National SCIENCE Challenges

RESILIENCE TO NATURE'S CHALLENGES

Kia manawaroa – Ngā Ākina o Te Ao Turoa

Building natural hazard resilience; what knowledge "push" do we need?

Professor Shane J. Cronin

Director of the Resilience Challenge

National Science Challenges

University of Auckland and GNS Science, New Zealand

What do I mean by Resilience?

The features of a system to:

- *anticipate threats*,
- *accept there will be impacts*,
- *quickly pick up the pieces*,

as well as

- *learn and adapt from the experience*

to better absorb and rebound from future shocks.

Resilience Challenge Mission

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Bring about a "step-change" in New Zealand's resilience to natural hazard by transforming our governance, business, public and science knowledge and responsibilities

Image: stuff.co.nz

Our Partners

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- GNS Science (host), NIWA, Scion, U Auckland, Massey U, Victoria U, U Canterbury, Lincoln U, Otago U, BRANZ, Opus Intl.
- Other programme leaders from: ResOrgs and Market Economics
- Key researchers also from: Landcare, U Waikato, Auckland Council, Awanuiārangi
- Partnerships with lifelines/utility organisations and unitary authorities in districts and regions throughout New Zealand

GNS SCIENCE TE PŪ AO

NIWA Taihoro Nukurangi

MASSEY UNIVERSITY TE KUNENGA KI PŪREHUROA UNIVERSITY OF NEW ZEALAND

THE UNIVERSITY OF AUCKLAND NEW ZEALAND

UC UNIVERSITY OF CANTERBURY

UNIVERSITY of OTAGO NEW ZEALAND

VICTORIA UNIVERSITY OF WELLINGTON

Lincoln University CHRISTCHURCH–NEW ZEALAND New Zealand's specialist land-based university

SCION forests · products · innovation

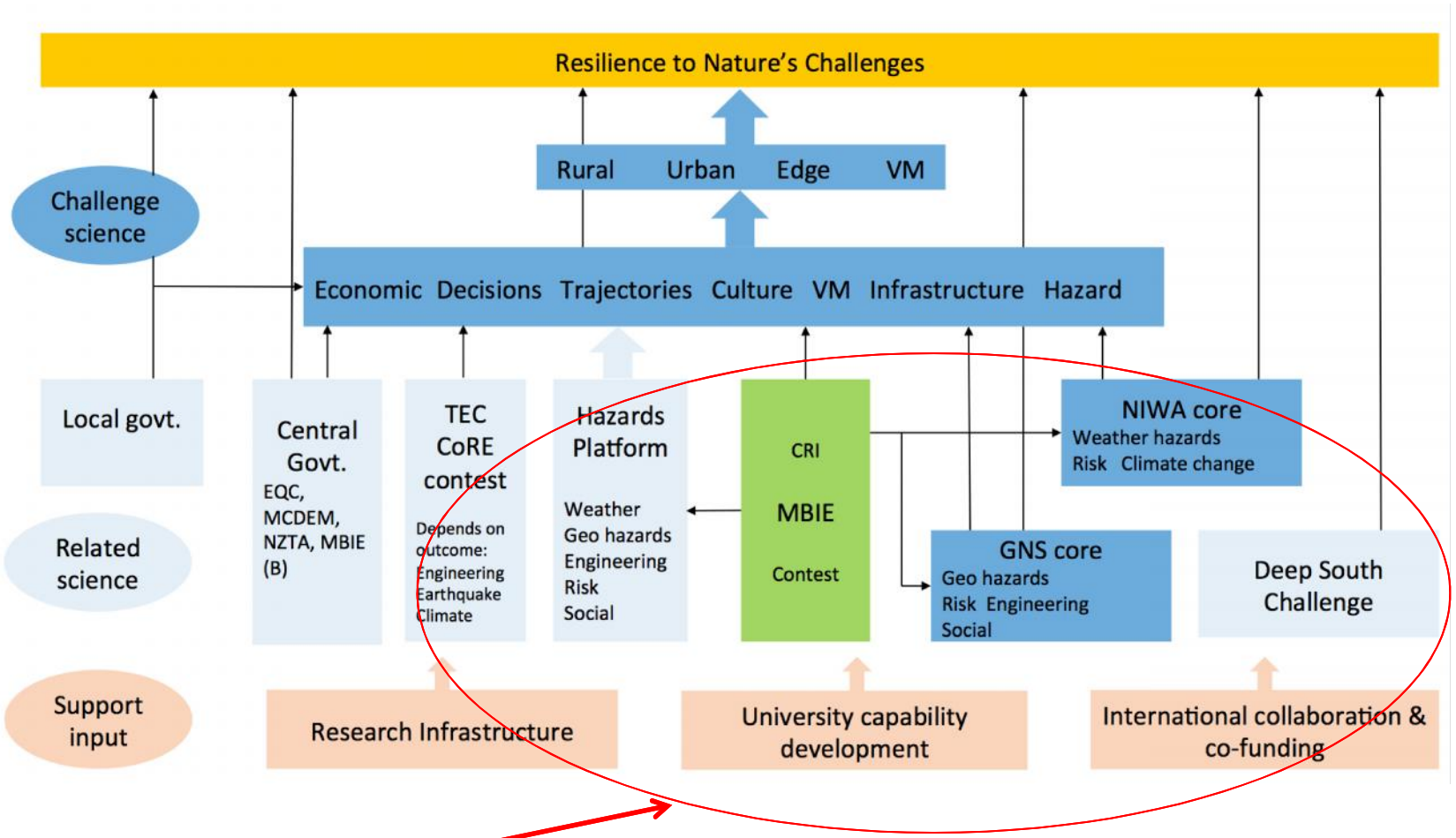
BRANZ

OPUS

Resilience Value Proposition

- New Zealand is the third most vulnerable economy in the world to the impact of natural disasters as a percentage of GDP (*Centre for Economics and Business Research, 2012, Lloyds Global Underinsurance Report 2012*).
- Since 1900, natural disasters cost this country an average 1% of its GDP in any year (*Insurance Council for New Zealand: 2014 Protecting New Zealand from Natural Hazards*).
- If the Reslience Challenge succeeds in reducing the severity of impacts by just 5%, this would have a total net present value of $9.7 billion.

Resilience Challenge in the NZ Hazards Landscape



Underpinning Hazard Research

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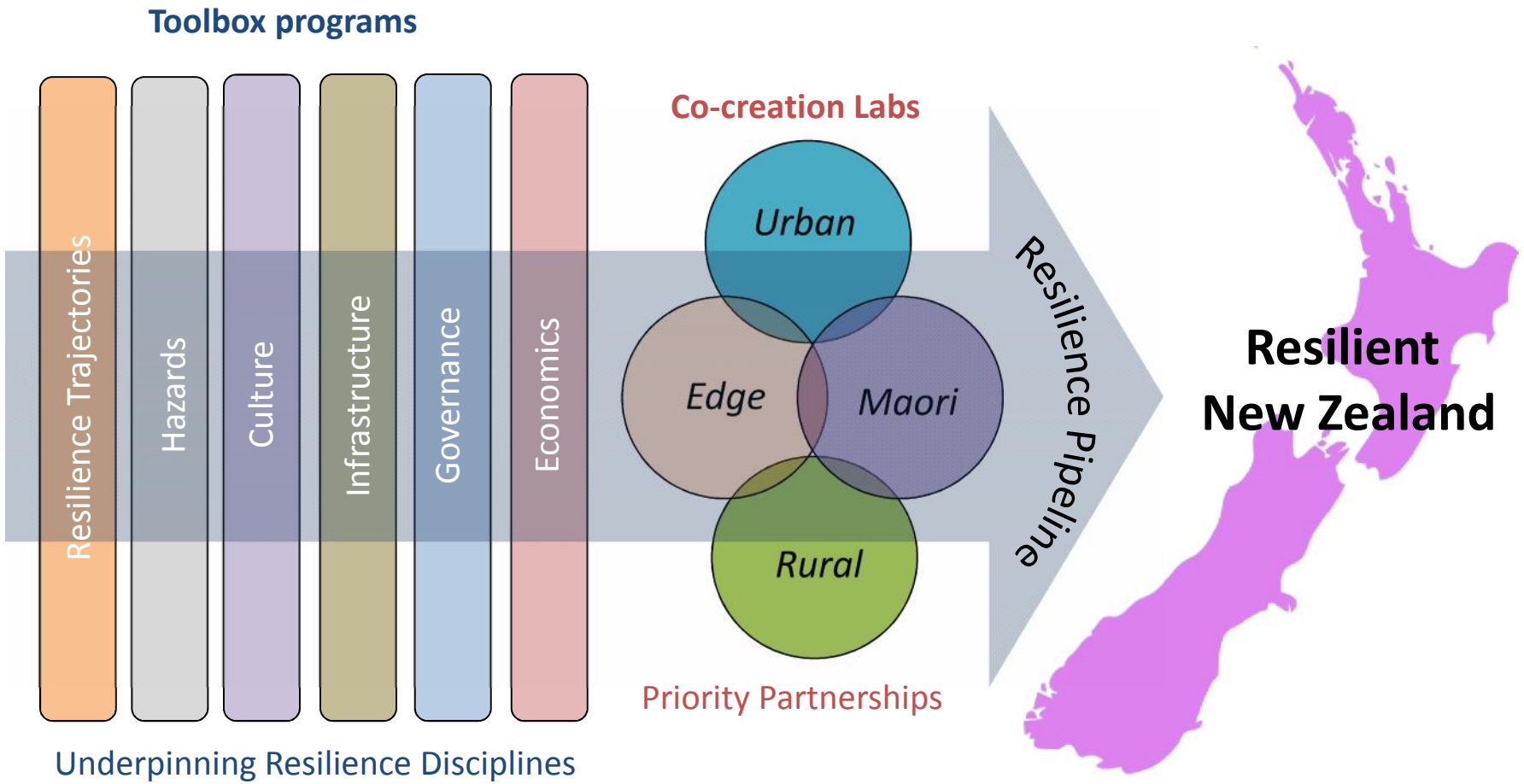
2015-19 Research Program – Resilience Challenge



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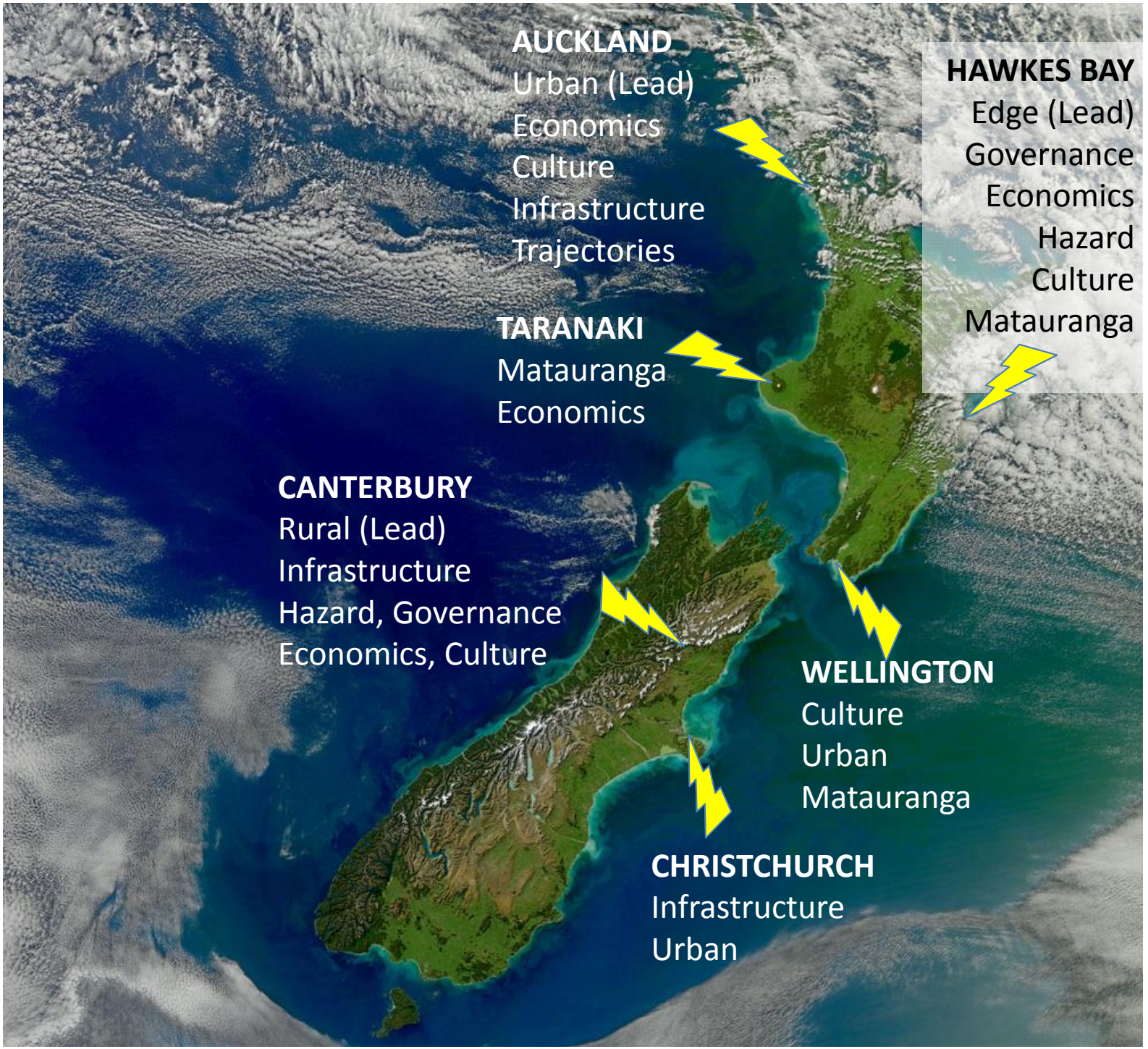
Case studies

NATIONAL
Governance
Hazard
Economics
Matauranga
Rural
Trajectories



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“Laboratories”

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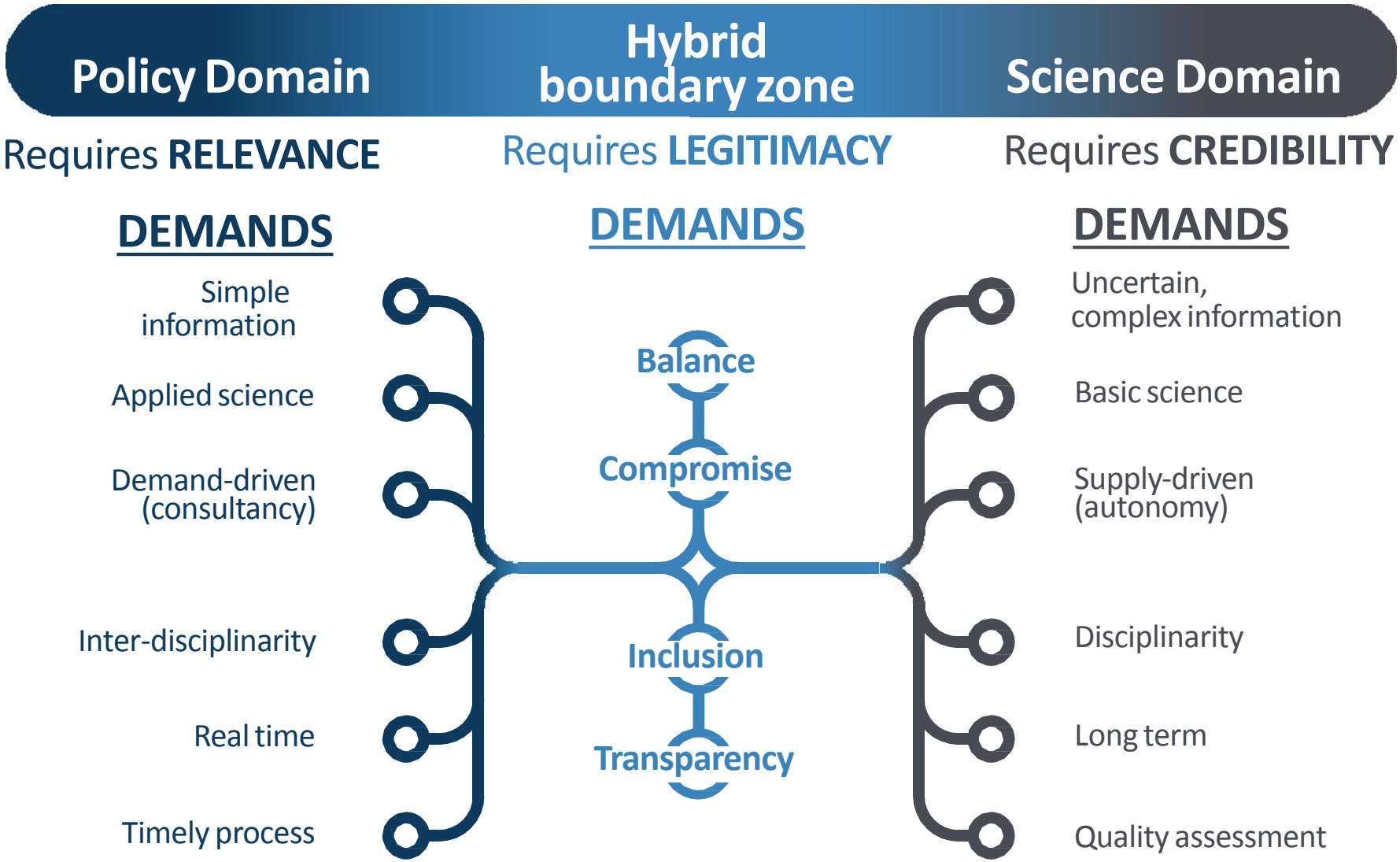
Rural – *Tom Wilson* – Rural resilience support, supply-chain resilience, community resilience to wildfire

