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Wildfires and Climate Change: An American Perspective on a Global Issue¹

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*If fire were invented today, it would never make it through the regulatory process.
It's much too dangerous for humans to use.*

- Stephen Pyne

Introduction

Beginning 1910 as a reaction to the severe western fires, the rule to exclude all fires from national and state forests in America has resulted in the accumulation of dead and dying vegetation - volatile fuels for intense and quickly moving forest fires. When a 1988 fire over a million acres burned for months in America's first national forest (Yellowstone National Park), fire agencies and law makers realized that the policy was flawed. However, during the eight decades of excluding fire, millions of homes had been built close to or within forest boundaries.

Every year becomes the worst fire season ever. Fire occurrence and behavior are similar in many counties of the world. How much does global climate change affect forest fires? How large can these fires grow? Where will this growing trend likely take us? And what should and can we do about it?

This article will offer an examination of the possible impacts of climate change as it relates to the current fire experience and the possible impacts on how we think about and deal with wildland fires in the coming years.

According to climate change studies and meta-studies around the world, our most recent years have been the warmest (and wettest) in the past millennium and quite possibly for 100,000 years or more. Human activities are in part responsible for an increased the concentration of heat-

¹ The presentation is available from <http://www.fires-seminars.org.uk/programme/seminar2/>

trapping gases in Earth's atmosphere to levels not seen in the past million years and probably much longer.

A continued warming trend will result in increased melting of polar and glacial ice, rising sea level, altered weather patterns, and more intense precipitation and storms, but how will it affect future wildfires, fire management and our ability to adapt to fire in the future?

Expectations of Climate Change

There are three conditional expectations of climate change that will help focus on the future ahead. The first is that **climate change is certain**. Solid science supports climate change, the myriad evidence pointing to ongoing global warming, and the modeling techniques used to project future climate. A firm understanding of the scientific issues that underlie climate change—issues that must ultimately guide public fire management policies and our response in the coming decades.

In fact, the Intergovernmental Panel on Climate Change (IPCC) states that “Warming of the climate system is *unequivocal*.” Most of the global warming since the mid-20th century is “*very likely*” due to the observed increase in anthropogenic greenhouse gas concentrations.” In IPCC reports, the term “Unequivocal” equals 100% certainty, and “Very likely” indicates 90% certainty¹.

Global Top 10 Warmest Years	Anomaly °C	Anomaly °F
2005	0.60	1.08
1998	0.58	1.04
2002	0.56	1.01
2003	0.56	1.01
2007	0.55	0.99
2006	0.54	0.97
2004	0.53	0.96
2001	0.49	0.89
1997	0.46	0.83
1995	0.40	0.72

The above chart Climate of 2007 Annual Report from NCDC indicates that all of the top 10 global warm years have occurred since 1995; every year from 2001 to 2007 is on this list.

An obvious player in climate warming is the burning of fossil fuels, mostly to heat and cool buildings, and move our vehicles. This is the predominant contributor to atmospheric climate change, has been identified as a contributing factor to the increase in concentrations of carbon dioxide (CO₂), now at a level 35% higher than they have ever been.²

Obviously, much of the CO₂ is attributable to exhaust gases from cars and trucks on our roads. The increasingly rapid development of residential areas in the wildland/urban interface has extended the worst characteristic of urban sprawl – auto dependency to shop, work and recreate. Bill Bryson recounts his observations in small town New Hampshire of a person parking the car, running into a store, returning, pulling out of the parking space, traveling only tens of feet, and repeating the action over and over³. Instead of parking and walking, Americans choose to drive from shop to shop. Instead of taking public transit, we drive; and instead of carpooling, we take separate vehicles. We do these things not because we don't "get it" but because the designs of the public transit system, the residential community, or the shopping center have not considered how adaptive, innovative design can affect human behavior in positive ways - another challenge for current and future municipal planners and elected officials.

