Working Paper for Northeast Forest Fire Compact Project

Vermont's Fire History 1905-2011:

Initial observations, with Analysis of

Individual fire data 1977-2011[1]

Revised Draft

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Highlights

1. This paper presents a descriptive summary of Vermont fire history 1905 to the present, and a detailed analysis of individual fire data from 1977.
2. As far as data allow us to tell, Vermont experienced its worst area burned in the late 20's and early 30's. Are burned fell rapidly after that, to nominal levels by the 2000's. Fire numbers, however, remain at levels similar to the 50's. Fire sizes have fallen, suggesting effective suppression efforts.
3. Monthly data from 1977 to the present suggest that the fall fire season has nearly vanished compared to historical experience. Vermont does not at present experience a bimodal fire season. Area burned is concentrated in April and May to a historically high degree.

[1] Assistance from Tess Greaves of the Vermont Department of Forests, Parks, and Recreation is gratefully acknowledged.

4. Comparison of causes over the period shows that miscellaneous and debris burning remain the leading causes. Smoking, children and arson have declined in relative importance. Lightning causes the fewest fires of all, but these fires reach the largest average size.
5. We divided Vermont into 3 subregions for geographic analysis. Fire occurrence varies widely across these regions from year to year but there seems to be no longterm trend.
6. Comparing the late 70's and early 80's to the present, the fire size distribution has been compressed. In proportion, more fires are 1 acres or smaller and there are fewer large ones. This suggests effectiveness of suppression programs in keeping fires small. It could also be related to the recent period of milder fire weather, though this hypothesis cannot be conclusively tested.
7. The number of days with more than 5 reported fires fell significantly after the early 90's.
8. Measured by days between the first and last fire, the fire season did not change for all fires, but it declined for fires above 1 acre.
9. Analysis of April and May drought index and precipitation over the 1905-2011 period shows virtually no clear relation, except for the wettest few springs. When the same data are examined for 1977-2011, there is a hint that the wettest springs have the least fire, but dry springs may have little or much. Vermont can have fire without drought, and drought without fire, due to the importance of wind and relative humidity.
10. In most years, there is no relation between area burned in Vermont and New York. But it does happen that when other states have especially bad years, Vermont does also. It cannot be assumed that Vermont's bad years will never coincide with bad years for its neighbors.

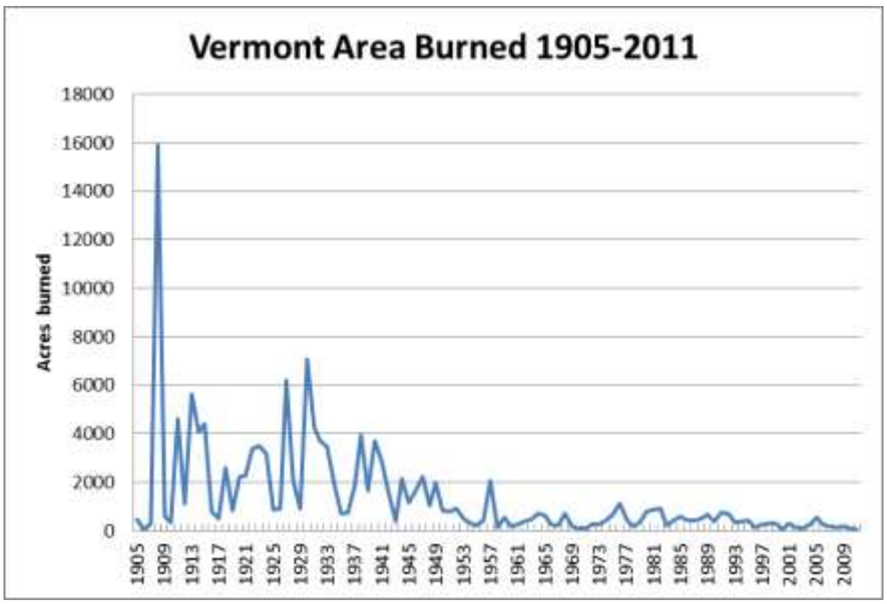
This note presents an initial summary and exploratory analysis of key data on Vermont fire history. We reach back into history for several reasons. First, it is useful to see whether major fire years are synchronous across the region or not, and if so to associate those with weather conditions to the extent we can. Second, the history can yield clues to important associations with weather that might not be evident from a short period of records. Analyzing this kind of information is subject to the usual caveats; especially for the older data completeness and accuracy of coverage cannot always be assured. For example, it is easy to finds in the literature, press clips, and administrative records widely differing estimates of the area for the same fire! Most importantly must take care in making casual extrapolations to the future. Ultimately we hope to analyze circumstances surrounding the very largest fires in the region, and hope to use the annual fire occurrence data to identify years when those occurred.

We would observe that as a policy matter, the number of acres burned annually may not be a sensible way to discuss policy. A year is an arbitrary unit of time. Would it make more sense to think in terms of area burned per decade or even longer, given resource and property values involved? Also, in this research we are searching for general empirical regularities to the extent they can be observed, but our purpose is not to develop methods for prediction.

The data used here come from three sources: first, an unpublished paper by Richburg and Patterson for the US Forest Service that compiled extensive detail to 1998; second, official USFS summaries, based on state submissions, for years 1999-2010; and third, detailed computer listing of reported fires from 1977-2011, supplied by Forests and Parks. In all of our work, we are at the moment giving no attention to costs, estimated damages, or damages to structures. We are now able to provide a detailed analysis of individual fire data since 1977 that significantly extends our understanding of peak loads on the fire response systems. Our thanks for Bill Patterson, Tess Greaves, and others for their help. Data are given in the appendix table.

Based on this information, 1908 was an extreme fire year, followed by pulses of fires in the early teens and late 20's to early 30's (Fig 1). The series of bad fires years during the Depression seems to have occurred widely over the region. A further pulse occurred in the early 40's. From 1944-48, a somewhat jagged decline to about 1960 took place. In contrast to other northeastern states, 1947 was an unremarkable year in Vermont, though 1957 stands out. After 1957, in only one year did area burned exceed 1000 acres again (1976), and in most years it was below 500 acres. Over the entire period, an estimated 143,000 acres burned. Especially in earlier years, a portion of this area was likely not forest but pasture or brushland. Also, some of this area was likely reburns in previous fires. In all, there were six years with area burned exceeding 1,000 acres. In these years, 7% of the period total was burnt. This is unusual, as in other northeastern states the very largest years account for a far larger portion of cumulative area burned.

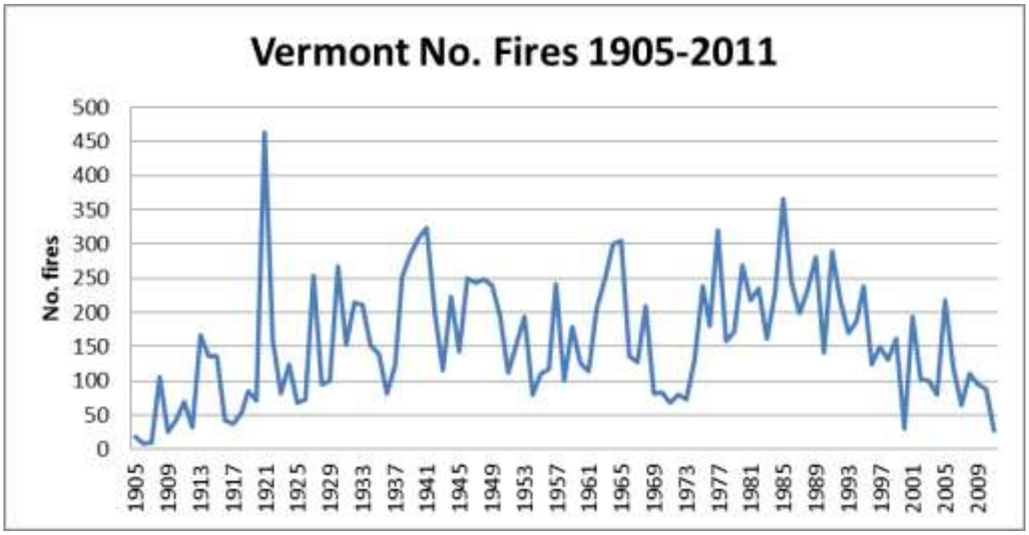
Figure 1.



Vermont's current forest area is about 4.6 million acres (2010). The area burned from 1905 to 2011, then, is equivalent to about 3% of the state's current forest area. (will do comparison – but is likely the smallest such proportion of any other Northeastern state)

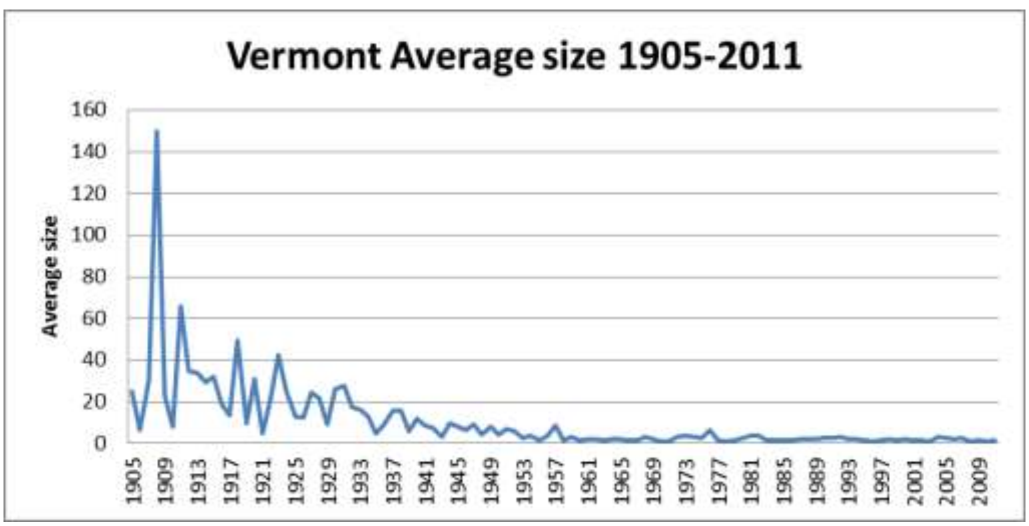
After spiking in 1920, fire numbers moved in a wide band between 100 and 300 fires per year (Fig 2). They showed a spike consistent with effects of the early 60's drought, but even then fire numbers did not exceed their 1940 peak. An early 70's trough was followed by a jagged rebound to a mid 80's peak and then a decline to very low levels.