Urban – *Suzanne Wilkinson* – Urban resilience network, Resilient Auckland communities, planning, infrastructure and businesses

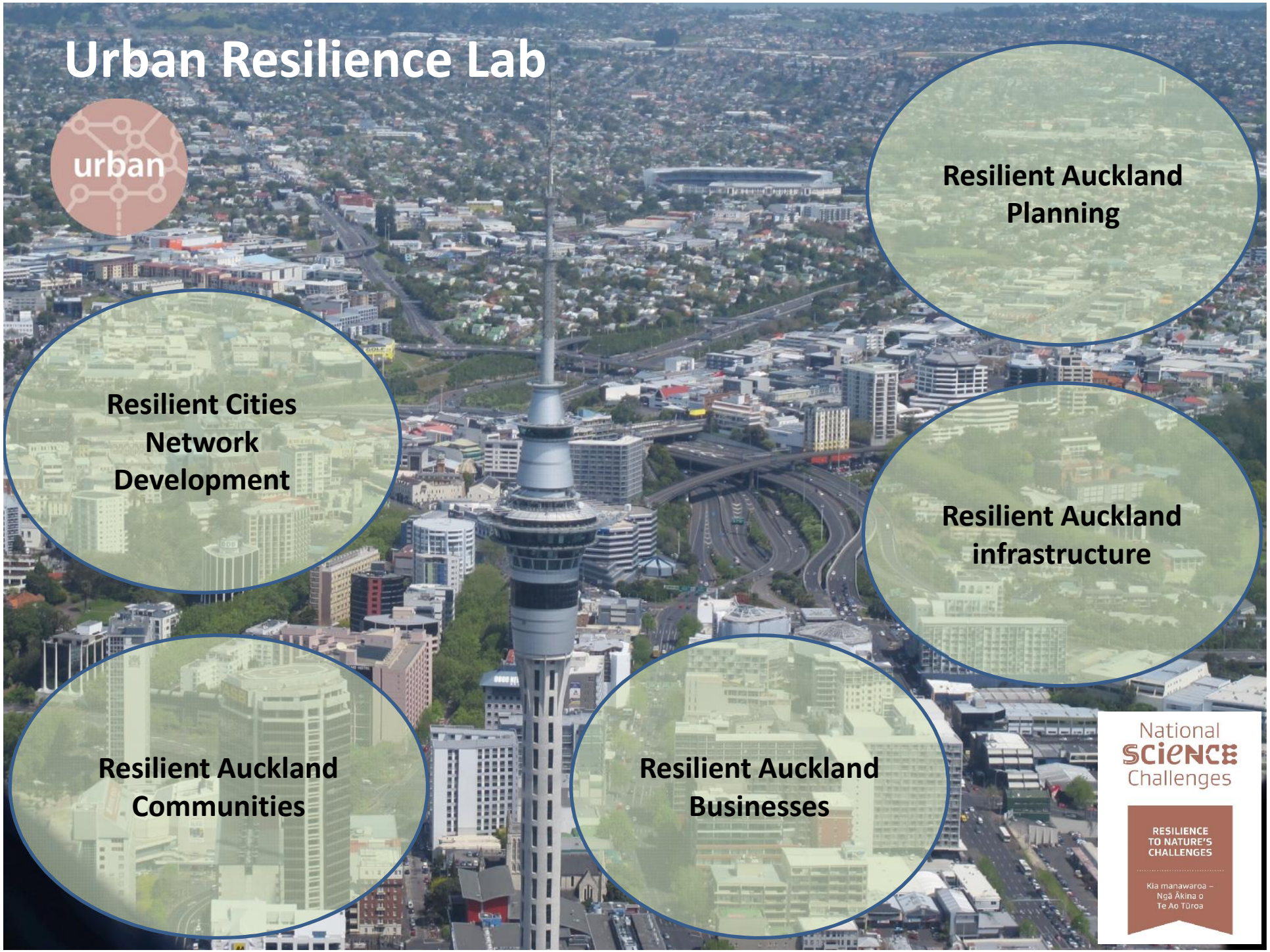
Edge – *Paul Kench* – Shared answers for coastal futures.

Matauranga Māori – *Jon Procter* - Wāhanga Tuatahi (Tikanga Māori), Wāhanga Tuarua (Māori Assets), Wāhanga Tuatoru (cultural landscapes and kaitiakitanga)

Science/policy tensions



Cash et al (2003). Knowledge systems for sustainable development ¨.Parker & Crona 2012, Sarkki et al 2014


Urban Resilience Lab
urban
Resilient Auckland Planning
Resilient Cities Network Development
Resilient Auckland infrastructure
Resilient Auckland Communities
Resilient Auckland Businesses
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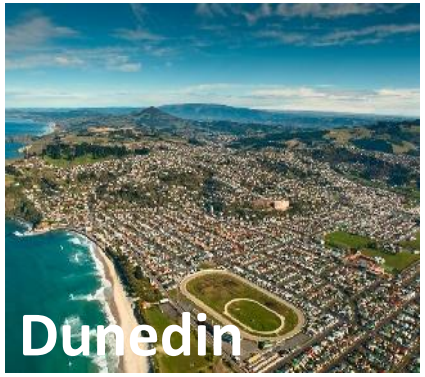
Resilient Cities Network Development Project:

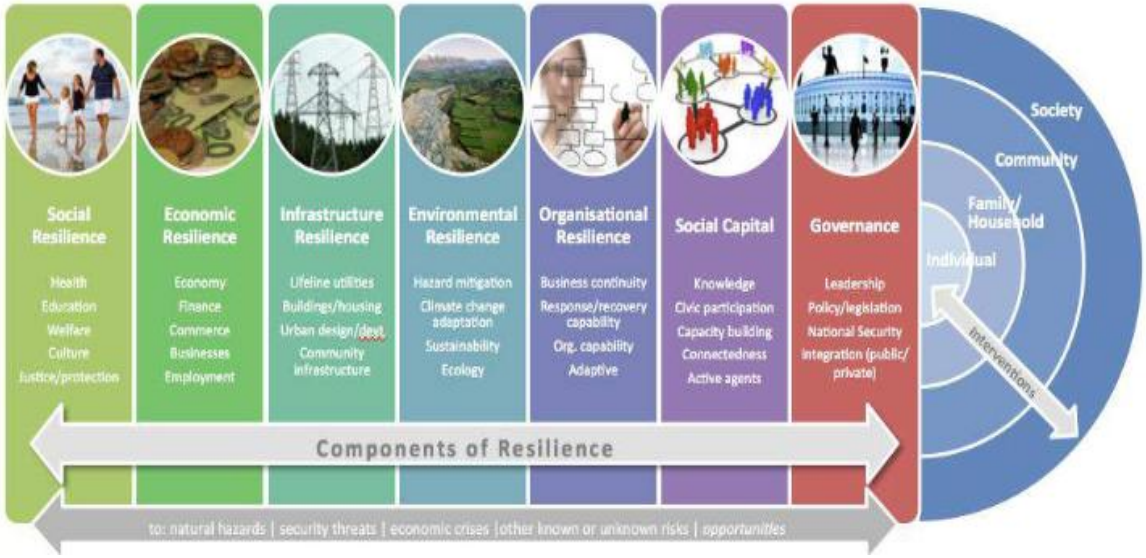
Resilience of New Zealand Cities – An Expert Overview



Resilient Cities Network Development Project:

Resilience of New Zealand Cities – An Expert Overview

National Resilience Framework (Horrocks, 2014)



FOR EACH CITY:

- Resilience Strategy
- Resilience Measurement
- Shocks, Stresses and Strains
- Hazards Knowledge and Awareness
- Community Resilience
- Infrastructure Resilience
- Governance for Resilience
- Economics of Resilience
- Future

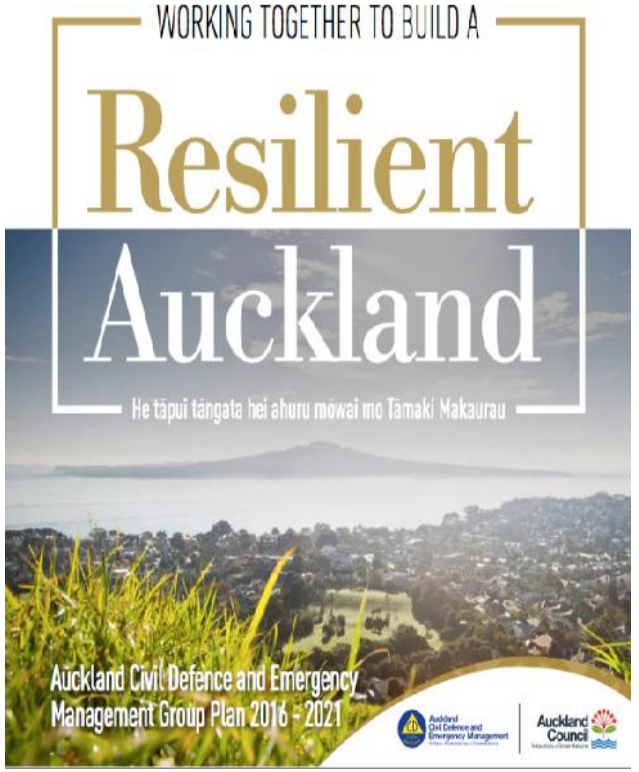
Resilient Cities Network Development Project:

Resilience of New Zealand Cities – An Expert Overview

FINDINGS

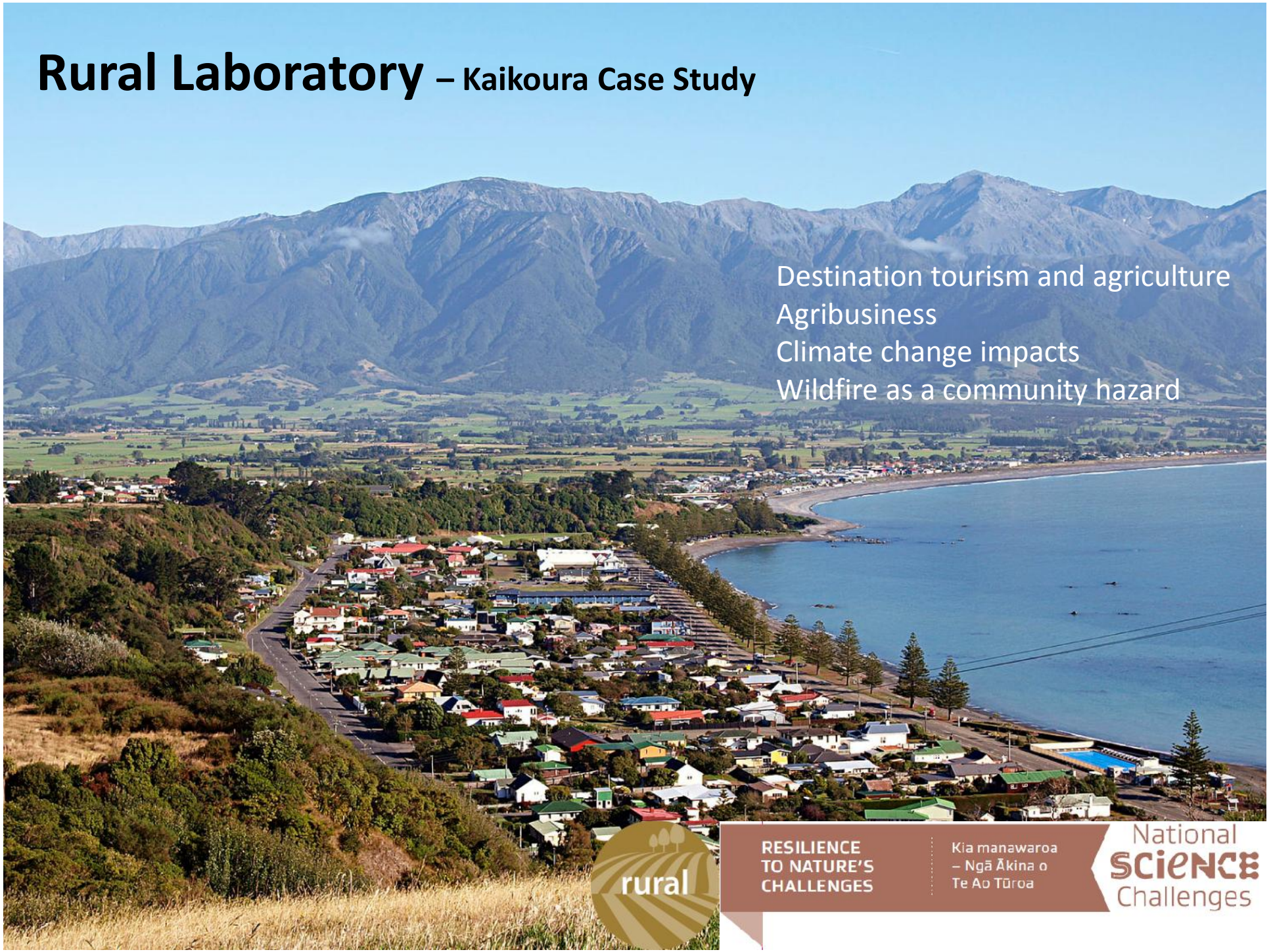
Resilience Strategies on Rockfeller 100 Res Cities framework, Wellington and Christchurch

Auckland is doing its own thing



Smaller cities are generally under-resourced, follow Civil Defence – Emergency Management guides..

Rural Laboratory – Kaikoura Case Study



- Agribusiness + Tourism
- Socially important for regional economies and identities.
- Rural regions are experiencing:
  - Structural change
  - Social change
  - Globalisation and teleconnections
- Integrated Hazard with water management and climate change adaptation

Programme Overview

1. Resilience Solutions for Rural New Zealand co-produce and broker innovative solutions for enhancing the resilience of rural New Zealand

2. Multi-level Resilience develop and apply an integrated, analytical framework for promoting resilience at multiple scales across **rural value chains**

3. Resilience to Wildfire Challenges will co-develop resilience initiatives for wildfire with communities and integrate resilience initiatives within a multi-hazard environment

UC UNIVERSITY OF CANTERBURY

Landcare Research Manaaki Whenua

Lincoln University Te Whare Wānaka o Aoraki CHRISTCHURCH, NEW ZEALAND

University of Otago Te Whare Wānanga o Otāgo NEW ZEALAND

SCION FORESTS PRODUCTS INNOVATION

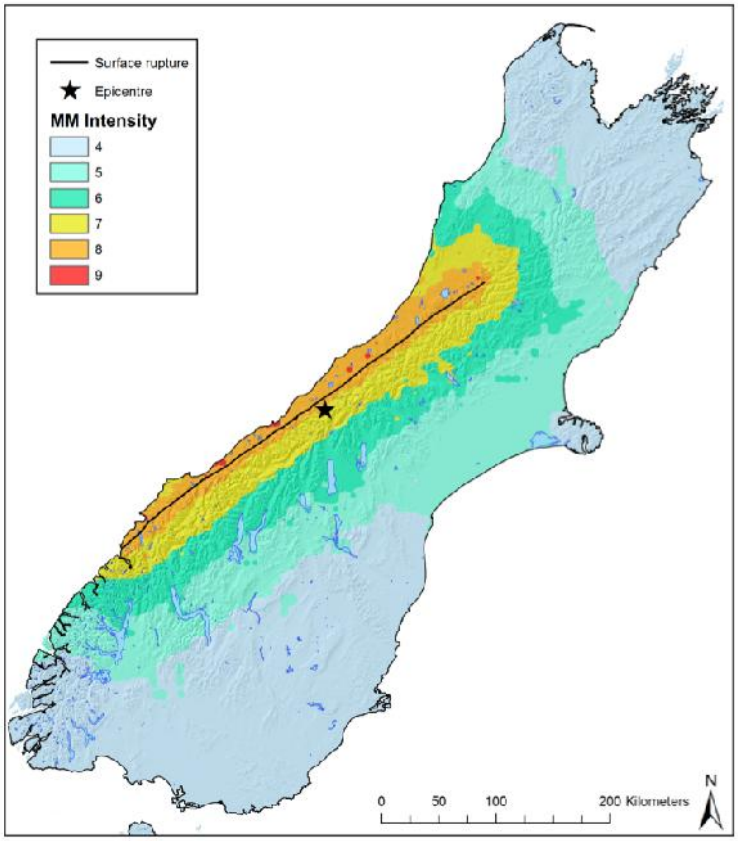
Resilience to Wildfire Challenges:

Improving community resilience

- Hazard modelling –
  - Prometheus models for likelihood and consequence
  - Interface with infrastructure and other hazard
- Community resilience and community-based planning
  - Kaikōura district case study: stakeholder and community engagement with focus on iwi
- Māori engagement for wildfire resilience
  - Karikari Peninsula research
  - Hokianga case study
- Volunteering: formal & informal
  - International literature review and learnings for New Zealand

Rural focus project AF8:
planning for a future Alpine Fault earthquake

- **GOAL:** to build a collective South Island earthquake response plan for a future Alpine Fault earthquake
  - South Island Alpine Fault Earthquake Response (SAFER) Plan
- Involves all 6 South Island CDEM Groups
- Joint practitioner and research funding



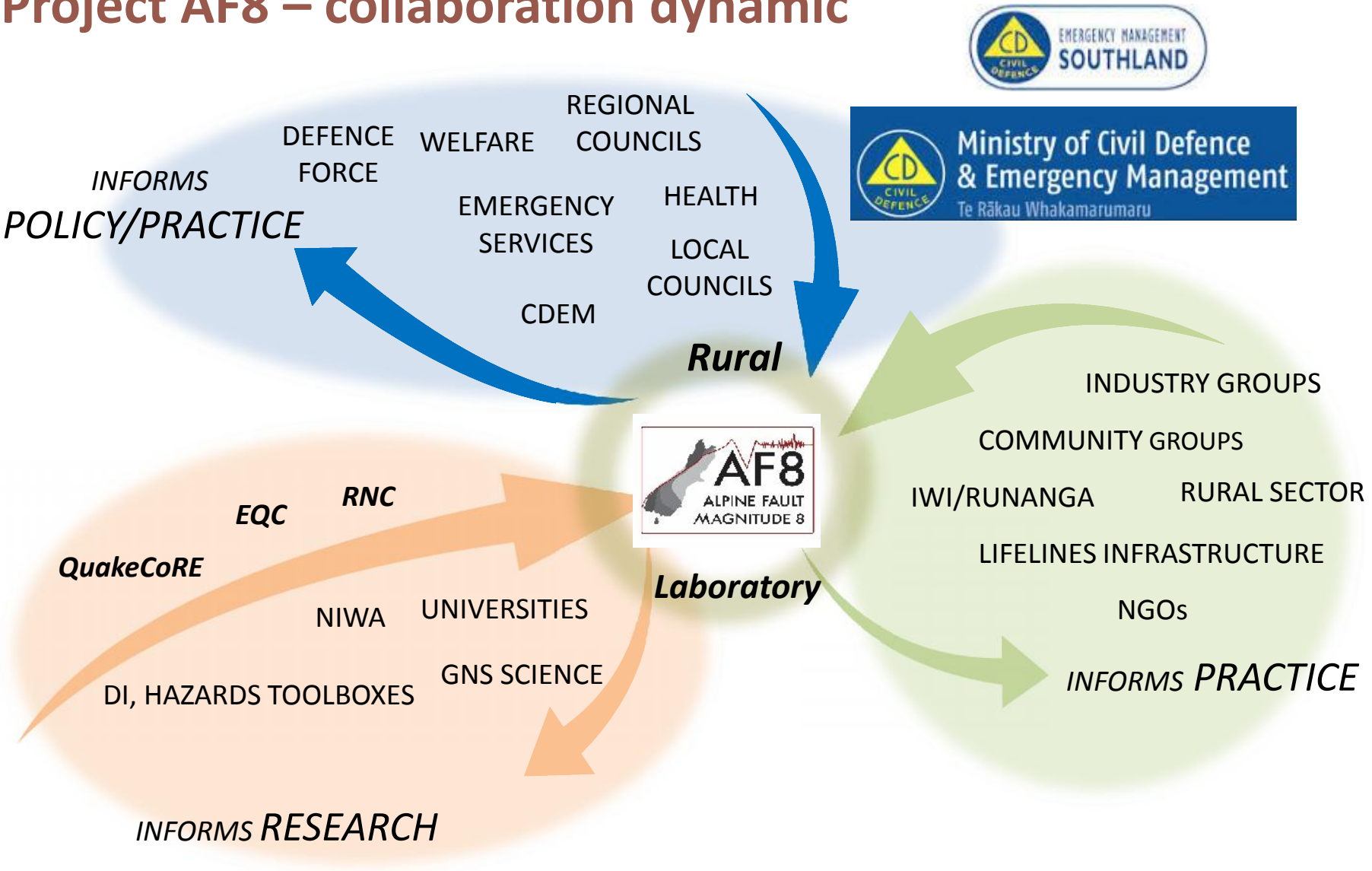
Risk team

30+ researchers
6 Universities
2 CRIs
2 Consulting firms

Response team

Six CDEM groups
Project AF8 Programme Manager
MCDEM

Project AF8 – collaboration dynamic



rural

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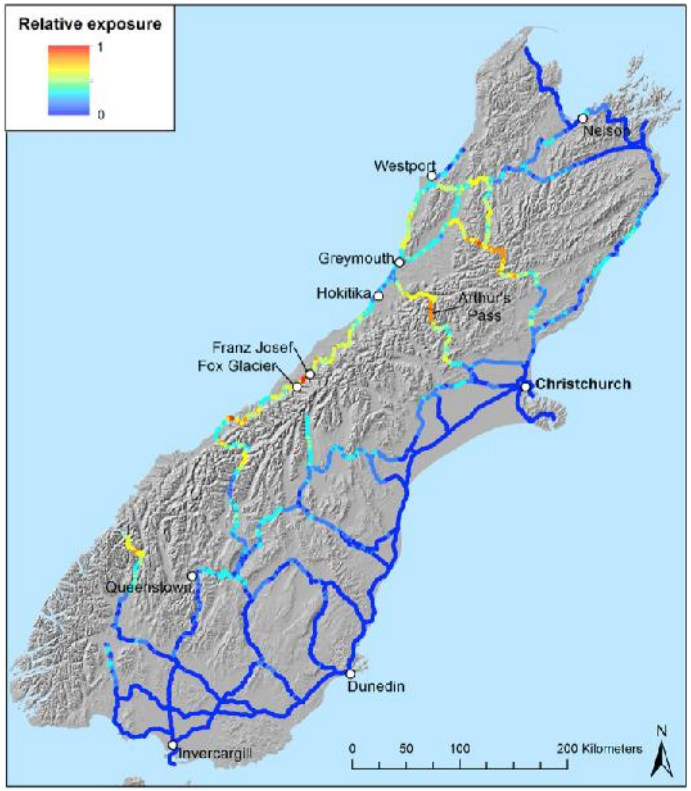
What does this mean? …damage estimates

State Highway Network



Exposure maps show the likelihood of a section of road being affected by a landslide

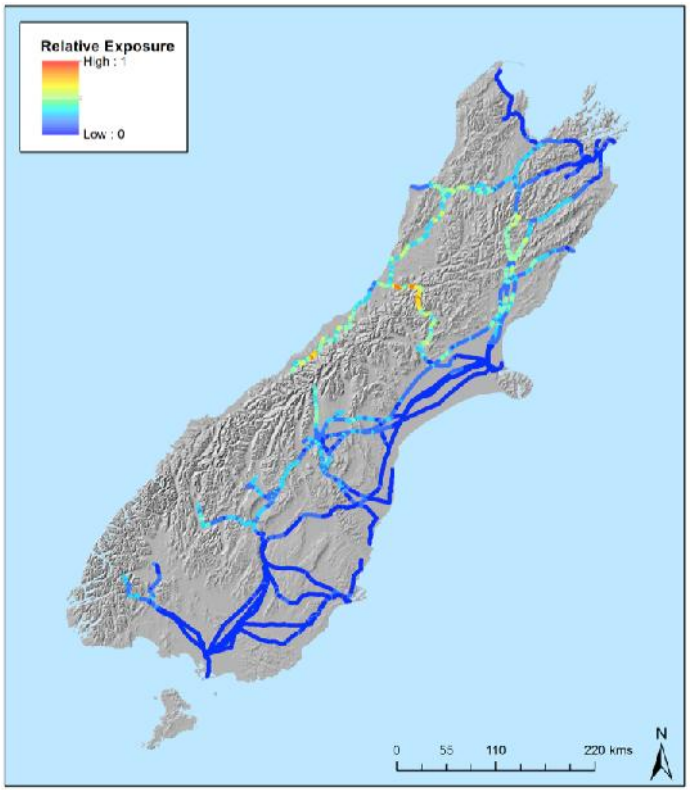
1 = almost certainly

0 = almost impossible

5 sections are particularly exposed:

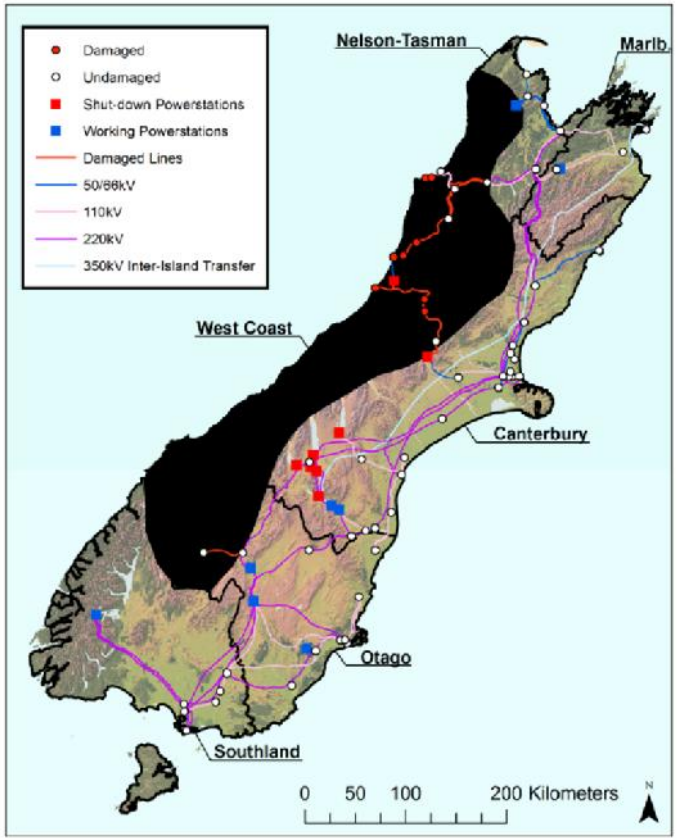
1. Arthur's Pass
2. Lewis Pass
3. Fox Hills (Franz-Fox)
4. Haast Pass
5. Milford Road (Homer Tunnel)

Power Transmission Network



What is the End-User Experience?

Loss of Service (electricity distribution)



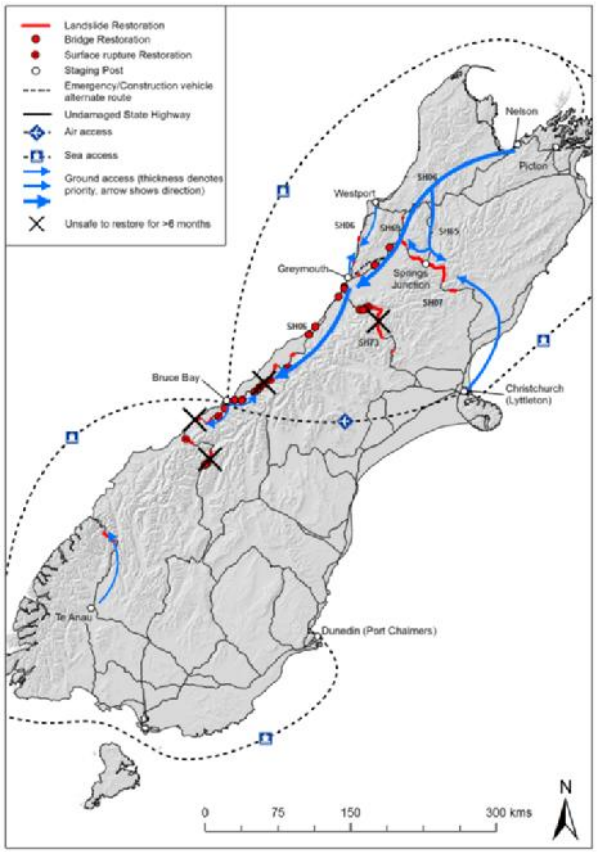
- Scale of outage…
- Duration of outage…
  - Time slices through the scenario

Collaboration with CDEM (including lifeline) agencies to establish level of service estimates, restoration priorities.

- Aftershocks
- Accessibility
- Available resources
- Interdependencies

Build a picture of recovery through time

Restoration Priorities



Lessons…

- Impact is most useful information (not hazard)
  - Casualties, damage, disruption of infrastructure
  - Economic and social impact information

- Communication is essential and has been a challenge
  - Visualizations work well
  - Scenarios highly effective…but need to show range of possibilities (uncertainties)

- Gaps
  - Habitability post-earthquake
  - Economic and social information….pre-event recovery planning
  - Benefits of risk reduction strategies/Costs of increasing risk
  - *Aftershock sequence*

- **End-users don't always know what they want…has to be a collaboration**

LIVING AT THE EDGE - Lab

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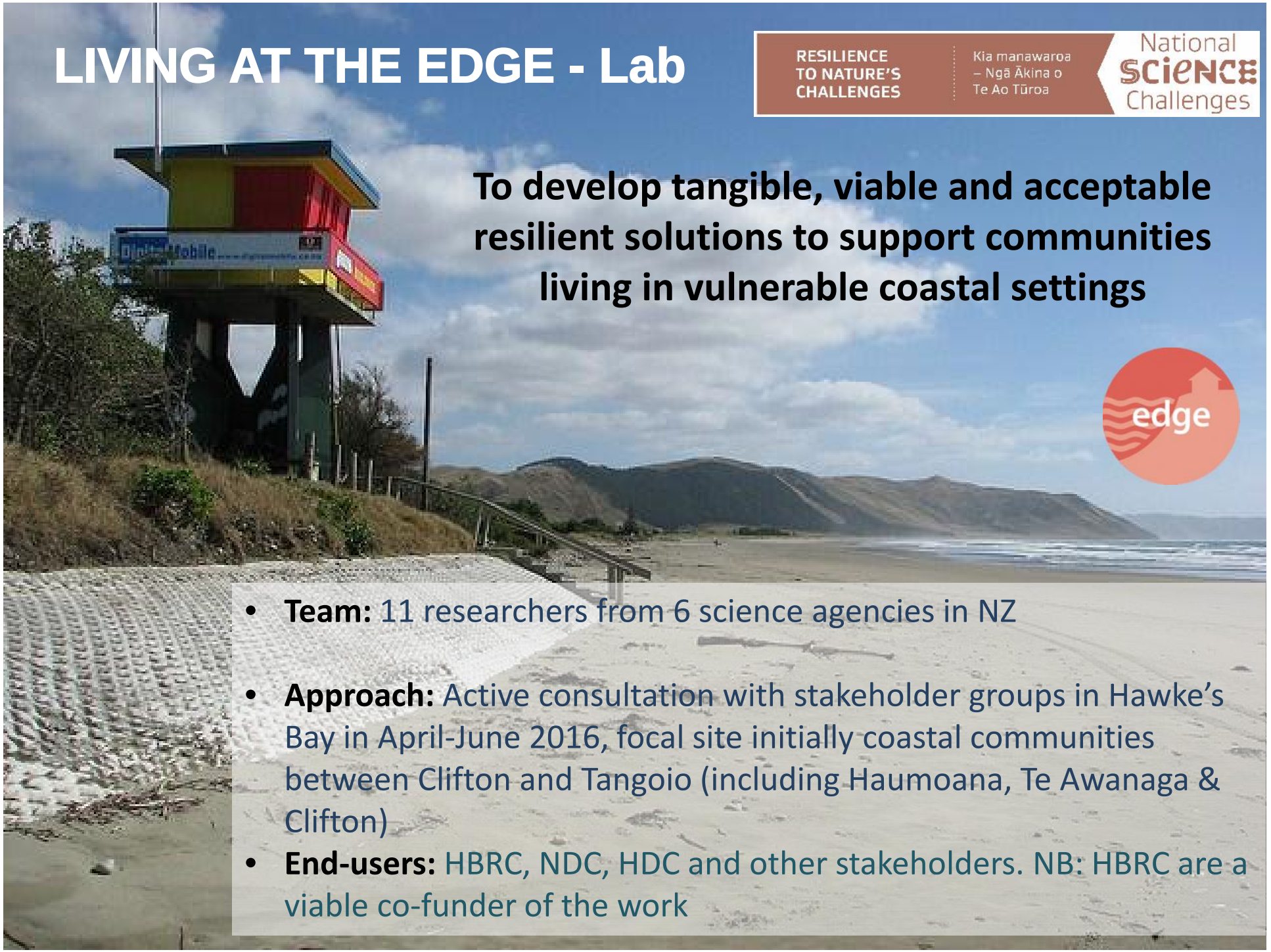
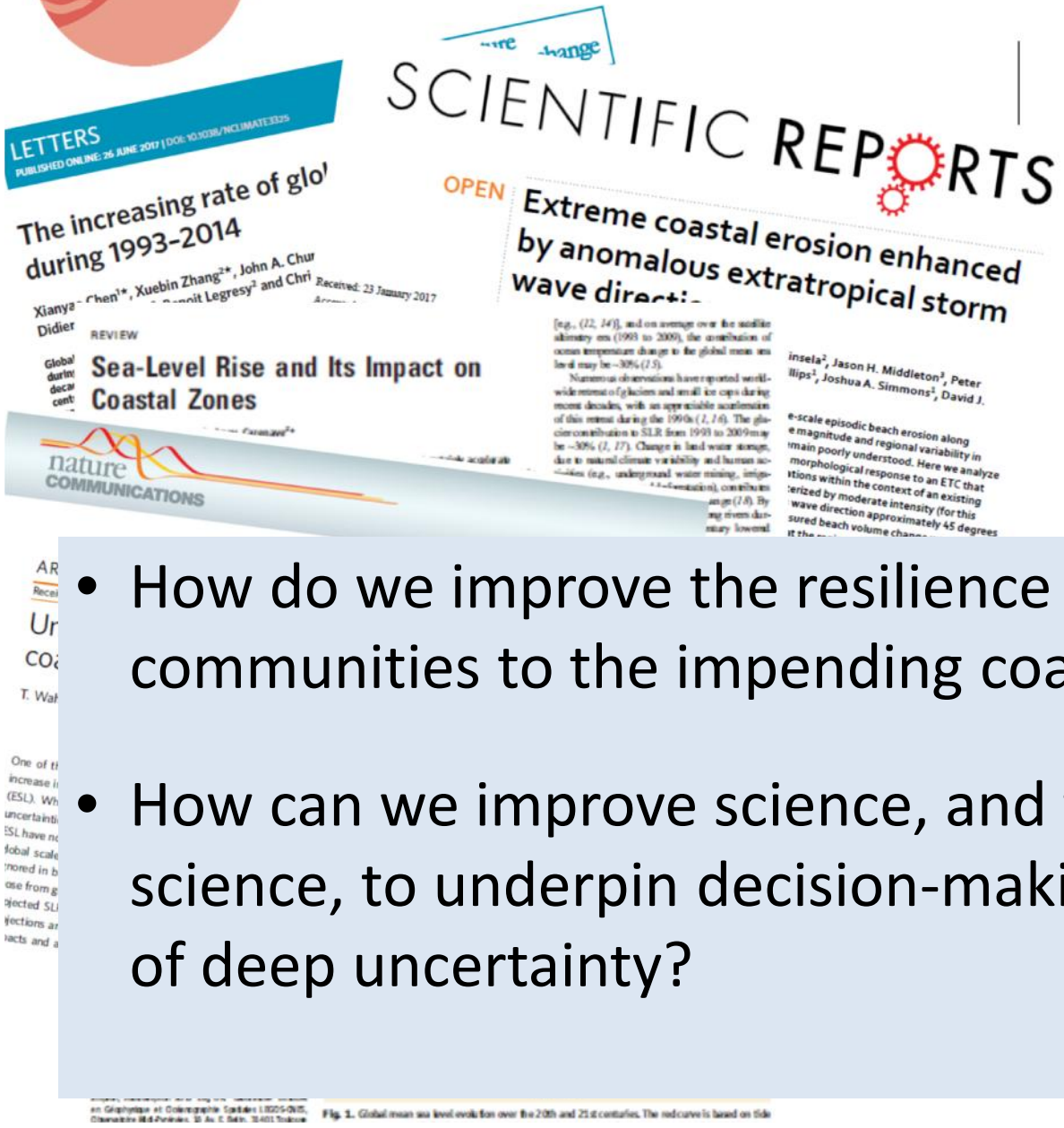


