



*Complex Adaptive System of Systems
(CASoS) Engineering Initiative
<http://www.sandia.gov/casos>*

Developing a theory of the societal lifecycle of cigarette smoking: Explaining and anticipating trends using information feedback

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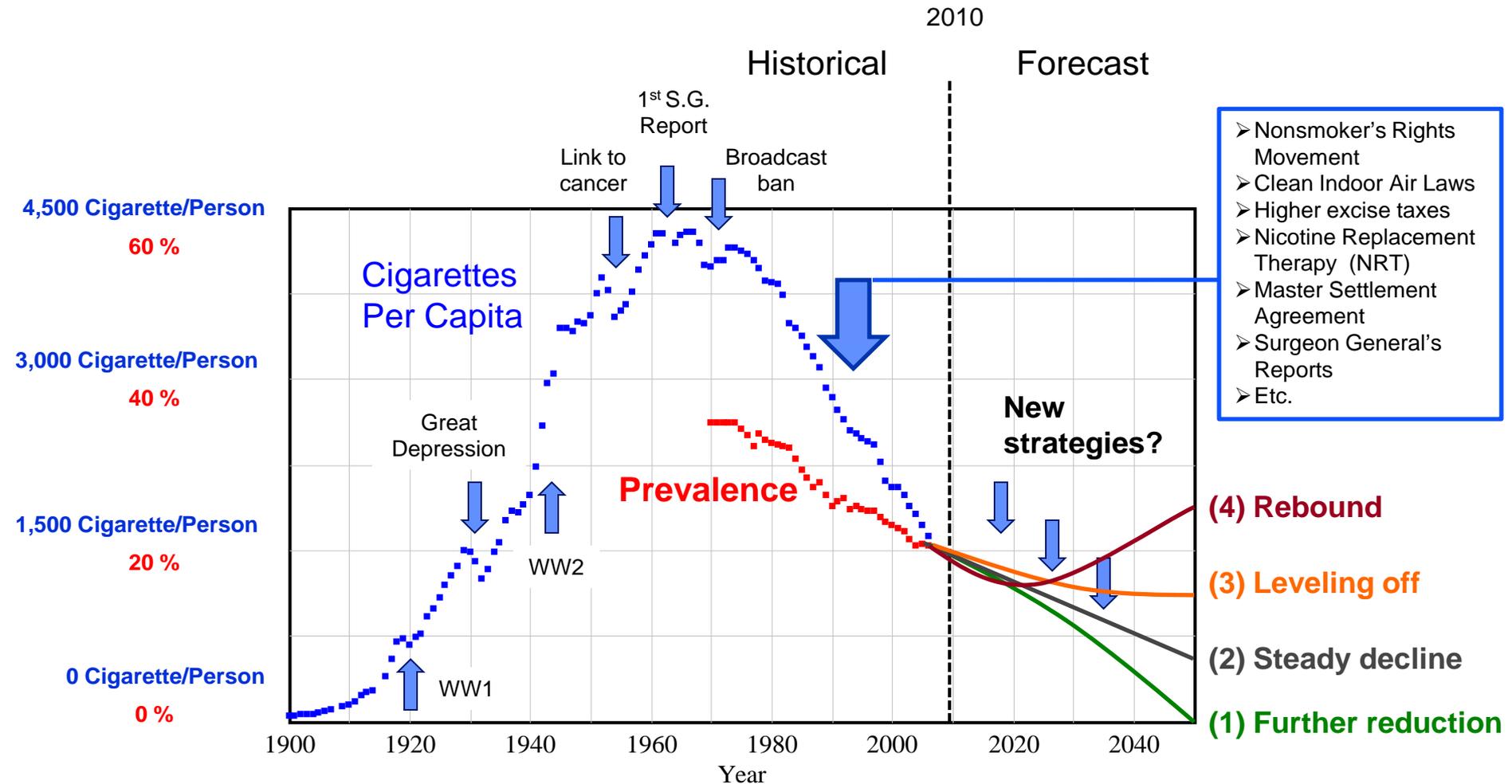
Modeling for Public Health Action: From Epidemiology to Operations
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Smoking prevalence (cigarettes)



Data sources:

Cigarettes per capita - http://www.cdc.gov/tobacco/data_statistics/tables/economics/consumption/

Prevalence - David Mendez & Kenneth Warner, SGR Meeting (July 2010)

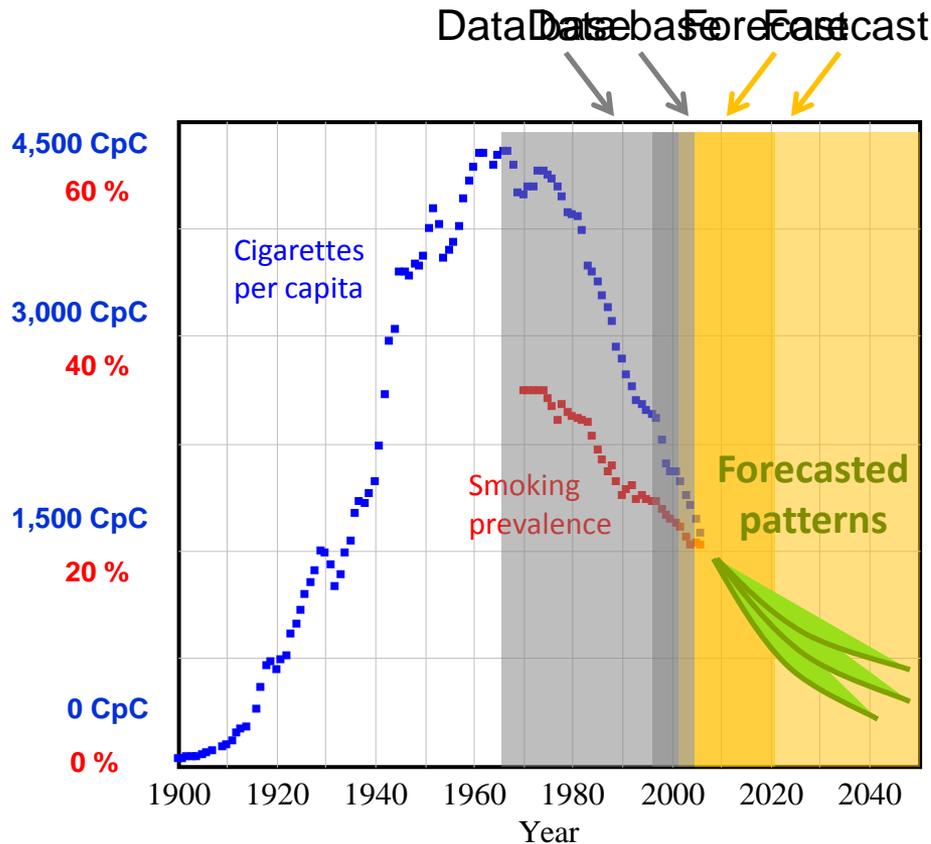
Began with a review of previous System Dynamics studies

