Key insights

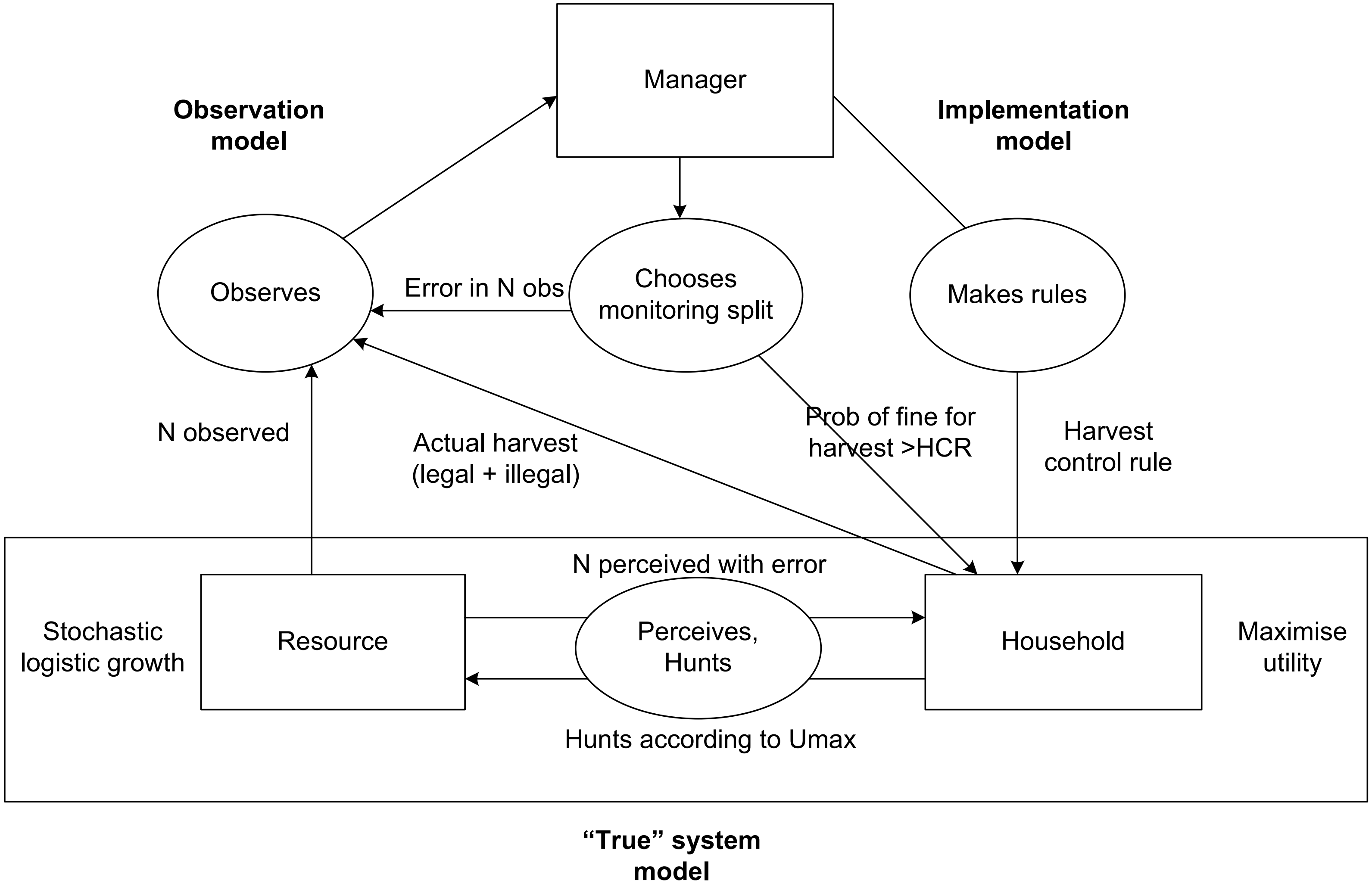
- The resource harvesting system is not just the stock and the harvesters – it includes the scientists, managers and policy-makers as well
- Uncertainty is fundamental to the problems that we have in monitoring and managing use of natural resources



Questions addressed

- What’s the effect of introducing household utility and livelihood trade-offs into the model?
- What is the effect of manager ignorance about household dynamics on management performance?
- How do performance metrics based on utility, resource stocks and harvests compare?
- How do different specifications of market access and returns to labour change the model?

