Systemic Change and Systematic Change: Using Systems Science Tools to Communicate Complex Concepts

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Steve Marshall, PhD
Injury Prevention Research Center
Department of Epidemiology, Gillings School of Global Public Health
University of North Carolina at Chapel Hill

Outline

Systemic change versus systematic change

- –*How to save New Zealand’s Kauri forests*
- –*How to get people to conserve water in Las Vegas*
- –*How to maximize investment in commuting cycling*

Readings

- *McClure RJ, Mack K, Wilkins N, Davey TM. Injury prevention as social change. Inj Prev. 2016 Jun;22(3):226-9*
- *Stave KA. A system dynamics model to facilitate public understanding of water management options in Las Vegas, Nevada. J Environ Manage. 2003 Apr;67(4):303-13*
- *Macmillan A, Connor J, Witten K, Kearns R, Rees D, Woodward A. The societal costs and benefits of commuter bicycling: simulating the effects of specific policies using system dynamics modeling. Environ Health Perspect. 2014 Apr;122(4):335-44. doi:10.1289/ehp.1307250. Open Acess https://ehp.niehs.nih.gov/1307250/*

Injury prevention as social change

R J McClure,[1] K Mack,[1] N Wilkins,[1] T M Davey[2]

INTRODUCTION

We will not solve the public health problem of injury simply by educating individuals about the nature of injury risk, improving their risk assessment and providing these individuals with information to enable them to reduce the level of risk to which they are exposed. Substantial improvement in the societal injury burden will occur only when changes are made at the societal level that focus on reducing the population-level indicators of injury.[1,2] The shift from an individual to a population perspective has substantial implications for the way we perceive, direct, undertake, and evaluate injury prevention research and practice. The analogy of 'the population as patient' provides a clear illustration of the foundational truths that underpin the preferred public health approach to the prevention of injury.

Society is the system within which populations exist. Sustained change made at the societal level to reduce population-level indicators of injury morbidity and
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person on a given day could double her or his risk of death without noticing the change in their likelihood of dying on the road. If, on that day, the person sustains no adverse consequence from his or her risky driving behaviour, the person's tendency to take that risk again would be reinforced. However, in a city, state or nation with a population of 10 million people, and 11.8 RTC deaths per 100 000 person years that increase in population fatal crash risk by 0.000118 would result in three extra deaths in that population per day, and 1179 deaths extra for the year. Furthermore, a person who moves from Sweden, where there is an estimated national RTC fatality rate of 2.8 per 100 000 per year,[6] to South Africa where there is an estimated rate of 25.1 deaths per 100 000 per year,[6] dramatically increases their personal risk of injury, even if they do not consciously change their driving behaviour—simply because they are changing the context within which their driving occurs.

If we understand causation of injury at
h d d l l l d h bl

potential solutions can be pegged, decisions made and societies held accountable.

Perhaps the most compelling benefit of the 'population as patient' approach is that it provides a clear scope for injury prevention and a means by which prevention goals can be achieved. While we may not know enough to cure a disease, we do know enough to at least shift the health of the least healthy populations to match that of the healthiest.[7] All countries of the world have access to the same evidence base to support technical and behavioural solutions for RTC injury, yet the RTC death rate in some populations is 10 times the rate in others.[6,7] When setting out to halve the global road toll,[8] the first step is to recognise that the occurrence of disease and injury reflects the circumstances of society as a whole.[7,8] There is tremendous opportunity for reduction in RTC injury that can be achieved by bringing the road transportation system of the highest risk populations into line with transport systems already existent in populations of lowest risk. Public health approaches to unintentional injury and violence prevention should not be merely educating individuals about their own individual risk, but instead should focus on putting in place changes to the system that are required if lives are to be saved.

McClure RJ, Mack K, Wilkins N, Davey TM. Injury prevention as social change. Inj Prev. 2016 Jun;22(3):226-9

Commentary

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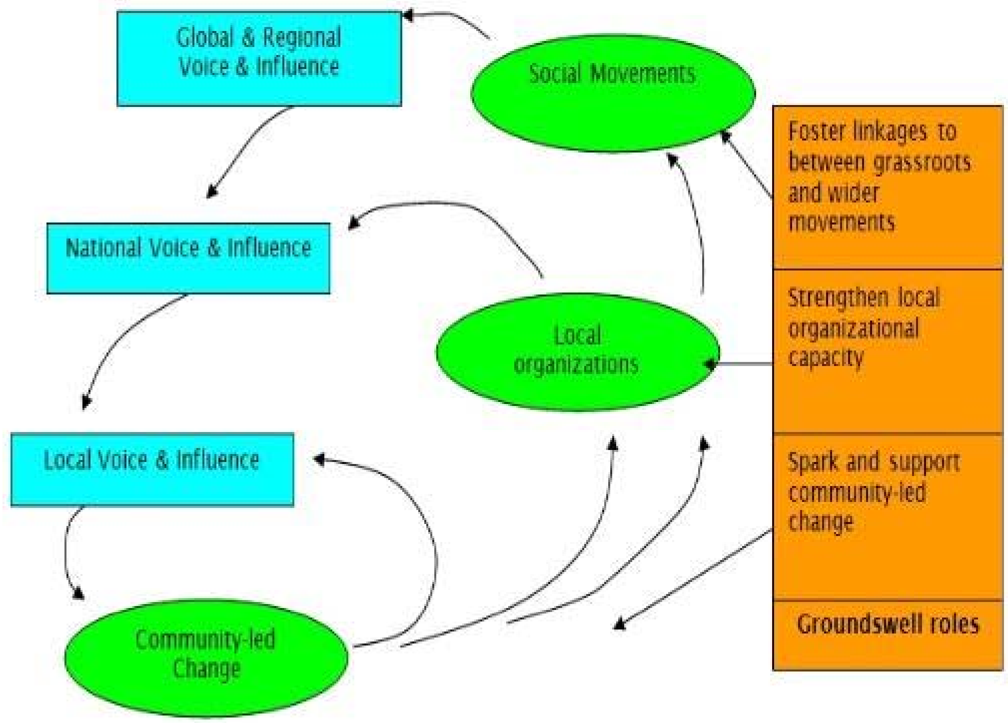
Shift away from

