

## Systems Thinking & Problem Solving:

(Understanding Our Most Important Messes)

Loops with Delays, The Product Life Cycle "S-Curve"  
Shifting Loop Dominance, Customer Service, Easter Island

MGM315 11/12/03

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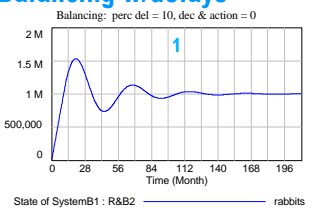
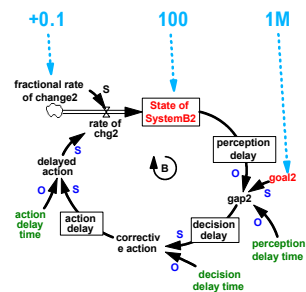
## Problems with "repair service" behavior

- In medical situations, the most seriously wounded are no longer screaming
- We may solve the obvious problems, but not the most important problems
- We may solve the problems we're competent to solve, but not the most important problems
- We may ignore more important problems that are small now, but will emerge later

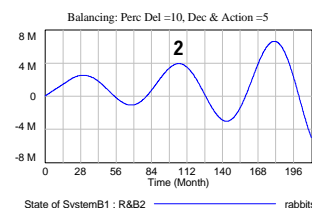
## Loop with Delays

## Basic Feedback Loops - Balancing w/delays

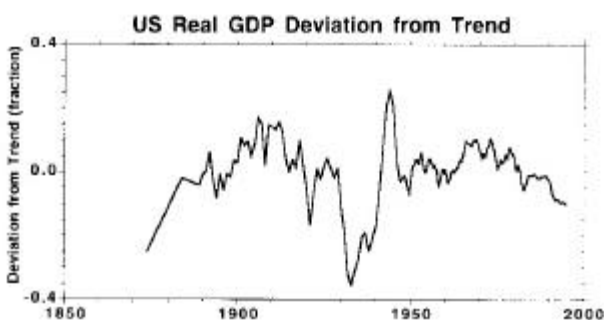
1. Delays: Perc 10, Dec 0, Action 0



2. Delays: Perc 10, Dec 5, Action 5



## Balancing Loop Oscillation: GDP Deviation



## Balancing Loop Oscillation: U.S. Mfg'g Capacity Utilization

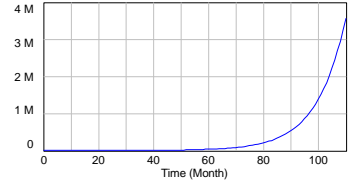
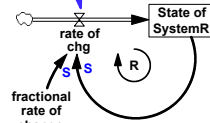


## Balancing Loop Oscillation: U.S. Employment Rate



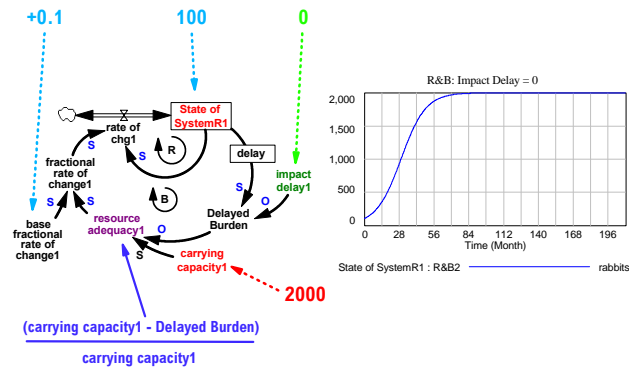
## First We Looked at Reinforcing (positive) Feedback

fractional rate of change \* State of System R

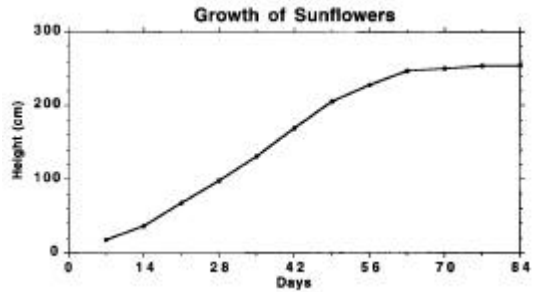


What if, as we grow,  
the rate of change  
becomes limited?