One of the more important trees in Vermont is the sugar maple, which yields its sap to the syrup industry to produce that wonderful flavor for waffles, pancakes, candy, and beverages. However, in recent years, winters in Vermont (and New England) have milder and shorter. The bottom line is that Vermont residents and elected leaders are considering the possibility of losing maple sugar industry to Canada and the impact of this loss to the state's economy. Events like these, as steps in a long journey, accumulate as small incremental changes that escape our notice until we recognize larger changes.

Climate impact on vegetation is our most immediate concern in many ways. First, with extreme weather (fast moving, torrential rains) followed by extended hot, dry spells, grasses and other light fuels tend to grow rapidly with the moisture, only to die and dry out within days of the change in weather. Second, vegetation acts a carbon sink, capturing GHG and lowering the concentrations in the atmosphere. However, upon dying, vegetation turns instantly into a carbon emitter, releasing carbon into the atmosphere.

The protection of forests and grasslands, therefore, is critical to all of us. Live, healthy vegetation (particularly in temperate forests) is a carbon sink, in that it absorbs CO₂ in exchange for oxygen. Every individual on the planet requires approximately 5,000 ft² (464 m²) of forest for oxygen and 7,500 ft² (696 m²) to mitigate the CO₂ exhaled.

Of course, wildfires themselves contribute to CO₂. Fires in Norway, Greece, and Portugal have produced GHG, but perhaps more notable are the fires in Central Siberia that destroyed 15,000 square miles in 2003, producing smoke that was linked to air pollution in the United States. The

forest fires produced as much GHG into the atmosphere as the total EU reduction commitment under the Kyoto protocol.

An international team concluded that the Siberian fires were influenced by climate change because the fire cycle (fires returning to the same region over a period of years) changed. Because the ecosystem in Siberia is largely controlled by temperature, the entire region is affected by climate change. The typical Siberian forest had about 100 years to recover from a major fire before it burned again, but now the cycle appears to be about every 65 years. Over the past 100 years or more, annual temperatures in Siberia have risen by almost two degrees Celsius, about twice as fast as the global average. And since 1990, the warming of Siberia has become even faster than before, unlocking the GHG in the permafrost and in organic soils, and accelerating the greenhouse effect.⁴

The second and third expectations of climate change are that the change will be sudden (at least by Earth's clock) and the resulting atmospheric and terrestrial events will be severe, including wildfires.

Geologists have observed that prior to a drastic global thermal shift, regional weather patterns exhibit up-and-down frequency oscillations and move from one extreme to another, with alternating changes in heavy rainfall to dry spells, and unusual waves of heat and cold from season to season. These changes are sudden, that is, in Earth terms, which may be 200 years or so. But micro-changes in may be more evident. Just recall the noticeable changes in the past two or three years (or more) in your local area. Consider the following personal observations.

Every year, the weather seems to be hotter, drier, colder, wetter, stranger – that is to say, significantly different than the previous. My neighbors and I frequently commented on the unusually dry late summer and fall we experienced in southern New England last year. But once downpours began last November and record snows appeared in December, many were convinced by pronouncements from television weather reports that the long drought was over. Similar concerns were expressed by residents in Georgia in 2007, only to find that much of the rhetoric and discussions about water availability waned following torrential downpours that dropped record amounts of precipitation around Atlanta. Even the threatened lawsuits and interstate challenges with neighboring Florida evaporated like the water in Lake Lanier last summer. It is the public perception that weather and climate are synonymous terms that will delay long-term actions.

When I was growing up in central Arkansas, the armadillo seemed to me like a mythical creature, living somewhere between extinct dinosaurs and southern Texas. I never saw a live one, until the late 1970s when I became director of the state fire academy at Southern Arkansas University. These odd creatures with somewhat unpleasant dispositions were all over the university campus and the fire training grounds, as well as the highways. In 2003, armadillos were present in and around the Mark Twain National Forest in southern Missouri. Within less

than three decades, the armadillo had moved from dry tall grass prairies to conifer/mixed hardwood forests habitat⁵.