Figure 2.



Over this period, average area burned per fire declined dramatically, reflecting several factors but surely due in large part to improved detection and initial attack (Fig 3). After 1960, average fire sizes larger than 2 acres were unusual. Averages are not the whole story, though, as we see below in our analysis of individual fire data.

Figure 3.



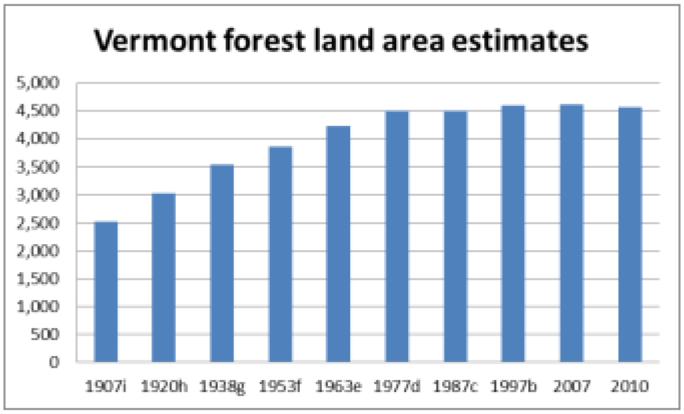
Defining subperiods for analysis is challenging. Simply doing this by decades has the merit of clarity, and avoids making judgments about complicated factors that may affect fire history (Table 1). When we analyze return periods and extreme values this problem will need to be confronted. We do not have a final view on this issue yet. But averaging by decade does not make the problem go away, as some of the decadal averages are affected by extreme individual years. Notably, *the number of fires is not that much lower in 2000-2010 than it was in the fifties, but the average sizes are lower*. As a result, area burned has fallen. Vermont gained 2 million acres of forest in the seventy years 1907-1977, which was the highest percentage increase of any other Compact state (Fig 4). Compared to its smaller forest area in earlier years, forest fires were a more serious factor. According to the reported data, the 1930's actually had the highest decadal total of forest area burned of the century, at 29,000 acres. This decadal total was less than 1 percent of the then forest area. For the 00's, the percent burned, over the whole decade was a tiny fraction of one percent.

Table 1 Vermont fire history, Decadal Averages.

Decade	Area burned	No. fires	Ave. fire size
1901-1910	2,941	35	84
1911-1920	2,683	83	32
1921-1930	3,036	169	18
1931-1940	2,611	192	14
1941-1950	1,581	219	7
1951-1960	609	142	4
1961-1970	389	181	2
1971-1980	458	169	3
1981-1990	545	231	2
1991-2000	370	171	2
2001-2011	214	117	2

Note: first decade averages only 5 years; last decade includes 11 years.

Figure 4.



The descriptive statistics for various periods (Table 2) show that skewed character of the size distribution (average well above medians)[2]. Also, the variability, measured by the CV, has declined.

Table. 2 Descriptive Statistics, Vermont fire history 1905-2011.

Entire period				
average		1,333	159	11
median		577	144	4
s .d.		2,012	86	18
c.v.		1.5	0.5	1.7
1950 to present				
average		431	167	3
median		360	161	2
s .d.		328	75	1
c.v.		0.8	0.5	0.6
1977 to present				
average		373	175	2
median		325	171	2
s .d.		235	79	1
c.v.		0.6	0.5	0.4

In analyzing peak loads on the fire system, the sizes of the largest fires are more important than the annual totals. Richburg and Patterson's compilation gives us a long run of data for the largest fires, from 1913 to 1935. This is something we have not been able to find for any other state, and which resources will not allow us to compile anew

[2] We would observe in passing that for highly skewed distributions as we are working with here, statisticians prefer other measures of central tendency and dispersion. But these are familiar and serve our purposes.

from primary documents. We have been able to augment this with more recent data. Heavy fire years often involve fires of unusual size. From 1977 to 1998, there were only 2 fires exceeding 200 acres. The long data gap from 1935-1977 is discouraging, but the picture (Fig 5) is consistent with other areas and shows a steep decline in largest fires after the 30's. After 2005, no fire exceeded 40 acres. Selected historic fires since the 1800s are listed in Table 3.

Figure 5.

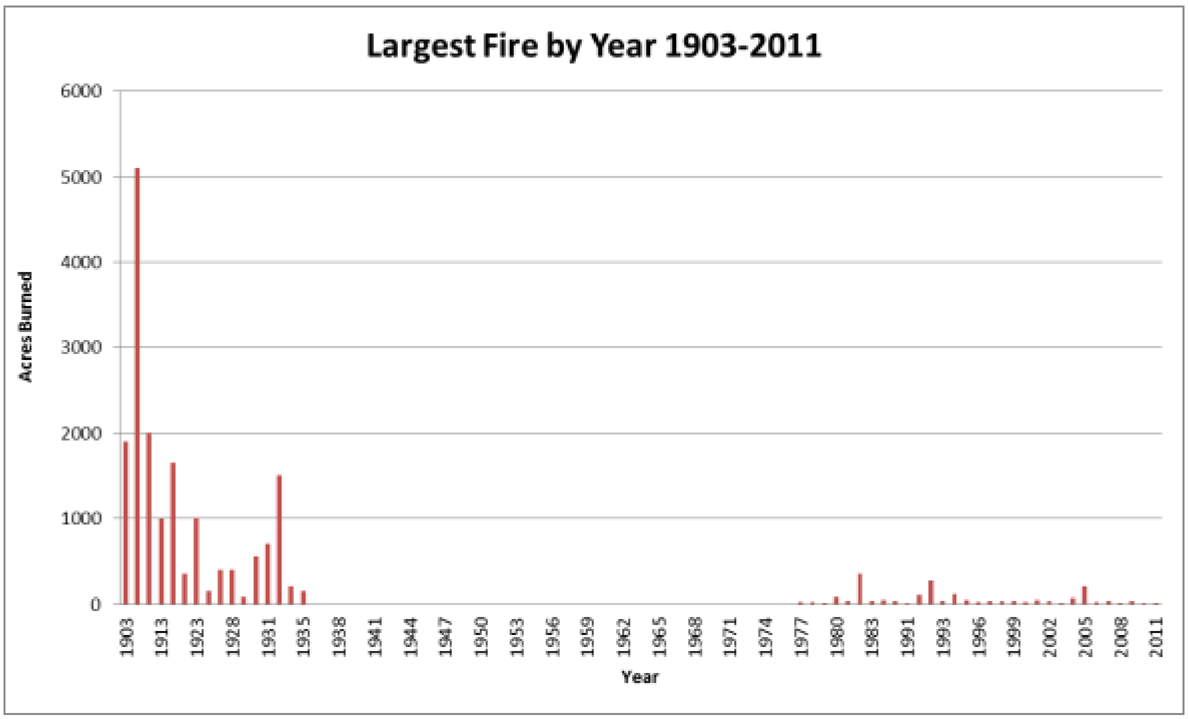


Table 3 (next page)

Vermont Historic Fires 1828-1930.		
1828 and again in 1903	Mt. Hunger, White Rock and Burnt Mountains	
1903	Worcester Mountain	600
1903	Lewis, Ferdinand, Bloomfield, Brunswick & Brighton	1200
	cause of famous lawsuit Connecticut River Lumber Co. v. Grand Trunk RR.	
1957	Entire range east of Manchester & Sunderland	
1869	Pico Peak in the Town of Sherburne	1628 acres
5/13/1883	Lake Groton - Montpelier & Wells River RR	1000+
Fall 1876	extensive fires in the woods of Vermont	
1903	Huntington and Duxbury	1900 acres
1903	Eden	1000
1908	Bolton	1315
1908	Mendon	1975
1908	Plymouth	5100
1908	Belvidere and Eden	4900
1908	Lowell	1400
1908	Hardwick	1000
1908	Monkton	500
1908	Enosburg	1000
1908	Richmond	400
1908	Rochester	500
1908	Glastonbury	1400
1908	Lake Groton	1000
7/8/1911	Dummerston	2000
5/5/1911	Essex	300
1913	largest fire caused by Central VT Railroad	1000
1913	separate fires in the towns of Wells, Sharon, Middlesex	2000+
1914	4 fires burned 2300 acres, 133 fires burn 1758 acres	
1914	Mt. Tabor - Emporium Lumber Co.	900
6/15/1915	Ferdinand - sparks from Grand Trunk RR ignited slash, fueled by high wind 1000 acres burned before a crew could be assembled, firefighters from Island Pond, CT Valley Co, American Reality Co responded, 3 days to contain the fire total expense of $2, 500 fell on state because fire occured in unorganized town	1650
5/4/1930	Grafton - fishermen	500
4/14/1930	Woodford	500
4/27/1930	Vernon	100
4/28/1930	Vernon	200
4/30/1930	Shaftsbury - railroad	100
4/15/1930	Putney - caused by motorists	100
4/5/1930	Halifax - incendiary	125
	Source: From Tessa Greaves, VT DF&P	

Ranked Data and Return Periods

The skewness of area burned stands out when the fire years are ranked. The pattern of persists when pre 1946 years are dropped from the analysis, only the level changes (Figs 6 & 7).