current **systematic** approaches

& towards **systemic** approaches



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"…the efficacy of seat belts, speed limits or roadside crash barriers, can be quantified in research settings, but these countermeasures can never comprise a motor vehicle safety ***solution*** *on their own…"*

"…These components can only influence ***population-level road traffic crash mortality and morbidity*** *if incorporated into a* ***larger intervention*** *that includes a strong* ***public demand*** *for change, committed societal leadership, a* ***climate of safety****, an* ***appropriate infrastructure****, cooperation and coordination between all stakeholders, and a* ***long-term perspective*** *from all…."*

WOW – how do we make THAT happen?

Commentary

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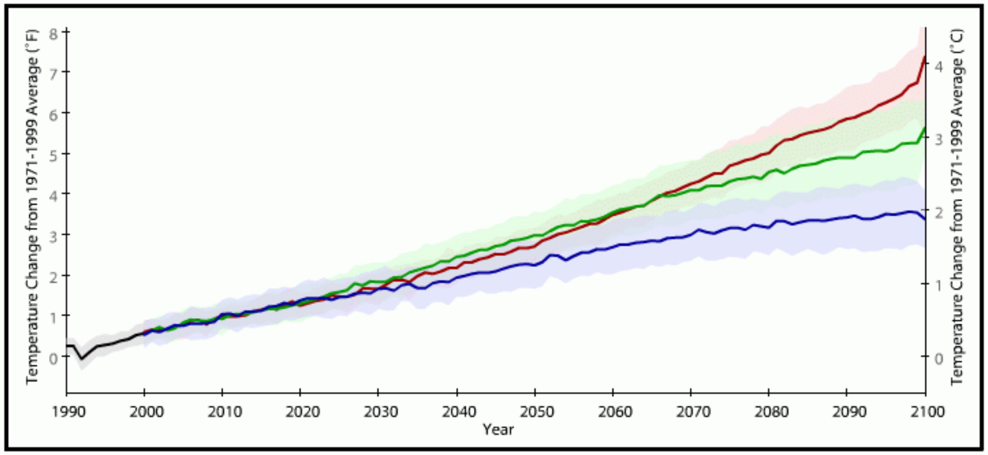
*"…A **systemic intervention** capable of achieving sustained population-level change is designed and built from the ground up **within the institutions and infrastructures that define society's form and function**."*

*This is why, as a collective, scientists are increasingly failing to have **impact** on society*

Our Inability to Positively Impact Climate Change is the Single Greatest Failure in Science:

We agonized over the nuances of climate models, but failed to do research on how to best communicate their results



Popular wisdom holds that homo sapiens is notable for its intellect. This is clearly wrong.

We are less well-organized than bees & ants and far more miserable than dolphins & whales.

We are hell-bent on destroying the natural resources of our planet, we inflict untold pain and suffering on one another, and we are unable to control our rampant population growth. We are the great cancer of the biosphere, and our growth is unchecked.

As a species, humans are NOT SMART. We are highly social and VERY competitive, but we are NOT communally intelligent.

The net intelligence of a group of people is almost always less than the sum of the parts. We're good at fighting battles against one another; lousy at winning wars together.

As a result, we often fail to plan for, or react to, CHANGE at a communal level. Notably, when faced with a challenge, we do not react in a cohesive and strategic manner as a group.

