Long-Term Global Threat Assessment: Challenging New Roles for Emergency Managers

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Abstract

Based on currently available published data and literature from multiple disciplines, this article examines medium- and long-term global developments and changes that will likely impact human society in disastrous or even catastrophic fashion, with significant impact on the roles and challenges of emergency managers. Some of the phenomena described are loss of fresh water, significant sea level rise with resultant flooding, increased heat leading to desertification and crop losses, storms that are both more frequent and more violent, massive food emergencies as crops fail for lack of water and/or saltwater inundation, loss of the petroleum-based economy, and massive population relocations on a level the world has never experienced. The perspective used is purposely global, in that the trends described do not respect political boundaries, bolstered by the recognition that mitigation and response activities may well involve many nations simultaneously. The article concludes with introductory suggestions of steps that emergency management should take in preparing to serve new and more complex roles to meet coming challenges.

Key words: global threat trends; global resource depletion; emergency management; new roles.

Introduction

We are at a turning point in history in which the huge human population growth, profligate consumption of limited resources, careless release of waste products, gasses and chemicals, and economies based on the assumption of endless growth are rapidly coming into conflict with the realities of biological, climate, and geological limits. The results are relatively predictable with current science and some of them are already beginning to show evidence that even the lay public can comprehend. This next 50 to 100 years of human existence will be characterized either by Hurculean struggle to re-establish a sustainable relationship between humans and their finite environment, with painful setbacks along the way, or by a catastrophic failure to negotiate needed changes with resulting collapse of many societies when resources and climactic conditions no longer support a large human population. Either way, the challenges for

emergency managers are rapidly on their way to multiplying in both complexity and consequence. The potential impact emergency managers can have is also increasing. The intention of this article is to familiarize emergency managers with emerging and future dynamics that will challenge us all, in the belief that good early knowledge will enable the profession to develop the threat assessments, skills, strategies and coalitions we will all need in trying times. We conclude the article with some suggestions regarding preparations emergency managers can initiate now in order to help the profession cope with increasingly difficult tasks.

One of the most important tools of the emergency manager is the implementation of a good threat assessment prior to beginning the processes of mitigation, planning and preparedness. Threat assessments, however, are frequently limited by the parameters in which they are conducted, and are typically focused on a single jurisdiction and a limited time period, looking perhaps no more than ten years into the future. These parameters are inadequate in a historical period in which major global changes are underway, many of which may provoke emergency situations some twenty to fifty years from now, but which also will require decades of mitigation and preparedness "spool-up" time in order to protect our populations. In this article we provide a brief overview of some of the myriad threats related to global climate change, diminishing petroleum supplies, economic globalization, new and changed infectious diseases, changes in warfare, and the availability of weapons of mass destruction. Unfortunately, the limited space in an article format restricts the depth of discussion of each threat.

A. Global Climate Change

Warming

Climatologists have been warning us for several decades that the Earth's temperature is rising at an alarmingly rapid rate. With newer sensing and mapping technologies, the earlier findings have been confirmed or even strengthened. While scientific consensus is not yet quite 100%, the overwhelming majority of the world's climatologists agree that the rapid warming is largely due to changes in the atmosphere caused by human use of carbon-based fuels, emitting carbon dioxide and other so-called greenhouse gases. [1]

It turns out that changes in the Earth's temperature are no small matter. Weather patterns, which have a huge impact on whether a particular area of land can support life at all, or life forms that humans use for direct sustenance, derive largely from the distribution of temperature differences. As temperatures change, so do the weather patterns that determine the distribution and amount of rainfall, the frequency and intensity of storms, and, hence, the distribution of arable land,

life-sustaining forests, and life-threatening storms. Let us take a closer look at some of the threatening effects of global warming:

Desertification

The result of both climate change and human land use behavior (i.e. the clearing of forests and other ground cover, diversion of stream flows), desertification is the process by which land that previously supported plant life converts into desert. The loss of vast tracks of previously arable land to encroaching desert in the northern parts of Africa is well documented. Less well known to many is the degree to which the same process is active in other parts of the world. For example, China, once a major grain producer (and now a no-longer self-sufficient major grain consumer) is losing about 360,000 hectares (1,400 square miles) of arable land *per year* to encroaching deserts.[2]

Rising Sea Level

As the climate warms, the northern and southern polar areas are warming disproportionately faster than equatorial regions. Not only does this have grave consequences for wildlife that depends on polar conditions for survival (polar bears, penguins, etc.), but it also results in massive melting of polar ice. The melting polar ice, particularly that in Antarctica and Greenland where it sits on land, and melting glaciers in sub-polar and temperate zones, eventually results in water added to the seas. Sea levels are currently rising, an estimated 20 centimeters in the 20th Century, and are predicted to rise significantly more. The most recent predictions at the time of this writing range from an additional increase of between 88 cm and 500 cm in the 21st Century (from 3 to 15 feet or more).[3] [4]

As a rising sea inundates islands like Tuvalu and lowland shoreline areas like Bangladesh and perhaps even the Netherlands, New York City, Florida, and New Orleans, the populations living there will have to out-migrate. This process may already be underway in New Orleans since Hurricane Katrina. Given the density of these populations, this out-migration will raise significant issues regarding the difficulties of resettling large migrating populations. There is little evidence in the last 500 years of human history of successful, peaceful migrations of large numbers of human beings.

Storms

Climatologists tell us that a consequence of global warming will be an increase in the number of significant storms, as well as an increase in their intensity. [5] Storms are the results of atmospheric temperature and pressure imbalances; as the earth warms up, the imbalances increase. Not only will storms increase in frequency and intensity, but they will likely also change patterns,

showing up at times, latitudes and in biomes not previously accustomed to them. The storms covered by the warning include all of those that are most destructive: tropical cyclones (hurricanes), tornados, violent thunderstorms, extended rain storms, and winter storms capable of bringing wind, snow and ice.

Winter storms often disrupt transportation and can knock out power supplies at the very moment that people need power for heating. Such storms can kill by way of freezing people and other life forms, by causing transportation crashes, and by way of interrupting life-sustaining power supplies and transportation. If major winter storms occur in places unaccustomed to them, they can also destroy agricultural crops, leading to hunger, adding to the already high index of suffering imposed on a population that is unprepared for winter storms.