Figure 6.

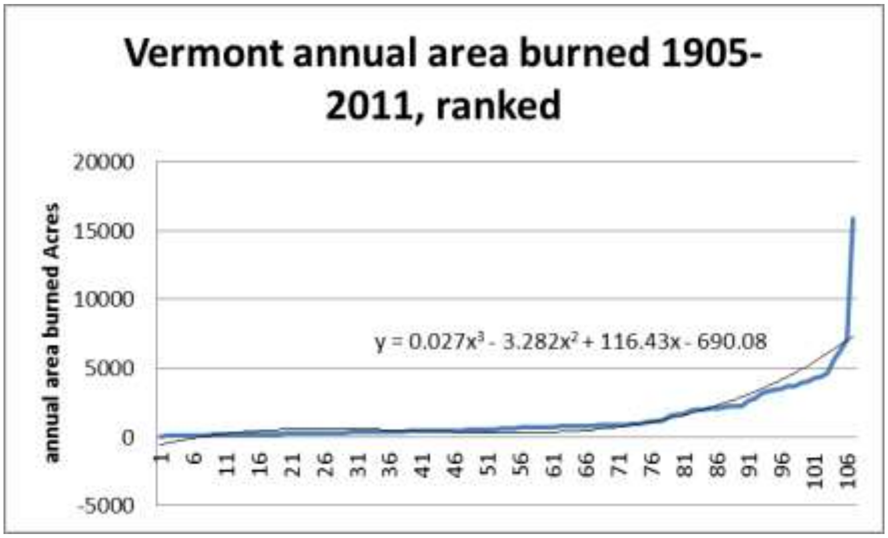
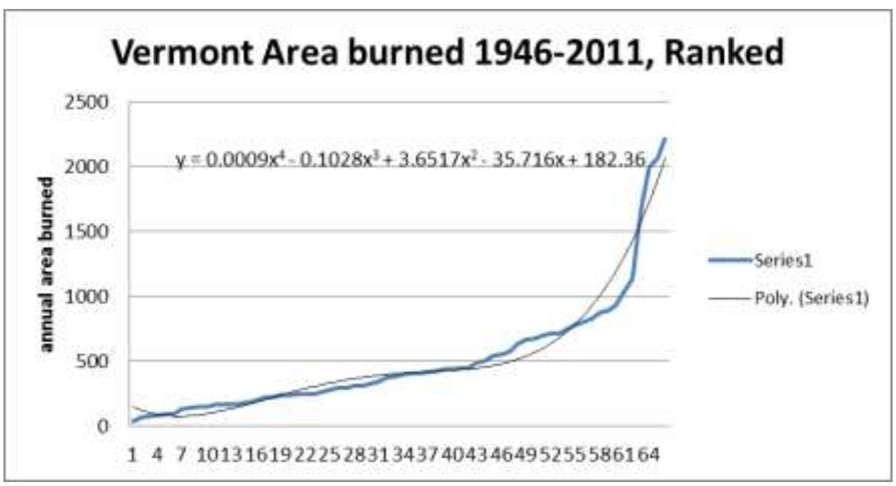
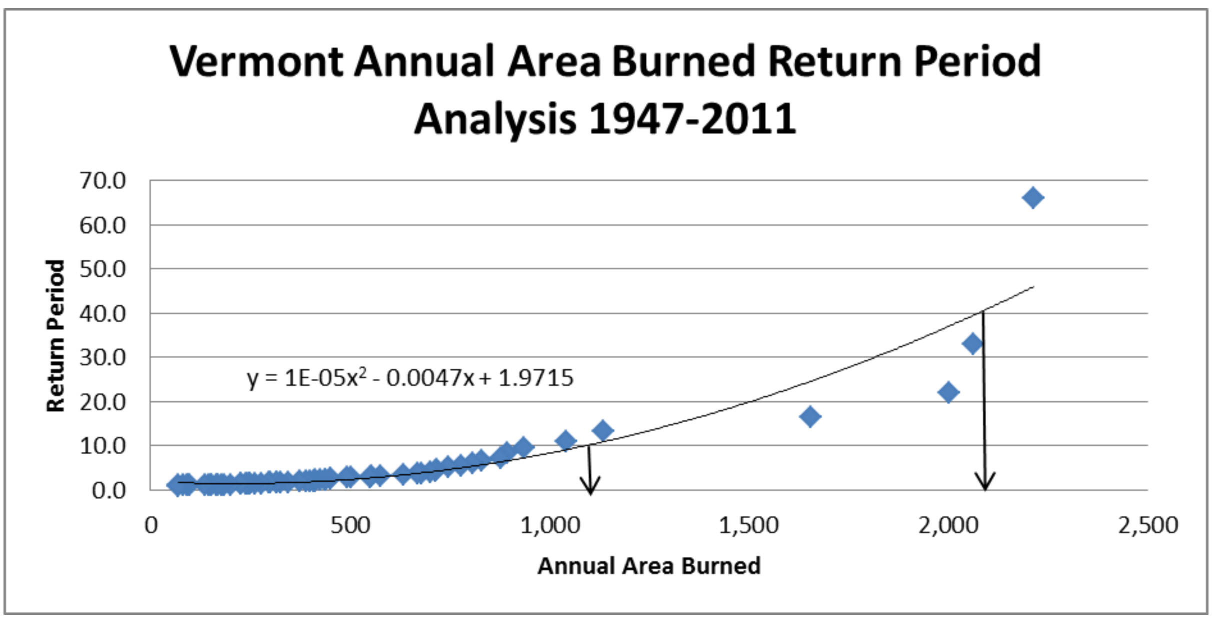


Figure 7.



Using only the years 1946 to present, we performed a rudimentary return period analysis. This uses a concept familiar in analyzing longterm flood risks. It brings the problem of defining a suitable data period to the fore. It is not easy to see an objective basis for choosing the beginning of this data period. One would not recommend analyzing hurricane risks in New England by starting in 1939, simply on the grounds that 1938 was a long time ago. At the same time, we need to know much more as to what kinds of conditions have changed, and how significantly, in order to set an initial year for the data period. At the moment, then, this chart is only to suggest the method. The principal point is that one cannot talk of fire risks using averages, but should use some concept such as return periods instead, and cannot allow averages to wash out the extremes. We think that presenting such an analysis may be of use to decisionmakers. We would prefer to use this method on the largest fires each year (as is done for flood risk), but at present we have only limited data on individual fires, which is reviewed below. Based on this analysis for 1946-2011, to plan for a return period of 10 years would mean expecting about 1100 acres of area burned to occur once a decade (Fig. 8). For 20 years, the figure rises to roughly 1500 acres. The important point is that both figures significantly exceed recent averages (509 A for 1946-2011; 200 A for the 00s) .

Figure 8.



Fire Season

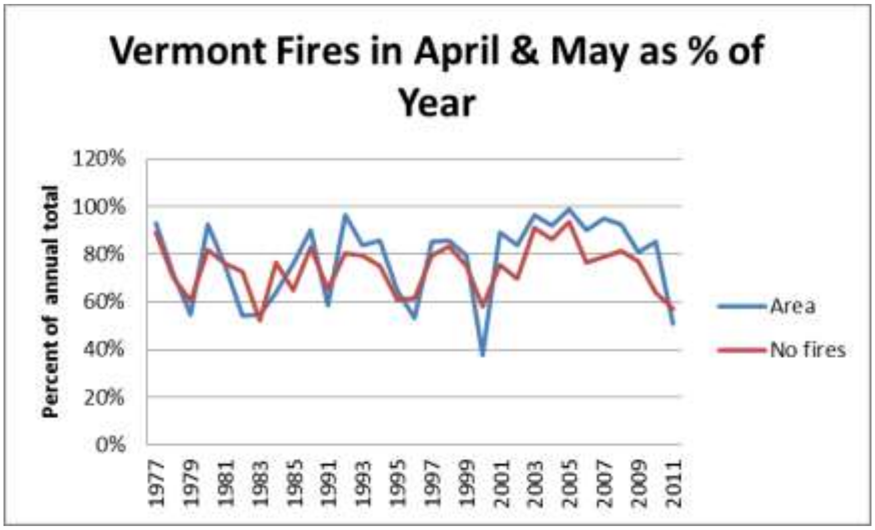
Richburg and Patterson's compilation by months, now updated here, gives us the only example of a longterm trend we have uncovered of a truly longterm dataset on monthly fire occurrence (Table 4). Even with its gaps, it yields interesting insights. We analyzed this data in two ways. First by comparing groups of years . The 1927-36 period was chosen to cover the major fir outbreak of those years; subsequent ones hit 20-year intervals thereafter, and the 2002-2011 is the most recent decade. For the periods covered, it seems that Vermont has not typically had a bimodal fire season at all – this only occurred in the 47-56 period; in the fire outbreak of the 20's and 30s, fall fires were scarce, and in the most recent decade, virtually nonexistent. Looking at individual years, there is high variability in these relationships and choice of data periods may influence the comparisons. Was the weather in the 47-56 period unusual? These years had the lowest proportion of Apr/May fires of any period and the highest in Oct.

Table 4.

Table Changing Fire Seasons, 1920s to Present. Area Burned by month and percentages								
	1927-36	%	**1947-56**	%	**1977-1984**	%	**2002-2011**	%
January	9	0%	8	0%	26.70	1%	0.26	0%
February	0	0%	10	0%	23.45	1%	0.50	0%
March	902.22	3%	525	6%	275.06	7%	77.34	4%
April	15635.8	50%	2669	29%	1782.16	48%	1494.60	79%
May	10756.1	34%	2007	22%	887.18	24%	234.05	12%
June	450.15	1%	914	10%	36.01	1%	15.63	1%
July	404.4	1%	166	2%	96.60	3%	6.95	0%
August	330.32	1%	175	2%	17.20	0%	10.04	1%
September	151.25	0%	264	3%	16.30	0%	23.95	1%
October	1630.15	5%	2102	23%	463.15	12%	3.33	0%
November	825.1	3%	362	4%	118.16	3%	21.90	1%
December	240.1	1%	22	0%	2.10	0%	0.20	0%

Next, we compare the share of April and May fires by individual years since 1977. Most years since 1977, April and May accounted for less than 80% of area burned, while between 2001 to 2010, they accounted for more than 80% (Fig. 9).

