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Disaster Mitigation and Public Risk Perception:

Designing a model to Disaster Policy

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by

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Abstract

Public concern for terrorist disasters is far greater than that for the much more probable natural disasters. Simulations using a system dynamics model indicate that a government policy of raising the level of public concern for terrorist as opposed to natural disasters, reflected in the media, may raise the perceived probability of disasters. The increase in public concern in turn leads to legislation that ultimately will be repealed, costing valuable resources in the process.

With natural disasters on the rise, and a new type of terror-based disaster emerging just recently in the United States, it is important to know what mitigating factors exist to cope with these threats. This section seeks to describe several aspects of the impacts of such disasters and how these can impact the next disaster in its turn. Several key variables will be described. These will be embedded in the structure of a simulation model in order to assess the impact these variables have on society, as well as to offer insight into methods to improve mitigation.

Background

First and foremost, the assumption of this paper is that disasters, in most if not all cases, cannot be prevented. Some disasters can be mitigated, the effects lessened, but ultimately disasters, both natural and terrorist will occur. While it may be an easy concept to grasp that a natural disaster cannot be prevented, it is a difficult concept for most that terrorist attacks cannot be prevented. To this I offer this logic: it is simply not possible with the current level of technology of any nation to secure all of the area within its borders as well as foreign embassies and territories. While individual terrorist acts provide the potential for prevention, as a whole terrorism is still as uncontrollable as any other natural disaster.

Perceived Probability of Natural Disasters:

The probability of disaster tends to be either perceived as extreme or nonexistent. The perception of the probability of a disaster is integral to the response to it. To this effect, it appears that the reaction to the probability of disasters is either an extreme reaction or little reaction at all. The existence of a probability threshold, a limit that until reached will not produce a reaction, is not unheard of in dealing with natural disasters.

The observed phenomenon is that if the probability is perceived to be very low, and given the wide variety of more frequent problems more encountered, the probability is treated as though it were zero (Palm, 1981). In this country the magnitude of reaction to a terrorist disaster is far more than that of natural disasters, as indicated by the media frenzy surrounding the September 11th attacks. This is the case even though natural disasters are far more frequent and arguably far more probable. In the past 5 years, FEMA has made 265 Major Disaster Declarations, of which 2 have been terrorist related, and the remaining 263 were all due to natural disasters.

(<http://www.fema.gov/news/disasters.fema>)

Legislation Decay over Time:

The public's perception of the probability of natural disasters is greatly understated. As a result much of the disaster mitigation has shifted not toward reducing the probability, but on increasing the effectiveness of the response. Furthermore, Palm (1981) finds that the state of California has on several occasions enacted legislation due to major damaging earthquakes. However these legislations are quickly 'watered down' or amended.

Even when people are made aware of the risk, they still tend to underestimate the probability. Following the mandating of disclosure of these special studies zones in California, there was little measurable change in buyers' or real estate market behavior. Surveys of homebuyers within and nearby these zones showed that the zones had little or no impact on their purchase decision. In these surveys buyers were asked to rate fifteen factors from most important to least important. It should be noted that among the least important was not only distance from an active earthquake fault but also location of

floodplain. Among real estate agents surveyed only twelve could recall refusal after disclosing the special studies zones, and only four of these could recall this occurring more than once. Palm argues that the following assumptions that this legislation was based on are incorrect; first, that individuals are risk averse, and second, that decisions are generally rational, given only limited knowledge of alternatives and their consequences.(Palm 1981) In contrast to these assumptions, even those who have been informed tend to ignore the risk.

Even with knowledge, the public will take unreasonable risks. As stated earlier the proximity to fault lines in special study zones is disclosed to consumers, yet even with this, people still move into earthquake prone areas. There appears to be the mentality that all of California is at the same probability of earthquakes so there is nothing one can do. This, however, is not the case, and a better understanding of risk mitigation this could lead to better purchasing decisions resulting in fewer casualties and less property loss.

Perceived Probability of Terrorism Disasters:

Conversely, the probabilities of other disasters are greatly over estimated. In the wake of September 11th, an unprecedented disaster in United States history, people have prepared for another disaster of this type. This disaster is unlike natural disasters in only one way: it was man made. From this distinction appears to follow a conclusion that is not necessarily correct: that it can be prevented. The fact that because it was orchestrated by people rather than occurring as a result of environmental factors, does not mean it is any more preventable. The fact remains that once the planes were in the air, the disaster was more or less inevitable. Natural disasters simply do not elicit the same level of public concern and response as man-made disasters (Kasperson 1985). While there is not

enough information currently to estimate the actual probability of another event of this type, it can be stated with relative certainty that another natural disaster is more likely to occur than another September 11th type event. Yet in the aftermath, the perceived probability of such an event has caused such responses as the Patriot Act, the Guantanamo Bay incidents, as well as the expense of many millions of dollars that could potentially be better spent on natural disaster mitigation. The US government has also assumed the right to use military force against other sovereign nations associated with ‘international terrorism.’ The arguably small probability of a terrorist attack has been overemphasized by the media sensation following Sept. 11th. In this instance, the publication of probability has led to its overemphasis, and the overreacting toward that probability. While some of the response can be justified, there has undoubtedly been the overuse of resources in preparation for a disaster with a relatively low probability of recurrence.

Governmental Role in Disasters:

The government primarily takes a reactive role, but does offer some preventative measures. Regardless of what the probability is, there always exists the possibility of a disaster occurring. In this eventuality there is a need for ways to mitigate the impact of these events. Risk management, defined by Karwan (1984) as the “recognition and control of perils of fortuitous nature which, in their occurrences, can adversely affect individuals.” The responsibility of handling disaster mitigation falls largely upon the government, where the government tends to assume a reactive role. Numerous federal agencies exist to assist with the rebuilding after a disaster as well as local and state emergency services to deal with disasters as they occur. During the immediate disaster,

emergency workers from a variety of agencies assist. These include local rescue workers and in more serious disasters the national guard and FEMA. The Federal Emergency Management Agency (FEMA) has programs that assist with the costs of rebuilding municipal infrastructure up to 75% of the costs.

Government Aid:

FEMA has the authority to issue grants from the presidential disaster relief fund, as well as coordinate disaster assistance functions of all federal agencies. Additionally the director of FEMA appoints a Federal Interagency Hazard Mitigation Team (HMT) to advise lower levels of government and report on the disaster (Rubin 1985). Other agencies including the Corps of Engineers, Soil Conservation Services, Federal Highway Administration, and the Department of Education, provide assistance as well (Settle 1985). Even in the event of a natural disaster in which federal aid is not approved, state and local governments step up to offer aid.

Emergency Response:

Emergency management is then most readily handled by semi-local governments, in most cases county government. Agencies at this level vary from state to state. Whereas some are tied to offices of elected or appointed officials, others are autonomous and some are mere units or divisions of larger semi-related agencies. A few of these agencies are even geared specifically toward natural disasters or simply tie it into civil defense (Waugh 1994).

Policy of Information Dissemination by Government:

In addition to rebuilding assistance, the United States government also maintains a website to disseminate information to aid in the safety of individuals and businesses.

This website provides informative links to a variety of hazard information, including disaster preparedness, cyber security, Department of Homeland Security, travel information, and even weapons of mass destruction. (<http://www.fema.gov/>) The information available for individuals including a link to the Citizens Guide for Disaster Preparedness is certainly informative, and offers many valuable tips for safety alongside advice for what to do in the event of disastrous attacks of terror. For businesses and industry, this website provides an extensive manual for emergency management, produced by FEMA, which includes planning, response, and recovery. This guide provides detailed planning advice on both natural disasters and terrorism. The manual, 73 pages in length, identifies eight specific hazards including fire, hazardous materials, floods, hurricanes, tornadoes, severe winter storms, earthquakes, and technological emergencies. This website also provides easy access to the Department of Homeland Security terror alert level; a simple, efficient color-coded device invented to elevate concern in the general public.

Business Continuity Aid:

The responsibilities of businesses and residences have been mitigated in disasters by the availability of federal loans. FEMA coordinates with the Small Business Administration in offering these loans to businesses and homeowners affected by disasters. In addition to these federal loans many states have offices of emergency services that among other things organize, coordinate and implement statewide disaster assistance programs (Settle 1985). The state and federal assistance programs are offered complimentary to insurance benefits.

Insurance:

Insurance is a means by which individuals and businesses can voluntarily protect themselves from disasters. Insurance is a means by which risk is transferred from an individual or business to an insurer. This is done by the purchase of an insurance contract that is paid for over time. In the event of a disaster the insurer pays a given amount to the policy holder. In the cases of natural disasters, regional insurance companies often find they must pay a large number of individual in that region. To manage these losses, insurers frequently seek reinsurance from another company or in many cases the government (Lewis 1996). It should also be noted that the level of reinsurance increases the capacity of primary insurance.

Insurance is possibly the most viable means of disaster mitigation. The United States suffered \$90 billion in insurance losses from natural disasters. This amount is the largest of any before and is expected to increase substantially. Insurance is the main financial backing for rebuilding efforts. In addition to assisting in rebuilding, insurance companies are also involved in efforts to mitigate loss. It is this industry that has the most incentive to reduce losses caused by natural disasters. Insurance companies offer incentives to those who take precautionary measures. They educated the public to the dangers of natural disasters, and coordinate with government agencies to determine the best and most efficient method of handling disasters (Ryland 2000).

Currently disaster insurance is purely voluntary. While federally subsidized programs do exist to manage the cost of these programs, few of those eligible take advantage of them (Kunreuther 1973). The possibility of mandating disaster insurance has been proposed, as well as a system by which the premiums would reflect the risk and thereby act as a deterrent from constructing in high risk regions. However, such

programs would not only be difficult to implement, but also confusing to the general populace (Kunreuther 1985). Kunreuther further states that while insurance is not mandated, most banks require a certain level of insurance on mortgaged properties to insure payment in the event of a fire. Legislation could be introduced compelling banks to also require insurance for flood and earthquake, where applicable, for mortgaged properties. This would not only protect bank investments but individuals as well.

The government has in the past acted as an insurer for many applications including life insurance, auto insurance, even hail insurance in states where it does not fall under homeowner's insurance. The government has not resisted competing with private industry in this regard (Greene, 1975). The National Flood Insurance program is a subsidized flood insurance program that is available to landowners in flood prone areas, provided the town/city in which it presides complies with flood plain management mandates. It has been suggested that rather than paying for emergency aid through disaster relief funds, the government could act as the insurer. In essence the aid would be paid for by the very people in need of it, beforehand (Greene, 1975).

Public Concern

A large focus of this paper is that of how concerned the general public is with the threat of a disaster. In any major event, it is the concern of the public that drives all following events (Birkland 1997). If there was no public outcry about an event, then no action would result.

On September 11th 2001, a major terrorist disaster occurred resulting in the destruction of two of the largest buildings in this country, and the loss of thousands of

lives. Following this, there was an unprecedented level of public concern. As a result more action has been taken resulting from that disaster than any preceding disaster.

On December 6th and 7th 2004, many counties in New Hampshire reported record snowfall in a 10 hour period. The local residents, having experienced snowfall before, were barely concerned at all. As a result, the only action taken was the usual snow removal, and reimbursement of 75% of the snow removal cost by the federal government. (<http://www.fema.gov/news/disasters.fema>)

Both of the preceding examples were federally declared disasters, and the action taken following the disasters were both driven by public concern. The level of the concern determined the amount of action taken.

Media Factor

Public concern is all too often driven by the media (Birkland 1997). Disasters are for the most part localized; therefore the media is the forum by which the public is made aware of disasters. Responsible media coverage is important, for it is the media that can color or bias an event, even unintentionally. The amount of coverage given to an event can determine how important or probable that event seems (Kahneman 1974).

Inadequate Legislation

Since most disasters only recur every few decades or more, there is a tendency for the strictness of legislation to decay between disasters. Safety protocols and programs either decline or fail to be updated resulting in lack of preparedness for the following disaster (Finlay 1997). Still others, in the case of disasters that have not occurred before,

have inadequate or ineffective legislation enacted immediately following the disaster (Palm 1981).

California has on several occasions enacted legislation due to major damaging earthquakes. However these legislations are quickly ‘watered down’ or amended. An example of this is the San Fernando-Sylmar earthquake in 1971. Eleven months after the earthquake the Alquist-Priolo Geological Hazard Zones Act was passed requiring the establishment of geological hazard zones around fault lines and seismic risk areas. In these zones, city or county approval was required for all new development. Later that year, the act was modified to exempt single-family frame dwellings. In 1975, the act was further amended, renaming the ‘geological hazard zones’ to ‘special study zones’ and merely requiring disclosure in sale of property within these areas.

Following the attacks of September 11th 2001, the Patriot Act was enacted. In addition to its constitutionality being questioned, its effectiveness has also been questioned (Nacos 2003). It has also been suggested that while being a wide reaching legislation it still may not prevent terrorism.

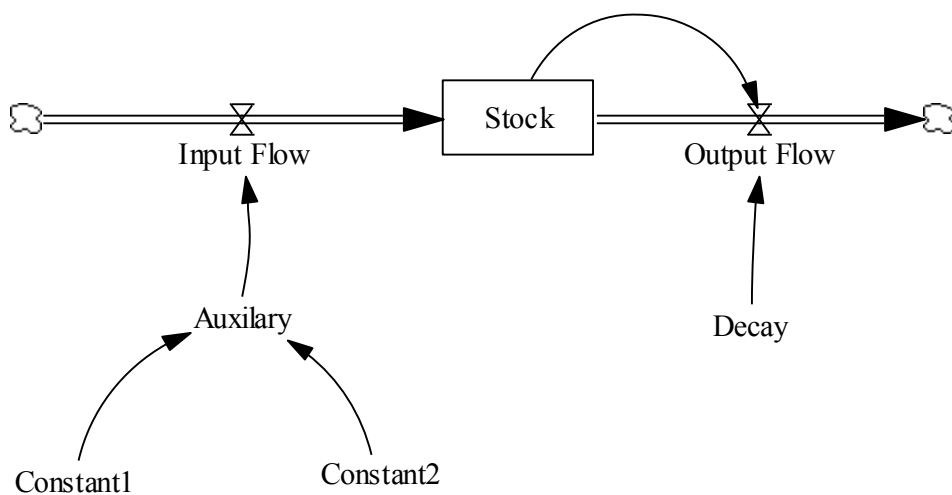
Methodology

In the previous section problems were noted concerning public concern and governmental response following a disaster. The method used to explore these problems is that of system dynamics (Sterman, 2000).

