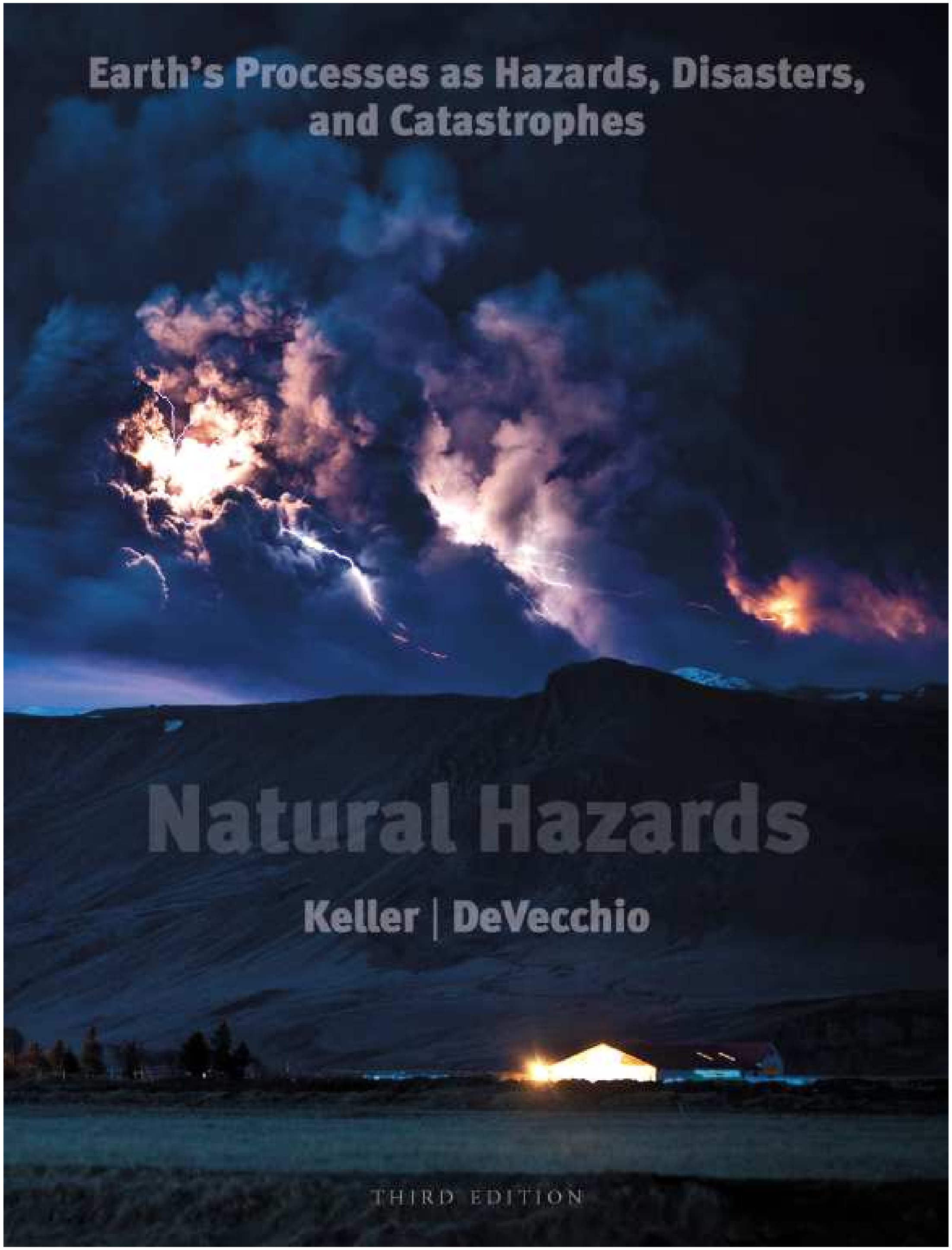

Lecture Presentation

Chapter 1

Introduction to Natural Hazards

Learning Objectives

- Know the difference between a disaster and a catastrophe
- Know the components and processes of the geologic cycle
- Understand the scientific method
- Understand the basics of risk assessment
- Recognize that natural hazards that cause disasters are generally high-energy events caused by natural Earth processes

Learning Objectives, cont.

- Understand the concept that the magnitude of a hazardous event is inversely related to its frequency
- Understand how natural hazards may be linked to one another and to the physical environment
- Recognize that increasing human population and poor land-use changes compound the effects of natural hazards and can turn disasters into catastrophes

Processes and Natural Hazards

- Processes
  - Physical, chemical, and biological ways in which events affect Earth's surface
- Internal processes come from forces within Earth
  - Plate tectonics
  - Result of internal energy of Earth
- External processes come from forces on Earth's surface
  - Atmospheric effects
  - Energy from the Sun

Hazard, Disaster, or Catastrophe

- **Hazard**
  - Natural process or event that is a potential threat to human life or property
- **Disaster**
  - Hazardous event that occurs over a limited time in a defined area
  - Criteria:
    - Ten or more people killed
    - 100 or more people affected
    - State of emergency is declared
    - International assistance is requested
- **Catastrophe**
  - Massive disaster that requires significant amount of money or time to recover.