- The **MIT model** (Roberts *et al.*, 1982)
 - 1 publication; model *not* available
- The **Tobacco Policy Model** (Tengs, Ahmad, *et al.*, 2001-2005)
 - 7 publications; model *not* available
- The Initiative on the Study and Implementation of Systems – **ISIS Model** (Richardson, 2007)
 - 1 publication; model available
- The **New Zealand TPM** (Cavana, Tobias, Bloomfield, 2008 & 2010)
 - 2 publications; model available
- The Prevention Impacts Simulation Model – **PRISM** (Homer, Milstein, Hirsch, *et al.*, 2008-2010)
 - 3 publications; reference manual available (but *not* model)

(The full references are captured in two slides at the end.)

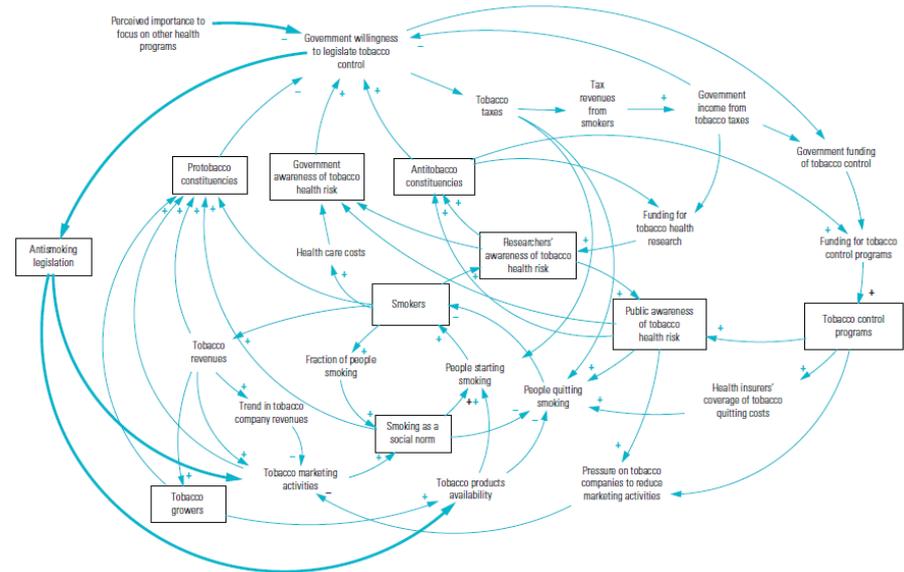
Three Main Points: Time horizon – Feedback – Forecast patterns

Time horizon of interest



(Post tipping point period of decline)

Feedback perspective



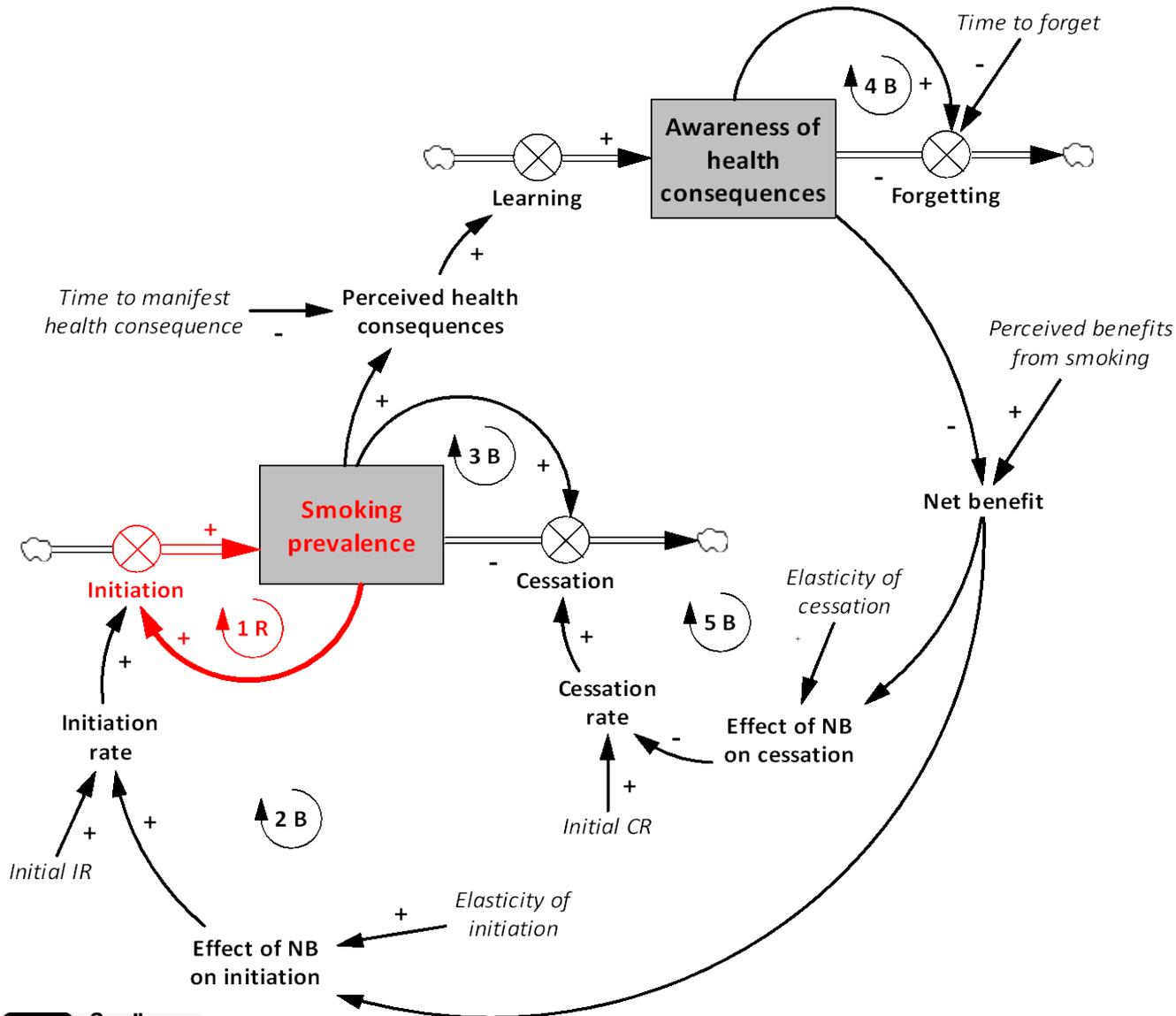
Major feedbacks captured:

- Reinforcing feedback of smoking as a social norm
- Balancing feedback due to public awareness of tobacco health risk

Take away messages from literature review

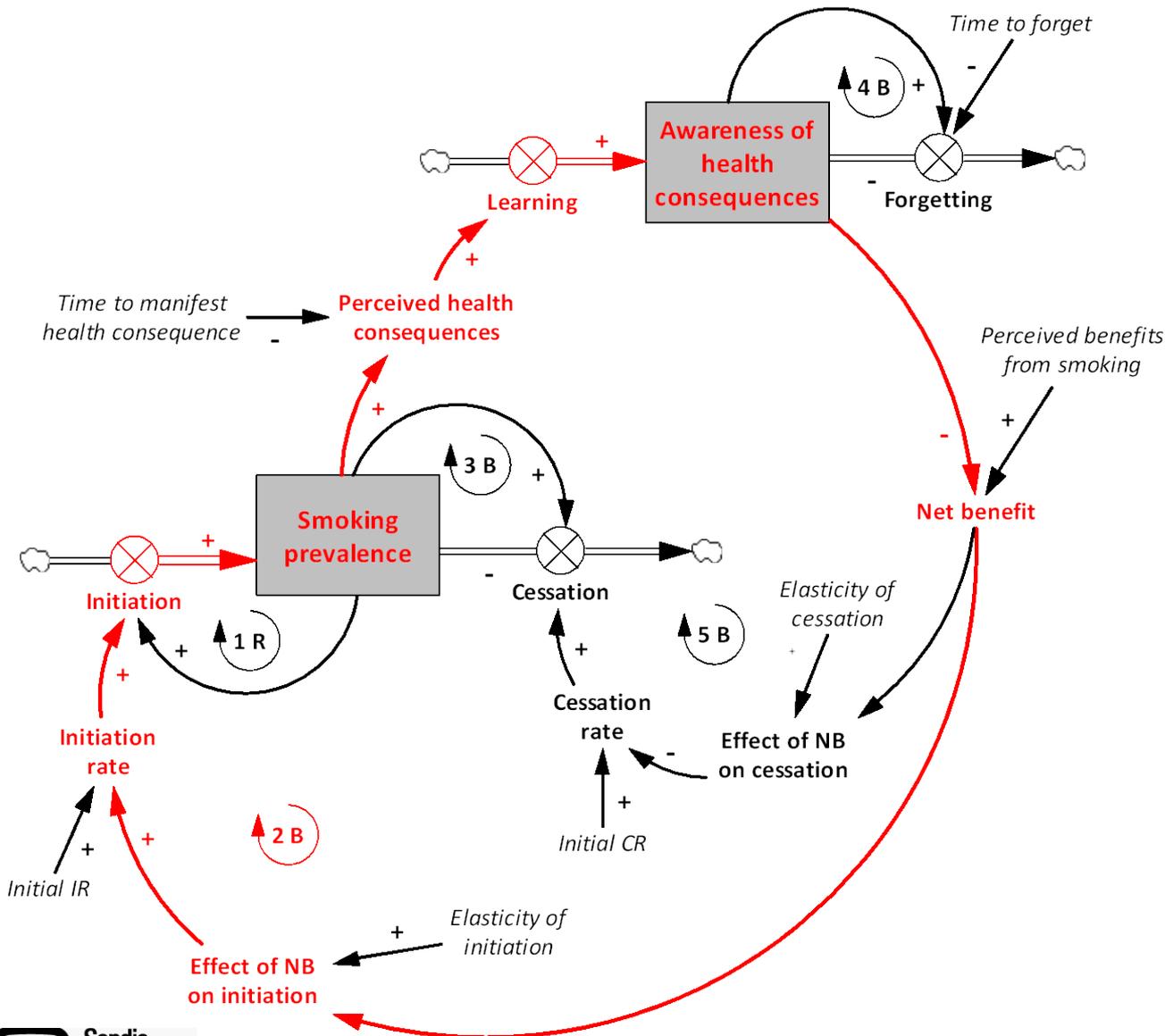
- Provides a foundation upon which to identify system structure, determinate morbidity and mortality, assess potential impacts of interventions and measure their cost effectiveness
- Demonstrated impact in influencing public health policy and decision making
- Provided insight on information feedbacks, such as:
 - Reinforcing feedback between prevalence and initiation rate
 - Balancing feedback due to awareness of the health consequences of smoking
- All models looked at a relatively short historical period of reference
- None of the models looked at the possibility of an increase in smoking
- There is a **path open to expand this body of knowledge**, involving:
 - A **study of the long-term history** of cigarette smoking behavior, to arrive at the structure needed to account for the societal lifecycle of cigarette smoking
 - **Emphasis on information feedback, using an Occam's razor approach**

