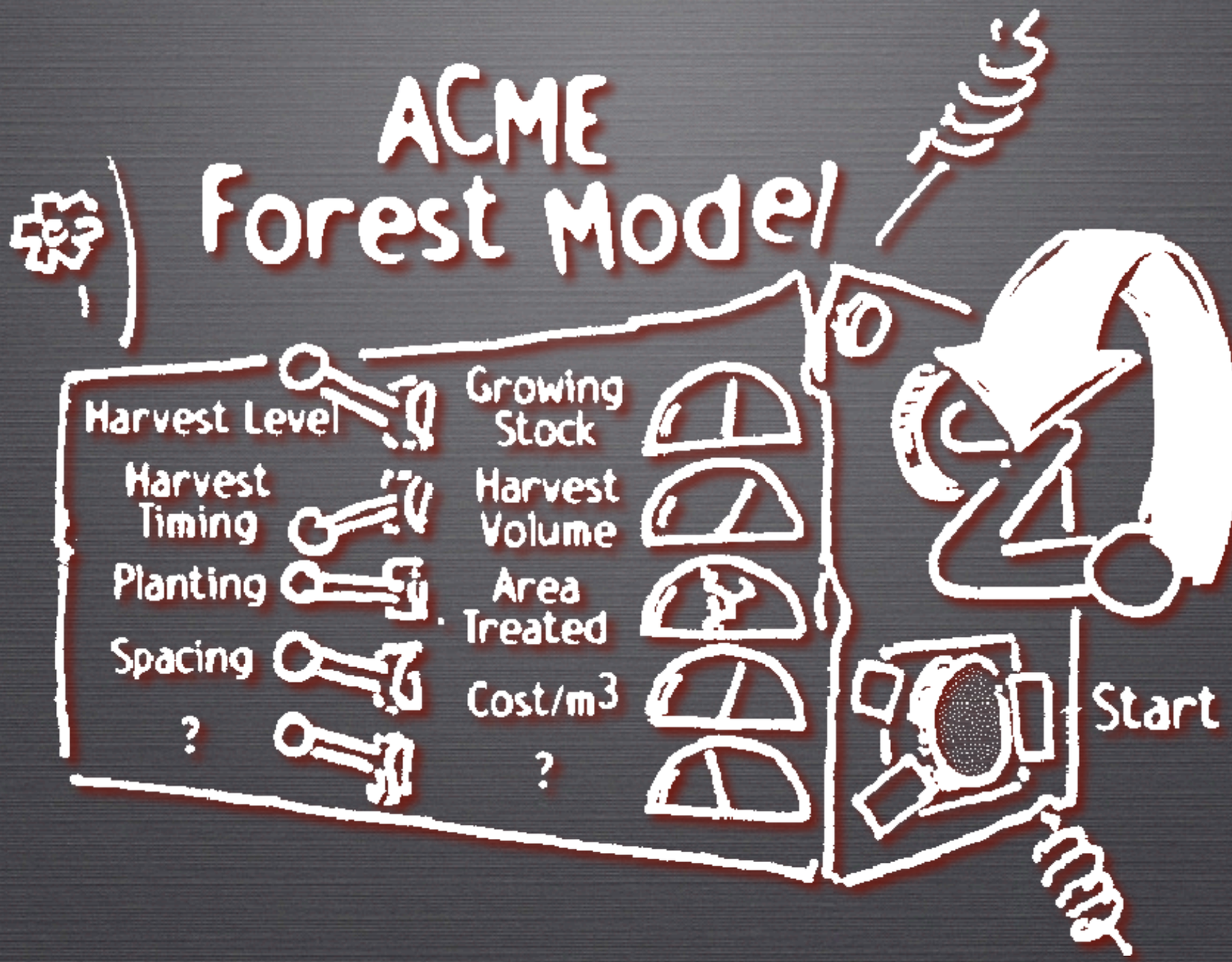
COMPLEXITY & UNCERTAINTY

Don Morgan, MFR Research Branch

CLIMATE CHANGE ADAPTATION ISSUES

- Complexity, forests are a complex system
- Uncertainty, ecological and management interactions, shifts in disturbance regimes and ecological community reorganization
- Accelerated Rate of Change, the climate has always changed, however the current rate of change exceeds historic climatic trends and is likely to overwhelm the capacity for some species to adapt both temporally and spatially.

Mental Models



Mental models (metaphors)

- Framework or general narrative
- Underlie much thinking, reasoning, language
- Enable us to conceptualize complex or subjective situations by projecting concrete elements of experience
  - e.g. fairness = (physical) balance
- Mostly unconscious