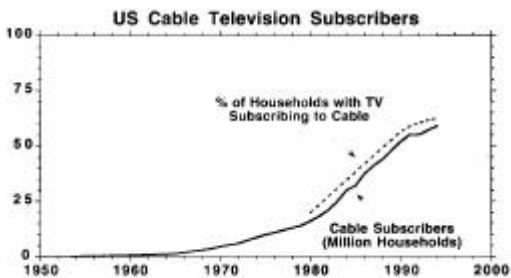
## Combining Feedbacks - Limits to Growth



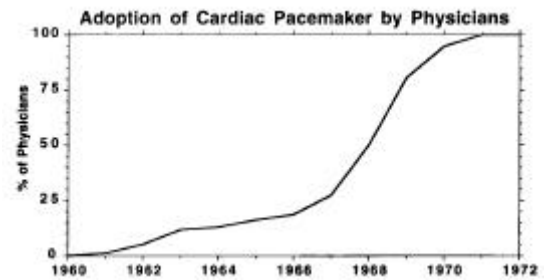
## Limits to Growth: Growth of Sunflowers



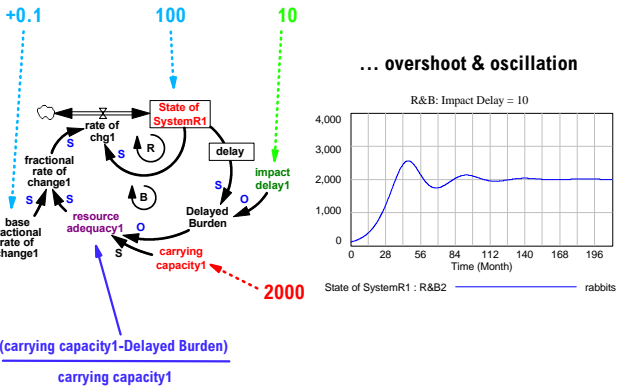
## Limits to Growth: Cable TV Subscribers



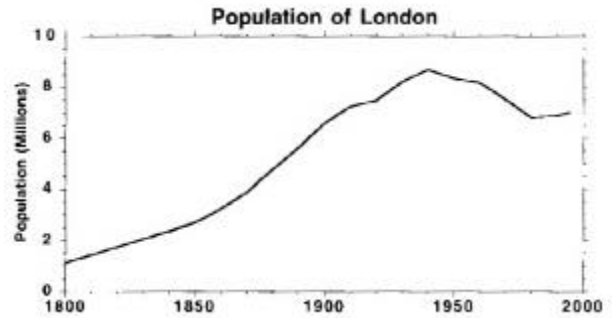
## Limits to Growth: Pacemaker Adoption



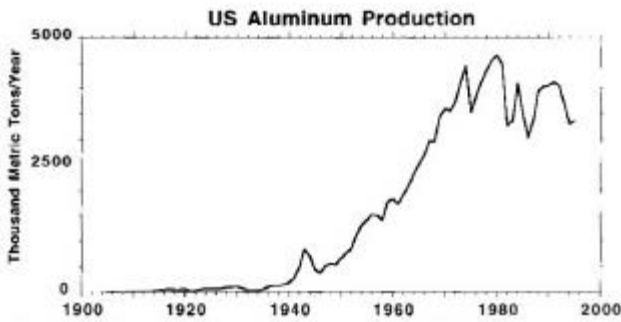
## Combining Feedbacks - Limits to Growth with delay resulting in ... ???