The tools available to emergency managers for response to storms are well known to the reader. However, the quantity and distribution of these human and materiel resources may not be sufficient in the face of changing storm patterns, even in economically wealthy countries. The populations of developing countries can be expected to be even more at risk of suffering from storms that overwhelm protective and response resources. However, lest one would think that residing in a wealthy country provides sufficient protection against storm-caused suffering, the United States' experience with Hurricane Katrina in 2005 may serve as prologue to even worse experiences.

Abrupt Ice Age

It sounds paradoxical, but rapid global warming could lead to a rapid-onset ice age, at least in the northern hemisphere. Most readers are familiar with the Gulf Stream, the current of tropical water that circles from the Gulf of Mexico, up the U.S. East Coast, and across to Northern Europe. This current (called the thermohaline conveyer by many climatologists) is what makes it possible for 300 million Europeans and perhaps 50 million North Americans (Canadians and northern tier U.S. residents) to live in relative comfort at high latitudes, by transferring the heat stored in tropical waters to what would otherwise be a much colder part of the globe.

The rapid melt-off currently underway in the North Atlantic is already diluting the salinity of the water that contributes to the thermohaline conveyer, and now there is preliminary evidence that the conveyer may be slowing.[6] If this current fails and the life-supporting Gulf Stream stops its circulation, parts of North America and large parts of Europe could, within a relatively short period of time, be thrust into a vast and extreme drop in temperature…in short, a rapid-onset ice age.

Emergency Management Considerations: Put succinctly, we have no history of being able to coordinate a peaceful and efficient mass migration and resettlement

of hundreds of millions of victims fleeing catastrophe. We have no plans to do so, no stored resources, and no cooperative agreements, all of which are core tools-in-trade of emergency managers. Emergency management has traditionally focused on local jurisdictions, or even jurisdictions the size of a province or state, but not entire civilizations, and we have not developed the conceptual or logistical tools to face such a challenge.

Increased Spread of Tropical Diseases

Lethal tropical diseases such as malaria, dengue, chagas, yellow fever and numerous parasites are limited to the tropics because either the microbes or their vectors are unable to survive or reproduce in cold weather. As warming sets in, with milder winters and longer summers in areas that not too many years ago could count on at least several days of freezing temperatures per year, those same areas are now experiencing, or are susceptible to tropical diseases not normally present. The local population will have no previously developed immune response to the microbes, and local health care workers may have no previous experience diagnosing and treating such illnesses. Already, malaria, which is a massive worldwide killer, has been seen as far north as the state of Virginia in the U.S., with two 2002 cases that were confirmed as not being imported.[7] The *anopheles* mosquito that carries malaria has been found to winter over in suburban northern Virginia.

Emergency Management Considerations: Environmental control of tropical disease vectors may limit funds that could otherwise be invested in other disaster prevention or mitigation programs. Emergency managers may be asked to help health departments with logistics.

B. The Threat of Infectious Disease in a Global Community

Our modern global transportation network allows for worldwide travel of people (and their illnesses) to nearly any destination in less then 24 hours. This ability has helped set the stage for potential infectious disease spread at a terrifying pace and at pandemic proportions. Historically, diseases such as smallpox or bubonic plague, came in waves of outbreaks with a very high mortality rate. When diseases that are known to one population are introduced to another population without such experience, the results can be devastating. Such was the case when measles was first introduced by European explorers into the native populations of the Americas. Measles contributed to a greater than 90% fatality rate among native peoples.[8] New diseases can also come as a result of cross-overs from animals to humans. Recent examples are Acquired Immunodeficiency Syndrome (AIDS), believed to be from monkeys in Africa,

Severe Acute Respiratory Syndrome (SARS), from civets, badgers and raccoon dogs in China, and avian influenza (from wild ducks, swans and domesticated chickens). These diseases have, and will continue to threaten human populations with diseases that develop first in animals and then transmit to humans who have no specific immunity to them. Public health researchers have established that the 1918-19 influenza pandemic, which started first in domesticated farm animals, killed more than 40 million people.[9],[10] Epidemiologists estimate that a new (to humans) influenza such as "avian flu" (H5N1) could, if it mutated slightly, kill at least as many people as perished in the 1918-19 outbreak, and perhaps considerably more.[11]

Microbial mutations present various serious challenges. Some bacteria have developed resistance to even our strongest antibiotics, including some of the pathogens previously responsible for a huge amount of suffering and death, such as the tubercle bacillus that causes tuberculosis. There is the treat of non-natural mutations in some microbes, constituting the newest public health threat. Biological warfare is the use of pathogens, usually bacteria and viruses that are intentionally manipulated by humans to evade the best efforts of our immune response systems and health care systems. Such examples include genetically altered versions of *bacillus anthracis* (anthrax) and *yersinia pestis* (plague) and viruses such as smallpox. Of particular concern is that we do not know the extent to which many countries may have researched and developed such programs.

Emergency management considerations: Even without purposely manipulated or weaponized pathogens, infectious diseases constitute a major threat. Public health experts are warning that the world is poorly prepared for even a major influenza outbreak. Although the tools for the prevention and mitigation of epidemics are clearly in the domain of public health and medicine, response to a massive epidemic would require logistical assistance from emergency managers for obtaining and delivering medical supplies and personnel to the locations most in need, and acquisition of facilities where the ill could be treated once the hospitals fill beyond capacity. While epidemics do not destroy physical resources, they do affect the human resources that emergency managers can bring to the work of supplying and managing the physical resources needed by the health care sector to respond to the epidemic. Emergency managers could find themselves without a workforce, and governments could find themselves without emergency managers.

C. Human Population Growth

Over the last 50,000 years of modern human development, our species has shown remarkable ability to expand its territory, moving into and acclimating to environments as extreme as desert and arctic barrens, tropical rain forests, wide

savannas, and densely populated cities. Three major developments occurred within the past five to ten thousand years to wildly increase our population size: domestication of some plants and animals in a new technology called agriculture; development of cheap and abundant sources of fuel, and; development of modern public health and medical techniques.