Along with extreme weather events and erratic seasons are a number of related issues must be considered: aging infrastructure (especially in rural and non-urban communities and in expanding residential areas, as transportation and public safety concerns lag behind); forest/wildland use and health issues; increasing population in interface areas; and, as a possible result, even more erratic fire behavior. For example, faster moving fires were experienced in many instances in the October 2003 fires in California, burning 20 to 50 times as fast as those two decades earlier as a result of the accumulation of dried and dead fuels that lay among the homes that became additional fuel sources.

These issues present yet another series of challenges, including evacuation, suppression, mitigation requirements in residential communities at risk and how to best design and deliver public education programs for those living in them.

The problem of wildland fires is a very complex and multifaceted one, and the solutions required to address it are necessarily diverse. The issue of fire fighting forces will continue to concern all agencies until a new paradigm is adopted and hard decisions are made to adjust traditional methods and expectations. Subsequent changes to firefighter training and incident management must follow. New research being conducted into areas of social change in residents of interface areas will hopefully provide insights into new concepts in structure design and resident preparation/response, and the impact of forest treatments with other elements of the ecosystem. Too often decisions made to mitigate one hazard exacerbate another problem.

The concept of building, maintaining and protecting communities and landscapes with wildland fire preparedness in mind is a new way of thinking for many people. This approach, while promising the most lasting effect, requires a multi-level outreach effort that may take a generation or more of behavioral change incentives to fully realize full potential. In order to be successful, fire management agencies in all countries need to work together to reduce future losses of lives, resources and structures.

As the earth warms, vegetation becomes stressed opening opportunities for disease and infestation. Trees are one of the planet's best defenses against global warming because they absorb and store a lot of the carbon dioxide emitted by power plants, factories and cars. But when trees are killed by fire, disease or uprooting by storms, they decompose and start releasing that carbon dioxide back into the air. Then they become part of the problem instead of the solution to climate change. Forest fires may account for about 4-6% additional carbon dioxide in the atmosphere each year but burned trees are not the largest source of green house gas (GHG). In fact, just the trees killed during Hurricane Katrina in 2005 will release about as much CO₂ into the air as all the trees across the nation soak in over the course of one year⁶.

A corollary to the expectation that wildfires will be more severe is that future wildfires will exceed in **size, behavior, and cost**.

Recent erratic fire seasons may help us visualize the future and necessitate adjustments in our reactions. Wildfires occur in every state of the USA at some time during each year. Information from the US Department of Agriculture and the Department of the Interior shows the yearly pattern of wildfires during 'normal peak fire seasons' in the 1990s⁷. But following more than a decade of increasingly severe wildfires, it is now becoming difficult to define a 'normal peak fire season'. Ten to twenty years ago, a wildland fire exceeding 100,000 acres (40,470 ha) was a severe occurrence and the sign of an unusual fire season. Today, these large-scale fires are no longer the exception; they are starting to define what a normal peak fire season may be for years to come.