Our feedback-rich concept model



Feedback loops:
1 – Reinforcing
“Initiation loop”

Our feedback-rich concept model

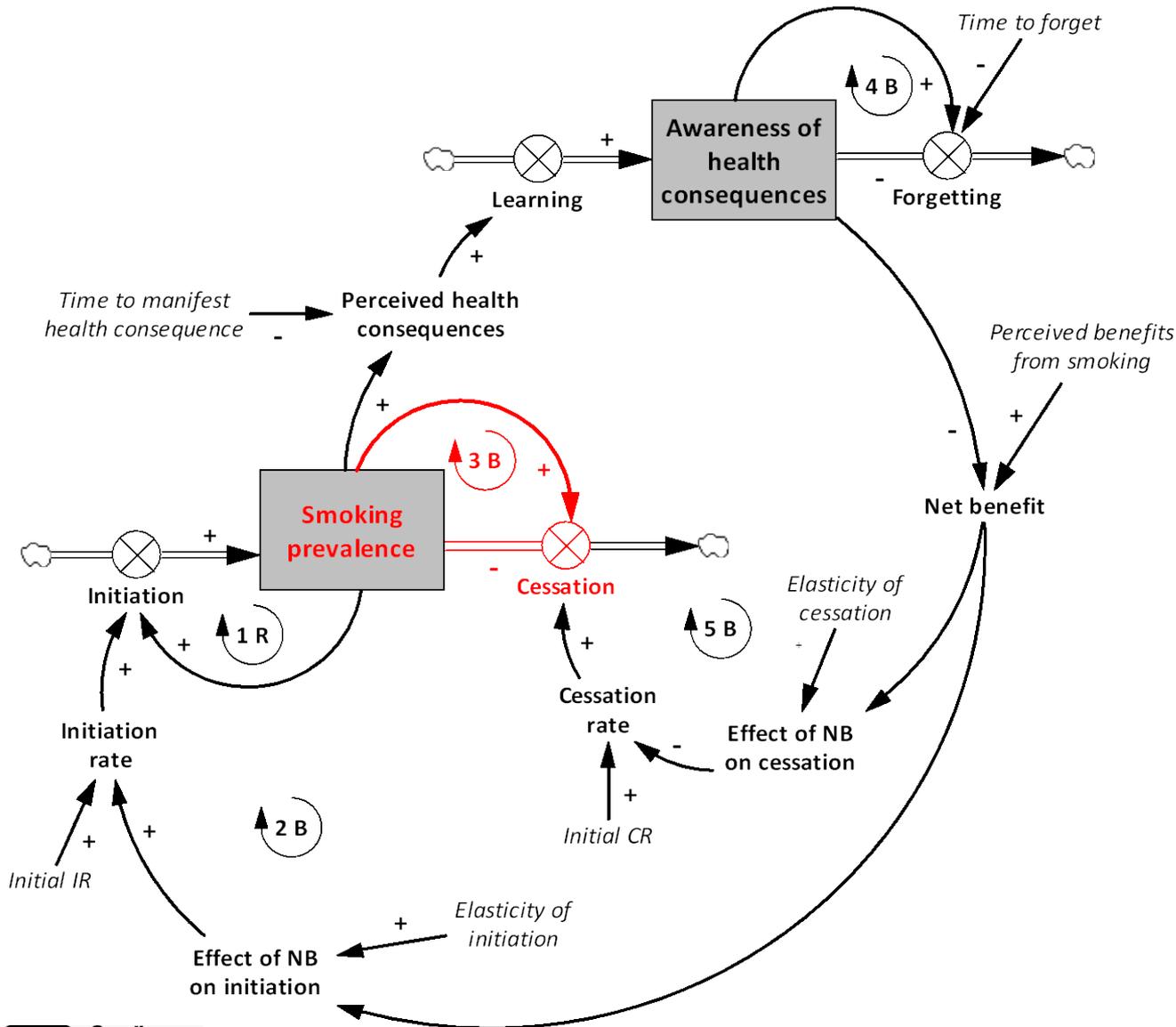


Feedback loops:

1 – Reinforcing
“Initiation loop”

2 – Balancing
“Awareness curbs initiation”

Our feedback-rich concept model



Feedback loops:

1 – Reinforcing

“Initiation loop”