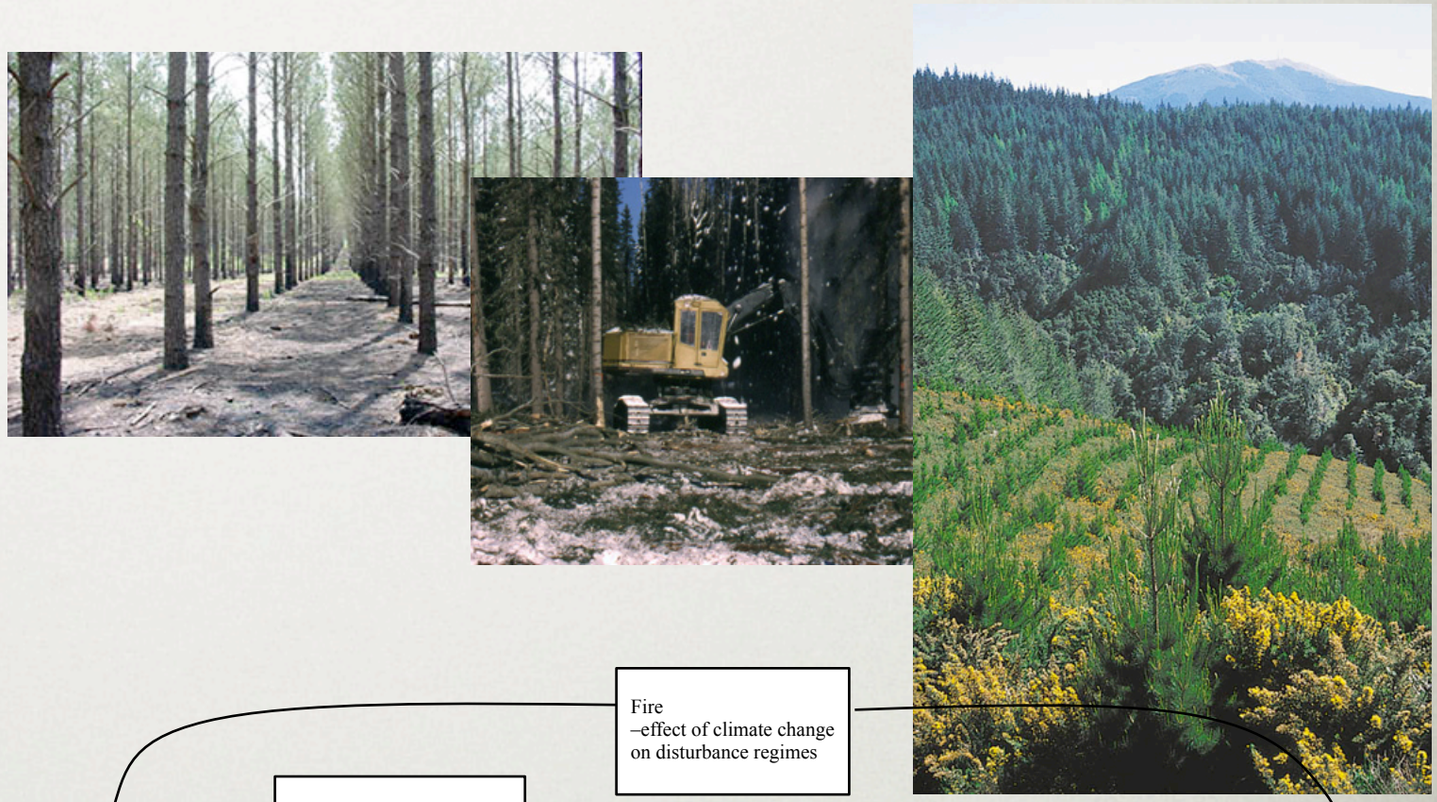
Why mental models?

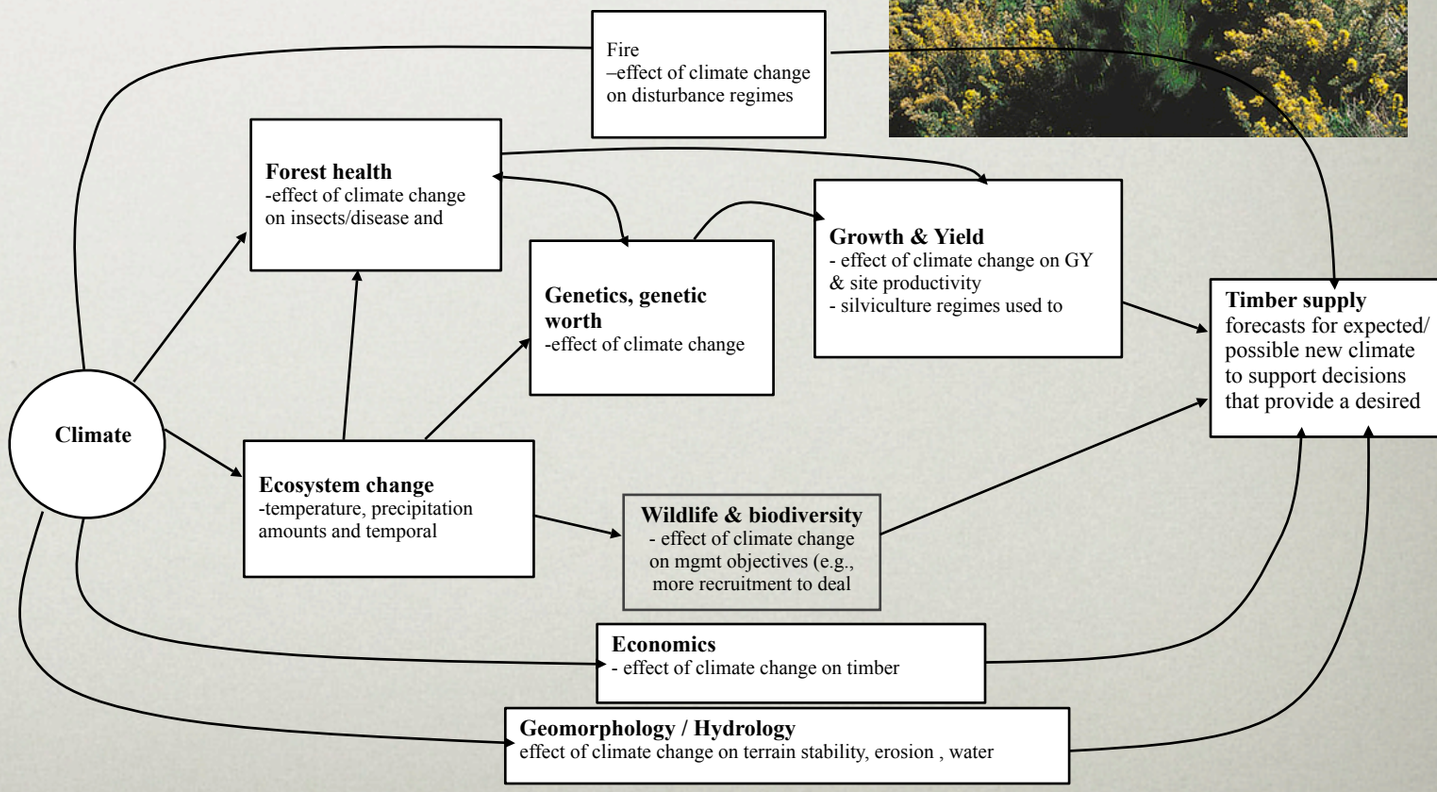
- Is our current thinking limiting adaptation?
  - our understanding of the situation facing us
  - possible responses

