather observations. This information is then analyzed with historic wildland fire occurrence data, allowing fire managers to support both long and short-term fire management decisions based on current and expected fire danger. Daily fire weather data is obtained from the Division's network of Remote Automated Weather Stations (RAWS) strategically located across the State. However, this network is relatively new, with the oldest RAWS placed in service in 1996. The lack of a historical database limits the accuracy of the NFDRS outputs, which in turn limits the confidence value of decisions based on the process. Likewise, until this project, the Division also lacked a comprehensive statewide electronic database of wildland fire occurrence that is required for the calculations and comparisons.

Historical fire and weather information has many uses for fire management beyond fire danger calculation, such as the assessment of fire severity and prescribed burn planning. A New York state historic fire-weather and wildland fire occurrence database to support the Division's Wildland Fire Management Programs was desired to meet these uses, and to gain a better understanding of both the weather and fire climatology in this region. Following a coarse data quality analysis of the weather elements in the dataset including temperature, relative humidity, wind speed, wind direction and precipitation, multiple linear regression equations were developed using data from the North American Regional Reanalysis (NARR) dataset as predictors to estimate weather data for missing and questionable RAWS observations, and to extend the period of record. The end result produced weather data for 18 stations through New York State from 1980 through 2004. However, during this database construction, a complementary project was undertaken with the national Fire Program Analysis (FPA) effort that allowed for the development of gridded RAWS-like observations for every 32-by-32 kilometer area across the U.S. for 1980 through 2007. This provided a new higher resolution dataset for New York, that after some assessment, has shown to be highly desirable for state-level fire danger analyses. These gridded data, similar to RAWS, are formatted to allow input into decision-support tools such as *FireFamily+*, which is commonly used to assess weather, fire danger and fire occurrence at the local level.

An historical fire occurrence database was substantially expanded that utilized an existing NY Forest Ranger database, and by data entry of records from logbooks. For integrating the fire occurrence into the *FireFamily+* software, a new agency fire planning definition for New York was created that used region, county and township information for each fire to categorize fire occurrence into associations for relating to local weather station data. Analysis was performed to examine and quantify relationships between weather and fire across the state.

The primary project objectives included:

1. Build an historical weather database for New York State that is Weather Information Management System (WIMS) compatible and has undergone quality control.
2. Develop a methodology to produce proxy data for RAWS when gaps occur.
3. Develop monthly climatological summaries for weather variables relevant to fire danger.
4. Build an historic fire occurrence database for New York State that is National Interagency Fire Management Integrated Database (NIFMID) compliant.

Project deliverables during the reporting period included:

1. A 25-year database of relevant 1300-hour fire weather variables including state of the weather, temperature, relative humidity, 20-foot wind speed and direction, and precipitation occurrence in the 1998 weather observation data transfer format;
2. A 25-year database of relevant 24-hour fire weather variables including maximum/minimum dry bulb temperatures, maximum/minimum relative humidity values, and precipitation amount and duration in 1998 weather observation data transfer format;
3. Monthly climatological summaries of temperature, relative humidity, wind speed and direction, and precipitation;
4. A 25-year historic wildfire occurrence database compiled into standard NIFMID format; and
5. Presentation of the Project, including methodology and findings, to the New York State Wildland Fire Management Program.

This report provides descriptions of the task elements and deliverables, and summarizes the project.

## Introduction

The National Fire Danger Rating System (NFDRS) is the national standard for fire danger rating in the United States, and is the accepted standard for the New York Division of Environmental Conservation Wildland Fire Management Program. NFDRS calculates daily fire danger indices and components based on weather observations. This information is then analyzed with historic wildland fire occurrence data, allowing fire managers to support both long and short-term fire management decisions based on current and expected fire danger. Daily fire weather data is obtained from the Division's network of Remote Automated Weather Stations (RAWS) strategically located across the State. However, this network is relatively new, with the oldest RAWS placed in service in 1996. The lack of an historical database limits the accuracy of the NFDRS outputs, which in turn limits the confidence value of decisions based on the process. Likewise, until this project, the Division also lacked a comprehensive statewide electronic database of wildland fire occurrence that is required for the calculations and comparisons.

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The primary project objectives included:

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2. Develop a methodology to produce proxy data for RAWS when gaps occur.
3. Develop monthly climatological summaries for weather variables relevant to fire danger.
4. Build a historic fire occurrence database for New York State that is National Interagency Fire Management Integrated Database (NIFMID) compliant.