Figure 9.



Trends in Fire size distribution and Area Burned 1984- 2010: USFS Data.

We will analyze fire size distributions in 2 ways. First, in this section we use the USFS fire report data that employ standard national size classes. For this dataset we do not have the primary data. This will enable ready comparison with other analyses and other regions. Then, below, we analyze Vermont's individual fire data in somewhat different ways for a longer data period, 1977-2011.

The skewed nature of the fire size distribution is illustrated by the cumulative '84-2010 data (Table 5). The smallest fires are the most numerous but affect the least amount of area, while the less frequent larger fires affect much more area. Over this period, only 6 Class D fires burned an estimated 1,000 acres, or 11% of the cumulative area burned over the period. In fires 10 A and larger, a total of 194 patches, totaling 4800 acres, was affected by fire. These may have been minor ground fires; many were probably not stand-replacing. In the largest fires, unburned islands may have persisted within outer fire perimeters. For at least some of these, effects visible at a later time may have been negligible or very subtle.

Table 5. Vermont Fire size distribution, 1984 to 2010. Source: USFS

NUM	Cum 1984				
	to 2010	PERCENT		In 27 seasons…	
Class A	1,731	39%		10 a & Larger	
Class B	2,496	56%			
Class C	188	4%		194	patches
Class D	6	0%			
Class E	0	0%			
Class F	0	0%			
Class G	0	0%			
TOTAL	4,421	100%			
ACRES					
Class A	234	3%			
Class B	4,281	46%			
Class C	3,793	41%		4843	acres
Class D	1,050	11%			
Class E	0	0%			
Class F	0	0%			
Class G	0	0%			
TOTAL	9,358	100%			

The annual data display significant patterns (Fig 10). Attributing these patterns to specific causes, however, will take some discussion and further analysis and may not yield precise answers. In Fig 10A, the general downtrend in both numbers and area is evident, together with the volatility. In Fig 10b, we can see that some years pass with no large fires at all, and the mix of fires by size can change. Over the period, the number of fires in the middle of the distribution seems to be shrinking considerably. This may be a result of more fires being extinguished before they reach that size. In Fig 10c we can see the importance of the occasional larger fires, and the fact that the smallest fires burn a tiny share of the total area. Fig 10-D reformats the data to show shares of total area burned by fire size classes.

Fig 10 a-d Vermont fire size distribution 1984-2010

Fig 10-A. Totals.

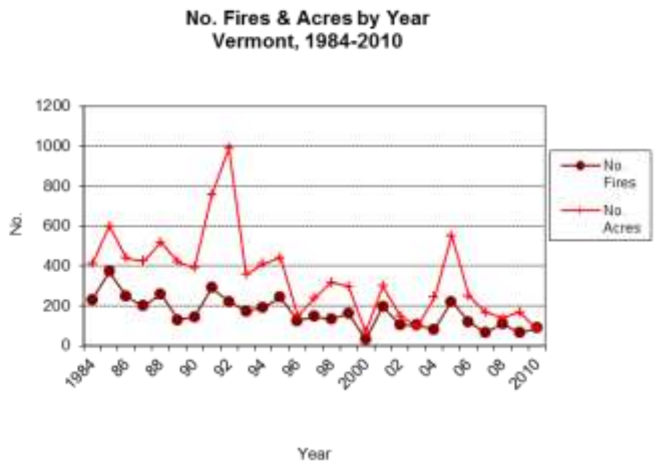


Fig 10-B

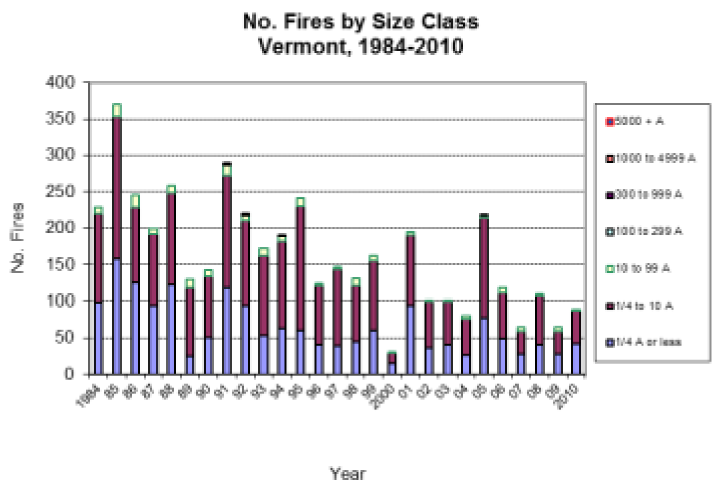


Fig 10-C --absolute numbers

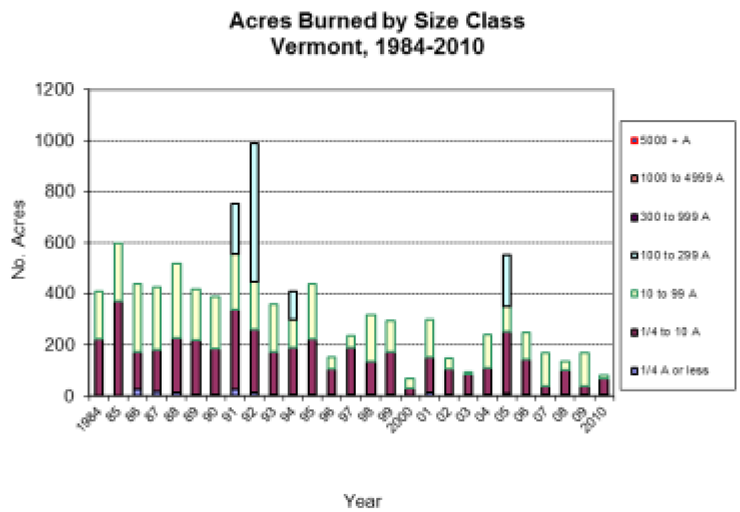
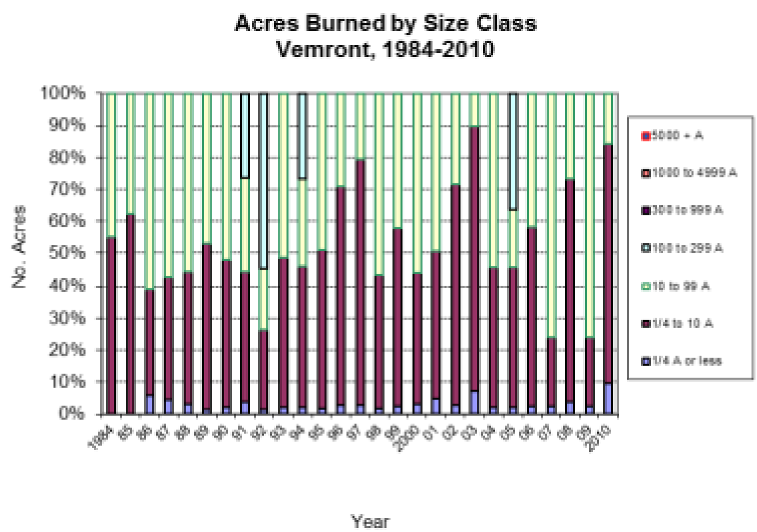


Fig 10-D Percentages of totals



Based on this data, fewer fires are exceeding ¼ acre in size over this period.

Changes in Forest Fire Causes 1977-2011

While a longer historical survey of changes in fire causes would be of interest, here we will focus on the data since 1977. Since the 1980s, attribution of fires to causes has improved, though it remains an necessarily uncertain task. Generally more than half of the fires are attributed to debris burning or unknown causes (Tables 6 A and B). For fires above 1 acre, the largest fires (on average) were attributed to arson in ’77-84, while the place went to lightning in 2002-11.

Table 6 A . Causes of Vermont Fires above 1 acre:

TOTAL	1977-1984		TOTAL	2002-2011	
	Average			Average	
Cause	Fire Size	No. Fires		Fire Size	No. Fires
TOTAL	4.6	752	**TOTAL**	**4.23**	**407**
9 – misc/unknown (includes grass fires)	4.7	334	4 – debris burning (including brush)	2.92	199
4 – debris burning (including brush)	3.6	198	9 – misc/unknown (includes grass fires)	6.48	108
3 – smoking	2.6	60	6 – equipment	5.10	34
5 – arson	11.9	41	2 – campfire	3.45	22
8 – children	3.7	38	7 – railroad	3.51	15
6 – equipment	5.8	30	5 – arson	3.21	11
2 – campfire	2.9	28	3 – smoking	3.18	7
7 – railroad	3.4	14	1 – lightning	10.00	6
1 – lightning	7.4	9	8 – children	4.00	5

Looking at all reported fires, the same pattern is seen for the largest average fire sizes. Between periods, equipment and campfires increased in relative ranking according to number of fires.