To develop tangible, viable and acceptable resilient solutions to support communities living in vulnerable coastal settings

edge

- **Team:** 11 researchers from 6 science agencies in NZ
- **Approach:** Active consultation with stakeholder groups in Hawke's Bay in April-June 2016, focal site initially coastal communities between Clifton and Tangoio (including Haumoana, Te Awanaga & Clifton)
- **End-users:** HBRC, NDC, HDC and other stakeholders. NB: HBRC are a viable co-funder of the work

The Science Problem



- Accelerate coastal erosion
- Increased frequency & extent of coastal flooding

- How do we improve the resilience of coastal communities to the impending coastal crisis?
- How can we improve science, and the delivery of science, to underpin decision-making in an environment of deep uncertainty?

Aims of the Edge

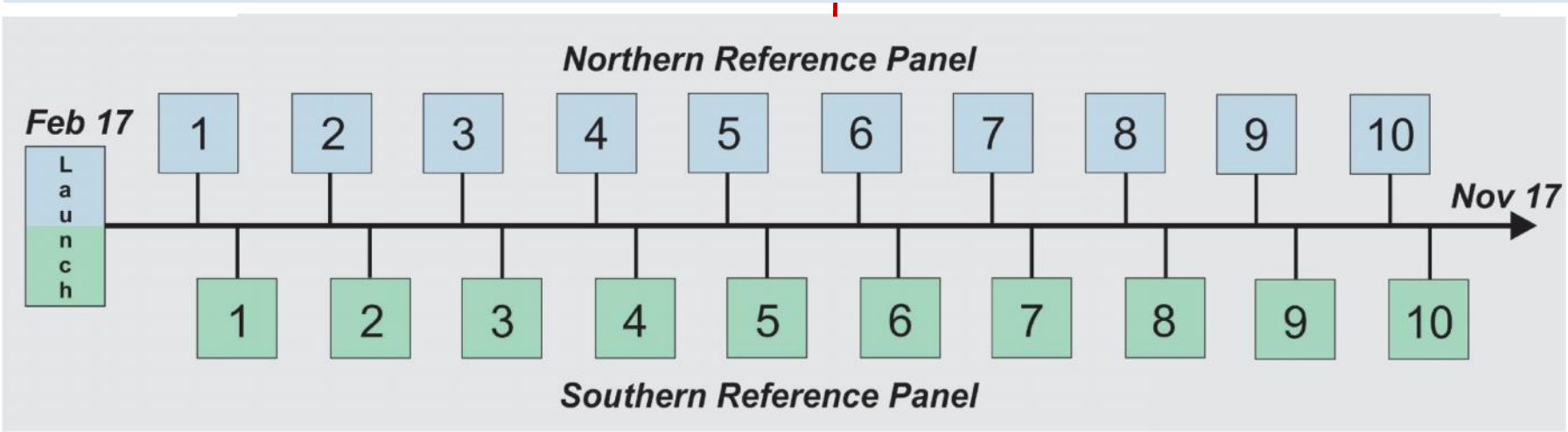
*To develop **pathways that enable communities** to meaningfully engage, understand and contribute to the **resolution of intense conflicts in high-risk locations**, especially those exacerbated by changing climate, environment, socio-economic and land development scenarios.*

*…will co-produce understanding of **local-scale experience of hazards** and **support the implementation of shared adaptation pathways**, to be integrated with enabling planning and governance processes*

A Co-created Start-up……

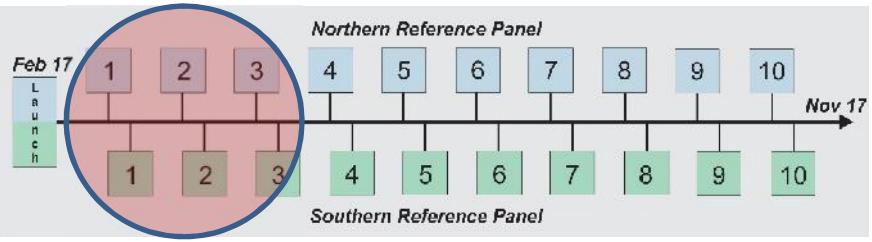
The EDGE is both:

- Implementing research activity within the process, and…….
- Researching entire process…and evaluating lessons on collaborative decision-making

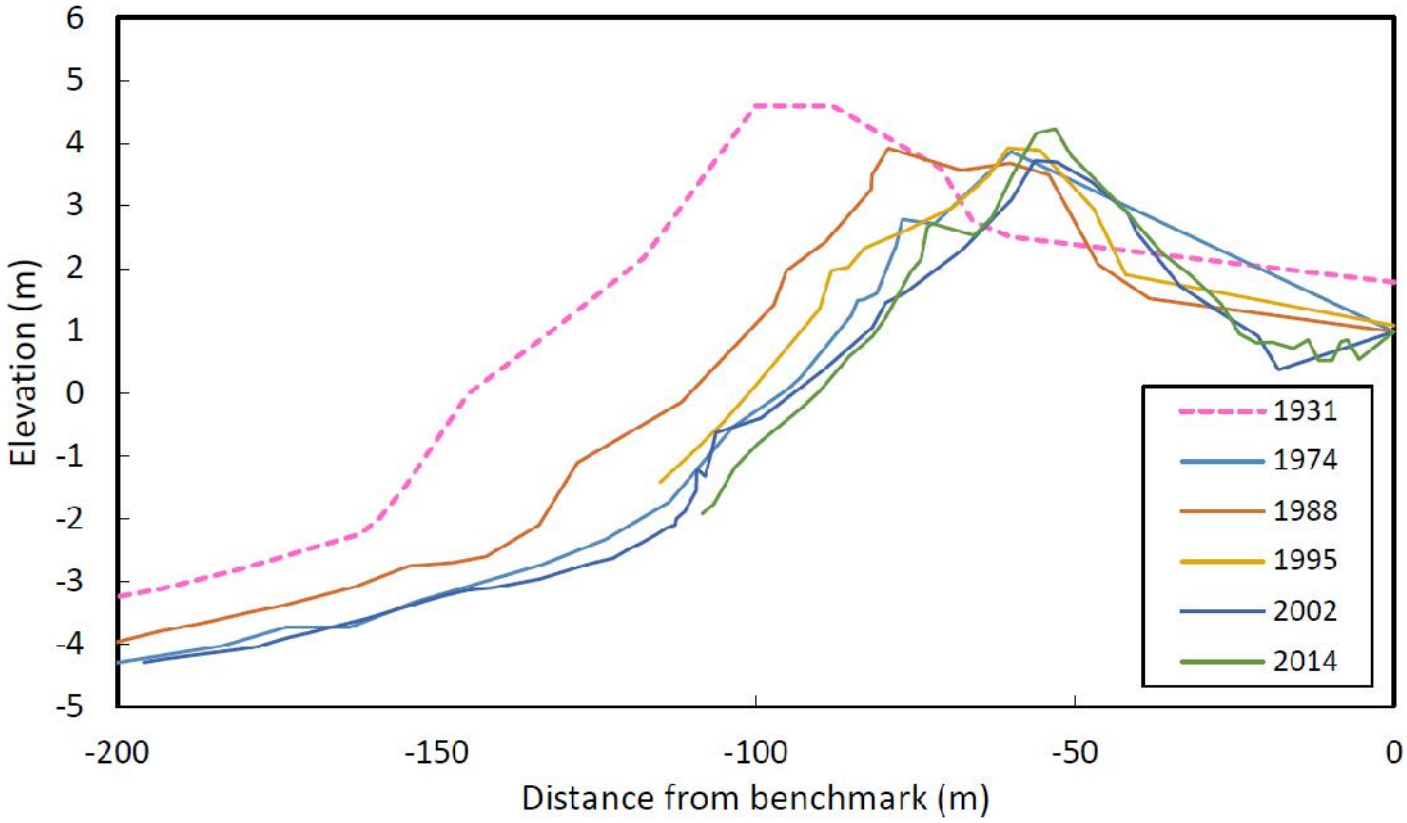


Physical Science

Science questions identified

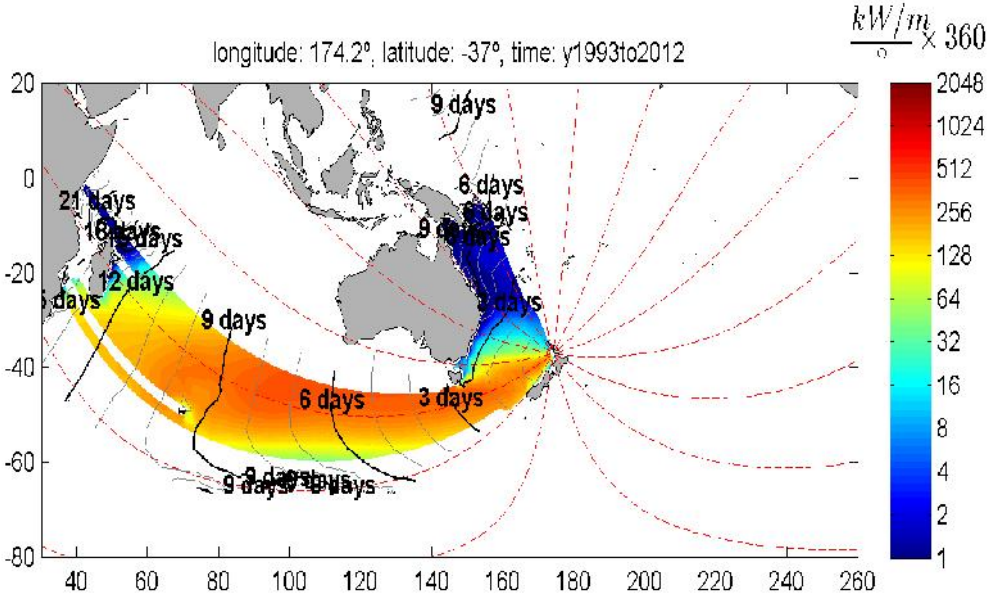


- Post earthquake coastal response near Haumoana (XBeach-G)

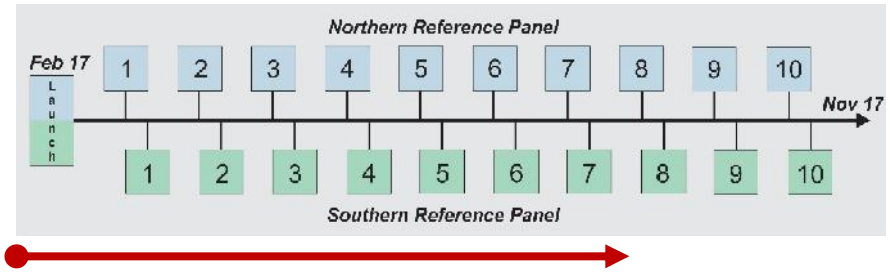


MSc project: Sophia Brown, UoA

Climate change impacts on weather-related hazards



Community Understanding of Coastal Hazards



- Evaluated community values
- Knowledge of different hazards
- Attitudes to different management strategies
- Willingness to pay

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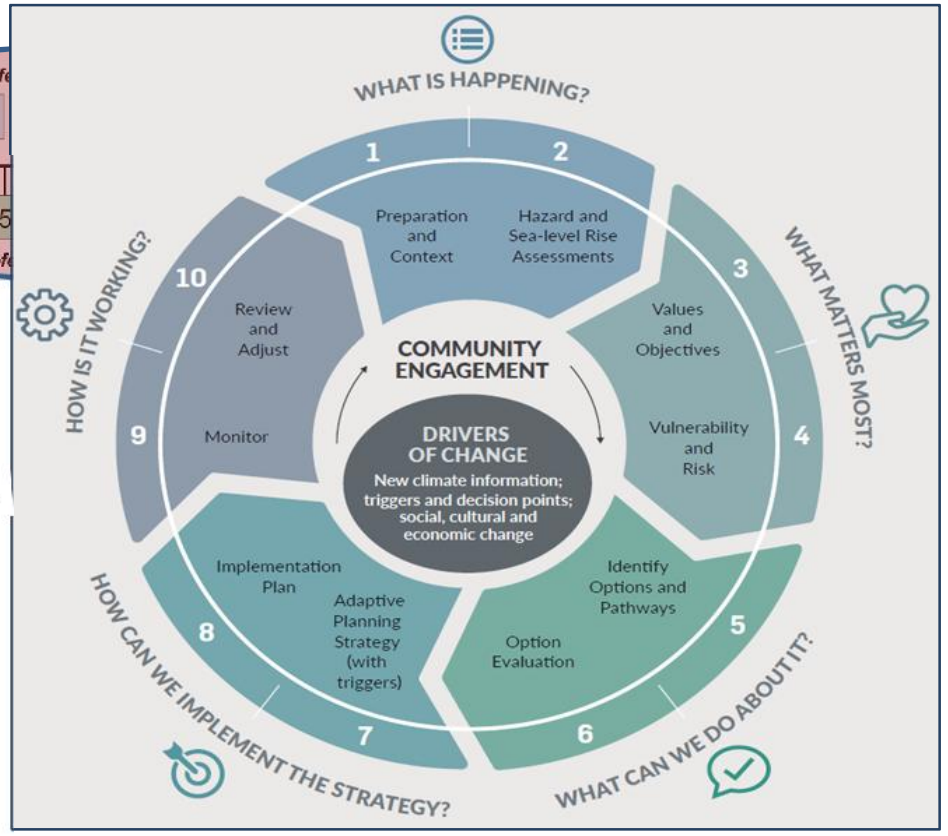
Supporting change in adaptation planning