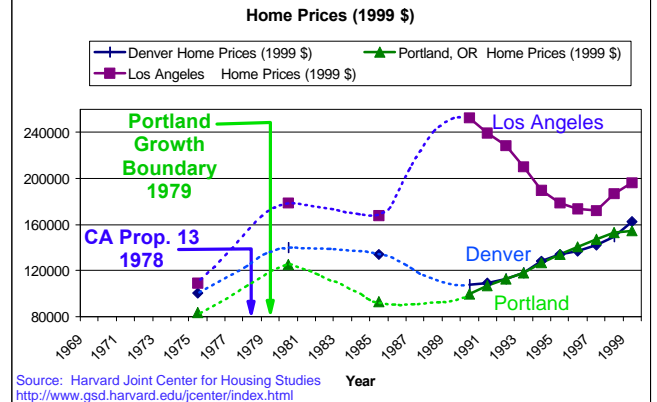
## Limits to Growth Overshoot & Oscillation: London Population



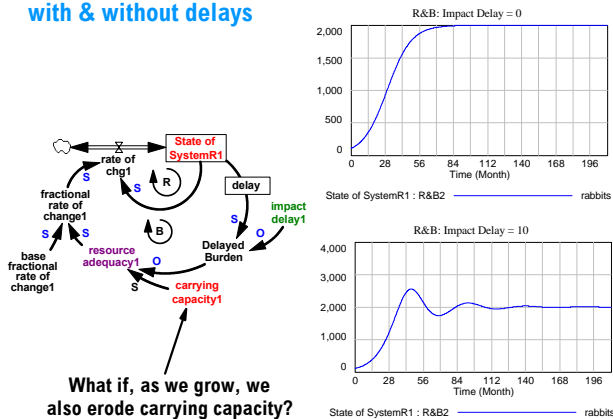
## Limits to Growth Overshoot & Oscillation: U.S. Aluminum Prod.



## Limits to Growth Overshoot & Oscillation: Home Prices

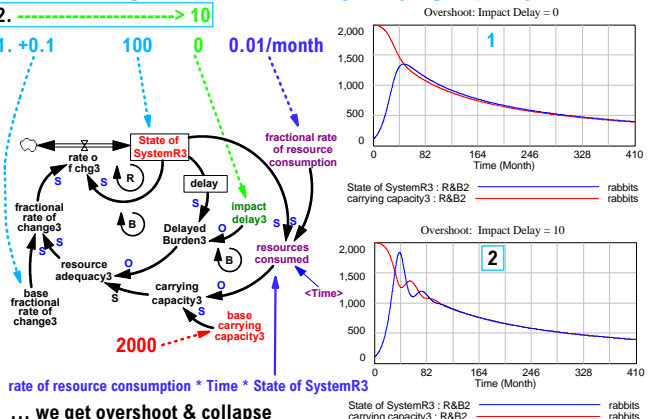


## Last We Looked at "limits to growth" with & without delays



What if, as we grow, we also erode carrying capacity?

## Combining Feedbacks: eroding carrying capacity?



... we get overshoot & collapse

### Overshoot & Collapse: Fish Catch & Atari Sales



### Overshoot & Collapse: Nuclear Power & Silver Prices



### Basic Growth Dynamics: The Product Life Cycle "S-Curve" & Customer Service

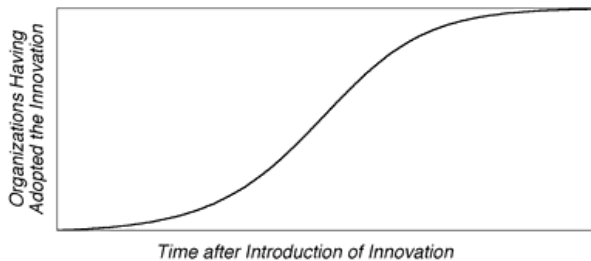
### Success and failure

- "To create realistic and useful models of product diffusion and innovation adoption, you must explicitly portray the feedback structure of adoption and growth,
- ... including the sources of attractiveness for the new idea or product, the competition, technical innovation, changing criteria of use and other factors that influence adoption and growth.
- Only models that capture the causal structure of the system will respond accurately as conditions change and policies are implemented."