More people were added to the world's population in the 20th Century than had lived in all previous human history.[12] What allowed such massive growth? A combination of two developments: power and public health. It was in the 1800s that humans began to harness the vast energy sequestered below ground in the form of coal and oil, and by the 1900s petroleum products and coal allowed humans to do things we had never before had available. Using petroleum to drive tractors and other large farm machinery, and petroleum-based fertilizers and pesticides, humans could raise crops in an abundance never before imagined. Using coal to create electricity, we could freeze and refrigerate perishable food, so that it could be transported to other places and used at other times. Using petroleum, we could distribute food to consumers who lived far away from where it was produced, making it possible for populations to grow and thrive in areas that cannot support agriculture. Las Vegas, Nevada is an example of such a population. In fact, population growth was essentially without food limits, and where people fell hungry in poorer parts of the world, humanitarian organizations responded with (petroleum-driven) food lifts. The importance of petroleum products and coal in supporting exponential human population growth cannot be overestimated.[13],[14],[15],[16],[17]

The other major contributor to the massive growth of the human population in the last century is our significant progress in using science to keep people from becoming ill, and curing them when they do. Population size, at its very most basic, is an equation between food availability, birth rates and death rates. Death rates have dropped dramatically in the last 200 years. This is because of the application of fairly simple techniques to keep food, water and hands clean, and more complicated technologies such as vaccination, antibiotics, and epidemiologic disease control strategies. The United Nations Economic Commission on Africa notes that, on a world-wide level, the crude death rate drop from 1950-55 to the period 2000-2005 was an astonishing fall from 19.8 per thousand to 8.6. [18]

Using data from the World Bank, which unfortunately estimate only back to the year 1800, we can see a radical change in death rates (Table 1).

At better than 6 billion people alive today, and with a population that is still growing, we are consuming the resources of the planet faster than they can be replenished. Over-population affects virtually everything we will cover in this article, but we will only discuss the problems of dispersion, density, and overshooting earth's carrying capacity in this section

Table 1
Crude Death Rates in Developed and Developing Countries 1800-2000

Time Period	Developed Countries CDR (1)	Developing Countries CDR (2)
1800AD	**33**	**37**
1850AD	**31**	**37**
1900AD	**22**	**33**
1950AD	**11**	**23.5**
2000AD	**8**	**9.2**

(1) Crude Birth/Death rates - Number of births/deaths over a given period divided by the person-years lived by the population over that period. It is expressed as number of births per 1,000 population.
(2) Developing countries: Less developed countries include all countries in Africa, Asia (excluding Japan), and Latin America and the Caribbean, and the regions of Melanesia, Micronesia, and Polynesia.
Data sources: See: World Bank Development Education Program (http://www.worldbank.org/depweb/beyond/beyondco/beg_03.pdf) and UN World Population Prospects, by country at the UN International Data Base (IBD) Demographic Data Page (http://www.census.gov/ipc/www/idb/).

Dispersion refers to the expansion of human habitats into previously unpopulated or lowly populated areas of the world. From public health and emergency management viewpoints, the problems with population dispersion are:

- Deforestation, leading to increased flooding and landslides, loss of habitat for plants and animals important to the overall ecosystem and important for potential sources of medications. .
- Populations that move to ecosystems with which they have no microbiological experience, frequently put themselves at considerable risk of major disease burden.
- Relocation into hazard zones such as exposed coastlines and flood plains has occurred when the population density is too high in their place of origin to supply necessary resources, thus trading one risk for another. Also, in wealthier countries, the rich frequently select high-risk habitats for their views or other social values.

Density refers to the degree to which a large number of people occupy limited space. It is often measured by the number of people per square kilometer (or mile). For example, Table 2 shows several current population densities:

Table 2
Select Population Densities, People per KM^2

Hong Kong	6 407
Rwanda	343
India	336
Germany	232
United States	31
Canada	3
Mongolia	2

Data source: http://www.un.org/esa/population/publications/WPP2004/World_Population_2004_chart.pdf

The problems with population density can be summarized as:

- High population density creates ideal conditions for disease propagation.
- High density results in concentrations of waste.
- Densely populated areas are prone to maldistribution of resources and resulting violence.
- When densely populated areas are hit by a major disaster, the sheer number of people available to be hurt can easily overwhelm response resources, and also make evacuation difficult or even impossible,
- Large urban areas may be hard to sustain when power supplies become scarce.

Carrying Capacity refers to the ability of a given jurisdiction, region, or planet to permanently support life (or a particular species), given its resources, and is based on renewable resources, to include water, arable land, etc.[19] *Temporary* carrying capacity may include the availability and use of non-renewable resources, such as petroleum. The estimated human carrying capacity of the Earth, *based upon entirely renewable energy resources* is between 2 billion[20], [21] and 5 billion.[22]

Emergency Management Considerations: Population size is a huge challenge because of the way it affects every other issue related to sustainable survival of the human species. Prevention is no longer an option; emergency management strategies of mitigation, response and recovery are all that is left. The field of emergency management has little experience with population control issues, but

world and national policy makers will do well to incorporate emergency management's concept of mitigation at the earliest possible moment. Societal response to the suffering caused by reaching beyond the planet's long-term carrying capacity may well benefit from incorporating logistical and management strategies developed by emergency management, but the task will be larger than the field of emergency management can handle with its own resources.

D. ENVIRONMENTAL DEGRADATION

The Earth provides all the resources that we need to survive and flourish, including food, water, oxygen, energy, and raw materials that we use to create the structure of modern civilization. However, industrialization and the over exploitation of natural resources by an ever increasing human population has made the Earth's physical environment progressively more imbalanced over the past 150 years, and the resulting environmental degradation further limits the Earth's ability to support human life over the long term.

Loss of Watershed and Flood Protection

Watersheds receive water from rainfall and release it slowly to streams, lakes and the ocean. The most common watersheds are forests and so-called wetlands - low-lying areas of land that are typically wet year-round, and harbor aquatic plants and animals. Forests provide oxygen, lumber, fuel, landslide and flood protection , and habitats for many of the world's plant, animal and microbial species. They also provide invaluable services in terms of water management by storing and then slowly releasing water, and, in the process, cleaning the water of a multitude of impurities and pollutants, such as carbon dioxide, nitrogen, phosphorus, sulfur, heavy metals (such as gold, mercury, platinum, lead, silver), microbial pathogens, fuels, fertilizers, herbicides, antifreeze and suspended solids.[23] Like forests, wetlands also serve to provide habitats for species, flood protection, and water purification and management services. Using man-made technologies, we could neither accomplish all of this nor afford to do it if we could.