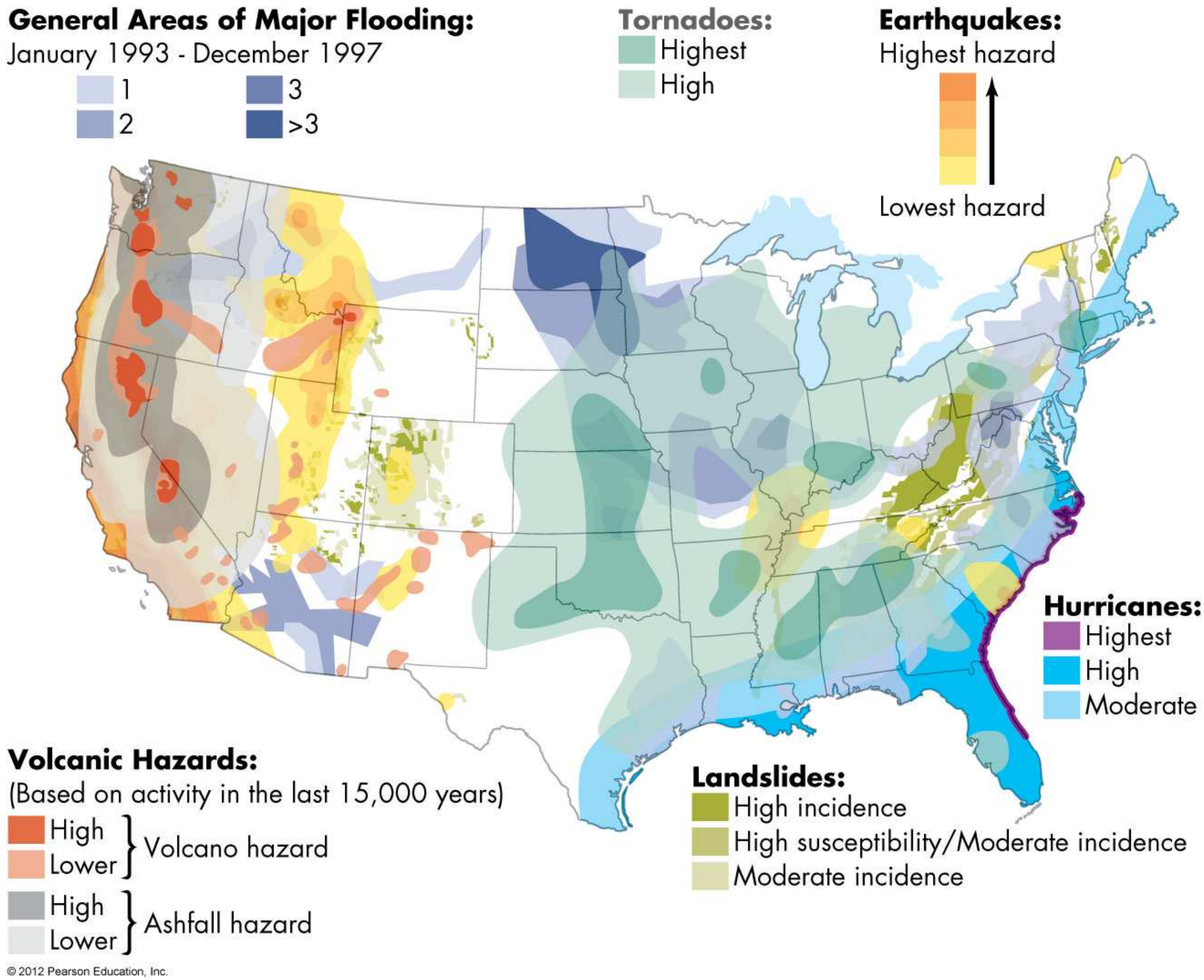
General Areas of Major Flooding:
January 1993 - December 1997
1
2
3
>3
Tornadoes:
Highest
High
Earthquakes:
Highest hazard
Lowest hazard
Hurricanes:
Highest
High
Moderate
Volcanic Hazards:
(Based on activity in the last 15,000 years)
High
Lower
Volcano hazard
High
Lower
Ashfall hazard
Landslides:
High incidence
High susceptibility/Moderate incidence
Moderate incidence
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Figure 1.3

Disaster Trends

- Recently, there has been a dramatic increase in natural disasters
  - Haitian earthquake, Indonesian tsunami, Hurricane Katrina
- United Nation 1990's "Decade for Natural Hazards Reduction"
  - Mitigation
    - Reduce the effects of something
    - Natural disaster preparation


500
450
400
350
300
250
200
150
100
50
0
Number of natural disasters
Trend
Number of natural disasters
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
Year