The System Dynamics Method:

The following components are used to model any problem in system dynamics: stocks, auxiliary variables, flow or rate variables (inflow to the stock or outflow decaying

the stock), and constants. The constants are as labeled, fixed quantities. The auxiliary is a variable that is represented as an equation of two or more other variables. The stock variable can be described as the integration of the difference of the input flow and the output flow. The input flow is determined by the auxiliary that leads into it. The output flow is defined by the stock and the decay put on it. It is this structure along with feedback loops of other variables that creates a behavior pattern.



The method employed here is first to develop a model that mimics the behaviors of key variables described in past sections. Next, policies will be tested in simulation to see if they modify these behaviors. Finally, results will be compared to yield recommendations for policies to manage disasters and risk perception.

The Model:

The problems stated in the previous section will be explored using system dynamics modeling through Vensim 3.0D. Vensim is software by which system dynamics models can be simulated.

Having limited background in system dynamics, the approach that I took was a “part-to-whole” methodology. In this, a series of models were created with increasing complexity. A conceptual map was initially created to demonstrate the basic structure. From the conceptual map a structural model was created. Later on the equations were filled in, and a casual loop diagram was created for reference.

The conceptual map is only the final map of the system dynamic concept that emerged after several previous versions. The previous versions were either rejected or modified after proving to be conceptually unsound. While this map does contain equations, the equations found within are merely for reference in the next iteration of the model.

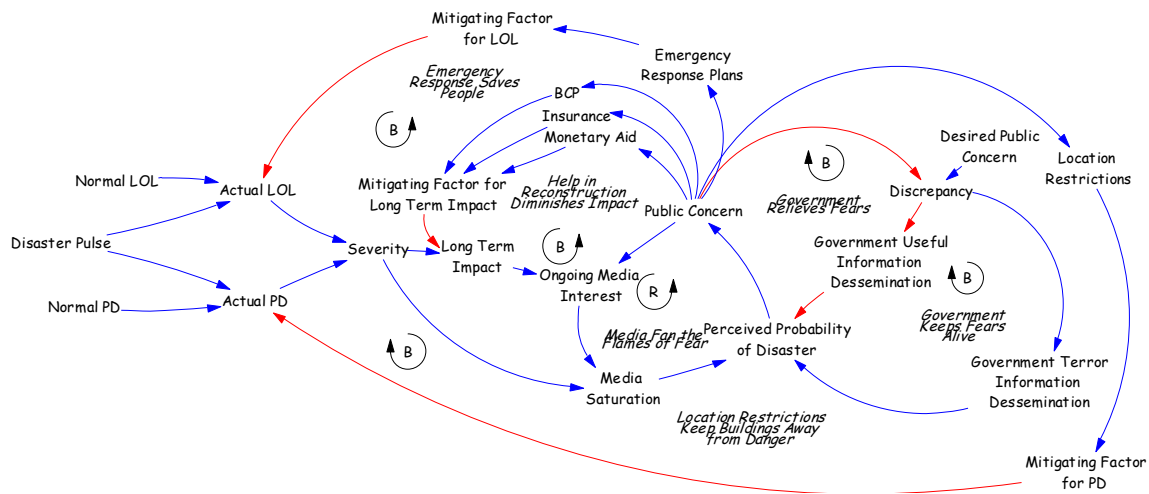
The structural model contains the basic structure of the simulation. While refinement took place at this stage of development most of the equations were not added, and the refinement was almost purely structural. This model, which spans across four views on Vensim, contains valuable information to determine the next stage of the model.

The final stage of the model (see Vensim file <Disaster Mitigation and Risk Perception>) contains a full structure of the model complete with equations. This allows each variable to be independently defined. The final model, contained on twelve views in Vensim, was again refined based on new concepts and ideas.

The structure of the final model consists of a system dynamics simulation. The model is entirely made of four different components: auxiliaries, constants, flows, and stock variables.

The final model is described in equation format in Appendix 2. The final model centers on several stock variables. These stock variables are Public Concern, Media

Saturation, Impact, Perceived Probability of Disaster, Severity of Disaster, Total Amount of Property Damage due to Disaster, Lives Lost Due to Disaster, Government Useful Information Dissemination, Government Terror Information Dissemination, and many types of legislations. These variables form the basis for several loops. These loops demonstrate several principles. The casual loop diagram (as seen below) was created to demonstrate loops within the model. It was created after the final model and is for reference.



There are two severity loops, so called because they pass through the variable ‘severity.’ These loops each have a part in determining the severity of a disaster.

The first of these loops, Emergency Response Saves People, can be described as the effect of emergency response on lives lost. As a result of a disaster, the lives lost increases as well as the general negative impact on society. Both the initial lives lost and the longer term impacts keep the disaster in the media, raising the public’s perception of the future risk of the same disaster. Because the public sees the disaster as probable,

concern is expressed through lobbies, and legislation is enacted to improve emergency response.

The second of the severity loops, Location Restrictions Keep Buildings Away from Danger, can be described as the effect of building restrictions on the amount of damage to buildings. As a result of a disaster, the buildings damaged or destroyed increase as does the negative effect on society. This in turn keeps the disaster in the media, and raises the concern that such an event may recur. The public sees this media coverage and expresses its concern through the demand for legislation to restrict building in disaster prone areas.

The next loop, Help in Reconstruction Diminishes Impact, is a series of parallel loops. This series of loops contains several legislations that help to diminish the impact following a disaster. Following a disaster, there is an impact that is felt; this impact determines how much media coverage the disaster is given and in turn how likely the disaster is to recur. This then translates into public concern, which then pressures for legislation to mitigate the impact and assist with reconstruction.

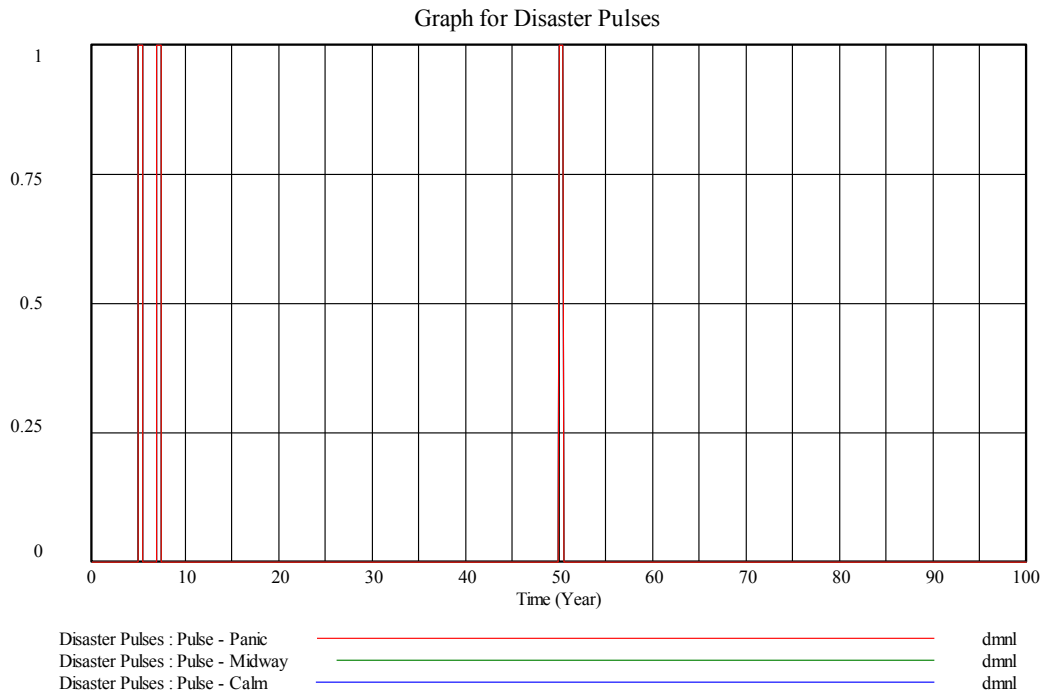
Media itself is impacted by public concern as shown by the loop Media Fans the Flames of Fear. In this loop the media reports about a disaster, which results in the public believing this event to be more probable and shows a greater concern for it. The media, then seeing that the public is interested in knowing about this disaster will further report on it.

The final two opposing loops are Government Relieves Fears and Government Keeps Fears Alive. In this there are two distinct types of information provided by the government. Useful information is provided to help reduce public concern. However,

terror information is provided to raise public concern. The government, knowing about a disaster, will make a decision about how concerned the public should be. Then, through policy, the government will release two types of information to the public. The amount of information of each type, useful or terror will then impact the public concern. Once the public concern is at the desired level, the the government will keep the level of each type of information constant.

In addition to the stock variables contained in these loops there is an additional terminating stock variable. Government Cost is a measure of the cost of enacting legislation throughout the model.

The model described above can be used to provide insight into the problem of natural and terrorism disasters. While this model is only as accurate as the information available at the time of its conception, these insights can be used for policy formulation over the long term.



The graph above depicts the pulses that were used to perturb the model to represent the occurrence of three disasters. For the purposes of these simulations the severity level of each disaster is the same. The pulses are used to depict any one type of disaster. The model includes a number of parameters that can be set to reflect the conditions of a specific scenario.

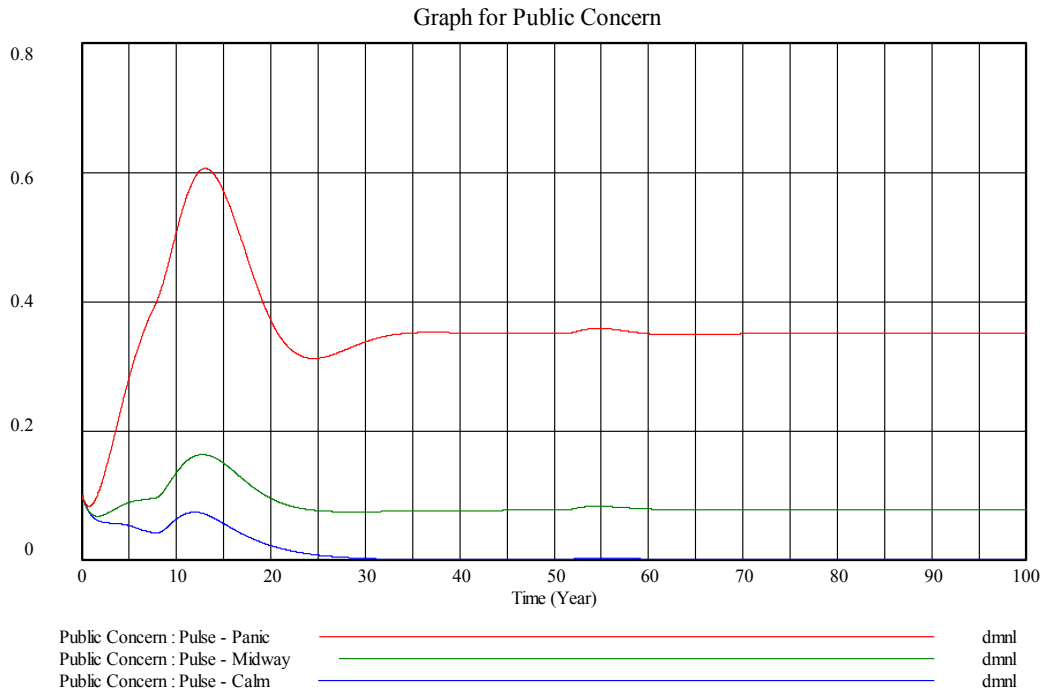
This model compares three distinct policies. These policies, panic midway and calm, are the level of public concern desired by the government. For the purposes of this paper it can be assumed that in the event of a terrorist disaster government will set policy

such that desired public concern is panic, whereas in the event of a natural disaster such as flood or earthquake government will set policy such that desired public concern is midway or calm.

For the purposes of this model it will be desired public concern that will change, and the results from the setting of this variable will be explored. Desired public concern determines the policies made by the government to inform about such a disaster.

Results

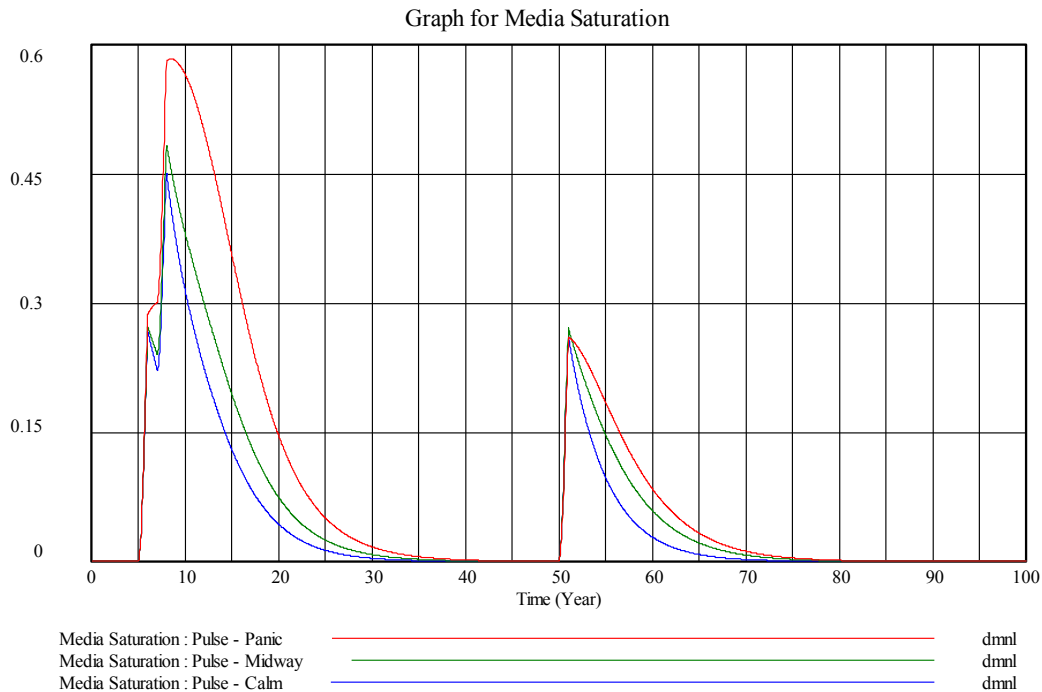
Public concern:



In the graph above we can observe the impact on public concern of the three disasters given the desired public concern at each level: calm, midway, and panic. For a desired public concern of panic (assumed to be the case for a terrorist disaster), the graph depicts a marked increase in the public concern with the initial two disasters. For the third disaster, since the public concern is already elevated, the impact is far less severe.