Forests and wetlands are shrinking and disappearing at an increasing rate around the world because of both direct and indirect damage from human activities, and as protective watersheds disappear humans are more threatened by flooding and landslides. Wetlands are typically lost as a result of humans filling them in to use the land for other purposes, and from having their water source diverted for other uses. Environmentalists report significant wetland losses in many parts of the world, with this trend accelerating in the last few decades as human population has rapidly expanded.[24] Damage to and loss of protective

watersheds contributed to the flooding of New Orleans in 2005's Hurricane Katrina.[25]

Loss of Clean Water

In addition to leading to an increase of flood and landslide hazards, the loss of watersheds and wetlands, combined with the diversion of water for agricultural and industrial use, climate change-induced shifts in rainfall patterns, and human-caused pollution of available water sources have combined to decrease the availability of clean water where it is needed for a large and growing human population.[26] Major aquifers in the United States (Ogallala), China (North China Plain) and other parts of the world are being rapidly depleted due to vast pumping for agricultural use; when these aquifers are no longer producing water for agriculture, significant reductions in the world's available food supply will occur.[27] Additionally, major world population centers depend on rivers such as the Ganges, Indus, Yellow and Colorado Rivers that are fed by glaciers and winter snow packs. As warming continues, the glaciers are disappearing and snow accumulations minimized, which will lead to dramatic loss of potable water to hundreds of millions of urban residents and the farmlands that support them.[28] Current experiences may be signs of water problems to come: a major water shortage in northern Georgia and other parts of the Southeast, and the prediction that Lake Meade, upon which some 22 million people in the American Southwest depend for water, may go dry by 2021 or earlier.[29]

Loss of Biodiversity

Biodiversity is the existence of a broad variety of life forms within the same biosphere. Life is complex and science is still learning much about how all life forms depend on a balanced relationship with other life forms in order to prosper, or even exist. For example, Harvard biologist Edward O. Wilson points out that the most abundant organism in the oceans, and which we now know is responsible for "a large part of the organic production of the ocean", the *Prochlorococcus,* was unknown to science until 1988.[30] Organic production in the ocean affects many life forms, including humans, significantly. There are two key reasons biodiversity is important to human survival: biological balance that keeps everything going; and access to organic compounds and genes that can help keep us alive in our struggle against microbiological adversaries and the challenges of changing conditions. Without biodiversity, the balance that supports all of life may be difficult to maintain, at least in a time frame that is too short to allow for mutation and the development of new species, and we will lose access to biological compounds and genes we may not even recognize as important today.

Harvard's medical biologist Eric Chivian writes: "Species numbers are now being reduced so rapidly that some experts have predicted that 25% or more of all species currently alive may become extinct during the next 50 years if these rates persist."[31] Dr. Chivian sums it up by saying:

> Despite an avowed reverence for life, human beings continue to destroy other species at an alarming rate, rivaling the great extinctions of the geologic past. In the process, we are foreclosing the possibility of discovering the secrets they contain for the development of new life-saving medicines and of invaluable models for medical research, and we are beginning to disrupt the vital functioning of ecosystems upon which all life depends. We may also be losing some species so uniquely sensitive to environmental degradation that they may serve as our "canaries," warning us of future threats to human health.[32]

Emergency Management Considerations: Emergency management is poorly prepared to intervene with problems related to biodiversity loss. The emergency management concepts of prevention and mitigation, however, are valuable.

Use of Fossil Fuel

'The use of fossil fuels, principally oil and coal, has had a significant impact on the natural environment over the last couple of hundred years, due primarily to:

- the addition of greenhouse gases to the atmosphere, mostly carbon dioxide;
- the pollution of the air with substances that directly affect human and animal health by way of entry through the respiratory tract, and indirectly by way of polluting forests and waterways with "acid rain" precipitate of chemicals from the air, and;
- direct pollution of waterways and ground water via spills and run-off of petroleum products (including oil-based pesticides and herbicides), and water pollution resulting from the coal mining process.

The contribution of greenhouse gases to the accelerating change in the global climate has been well documented by scientists from many countries.[33],[34],[35] Petroleum, chemical and coal mining pollution in the air and water do not constitute new hazards for the 21st Century, and although they are very real and serious, these hazards will not be highlighted here.

Loss of Cropland and Desertification

The consequences of cropland loss are serious in an era of growing human population, and will be discussed below in a section titled "Food Security." Desertification is one of the causes of cropland loss, with both China and North Africa currently suffering major losses of cropland to encroaching deserts.[36]

Cropland is also lost to other causes. For example, suburban sprawl surrounding major cities has consumed millions of hectares of former cropland, particularly in the United States and some parts of Europe and Australia. [37] Cropland is also rendered unusable by agricultural practices that lead to nutrient depletion within the soil, particularly in tropical countries where soil nutrients may not be plentiful in the first place. While cropland loss may not be a new phenomenon as we work on setting priorities for the 21st Century, its extent and seriousness is increasing rapidly at a time when loss of agricultural productivity will have serious consequences for millions of humans (see Food Security below).

Emergency Management Considerations: See the Food Security Section below.

Summary for environmental degradation: Human practices related to land and water use, as well as the byproducts of the fossil fuels and chemicals we use, have led to significant losses of the very resources that sustain us: clean water, clean air, and dependable cropland. Together, these losses will present major challenges in the 21st Century, particularly when these losses are accentuated by the upcoming loss of petroleum, which has allowed humans to temporarily live at a population size that is beyond the sustainable resources of the earth.