Model structure



Performance metrics

- Mean harvest level
- Mean utility
- Proportion of years in which the population is below the conservation threshold of 30% of carrying capacity
- Proportion of years in which utility is below 50% of the maximum for the run

Resource operating model

Simple stochastic logistic growth:

$$N_{t+1} = \left[z_{N,t}\sigma_N + \frac{\exp(r)\, N_t K}{K + (\exp(r) - 1)N_t} \right] - H_t$$

Harvest

Stochasticity

Population growth

Population size at time t+1 = population growth rate - harvest

Harvester operating model
Shown for when both goods are sold

Cobb-Douglas utility function

utility

Consumption of the composite good

$$\max[U_t = \alpha \ln G_t]$$

Subject to a budget constraint

$$p_G G_t = p_F Q_{F,t} + p_H H_t - c_H L_{H,t} - \delta\theta_t P(H_t - Hrule_t)$$

Amount of good you can buy =

Net revenues from farming

+ Gross revenues from hunting

- Direct costs of hunting

- Expected costs of being caught hunting over the limit

Returns to labour

For farming: $$Q_{F,t} = AL_{F,t}^{\beta_F}$$

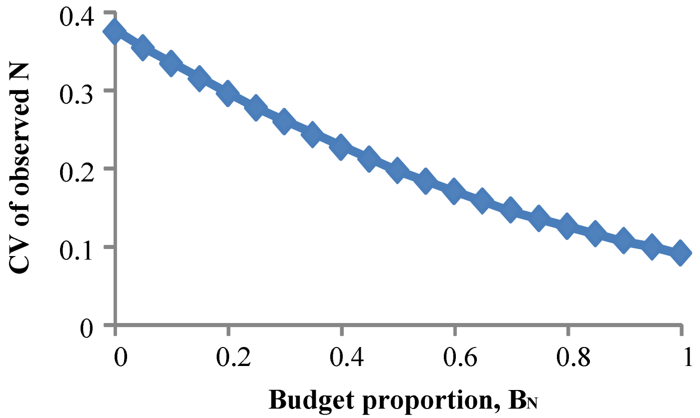
Output = Area x Labour invested ^ elasticity

For hunting: $$H_t = qNperc_t L_{H,t}^{\beta_H}$$

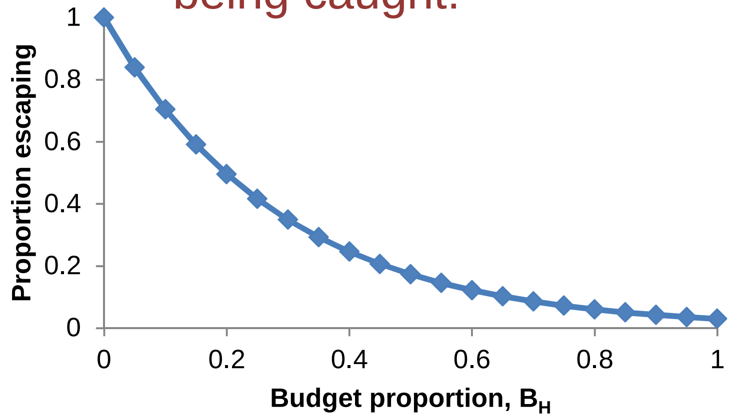
Expected output = Catchability x perceived population size x Labour invested ^ elasticity

Observation model

Effect of budget on error of population estimate:



Effect of budget on probability of poacher being caught:



Either: A fixed proportion of the budget is allocated to each activity

Or: Allocation is done based on an a priori rule - maximise allocation to monitoring population, subject to illegal harvesting being <10% above the legal level

Assessment model

Three simple formulations for harvest control rule tested

Proportional harvest:

$$Hrule_t = hm * Nobs_{t-1}$$

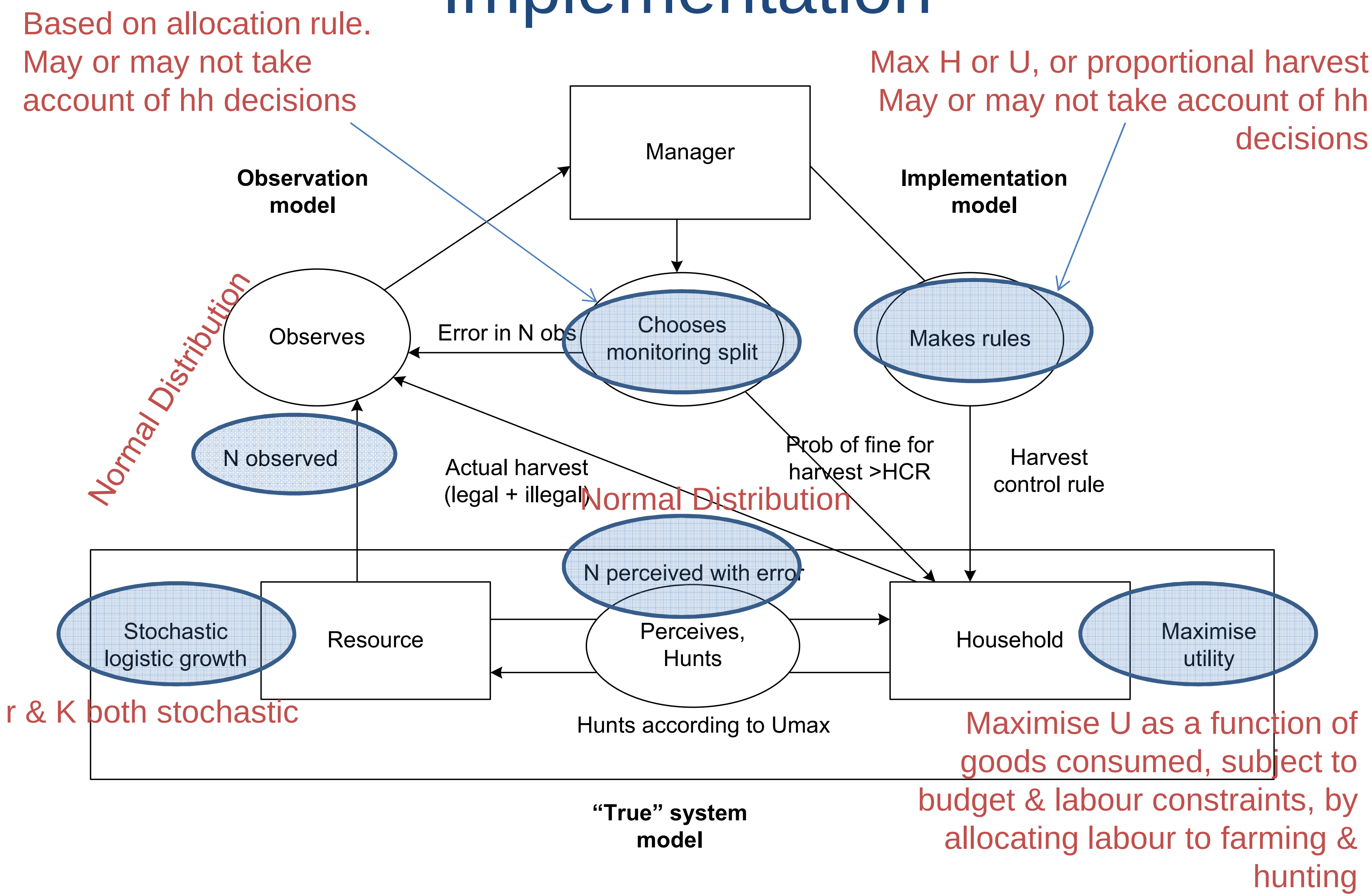
Harvest rate

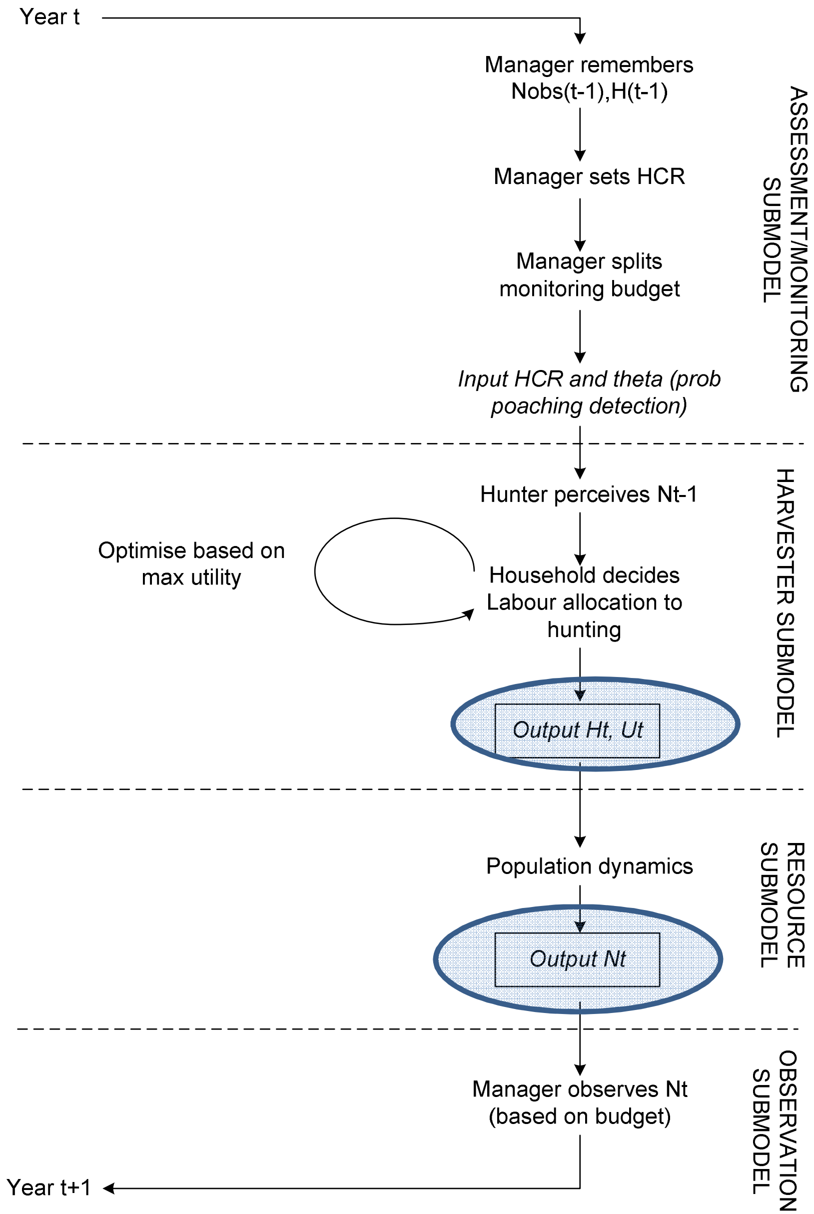
Observed stock size

Maximise yield: subject to conservation threshold (population staying >0.3K with >0.9 probability), based on 1 run of the model