Figure 1.6

Death and Damage from Natural Hazards

- Effects of hazards can differ
- Those that have a great impact on human life, may not have the greatest effect on property
- Hazards vary greatly in their ability to cause catastrophe

TABLE 1.1

Effects of Selected Hazards in the United States

Hazard	Deaths per Year	Occurrence Influenced by Human Use	Catastrophe Hazard Potential
Flood	86	Yes	High
Earthquake[a]	50 + ?	Yes	High
Landslide	25	Yes	Medium
Volcano[a]	<1	No	High
Coastal erosion	0	Yes	Low
Expansive soils	0	No	Low
Hurricane	55	Perhaps	High
Tornado and windstorm	218	Perhaps	High
Lightning	120	Perhaps	Low
Drought	0	Perhaps	Medium
Frost and freeze	0	Yes	Low
Heat wave	10s to 100s	Yes	High
Wildfire[b]	<10	Yes	High
Extraterrestrial impact	0	No	Very high

[a] Estimate based on recent or predicted loss over 150-year period. Actual loss of life and/or property could be much greater.

[b] Deaths mostly firefighters.

Source: Modified after White, G. F., and Haas, J. E. 1975. Assessment of research on natural hazards. Cambridge, MA: MIT Press.

Table 1.1

Role of History in Understanding Hazards

- Natural hazards are repetitive

- History of an area gives clues to potential hazards
  - Maps, historical accounts, climate and weather data
  - Rock types, faults, folds, soil composition

Geologic Cycle

- Geologic conditions govern the type, location, and intensity of natural processes
- All processes are called geologic cycle
- Subcycles:
  - Tectonic cycle
  - Rock cycle
  - Hydrologic cycle
  - Biogeochemical cycle

Tectonic Cycle

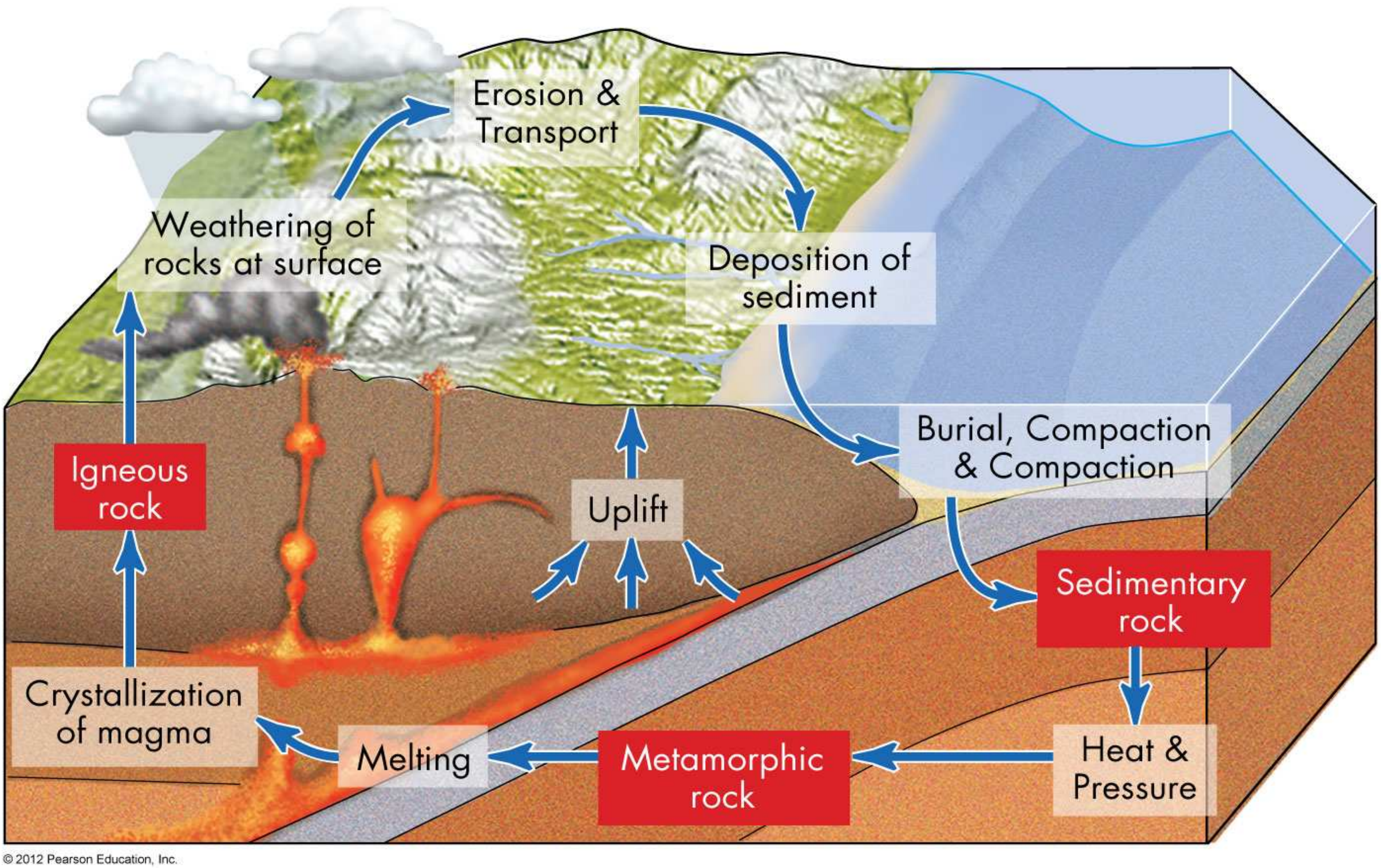
- Refers to large-scale processes that deform Earth's crust and produce landforms
- Driven by forces within Earth
- Involves the creation, destruction, and movement of tectonic plates