E. Collapse of Petroleum-Based Economies

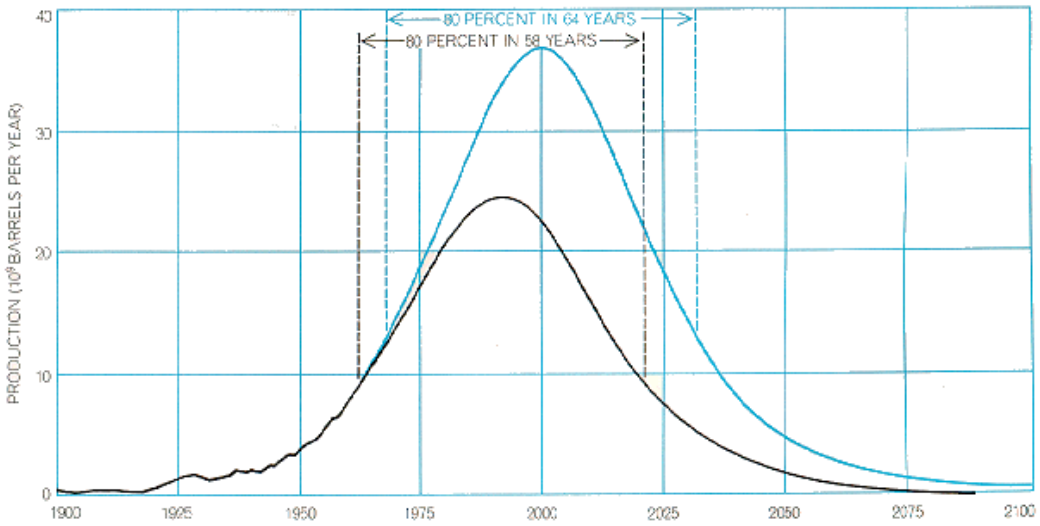
Humankind received a one-time gift inheritance in the form of fossil fuels, principally in the forms of coal, oil, and natural gas. This environmental gift is one-time, in that it is non-renewable, at least within the timeframe current humans are concerned with. Once oil, coal, and natural gas are extracted from the earth and burned for fuel, they are gone, and there is no such abundant and easily accessed and transportable replacement available. It is largely because of our utilization of fossil fuels that humankind has been able to grow such a huge population in the last 200 years. With these fuels we are able to vastly increase how much food we can grow, where we can grow it, and to whom and where we can distribute food.

As important as food might be, fossil fuels also play a key role in other critical human functions. It is hard to imagine anything in a modern economy that is not connected directly or indirectly to oil, natural gas, or coal…and many services and products of our economy are connected to all three.

Cheap fuel for transportation is what allows for manufactured goods from China to be sold in Connecticut, Schleswig-Holstein, and Abu-Dhabi. Without cheap fuel the world's current trend toward rapid "globalization" will come to a halt, and here we are talking about diminishing trade in goods more important than motorized dolls from Singapore or Viet Nam. Food stocks, basic minerals, lumber and other building supplies, and high-tech life-saving equipment all travel long distances to reach the final consumers in the current economy. Settlement patterns have been built based upon the assumption of the continued presence of cheap private transportation, especially the vast suburbs that have grown up around cities in the United States, Australia and Canada.

The problem with all of this is that petroleum is coming to an end much more quickly than most of us realize, and natural gas is not far behind. Independent petroleum geologists and petroleum economists, starting with M. King Hubbert in the 1950s and 60s, have tracked the extraction and utilization of oil, and plotted it against confirmed and expected petroleum reserves (oil not yet raised to the surface). Hubbert, who had correctly predicted the peak production of oil in the United States, in 1969 used the same methodology to predict the world peak production would occur in the year 2000.[38] By peak oil, scientists mean the peak in oil production, after which time production will continue to decrease in volume. Essentially this represents the point at which the first 50% of all extractable oil has been taken from the earth; after this point there is always diminishing return.

Figure 1

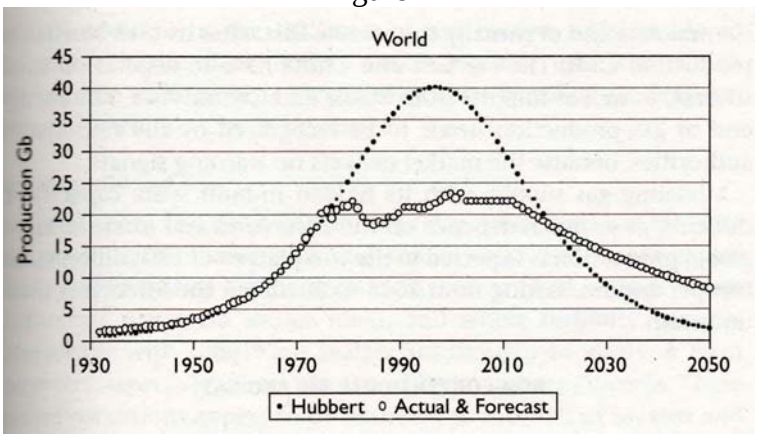


CYCLE OF WORLD OIL PRODUCTION is plotted on the basis of two estimates of the amount of oil that will ultimately be produced. The colored curve reflects Ryman's estimate of $2{,}100 \times 10^9$ barrels and the black curve represents an estimate of $1{,}350 \times 10^9$ barrels.

from *Energy and Power*, A Scientific American Book, 1971, pg 39

Hubbert died before the year 2000 was reached, but numerous scientists and analysts, using a somewhat refined version of his methods and better estimates of world oil reserves updated the expected world peak production for a few years later. [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50], [51] Princeton petroleum geologist Kenneth S. Deffeyes, a student of Hubbert, refined his prediction of world peak petroleum production to the latter half of November, 2005. [52] Whether the peak has already occurred as predicted by Deffeyes, or in 2020, is essentially immaterial…the reality is that we are at or near the peak period and oil will become more scarce from here on out (see Figure 2).

Figure 2

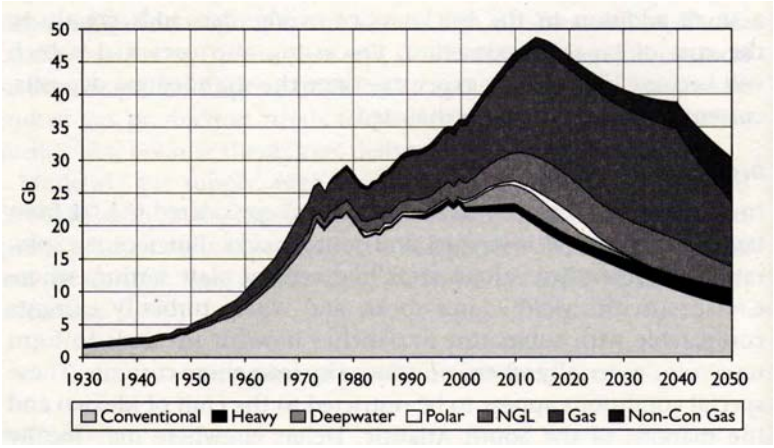


Hubbert's Curve

Source: Colin J. Campbell: The Assessment and Importance of Oil Depletion. Chapter 2 in The Final Energy Crisis. Andrew McKillop and Sheila Newman, eds. Ann Arbor, Pluto Press, 2005, p. 42

Unfortunately, natural gas is not far behind oil in approaching its peak.[53],[54]. Known for its wonderful clean burning characteristics, industries of all kinds have in the last 20 years switched from coal and oil to burning natural gas, making us, ultimately more dependent on natural gas. Gas depletion is a little more difficult than oil to predict, because production tends to plateau and then end suddenly, whereas oil follows more of a Gaussian curve. Nonetheless, predictions for gas center on a peak production period ending some time between 2010 and 2030.[55] If you combine all forms of oil and natural gas as a single reserve of energy and graph out their predicted production/depletion, you have what is seen here in Figure 3. It is clear in this graphic that by 2030 the world will be experiencing significant decline in petroleum and gas resources.