The Story of New Zealand's Kauri Forests (Agatha Australis)

- Greatest Tree in the World
- Tall straight trunk
- Spreading canopy supports enormous biomass
- Shallow spreading roots
- 50m tall with 15m girth
- Mature after 200-500 years
- Live for 2,000 years
- Once covered 1.2M hectares
- Amazing eco-system would be worth $$$Billions in today's global eco-tourism economy

The Sad Part of the Story

- Forest reduced by ~75% over ~50 years of systematic logging by Europeans settlers (1980s-1930s)
- Horrified at the destruction, loggers and the gov't set up preserves comprising a few fragmentary forest remnants
- These are now protected parklands

- <u>Lesson</u>: Markets Maximize Short-Term Profit, Not Long-Term Value

The Sadder Part of the Story -- Kauri Dieback (2010 onwards)

- Kauri dieback is a mold that infects kauri roots and kills these trees
- People & shoes are the main vector
- Pathogen can be killed by common disinfectant
- BUT: Infected areas often appear uninfected
- BUT: Voluntary disinfection stations in forest areas have been a marked failure due to lack of adoption of shoe-disinfection behavior

- Lesson: Failure to grasp the potential for destruction and immediately close parks has perhaps doomed the few remaining trees
- A CLASSIC FAILURE TO THINK OF THE PEOPLE AND THE FORESTS AS A SYSTEM

How can we get people to step back from their own petty self-interests and see the big picture?

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A system dynamics model to facilitate public understanding of water management options in Las Vegas, Nevada

Krystyna A. Stave*

Department of Environmental Studies, University of Nevada, 4505 Maryland Parkway, P.O. Box 454030, Las Vegas, NV, USA

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Abstract

Water managers increasingly are faced with the challenge of building public or stakeholder support for resource management strategies. Building support requires raising stakeholder awareness of resource problems and understanding about the consequences of different policy options. One approach that can help managers communicate with stakeholders is system dynamics modeling. Used interactively in a public forum, a system dynamics model can be used to explain the resource system and illustrate the effects of strategies proposed by managers or suggested by forum participants. This article illustrates the process of building a strategic-level system dynamics model using the case of water management in Las Vegas, Nevada. The purpose of the model was to increase public understanding of the value of water conservation in Las Vegas. The effects of policies on water supply and demand in the system are not straightforward because of the structure of the system. Multiple feedback relationships lead to the somewhat counterintuitive result that reducing residential outdoor water use has a much greater effect on water demand than reducing indoor water use by the same amount. The model output shows this effect clearly. This paper describes the use of the model in research workshops and discusses the potential of this kind of interactive model to stimulate stakeholder interest in the structure of the system, engage participant interest more deeply, and build stakeholder understanding of the basis for management decisions.

1. Define the problem
2. Describe the system
3. Develop the model
4. Build confidence in the model
5. Use the model for policy analysis
6. Use the model for public outreach

The workshops lasted approximately two and a half hours. Participants were given a brief introduction to the problem using Fig. 1 above and an overview of the water system structure using Figs. 2 and 4. After the introduction, we spent about 45 min in a facilitated discussion of what might be done to extend the time at which demand would exceed supply. We took 5–10 min to introduce the concept of a model, describing it as an abstraction of reality for a given purpose, and stepped through Figs. 2, 3, and 6 to show how we progressively abstracted from the map of the watershed to create the model. The key to this transition was showing the same pathway of flow—from Lake Mead, into the distribution system, to the treatment plants, into the Wash, and back to Lake Mead—in each diagram. We explained that the purpose of this model was to help evaluate the relative merits of different policy options for addressing the problem of water demand exceeding supply in the near future. We then used the model to simulate the effects of policy and management ideas participants had proposed in the earlier discussion, and used the model output to continue the discussion of potential policy and management options.

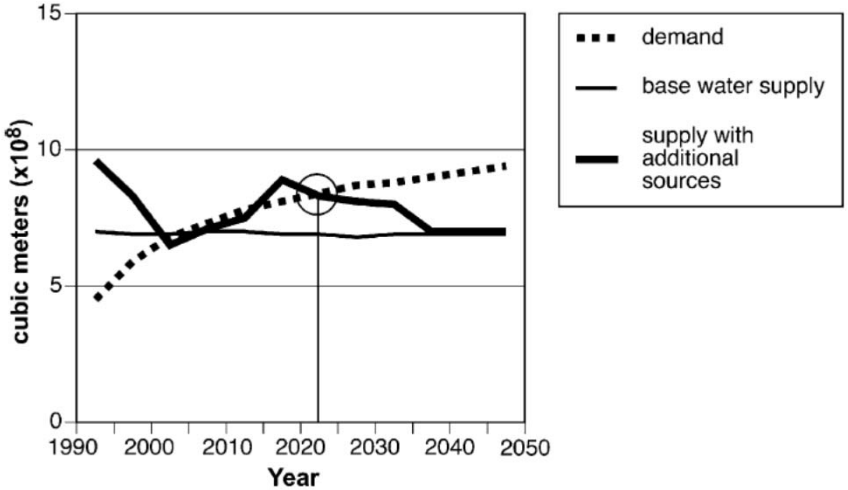

Fig. 1. Las Vegas, Nevada metropolitan area water supply and demand. (Source: SNWA (1997, 2000)).