Maximise utility: Same

Implementation





Performance measures:

Maximise mean harvest

Maximise utility

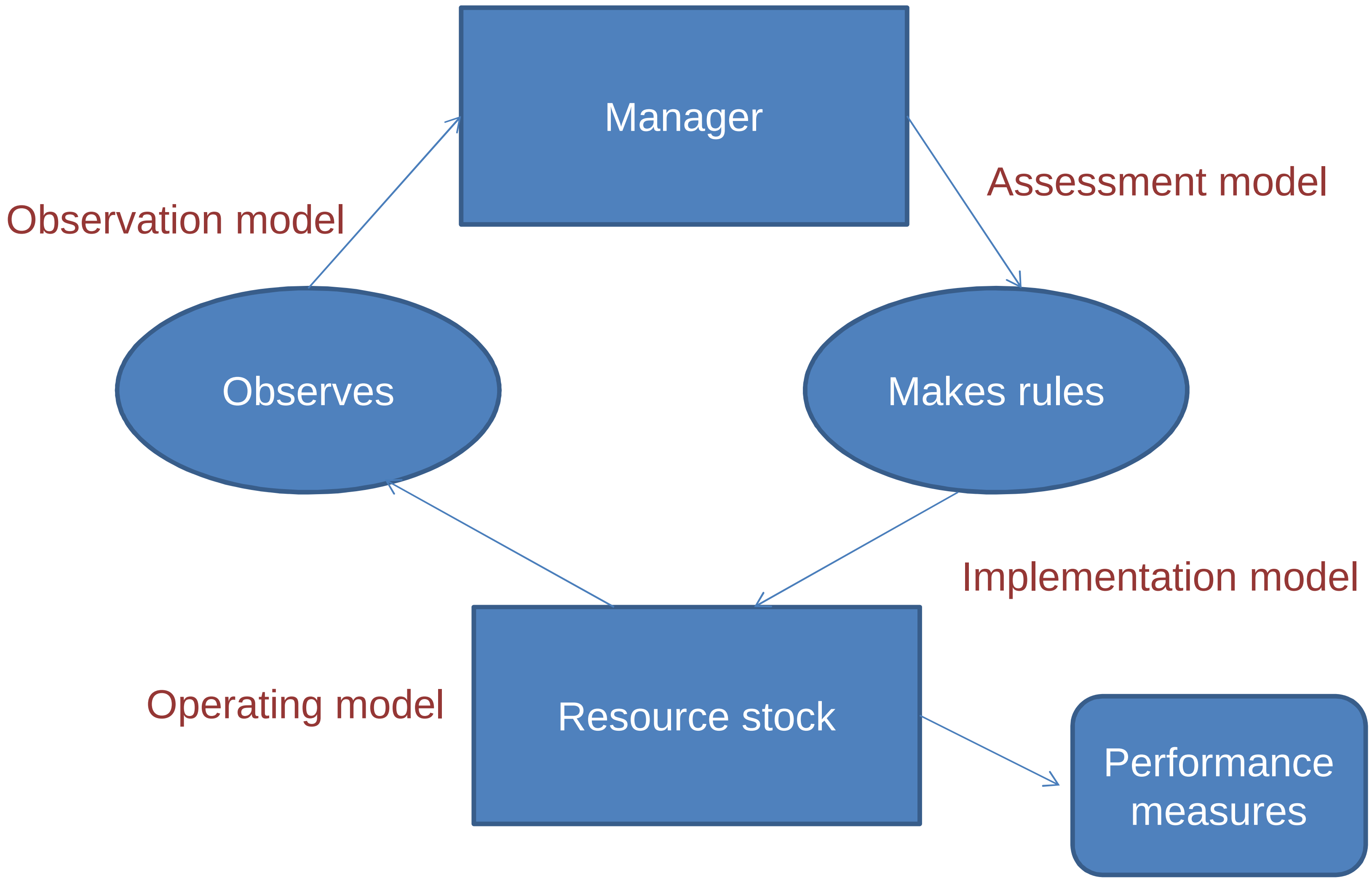
Minimise probability of N falling below threshold - 0.3K