- Open up to a broader set of possibilities that enhance our adaptive capability

Mental models in forestry

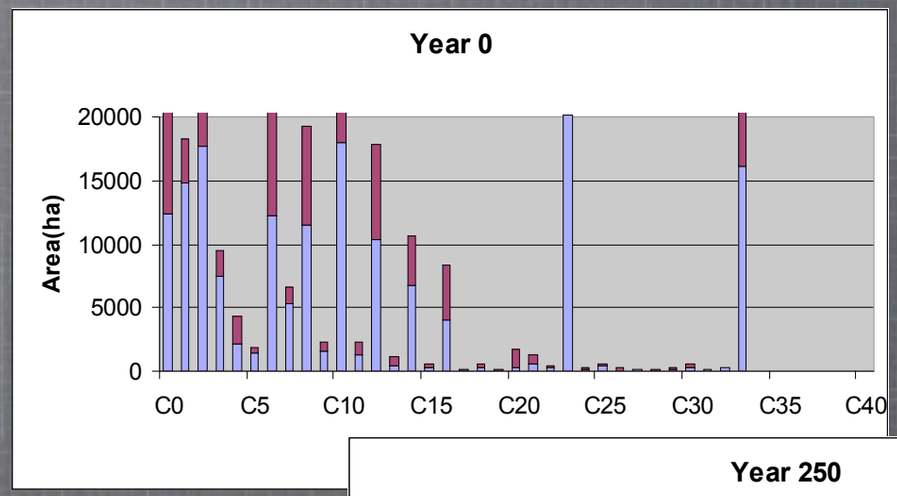
- Farming
- Machine or structure
- Electrical circuit / system
- Etc.

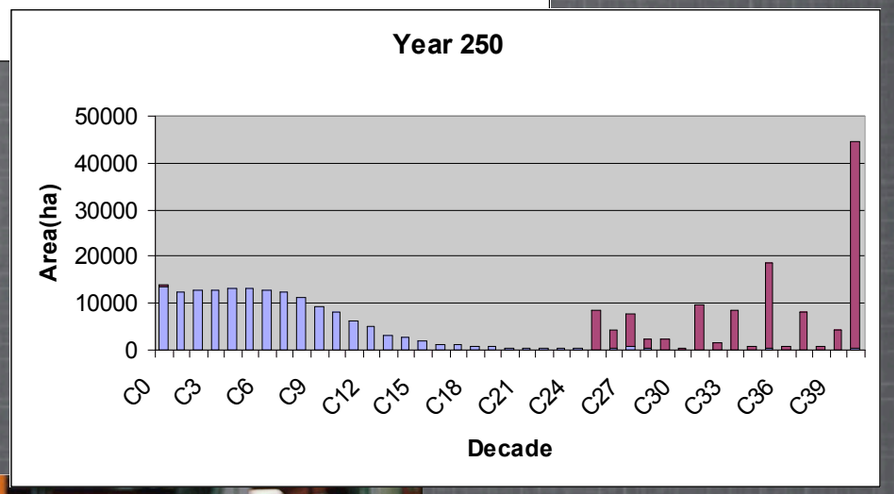


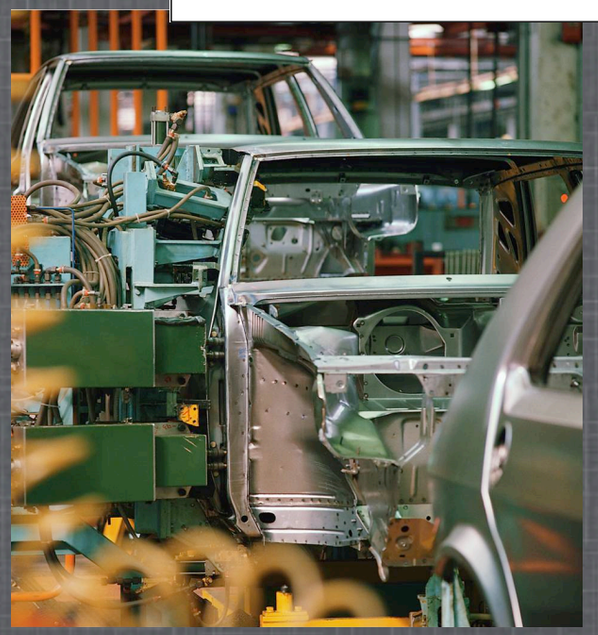


CONVENTIONAL APPROACH

- Certainty:
  - Data Collection
  - Analysis
  - Models
- Efficiency
  - Maximizing Supply
  - Minimizing Regret