Figure 3



Depletion of All Hydrocarbons
Source: Colin J. Campbell, ibid, p. 46

Coal is the fossil fuel we started out with and is likely to be the one we continue using well after gas and oil are gone. Worldwide reserves may be enough for more than 200 years of use, *at the current level of production and depletion.*[56],[57] More careful recent research indicates that world coal reserves could be exhausted between the years 2060 and 2160, depending on assumptions made about usage rates.[58] On the plus side, the molecular make-up of coal is similar enough to hydrocarbons, that coal can be processed into synthetic oil, gasoline, and (un-natural?) gas, at a cost, of course. Currently only limited conversion capacity exists, and if large amounts of coal are used to make synthetic hydrocarbons, the depletion of coal will be rapidly accelerated. It is doubtful that there could ever be sufficient coal production and conversion capacity to replace even a substantial portion of the current oil and natural gas usage. Vaux estimates that world coal supplies will be exhausted by the year 2060 if there is substantial conversion of coal into gas and oil (assuming a 3.1% annual growth rate in coal use as oil disappears).[59] Clearly, if we use coal intelligently, it can be an important component of any plan to wean ourselves off of disappearing oil, knowing all the while that it cannot replace oil and is a massive contributor to greenhouse gases in applications using current technologies.

From the perspective of physics and chemistry, fossil fuels represent massive stores of solar energy from the geologic past, a gift that has temporarily allowed humankind to go beyond the energy coming to us from the sun in current times. With natural gas and oil going away, the challenge for humanity will be to return to living with the energy provided by the sun, using so-called renewable sources of energy (wind, biomass, solar-electric, ocean currents, etc.), and nuclear energy. The period of transition will be fraught with difficulties. Economic realignments will be required, assisted by changing technologies and priorities.[60]

Such a time of struggle can result in exaggerated inequalities, and maybe even open warfare.

Emergency Management Considerations: Prevention is not possible, but there is still time for mitigation of the effects of oil depletion with good planning and purposeful action. Emergency management's resources will never be sufficient to deal with the consequences if mitigation is not implemented as the strategy of choice. Emergency managers will need to devise new methods of response and logistics management that do not depend on petroleum.

F. Food Security

Food security is an issue as a result of other challenges mentioned in this treatise, but it is such an important issue that it merits attention as a major challenge in its own right.

Emergency managers and disaster researchers know that disasters are rarely the result of just one thing happening. Whether we look at natural events, such as floods or earthquakes, or human-caused events, the ability of the event to cause harm to humans is almost always the result of poor human decisions or skills application, plus natural or accidental events.

Hurricane Katrina directly affected several million people and cost the lives of over a thousand. A failure to provide enough food for the world's population could cost the lives of millions, or even billions if we make really bad choices and have a bit of bad luck. And dying of hunger or hunger-related disease is not a gentle way to go.

Food security ***IS*** a major issue because of the concurrence of the following phenomena:

- We are losing cropland to desertification, over grazing, poor plowing practices, erosion from water and wind, depletion of the soil's minerals and microbes, as well as suburbanization and urban sprawl. China alone loses some 360,000 hectares of arable land to desert each year.[61]
- We are losing access to adequate supplies of clean water due to changing rain patterns, aquifer depletion, loss of glaciers that feed major rivers, wasteful irrigation practices, pollution of water by industry, urban runoff, and salinity from irrigation practices.
- We will lose access to many petroleum-based fertilizers and pesticides, at least at prices farmers can afford, as oil and natural gas become scarcer.
- Unless cheap farm-based fuels become available, the loss of oil will also decrease the productivity of farms when it becomes very expensive to run tractors and other large farm machinery.

- Another victim of the loss of oil will be the ability to cheaply transport food all over the world. Currently, food surplus nations such as the United States, Canada, France and Argentina feed populations around the world who cannot grow enough to feed themselves. Even in wealthy countries, populations who live far from food growing areas, such as Las Vegas or Riyadh, may find it economically unfeasible to try to sustain a large settlement because of the cost of bringing in precious food stocks from the outside.
- The human population continues to grow, even though we are rapidly reaching food production capacity, *even with petroleum available.*
- The beneficial effects of genetic manipulation of food plants have leveled off, or are even in decline.
- Increased heat diminishes the productivity of basic grain crops (wheat, rice and corn). Agricultural experts estimate that each 1 degree Celsius rise in temperature during the growing season decreases grain production by 10 percent[62], and we are now in a period of global warming.

As a result of these things coming together now, what has been a net growth of per capital nutrition availability over the last 50 years is now in the process of reversing into decline. For example, from 1996 to 2003, after 30 years of producing grain surpluses, the world produced less grain than it consumed.[63] As reserves decline, more people will go hungry with potentially massive consequences.

Emergency Management Considerations: This challenge is an up-hill task for emergency management. Prevention is the only truly effective intervention. For the eventuality of localized food crises, the planning and logistics tools of emergency managers can be of significant assistance. However, if the hunger is widespread and based on a worldwide lack of basic food resources, emergency management will have but little to offer.

G. Changes in Warfare

Despite current and past attempts to glamorize it, war has always been horrible, as it is the purposeful mass killing of other human beings to achieve political, economic or logistical objectives.