In the midway and calm policy runs, which each depict the desired public concern for natural disasters, the increase is very little yet decays into an equilibrium just as quickly as panic.

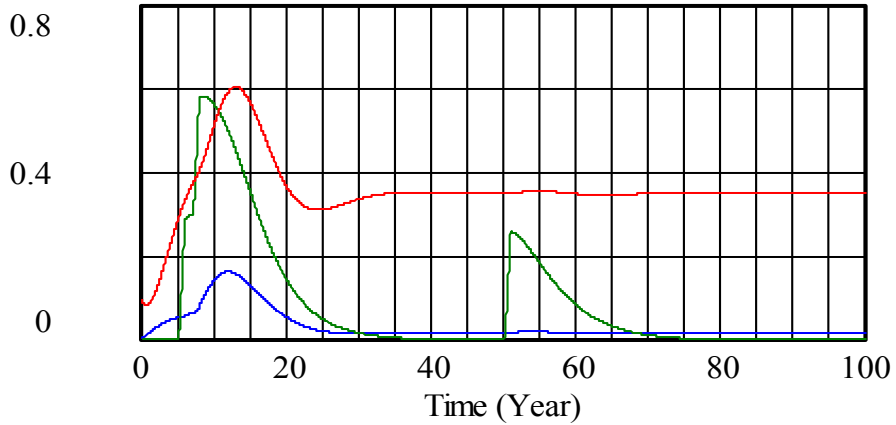
Media:



Media saturation, depicted above, is the primary force behind public concern. It can be seen that there is more media coverage for the terrorist disaster than the natural disasters; in addition it takes longer for the coverage to decay. The media responds more strongly for the terrorist disaster than the natural disaster of the same severity because of the government information dissemination that it is also reporting on.

As shown in the figure below for the government's panic policy, the media saturation drives the public concern by being the first source of information about disasters. Each of the increases in media saturation can be seen to occur just prior to an increase in public concern.

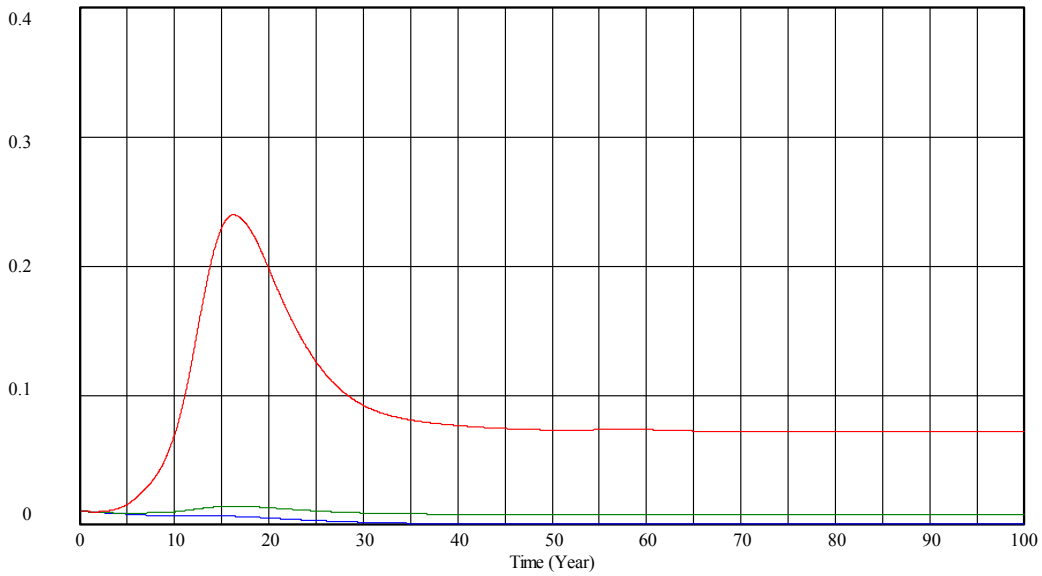
Media+Public



Public Concern : Pulse - Panic	—	dmnl
Media Saturation : Pulse - Panic	—	dmnl
Perceived Probability of Disaster : Pulse - Panic		dmnl

Inadequate Legislation:

Graph for Emergency Response plan Legislation Strictness



Emergency Response plan Legislation Strictness : Pulse - Panic	—	dmnl
Emergency Response plan Legislation Strictness : Pulse - Midway	—	dmnl
Emergency Response plan Legislation Strictness : Pulse - Calm	—	dmnl

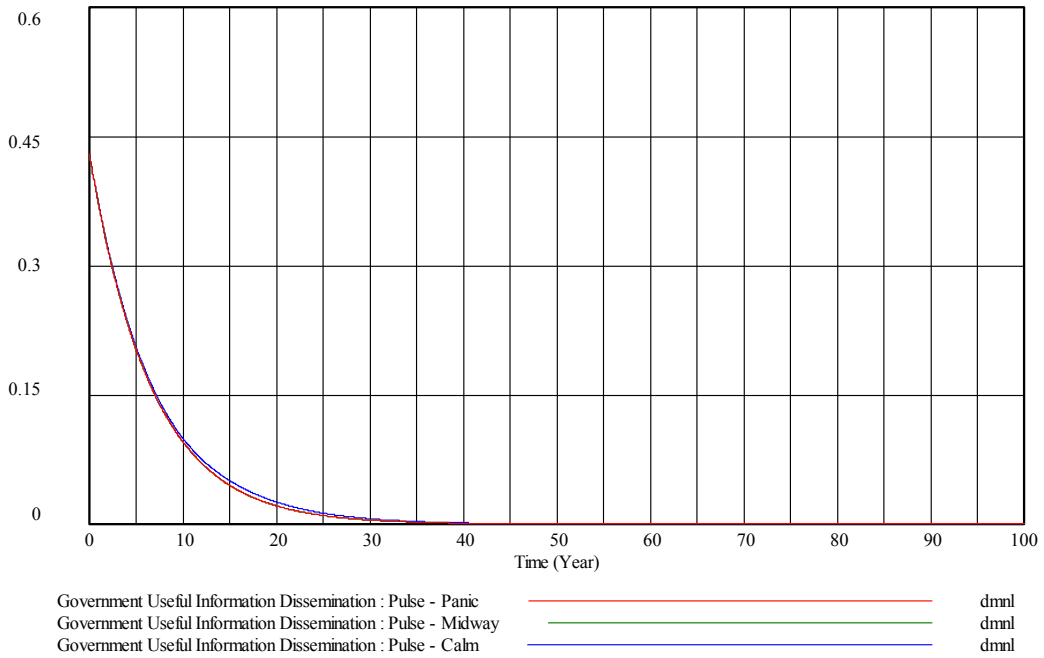
The graph above depicts the emergency response legislation enacted following the disaster. This graph is consistent and identical to all of the other legislation graphs such

as business continuity legislation, (see appendix 3). In this graph, following a terrorist disaster in which the government's desired level of public concern is panic, there is sufficient public concern to enact far reaching legislation. However the legislation quickly decays to a less restrictive, but not ineffective level, and at this point it reaches equilibrium. This decay can be observed since there is no increase in legislation following the third disaster. After a natural disaster, when the government's desired level of public concern is calm, legislation barely registers an increase, and even that increase decays to a less restrictive level.

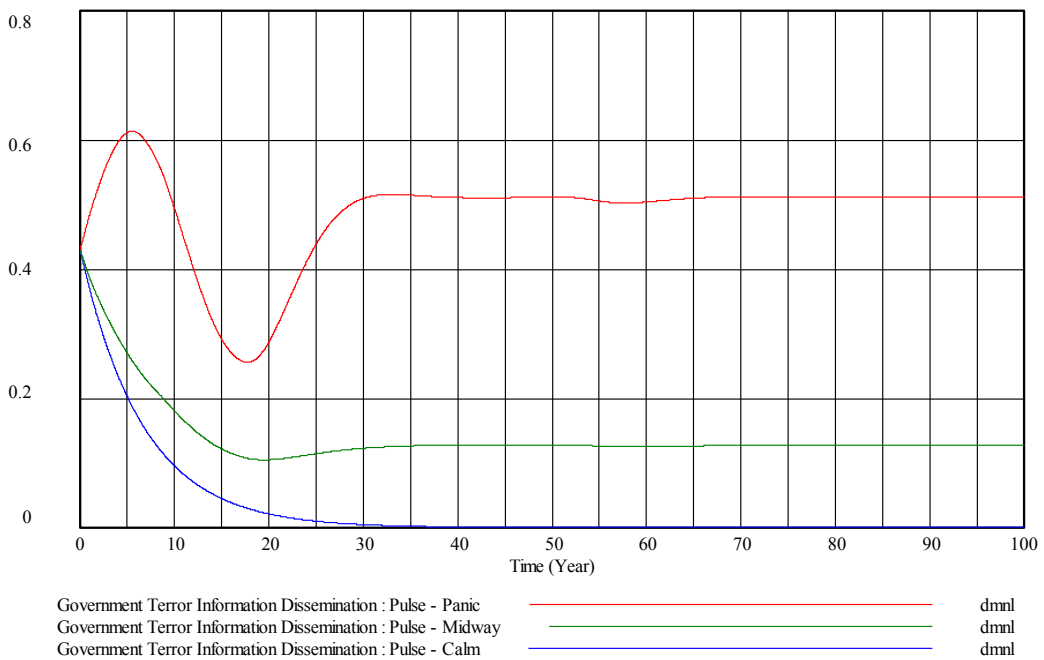
Government information dissemination:

The second driving force behind public concern is that of government information dissemination.

Graph for Government Useful Information Dissemination



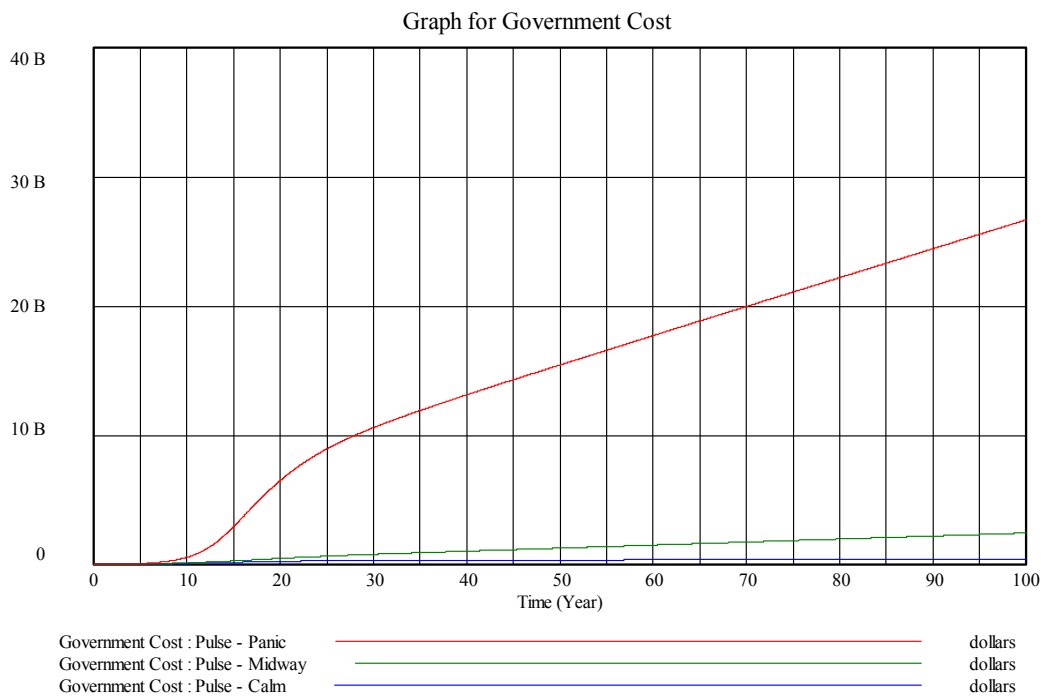
Graph for Government Terror Information Dissemination



The two preceding graphs depict the useful versus the terror information disseminated through policy by the government. The first depicts the useful information disseminated by the government; this represents the information that the government

distributes that has a calming effect on the public. In contrast, the government terror information dissemination represents the level of information that has a terrifying effect on the public. In a terrorism disaster there is an increase in the terror information and a decrease in the useful information whereas with a natural disaster, there is a decrease in terror information but an increase in useful information given by the government. However it should be noted that with a severe natural disaster, midway, the level of terror information does not drop to zero. This is indicative of ongoing information about severe natural disasters.

Costs:



The costs of the legislations enacted are displayed above. The large constant increase in cost in a terrorism (panic) situation should be noted. It should also be restated that there is a decay on all legislation enacted. That is to say the original legislation is far more encompassing than the final equilibrium level of legislation.

Discussion:

It should first be stated that the model presented here is merely a model, a simulation. It is as accurate as possible given the data available. However it does not claim to be infallible, nor does it claim to be complete. The intention of this project is to provide a starting point for further research. This model is preliminary, and expansion upon it is encouraged.

This model, though incomplete, does provide insights that are none the less valid in that it demonstrates a pattern for public concern following a disaster. It also shows how media coverage affects the level of public concern, and how governmental policy affects public concern. Finally it provides a trend of costs for legislation following natural and terror disasters.

Public concern is perhaps the most important driving force behind legislation, in the model. This model shows that public concern quickly rises following a disaster, but decays. Public concern is also much higher for terrorism disasters than for natural.

The goal of society should be to return to normality as soon as possible in the event of any kind of disaster, but this is not the case. While it is understandable that it is more infuriating to know that a disaster was perpetrated by people as opposed to a natural occurrence, it is not more productive to create more legislation for terrorist-based disasters as a result. Natural disasters are far more frequent than terrorist based ones. Disasters will occur; they are inevitable.

However the public is not entirely responsible for the overreaction. The media has a large part in this. When a disaster occurs, the media is the method by which the public becomes aware. The spin the media puts on a particular disaster has a profound

impact on how that disaster is viewed. Responsible media coverage is important to the goal of returning to normality.