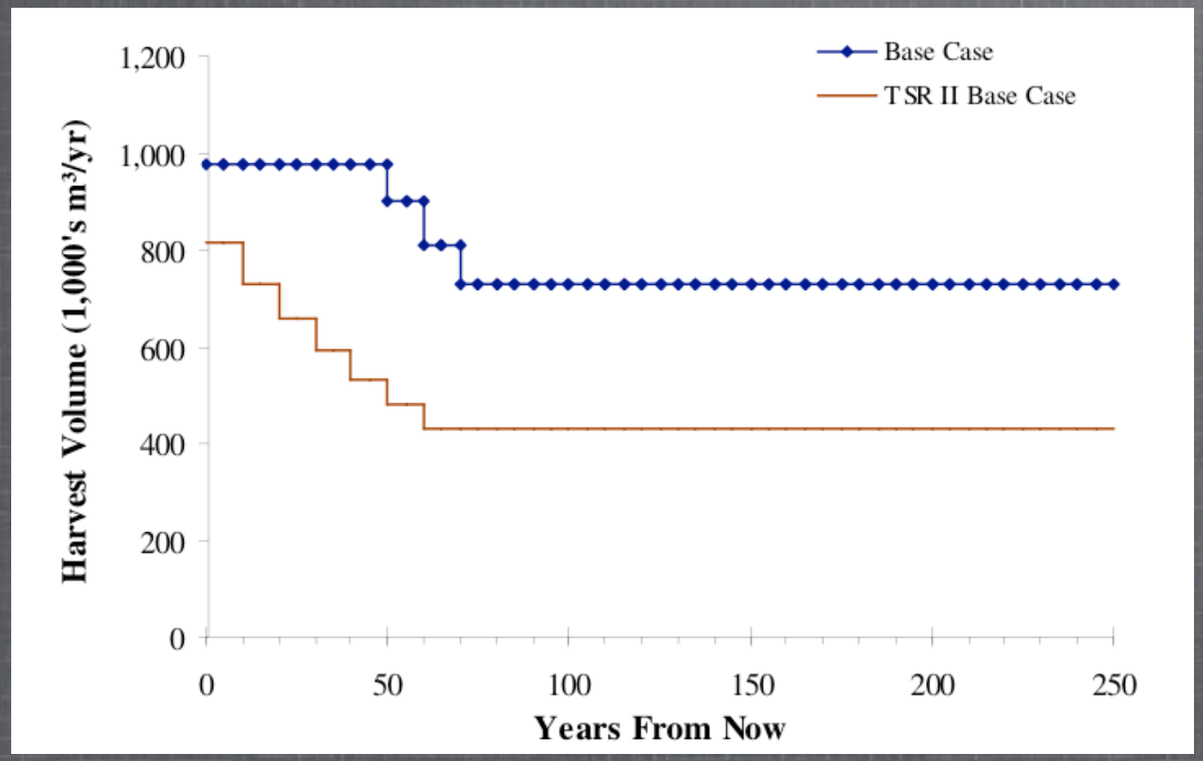


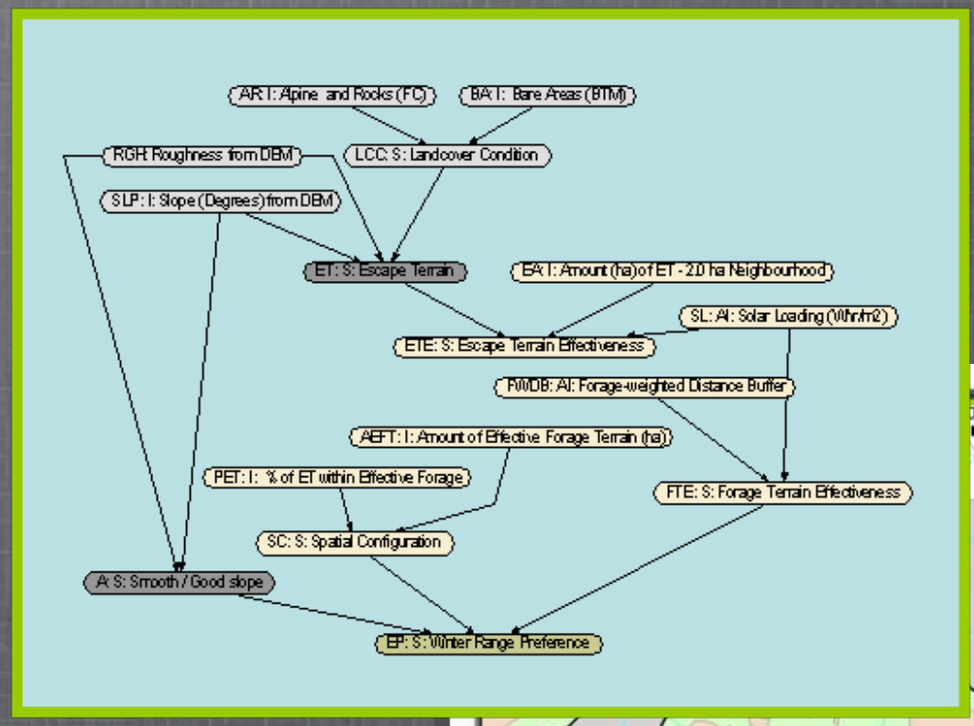




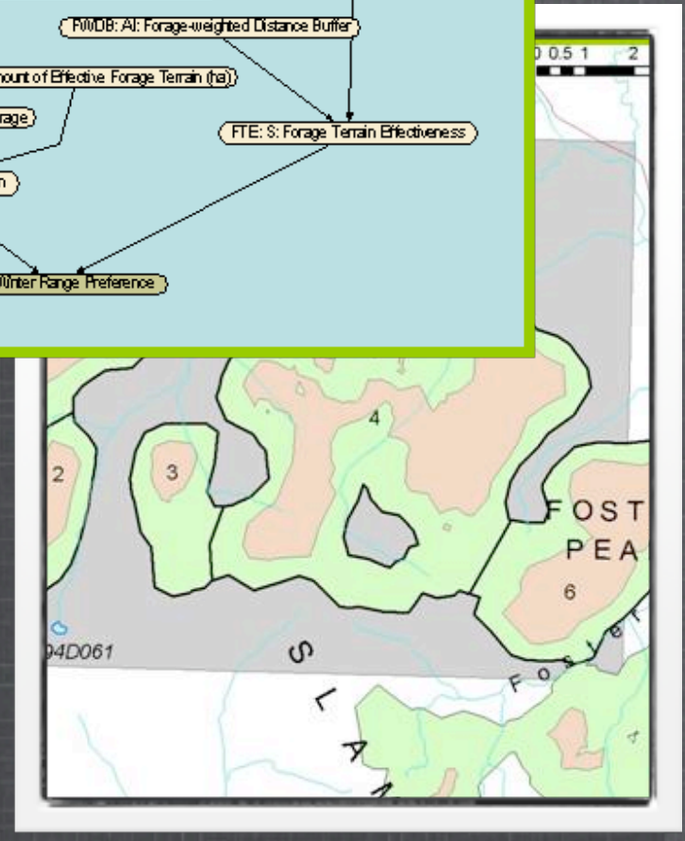
MANAGING THE SUPPLY OF ECOSYSTEM SERVICES

Timber Supply





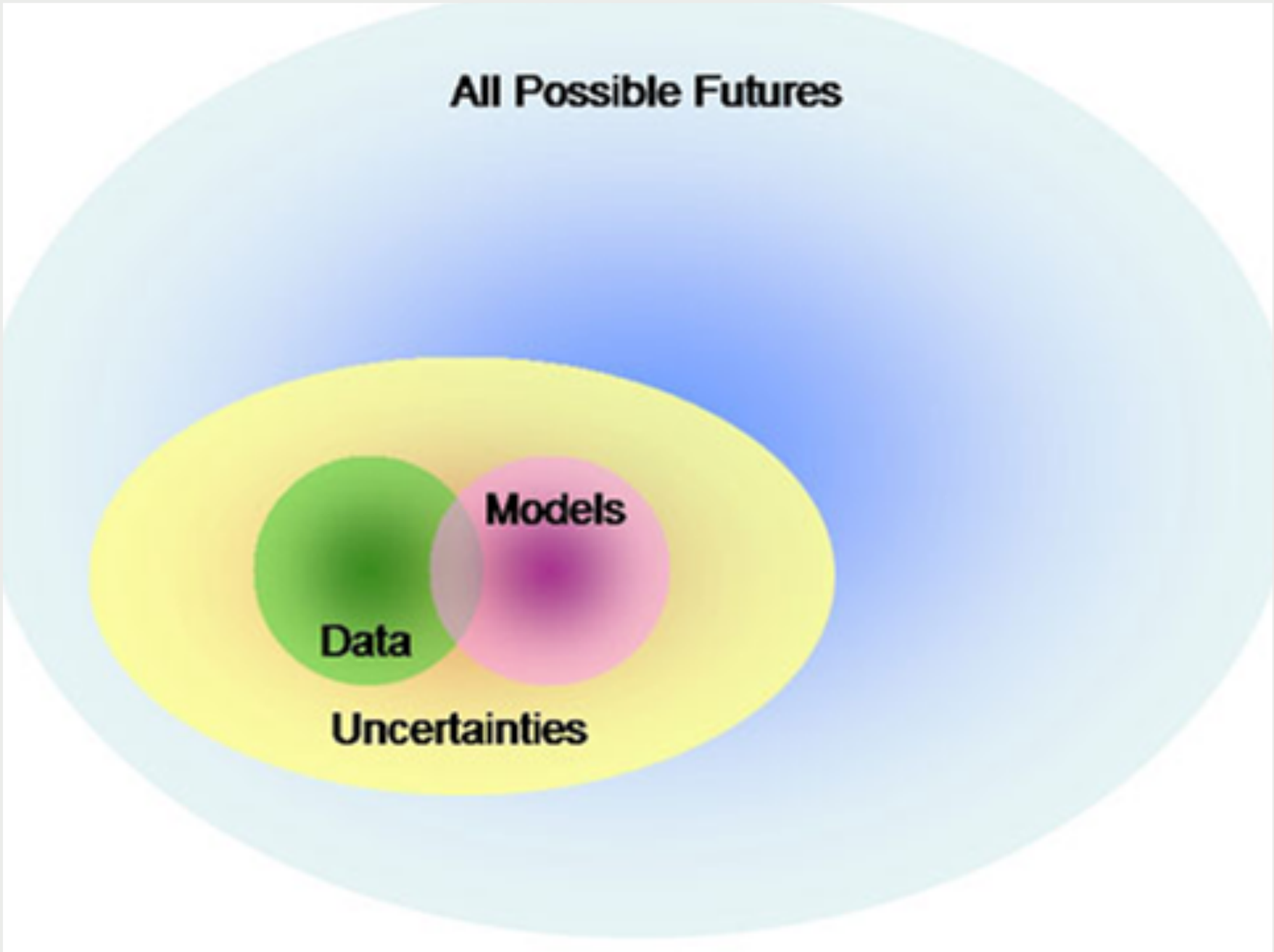
Habitat Supply



TWO TYPES OF UNCERTAINTY

1. Knowledge Uncertainty:
   - epistemic - Greek for knowledge
   - reducible
   - incomplete understanding
2. Inherent Uncertainty:
   - aleatoric - Latin for dice roll
   - irreducible
   - due to variability and chaos of system
   - wild cards/surprises