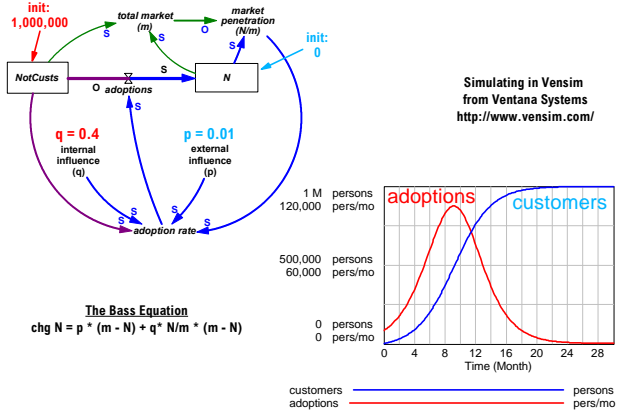
John Sterman  
*Business Dynamics, 2000*

### Bass Formula and Curve

$$N_t = N_{t-1} + p(m - N_{t-1}) + q \frac{N_{t-1}}{m} (m - N_{t-1})$$



### The Bass Model





## Escaping Old Ideas

- "Our problems are not so much in finding new ideas as in escaping from old ones."

John Maynard Keynes

## Computers in the Home?

- "There is no reason any individual would want a computer in their home."

Ken Olson, president, chairman and founder of Digital Equipment Corporation, 1977

## The Computer Market

- "I think there is a world market for about five computers."

Thomas J. Watson, chairman of IBM, 1943

## A Long Habit of Thinking

- "A long habit of not thinking a thing wrong, gives it a superficial appearance of being right."

Thomas Paine

## Famous Last Words

- "Heavier-than-air flying machines are impossible."
  - Lord Kelvin, British mathematician, physicist, and president of the British Royal Society, c. 1895
- "With over fifty foreign cars already on sale here, the Japanese auto industry isn't likely to carve out a big slice of the U.S. market for itself."
  - Business Week, 8/2/68
- "A severe depression like that of 1920 - 1921 is outside the range of probability."
  - The Harvard Economic Society, 8/16/29
- "We don't like their sound. Groups of guitars are on their way out."
  - Decca Recording Co. executive, turning down the Beatles in 1962
- "The phonograph ... is not of any commercial value."
  - Thomas Alva Edison, inventor of the phonograph, c. 1880
- "No matter what happens, the U.S. Navy is not going to be caught napping."
  - Frank Knox, Secretary of the Navy, 12/4/41, just before the Japanese attack on Pearl Harbor
- "They couldn't hit an elephant at this dist . . ."
  - General John B. Sedgwick, last words, Battle of Spotsylvania. 1864

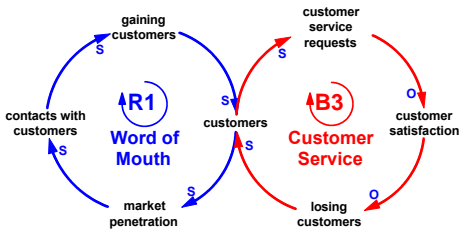
Source: C. Cerf and V. Navasky, *The Experts Speak* (New York: Pantheon Books, 1984).  
As quoted by Paul Shoemaker in "Scenario Planning:  
A tool for Strategic Thinking," *Sloan Management Review*, Winter 1995

## Reacting to Symptoms

- "Managers continually find themselves drawn into reacting to symptoms."
  - Frequently, problems are defined by their symptoms.
  - In most organizations the pressures for immediate management intervention far outweigh the understanding to guide intervention wisely.
  - While the willingness to tackle important problems is a necessary characteristic of effective leadership,
  - ... the wise leader appreciates that efforts to manipulate problem symptoms are rarely successful in complex systems."