Rock Cycle

- Rocks are aggregates of one or more minerals
- Different rocks are formed by different processes
- Recycling of earth materials
- Rock cycle is linked to all other cycles
  - Energy comes from tectonic cycle
  - Water for erosion and weathering from hydrologic cycle
  - Minerals from biogeochemical cycle

Rock Cycle, cont.

- Igneous rocks
  - Form from crystallization of magma
- Sedimentary rocks
  - Rocks are weathered into sediment by wind and water
  - Deposited sediment is lithified into sedimentary rocks
- Metamorphic rocks
  - Rocks are changed through extreme heat, pressure or chemically active fluids



Erosion &
Transport
Weathering of
rocks at surface
Deposition of
sediment
Burial, Compaction
& Compaction
Igneous
rock
Uplift
Sedimentary
rock
Crystallization
of magma
Melting
Metamorphic
rock
Heat &
Pressure
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Figure 1.7

Hydrologic Cycle

- Solar energy drives movement of water between atmosphere and oceans and continents
- Processes include: evaporation, precipitation, surface runoff, and subsurface flow
- Water is stored in compartments such as oceans, atmosphere, rivers, stream, etc
  - Residence time is estimated average time that a drop of water spends in any compartment
  - Only a small amount of water is active at any given time

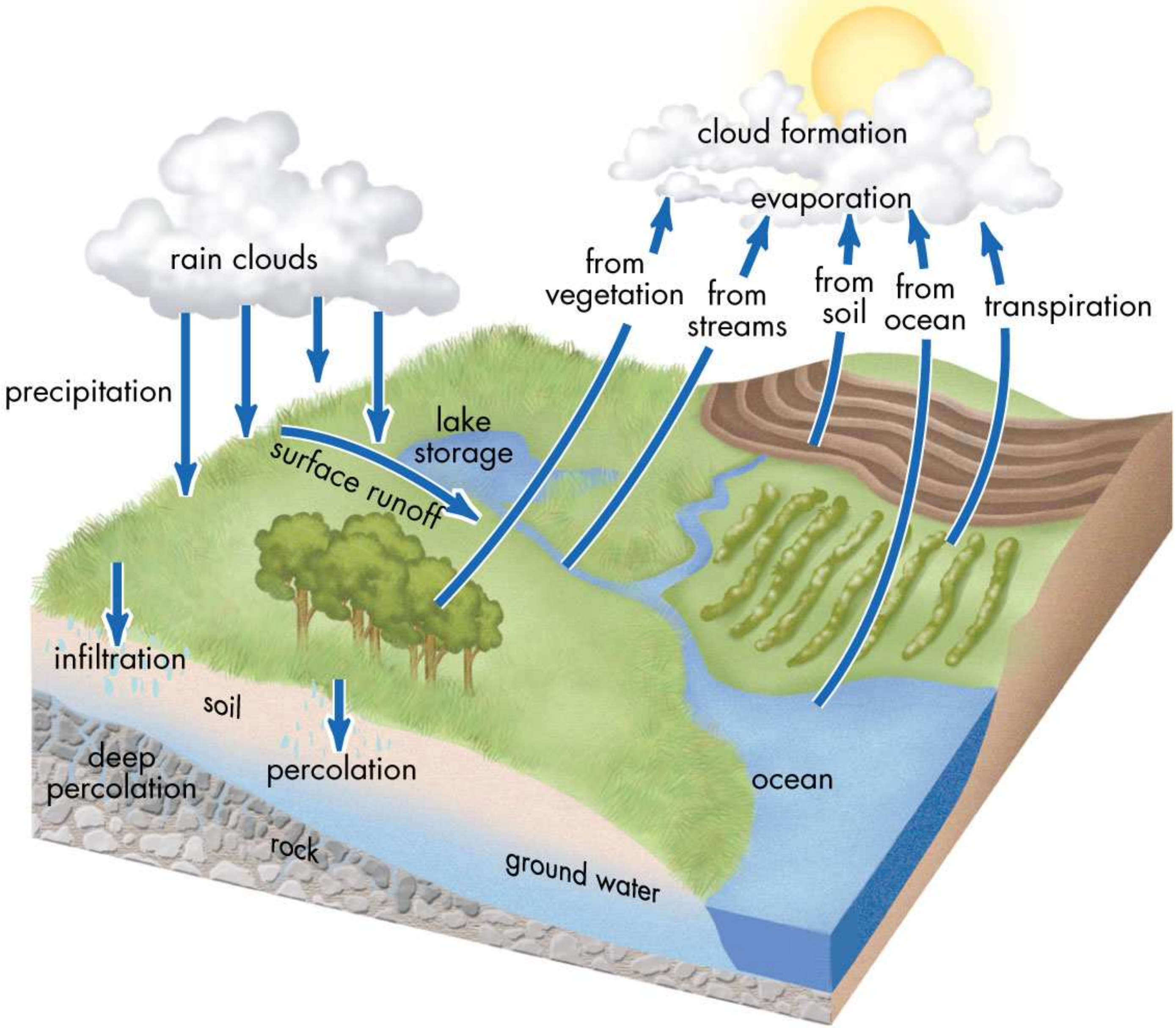
rain clouds
precipitation
surface runoff
lake storage
cloud formation
evaporation
from vegetation
from streams
from soil
from ocean
transpiration
infiltration
soil
deep percolation
percolation
rock
ground water
ocean