Perhaps the greatest responsibility falls upon the government for controlling the public concern. The government has a unique task: to inform the public without causing panic. In the cases of terrorist disasters the government has not done the best job with respect to informing the public. The policy of fanning the flames of fear has led to over legislation that eventually will simply be reduced. Not only are the legislation efforts overdone, but there is a cost involved. For every year that the over legislation remains, millions of dollars are expended to enforce these laws and even more money is expended to reduce these laws after the decay period. Governmental policy has a large impact on just how much legislation is initially made and if the government can properly inform the public, a panic situation will not arise.

Disasters, natural and terrorist-based, are an inevitable part of existence on this planet. It becomes the goal of everyone affected to strive to return to normal following these events. We should strive to avoid undue attention to these events and go on with our lives. These events are not insignificant, but are only as cataclysmic as natural disasters of equal severity.

Appendix 1

Important Variable definitions

- Media Saturation-
 - The fraction of the readily accessible media to the general public that is focusing on a particular event or story, in this case the disaster.
- Impact

- The effect of an event, in this case a disaster, that has been mitigated or exacerbated by factors in the environment that respond or react to such an event, measured as a fraction.
- Public Concern
 - The fraction of the level of interest or sensation that a particular event, in this case a disaster, has on the general population.
- Perceived Probability of Disaster
 - The estimated likelihood of an event to occur as observed by the general population.
- Severity of Disaster
 - A measurement of an event based on the two following weighted factors(not a stock variable)
- Total Amount of Property Damage due to Disaster
 - The measure of Damage to property as a result of a given event. Once this damage is done it cannot be mitigated except as a preventative mitigation on the following event.
- Lives Lost Due to Disaster
 - The total number of lives lost as a result of a given disaster. Once these lives are lost, this effect cannot be mitigated except as a preventative mitigation on the following event
- Government Cost
 - This represents the increase in cost due to legislation enacted.
- Government Useful Information Dissemination

- The information given to the general population that has the effect of lowering public concern.
- Government Terror Information Dissemination
 - The information given to the general population that has the effect of raising public concern
- Legislations- a series of stock variables that share a common structure, yet have unique weights on the rest of the model
 - Government Monetary Aid Legislation Strictness
 - The level of legislation releasing monetary aid to mitigate an event.
 - Emergency Response Plan Legislation Strictness
 - The level of legislation creating effective emergency response plans to mitigate an event.
 - Location Restriction Legislation Strictness
 - The level of legislation restricting the settlement of high risk areas, and rendering of previously settled areas as restricted areas to mitigate an event.
 - Government insurance avail Legislation Strictness
 - The level of legislation making insurance available to the general population.

Appendix 2

Constants in italics

Auxiliary in normal

Stocks in bold

Variables:

BCP Multiplier=0.75

Units: dmnl

BCP Parameter=0.25

Units: dmnl

Business continuity plans=

Public Concern*BCP Multiplier

Units: dmnl

Cost for Monetary Aid=1.2e+010

Units: dollars

Cost per Insurance Program=1.2e+009

Units: dollars

Cost to disseminat info=153000

Units: dollars

Decrease of Impact per Year=

Impact*Impact Decay Fraction per year

Units: dmnl/Year

Decreases in Useful Info Publication Rate=

Government Useful Information Dissemination*

Info Publication Rate Decay Fraction

Units: dmnl/Year

Decreases of Terror Alerts per Year=

Info Publication Rate Decay Fraction*

Government Terror Information Dissemination

Units: dmnl/Year

Desired PC=X

X= calm=0, midway=.5, panic=.99

Units: dmnl

Disaster Pulses=

PULSE(5, 0.5) + PULSE(7, 0.5)+ PULSE(50,0.5)

Units: dmnl

Discrepancy in PC=

Desired PC-Public Concern

Units: dmnl

Education Multiplier=0.5

Units: dmnl

Effect of Business continuity plans=

BCP Parameter*Business continuity plans

Units: dmnl

Effect of Emergency Response Legislation on Loss of Life=

Emergency Response plan Legislation Strictness*

ERP Legislation Parameter on LOL

Units: dmn1

Effect of Emergency Response Plan on Property Damage=

Emergency Response plan Legislation Strictness*EMR Parameter on PD

Units: dmn1

Effect of Gov Insurance programs=

GIP Parameter*Gov insurance programs

Units: dmn1

Effect of Government Education on Perceived Probability f(

[(0,0)-(1,0.25)],(0,0),(0.2,0),(0.329305,0.03),(0.450151,0.08),(0.5,0.12),
(0.564955,0.18),(0.682779,0.23),(0.8,0.25),(1,0.25))

Units: dmn1

Effect of Info=

Info Parameter*(Government Terror Information Dissemination-
Government Useful Information Dissemination)

Units: dmn1

Effect of Interaction of Perceived Probability and Experience=

Interaction Parameter*Interaction of Probability and Experience

Units: dmn1

Effect of Location Restriction Legislation on Loss of Life=

Location Restriction Legislation Strictness*

Location Restriction Parameter on LOL

Units: dmn1

Effect of Location restriction on PD=

Location Restriction Legislation Strictness*LR Parameter on PD

Units: dmn1

Effect of Loss of Life=

LOL parameter*Lives Lost Due to Disaster

Units: dmn1

Effect of Media Saturation on Perceived Probability f(

[(0,0)-(1,0.25)],(0,0),(0.2,0),(0.329305,0.03),(0.450151,0.08),(0.5,0.12),
(0.564955,0.18),(0.682779,0.23),(0.8,0.25),(1,0.25))

Units: dmn1

Effect of Monetary Aid=

MA Parameter*Monetary aid to mitigate impact

Units: dmn1

Effect of Perceived Pressure on Legislation f(

[(0,0)-(1,0.6)],(0,0),(0.110092,0.006579),(0.24159,0.01754),
(0.379205,0.05),(0.513761,0.1325),(0.574924,0.2079),(0.617737,0.2746),
(0.675841,0.3596),(0.706422,0.3991),(0.761468,0.4474),
(0.844037,0.4825),(1,0.5),(1,0.5))

Units: dmn1

Effect of Perceived Probability of Disaster=

Probability Parameter*Perceived Probability of Disaster

Units: dmn1

Effect of property damage=

PD parameter*Total Amount of Property Damage due to Disaster

Units: dmnl

Emergency Response plan Legislation Strictness=

INTEG (Strictness Increases of Emergency Response Plan Laws per Year-

Strictness Decreases of Emergency response plan Laws per Year,0.01)

Units: dmnl

EMR Parameter on PD=0.7

Units: dmnl

ERP Legislation Decay Fraction per Year=0.15

Units: 1/Year

ERP Legislation Parameter on LOL=0.75

Units: dmnl

FINAL TIME = 100

Units: Year

GIP Parameter=0.35

Units: dmnl

Gov insurance programs=

Government insurance avail Legislation Strictness*Public Concern

Units: dmnl

Government Cost=

INTEG (Net Increases in Cost,0)

Units: dollars

Government Education=

Education Multiplier*(Government Terror Information Dissemination+
Government Useful Information Dissemination)

Units: dmnl

Government Effort for Decreasing Public Concern=

-MIN(Discrepancy in PC,0)

Units: dmnl

Government Effort for Increasing Public Concern=

MAX(Discrepancy in PC,0)

Units: dmnl

Government insurance avail Legislation Strictness=

**INTEG (Strictness Increases of Gov Insurance Laws per Year-
Strictness Decreases in Gov Insurance Avail Laws per Year,0.0018)**

Units: dmnl

Government Monetary Aid Legislation Strictness=

**INTEG (Strictness Increases of Aid Laws per Year-
Strictness Decreases of aid Laws per Year,0)**

Units: dmnl

Government Terror Information Dissemination=

**INTEG (Increases of Terror Alerts per Year-
Decreases of Terror Alerts per Year,0.43)**

Units: dmnl

Government Useful Information Dissemination=

INTEG (Increases in Useful Info Publication Rate-

Decreases in Useful Info Publication Rate,0.43)

Units: dmn1

Govt Aid Legislation Decay Fraction per Year=0.15

Units: 1/Year

Govt Insurance Legislation Decay Fraction per Year=0.15

Units: 1/Year

Impact=

INTEG (+Increase of Impact per Year-Decrease of Impact per Year,0)

Units: dmn1

Impact Change Speed=1

Units: 1/Year

Impact Decay Fraction per year=0.25

Units: 1/Year

Implementation Speed=0.25

Units: 1/Year

Increase of Impact per Year=

MAX(Potential Full Impact of Disaster-Total Effect of Planning,0)*

Impact Change Speed

Units: dmn1/Year

Increase Rate of PC=

Public Concern Change Speed*Sum Total of Factors Affecting Public Concern

Units: dmn1/Year

Increases in Useful Info Publication Rate=

Effect of Perceived Pressure on Legislation f(
Government Effort for Decreasing Public Concern)*
Implementation Speed

Units: dmn/Year

Increases of Terror Alerts per Year=

Effect of Perceived Pressure on Legislation f(
Government Effort for Increasing Public Concern)*Implementation Speed

Units: dmn/Year

Info Parameter=0.1

Units: dmn

Info Publication Rate Decay Fraction=0.15

Units: dmn/Year

Information expense=

(Government Terror Information Dissemination+
Government Useful Information Dissemination)*Cost to disseminat info/2

Units: dollars

INITIAL TIME = 0

Units: Year

Insurance Expense=

Gov insurance programs*Cost per Insurance Program

Units: dollars

Interaction of Probability and Experience=

Perceived Probability of Disaster*Lack of Familiarity with Disaster

Units: dmnl

Interaction Parameter=0.3

Units: dmnl

Lack of Familiarity with Disaster=

-Prior Experience With Disaster

Units: dmnl

Lives Lost Due to Disaster=

INTEG (Lives Lost due to Disaster per Year-LOL Clear,0)

Units: dmnl

Lives Lost due to Disaster per Year=

Net Lives Lost per Year due to Disaster*Implementation Speed

Units: dmnl/Year

Location Restriction Legislation Decay Fraction per Year=0.15

Units: 1/Year

Location Restriction Legislation Strictness=

INTEG (Strictness Increases of Location Restriction Laws per Year-

Strictness Decreases of Location Restriction Laws per Year,0.0018)

Units: dmnl

Location Restriction Parameter on LOL=0.25

Units: dmnl

LOL Clear=

IF THEN ELSE(INTEGER(Time)=Time , Lives Lost Due to Disaster/
TIME STEP, 0)

Units: dmn/Year

LOL parameter=0.7

Units: dmn

LR Parameter on PD=0.3

Units: dmn

MA Parameter=0.4

Units: dmn

Media Saturation=

**INTEG (Media Saturation increase per year-
Media Saturation decrease per year,1e-005)**

Units: dmn

Media Saturation Change Speed=3

Units: 1/Year

Media Saturation Decay Fraction=0.25

Units: 1/Year

Media Saturation decrease per year=

Media Saturation*Media Saturation Decay Fraction

Units: dmn/Year

Media Saturation increase per year=

(Relative Severity of Disaster+Public Concern*Impact)*

Media Saturation Change Speed

Units: dmnl/Year

Monetary aid to mitigate impact=

Money Available*Government Monetary Aid Legislation Strictness

Units: dmnl

Monetary Expense=

Cost for Monetary Aid*Monetary aid to mitigate impact

Units: dollars

Money Available=I

Units: dmnl

Net Increases in Cost=

(Insurance Expense+Information expense+Monetary Expense)*

Implementation Speed

Units: dollars/Year

Net Lives Lost per Year due to Disaster=

Disaster Pulses*Normal Loss Of Life*

Total Effect of Legislation on Loss of Life due to Disaster

Units: dmnl

Net Property Damage per Year due to Disaster=

Disaster Pulses*Normal Property Damage*

Total effect of Legislation and Planning on Property Damage

Units: *dmnl*

Normal Full Impact=58

Units: *dmnl*

Normal Loss Of Life=100

Units: *dmnl*

Normal Property Damage=100

Units: *dmnl*

Normal Severity of Disaster=100

Units: *dmnl*

PD parameter=0.3

Units: *dmnl*

Perceived Probability decrease per year=

Perceived Probability of Disaster*Perceived Probability decay

Units: *dmnl/Year*

Perceived Probability Increase per year=

Implementation Speed*IF THEN ELSE(

Perceived Probability of Disaster>0.99999,0,

Effect of Media Saturation on Perceived Probability $f(\text{Media Saturation}) +$

Effect of Government Education on Perceived Probability $f($

Government Education))

Units: *dmnl/Year*

Perceived Probability of Disaster=

**INTEG (Perceived Probability Increase per year-
Perceived Probability decrease per year,1e-006)**

Units: dmnl

Perceived Probability decay=0.2

Units: 1/Year

Potential Full Impact of Disaster=

Severity of disaster/Normal Full Impact

Units: dmnl

Prior Experience With Disaster=0.5

Units: dmnl

Probability Parameter=0.6

Units: dmnl

Property Damage Clear=

IF THEN ELSE(INTEGER(Time)=Time ,

Total Amount of Property Damage due to Disaster/TIME STEP, 0)

Units: dmnl/Year

Property Damage per Year=

Net Property Damage per Year due to Disaster*

Implementation Speed

Units: dmnl/Year

Public Concern=

INTEG (Increase Rate of PC-Rate of Decrease of Public Concern,0.1)

Units: dmn1

Public Concern Change Speed=3

Units: 1/Year

Public Concern Decay Fraction=0.5

Units: 1/Year

Rate of Decrease of Public Concern=

Public Concern Decay Fraction*Public Concern

Units: dmn1/Year

Relative Severity of Disaster=

Severity of disaster/Normal Severity of Disaster

Units: dmn1

SAVEPER =

TIME STEP

Units: Year [0,?]