## **Deliverables and Results**

Project deliverables during the reporting included:

1. A 25-year database of relevant 1300-hour fire weather variables including state of the weather, temperature, relative humidity, 20-foot wind speed and direction, and precipitation occurrence in the 1998 weather observation data transfer format;
2. A 25-year database of relevant 24-hour fire weather variables including maximum/minimum dry bulb temperatures, maximum/minimum relative humidity values, and precipitation amount and duration in 1998 weather observation data transfer format;
3. Monthly climatological summaries of temperature, relative humidity, wind speed and direction, and precipitation;
4. A 25-year historic wildfire occurrence database compiled into standard NIFMID format; and
5. Presentation of the Project, including methodology and findings, to the New York State Wildland Fire Management Program.

***Task element 1: Build a 25-year database of relevant 1300-hour fire weather variables including state of the weather, temperature, relative humidity, 20-foot wind speed and direction, and precipitation occurrence for the project area in a 1998 weather observation transfer format.***

The National Fire Danger Rating System (NFDRS) requires a standard set of weather and environmental inputs to produce fire danger rating indices. To provide for this information, RAWS have been installed in strategic locations within New York State. Figure 1 provides a map of RAWS locations, the oldest of which was implemented in 1996. To extend the historical weather database and fill data gaps revealed by a quality control analysis in the existing data, two methods were utilized. First, although the RAWS network in New York is relatively new, many of the stations in the network are located near hourly weather station locations (Figure 2) where manual or automated weather observations have been taken daily for many years prior.

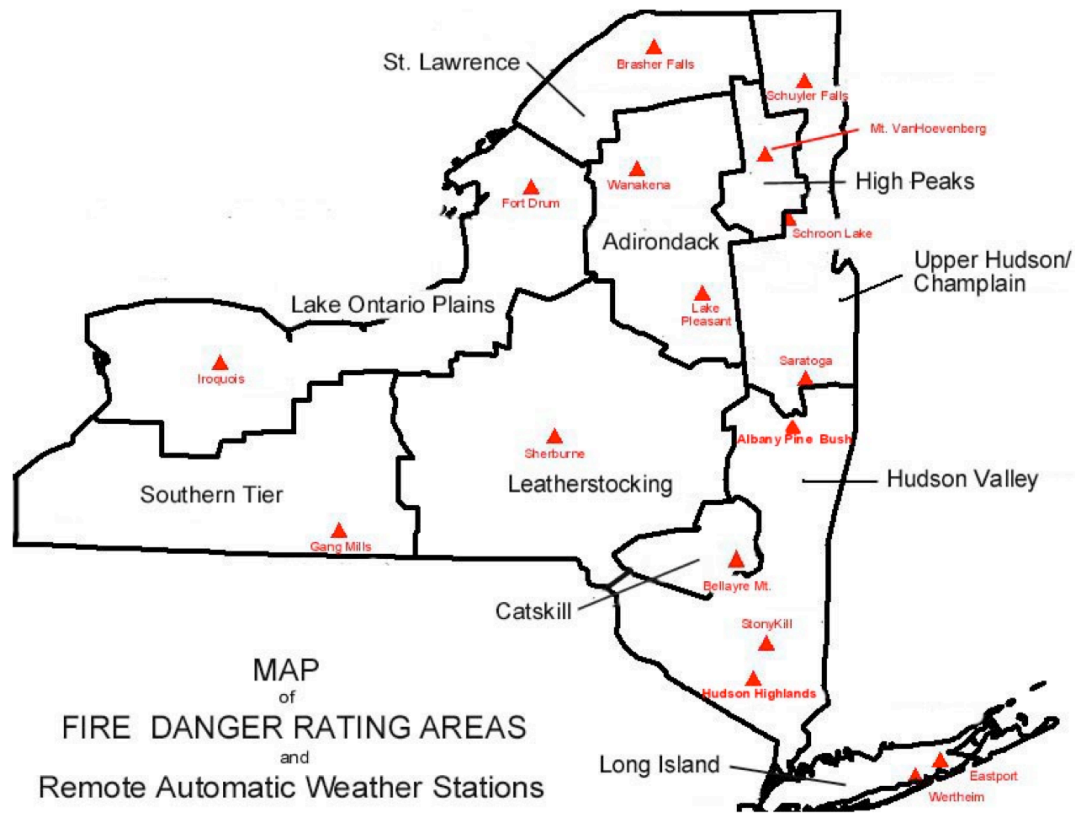


Figure 1. Map of 18 RAWS locations in New York State.