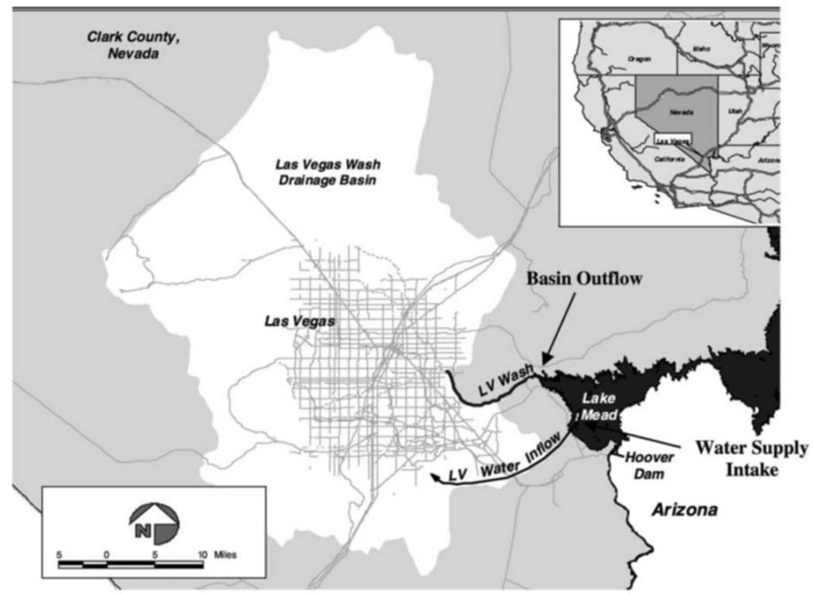

Fig. 2. Las Vegas Valley drainage basin showing water supply intake and Las Vegas Wash drainage.

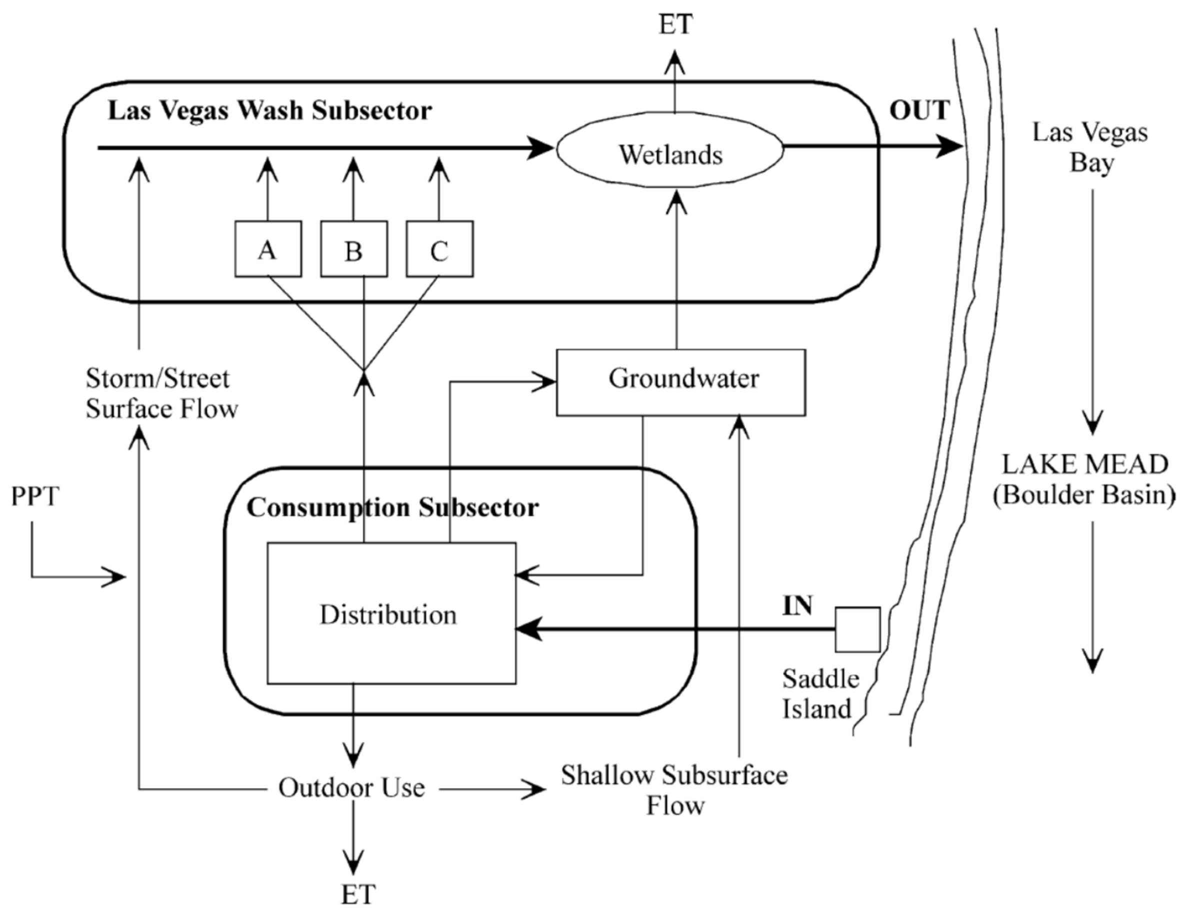

Fig. 3. Schematic diagram of the Las Vegas water system. ET represents evapotranspiration, PPT represents precipitation, and A, B, and C indicate the three wastewater treatment plants that serve the Las Vegas metropolitan area.