Minimise probability of U falling below threshold - 0.5 max U

The approach

- Explore the effects of potential policies in a virtual world
- Use a decision analysis framework:
  - Clear goals
  - Performance measures for these goals
  - Test strategies in a range of scenarios
  - Show strategy performance against measures in each scenario
  - User decides – no “best” solution offered

An MSE model


Manager
Observation model
Assessment model
Observes
Makes rules
Implementation model
Operating model
Resource stock
Performance
measures

An example – SESSF, Australia

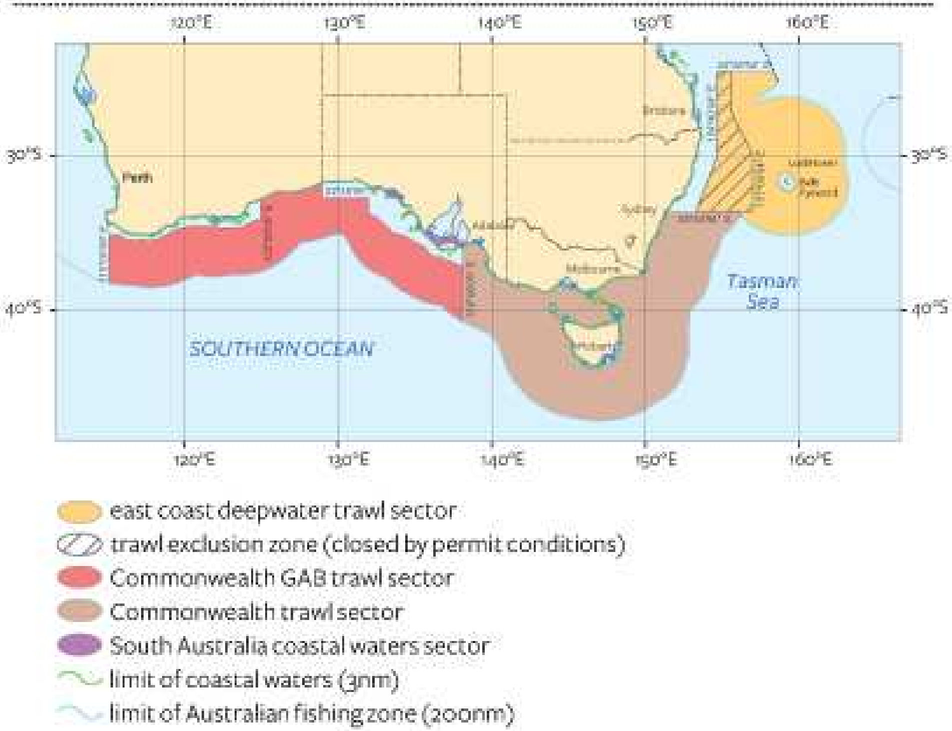
Complex multi-species fishery, worth Aus$96 million in 2006/7 (most valuable fishery in Australia)

Managed using MSE since 2006

Main success - stakeholder buy-in, so lower quotas set, and agreement reached much quicker (2 days not several weeks)

Smith et al. (2008) *Fish. Res.*

map 2 Southern and eastern scalefish and shark fishery
Commonwealth trawl sectors and South Australian coastal waters sector



Source: Australian Fishery Management Agency 2008. http://www.afma.gov.au/

However…

- Need to ensure any increase in model complexity is worthwhile in terms of the added insights it gives
- MSE as practiced in fisheries has not been perfect:
  - Very focussed on the biological side: implementation models very sketchy, little economic or social insight included
  - Complicated modelling procedures, highly technical
  - Narrow focus on individual target species
  - Though much of this is changing (ecosystems approach, economics included; see e.g. work of C. Dichmont, B. Fulton, E. Hoshino)