Severity of disaster=

Effect of Loss of Life+Effect of property damage

Units: dmn1

Strictness Decreases in Gov Insurance Avail Laws per Year=

Govt Insurance Legislation Decay Fraction per Year*

Government insurance avail Legislation Strictness

Units: dmn1/Year

Strictness Decreases of aid Laws per Year=

Govt Aid Legislation Decay Fraction per Year*

Government Monetary Aid Legislation Strictness

Units: dmn/Year

Strictness Decreases of Emergency response plan Laws per Year=

ERP Legislation Decay Fraction per Year*

Emergency Response plan Legislation Strictness

Units: dmn/Year

Strictness Decreases of Location Restriction Laws per Year=

Location Restriction Legislation Decay Fraction per Year*

Location Restriction Legislation Strictness

Units: dmn/Year

Strictness Increases of Aid Laws per Year=

(Effect of Perceived Pressure on Legislation f(Public Concern))*

Implementation Speed

Units: dmn/Year

Strictness Increases of Emergency Response Plan Laws per Year=

(Effect of Perceived Pressure on Legislation f(Public Concern))*

Implementation Speed

Units: dmn/Year

Strictness Increases of Gov Insurance Laws per Year=

(Effect of Perceived Pressure on Legislation f(Public Concern))*

Implementation Speed

Units: dmnl/Year

Strictness Increases of Location Restriction Laws per Year=

(Effect of Perceived Pressure on Legislation f(Public Concern))*

Implementation Speed

Units: dmnl/Year

Sum Total of Factors Affecting Public Concern=

MAX((Effect of Perceived Probability of Disaster+

Effect of Interaction of Perceived Probability and Experience

+Effect of Info),0)

Units: dmnl

TIME STEP = 0.03125

Units: Year [0,?]

Total Amount of Property Damage due to Disaster=

INTEG (Property Damage per Year-Property Damage Clear,0)

Units: dmnl

Total effect of Legislation and Planning on Property Damage=

1-(Effect of Emergency Response Plan on Property Damage+

Effect of Location restriction on PD)

Units: dmnl

Total Effect of Legislation on Loss of Life due to Disaster=

1-(Effect of Emergency Response Legislation on Loss of Life+

Effect of Location Restriction Legislation on Loss of Life)

Units: dmn1

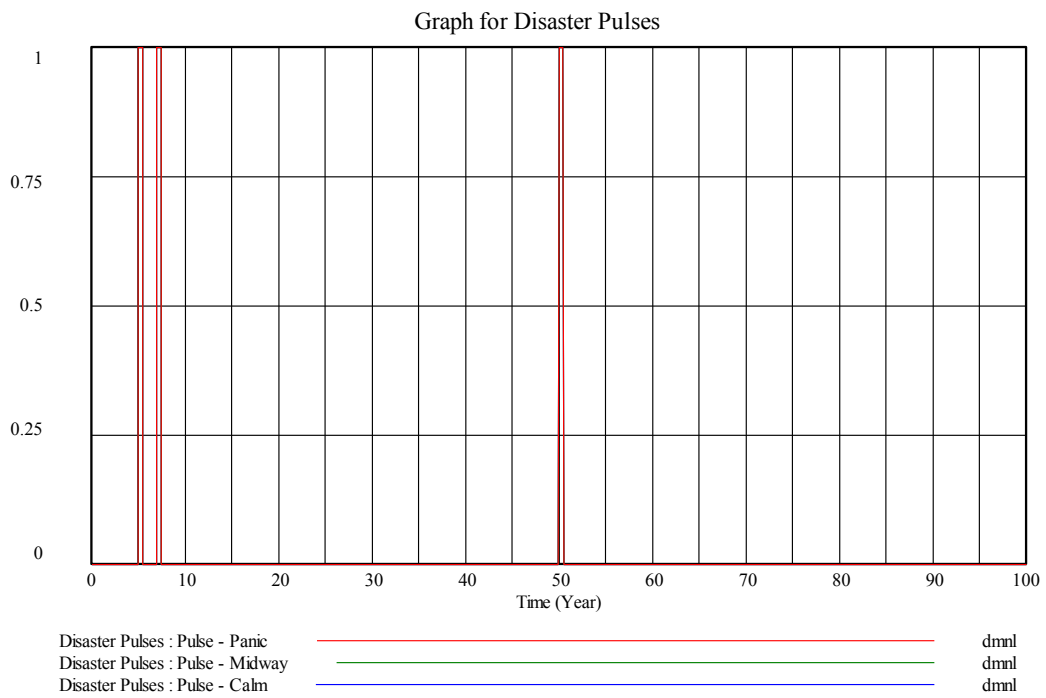
Total Effect of Planning=

Effect of Business continuity plans+Effect of Gov Insurance programs+

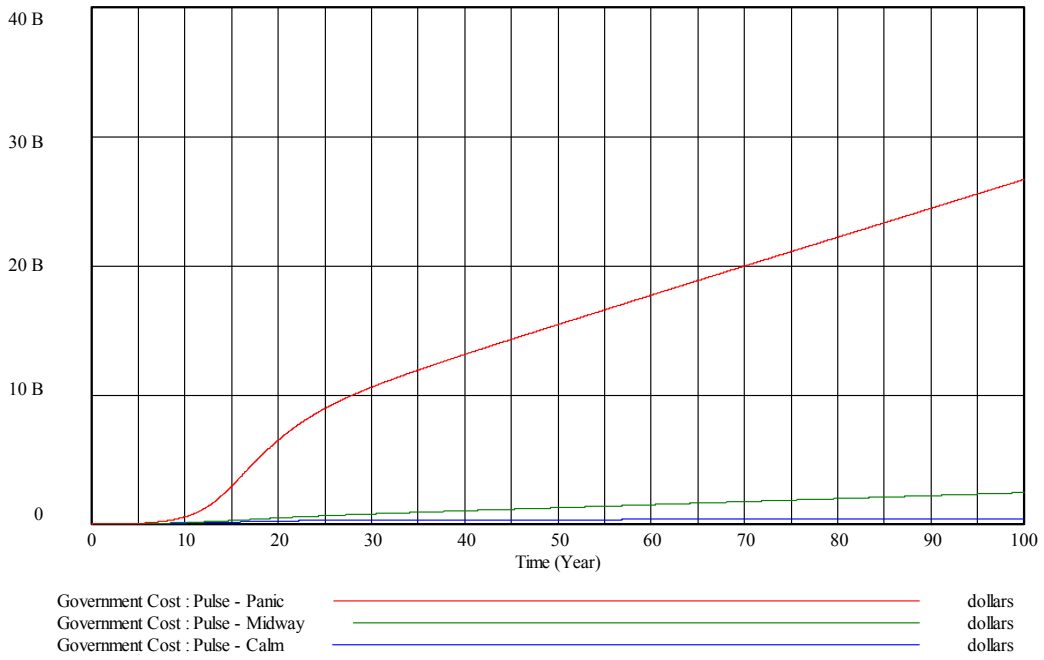
Effect of Monetary Aid

Units: dmn1

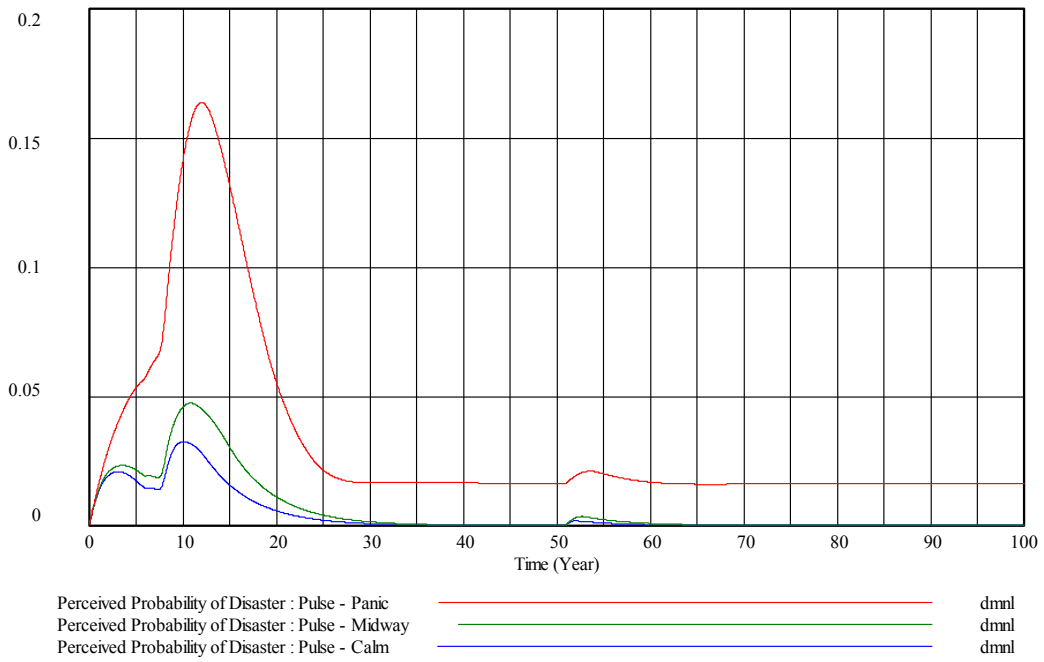
Appendix 3



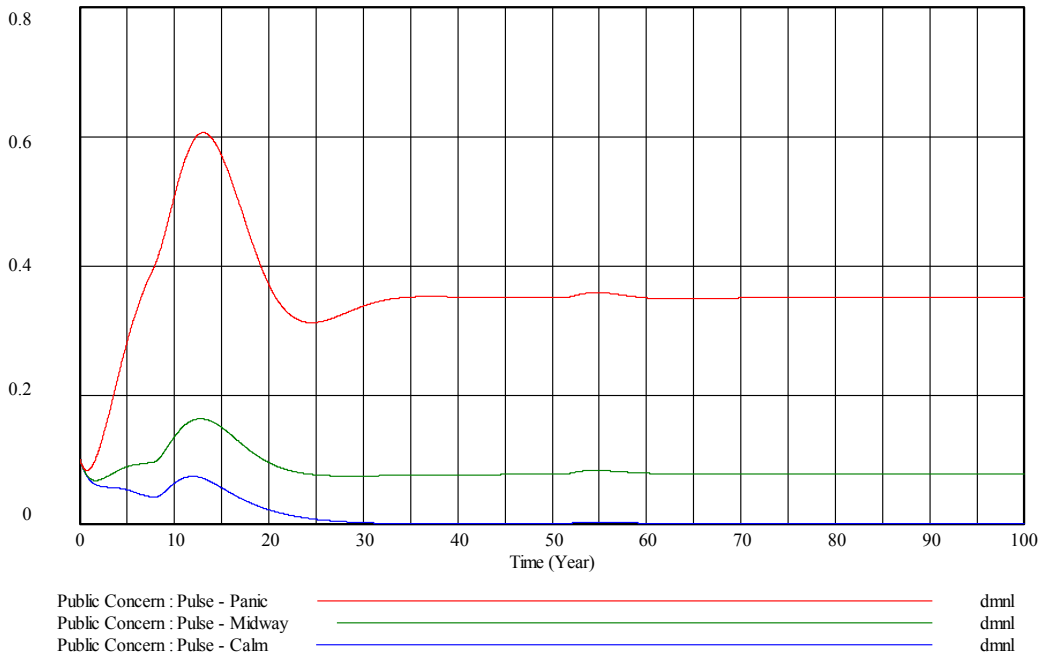
Graph for Government Cost



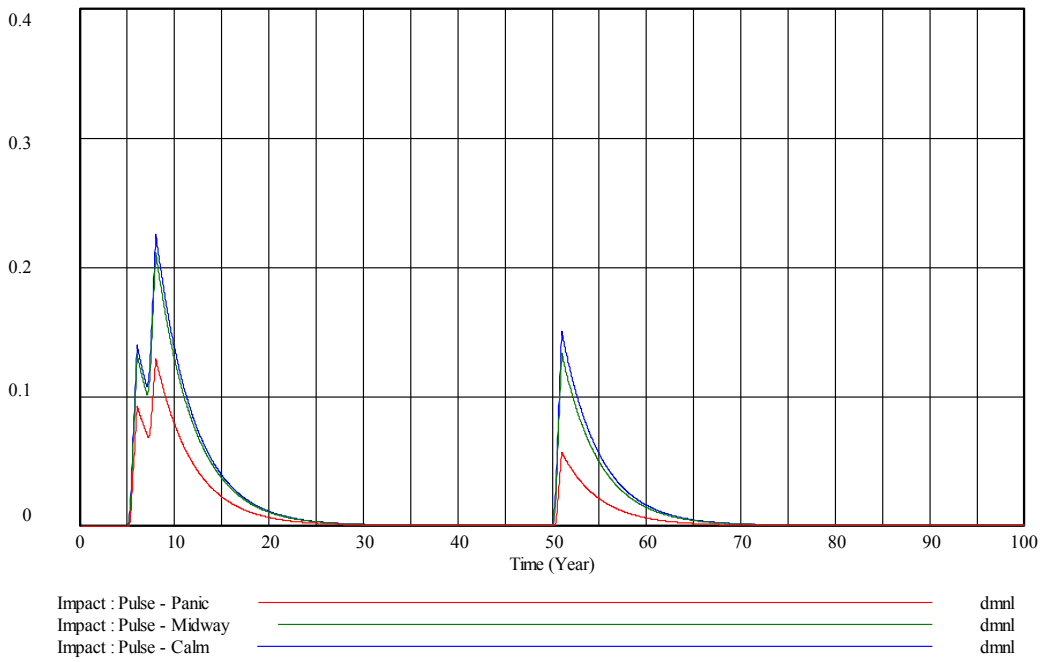
Graph for Perceived Probability of Disaster