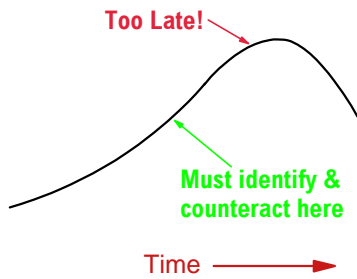
Peter M. Senge

## Dominance Shifts from Sales to Customer Service Due to an Increasing Customer Base

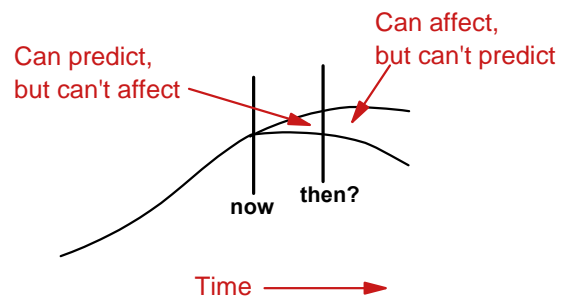


## Forecasting

## When to Identify What Will Limit Growth?

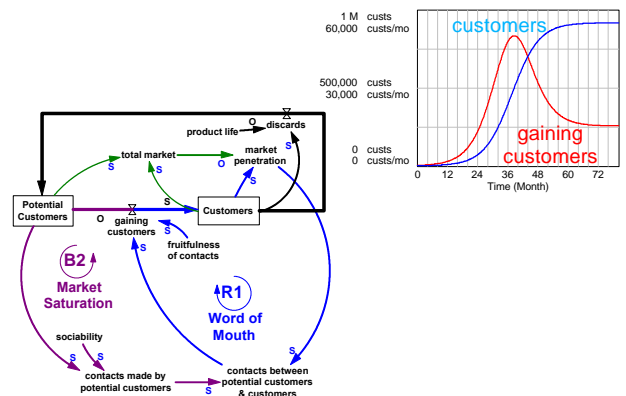


## The Problem With Projections Based on Trends

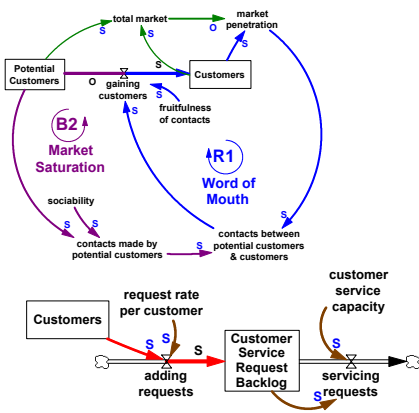


## Adding Product Replacement, and Shifting Loop Dominance to Customer Service

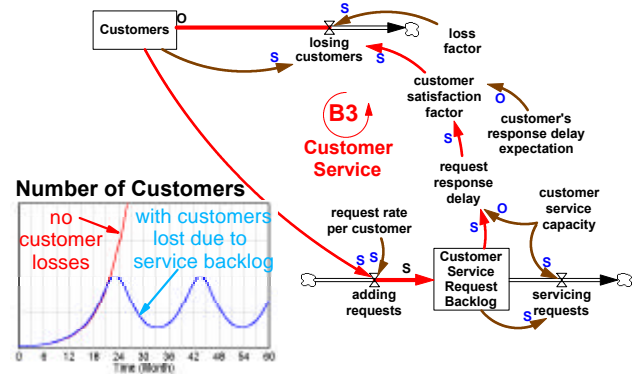
## Product Discard & Replacement



## Considering Customer Service Demand

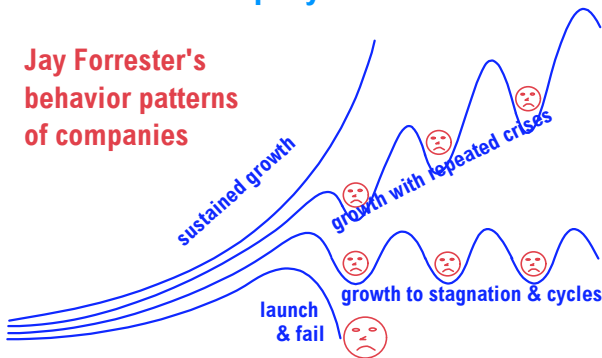


## Poor Customer Service Drains Customers



## Patterns of Company Evolution

### Jay Forrester's behavior patterns of companies



**"CEO's of major corporations lose their jobs at rates never before seen."**

Lester Thurow, *The Future of Capitalism*, 1996, p. 19

## Easter Island

## Easter Island

- "... one of the most remote spots on earth, is a small island of about 160 km<sup>2</sup> located in the eastern Pacific. Easter Island is most famous for the giant stone statues, known as moai, that dot the island. ... prior to the arrival of the first humans, Easter Island was lushly forested and supported a diverse set of fauna, particularly birds. However, as the human population grew, the forests were progressively cut to provide wood and fiber for boats, structures, ropes, and tools, as well as to provide firewood."

John Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, 2000

## Easter Island (cont'd)

- "There is clear stratigraphic evidence that soil erosion increased with deforestation as rain washed away the unprotected soil. Without tree cover, wind speeds at ground level increased, carrying still more valuable soil into the sea. The erosion was so severe that sediment washed from the higher elevations eventually covered many of the moai, so that European visitors thought the giant statues were just heads, when in fact they were complete torsos averaging 20 feet in height."

John Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, 2000