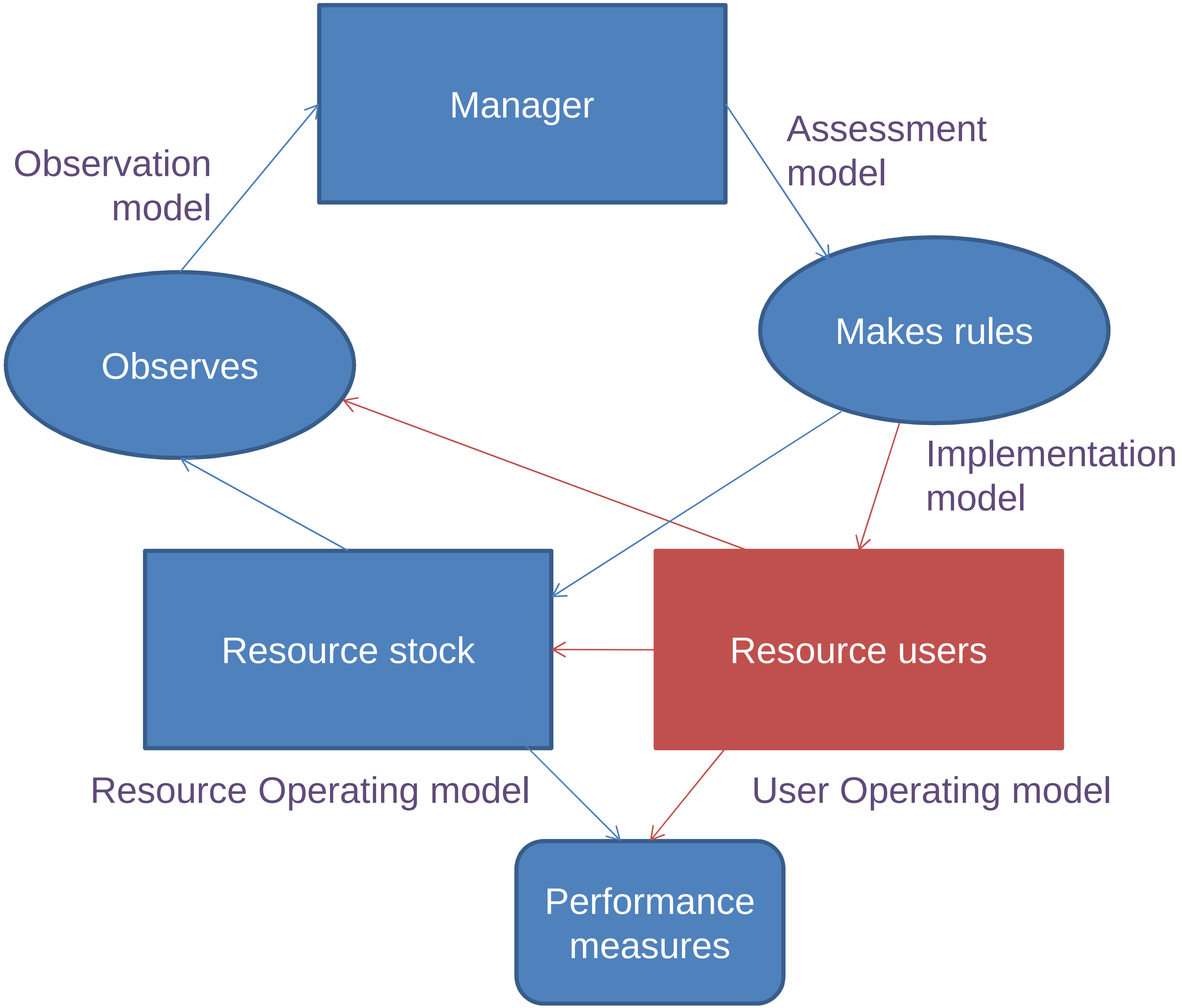
The systems I work on have..

- Many small-scale users with a range of livelihoods
- Rules affecting users’ behaviour – but not automatic compliance
- Users maximising household utility, not profits
- Sustainability measures including a range of actions, not just direct harvest controls
- Lack of basic information, lack of technical capacity, developing countries
- Human wellbeing often paramount – poverty alleviation

Fulfilling MSE's potential

- Can we take the framework and apply it to other systems?
- Can we include the human side more fully?