Figure 1.8

TABLE 1.2

The World's Water Supply (Selected Examples)

Location	Surface Area (km^2)	Water Volume (km^2)	Percentage of Total Water	Estimated Average Residence Time
Oceans	361,000,000	1,230,000,000	97.2	Thousands of years
Atmosphere	510,000,000	12,700	0.001	9 days
Rivers and streams	—	1200	0.0001	2 weeks
Groundwater; shallow	130,000,000	4,000,000	0.31	Hundreds to many thousands of years to depth of 0.8 km
Lakes (freshwater)	855,000	123,000	0.009	Tens of years
Ice caps and glaciers	28,200,000	28,600,000	2.15	Up to tens of thousands of years and longer

Source: Data from U.S. Geological Survey.

Table 1.2

Biogeochemical Cycle

- Combines the three previous cycles
- Transfer of chemical elements through a series of reservoirs
- Many important chemical elements are not well understood
  - Carbon, Nitrogen, Phosphorus

Fundamental Concepts for Understanding Natural Processes as Hazards

1. Hazards are predictable from scientific evaluation
2. Risk analysis is an important component in our understanding of the effects of hazardous processes
3. Linkages exist between different natural hazards as well as between hazards and he physical environment
4. Hazardous events that previously produced disasters are now producing catastrophes
5. Consequences of hazards can be minimized

1. Hazards Are Predictable From Scientific Evaluation: Science and Natural Hazards

- Science is body of knowledge that has resulted from investigations and experiments

- Scientific Method
  - Formulation of a question
  - Hypothesis is a possible answer to a question and is testable
  - Data is taken to test the hypothesis

- Scientific investigation has improved understanding of natural disasters

1. Hazards Are Predictable From Scientific Evaluation: Hazards are Natural Processes

- They are a result of natural forces
- They become hazardous when people live or work near the hazard or when human activities amplify their effects
- It is possible to control some of these processes to some degree
  - Most are NOT within our control
- Best solution is preparation

1. Hazards Are Predictable From Scientific Evaluation: Forecast, Prediction, and Warning

- Uniformitarianism
  - “The present is the key to the past”
  - Processes that are happening today have happened in the past

- Human interaction has an effect on geologic processes
  - “The present is the key to the future”
  - Actions of people today may affect hazards for the future

- Environmental Unity
  - One action causes others in a chain of actions and events

1. Hazards Are Predictable From Scientific Evaluation: Forecast, Prediction, and Warning, cont. 1

- **Prediction**
  - Specific date, time, and magnitude of event

- **Forecast**
  - Range of probability for event

- Some hazards can be predicted; most can be forecasted

1. Hazards Are Predictable From Scientific Evaluation: Forecast, Prediction, and Warning, cont. 2

- Identify the location of probable event
  - Most hazardous areas are mapped
  - Example: volcanoes and earthquake events are located

- Determine probability of event
  - Estimated based on past events and current conditions

- Observe precursor events
  - Events that precede a hazardous event
  - Example: earthquakes often precede volcanic eruptions

1. Hazards Are Predictable From Scientific Evaluation: Forecast, Prediction, and Warning, cont. 3

- Forecast or predict event
  - Forecast gives probability of event
  - Prediction will give a specific arrival time for events
- Warning the public
  - Involves statements to media and public at large