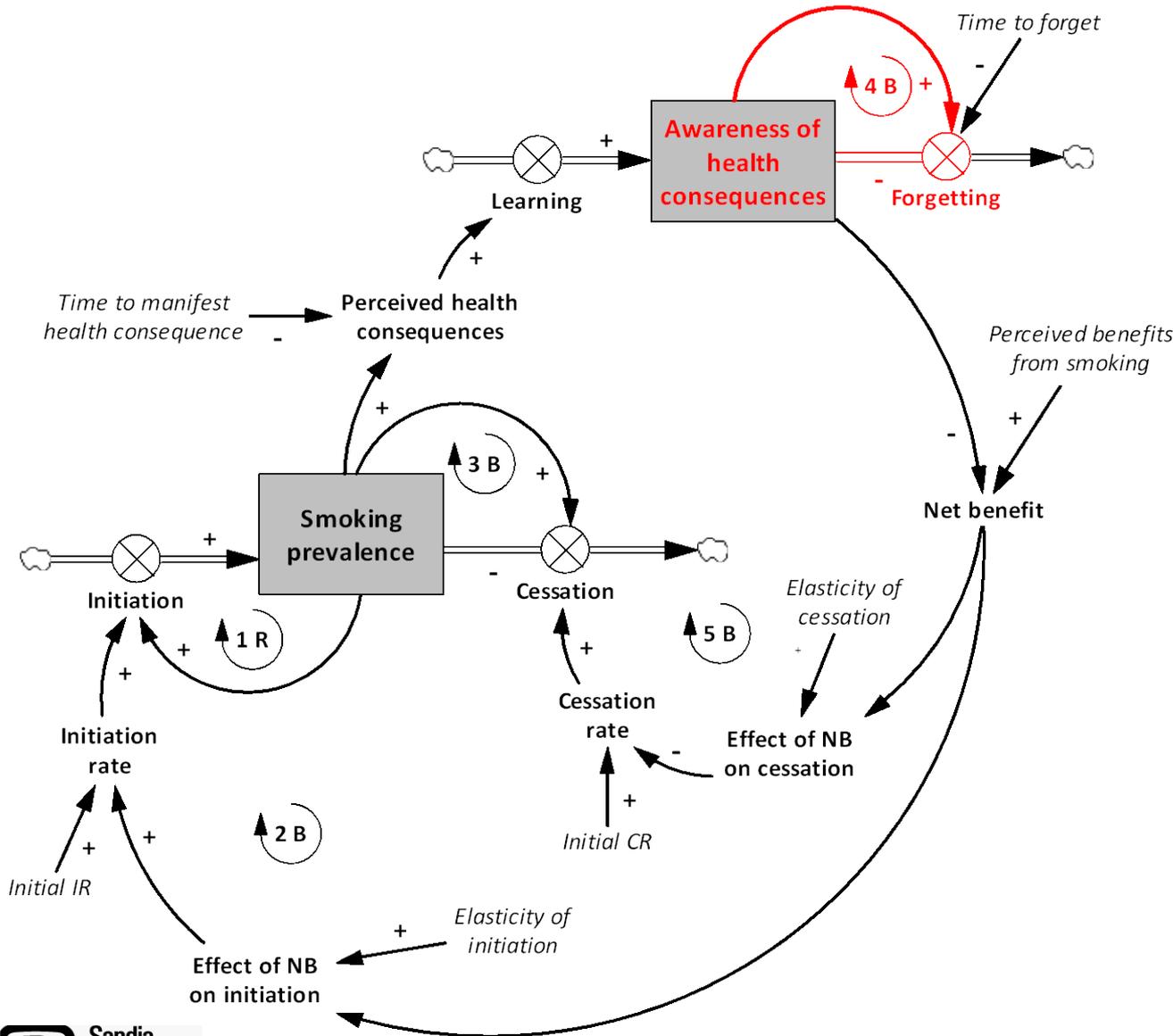
2 – Balancing

“Awareness curbs initiation”

3 – Balancing

“Cessation loop”

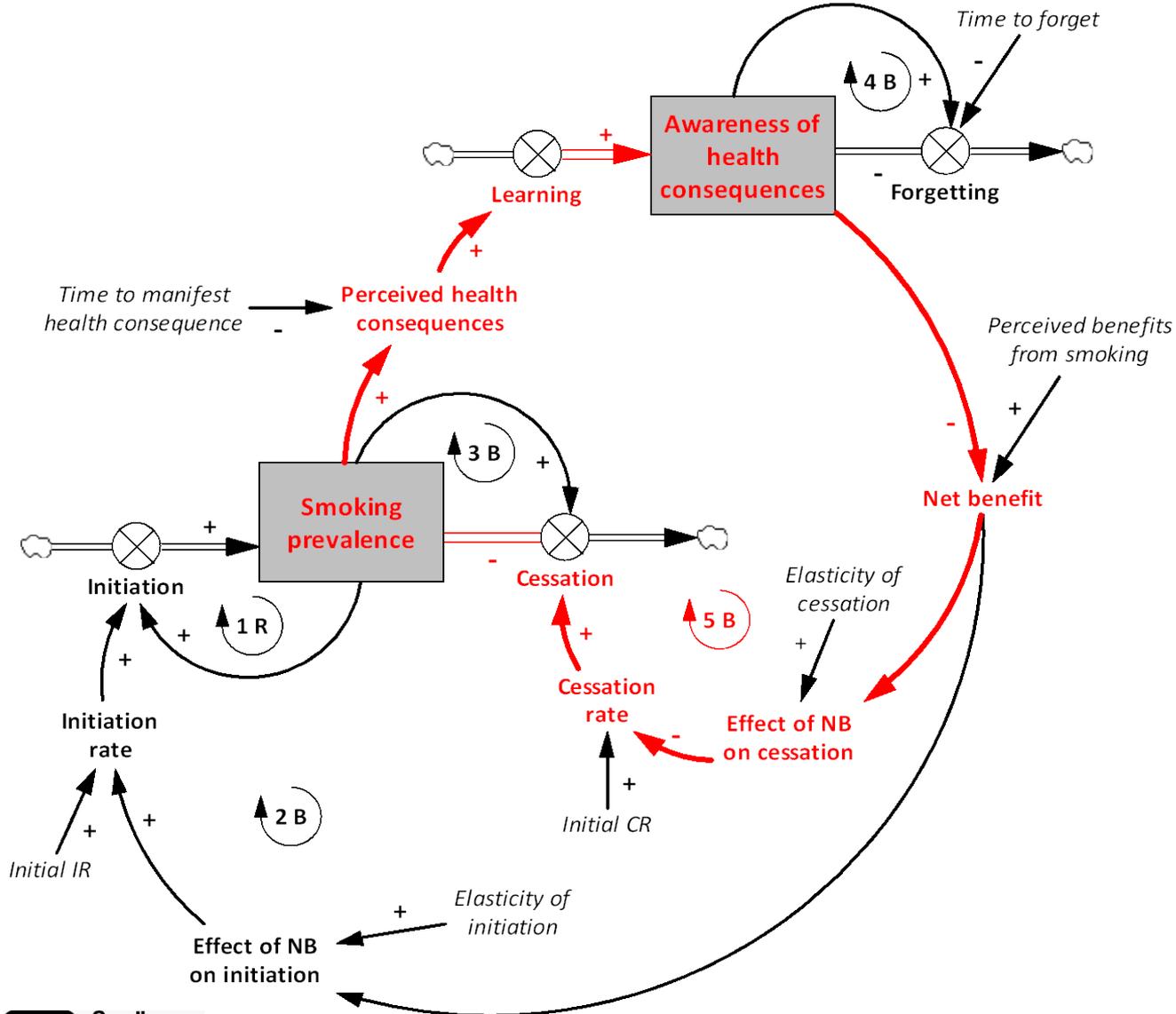
Our feedback-rich concept model



Feedback loops:

- 1 – Reinforcing
“Initiation loop”
- 2 – Balancing
“Awareness curbs initiation”
- 3 – Balancing
“Cessation loop”
- 4 – **Balancing**
“Losing awareness”

Our feedback-rich concept model

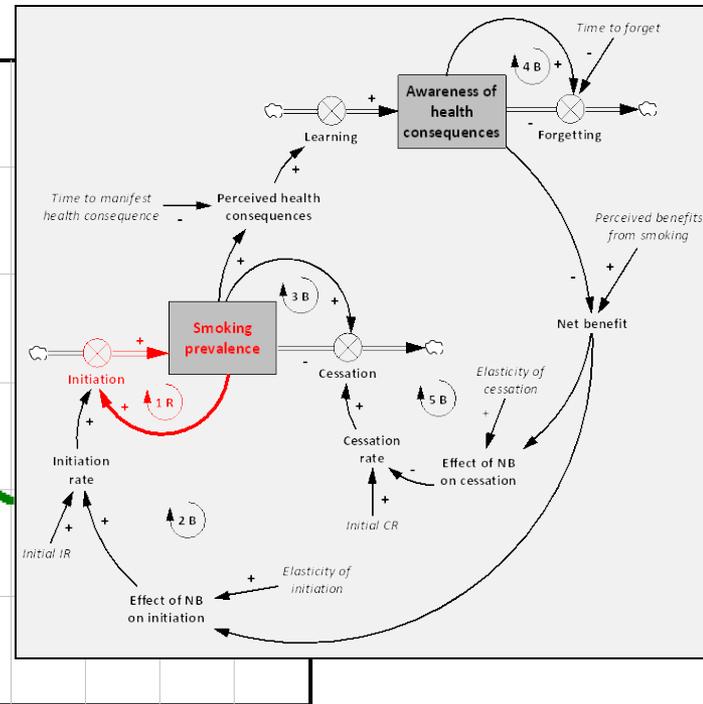
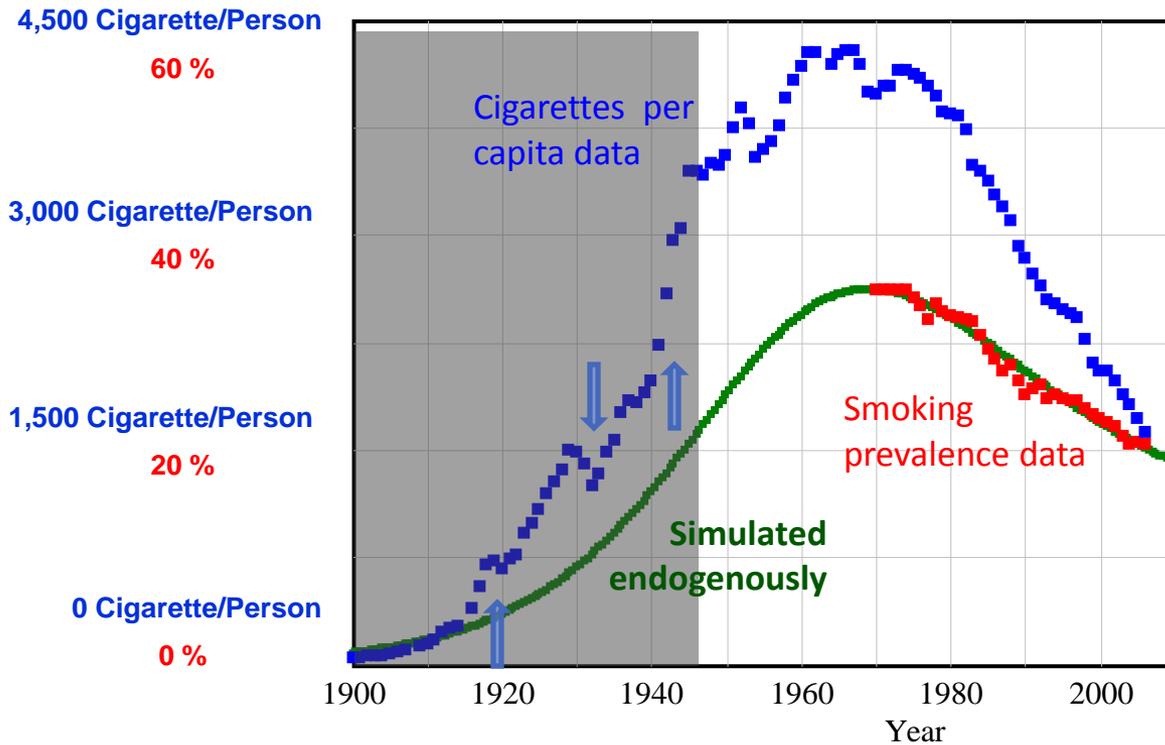


Feedback loops:

- 1 – Reinforcing
“Initiation loop”
- 2 – Balancing
“Awareness curbs initiation”
- 3 – Balancing
“Cessation loop”
- 4 – Balancing
“Losing awareness”
- 5 – Balancing
“Awareness boosts cessation”