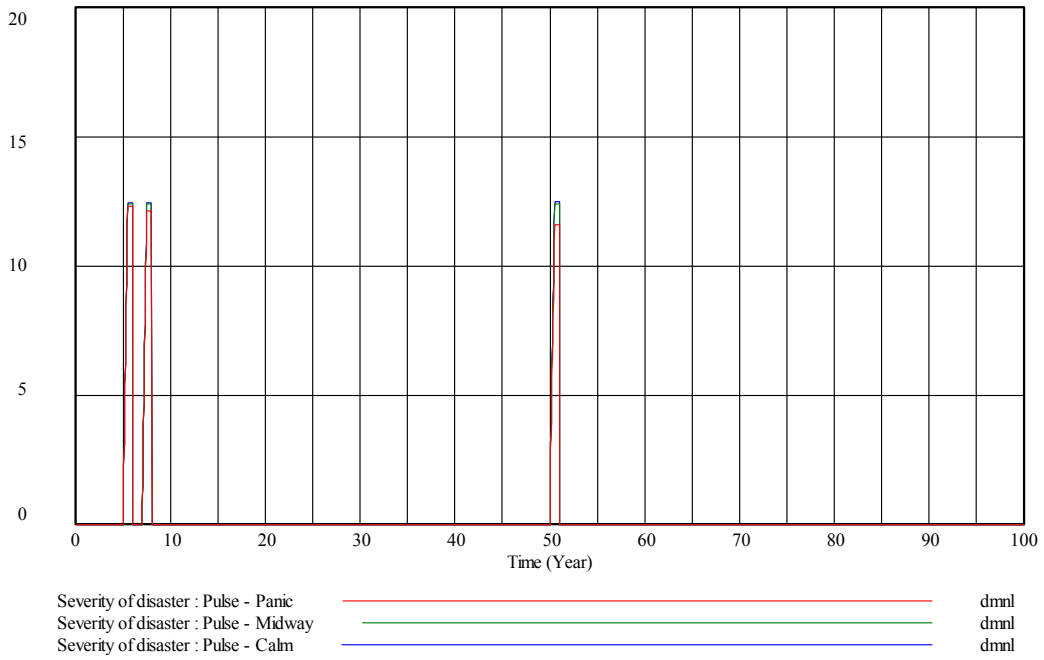
Graph for Public Concern



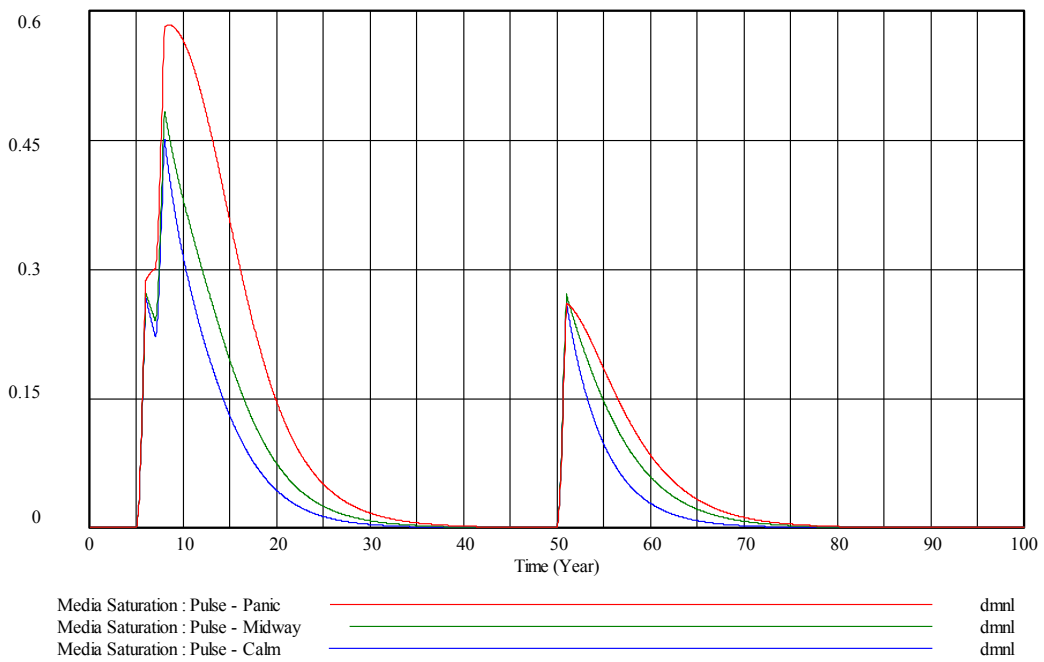
Graph for Impact



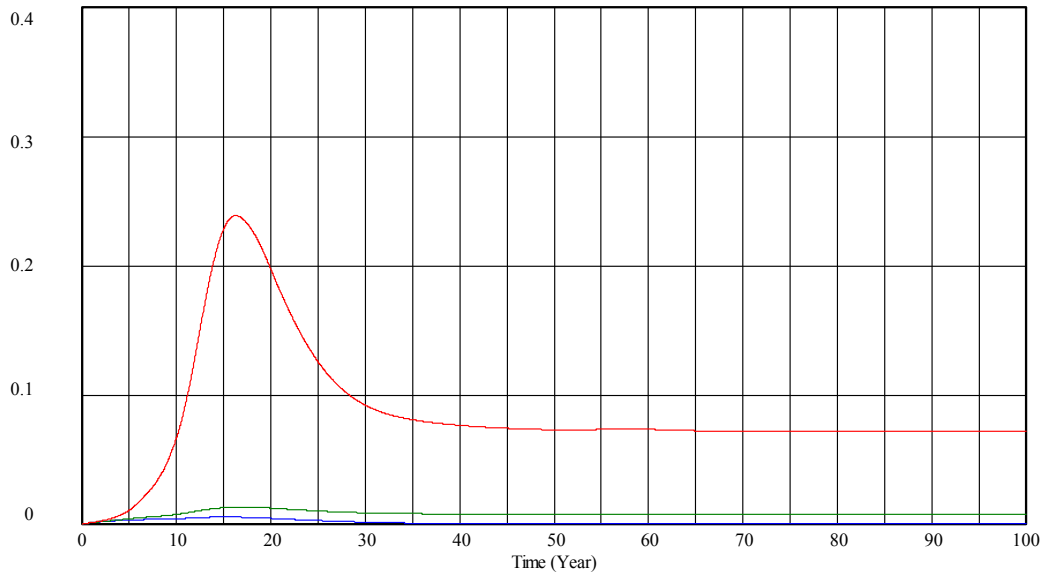
Graph for Severity of disaster



Graph for Media Saturation

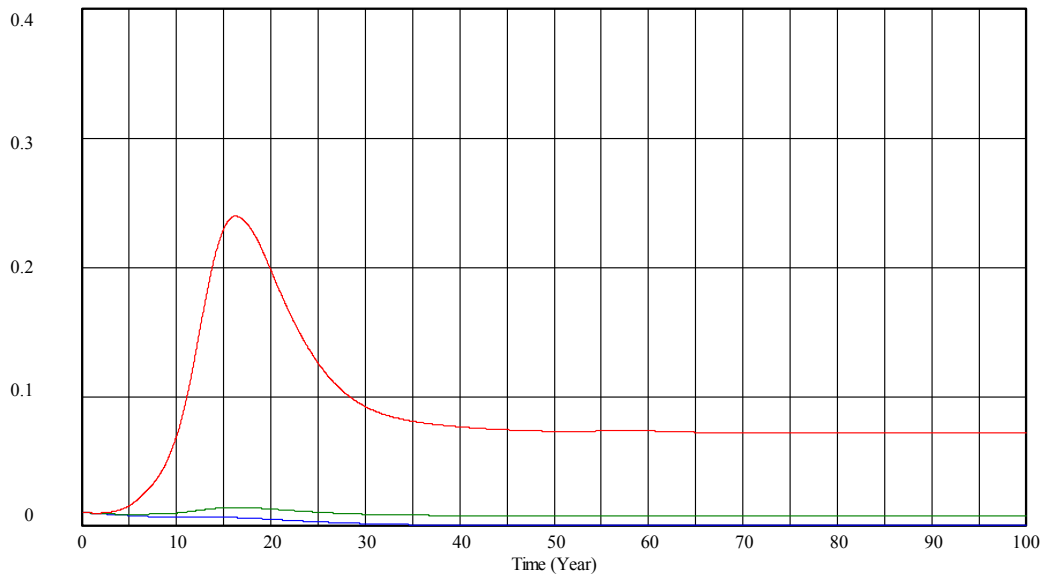


Graph for Government Monetary Aid Legislation Strictness



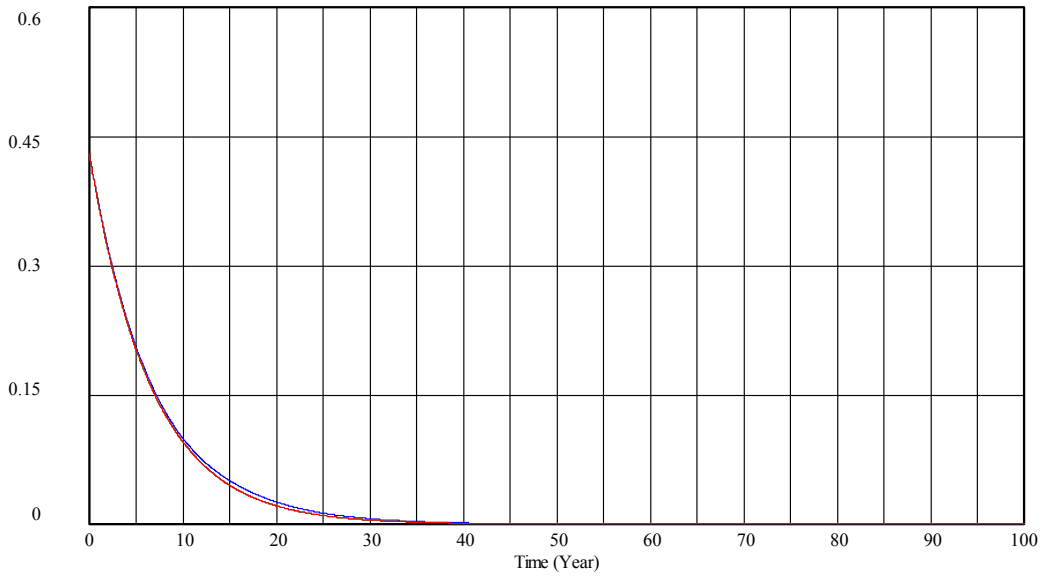
Government Monetary Aid Legislation Strictness : Pulse - Panic dmnl
 Government Monetary Aid Legislation Strictness : Pulse - Midway dmnl
 Government Monetary Aid Legislation Strictness : Pulse - Calm dmnl

Graph for Emergency Response plan Legislation Strictness



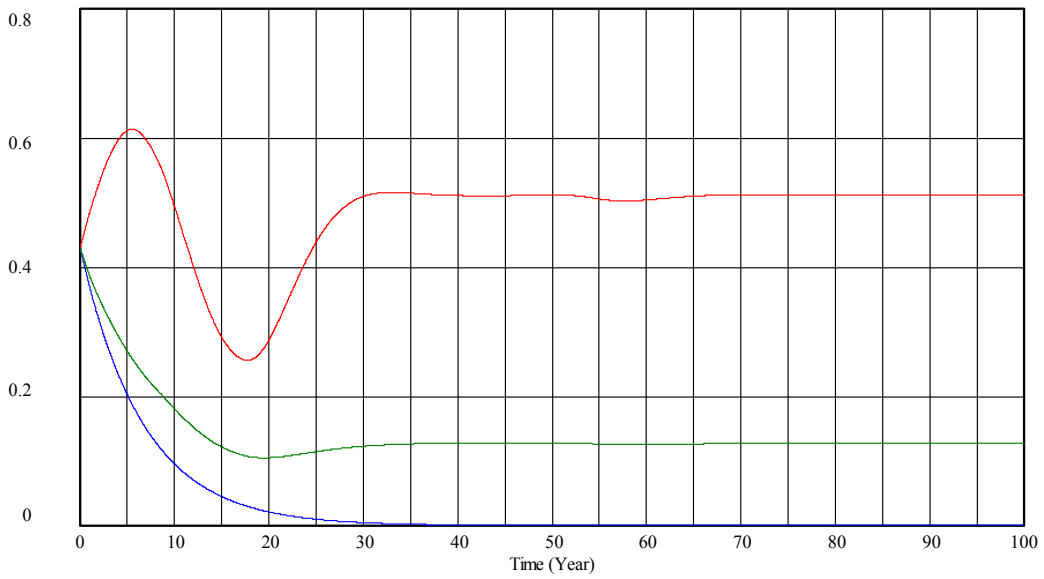
Emergency Response plan Legislation Strictness : Pulse - Panic dmnl
 Emergency Response plan Legislation Strictness : Pulse - Midway dmnl
 Emergency Response plan Legislation Strictness : Pulse - Calm dmnl

Graph for Government Useful Information Dissemination



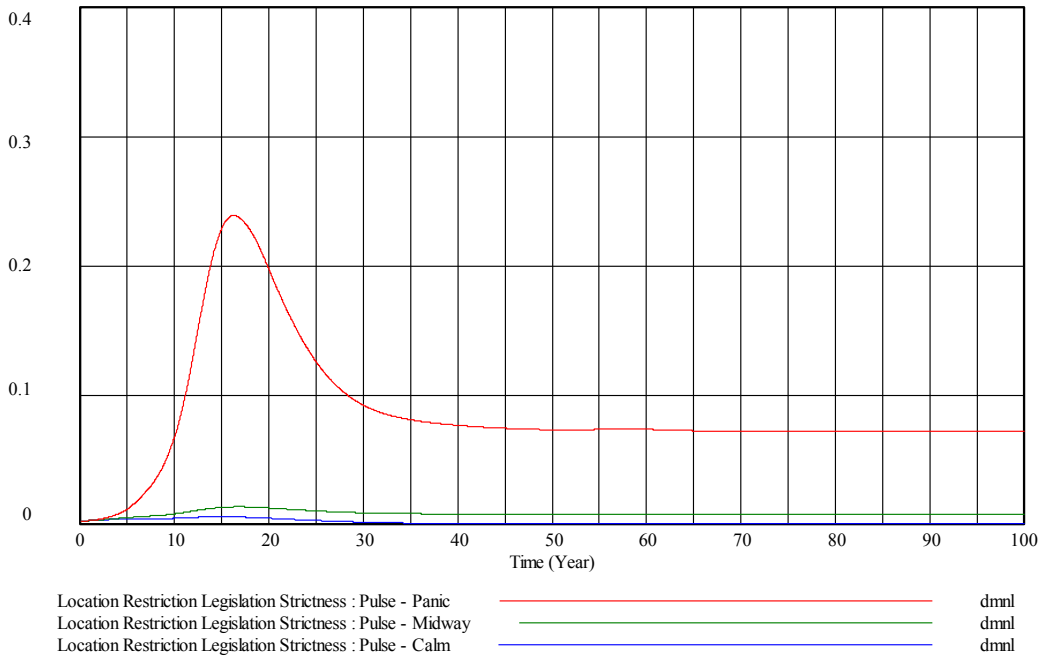
Government Useful Information Dissemination : Pulse - Panic — dmnl
 Government Useful Information Dissemination : Pulse - Midway — dmnl
 Government Useful Information Dissemination : Pulse - Calm — dmnl