First robust trial of *Dynamic Adaptive Pathways Planning (DAPP)* in a Coastal Context in NZ

A clear decision support process



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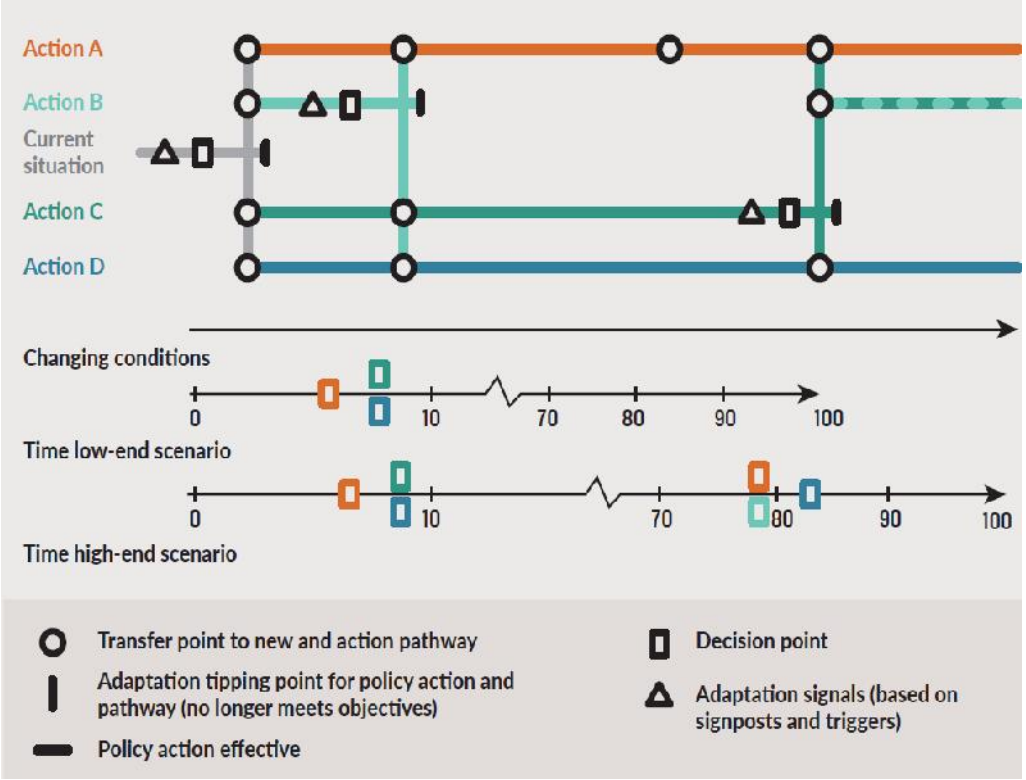
First robust trial of *Dynamic Adaptive Pathways Planning (DAPP)* in a Coastal Context in NZ



Outcomes……

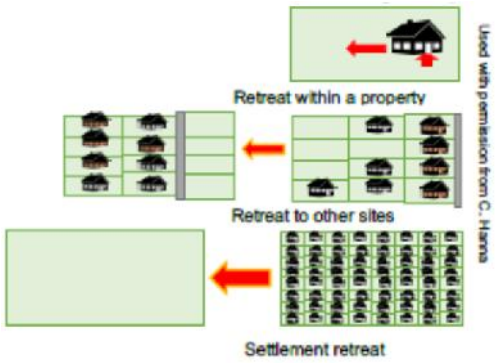
Short-term investment decisions can be made that don't close off future options

Explores different pathways and identifies robust and flexible ones

Defines use-by date of options when objectives are no-longer met when the path can be changed

Monitors signals and triggers to identify risks and opportunities for timely actions

Changing Attitudes
Managed Retreat



*"the idea of being **forced to shift home** and relocate to some as yet undefined location so the ocean can move further inland, **seems ludicrous to most Cape Coast residents**"* and *"to make kneejerk reactions that impact coastal villages such as Haumoana, based on 105-year climate change and sea rise projections seems incomprehensible"*.

"Managed retreat is not a solution, it is merely the consequence of doing nothing… "

Community member – Haumoana,

Changing Attitudes

Managed Retreat

NORTHERN CELL

Pathway One		Coastal Unit D: Westshore
Short term	Medium term	Long term
RENOURISHMENT[2,3,4,6,7] Regular gravel and sand renourishment to offset erosion losses in combination with beach maintenance and planting	**MANAGED RETREAT**[18] Property and Assets relocated outside coastal hazard zone, natural character of coastline reinstated	**MANAGED RETREAT**[18] Property and Assets relocated outside coastal hazard zone, natural character of coastline reinstated

NOTES:

Combination of gravel renourishment and offshore sand nourishment in the short term. (*Gravel* – Land based replenishment at key areas. *Sand* – Material placed offshore, using marine plant, and allowed to naturally migrate northwards and towards the beach raising foreshore levels)

Gravel – Land based replenishment at key areas

Sand – Material placed offshore and allowed to naturally migrate northwards and towards the beach raising foreshore levels

Staged managed retreat of assets over the medium to long term when risk becomes unacceptable due to erosion losses and sea level rise.


Te Reo development
Understand resilience within the Māori economy
Establish frameworks for Iwi/Hapu plans
Iwi indicators of natural hazards
Strategies that empower Māori landuse planning
Mātauranga Māori and Mātauranga a Iwi identification of resilient strategies
mātauranga māori
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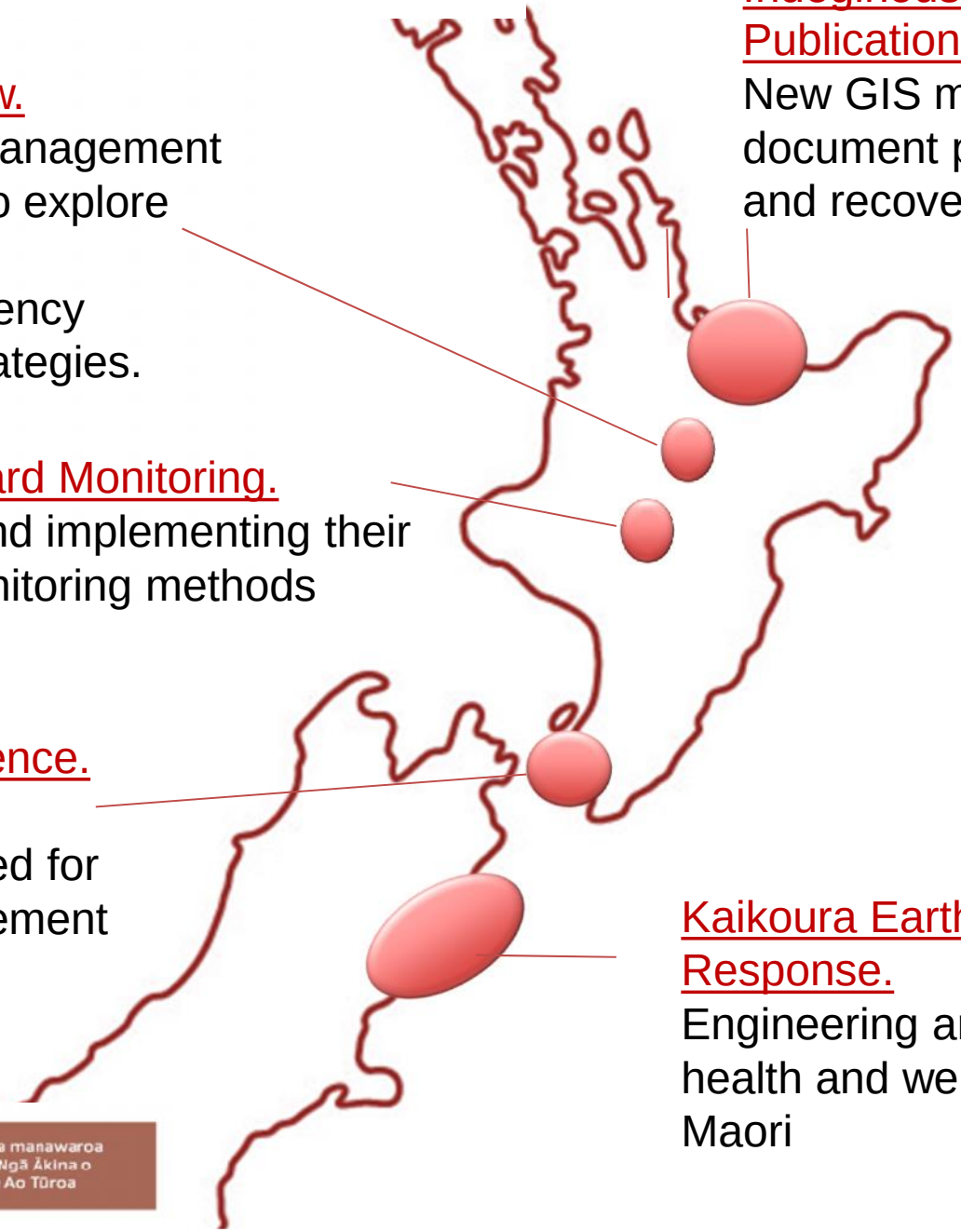
Māori Resilience Lab

Research Highlights 2017

Indeginous Knowledge Publications.
New GIS methods to document past response and recovery

Legislative review.
Environmental management plans reviewed to explore synergies for resilience/emergency management strategies.

Community Hazard Monitoring.
Iwi developing and implementing their own volcano monitoring methods



mātauranga māori

Hapu/Marae Resilience.
Hui held plans and guidelines developed for emergency management

Kaikoura Earthquake Response.
Engineering analysis for health and well being of Maori

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Toolboxes

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Governance – *Vivienne Ivory* – Successful resilience decisions, governance contexts

Infrastructure – *Liam Wotherspoon* – Resilient networks and community infrastructure

Economics – *Garry McDonald* – Benefit-cost incentives, valuing resilience initiatives

Culture – *Julia Becker* – Resilience norms, Citizen science, Social media and resilience

Hazards – *Mark Bebbington* – size/frequency hazard-spectrum, scenario approaches

Trajectories – *John Vargo* – Resilience Indicators, Resilience digital information system

Resilient Governance

Rural Mobility

How do decisions affecting resilience of a multi-modal, multi-agency, multi-regional transport network (system) get made?

- Who is involved?
- Where are the key interactions between parties?

Case: Canterbury / West Coast transport network

- North Canterbury 2016 earthquake
- Applying system view to governance of infrastructure networks

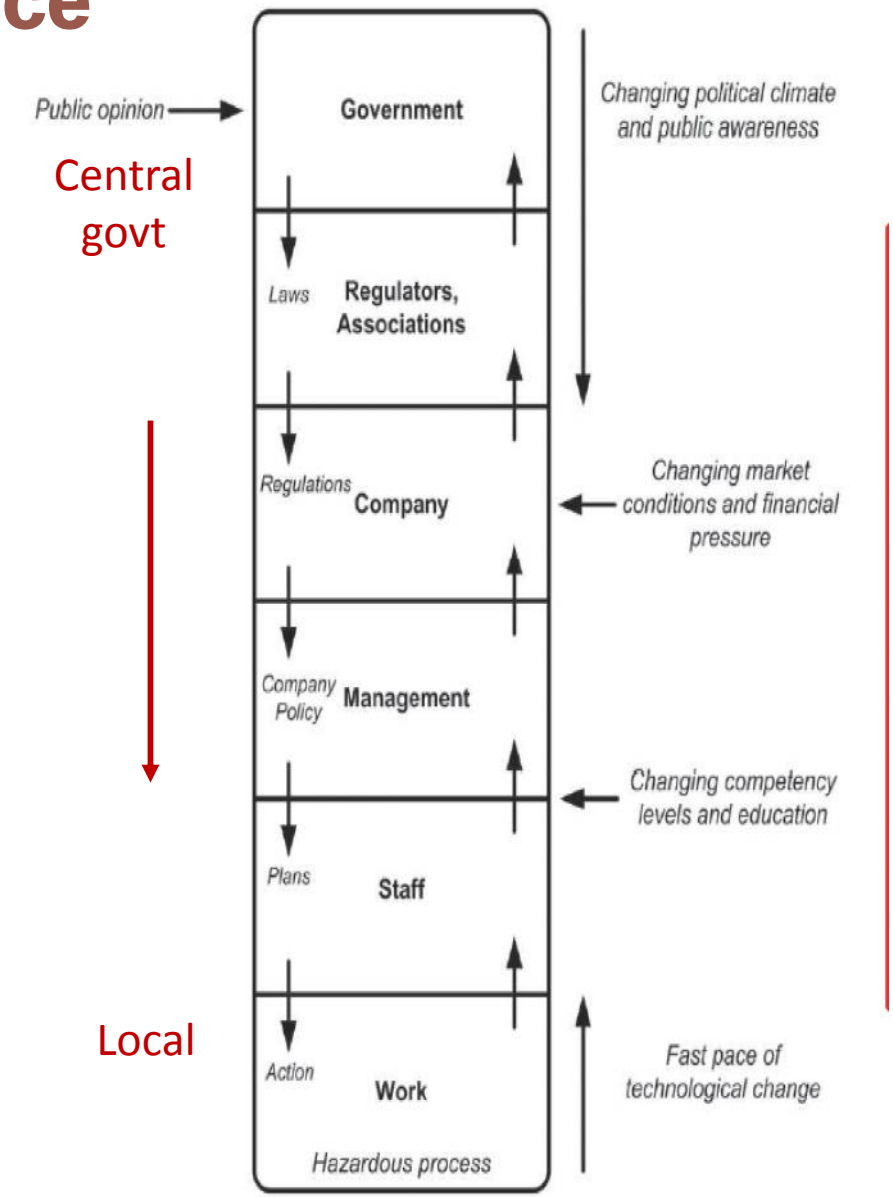
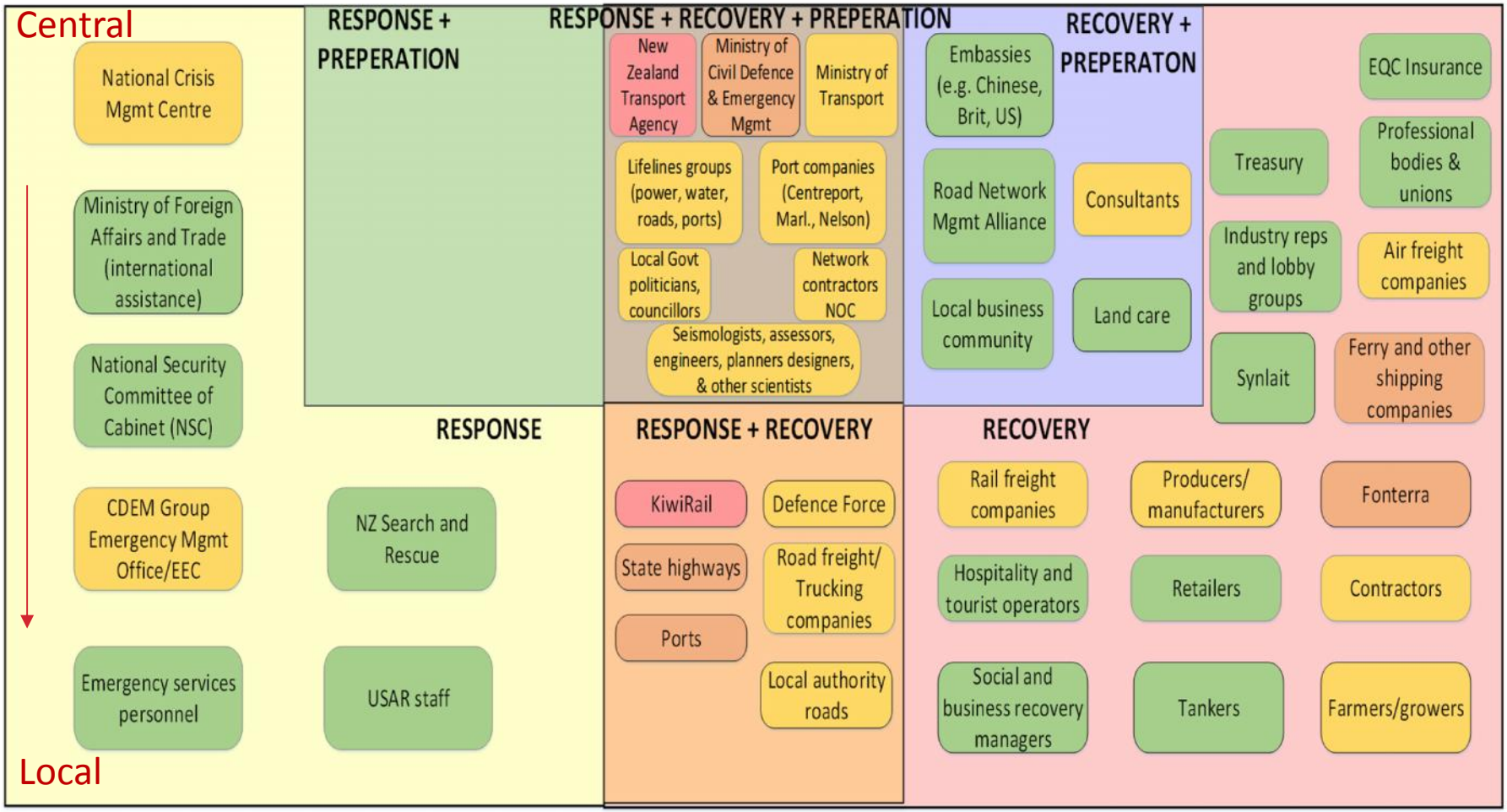


Figure 2. Rasmussen's risk management framework.
Source: Adapted from Rasmussen (1997).