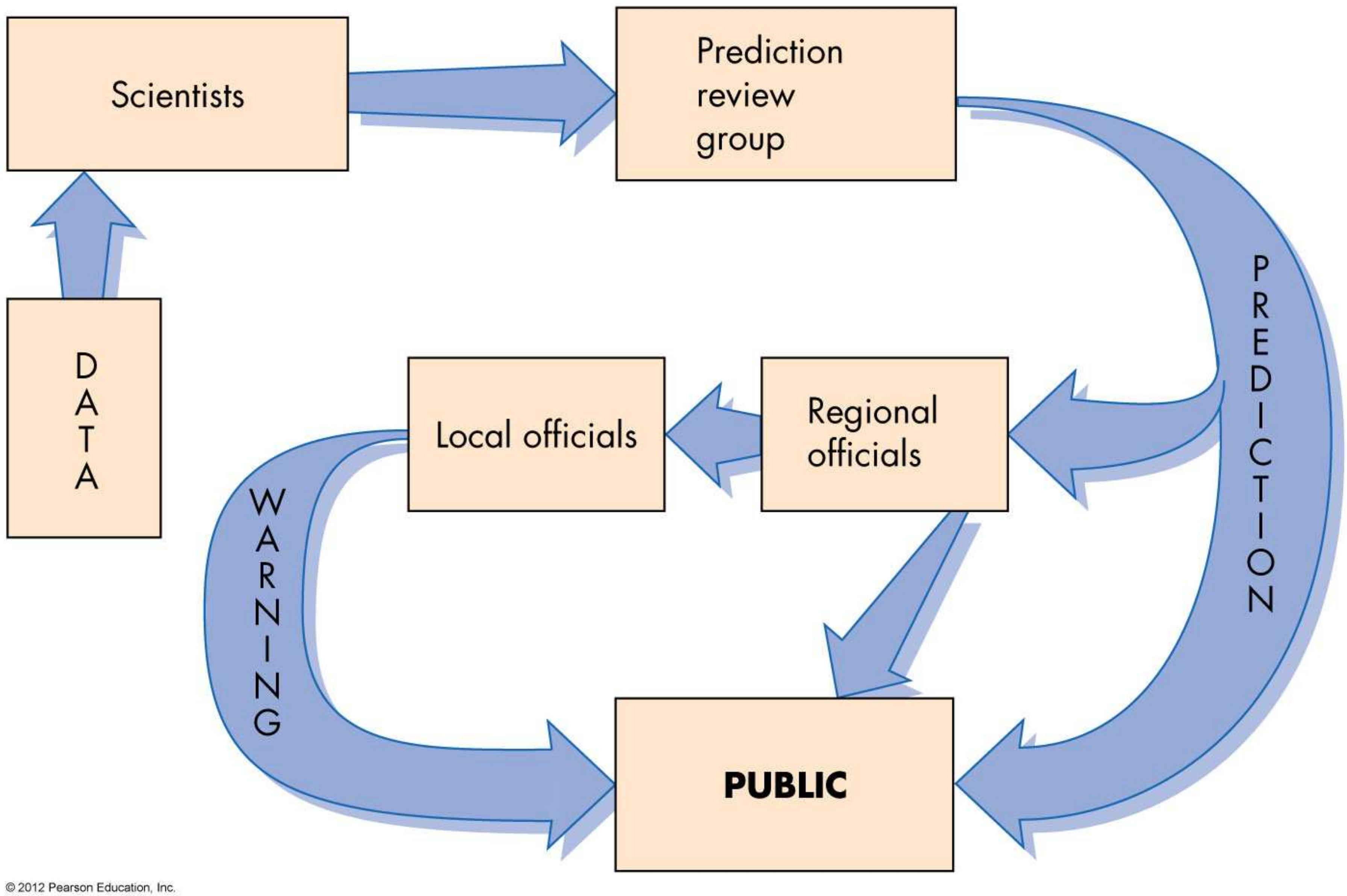
Scientists
Prediction review group
D A T A
Local officials
Regional officials
W A R N I N G
P R E D I C T I O N
PUBLIC
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Figure 1.10

2. Risk Analysis

- **Risk** = (probability of event) x (consequences)
- Consequences: damages to people, property, economics, etc.
- **Acceptable Risk** is the amount of risk that an individual or society is willing to take
- Often there is a lack of data of either the probability of the event or the magnitude of the consequences

3. Linkages

- Hazards are linked to each other
  - Some events may cause others
    - Example: Earthquakes and Landslides
- Physical environment is linked to hazards
  - Example: Some rock types are prone to subsidence

4. Disasters Are Now Becoming Catastrophes: Human Population Growth

- World's population has more than tripled in the past 70 years
  - Population bomb
- Population grows exponentially
  - Grows by the addition of a constant percentage of the current population
- Increases exposure to hazards, increased pollution, reduced availability of food and clean drinking water, and a greater need for waste disposal