Table 6 B Causes of all reported fires

TOTAL	1977-1984		TOTAL	2002-2011	
	Average			Average	
Cause	Fire Size	No. Fires		Fire Size	No. Fires
TOTAL	**2.13**	**1755**	**TOTAL**	**1.87**	**1012**
9 – misc/unknown (includes grass fires)	2.39	708	4 – debris burning (including brush)	1.38	481
4 – debris burning (including brush)	1.76	454	9 – misc/unknown (includes grass fires)	2.70	276
3 – smoking	1.23	143	6 – equipment	2.05	92
8 – children	1.19	140	2 – campfire	1.78	46
5 – arson	5.15	98	3 – smoking	0.84	36
2 – campfire	1.46	64	7 – railroad	1.93	30
6 – equipment	2.96	62	5 – arson	1.80	21
7 – railroad	1.14	50	8 – children	1.29	17
1 – lightning	1.97	36	1 – lightning	4.72	13

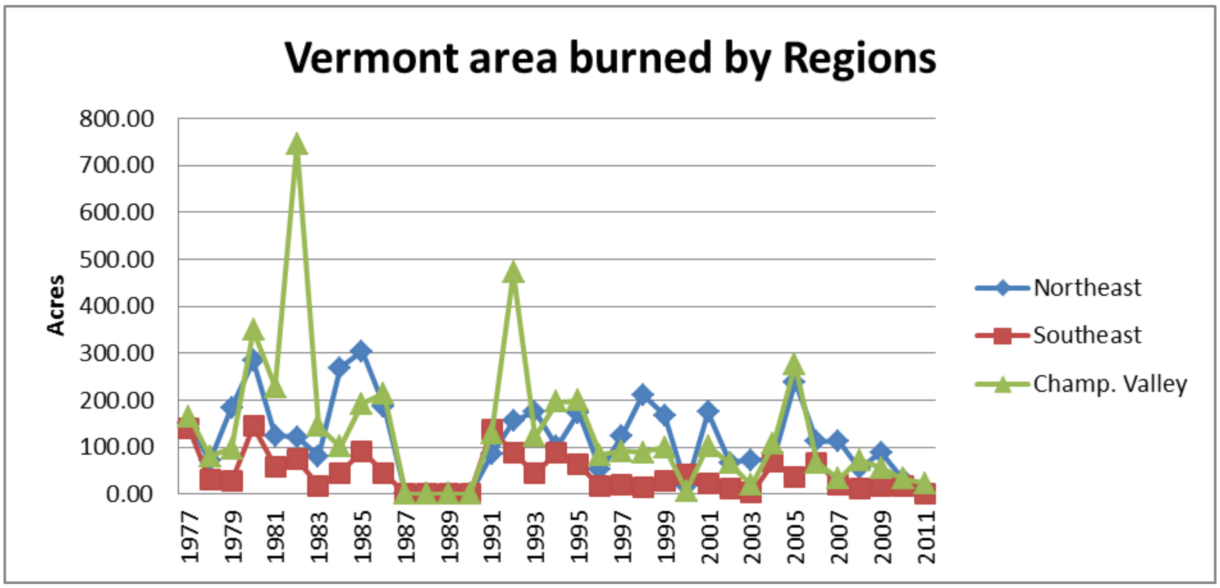
Further analysis of this information may be useful to fire prevention programming and public education efforts.

Analysis of Individual Fire Data 1977-2011

The dataset analyzed here, from 1977 to 2011 has an unfortunate gap from 1987-1990, but it provides a base for a much more detailed understanding of issues that can affect operational fire protection programming.

One question of interest is, has **the geography of fire** been changing? Where have they been occurring? To initially sketch an answer, we have divided Vermont into 3 regions, roughly corresponding to climate zones; the Northeast, the Champlain Valley, and Southeast[3]. Using the tabs of the county data other subregions could readily be defined. This way of looking at the geography suggests that the bad years happen in the Valley. Otherwise, the Northeast, in accord with its large area, has the largest area burned. The Southeast has had only 3 years burning more than 100 acres, and none since 1991 (Fig. 11).

Figure 11.



In proportional terms, the experience has been so volatile that it is hard to say that the proportional distribution of fire across these regions has changed significantly.

A further question is, has the **size distribution** of fires changed? We have noted this for 1984 to the present in a previous section. Comparing the first and last decades of this period, it seems clear that the size distribution has changed – proportionally more of the fires are less than

[3] Northeast: Caledonia, Essex,Franklin, Lamoille, Orange, Orleans, and Washington Counties (a bit more expansive than the "Northeast Kingdom); Southeast: Windham and Windsor, and Champlain Valley: all remaining counties , essentially those abutting the west line of the state.

one acre (Fig 12 a & B) . Or, seen the opposite way, a smaller proportion of the fires is exceeding one acre. A more technical presentation of this point is given in the Appendix.

Figure 12A.

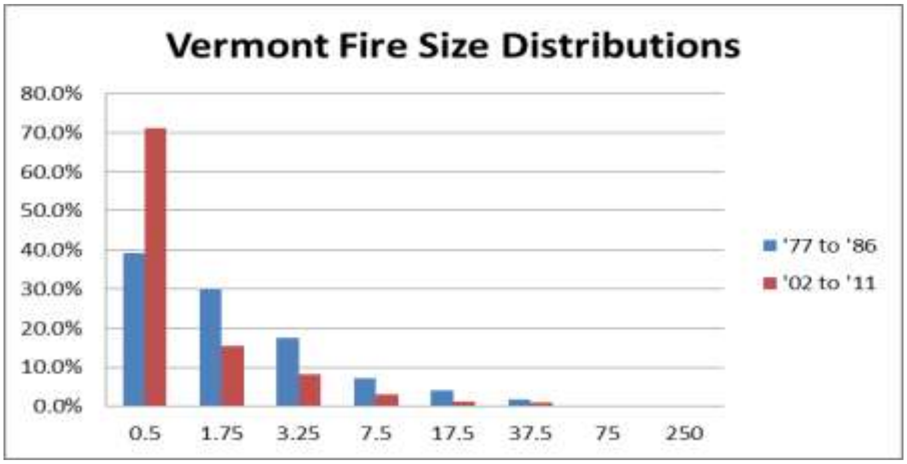
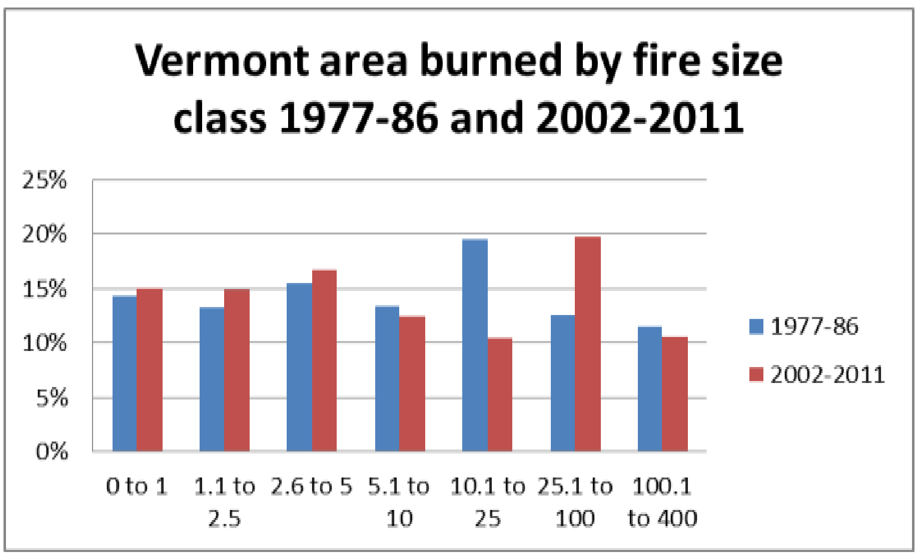
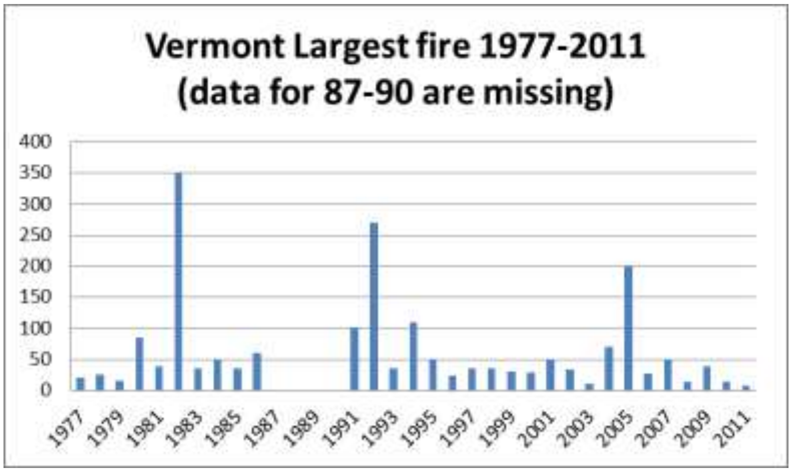


Figure 12B



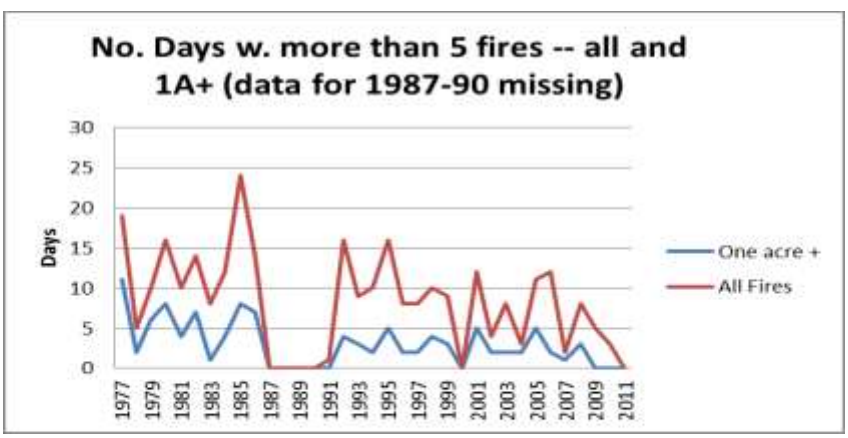
We have analyzed **the largest fires** over a longer period above. For recent years, it appears that about once a decade Vermont has experienced a 200 acre or larger fire. But in many years the largest is well below 50 acres (Fig 13).