Graph for Government Terror Information Dissemination

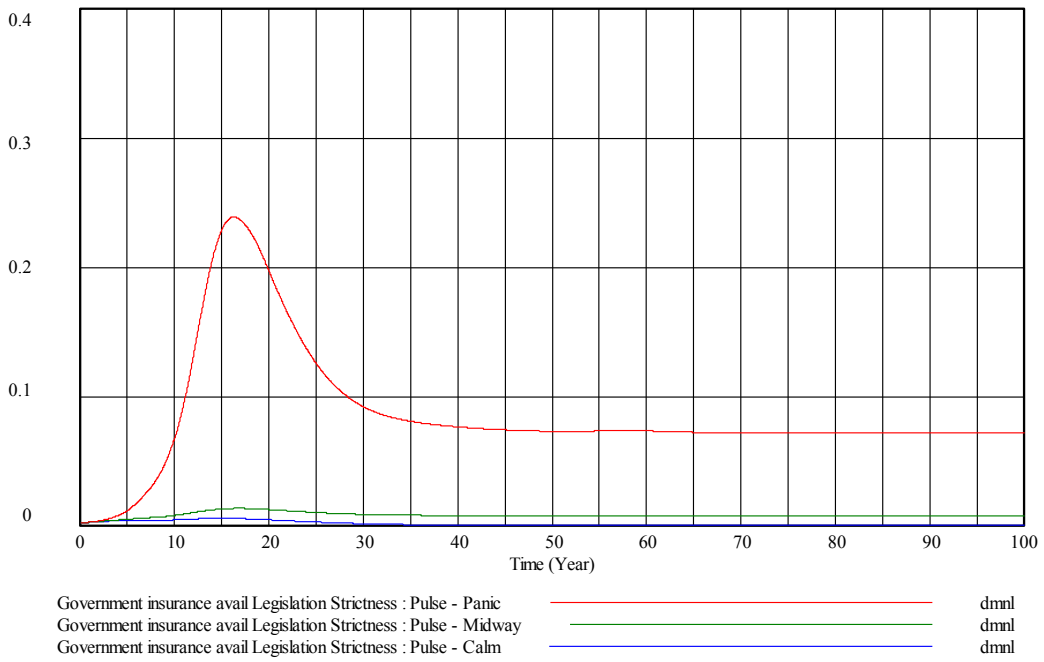


Government Terror Information Dissemination : Pulse - Panic — dmnl
 Government Terror Information Dissemination : Pulse - Midway — dmnl
 Government Terror Information Dissemination : Pulse - Calm — dmnl

Graph for Location Restriction Legislation Strictness

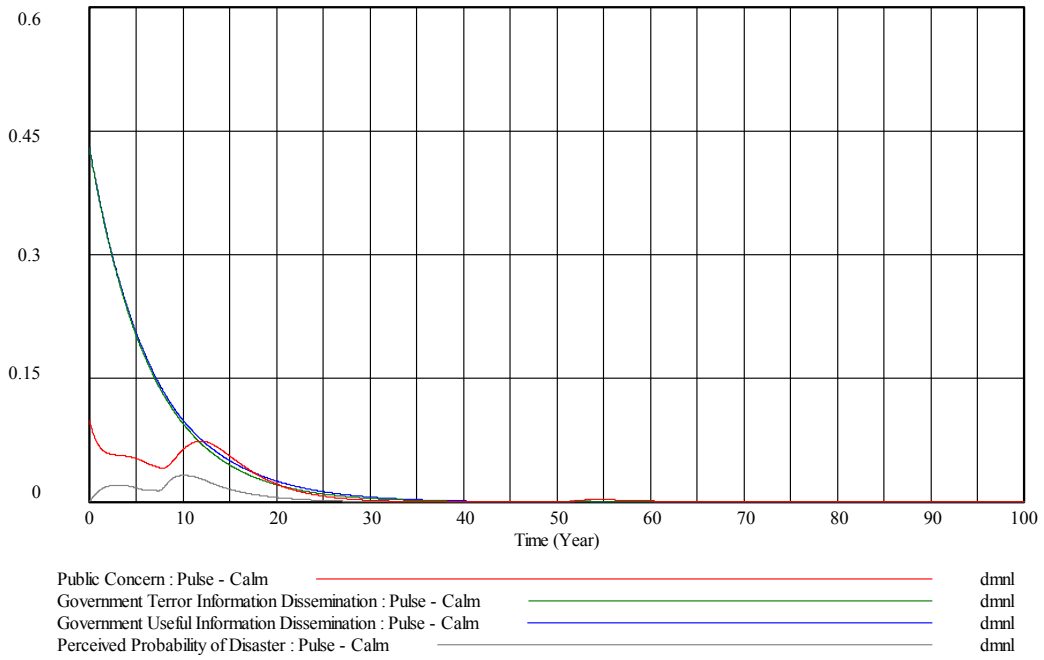


Graph for Government insurance avail Legislation Strictness

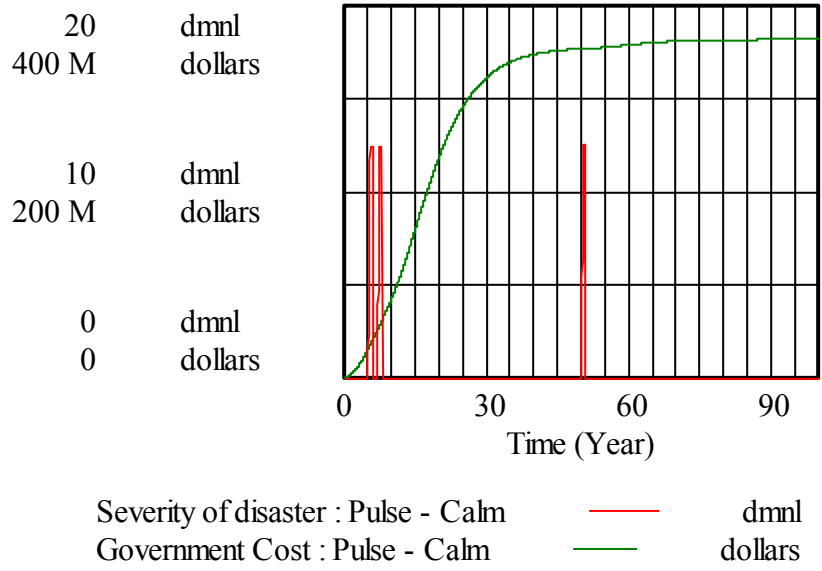


Appendix 4

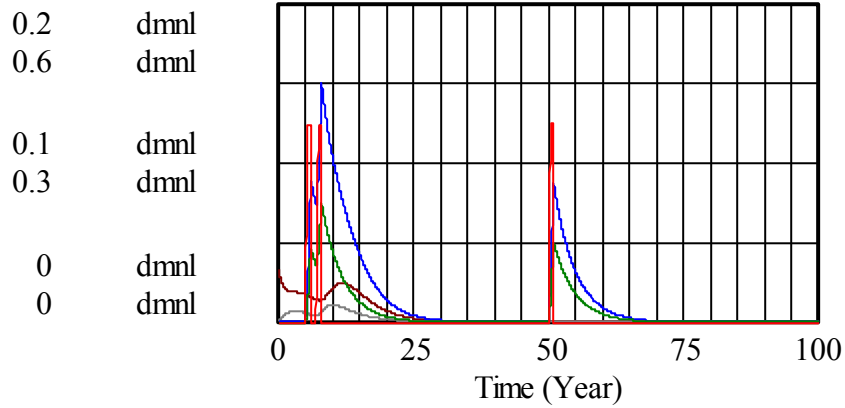
Information Dissemination



Costs and Benefits

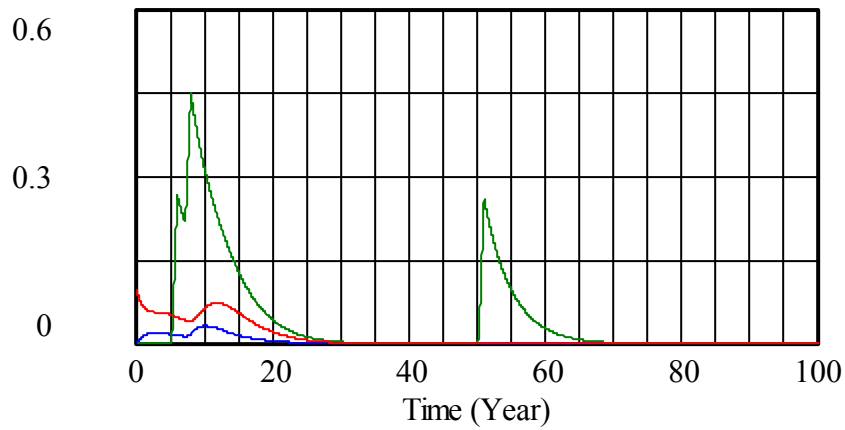


Key Variables



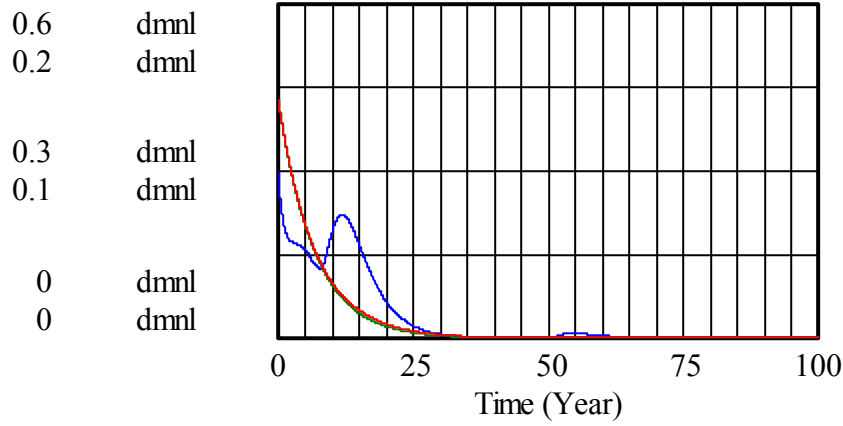
Relative Severity of Disaster : Pulse - Calm	—	dmnl
Impact : Pulse - Calm	—	dmnl
Media Saturation : Pulse - Calm	—	dmnl
Perceived Probability of Disaster : Pulse - Calm	—	dmnl
Government Education Legislation Strictness : Pulse - Calm	—	dmnl
Public Concern : Pulse - Calm	—	dmnl

Media+Public



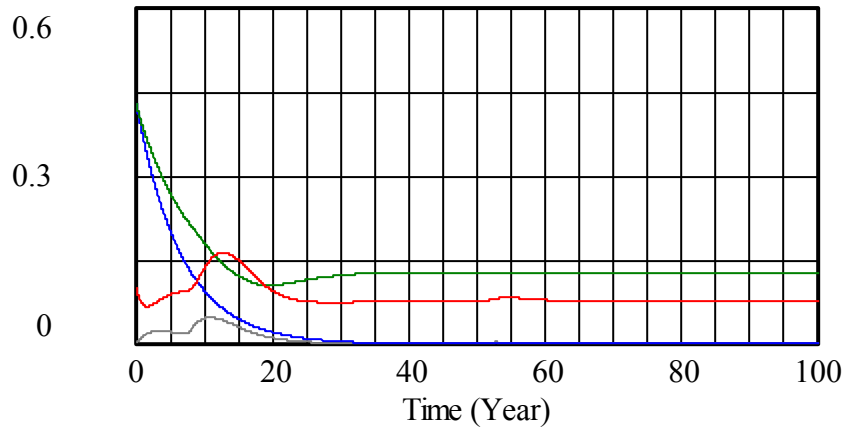
Public Concern : Pulse - Calm	—	dmnl
Media Saturation : Pulse - Calm	—	dmnl
Perceived Probability of Disaster : Pulse - Calm	—	dmnl

Gov Info



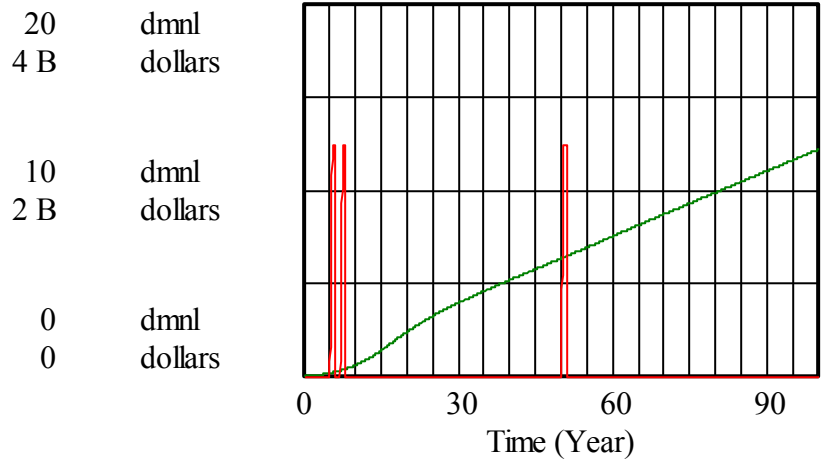
Government Useful Information Dissemination : Pulse dmnllm
 Government Terror Information Dissemination : Pulse dmnllm
 Public Concern : Pulse - Calm ———— dmnll

Information Dissemination



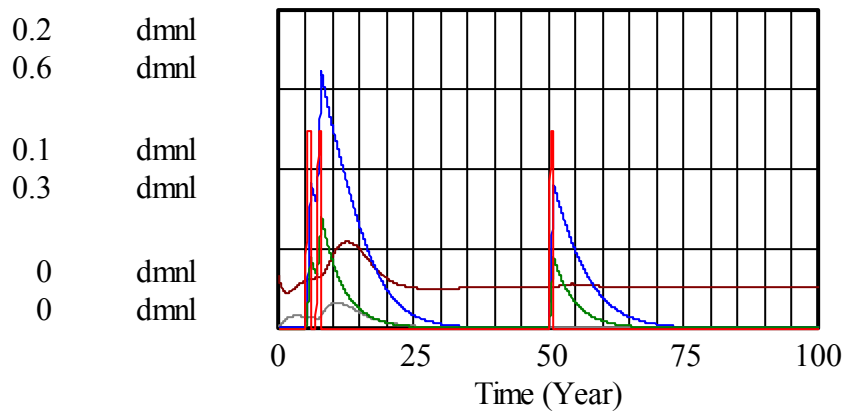
Public Concern : Pulse - Midway ———— dmnll
 Government Terror Information Dissemination : Pulse - Midway dmnll
 Government Useful Information Dissemination : Pulse - Midway dmnll
 Perceived Probability of Disaster : Pulse - Midway ———— dmnll