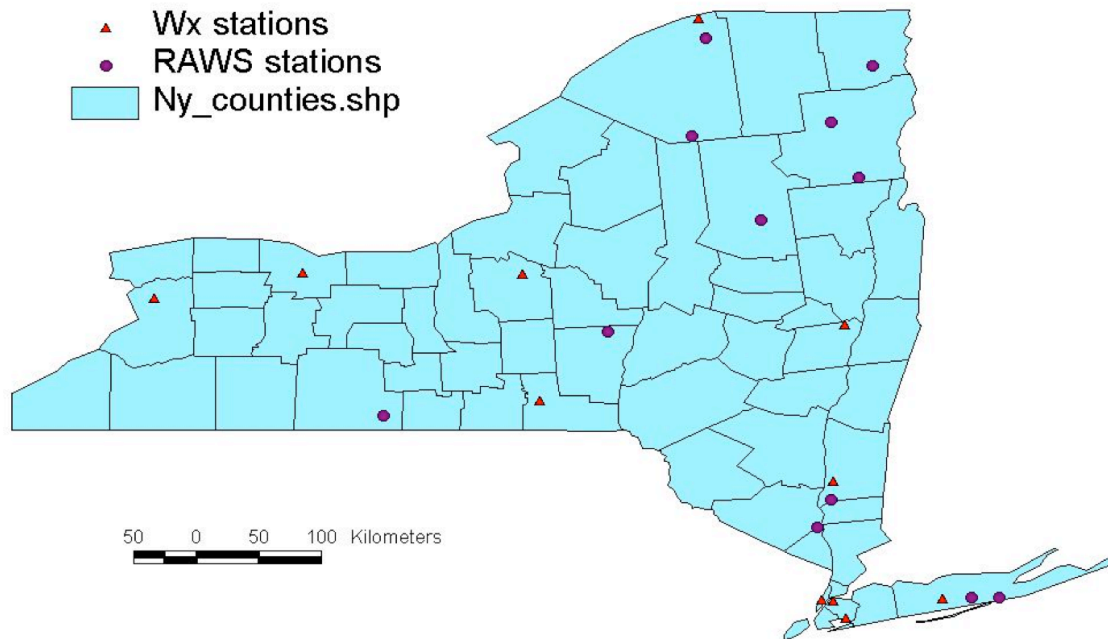
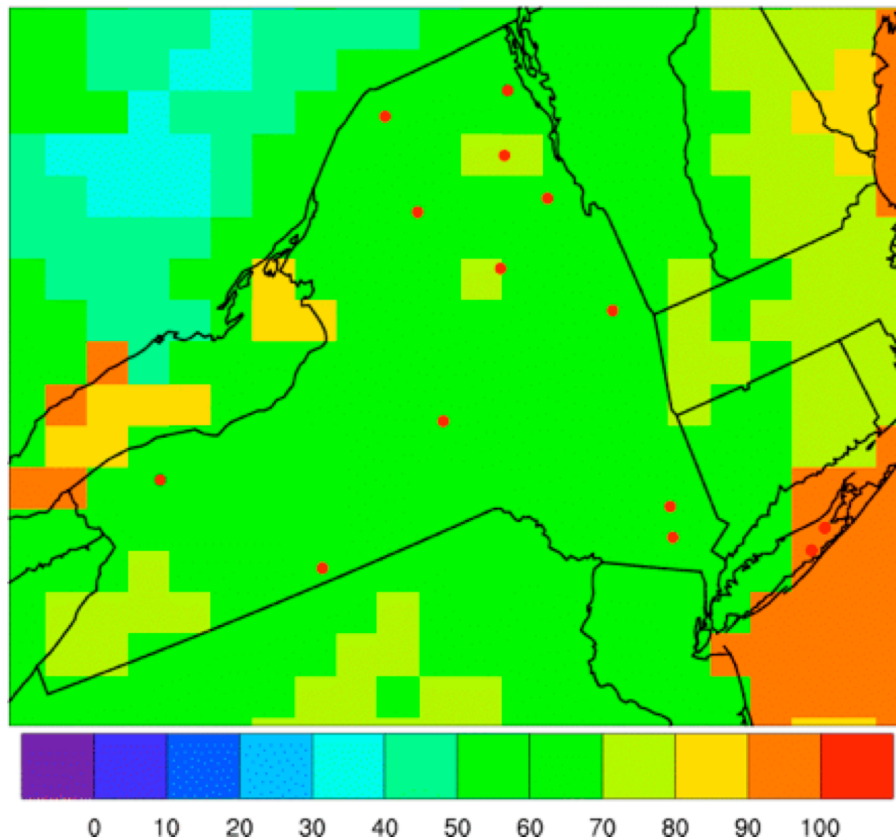


Figure 2. Locations of first order hourly weather stations (triangles) from which historic manual observation data were acquired to develop proxy historic RAWS data. Twelve RAWS locations are also shown on the map (circles).