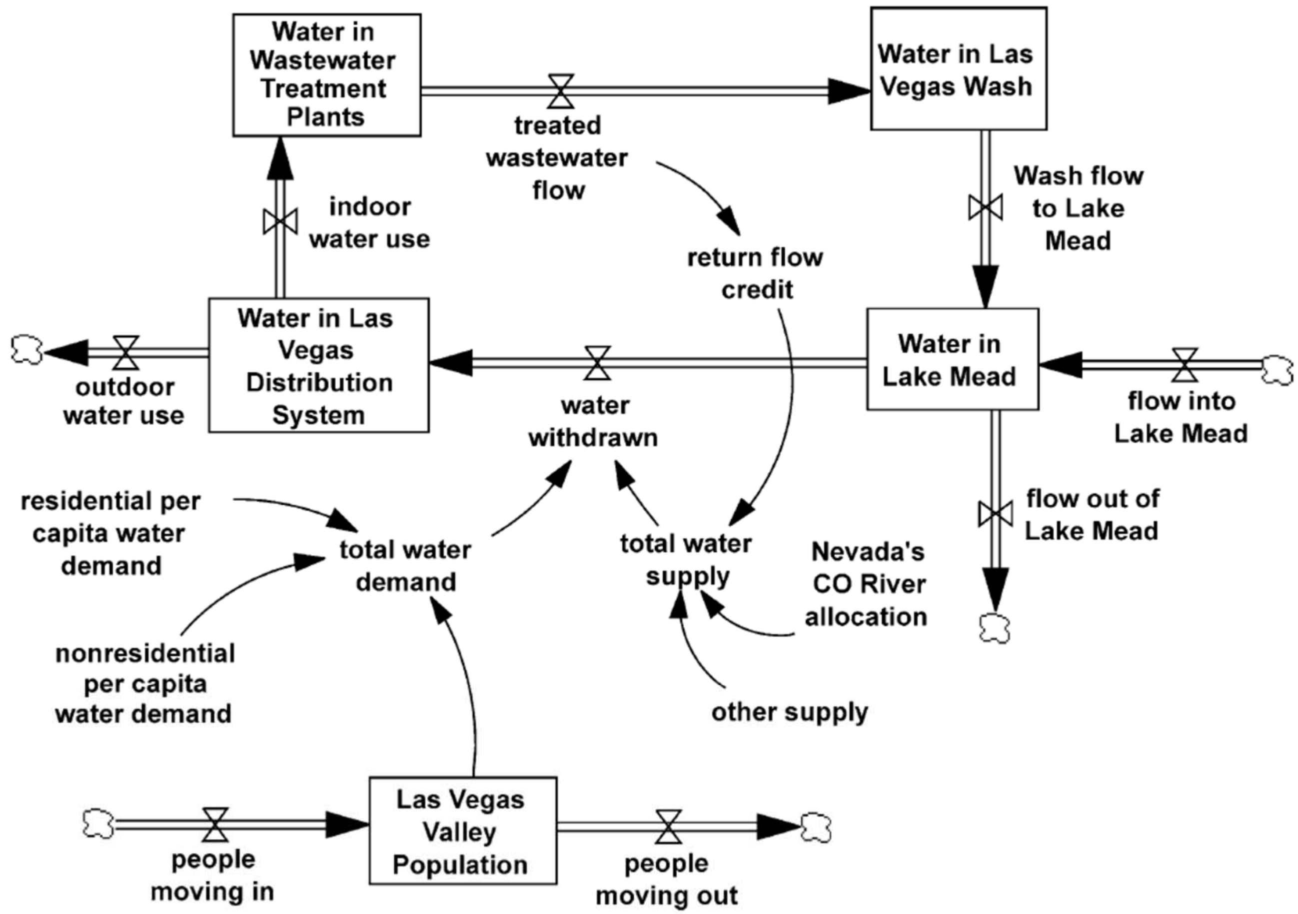

Fig. 6. Las Vegas water system model structure. Boxes represent stocks, or accumulations in the system. Double arrows represent material flow which is regulated by rate variables.

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The challenge resource managers face in communicating with resource stakeholders about a complex and dynamic resource system is to reduce the complexity of the system but still explain the key elements that govern the system's response to policy interventions. They also need to engage the interests of stakeholders who may have different levels of technical expertise. In our workshops, we found the model greatly enhanced participant discussions about the system. The use of the model shifted the discussion from who was to blame for the water problem (hotels and golf courses) and how to solve it (get more water or make the water wasters use less) to how the system works and why it responds to policy changes as it does. The model output graphs, generated from participant suggestions, served as a "hook" that engaged participant interest and led to further questions about the system.