Rural Mobility: Pilot Actor Map



Identified by all experts	Identified by 3 +	Identified by 2 +	Identified by 1

Infrastructure Toolbox

Distributed Infrastructure

- Impact assessment and network modelling
  - West Coast & Canterbury and Auckland
- Component modelling and site characterisation

- NZ research: mapping and collaboration
  - Universities
  - QuakeCoRE
  - Stakeholders & Lifelines groups
  - Riskscape
  - VISG & DEVORA

Image: Scott Kelly, ISS

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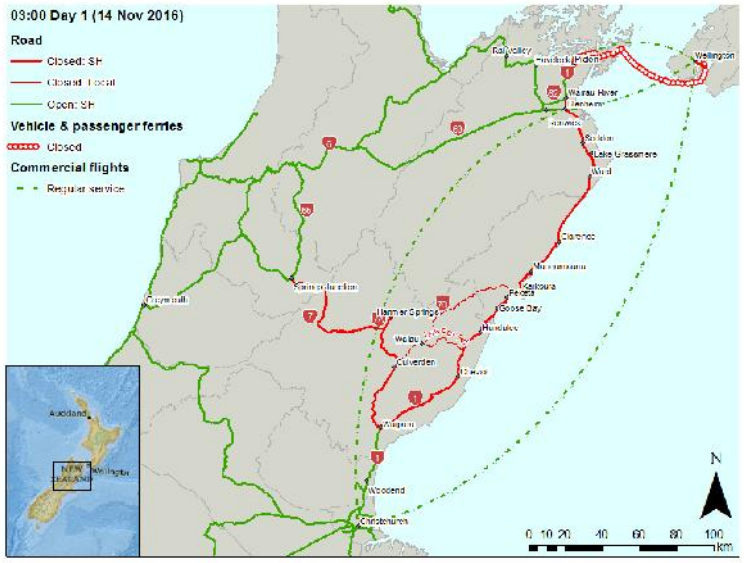
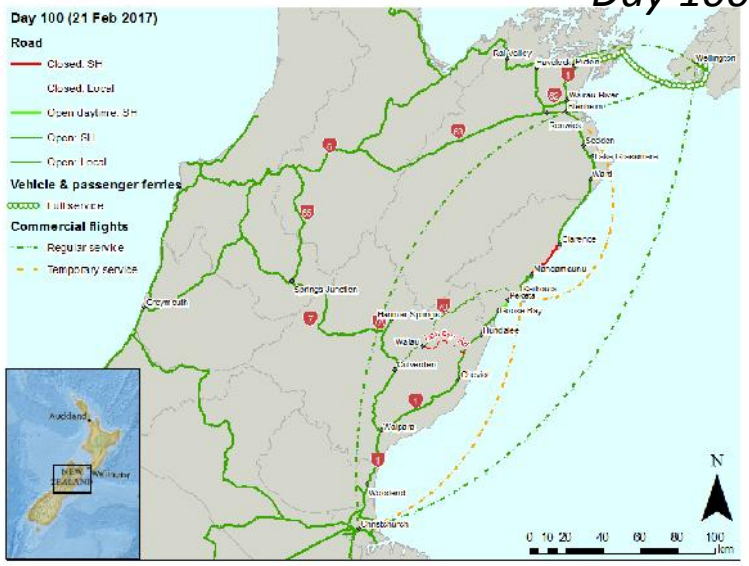
Kaikoura EQ Infrastructure Impacts

Davies et al.
Giovinazzi et al.

Transportation Day 0



Day 100



Rapid mobilization of infrastructure data with stakeholders

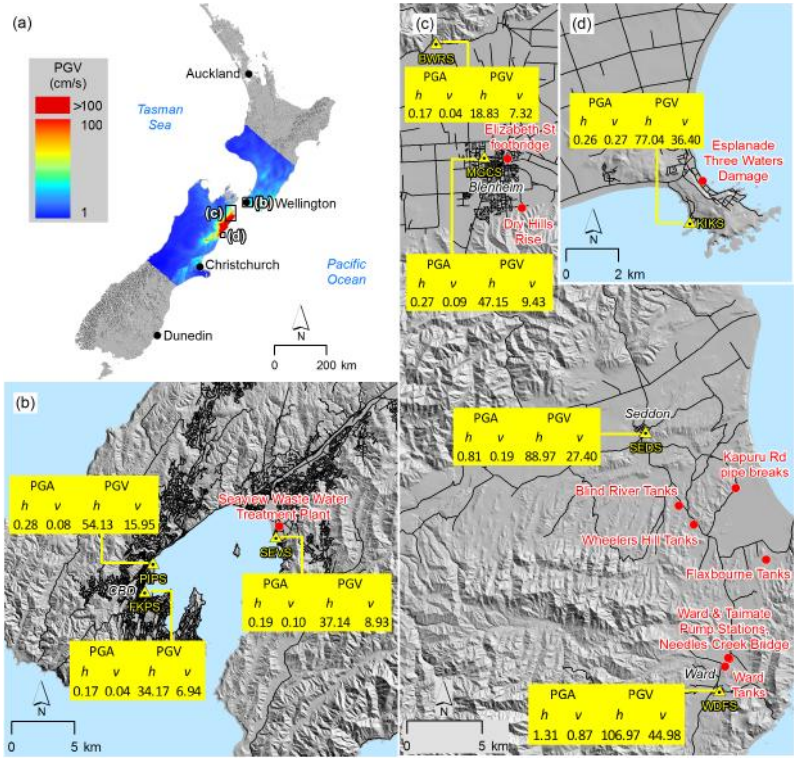
Telecommunications

Result: *Detailed post-event evidence base of infrastructure impacts and decision making*

Kaikoura EQ Infrastructure Impacts

Hughes et al.

Liu et al. *3 Waters*



Electric Power

Rapid mobilization of infrastructure data with stakeholders

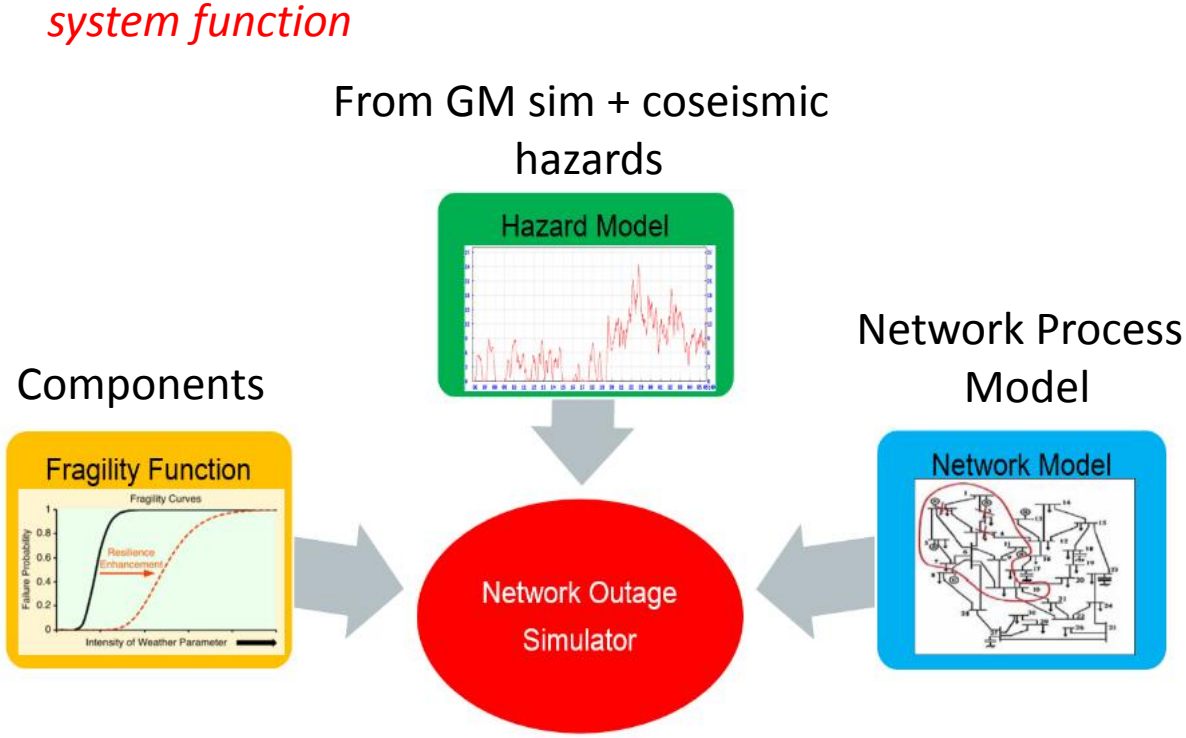
Result: *Detailed post-event evidence base of infrastructure impacts and decision making*

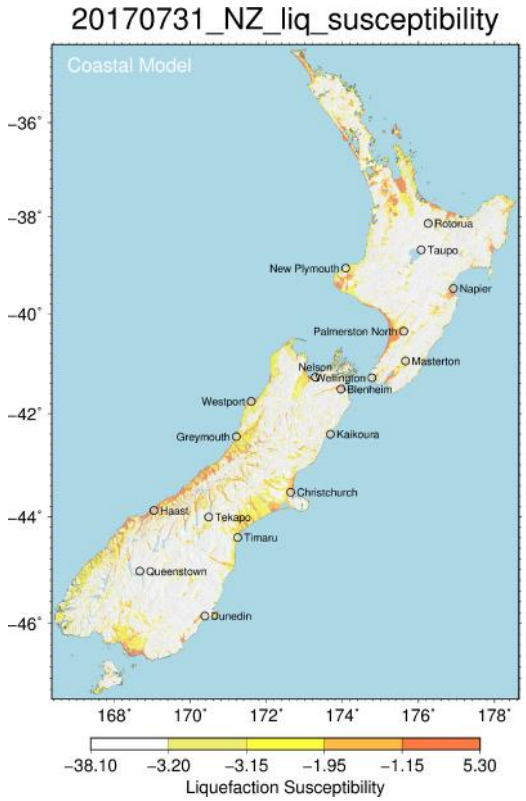
Electric Power Systems Resilience

Liu et al.

Electric power network process modelling for natural hazard events to assess degradation of system function

Broad scale co-seismic hazard modelling linked to GM sim





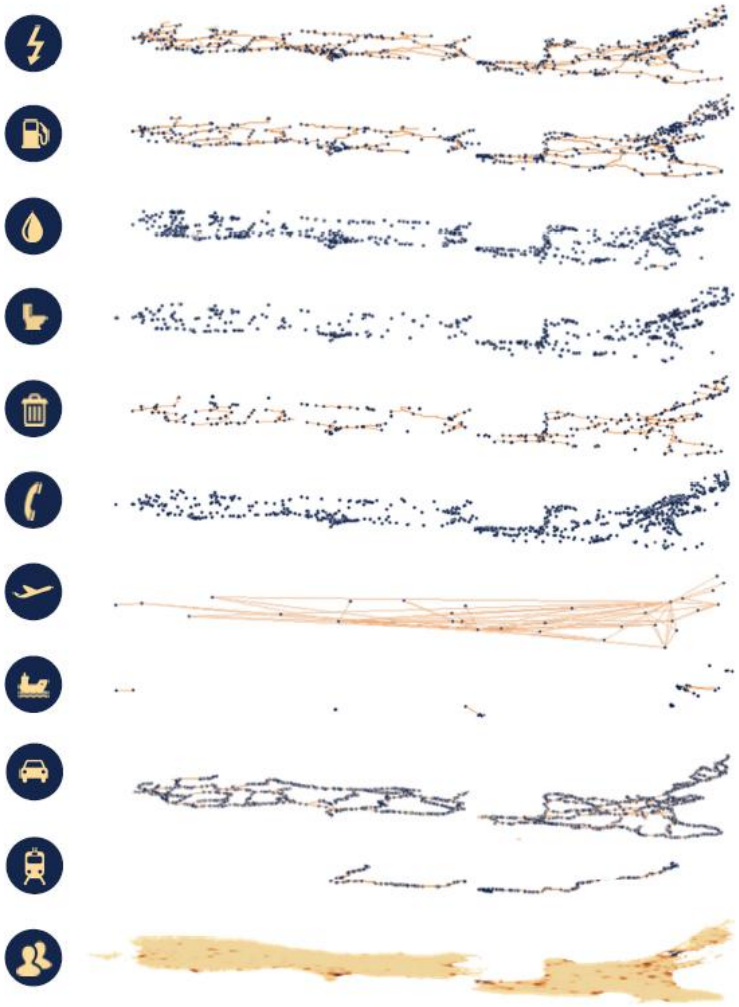
Power flow, state estimation, and transient stability analysis

Result: *Framework to move from electricity network reliability towards resilience quantification*

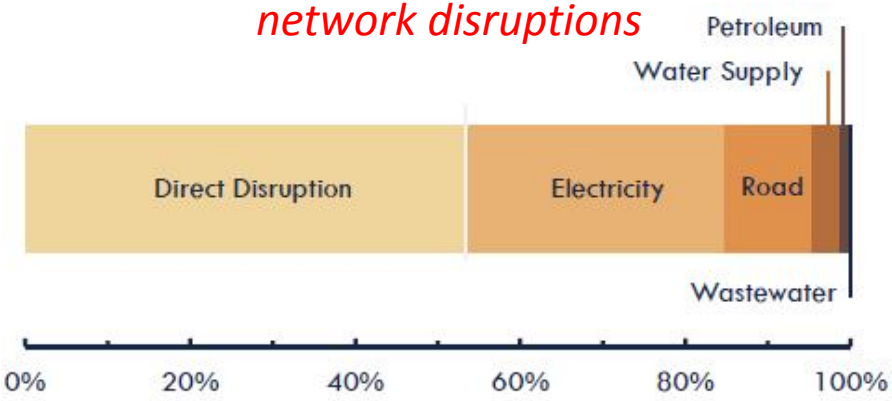
Modelling of Network Dependencies

Zorn et al.

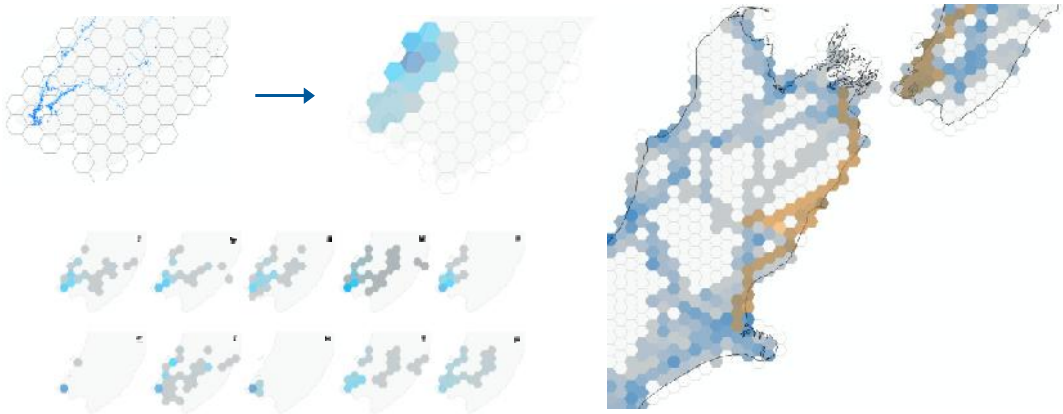
Hierarchical network of network models



Direct vs dependencies based network disruptions



Scenario and simulation based disruption propagation

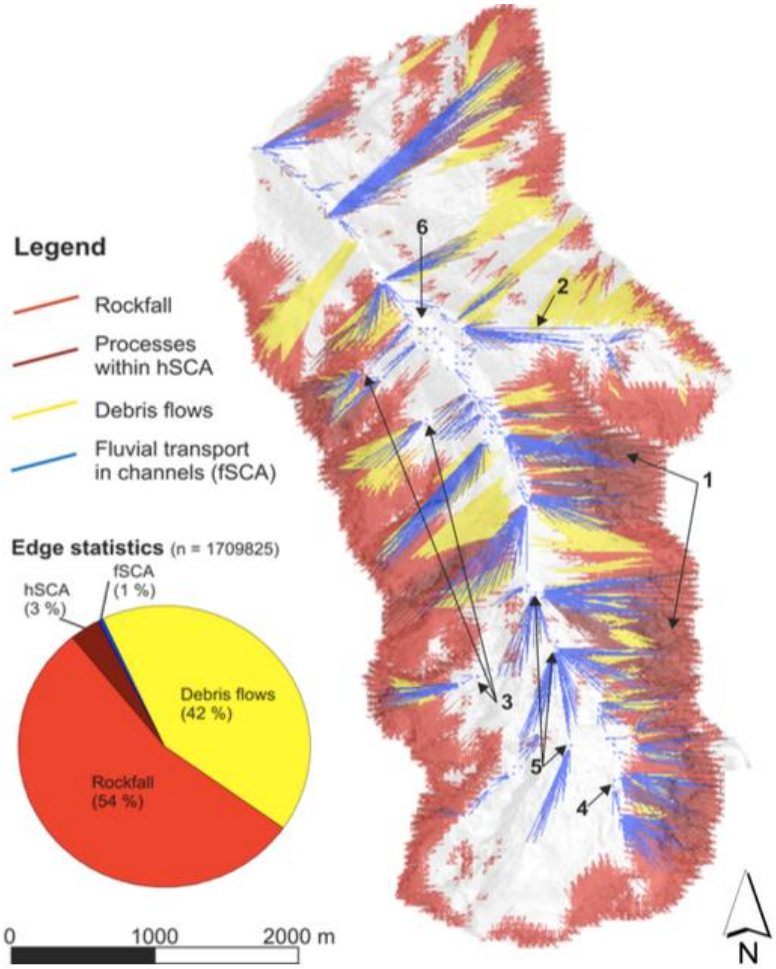


Result: *Quantification and simulation of national infrastructure network dependencies*