Second, the objective of creating 25 years of weather data for New York required the use of an additional data set that contained no missing data, and could be integrated with original observations in order to create a dataset that is as close to the expected observations as possible. Data from the North American Regional Reanalysis (NARR) project was acquired for this purpose. Data from NARR is on a 32-km grid at 3-hourly intervals from 1979 through present. Figure 3 shows an example relative humidity output field from NARR. Note the square shapes, which depict individual grid cells from the model.



**Figure 3.** An example relative humidity output field from NARR over New York State. The location of 14 RAWS is also shown (red points).

To produce a continuous record dataset for each RAWS, multiple linear regression analysis was applied using NARR as the predictor variables and the observed historical RAWS as the predictand. The set of original predictor variables from NARR included surface temperature, relative humidity, specific humidity, long- and short-wave radiation, vector components of low-level winds, and various parameters related to surface precipitation. Once a suitable set of predictor variables was determined in the multiple stepwise regression analysis, these equations were then used to estimate missing or questionable data from the original observation data set, and to extend the dataset back to 1980. The regression analysis revealed that while the NARR data was a good predictor of temperature and relative humidity, it did not estimate precipitation well. Historic daily Co-op station observation data produced higher correlations to the RAWS

observations, and improved the coefficient models for the analysis. An historical, 1300 LT, daily observation set was initially created for the period 1980-2004.

Shortly after the regression analysis was undertaken, it was recognized that the gridded NARR data itself might be suitable as a proxy-RAWS dataset for New York State. Analysis undertaken by Joe Kennedy, New York State Forest Ranger, showed that NARR could be suitable for this use. A desirable feature of this dataset is that it provides for weather information uniformly across the State at a 32-km spatial resolution (refer to Figure 3). Initial analyses showed that while NARR could be beneficial, there were some data accuracy issues, especially with precipitation. Once corrected and reanalyzed, data from NARR was formatted into the fw9 format allowing for use in fire weather analysis software. These data are now available online through the Western Regional Climate Center (<http://www.wrcc.dri.edu/fpa>).

***Task element 2: Build a 25-year database of relevant 24-hour fire weather variables including maximum/minimum dry bulb temperatures, maximum/minimum relative humidity values, and precipitation amount and duration for the project area in 1998 weather observation data transfer format.***

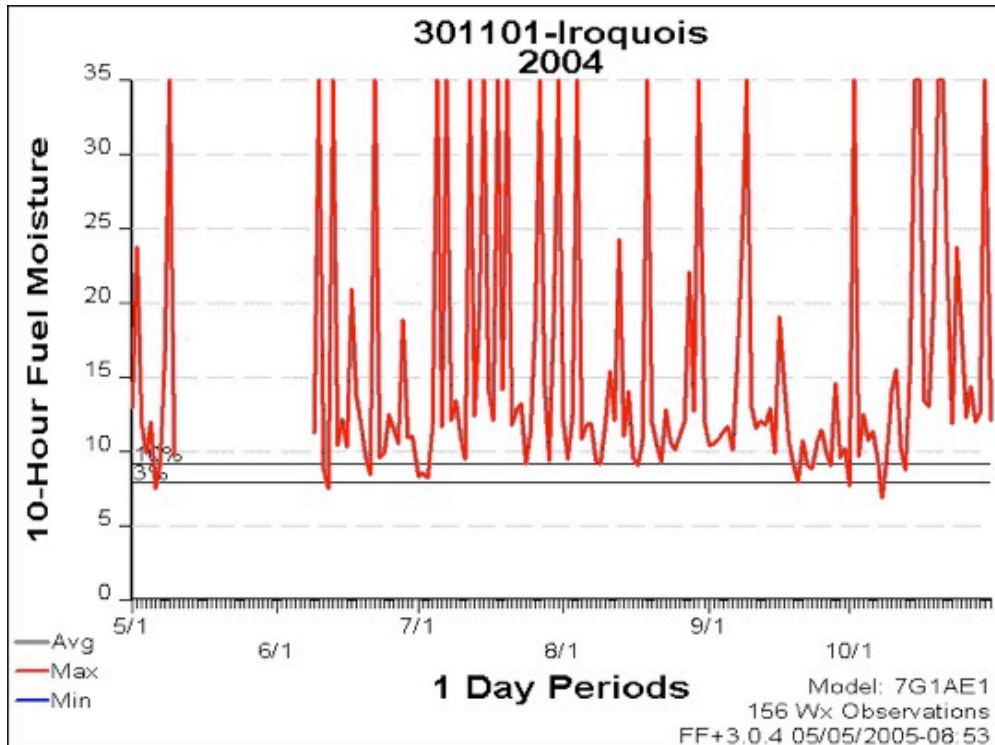
Once the hourly dataset was generated under Task Element 1, 24-hour summary statistics of maximum/minimum temperature and relative humidity, precipitation amount and duration was calculated. These values were then inserted into the 1300 LT observation to fill out the fw9 data format structure.