In World War One, 44% of casualties were civilian; by World War II, the percentage had risen to 62%. [64] By the time of the more recent wars in Bosnia, Kosovo, Liberia, Sierra Leone and the Darfur region of the Sudan, the vast majority of casualties were non-combatant civilians who were purposely targeted.[65] The fact of civilians as the predominant casualties is not only the

domain of local or regional war; a thermonuclear exchange between any of the nuclear powers would likely result in millions of non-combatant casualties.

From the 1600s through most of the 20th Century, most warfare of any sizeable consequence was between nation-states. This has changed over the past quarter century, and it is now common for ideological, ethnic or religious groups who do not represent a nation-state to wage war, often against a nation-state perceived as representing ideological/ethnic/or religious opposition, or which may simply occupy land desired by the invaders. The war that is waged usually directly targets civilians and is usually described as "terrorism" (the use of violence against civilians to achieve political or strategic goals). At the pinnacle of this kind of warfare (asynchronous warfare), are groups like Al Qaida that can attack virtually anywhere in the world. Modern conflicts may also morph from one form of violence to another. For example, the 2003 US-led invasion of Iraq initially took the form of combat between standing armies. Even with "precision" weaponry, an estimated 3,750 civilians are estimated to have died in that conflict (and about 13,151 combatants on both sides).[66] However, after the Iraqi government surrendered to the US-led coalition and the occupation of Iraq began, the style of violence changed from traditional warfare to insurgency / terrorism, with the targets being both occupying forces and Iraqi civilians who represent a competing sect of Iraqi society or who may be accused of collaborating with the occupiers. One recent study by researchers at Johns Hopkins estimated that 655,000 civilians have died from a combination of terrorist violence and loss of basic health support in Iraq.[67] In an age in which organizations such as Hamas or Al Qaida can recruit, train, and dispatch members to serve as suicide bombers or hijackers, extreme violence against civilians may occur anywhere in the world with little or no warning.

As if the new dispersion methods of violence were not enough, the world is rendered so much the more vulnerable by the lethality of the weapons available to those who would use them. Nuclear weapons have vast lethality, and, although to date they have been the exclusive domain of nation-states and carefully guarded, security experts fear that lax vigilance during the period immediately after the fall of the Soviet Union may have allowed radioactive material or even tactical nuclear devices to fall into the hands of terrorist organizations. Such organizations may also have the ability to create thermonuclear weapons, or may use readily available radiological material in a radiological disbursement device (RDD) or "dirty bomb" that uses a conventional explosive device to contaminate a target area with radioactive material.

Even more disturbing is the specter of germ warfare. This kind of warfare dates at least as far back as the English conflicts against Native Americans, during which the English purposely gave the "Indians" smallpox-tainted blankets.[68] More recently, during the period of the so-called "Cold War" between the US and

the Soviet Union, both sides participated in the development of germ weapons and germ weapon defenses.[69] Since the fall of the Soviet Union, as more information has come out, we now know that the Soviets developed genetically manipulated microbes that could bypass current vaccines or antibiotic therapy, and that combined the worst traits of several organisms.[70] The extent to which the United States or other countries developed similar weapons is not publicly known. Bioweapons are not the exclusive province of nation-states. In 1984, the Bhagwan Rashneesh cult used salmonella in the Dalles, Oregon in an attempt to steal an election[71] and the Japanese cult Aum Shinrikyo attempted the use of anthrax, botulin toxin and other microbes in Tokyo before they finally settled on the use of sarin nerve agent in the subways.[72] More well known are the anthrax mailings in the United States during fall 2001. The experiences in Oregon and Tokyo, along with the U.S. anthrax attacks demonstrate the potential for even relatively small groups to engage in microbial warfare. Unlike other agents, germ warfare is not necessarily limited to the initially targeted population but can, depending on the microbe chosen, potentially affect the world's population. Once a virulent person-to-person infectious disease is released, there is almost no control over where it goes and who is affected.

Chemical warfare agents are easier to manufacture and control than germ agents, and have a long history. Perhaps the most notable cases in the last century were the widespread use of chemical weapons in World War One, said by some to be responsible for many of the 20 million deaths during that conflict; [73] the use by the former Soviet Union of chemical weapons in Afghanistan and the use of chemical weapons by Iraq during its long war with Iran, and then against some of its own citizens.[74],[75] Chemicals present some advantages, in that the attacker can usually predict where and when the chemicals will spread, and can have appropriate protective equipment (gas masks, etc) ready for use. For the population hit by a chemical attack, being surprised and unprepared leads to injury and death. The target population and its first responders do not know what the chemical is, and do not usually have appropriate personal protective equipment (PPE) readily available. It is for this reason that Israel issued gas masks to all of its population during the Gulf War and then again during the 2003 Iraq invasion. The threat of chemical use by terrorists is significant because a wide range of easily obtained chemicals can be used, some with such high potency that a very small amount can cause immense harm.

Though germs, chemicals and ionizing radiation have been around for a long time, they are now becoming widely seen as weapons which are accessible to small radical groups who can use them to target civilians.

Emergency Management Considerations: Emergency managers may play key roles in preparing for responses to protect civilians in military or terrorism attacks

of many different kinds. They will also play important roles in managing actual responses. Militaries may have superior response capabilities from a combat perspective, but do not have jurisdiction-level resources and cannot cover the needs of an entire population.

H. Globalization of Economic Activity and Transportation

During the last 15 years of the 20th Century and on into the beginning years of the 21st, we have seen an accelerating trend toward what has been called "globalization." Globalization can be characterized by the trend for economic, social, and even political ties to be outside of the boundaries of one's own country. People who have resources in one country can obtain goods and services from anywhere in the world; they are not tied to the resources of their own province or country. So, the Japanese and Chinese eat rice from the United States, and US and German shoppers purchase Chinese goods brought to them by "big box" discount stores. Manufacturing shifts from its traditional locations, usually close to the raw resources needed 100 years ago (coal, iron, rivers, ports) to new locations in other countries where the resource of human labor is cheaper. And, manufacturing of finished goods is likely to consist of the assembly of component parts that come from many parts of the world, in a coordinated fashion made possible by computerized transportation and shipment schedules and cheap fuel. Investment capital moves rapidly from country to country by electronic transfer, and global communications media enable citizens in Cochabamba, Bolivia to know what the trends are and what is happening in Los Angeles, Paris, Moscow, Beijing, and Adelaide. So, while nation states still have a culture of their own, their inhabitants also have exposure to cultures and ideas from around the world. They are likewise exposed to economic opportunities and pressures from around the world.