## Easter Island (cont'd)

- "The overshoot and collapse of Easter Island is but one of many similar episodes documented in the history of island biogeography. In each case, population growth led to deforestation, the extinction of native species, and unfavorable changes in local climate, rainfall, and agricultural productivity, followed by starvation, conflict, and, often, population collapse."

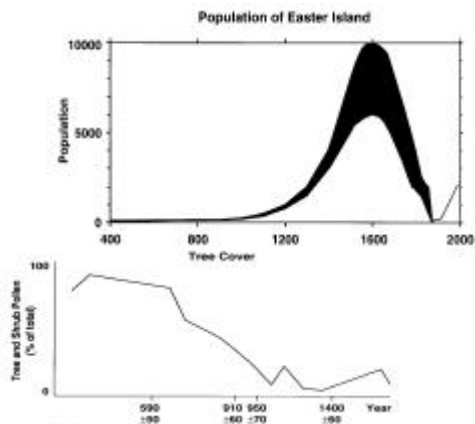
John Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, 2000

## Easter Island (cont'd)

- "A precipitous decline in population had set in by about 1680, accompanied by major changes in social, political, and religious structures. Spear points and other tools of war appeared for the first time, and there is evidence of large battles among competing groups. Some scholars believe there is evidence of cannibalism during this period."

John Sterman, *Business Dynamics: Systems Thinking and Modeling for a Complex World*, 2000

## Easter Island



## To Progress or Not ... ?

"Progress ... depends on retentiveness ... when experience is not retained, as among savages, infancy is perpetual. Those who forget the past are condemned to repeat it."

George Santayana, *Life of Reason*, Vol. 1, Ch. 12 (1905)

## The "teacher's fallacy"

- "The belief that if people know something and you keep telling them ...
  - ... it will translate into sustained behavior change."

from *Changing for Good*  
by John C. Norcross  
Professor of psychology, U. of Scranton, PA

## Bliss

- "Ignorance is bliss."
  - ... Enjoy it while you can."

Michael Grishaver  
*All I Really Need to Know I Learned in Junior High*

## The World's Problems

- "The problems we have created  
in the world today will not be solved  
by the level of thinking  
that created them."

Albert Einstein

## Technology

- "The machine does  
not isolate man from the  
great problems of nature,  
but plunges him  
more deeply into them."

Antoine de Saint-Exupery, *Wind, Sand and Stars*

## Common Sense

- "Common sense is a  
bundle of prejudices we  
develop before the age of 18."

Albert Einstein