***Task element 3: Create monthly climatological summaries of temperature, relative humidity, wind speed and direction, and precipitation.***

The proxy RAWS datasets created in Task Elements 1 and 2 were utilized to calculate climatologies using *FireFamily+*. This software package allows for the computation of weather and fire danger summary statistics by day or month. Figure 4 shows an example of daily 10-hour time lag fuel moisture for the Iroquois RAWS.

***Task element 4: Build a 25-year historic wildfire occurrence database compiled into standard NIFMID format.***

A combination of an existing electronic database and paper records were used to create an historical dataset of fire occurrence for New York. Hand-written logbooks (Figure 5) were acquired and coded into a spreadsheet. Over 7,000 fires were entered into the database after undergoing a coarse quality control assessment to fill gaps in the fire record and eliminate potential duplicates. These fire records were merged with the electronic database, which was also coarse quality checked. The two datasets were then merged and converted into the NIFMID format for a final database. As a result of this effort, the state's fire occurrence data now extends back to 1979.



**Figure 4.** Example of 10-hour fuel moisture plot from *FireFamily+* for 2004 at the Iroquois RAWS.

A fire analysis revealed where most fires occur spatially across the state. Figure 6 shows that the majority of fires have occurred in the eastern portion of the state, and along the Pennsylvania border. Figure 7 shows only where lightning fires have occurred, which is predominately in the northeastern portion of the state. The number of lightning fires is quite low compared to the totals shown in Figure 6, thus indicating that the vast majority of fires in New York are human caused. Figure 8 shows the number of fires by month, and hence the seasonality of the state's fire occurrence. Clearly, the spring season is the peak, with April having the largest number of fires.

Figure 9 summarizes the fire statistics in a number of ways. The upper panel shows fires (left axis and solid bar) and acres (right axis and hatched bar) by year for 1979-2004. For example, 1999 had the most fires for a single year, but 1989 had the most area burned (and had second most number of fires). The upper right panel shows the number of fires by month (similar to Figure 8), again indicating the spring season as most active with April having the most fires. The lower left panel shows fires by size class. Class B, having the most fires, represents a size of more than  $\frac{1}{4}$  acre, but less than 10 acres. Refer to <http://www.nwgc.gov/pms/pubs/glossary/s.htm> for a complete description of the size classes. The lower center panel shows fires by cause class. Class 1 is lightning, and classes 2-9 are various forms of human-caused fire. Note that lightning (class 1) is a small percentage, whereas class 4 (debris burning) represents the largest number of fires (nearly 35%). The lower right panel shows the number of fires per fire day. This represents multiple fires occurrence, which could be problematic for initial attack if too many fires occur in close time proximity over a geographic area.

State Sept 1.