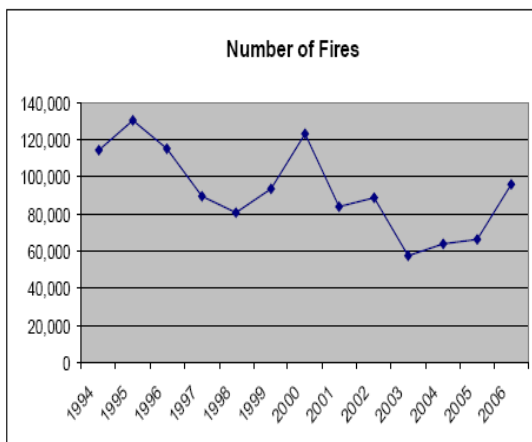


Figure 1. Number of Wildfires, 1994-2003

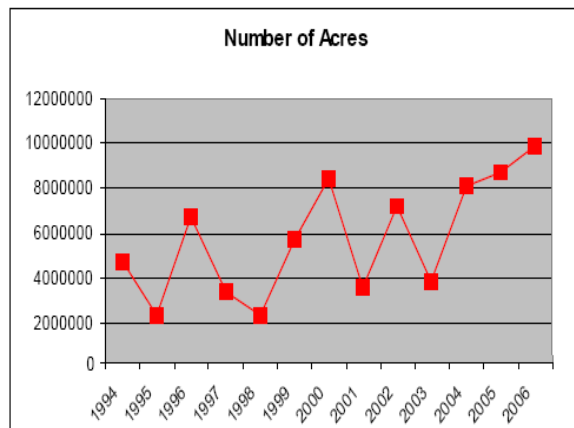


Figure 2. Number of Acres Burned, 1994-2003

Figures 1 and 2. Illustrate the overall downward trend of number of wildfires and the upward trend of affected acres. Of particular note is the noticeable growth of both fires and acres in the last in 5 years.

Fire seasons have been worsening for several years. In 2003, however, the numbers were down from the ten-year average. In 2003, the number of fires (62,000) and acres burned (3.8 million acres/1,537,860 ha) were below the average of 64,000 fires and 4.6 million acres (1,861,620 ha). See Figures 1 and 2. In other words, the average decreased from 72 acres (29 ha) per incident to 61 acres (25 ha) per incident. In the same year (2003), less acreage burned than in recent years, but what did burn was in populated areas.

Within the last three years, the number of fires and the affected acreage is growing. Although the variations in numbers may be up and down from year to year (distinctly upwardly in the last 4 years), it is the longer-term trends that are important, and a definite and troubling outlook is becoming evident. According to reports from the National Interagency Fire Center (NIFC)⁸, the

average size of wildfires approached 100 acres (40.5 ha), up from the ten-year average of 71 acres (28.7 ha). See Figure 3.

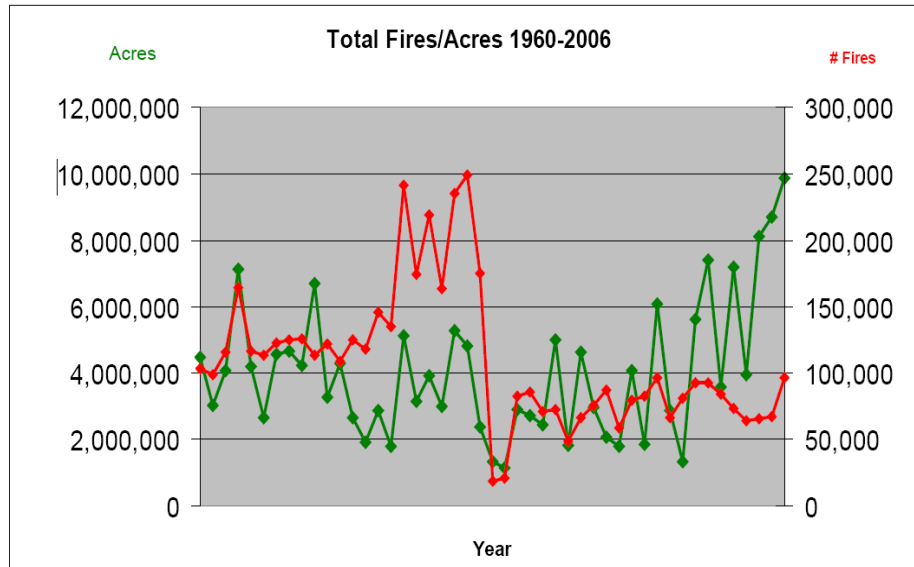


Figure 3. Total Wildfires and Acres Burned, 1960-2006. As fire incidents increase, the average size of each fire approaches 100 acres, up from the 10-year average of 71 acres. Fire data is shown in red; acres data in green.