Several things helped make this model effective for communicating with the public. We framed the presentation around a specific management question, tied the model introduction to a map with which everyone was familiar, and kept the model small. Instead of a general information session on the water system, we described the problem graphically, then started the discussion by asking: how do you think we could move the crossing point out later than 2025? Participants seemed to feel more comfortable with a specific management question posed in this way than when the discussion was presented as a general exploration of water management issues. After experimenting with several ways of introducing the water system, we found that the map of the drainage basin worked best. Participants could identify major streets and landscape features on the map. We anchored the next two levels of abstraction, the schematic diagram of the water system (Fig. 3), and the system diagram (Fig. 6) to map features (Lake Mead and the Las Vegas Wash) and at each level described the physical pathway of water flow

The People in This Room are Natural Systems Thinkers & Adaptive Learners

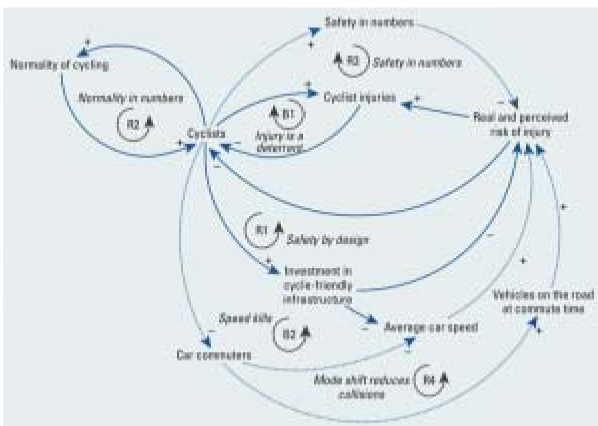
Here's a 6-minute Proof!

- *Find someone in this room that you don't know*
- *2 minutes:* Think of a time when you were effective as a leader in achieving a goal of yours (can be unrelated to roadway injury)
- *2 minutes:* Turn to the person next to you – share your story
- *2 minutes:* Listen to their story (positive comments only please; no need to comment)

The Societal Costs and Benefits of Commuter Bicycling: Simulating the Effects of Specific Policies Using System Dynamics Modeling

Alexandra Macmillan,[1] Jennie Connor,[2] Karen Witten,[3] Robin Kearns,[4] David Rees,[5] and Alistair Woodward[1]

[1]School of Population Health, University of Auckland, Auckland, New Zealan of Otago, Dunedin, New Zealand; [3]Social and Health Outcomes Research anc Zealand; [4]School of Environment, University of Auckland, Auckland, New Ze



Background: Shifting to active modes of transport in the trip to work can achieve substantial co-benefits for health, social equity, and climate change mitigation. Previous integrated modeling of transport scenarios has assumed active transport mode share and has been unable to incorporate acknowledged system feedbacks.

Objectives: We compared the effects of policies to increase bicycle commuting in a car-dominated city and explored the role of participatory modeling to support transport planning in the face of complexity.

Methods: We used system dynamics modeling (SDM) to compare realistic policies, incorporating feedback effects, nonlinear relationships, and time delays between variables. We developed a system dynamics model of commuter bicycling through interviews and workshops with policy, community, and academic stakeholders. We incorporated best available evidence to simulate five policy scenarios over the next 40 years in Auckland, New Zealand. Injury, physical activity, fuel costs, air pollution, and carbon emissions outcomes were simulated.

Results: Using the simulation model, we demonstrated the kinds of policies that would likely be needed to change a historical pattern of decline in cycling into a pattern of growth that would meet policy goals. Our model projections suggest that transforming urban roads over the next 40 years, using best practice physical separation on main roads and bicycle-friendly speed reduction on local streets, would yield benefits 10–25 times greater than costs.

Conclusions: To our knowledge, this is the first integrated simulation model of future specific bicycling policies. Our projections provide practical evidence that may be used by health and transport policy makers to optimize the benefits of transport bicycling while minimizing negative consequences in a cost-effective manner. The modeling process enhanced understanding by a range of stakeholders of cycling as a complex system. Participatory SDM can be a helpful method for integrating health and environmental outcomes in transport and urban planning.

Citation: Macmillan A, Connor J, Witten K, Kearns R, Rees D, Woodward A. 2014. The societal costs and benefits of commuter bicycling: simulating the effects of specific policies using system dynamics modeling. Environ Health Perspect 122:335–344; http://dx.doi.org/10.1289/ehp.1307250

BL=nothing RCN=mixed use roads ASBL=Arterial Segregated Bike Lanes SER=Self-Explaining Roads (Traffic Calming)