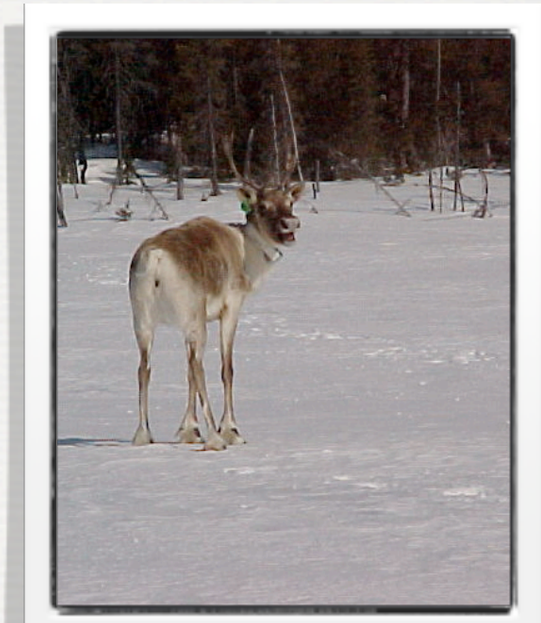
UNCERTAINTY



Carpenter et al. 2006

FORECASTING THE FUTURE - UNCERTAINTY

- External Disturbance
  - Fire
  - Mountain Pine Beetle
- System Response
  - Wildlife response to timber harvesting
- Underlying Structure of System
  - Incomplete Knowledge



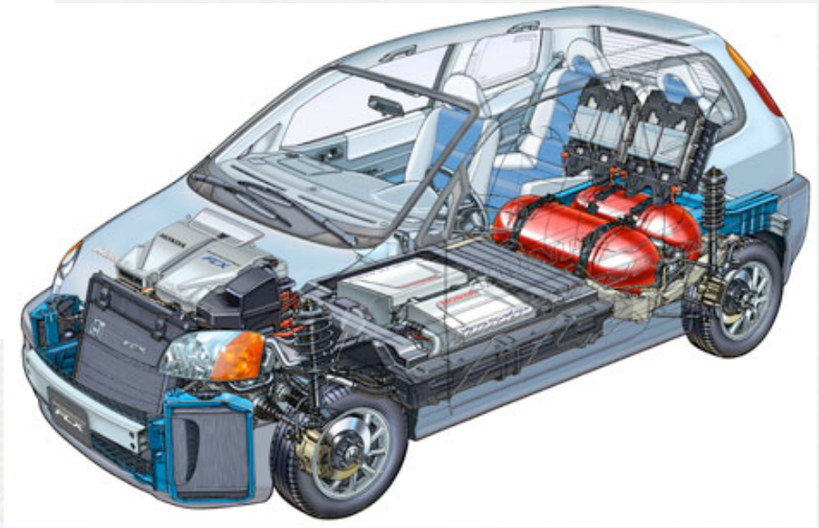
UNCERTAINTY

- “The phonograph is of no commercial value” Thomas Edison, 1880
- “There is no reason for any individual to have a computer in their home.” - Ken Olsen, President of DEC, 1977
- Internal sales forecasts for PCs for the 1980s: 295,000. Actual sales for PCs in the 1980s: over 25,000,000 - IBM, 1979
- “Anyone who thinks the ANC is going to run South Africa is living in cloud cuckoo land.” - Margaret Thatcher, 1987
- “The concept is interesting and well-formed, but in order to earn better than a 'C,' the idea must be feasible." -- Yale University professor’s response to Fred Smith – founder of Federal Express
- “They couldn’t hit an elephant at that dist…” - Last words of General Sedgewick, 1864