Figure 13



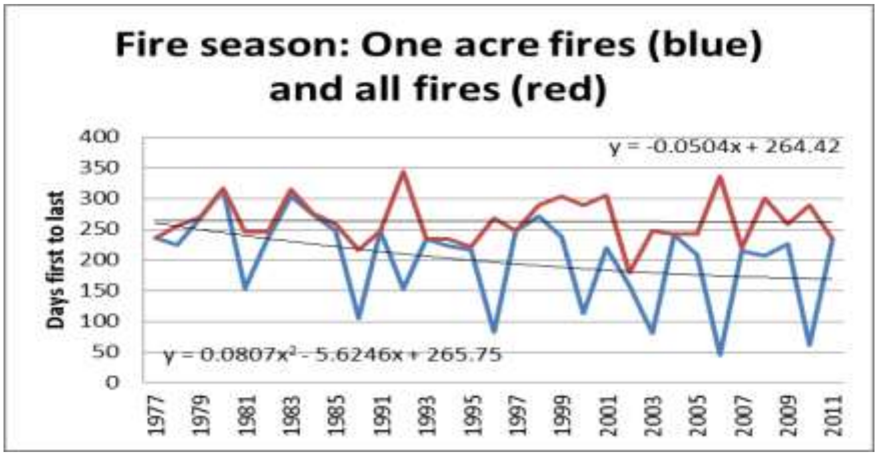
Information above shows that the fire season has become more concentrated in just 2 months, making the peak load management problem more acute. Another way of looking at peak loads is to ask **how many fires occur on any given day**? Over this period, the number of days with more than 5 fires has fallen strongly (Fig. 14). Over the entire period there were only 19 days experiencing more than ten fires per day.

Figure 14.



The individual fire data can also help us answer questions as to the **length of the fire season**. Naturally enough, fire control professionals think of the fire season in terms of fire danger ratings. Such information is not captured electronically over long time periods so we are unable to analyze it in the same way. But it is of interest to look at the fire season in terms of when fires actually are occurring. Here, we define fire season as the number of days between the first and the last fire. We further refine this by looking at the entire list of reported fires, versus only those that exceed one acre (Fig. 15).

Figure 15.



By these definitions, the fire season, for all fires seems to have changed not at all over the period, while for fires larger than one acre, it has materially declined.

Forces affecting Vermont's Fire History

Over the 20th century a number of factors contributed to the notable fall in fire occurrence following the bad years of the late 20's and 30's. One of these was the steady improvement in local fire protection and volunteer fire departments, which was especially marked after 1947. Detection, through fire towers, was well established by the 20s and 30s. Regulations on burning and on equipment improved from time to time. Improved compliance followed. Public awareness, symbolized by Smokey the Bear after the mid 40s, no doubt contributed. Better communication among forestry, landowner, and public safety organizations reduced response times. By the 00s wide use of cellphones meant that virtually every motorist could be an informal fire warden.

Access to the forest improved dramatically. Road mileage in Vermont did not change much from 1909 to 1959, but in 1909 it was only 18% "improved" but by 1959 81% of rural roads were paved. For an area with an April and May fire season, paving was critical to enable crews and vehicle to reach remote area without becoming bogged down in mud.

Changes in the lumber and pulp industries were important. Lumber output peaked in Vermont in 1909 at 460 MMbf/yr,. After the 1920's lumber production plummeted in the region due to the Depression, and secondarily the cutting out of the accessible mature stands, reaching a low of 101 MMbf by 1934. Methods changed after the 40's. Markets improved again, and no longer were large pines and spruced topped at the first limb. Topwood increasingly went for pulp. Slashpiles decreased. With new machinery, sizes of woods crews declined, though only slowly as methods changed. By the 00's mechanized operations had materially different fire risk profiles from the days of the 30's and 40's.

While railroading has declined in the region, railroad fires continue to occur. Smoking a much publicized factor, seems to have declined in importance, though attributions to smoking are often uncertain. Modern self-extinguishing cigarettes, and declines in smoking, are no doubt helpful.

Land use changes occurred, especially in the steeper slopes and valleys. There was less pasture, less occasion for debris burning on farms, etc. The regrowth of the forest following cutting and land abandonment has covered over former logging slashings with green canopies, generally of forest types of low fire hazard.

It may prove impossible to reach clear conclusions as to the impact of each of these factors separately, but clearly important forces have reduced fire risk and fire occurrence in Vermont to very low levels. This list should stimulate discussion and suggest additional points. One interesting question remains – to what degree has recent very mild fire experience been associated with weather?

Effects of weather conditions: Exploratory Analysis

Clearly drought alone does not explain the incidence of large fire years. in VT. Wind and RH are clearly major factors, but we do not at present have accessible longterm datasets to compare with fire experience[4]. There is no longterm dataset on occurrence of lightning, though lightning is not a prominent fire cause in Vermont. We can observe, however, that Vermont does not seem in the past to have been severely affected by regionwide droughts that were associated with major fire outbreaks that occurred across the rest of the region.

Monthly historic weather data from NOAA enable us to examine fire occurrence and compare it with weather conditions in particular months. We hope to do this using Richburn and Patterson's monthly dataset, which at present contains some gaps. Pending a full analysis, we have compared annual area burned to the April May Palmer Hydrologic Drought Index (PHDI), relying on the fact that these 2 months include a significant percentage of area burned in a typical year (62% on average for 1946-98, and more in recent years). Before 1930, Vermont did not have the frequency of very dry springs that occurred in other areas we have studied so far (Fig. 16). Also, it has experienced no dry springs worse than 2.3 since the mid 60's drought, and in the same years springs were on average wetter by this measure than from the 30's to 1960. The early 60's drought stands out, but as seen above it produced no notable increase in fire activity. It may be significant that since the mid 80's April and May have been generally wet as measured by PHDI. But there are numerous individual instances of wet springs occurring in bad fire years and also of the reverse. Because it only takes a few days of windy, low humidity weather, to set the stage for fires, totals for a two month period cannot fully explain fire occurrence. To do that we would need weekly data which is not conveniently available.

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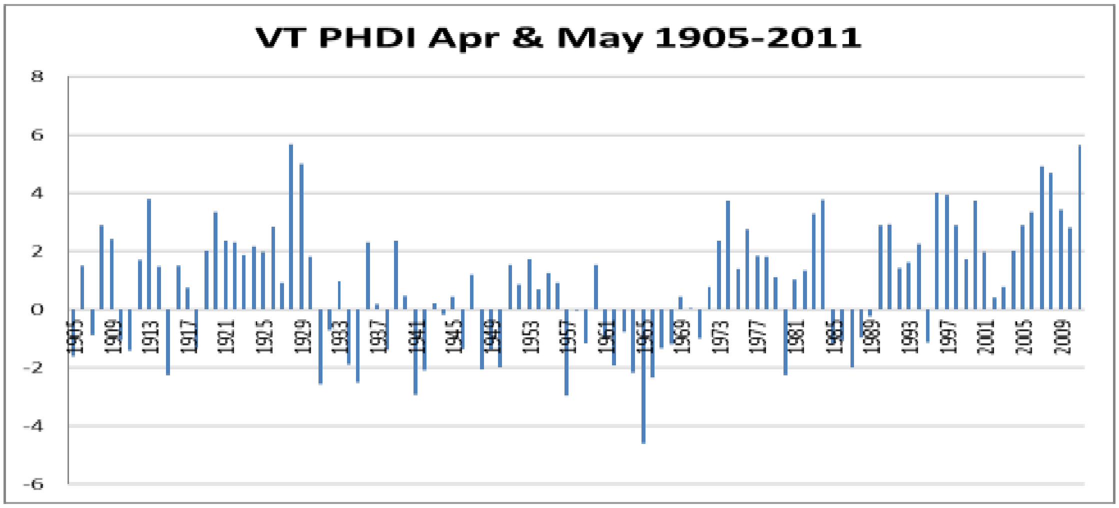
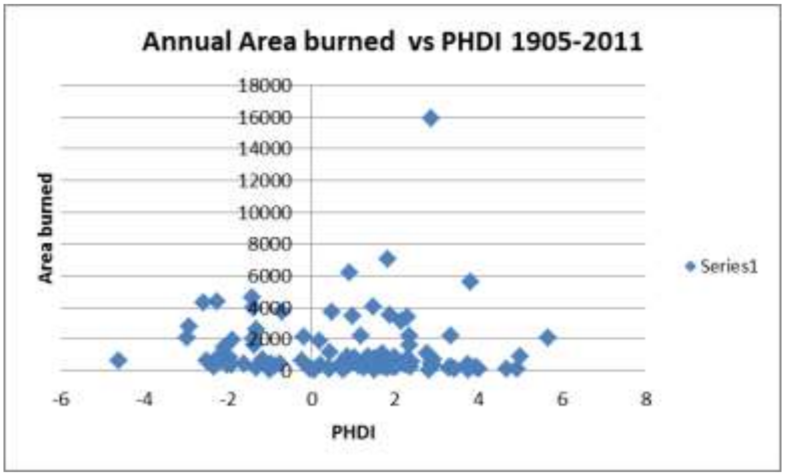
[4] Since the 80's, Forests, Parks, and Recreation has been using the National Fire Danger Rating System to calculate fire danger based on observations from fire weather stations. The oldest data is from Essex, Danby and for a time the Fairbanks Museum in St. Johnsbury. This data is available today through the National Fire and Aviation Management KCFAST (https://fam.nwcg.gov/fam-web/). A software program has been developed to utilize the data. This program is available online at http://www.firemodels.org/index.php/national-systems/firefamilyplus. While fire danger adjectives (low, moderate, high, very high, extreme) are not calculated using this software, the indices that fire danger adjectives are based on can be, i.e. the burning index (BI). For the record, the data has some errors, there is missing data, and since the stations only operate through fire season, data outside the April 1 to Oct 31 timeframe is limited, however in the years since I've been maintaining the system, I've needed to start collecting data earlier in some years, i.e. March (actually starting in mid Feb. this year due to lack of snow cover) and continuing through Nov. so in that way, fire season been longer several times in the last few years. (Tess Greaves, pers. comm., May 23, 2012)

Figure 16 .