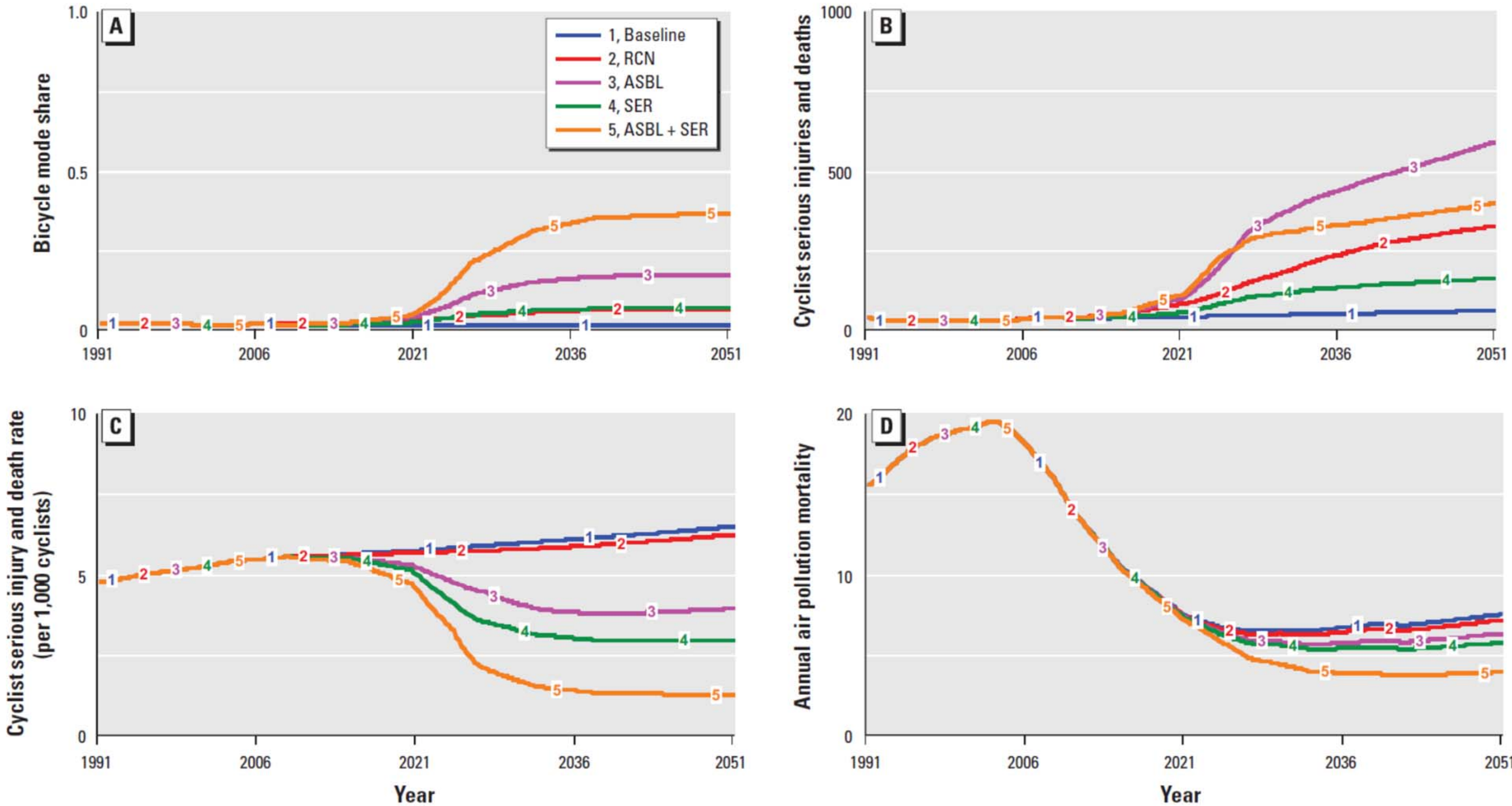
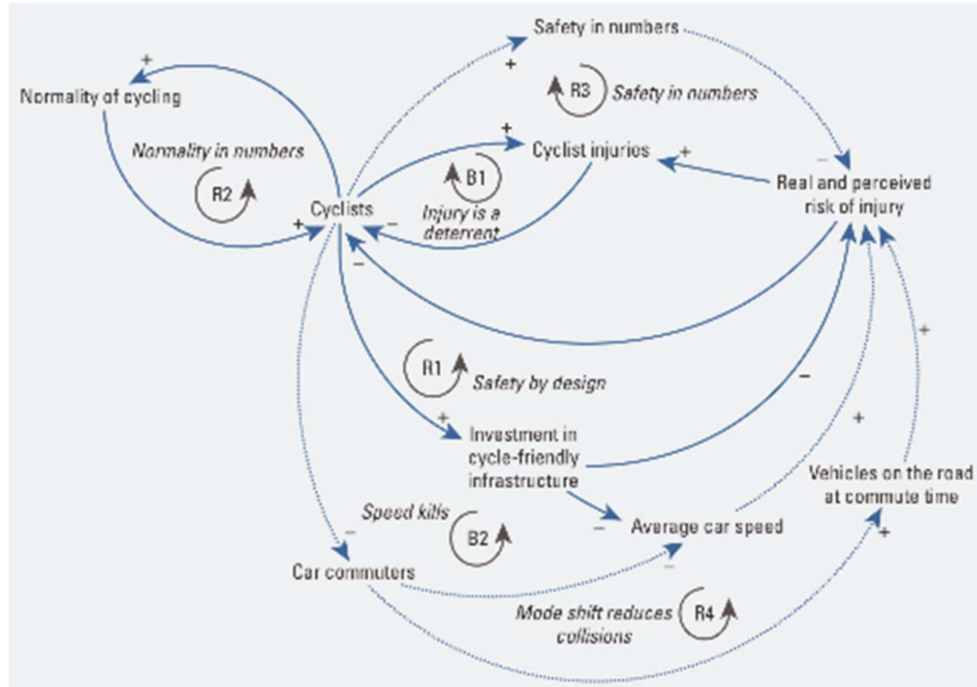
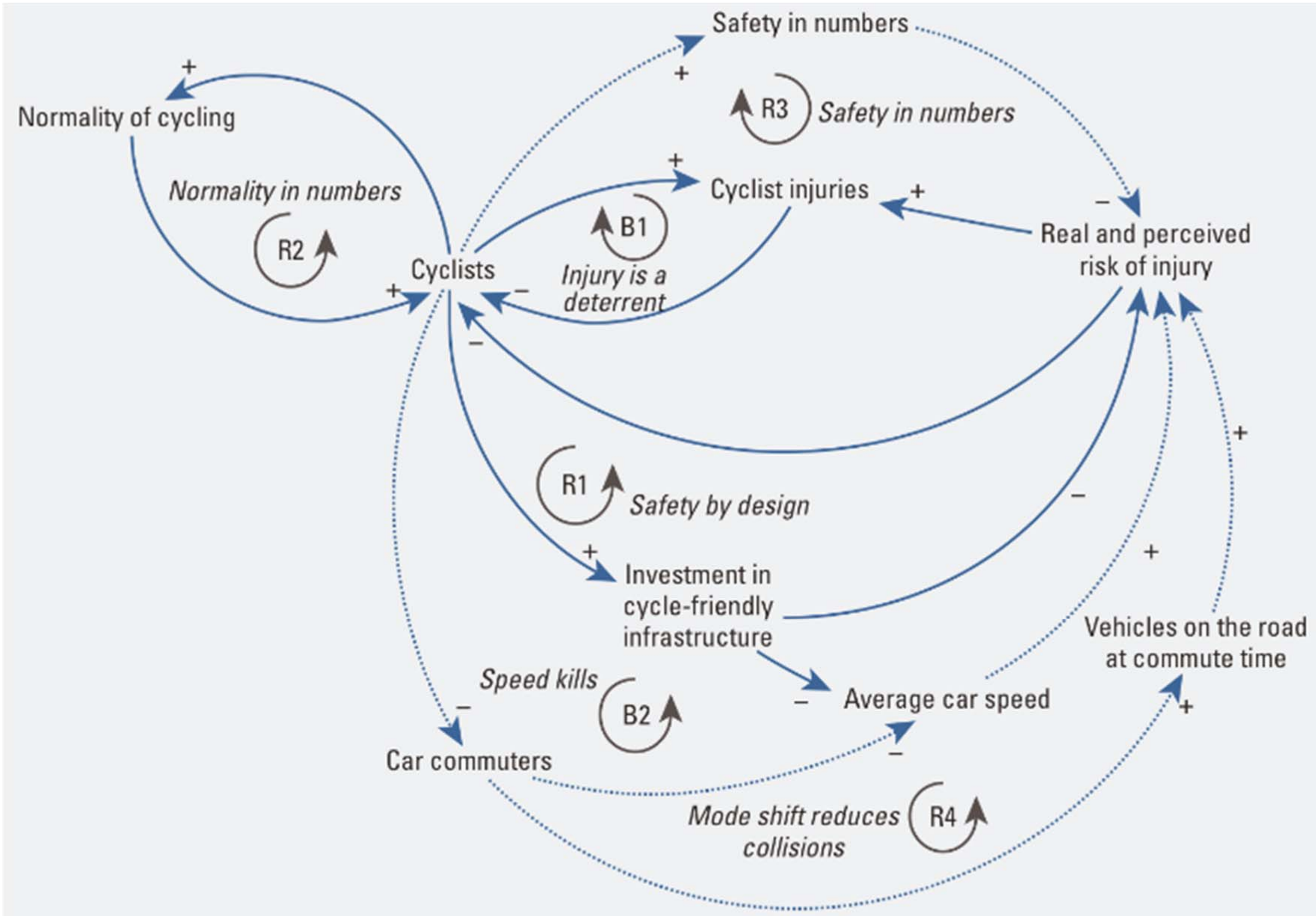


Figure 2. Dynamic model outputs 1991–2051. (*A*) Commuter bicycling mode share. (*B*) Annual serious and fatal injuries to commuter cyclists due to collisions with light vehicles. (*C*) Commuter cyclist injury rate per 1,000 cyclists. (*D*) Mortality due to air pollution from the commuting light vehicle fleet.

Causal loop diagram for bicycle commuting developed from stakeholder interviews and workshops, literature review, and data incorporation.

- Dotted lines denote loops identified by stakeholders and the literature, but where local data suggests they are currently inactive.
- Arrows with a positive sign (+) indicate that a change in the originating variable leads to a corresponding change in the variable at the arrowhead.
- Arrows with negative signs (–) indicate that a change in the originating variable leads to a change in the opposite direction for the arrowhead variable
- R, reinforcing or positive feedback loop
- B, balancing or negative feedback loop)




Safety in numbers
R3 Safety in numbers
Normality of cycling
Normality in numbers
R2
Cyclists
Cyclist injuries
B1
Injury is a deterrent
Real and perceived risk of injury
R1
Safety by design
Investment in cycle-friendly infrastructure
Vehicles on the road at commute time
Speed kills
B2
Average car speed
Car commuters
Mode shift reduces collisions
R4