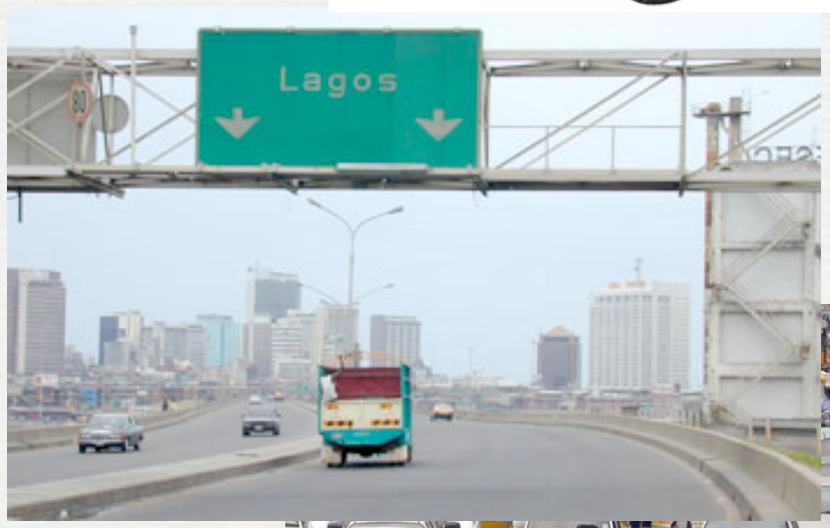
TYPES OF SYSTEMS

- Simple = easily knowable car key

- Complicated = not simple, but still knowable - car



- Complex = not fully knowable, but reasonably predictable - driving



- Chaotic = neither knowable nor predictable - driving in India

COMPLEX SYSTEM CHARACTERISTICS

Characteristic	Description
Undetermined Boundaries	boundaries of the system are difficult to determine and are open to external influences
Interacting Parts	parts interact with one another and their environment over multiple scales of time and space
Feedbacks	interactions may be strong or weak and can be modified by feedbacks that are either positive (amplifying) or negative (dampening)
Non-linearity	interactions are non-linear with minor changes producing disproportionately large and unpredictable changes
Memory	system's have history, the elements evolve with one another and past system states influence present and future system state
Emergence	complex systems arise from simple interactions - the whole is greater than the sum of the parts
Self Organizing	pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of the system with out being guided by an external source

FORESTS AS COMPLEX SYSTEMS

- they are made up of many parts and processes that interact with one another and their environment over multiple scales of time and space;

- they have negative or positive feedback loops with the environment to stabilize or destabilize ecosystems

- feedback loops may be non-linear - small differences in starting conditions following disturbance could cause large, unexpected, and unpredictable changes in ecosystem structure and development;

FORESTS AS COMPLEX SYSTEMS

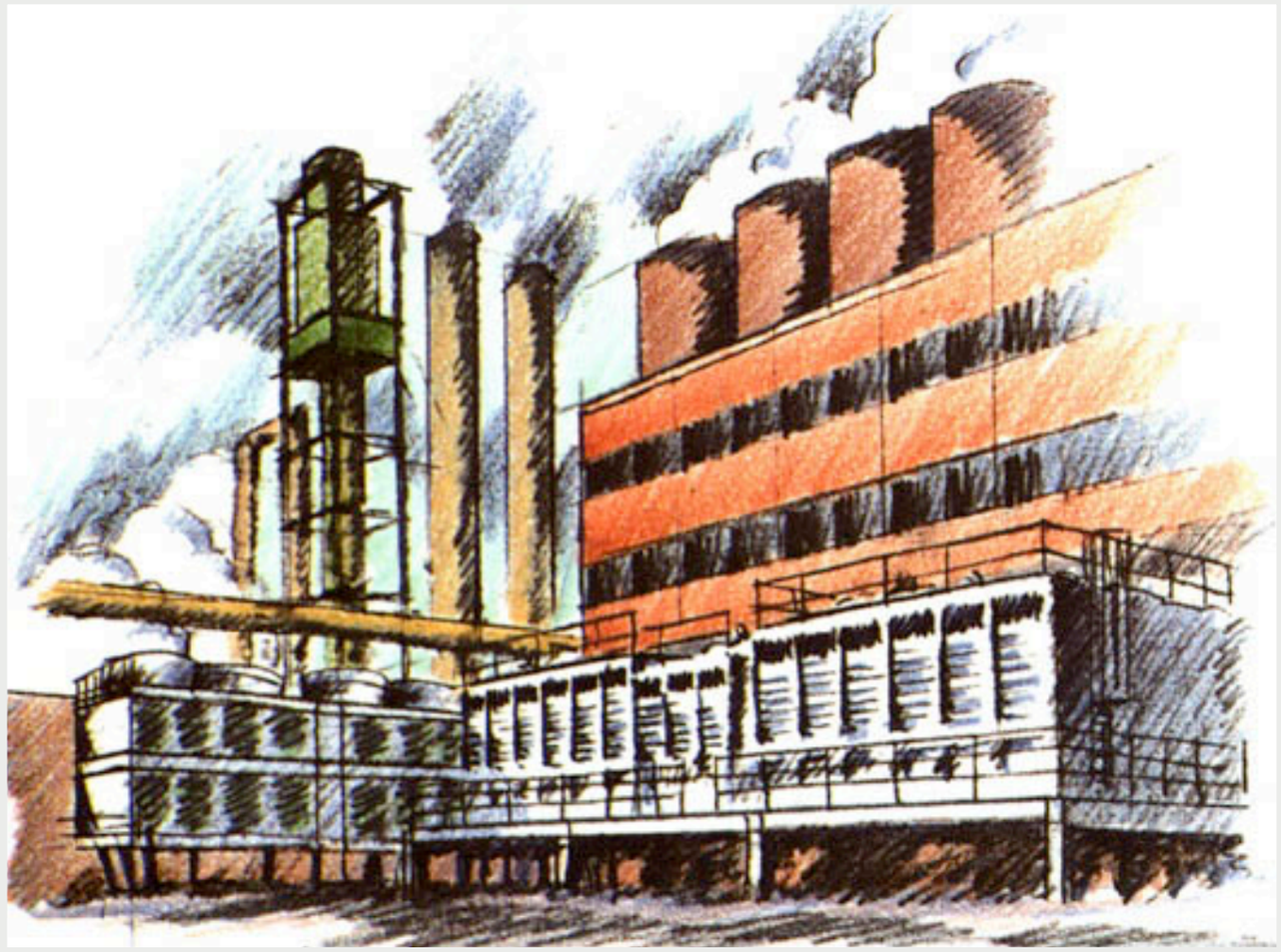
- forest ecosystem boundaries are difficult to determine and are open to influences outside the system;
- forest ecosystems have "memory," which means that biological legacies of previous states influence present and future states; and
- forest ecosystems are made up of smaller units of biological organization (i.e., individuals, populations, species, communities) that are also complex systems.