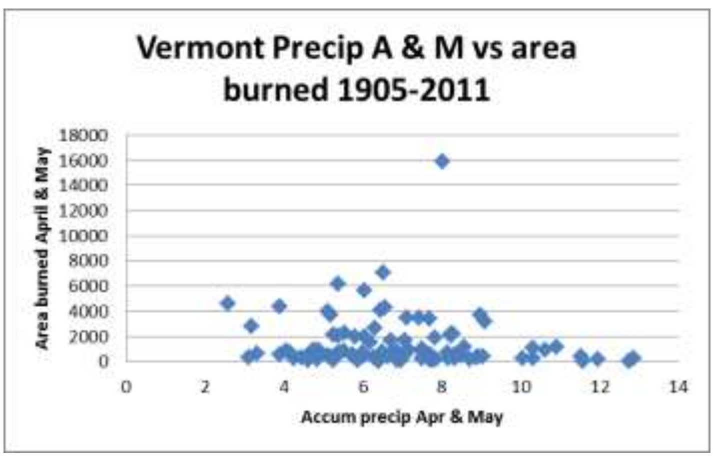
A scatter of annual area burned 1905-2011 vs PHDI for April and May shows a high degree of scatter (Fig 17). Wetter springs are only one factor in area burned. In fact, some of the worst fire years occurred in years of low drought index. If we could analyze also the separate fire seasons with monthly wind and RH data it would surely improve the picture. Likely, though considerable scatter would remain.

Figure 17.



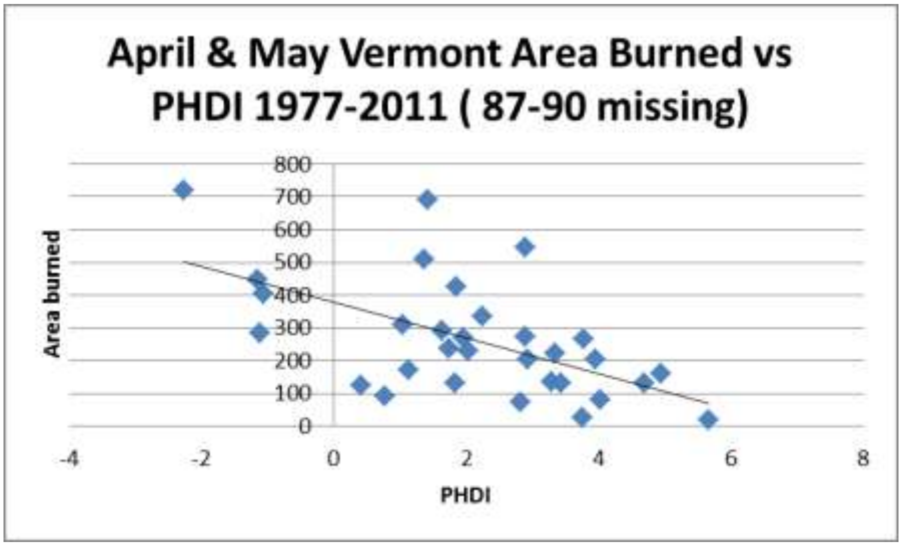
Performing the same analysis with accumulated April and May precipitation, we see a similar pattern. Up to about 9.5", there is no clear tendency of precipitation to be associated with annual area burned (Fig. 18) . It may be coincidence, but no year with more than this amount has exceeded 2000 acres of annual burn. Of course all this is of no use for predictions, as we can never know monthly precipitation in advance.

Figure 18.



For the period 1977-2011 (missing 87-90 data) we can tabulate April and May area burned, which as we have seen accounts for a higher share of the annual total than in previous decades. Using this data period not only enables us to use monthly area burned data but it also removes the influence of previous conditions that may differ significantly from present ones. Carrying out this step does illustrate one important point: the frequency of dry springs by PHDI since 1977 has been very low, and of wet ones has been fairly high. The absence of strong fit is emphasized by the fact that many 300 acre – plus spring fire seasons occurred during wet springs. But drought does affect the odds – there was no 300 acre plus spring season at PHDI above about 3.2 (Fig 19

Figure 19.



The plot using accumulated precipitation instead of PHDI points to the same result as the above plot for the entire data period with annual data – that the very highest rainfall springs are associated with the lowest springtime are burned (Fig 20).

Figure 20.

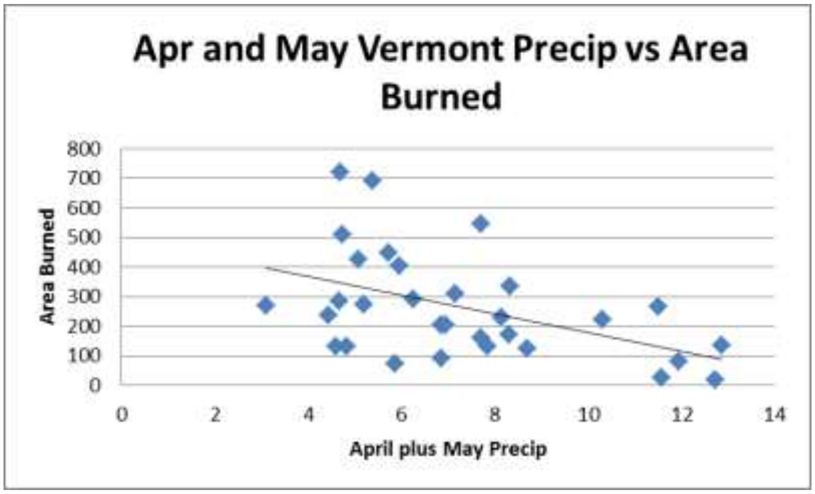
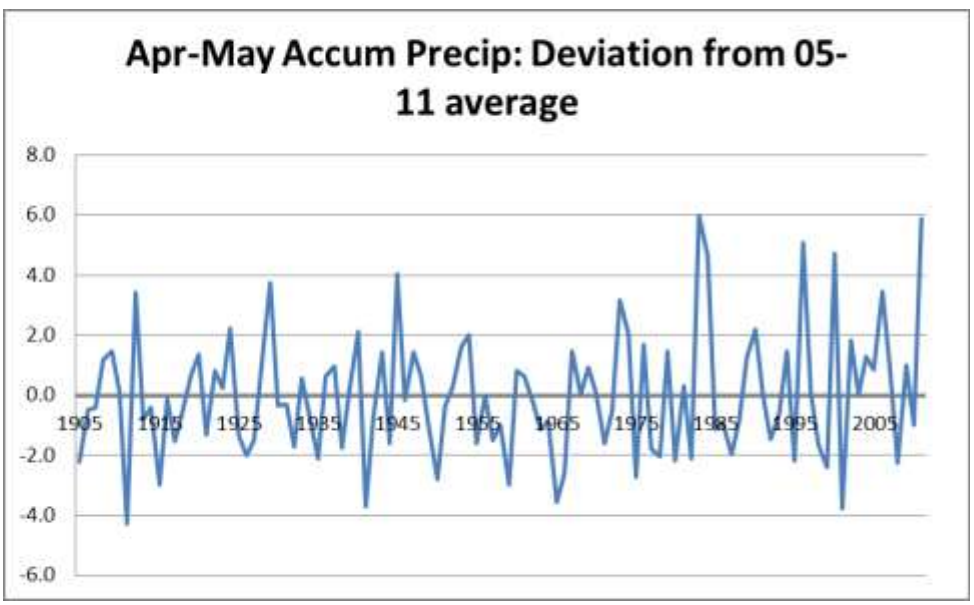


Figure 21 shows the high volatility of spring precipitation from year to year. Over this period, average annual precipitation. For Vermont increased by about one inch. This chart also shows that before the mid 60s, instances of dry springs were more frequent than more recently. Unusually wet springs have been more common recently. If climate were to shift to patterns more typical of the pre 1965 decades, it would be impossible to predict the effect on fire experience from the very loose relationships shown above. Still, the fact that weather has recently been mild from a forest fire perspective should not be forgotten.

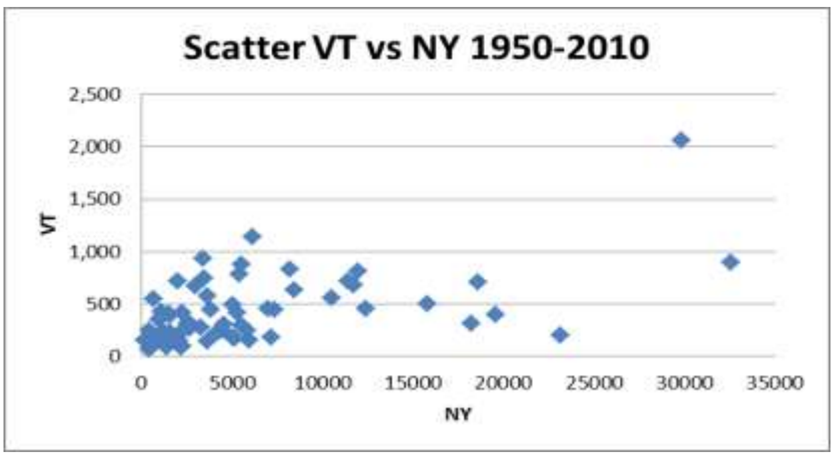
Figure 21.