Year 1957-1958

RECORD OF

County	Town	No.	Date	Acres Burned	Cause	Damage	Violation			Reported by
							Sec.	No.	Disposal	
Chenango	German	1	11/14/57	.3	Trespasser match		-	-	-	J. Curry
Chenango	New Berlin	2	10/16/57	100 54 ac.	Children Camp fire		-	-	-	H. Good
Broome	Nanticoke	3	11/8/57	25 ac.	Farmer Combine Caught on Fire.	\$200- to Millet.				Broome County Fire Control Cent
Chenango	Smithville	4	11/14/57	Free	Hunters smoke spindle		-	-	-	Ray Root Br Co FC
Broome	Pickuson	5	4/16/58	2 1/2	Campfire		-	-	-	Br. Co. F.C.
Broome	Richman	6	4/16/58	Four	Children		-	-	-	Br. Co. F.C. Endwell FD
Broome	Union	7	4/17/58	1 1/2	Smoked		-	-	-	Br. Co. FC Central
Broome	Chenango	8	4/16/58	1/2	Smoked		-	-	-	Bambridge FD
Chen	Bambridge	9	4/16/58	17	Smoked		-	-	-	Bambridge FD
Chen	Bambridge	10	4/19/58	7 3/10	Burning trash	28.00	-	-	-	Bambridge FD Five Mile FD
Broome	Kirkwood	11	4/16/58	7	Children		-	-	-	Air Line Pilot
Broome	Vestal	12	4/16/58	44	Smoked		-	-	-	Berry Hill ton Br. Co. Fire Control Center
Chen.	Smithville	13	4/14/58	-	False Alarm		-	-	-	Br. Co. Fire Control Center
Broome	Chen	14	4/16/58	1/10			-	-	-	Br. Co. Fire Control Center
Broome	Fenton	15	4/16/58	160	Burning trash	30.00	-	-	-	Br. Co. Fire Control Center
Chen	Smithville	16	4/17/58	-	False Alarm		-	-	-	Berry Hill
Chen	Bambridge	17	8/8/58	Tree	Lightning		-	-	-	E. Clayton

Figure 5. Example page from a handwritten logbook of fire occurrence records.

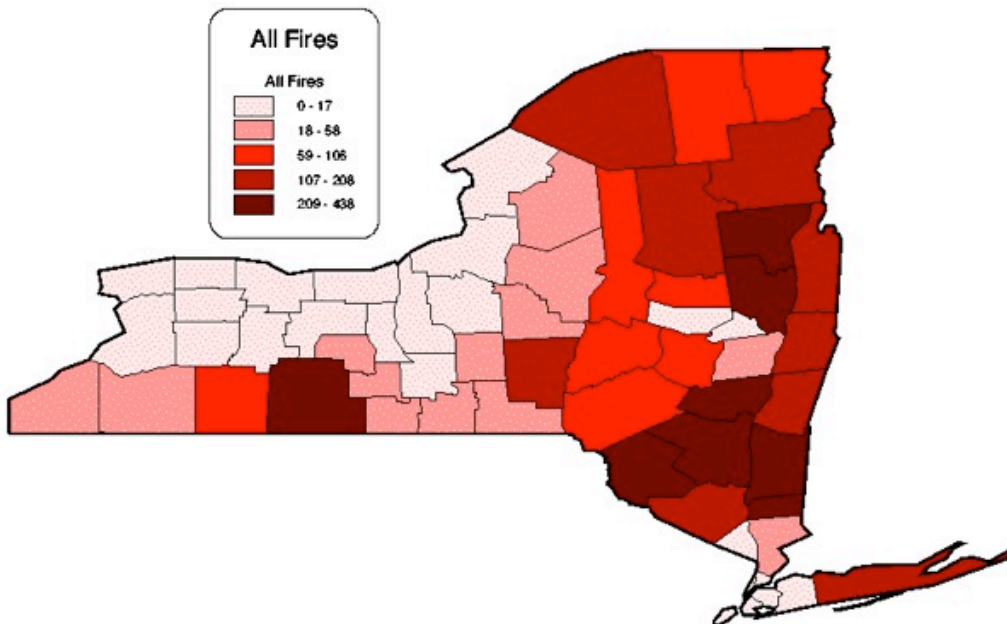
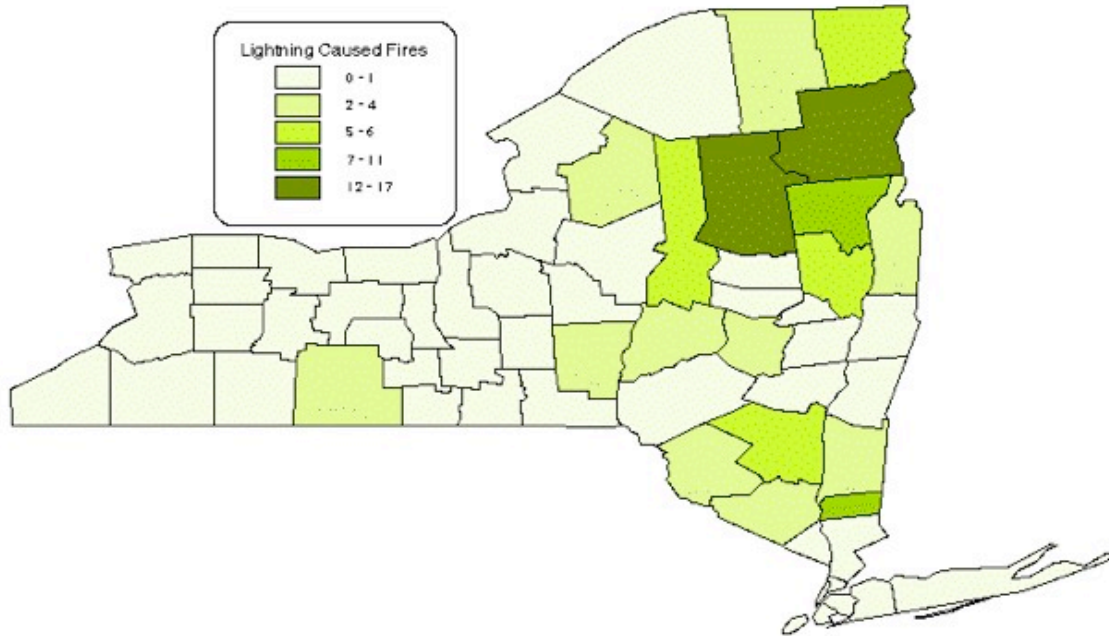
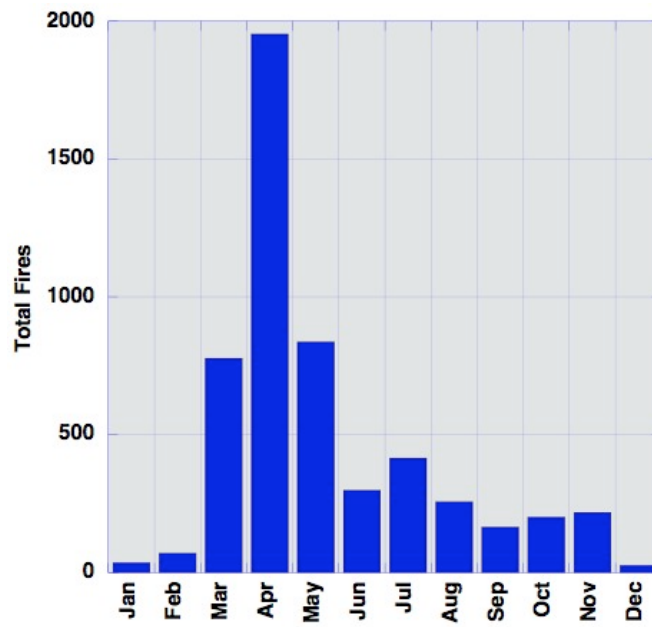