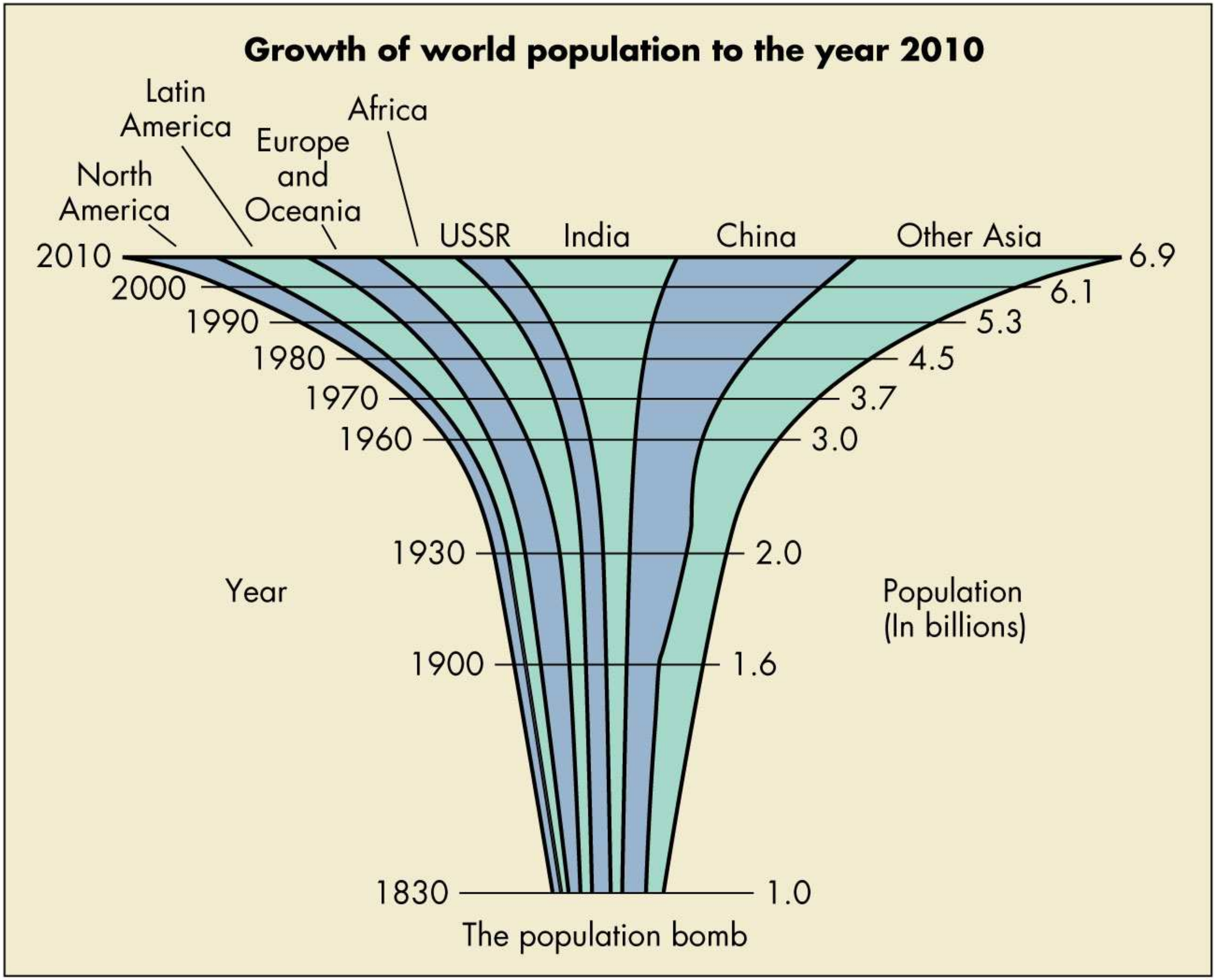

Growth of world population to the year 2010
Latin America
Africa
Europe and Oceania
North America
USSR
India
China
Other Asia
2010
2000
1990
1980
1970
1960
1930
1900
1830
6.9
6.1
5.3
4.5
3.7
3.0
2.0
1.6
1.0
Year
Population (In billions)
The population bomb

Figure 1.11

4. Disasters Are Now Becoming Catastrophes: Magnitude and Frequency of Hazards

- Impact of hazards depend on:
  - Magnitude
    - Amount of energy released
  - Frequency
    - Interval between occurrences
  - Other factors, including climate, geology, vegetation, population, and land use