Vermont fire experience in Relation to the Region

The Compact's reason for existence is to enable the sharing of resources among its members. It is then helpful to gain a sense of the extent to which bad fire years are correlated across states or not. Because NH data re reported on a fiscal year basis, we cannot directly compare the states with annual data. For New York, in many years when New York has had more than 10,000 acres of fire, Vermont is above its own longterm average for the period (Fig 22). Perhaps the most we can say is that while we cannot predict when it will happen, it is not true that Vermont's neighbor states never have bad fires years in the same year Vermont does.

Figure 22.



Notes on overall fire vulnerability of Vermont forests

Richburg and Patterson and other researchers have studied fire rotations and other issues concerned with landscape ecology in Vermont. They and many others agree that on the whole Vermont forests are virtually "asbestos forests" with extremely long average fire intervals, on the order of 500 to 1000 years. Of Vermont's timberland, in 1997, 67% was in the northern hardwoods type group, one of the region's most fire resistant cover types[5]. Birch and aspen were only 6%, a type often associated with fire at the regeneration stage but not especially fireprone once established. The state's softwood types (20% of area) are evenly divided between the pines and spruce fir. Oak-dominated types account for 5% -- in these types a bit more fire is believed to be ecologically and silviculturally desirable by many.

[5] I'm guessing VT has the highest % in NH of any Compact state – will check.

Mann, Engstrom and Bubier note that in local areas, the more fireprone forest types, such as local occurrences of pitch pine, have shorter fire return intervals than do the general average upland hardwoods. A study on this subject by Parshall et al used charcoal sediments in lakes but unfortunately for our purposes only included 2 sites in Vermont.

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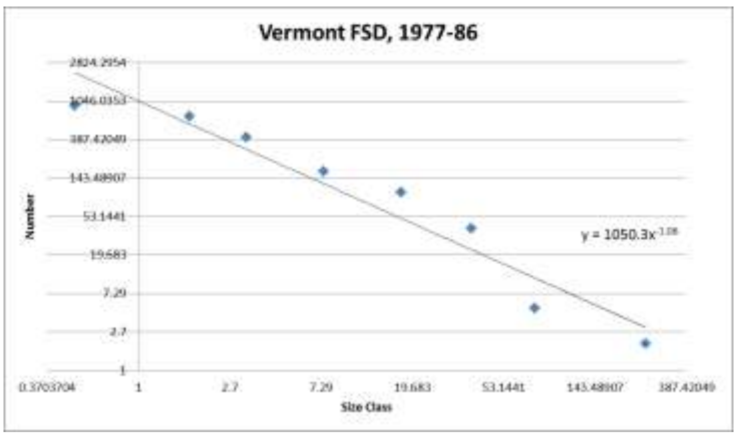
Appendix Table

Appendix Table 1. Vermont annual data, 1905-2011 – no. fires and area burned

Year	Area	No.	Year	Area	No.	Year	Area	No.
1905	473	19	1945	1167	144	1985	577	366
1906	59	9	1946	1655	250	1986	439	245
1907	307	10	1947	2214	244	1987	424	199
1908	15894	106	1948	1042	248	1988	492	233
1909	570	25	1949	2001	241	1989	678	281
1910	341	42	1950	830	196	1990	389	142
1911	4624	70	1951	808	113	1991	747	289
1912	1118	32	1952	896	154	1992	719	219
1913	5635	167	1953	503	195	1993	346	171
1914	4058	137	1954	315	80	1994	374	188
1915	4397	137	1955	201	110	1995	439	239
1916	812	42	1956	414	117	1996	152	125
1917	525	38	1957	2063	242	1997	238	150
1918	2617	53	1958	152	100	1998	316	131
1919	824	86	1959	555	179	1999	297	162
1920	2222	72	1960	184	126	2000	68	31
1921	2256	463	1961	248	115	2001	300	195
1922	3368	160	1962	399	206	2002	147	102
1923	3498	82	1963	450	249	2003	96	101
1924	3165	125	1964	703	300	2004	242	80
1925	880	68	1965	635	305	2005	550	219
1926	906	73	1966	249	136	2006	249	119
1927	6199	254	1967	228	128	2007	168	64
1928	2083	95	1968	714	210	2008	138	110
1929	927	101	1969	168	81	2009	164	95
1930	7073	268	1970	98	83	2010	83	88
1931	4285	154	1971	90	69	2011	38	28
1932	3708	214	1972	262	80			
1933	3439	211	1973	278	73			
1934	1977	151	1974	412	132			
1935	692	140	1975	670	239			
1936	760	82	1976	1134	180			
1937	1906	122	1977	451	320			
1938	3966	252	1978	179	159			
1939	1653	285	1979	325	172			
1940	3719	308	1980	780	270			
1941	2828	324	1981	879	218			
1942	1531	201	1982	935	236			
1943	399	116	1983	227	162			
1944	2147	224	1984	409	229			

Technical Appendix

Here we present another statistical approach to fire size distributions. Fire sizes are highly skewed toward smaller sized fires –fortunately. Many analysts find that fire size distributions are approximated by an inverse power law. These two figures present log-log plots of the FSD's for reported fires for the periods 1977-86 and then for '02-2011. The closeness of the linear fit is striking. There are various rigorous tests for seeing if differnces such as these charts suggest are in fact statistically significant. Without making any strong claims, the slope seems to have steepened-- that is, there seem to be fewer larger fires, proportionally, recently than in the 70's and 80's. For the record, frequency tables and pareto plots are provided as well.



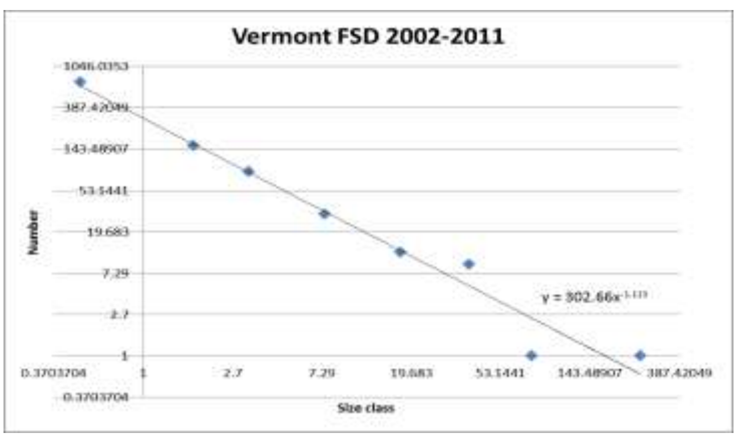
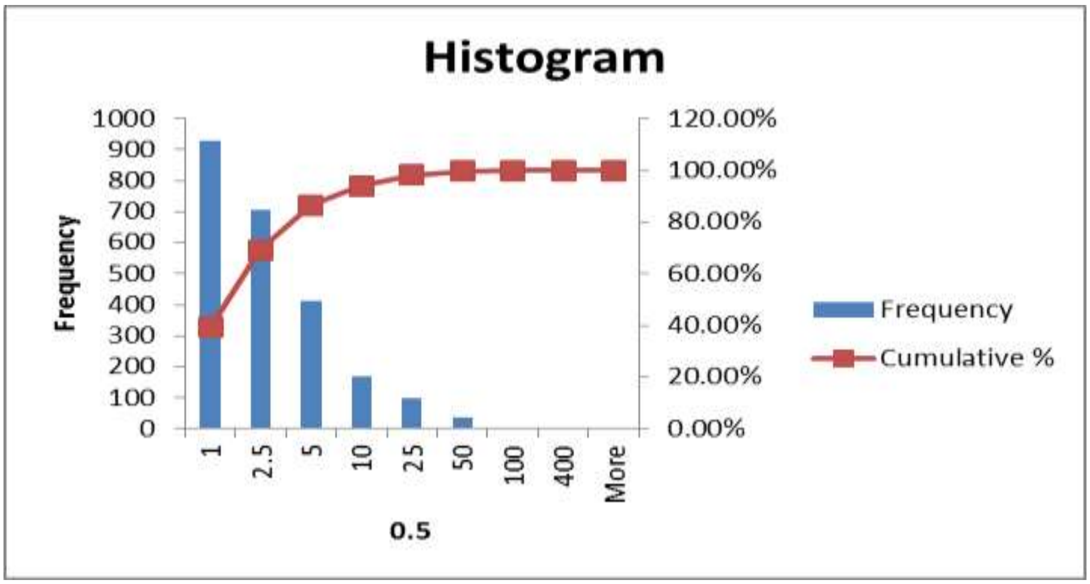


Table Frequency, 1977-1986						
	Frequency	*Freq %*	*Cumulative %*		*Frequency*	*Cumulative %*
1	927	39.3%	39.26%	1	927	39.26%
2.5	707	29.9%	69.21%	2.5	707	69.21%
5	411	17.4%	86.62%	5	411	86.62%
10	171	7.2%	93.86%	10	171	93.86%
25	99	4.2%	98.05%	25	99	98.05%
50	39	1.7%	99.70%	50	39	99.70%
100	5	0.2%	99.92%	100	5	99.92%
400	2	0.1%	100.00%	400	2	100.00%
More	0	0.0%	100.00%	More	0	100.00%
	2361	1				



Results for 2002-2011:						
Bin	*Frequency*	*Freq %*	*Cumulative %*	*Bin*	*Frequency*	*Cumulative %*
1	720	71.1%	71.15%	1	720	71.15%
2.5	156	15.4%	86.56%	2.5	156	86.56%
5	83	8.2%	94.76%	5	83	94.76%
10	30	3.0%	97.73%	10	30	97.73%
25	12	1.2%	98.91%	25	12	98.91%
50	9	0.9%	99.80%	50	9	99.80%
100	1	0.1%	99.90%	100	1	99.90%
400	1	0.1%	100.00%	400	1	100.00%
More	0	0.0%	100.00%	More	0	100.00%
	1012	1