Considered as the worst fire season in 80 years, 2000 was a landmark year, perhaps most remembered by the ‘escaped prescribed’ fire that overran its boundaries in Bandelier National Monument near Los Alamos, New Mexico. The fire eventually burned 47,650 acres (19,284 ha) and destroyed 235 homes. A moratorium on prescribed fire was put into effect following the blaze. The Cerro Grande fire as the fire became known was a harbinger of one of the most difficult seasons in the last half century.

In 2002, NIFC’s annual summary included an average ‘worst’ summary, noting that, based on previous years’ activities, future fire seasons of 85,000 fires and 6 million acre (2,428,200 ha) damage could be expected - a prophetic statement, to be sure, though somewhat underestimated, for in 2004, the total damage/loss was 8 million acres. In 2005, the total rose to 8.7 million acres (3,520,890 ha); and to 9.9 million acres (4,006,530 ha) in 2006.

As debate over ‘prescribed fire’ (how much, where, when and at what cost) continued, the price of suppression systems for tackling wildfires climbed and more unprotected homes and structures were lost, even though federal and state land management agencies treated millions of acres to reduce the fire risk using prescribed fire and mechanical means (such as cutting and clearing). Fires in largely untreated areas were the problem⁹.

Forest fires in the Western United States have occurred more frequently, burned longer, and covered more acres since 1987, and global warming is a big part of the underlying cause¹⁰. Researchers at the Scripps Institution of Oceanography and the University of Arizona found four times as many large wildfires occurred in Western forests between 1987 and 2003 compared to the previous 16 years. The more recent fires burned 6.5 more land, the average duration of the fires increased from 7.8 to 37 days, and the overall fire season during those years grew by an average of 78 days.

Those changes corresponded to an average 1.5-degree rise in temperature throughout the American West during the same time period. According to the study, the first to link global warming to wildfires, the warmer temperatures due to climate change have led to longer, drier seasons, creating ideal conditions for forest fires.

With all the increased activity in wildfires, the average fire season reinforces the fact that still about 95% of all wildfires are suppressed with initial attack (fewer fire fighters with minimum equipment) at about the 300 acre threshold. The concern is that the next 4% exceed initial attack efforts, resulting in a required extended attack. While these fires threaten to transition to large complex fires, they are often controlled within one or two burning periods.

With 95% of wildfires controlled at the initial attack level and 4% at the extended attack level, what about the remaining 1%? Those 1% wildfires require the management and oversight of a well-organized, trained, and experienced Incident Management Team (IMT). These national IMTs offer specialized personnel in the areas of planning, logistical, and operational leadership necessary to deal with a complex incident. Of the few large 1% wildfires, fewer yet become “mega-fires¹¹.”

“Mega-fires” are extraordinary, in terms of their size, complexity, and resistance to control. They often burn into the wildland-urban interface where values to be protected are high. They invariably break out when other wildfires are stretching firefighting capacity. With few exceptions, they usually occur in late seral stand conditions on drier sites, where the buildup of dead woody material and accumulation of live biomass can fuel high-intensity events. It is not unusual that fire severity in these stands is exacerbated following years of drought, insect infestations and disease. These few wildfires, often burning under extreme fire weather conditions and exhibiting extreme fire behavior characteristics, exceed all efforts at conventional control, until relief in weather or a break in fuel occurs.”¹²

Mega-fires remind us of our position on this planet. Watching a large wildfire is certainly awe-inspiring, but a mega-fire stirs a deeper emotional response in witnesses. What is occurring before them is an event, a situation, natural phenomenon of the planet. These fires defy definition and adequate description. These are the “news headline” wildland fires in which the limits of suppression forces, public perception and anxieties of doom, media scrutiny of the most minute details, and political pressures collide. Often, the impact and meaning of these fires is lost in the meaningless, inadequate assessment of the event. With questions like “Why and how did the fire

become so destructive”, “How did it escape efforts at control? Why could it not be extinguished”, and “Which agency is most responsible for the damage?”