COMPLICATED WORLD VIEW

- Linear - cause and effect
- Mechanistic
- Reductionistic
- Managing for the mean
- Prediction

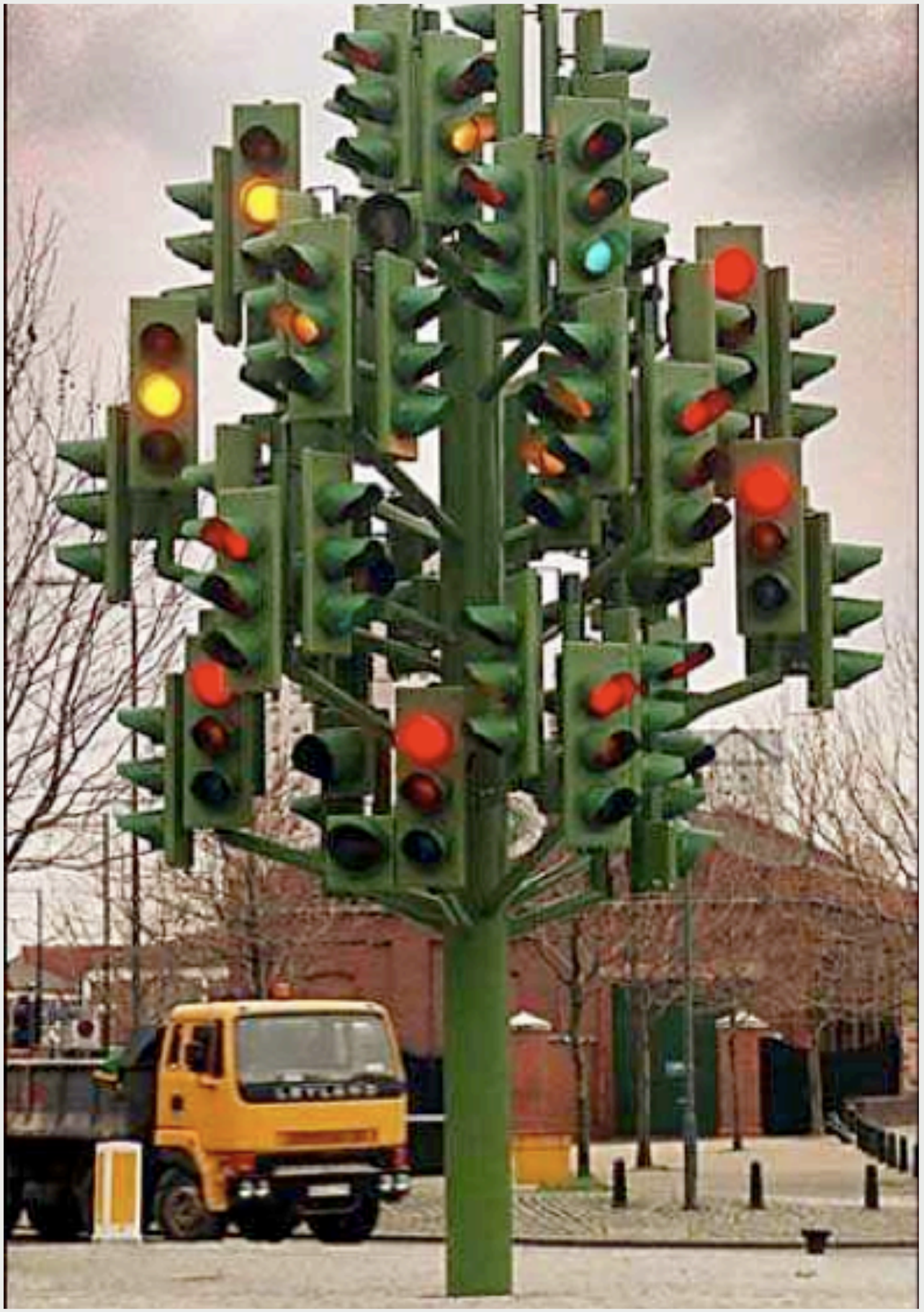
COMPLICATED

- Domain of experts
- Expert diagnosis required
- cause and effect discoverable, but not immediately apparent
- known unknowns
- Example - Factory



MANAGING FOR A COMPLICATED SYSTEM

One right answer



COMPLEXITY WORLD VIEW

- Non linear
- System's perspective
- Emergence
- Small changes - large effects
- Managing for variability
- Plausible futures

COMPLEX

- Domain of emergence
- flux and unpredictability
- no right answer; emergent instructive patterns
- innovative
- Unknown Unknowns
- Example - 10 year olds birthday party

MANAGING FOR COMPLEXITY

- difficult to identify a specific set of rules for managing for complexity
- will vary by:
  - location,
  - current activities,
  - past disturbances, and
  - nature of the specific ecosystems being managed.

MANAGING FOR COMPLEXITY

Way forward is emergent

MANAGING FOR COMPLEXITY & UNCERTAINTY

- Adapting to climate change requires three overarching questions to be considered by managers:
  - Does management address the complex nature of the ecosystem and the interaction with human activities?
  - Does management incorporate the uncertainty associated with ecological response and the uncertainty with respect to future ecological reorganization?
  - Will management accelerate the climate change increase in rate of spatial and temporal ecological change?