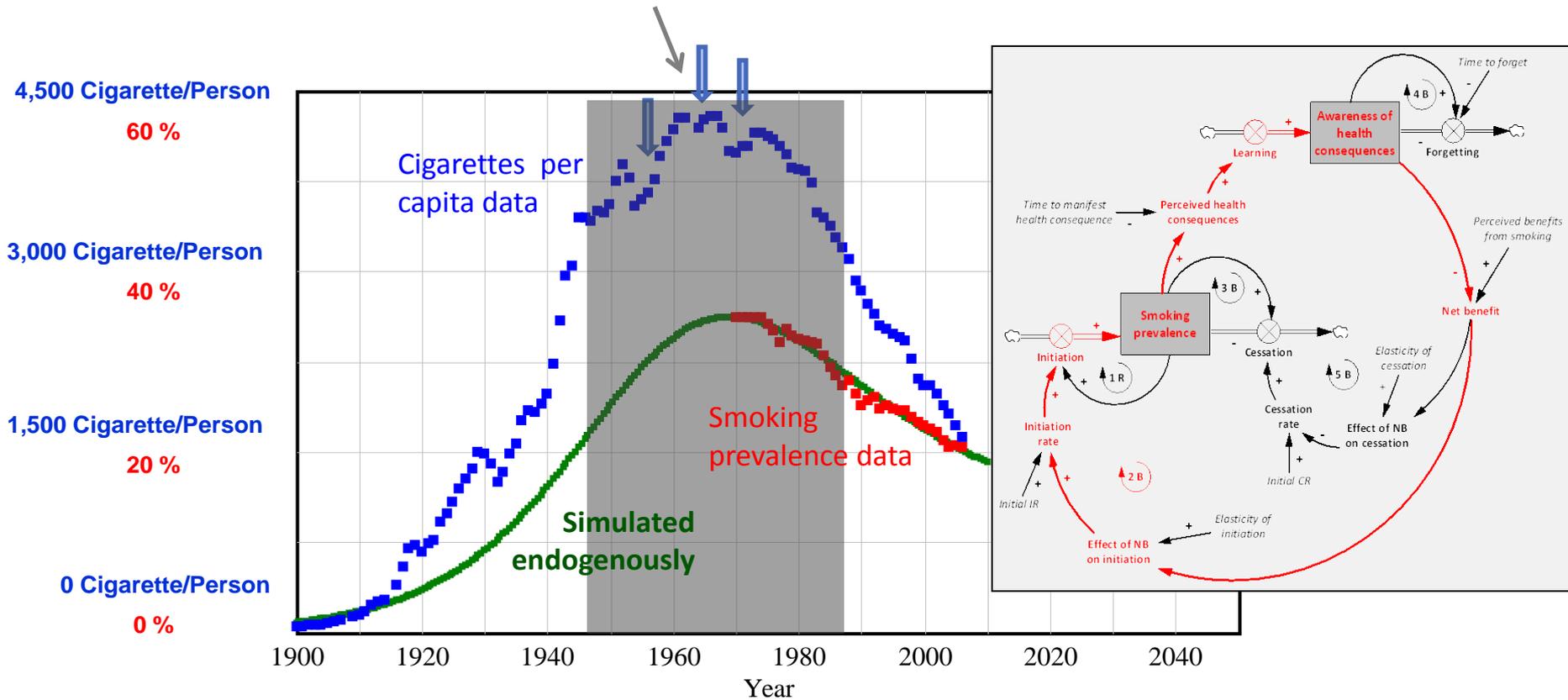
Analysis of the base run: Phase 1

Phase 1:
Unconstrained
growth

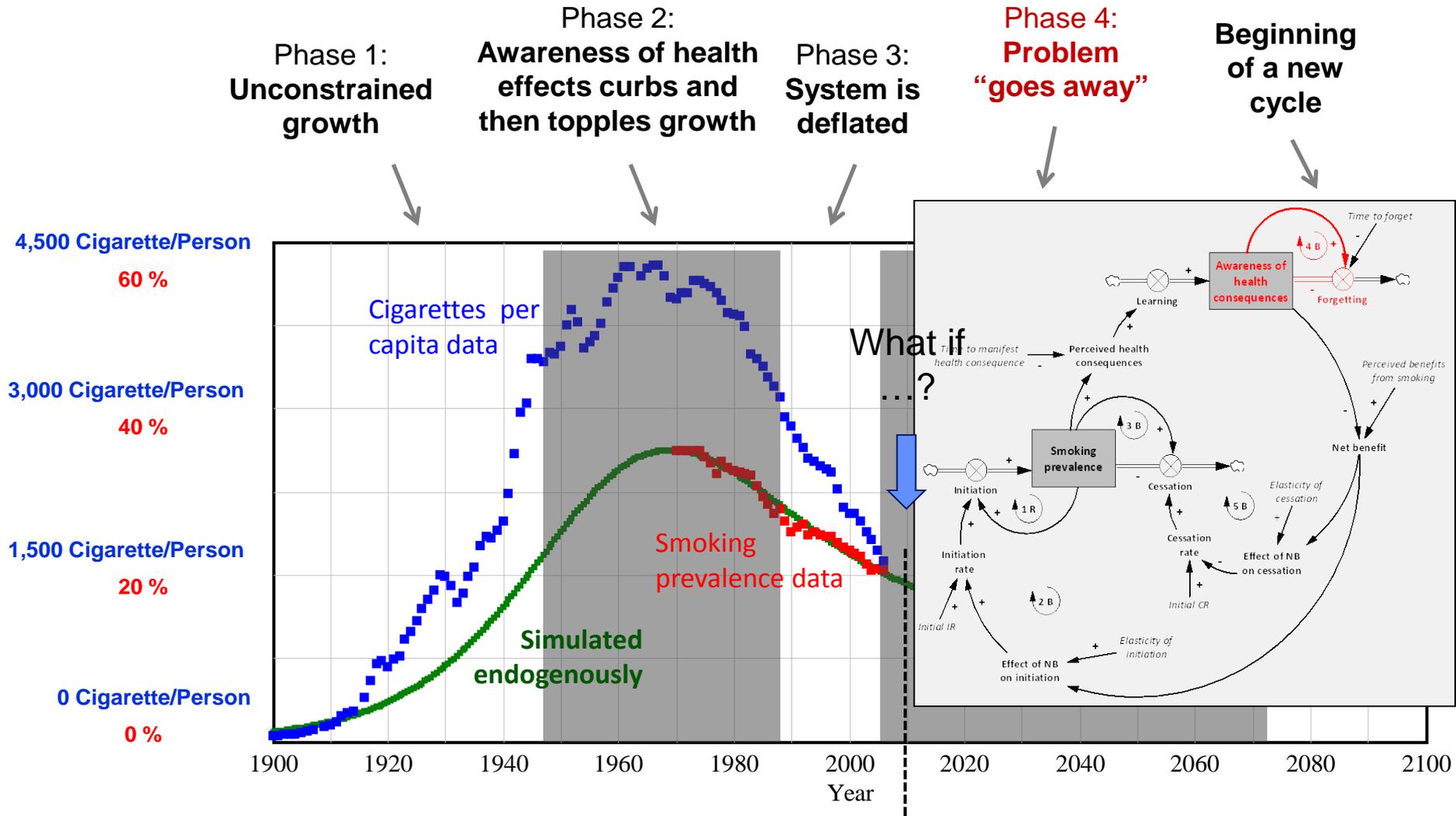


Analysis of the base run: Phase 2

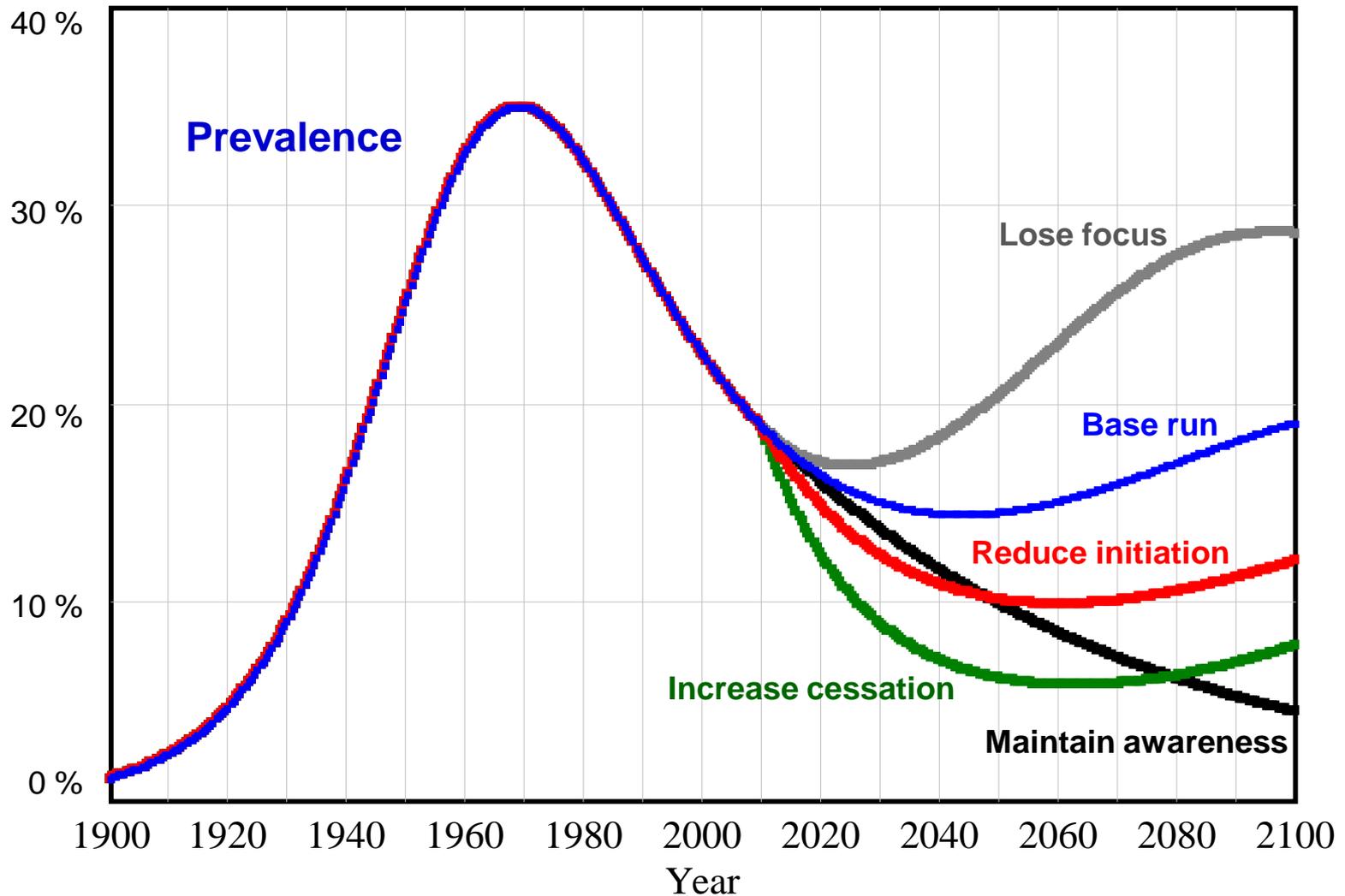
Phase 2:
Awareness of health effects curbs and then topples growth



Societal lifecycle of smoking



Four “what if” scenarios (changes implemented in 2010)



Why is a feedback-rich model/theory useful?

- It helps to understand and explain historical behavior
- It provides the ability to predict changes in patterns
- It helps to identify leverage points, i.e., locations for the most effective strategic interventions in a system
- If the model is kept sufficiently parsimonious:
 - It helps reveal the fundamental structure
 - “Looks at the forest as opposed to focusing at the trees”
- This kind of model is so general that it could be applied to other problem areas
 - where a behavior has a tendency to grow until it is perceived as unhealthy

- Previous studies de-emphasized feedback and/or looked at a limited time frame
 - Information feedback is less tangible and more subjective; it is therefore more open to question and less typical of evidence-based empirical analyses
- A feedback-rich concept model proposes a theory of the societal lifecycle of cigarette smoking and fits the data well
 - The goal was not to produce a perfect model or simulation but to underscore the role of time horizon and feedback in explaining the historical smoking behavior in the population and in capturing tipping points endogenously
- A formal analysis shows phenomena composed of different phases of behavior (patterns) with differing feedback loops dominant in each phase
 - The analysis indicates that we find ourselves in the beginning of a very long and gradual phase of “losing awareness” (aka, parable of the “boiled frog”), transitioning from a period where cessation > initiation to a period where initiation > cessation
 - Prevalence could bounce back if people “forget” or resources are placed elsewhere
- Simulated “what if” questions about access, cessation services, and public awareness of the health consequences of smoking cigarettes