Figure 4. Mega-fires, like the North Fork Fire in Yellowstone National Park (1988) remind us of our human place on the planet. The Yellowstone Fires burned for over four months and destroyed over 1 million acres (404,700 hectares). Photo by the author.

While extremely large in size with accompanying extreme fire behavior, it is their complexity that overwhelms procedures and policies. They quickly overwhelm local, state and even federal capabilities and capacities. Frequently long-lived (several weeks to months), mega-fires require a large commitment of suppression resources for an extended period.

The intensity of these mega-fires places fire fighting resources on the defensive and fire managers in a reactive mode. These become expensive campaign fires, due to the number of fire suppression personnel and equipment required over the duration. The paradox of the management of these fires is that while federal budget analysts insist that fire management operations (from line officers through incident commanders) reduce costs, public and political influences pressure the same fire managers to “do more.” As a result of political and public pressure and dissatisfaction within agencies, mega-fires often result in policy or procedural changes, but are usually limited to improving fire fighting operations – short term “fixes” that may not affect the actual problem and even be changed during periods when mega-fires do not occur in several months or years.

Over the past twenty-plus years, numerous internal and external reviews, have pointed consistently to the rapid rise in suppression costs, property losses, and resource damages resulting from wildfires. As the total expenditures for suppression alone approach \$2 billion per year, more fire managers and government officials become anxious, and the public demands information about the rising costs. cursory analysis indicates that it is only one percent of all wildfires (those wildfires that escape initial and extended attack efforts) that account for some

85% of total suppression related expenditures on federal lands. Federal wildland firefighters are remarkably successful in suppressing nearly all wildfires that threaten people, communities, and natural resources, but the consequences of those few fires that escape control efforts have become staggering. “Mega-fires” are only a fraction of that last 1% of all wildland fires that escape control, but their consequences stand out and resonate through fire plans and policies for years after the event.

How these mega-fires start (and grow) is often as inconsequential as how they end. Whether from inappropriate suppression decisions or the over abundance of forest fuels, the fact remains that the frequency and damage resulting from these fires is a growing problem warranting serious future study and consideration. Examples of selected mega-fire events are in Table 1.

Table 1. Summary of Selected Mega-Fires in the U.S. 1999-2004

State/ Year	Fire Complex and Acres Burned	Suppression Costs	Duration (Days to Contain)
Florida 1998	Volusia: 111,130 acres (44,974 ha) Flagler/St John: 94,656 acres (38,307 ha)		June 22 - July 21 & June 22-July 13
Montana & Idaho 2000	Montana: 950,000 acres (384,465 ha) Idaho: 1.3 million acres (526,110 ha)		Late June to Early October
Arizona 2000	Cerro Grande (3): 47,650 acres (19,284 ha) 250 structures		May 5 - May 25
Colorado 2002	Hayman: 137,760 (1) acres (55,751 ha)	\$39 million	June 08-July 18
Arizona 2002	Rodeo-Chediski: 468,638 (1) acres (189,658 ha)	\$ 40.4 million	June 18-July 02
Oregon 2002	Biscuit: 499,965 (1) acres (202,336 ha)	\$150 million	July 13-Sep 05
California 2002	McNally: 150,969 (1) acres (61,097 ha)	\$45.7 million	July 21- August 28
New Mexico 2002	Ponil Complex: 92,522 (1) acres (37,444 ha)		June 02- June 19
California 2003	Multiple complex fires: 739,596 acres (526,110 ha)		October 21- November 10
Alaska 2004	Taylor Complex: 1.3M acres (4) (526,110 ha) Others: .5 million acres (202,350 ha)	Not available	Late June- Mid Sept Others Mid Nov

Source: The Mega-Fire Phenomenon: Toward a More Effective Management Model – A Concept Paper, The Brookings Institution Center For Public Policy Education, Washington D.C., 2005.

Wildfires in our future?

An important aspect of wildfires in the future is where these fires may occur. Can we expect a smaller number but increasingly larger acreage fires in the future? And what might this mean for the environment, fire suppression resources, firefighter safety and structural loss?