Bunnefeld et al 2011 TREE



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Assessment model
Observes
Makes rules
Implementation model
Resource stock
Resource users
Resource Operating model
User Operating model
Performance measures

A toy model to explore MSE potential

- Includes a model of resource user behaviour (compliance with rules, and choices between livelihoods)
- Includes monitoring trade-off for manager (resource stocks to reduce observation uncertainty, or users to improve compliance)

Milner-Gulland (2011) PNAS

The set-up

- Based loosely on bushmeat hunting in Africa
- Households can allocate time to farming and hunting, for sale or consumption
- Households aim to maximise their utility (*not* profits)
- Managers have a limited budget for enforcing compliance with hunting limits and for monitoring the resource stocks

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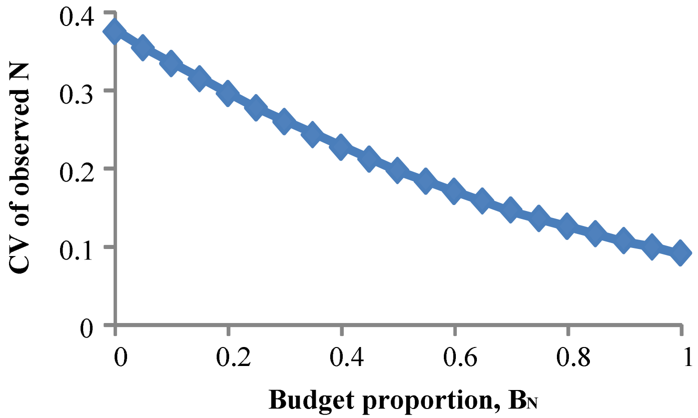

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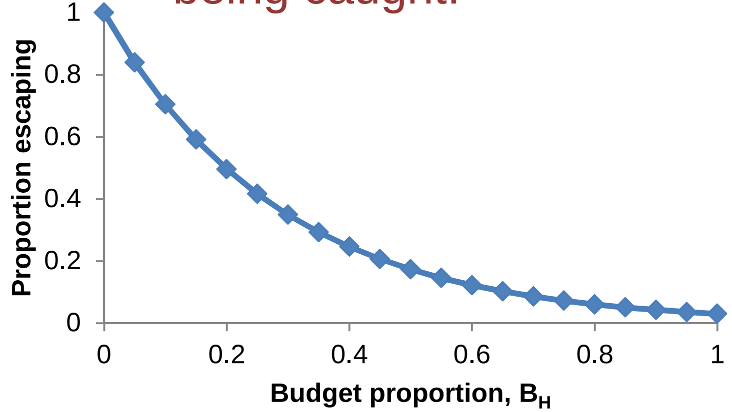

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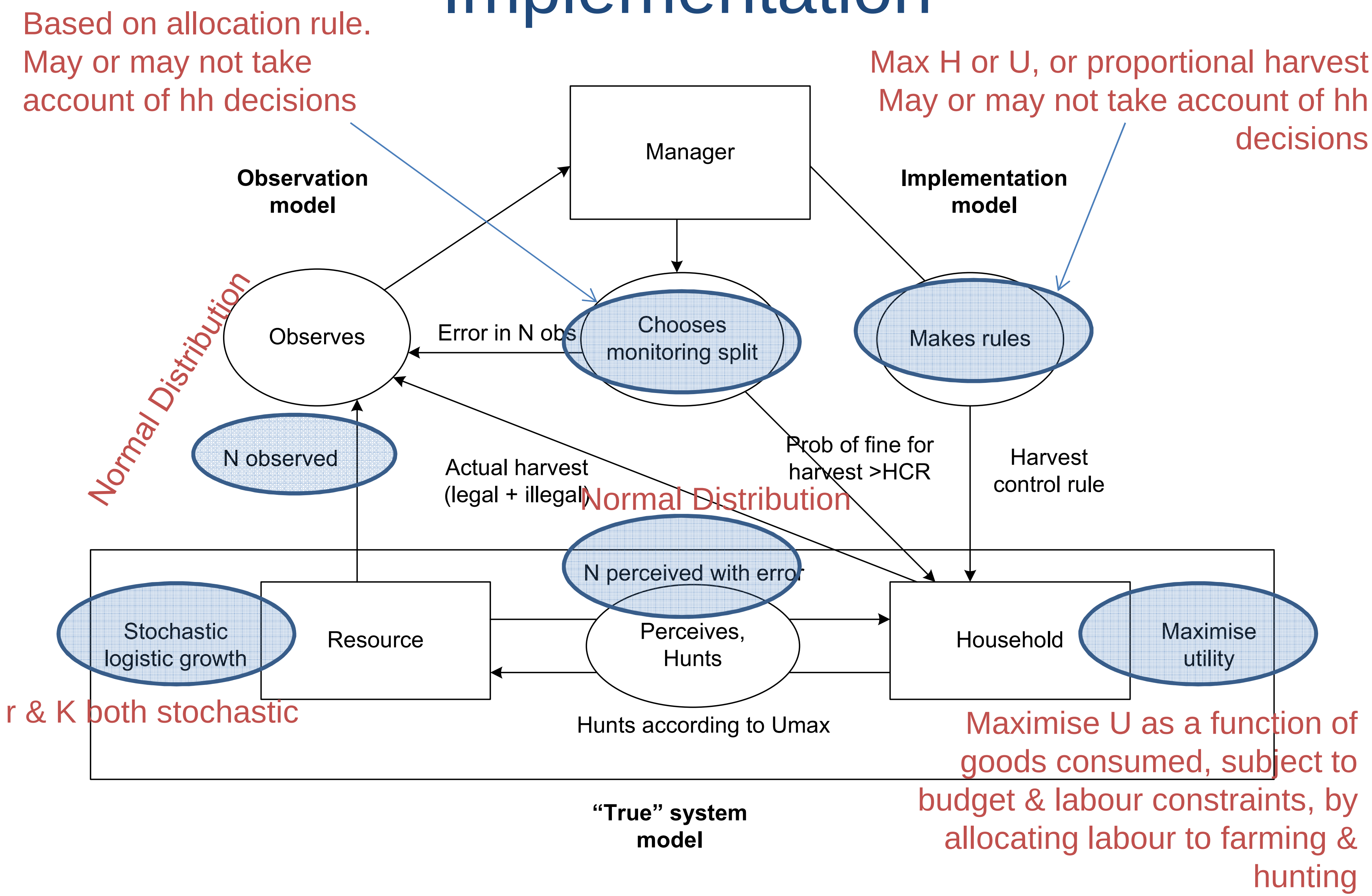