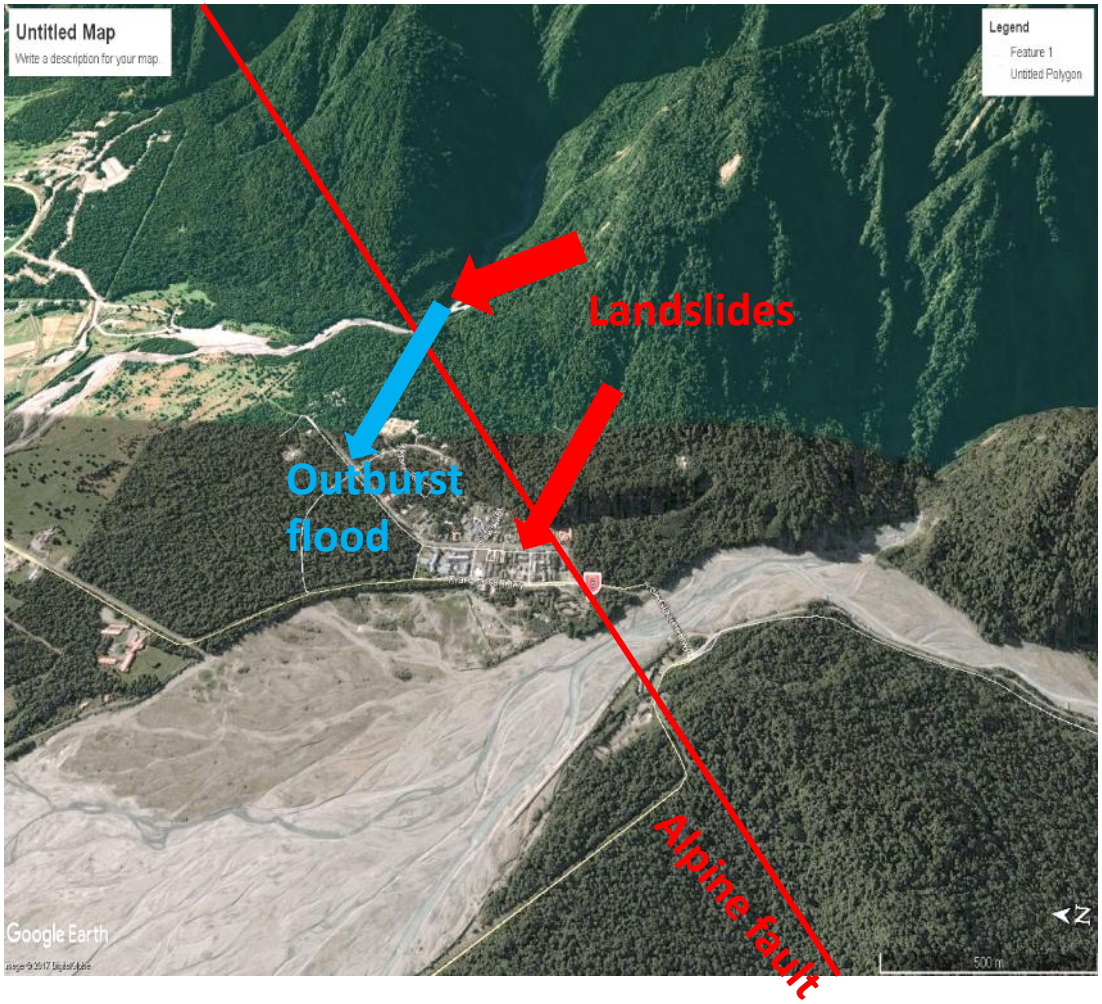
Hazards Toolbox – cascading and inter-dependent hazards

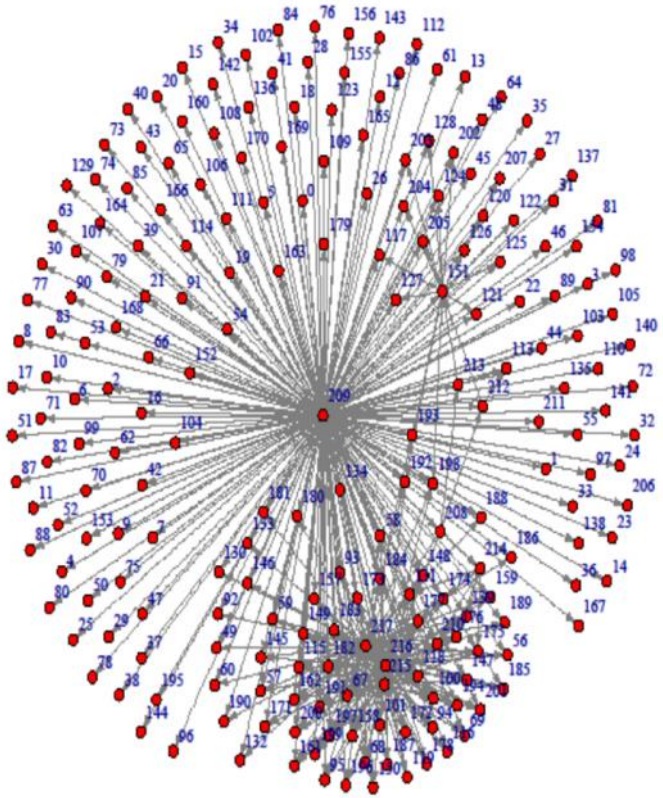
Graph theory or network theory used to analyse and quantify complex systems in geography, ecology and atmospheric sciences (Phillips et al., 2015). Extended to natural hazard related impact and risk assessment.

Example: Heckmann & Schwanghart (2013) used network theory to explore the sediment cascade in an Alpine catchment of Austria



Preliminary application to simulate earthquake, coseismic landslides and dambreak floods impacting assets at Franz Josef



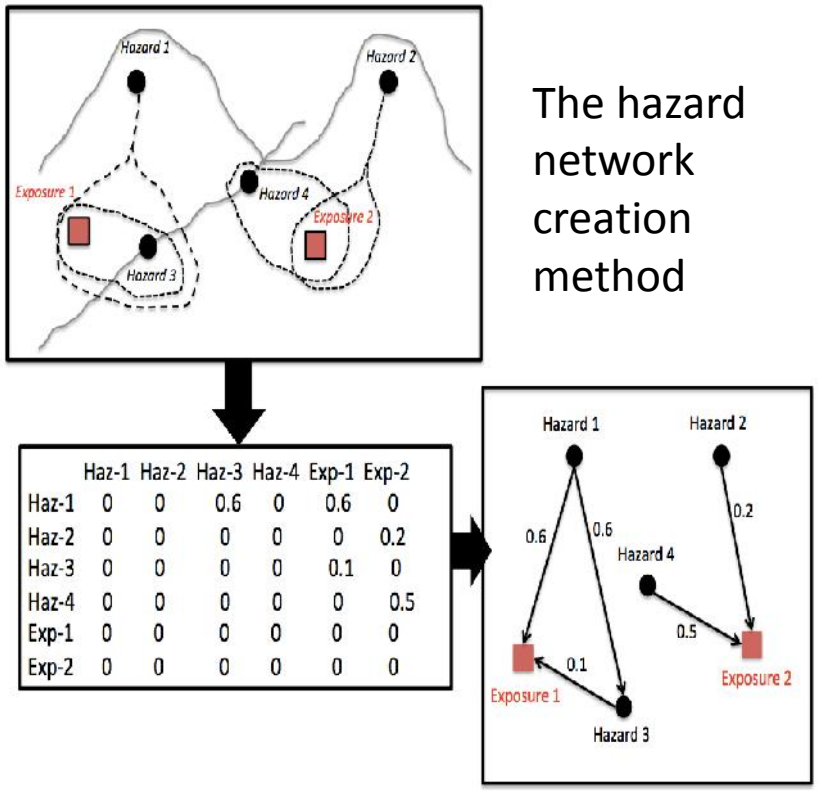


Graph Theory - analysis of the interactions between natural and man-made systems

- Natural and societal systems represented as networks using nodes and edges
- Allows different networks to be interrelated (e.g. geological hazards and power grid)
- Cascading impact of initial hazards through connected networks

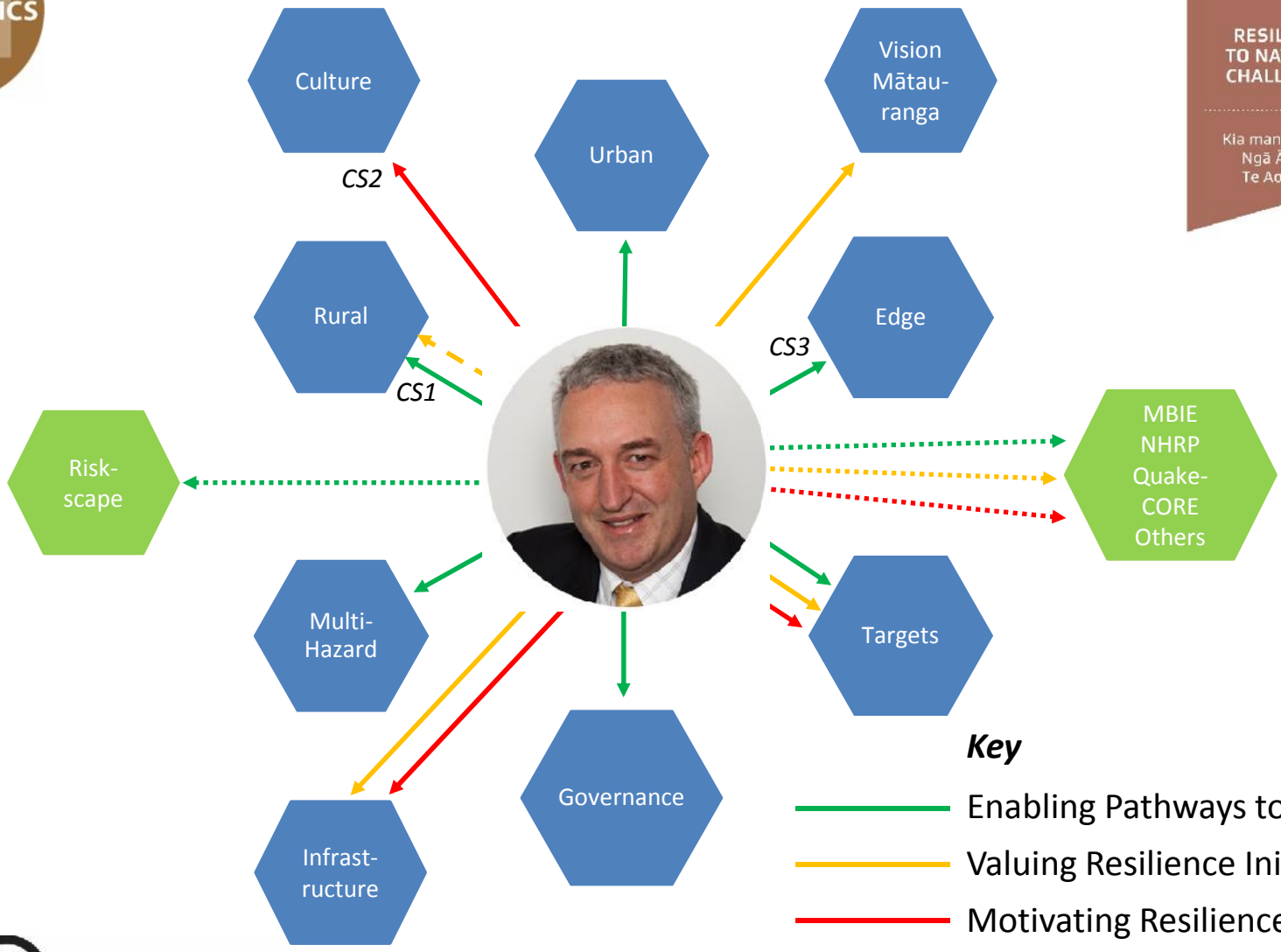
- Exposure networks developed in a co-creative effort with the communities and, more holistically, with all the people potentially involved.

- An accurate network of exposed elements needs to be based on the combined “insider knowledge” of communities, experts, officials and emergency services.



The hazard network creation method

Economics toolbox – motivating resilience

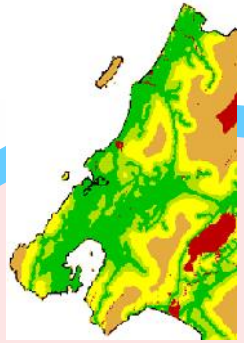


MERIT

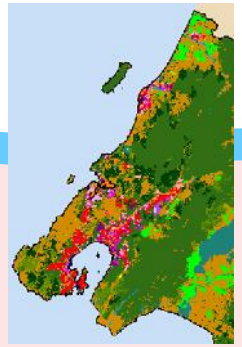
Modelling the
Economics of
Resilient
Infrastructure
Tool

Multi-Hazard Toolbox → Infrastructure Toolbox

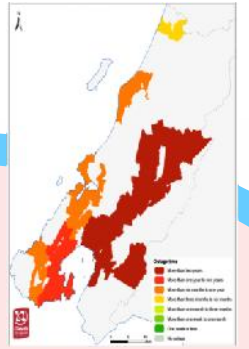
Direct Impacts on Tourism



Direct Impacts on Transport – Fuel, Road, Rail, Water, Air, Ports



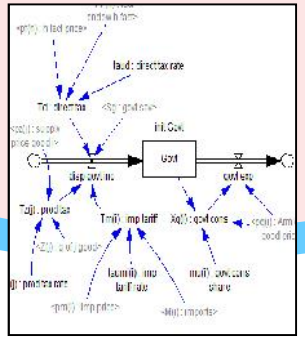
Direct Impacts of People & Business Relocation



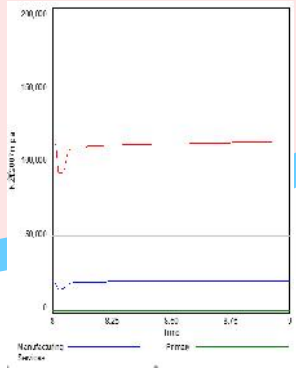
Riskscape – Hazard, Building Damage, Infrastructure Outage Maps

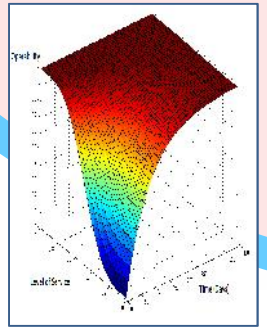
What's Included in MERIT?