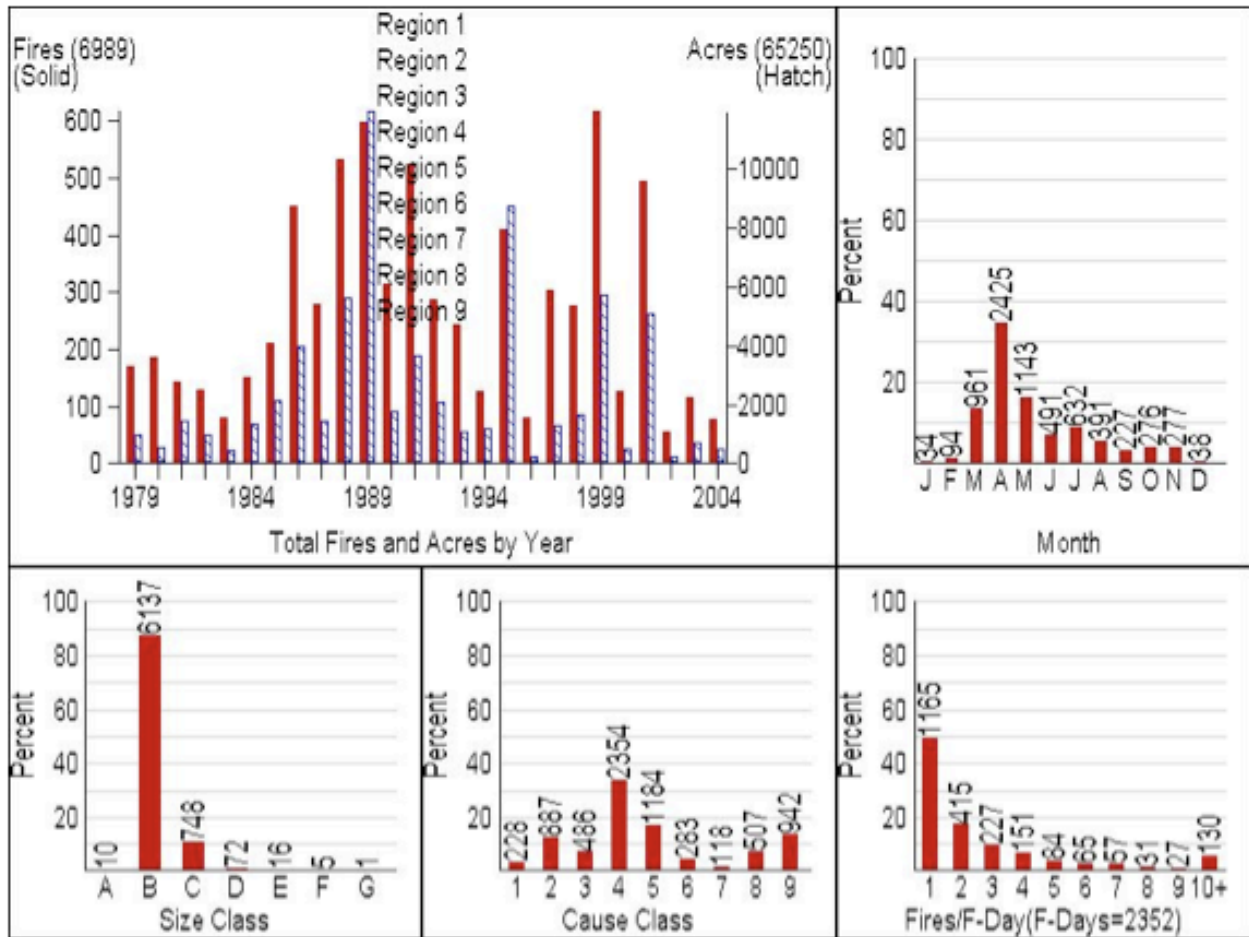
Figure 6. Number of fires by county.