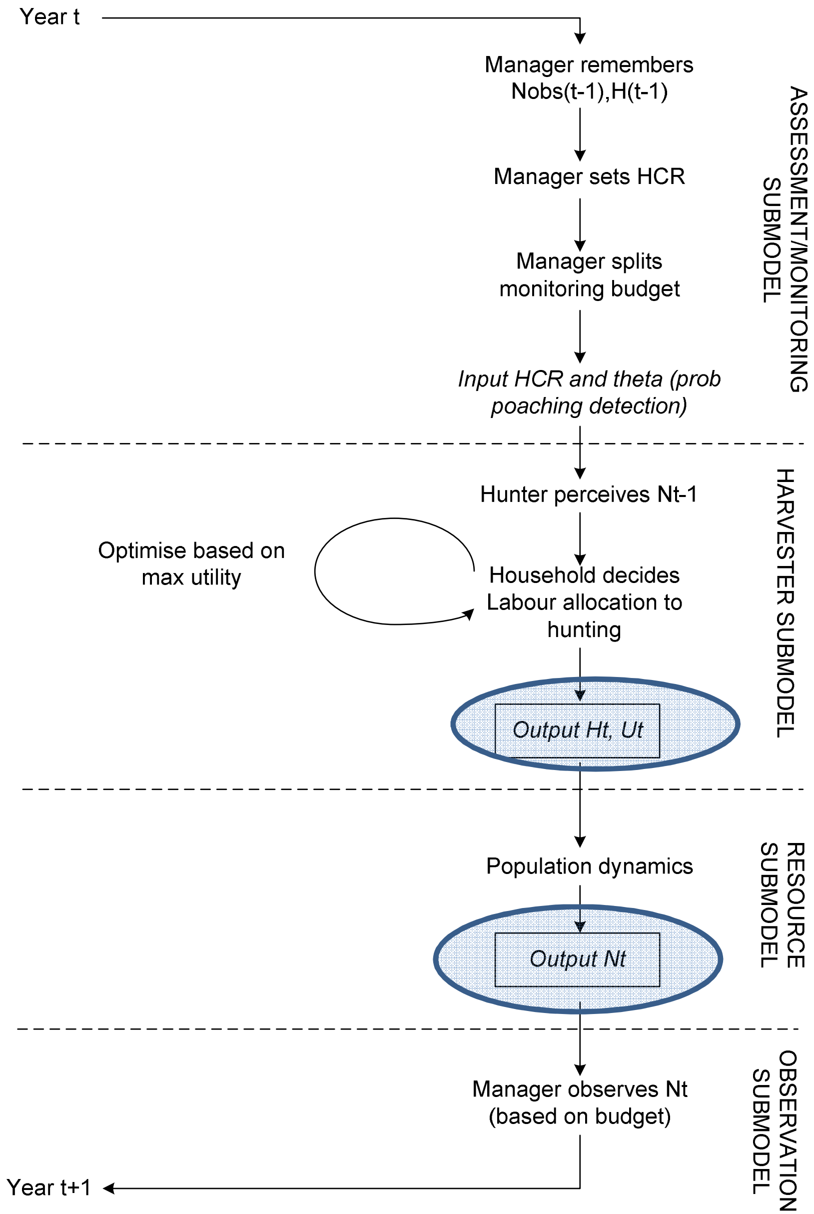

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