The dangers inherent in this worldwide trend can be best summarized by the following abbreviated list:

- Local economic self sufficiency is lost when manufacturing and farming are outsourced to cheaper work forces in other areas. When energy becomes much more expensive and it is no longer viable to send so many goods and services elsewhere, local economies may be left without the facilities and skills needed to be self-sufficient. Likewise, on the retail side of the economy, when globalized corporations like WalMart displace local retailers, they not only cause local economic disruption right now, but, perhaps more importantly, they decrease the local economy's ability to function in a self-sufficient manner when future skyrocketing energy costs likely put an end to the global "big box" stores.

- The massive transshipment of goods, services and people around the world significantly increases the ease with which microbes can rapidly "hitchhike" from one place to another. The 2002 SARS outbreak, with a China-based disease rapidly showing up in Toronto and other places, provides an excellent example of how local disease outbreaks now become a global concern. This same principle is valid for animal and plant diseases.
- To the extent that a globalized economy draws resources from all over the world, the process is accelerated by which precious local resources, important to the survival of a local population, are sold to the highest bidder, an outsider with more financial power. These resources might consist of farmland dedicated to foodstuffs for local consumption, which will now be used to grow cotton or soybeans for export, or they could be forests that serve as watersheds and protect endangered species, or local energy supplies. In each case, the local population is rendered more vulnerable.
- We can no longer expect hazardous materials to be geographically restrained to their place of manufacture or use. It is now common for hazardous materials to be shipped long distance by various modalities, complying with a great variety of strong or weak security norms.

Emergency Management Considerations: Emergency management personnel have traditionally concerned themselves with, and educated themselves for service pertaining to the known threats in their own jurisdictions. This no longer suffices. By virtue of the current and expanding degree of globalization of economies, transport, cultures, and conflicts, emergency managers must increasingly monitor worldwide trends in anything that could constitute a hazard for their own jurisdiction. This may require more flexibility and more education than has previously been the case.

I. Summary and Challenges for Emergency Managers

In summary, this article is only an introduction and overview of the challenges we can now see coming in the 21st Century. We invite the reader to review the references and new resources becoming available almost daily, given the extreme brevity of what we have presented here. A particularly readable and rich description of the complex changes taking place can be found in *Plan B 3.0: Mobilizing to Save Civilization* by Lester R. Brown (ISBN 978-0-33087-8). We do not claim to have the wisdom or foresight to be able to predict everything that might affect humans and their environment, but one thing is sure…change is coming, and some of the changes are coming so quickly that we have scarce time

to fashion plans and strategies for prevention, mitigation, response, and recovery. Before we do so, it is time that we take a quick look at what we have in our tool boxes of emergency management and related fields, such as public health. We will need every tool we can obtain if we are to minimize suffering and successfully fashion ways for humans to persist in sustainable harmony with the world in which we live.

It is important for emergency managers and the profession we represent, to critically re-think our roles in society and the means by which we seek to decrease vulnerability and suffering. It has been common for emergency managers to work quietly in the background, with elected officials taking the forefront on policy making and policy implementation. Given the very significant impacts of decisions made (or not made) today on future well-being or even sustainability, it may be that emergency management, as a field, will need to become more proactive at evaluating future risks and vulnerability, and feeding these evaluations into the policy-making process. Though this is not inconsistent with our profession's goals and ethics, it does represent a challenge to our profession's status quo. As professionals committed to protecting the well-being of our populations, we may need to assume the role of change agents. Politicians' short-term focus will tend to inhibit adequate governmental attention being paid to many of the threats and challenges we have discussed in this paper until they reach crisis proportions and the public starts clamoring for preparedness and response. Well-trained professional emergency managers may need to take a leadership role in bringing long-term threats to the forefront while there may still be time to implement mitigation efforts. For example, there are efforts being made by community groups and local government in places like Tompkins County, New York and Portland, Oregon to "relocalize" the production of food and basic products, so that the loss of petroleum will not leave these communities without basic necessities when the big-box stores are no longer practical. The participation of local emergency managers adds great strength to these efforts.

Many of the threats we have spoken about here have the capacity to lead to catastrophic disasters, that is, events that have such impact that the very structure from which a response would be expected is severely injured or rendered impotent. These kinds of events require some radically different thinking on the part of emergency managers, such as:

- We need to simultaneously conduct both broader and deeper thinking when considering mitigation/planning/preparedness/response partners, with deeper focus on local and regional non-governmental organizations and citizens groups, and broader focus on national and international partners. We also need to significantly increase the number of disciplines participating in these efforts due to the hypercomplexity of the causes and consequences.[76]

- All-hazards planning and preparedness provide a good core for addressing traditional hazards. The progenitors of catastrophic disasters, however, are often so different in their causes and the extent of their consequences, that emergency managers need to switch to scenario-based planning for these threats. Pandemics provide an example of the value of scenario-based planning.
- Complex plans may not serve well to guide the response to hypercomplex events. Rather, broad, flexible scenario-based plans that assume mechanisms for the formation of "spontaneous" alliances may better serve the needs of affected populations.
- Emergency managers should work with political scientists and international relations experts to explore mechanisms for rapid implementation of multi-national responses to catastrophic events.
- The traditional thinking of four emergency management phases with different people conducting the work of each phase may not make sense in many of the scenarios discussed here. Considerable effort will need to be made to achieve integrated work for events that demand the characteristics of all four phases simultaneously.
- We need to embrace a thorough discussion and study of the ethics of triaging or prioritizing the use of scarce resources when the scope of the scarcity is as broad as massive food shortages, scarcity of potable water, or immense immigration pressures from hundreds of millions of refugees fleeing climatic or food catastrophes.
- Current work being done by the United Nations to anticipate the dynamics of massive population relocation needs to be joined by experts in the logistics and dynamics of local and regional emergency management.
- Elected leadership has done poorly in managing recent large events. Emergency management needs to become more involved in training elected officials.
- Finally, the successful emergency manager of the future will need to be more conversant with a broad range of physical and social sciences, international trends, and policy-related methods.

This brings up one more challenge: that of educating emergency managers to be able to work as key professionals who are important for upcoming threats. The many universities and colleges now working with the FEMA/Emergency Management Institute's Higher Education Program are making a solid start on this crucial task.

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