**Figure 7.** Number of lightning-caused fires by county.



**Figure 8.** Number of fires in New York State by month.



**Figure 9.** Summary fire occurrence statistics for the period 1979-2004. Plots include fires and acres by year, fire by month, fire size class, fire cause class and fires per fire day.

**Task element 5: Presentation of the Project, including methodology and findings, to the New York State Wildland Fire Management Program.**

Project results were presented to the New York state Wildland Fire Management Program during a briefing at the Albany office. Also, results of the project were presented at the American Meteorological Society 6<sup>th</sup> Symposium on Fire and Forest Meteorology in Canmore, Canada, and to the Northeastern Forest Fire Protection Compact.

**Summary**

Historical fire and weather information has many uses for fire management beyond fire danger calculation, such as the assessment of fire severity and prescribed burn planning. A New York state historic fire-weather and wildland fire occurrence database to support the Division’s Wildland Fire Management Programs was desired to meet these uses, and to gain a better understanding of both the weather and fire climatology across the state. Historic fire weather data in the state of New York had never before

been assessed for quality control, nor had long-term consistent weather observations been recorded. A coarse quality control of the variables in the dataset including temperature, relative humidity, wind speed, wind direction and precipitation was necessary in order to utilize observations with confidence in climatological and fire danger analyses. Multiple linear regression equations were developed that use data from the North American Regional Reanalysis (NARR) project to estimate weather data for missing and questionable observations. The end result produced continuous weather data for 18 stations from 1980 through 2004. Also, 32-km gridded data from NARR was analyzed and formatted in the fw9 format to provide for both spatially and temporally continuous weather data. The project also produced a more complete fire occurrence database that can be analyzed to assess fire trends and historical fire occurrence to assist in fire management planning and decisions. The final dataset is in Weather Information Management System (WIMS) format compatible with decision-support tools such as *FireFamily+*. These data will be of enormous benefit to the New York state Wildland Fire Management Program.

### **Acknowledgements**

The report authors would very much like to thank Joe Kennedy, New York State Forest Ranger, for his project support and the on-the-ground education and training he provided the project researchers regarding fire and fire danger in New York state.