What about the impact of climate change on wildfires in other counties? In February of this year, unseasonably cold weather in southern China killed large areas of forests. These dead and downed trees could worsen forest fires later in the year and lead to landslides and pest outbreaks. Forest industries suffered direct economic losses of \$8.01 billion (57.3 billion yuan) from the snow and ice storms, which also affected millions of people who depend on forests for their livelihood. The large number of trees toppled in the storms would create ideal conditions for devastating fires, as did the tree loss from Hurricane Hugo in the late 1980s and in northern Minnesota a decade later.¹³

Fire protection professionals from both wildland and structural disciplines need to look at the impact on structural fire protection and the population living in or near forests and grasslands. Again, the future of wildfires in and through residential developments is certain. The change must be gradual. The challenges are serious but controllable with better planning, cooperation and coordination among agencies if they have a common vision and concern for public safety.

The final thing to realize about climate change certainty is that there is uncertainty. Climate models differ, as most scientific analyses are based on trend observations. The components of past trends have changed due to the degree of GHG concentrations. Just be aware that models calibrated with trend data may not accurately reflect the future. Yet, given the uncertainties and the information we have at this point, wildland fire management agencies should try to anticipate a future of wildfires and prepare themselves and the populations they protect regarding similar expectations we've examined for climate change.

Mr. Smalley is the manager of NFPA Wildland Fire Protection and the National Wildland/Urban Interface Fire Program, an initiative that, since 1986, has provided information, research, training, and education materials concerning the severity and impact of wildfires that threaten homes and other structures. In addition, he serves as the NFPA Staff Liaison for the Fire Service Training Committee and the Fire Service Data Exchange Committee (including Geographic Information Systems (GIS) data), the Executive Secretary for the Wildland Fire Management Section, one of NFPA's special interest membership sections.

Mr. Smalley is a graduate of the University of Arkansas, Southern Arkansas University, and the University of Delaware, with an A.S. degree in Fire Protection, a B.S. in Education, and a Graduate Certificate in Association Management. He is a professional member of the Society of American Foresters, the Institute of Fire Engineers, and the Society of Fire Protection Engineers.

Endnotes

¹ IPCC TAR4 Report

² Wolfson, Dr. Richard, Middlebury College VT, *Earth's Changing Climate*, The Teaching Company: Chantilly VA, 2007.

³ Bryson, Bill, *I'm a Stranger Here Myself: Notes on Returning to America After Twenty Years Away*, Broadway Books, New York, 1999, pp. 102-03.

⁴ Information from www.telegraph.co.uk, copyright Telegraph Media Group Limited, 18 Jan 07.

⁵ Prior to about 1850, the nine-banded armadillo was not found north of the Rio Grande River. The sudden and extremely rapid armadillo colonization of the southern United States has puzzled quite a few biologists. The degree of range expansion per year is nearly ten times faster than the average rate expected for a mammal. Sightings of the animals farther north are reported every year. Source: *Armadillo Online* website.

⁶ Shogren, Elizabeth, "Trees Lost to Katrina May Present Climate Challenge," National Public Radio, January 12, 2008.

⁷ Peak Fire Season information developed from data from USDA Forest Service and US Dept of the Interior. Fire season maps can be found at: www.firewise.org/pubs/peak_fire_seasons

⁸ The National Interagency Fire Center (www.nifc.gov) is supported by the USDA Forest Service, the Department of the Interior and others. It is located in Boise, Idaho, and provides daily and accumulated data and information regarding wildland fires.

⁹ Source: National Interagency Fire Center, Summary Fire Reports.

¹⁰ *Science* journal July 2006

¹¹ The Mega-Fire Phenomenon: Toward a More Effective Management Model – A Concept Paper, The Brookings Institution Center For Public Policy Education, Washington D.C., 2005.

¹² Ibid.

¹³ Reuters News, 19Feb08.