Costs and Benefits



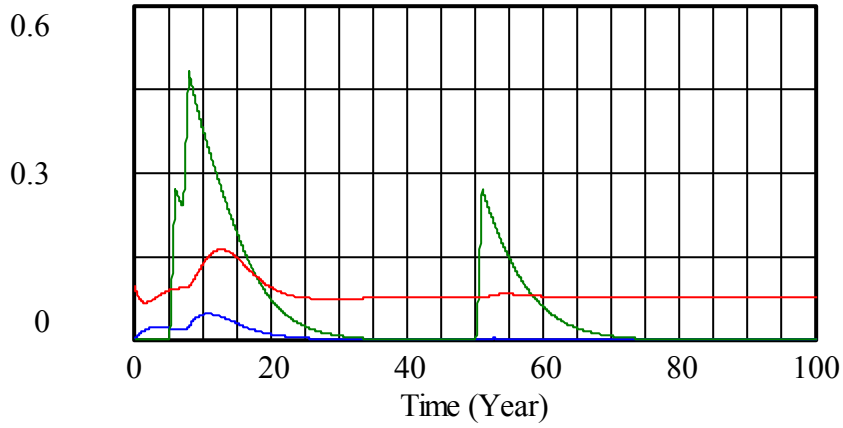
Severity of disaster : Pulse - Midway — dmnl
Government Cost : Pulse - Midway — dollars

Key Variables



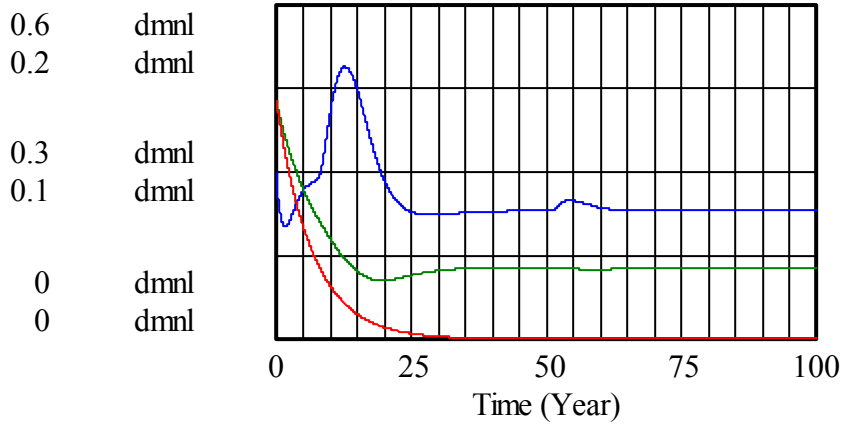
Relative Severity of Disaster : Pulse - Midway — dmnl
Impact : Pulse - Midway — dmnl
Media Saturation : Pulse - Midway — dmnl
Perceived Probability of Disaster : Pulse - Midway — dmnl
Government Education Legislation Strictness : Pulse - Midway — dmnl
Public Concern : Pulse - Midway — dmnl

Media+Public



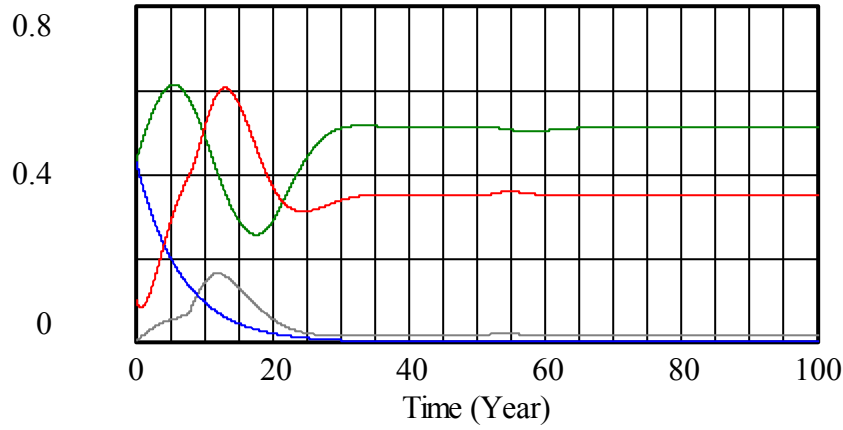
Public Concern : Pulse - Midway — dmnl
 Media Saturation : Pulse - Midway — dmnl
 Perceived Probability of Disaster : Pulse - Midway — dmnl

Gov Info



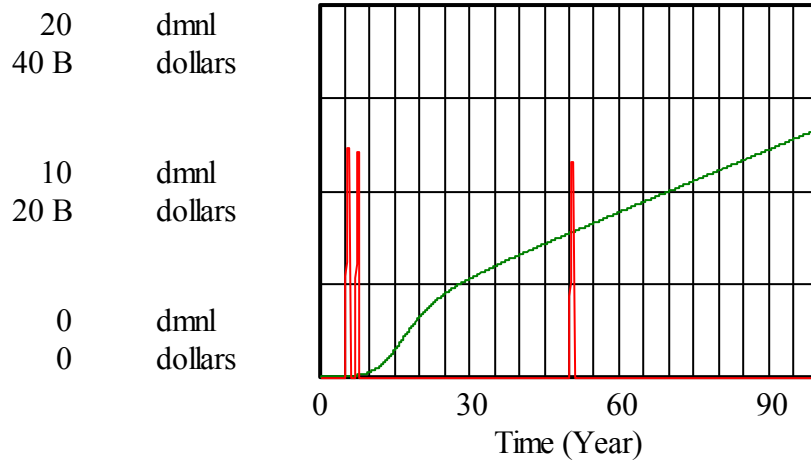
Government Useful Information Dissemination : Pulse dmnl
 Government Terror Information Dissemination : Pulse dmnl
 Public Concern : Pulse - Midway — dmnl

Information Dissemination



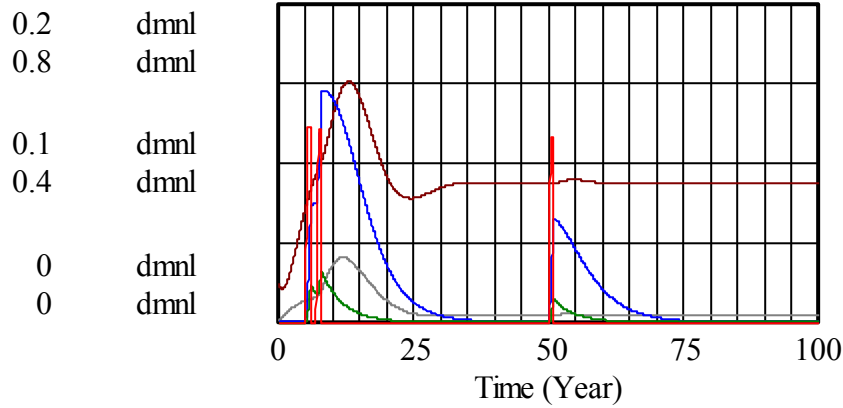
Public Concern : Pulse - Panic	—	dmnl
Government Terror Information Dissemination : Pulse - Panic		dmnl
Government Useful Information Dissemination : Pulse - Panic		dmnl
Perceived Probability of Disaster : Pulse - Panic	—	dmnl

Costs and Benefits



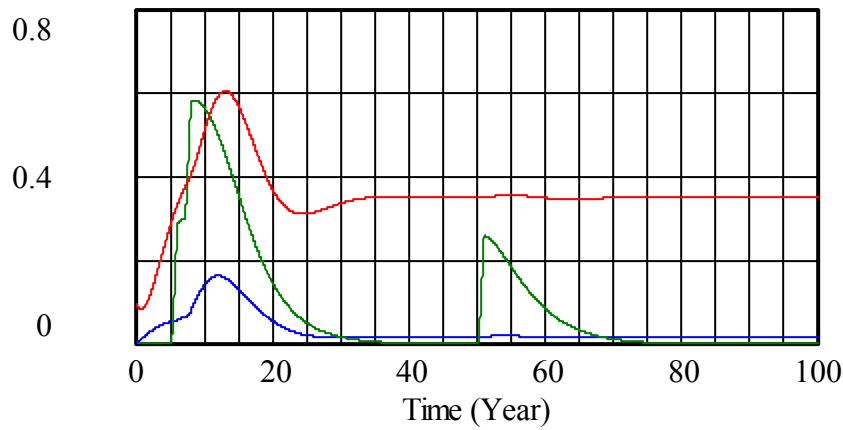
Severity of disaster : Pulse - Panic	—	dmnl
Government Cost : Pulse - Panic	—	dollars

Key Variables



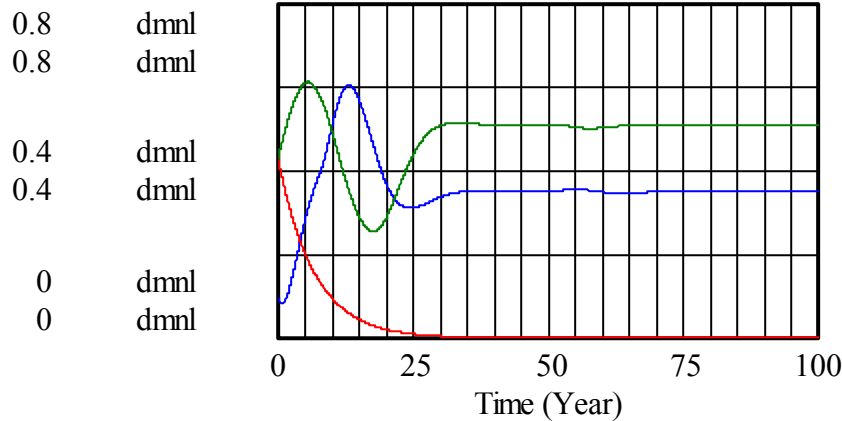
Relative Severity of Disaster : Pulse - Panic	—	dmnl
Impact : Pulse - Panic	—	dmnl
Media Saturation : Pulse - Panic	—	dmnl
Perceived Probability of Disaster : Pulse - Panic	—	dmnl
Government Education Legislation Strictness : Pulse - Panic	—	dmnl
Public Concern : Pulse - Panic	—	dmnl

Media+Public



Public Concern : Pulse - Panic	—	dmnl
Media Saturation : Pulse - Panic	—	dmnl
Perceived Probability of Disaster : Pulse - Panic	—	dmnl

Gov Info



Government Useful Information Dissemination : Pulse dmnhc
 Government Terror Information Dissemination : Pulse dmnhc
 Public Concern : Pulse - Panic ———— dmnl

Works Cited

- 2005 Federal Disaster Declarations (2005, May 27). [Internet]. Federal Emergency Management Agency. Retrieved May 30, 2005, from the World Wide Web: <http://www.fema.gov/news/disasters.fema>
- Birkland, T. (1997). After disaster : agenda setting, public policy, and focusing events. Washington D.C.: Georgetown University Press.
- Charney, J. I. (2001). The Use of Force against Terrorism and International Law. The American Journal of International Law, 95(4), 835-839.
- FEMA (2005, May 27). [Internet]. Federal Emergency Management Agency. Retrieved May 30, 2005, from the World Wide Web: <http://www.fema.gov/>
- Finlay, P. J., & Fell, R. (1997). Landslides: risk perception and acceptance. Journal of Canadian Geotechnolgy, 34, 169-188.
- Greene, M. R. (1976). The Government as an Insurer. The Journal Or Risk and Insurance, 43(3), 393-407.
- Kahneman, D., & Tversky, A. (1974). Judgement Under Uncertainty. Science, 185, 1124-1131.
- Karwan, K. R., & Wallace, W. A. (1984). Can We Manage Natural Hazards? Public Administration Review, 44(2), 177-181.
- Kasperson, R. E., & Pijawka, K. D. (1985). Societal Response to Hazards and Major Hazard Events: Comparing Natural and Technological Hazards. Public Administration Review, 45(Special: Emergency Management: A Challenge for Public Administration), 7-17.
- Katzman, G., & Meacheam, B. (2004). Risk and Security for New York City Buildings. New York City.
- Kunreuther, H. (1974). Disaster Insurance: A Tool for Hazard Mitigation. The Journal Or Risk and Insurance, 41(2), 287-303.

Kunreuther, H., & Miller, L. (1985). Insurance Disaster Relief: An Analysis Of Interactive Modelling for Disaster Policy Planning. Public Administration Review, 45(Special: Emergency Management: A Challenge for Public Administration), 147-154.

Nacos, B. L. (2003). Terrorism as Breaking News: Attack on America. Political Science Quarterly, 118(1), 23-52.

Palm, R. I. (1981). Public Response to Earthquake Hazard Information. Annals of the Association of American Geographers, 71(3), 389-399.

Paternoster, R., Saltzman, L. E., Waldo, G. P., & Chiricos, T. G. (1983). Perceived Risk and Social Control: Do Sanctions Really Deter? Law & Society Review, 17(3), 475-480.

Peek, L. A., & Beavers, J. E. (2002). Role of the Natural Hazards and Disaster Field in the Aftermath of September 11. Natural Hazards Review, 3(1), 2-3.

Rubin, C. B., & Barbee, D. G. (1985). Disaster Recovery and Hazard Mitigation: Bridging the Intergovernmental Gap. Public Administration Review, 45(Special: Emergency Management: A Challenge for Public Administration), 57-63.

Ryland, H. G. (2000). A Piece of the Puzzle: Insurance Industry Perspective on Mitigation. Natural Hazards Review, 1(1), 43-49.

Settle, A. K. (1985). Financing Disaster Mitigation, Preparedness, Response, and Recovery. Public Administration Review, 45(Special: Emergency Management: A Challenge for Public Administration), 101-106.

Sterman, J. D. (2000). Business Dynamics: System Thinking and Modeling for a Complex World (1 ed.). Indianapolis: McGraw-Hill.

Wahle, T., & Beatty, G. (2002). Emergency Management Guide for Business & Industry: A Step-by-Step Approach to Emergency Planning, Response and Recovery for Companies of all Sizes. Washington D.C.: Federal Emergency Management Agency.

Waugh, W. L. (1994). Regionalizing Emergency Management: Counties as State and Local Government. Public Administration Review, 54(3), 253-258.

Weaver, E. A., & Richardson, G. P. (under revision). Threshold Setting and the Cycling of a Decision Threshold.