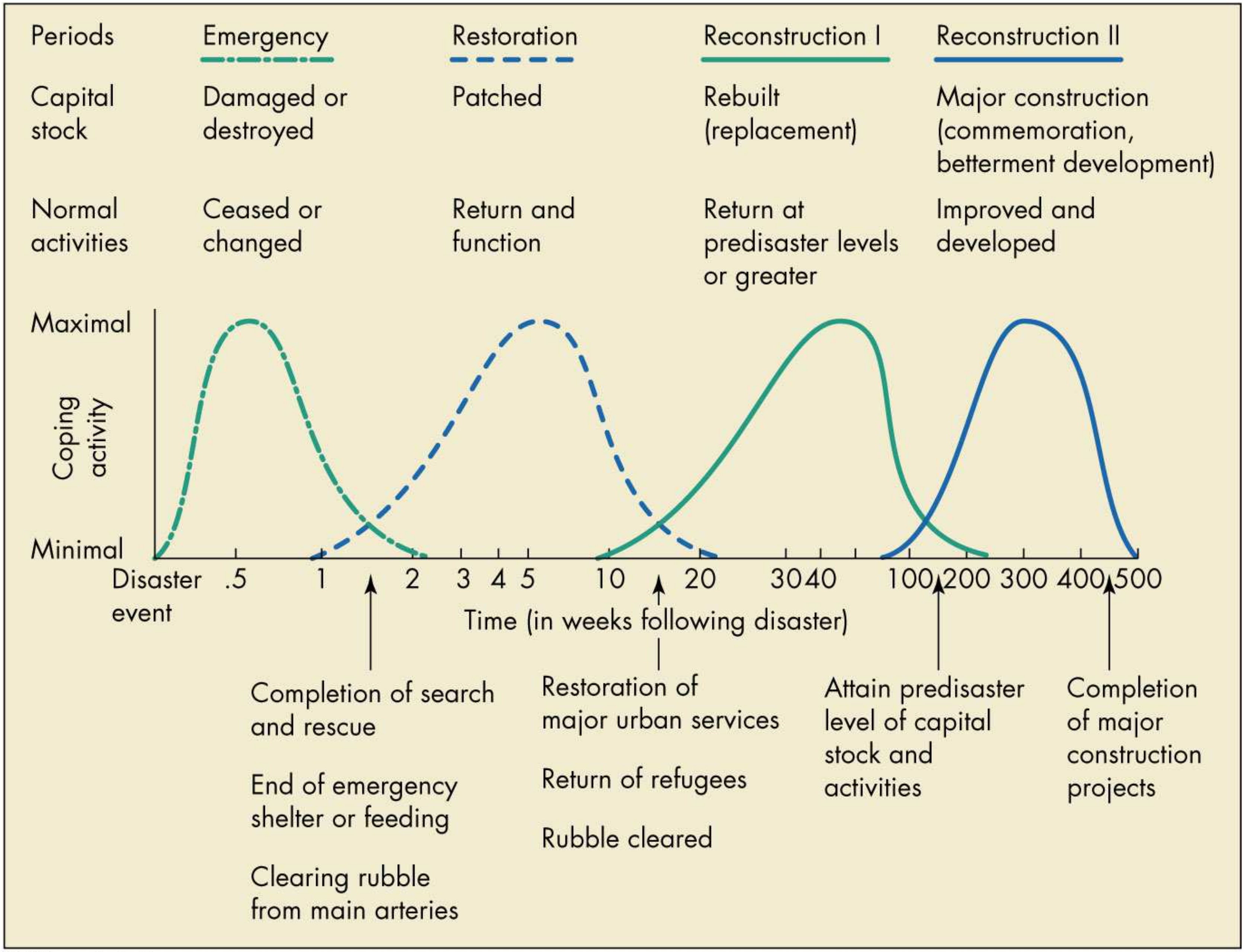
- Human population growth puts greater demand on Earth’s resources

- Land use affects magnitude and frequency of events

5. Consequences Can Be Minimized: Reactive Response

- Effects from a disaster can be
  - Direct, i.e. people killed, buildings damaged, etc.
  - Indirect, responses to disaster, i.e., emotional distress.

- Recovery from disaster
  - Emergency work
  - Restoration of services and communication lines
  - Reconstruction



Periods
Emergency
Restoration
Reconstruction I
Reconstruction II
Capital stock
Damaged or destroyed
Patched
Rebuilt (replacement)
Major construction (commemoration, betterment development)
Normal activities
Ceased or changed
Return and function
Return at predisaster levels or greater
Improved and developed
Maximal
Coping activity
Minimal
Disaster event
.5
1
2
3
4
5
10
20
30
40
100
200
300
400
500
Time (in weeks following disaster)
Completion of search and rescue
End of emergency shelter or feeding
Clearing rubble from main arteries
Restoration of major urban services
Return of refugees
Rubble cleared
Attain predisaster level of capital stock and activities
Completion of major construction projects

Figure 1.12

5. Consequences Can Be Minimized: Anticipatory Response

- Avoiding and adjusting to hazards
  - Changing people’s perception of hazard
  - Land-use planning
  - Building codes
  - Insurance
  - Evacuation
  - Disaster preparedness
  - Artificial control

Natural Service Function

- There are some benefits to hazards

- Examples:
  - Flooding provides nutrients for soil
  - Landslides form dams to create lakes
  - Volcanoes create new land

Global Climate Change

- Global climate change is likely to change the incidence of some natural hazards
  - Sea-level rise increases coastal erosion
  - Deserts and semiarid regions are likely to expand
  - Warmer ocean water is likely to increase storm activity

End

Introduction to Natural Hazards

Chapter 1