Wider Economic Impacts using the Dynamic Economic Model



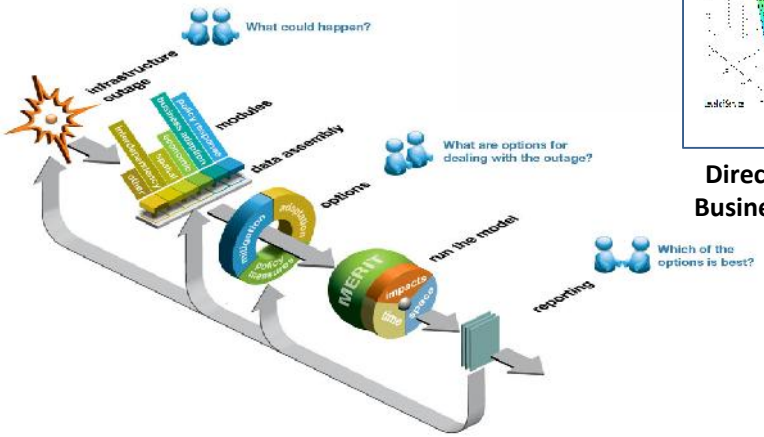
Results for Region, NZ – GRP, Income etc by industry





Direct Impacts on Business Operation

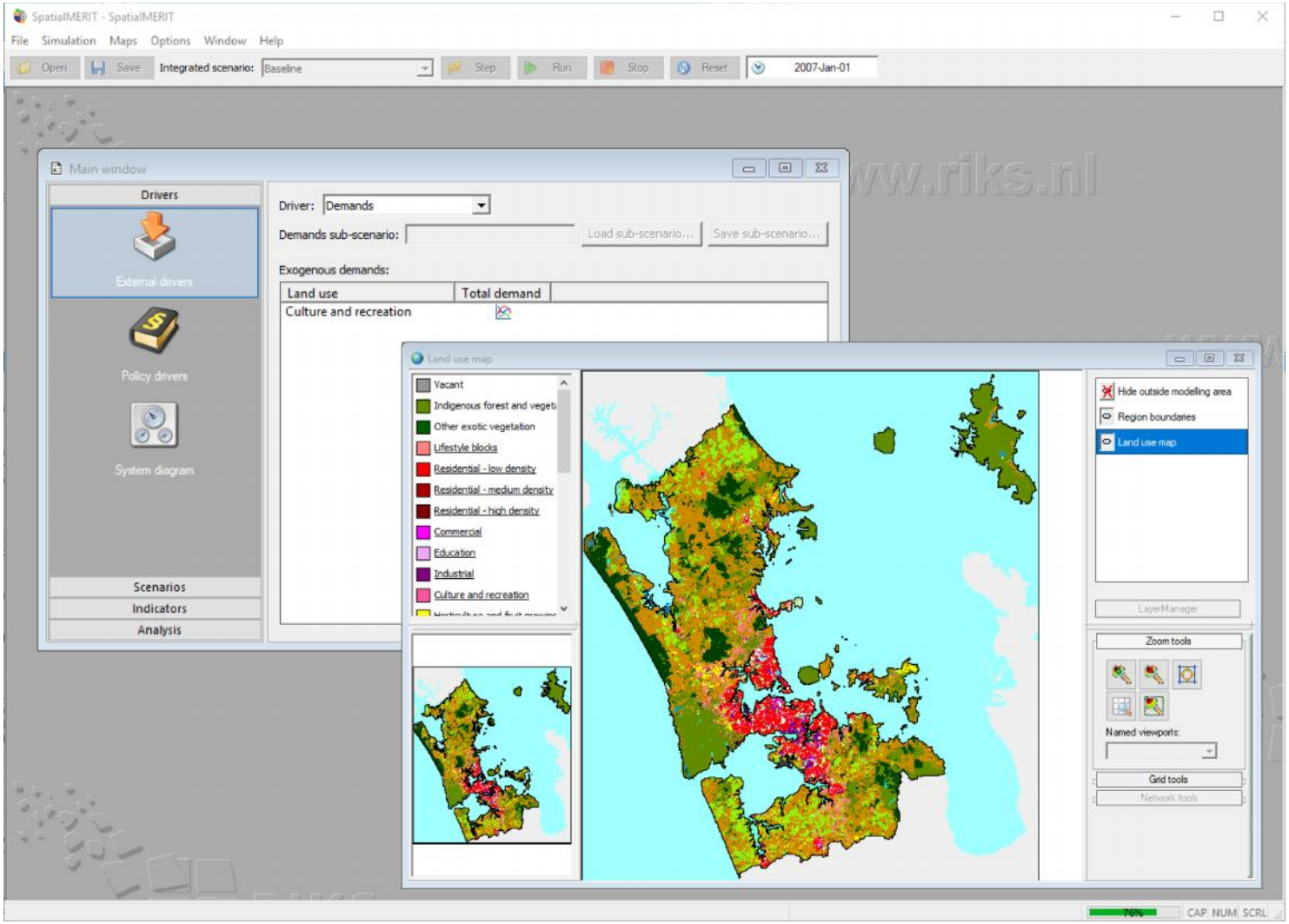
What's the MERIT modelling process?



Kaikōura Earthquake 2016

	Baseline GDP ($2016m)	OPTIONS 1&2				OPTION 3			
		Time Period After Event				Time Period After Event			
		0-12 months	12-24 months	Total (0-24 months)	Total (0-24 months)	0-12 months	12-24 months	Total (0-24 months)	Total (0-24 months)
Regional Results		Estimated change in GDP ($2016m)			% change from YE March 2016	Estimated change in GDP ($2016m)			% change from YE March 2016
Total New Zealand	241,200	-402	-62	**-465**	**-0.1%**	-418	-95	**-513**	**-0.1%**
Canterbury	32,900	-107	-10	**-117**	**-0.2%**	-117	-20	**-137**	**-0.2%**
Rest of New Zealand	208,300	-295	-53	**-348**	**-0.1%**	-301	-75	**-376**	**-0.1%**
Industry Results		Estimated change in Value Added ($2016m)			% contribution to GDP loss	Estimated change in Value Added ($2016m)			% contribution to GDP loss
All industries		-382	-57	**-439**	**94%**	-396	-91	**-488**	**95%**
Agriculture	10,500	-21	-9	**-31**	**7%**	-28	-16	**-43**	**8%**
Other primary	5,200	-36	-7	**-43**	**9%**	-44	-14	**-57**	**11%**
Food manufacturing	9,500	-115	-4	**-119**	**26%**	-139	-28	**-168**	**33%**
Wood and paper manufacturing	2,100	-37	-2	**-39**	**8%**	-55	-17	**-72**	**14%**
Other manufacturing	14,400	-86	2	**-84**	**18%**	-112	-12	**-124**	**24%**
Utilities, construction & transport	31,900	174	-75	**98**	**-21%**	286	-33	**253**	**-49%**
Trade and hospitality	27,300	-36	4	**-32**	**7%**	-42	2	**-41**	**8%**
Government, education & health services	35,000	-87	22	**-65**	**14%**	-106	18	**-88**	**17%**
Other services	87,600	-140	13	**-126**	**27%**	-156	9	**-148**	**29%**

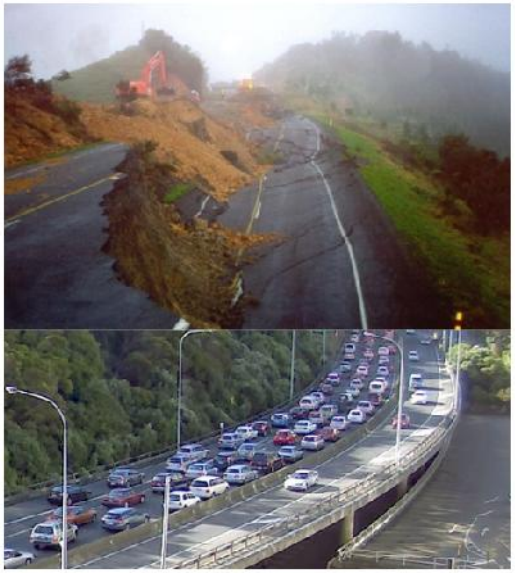
Spatial MERIT



Uptake: NZTA Resilience Group

YouTube clip on Transport-MERIT:-
https://youtu.be/IRVD3PvZHHY

The economic impacts of road outages in New Zealand



Cultural Resilience Toolbox

RESILIENCE TO NATURE'S CHALLENGES | Kia manawaroa – Ngā Ākina o Te Ao Tūroa | National SCIENCE Challenges

culture

1. **Developing Social Norms**

   Investigate how to develop social norms for resilience. Includes qualitative (e.g. focus group) and quantitative (e.g. survey) work, and research into cultural Kaupapa.

2. **Emerging Technologies**

   Investigate how information and communication technologies (via Facebook and Twitter) can contribute to a resilient culture.

3. **Connecting Citizens to Science**

   Investigate citizen science as a tool for involving New Zealanders in science activities (including developing a strategic framework).

The influence of Social norms

- Rules and standards understood by members of a group (Cialdini, 2003)
- Guide our behaviour
- Encouraging pro-environmental behaviours (e.g., Abrahamse & Steg, 2013)
  - Reducing littering
  - Recycling
  - Water conservation
- Important in encouraging resilient behaviour
  - People more likely to prepare when others prepare (e.g. Mileti & Darlington, 1997)
  - Descriptive norm message increase preparedness behaviour (Japan; Ozaki & Nakayachi, 2015)

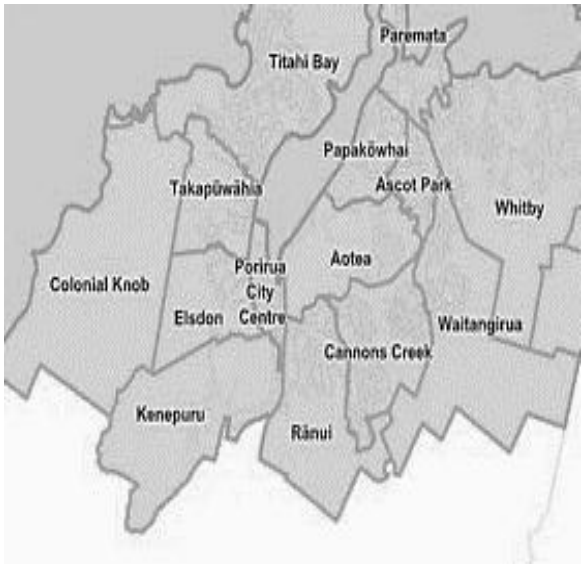
Challenges of Measuring Resilience at a Community Level

RESILIENCE IS DEPENDENT ON:

- Individual, community and societal factors
- Context
- Interactions
- Timeframes.

LOCAL VS NATIONAL AND REGIONAL VIEWS

- Variable perspectives.
- Consequent actions required to resilience will differ from place to place.
- How to integrate local community resilience 'indicators' with national and regional indicators?



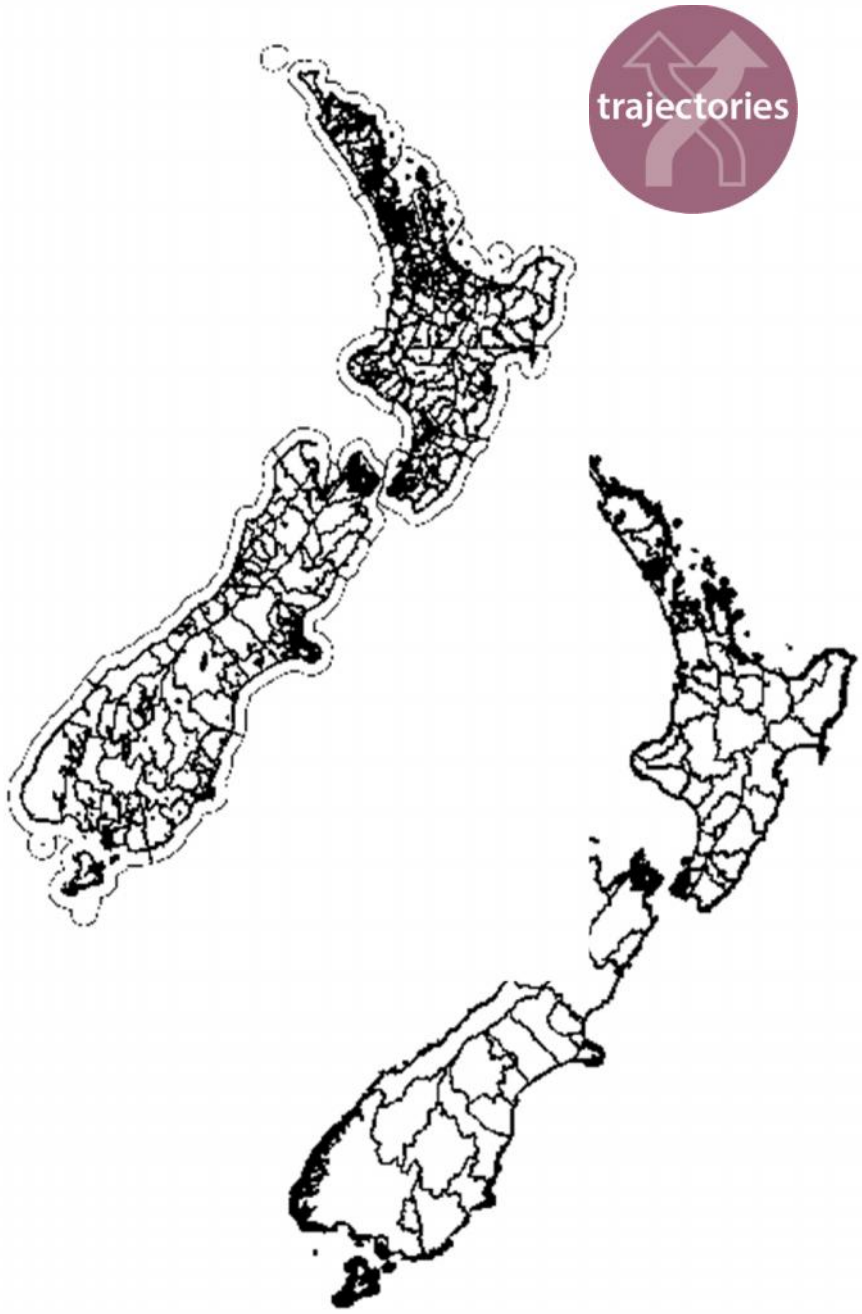
"Resilience measurements need to account for place-based conditions and dynamics."

Kwok et al., (2017)

New Zealand Place-Based Resilience Index

To compare ‘resilience’ characteristics across NZ’s geography and over time.

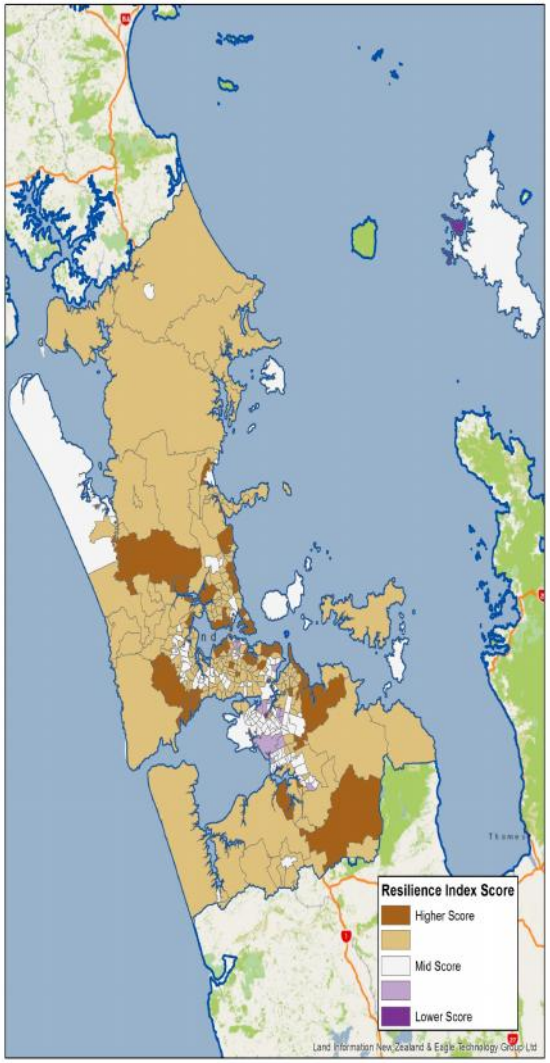
This index will allow us to benchmark resilience, monitor progress, and evaluate the efficacy of resilience interventions.



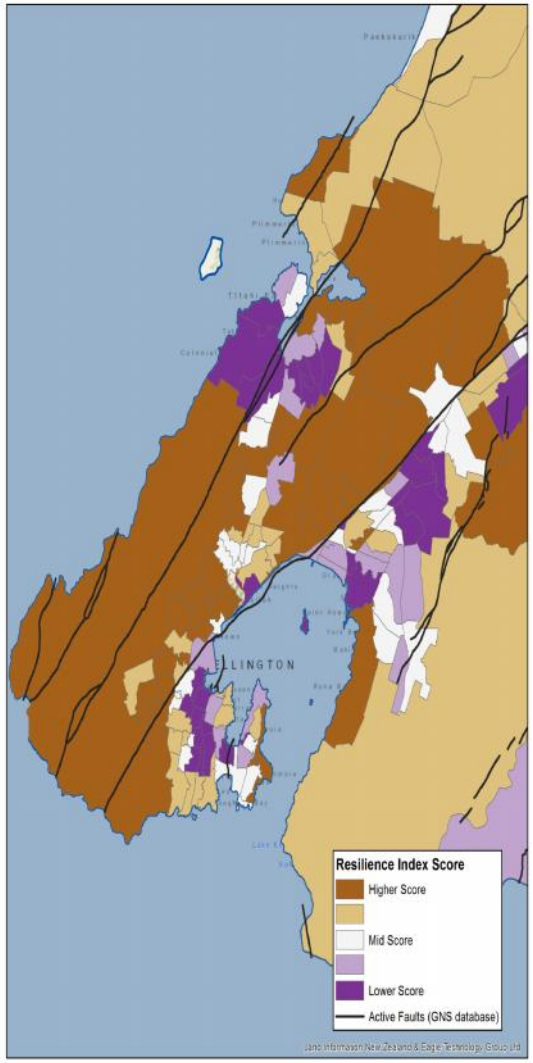
Multi-capital Model in Alignment with New Zealand's National Resilience Strategy

The factors that contribute to national disaster resilience (Horrocks, 2017)

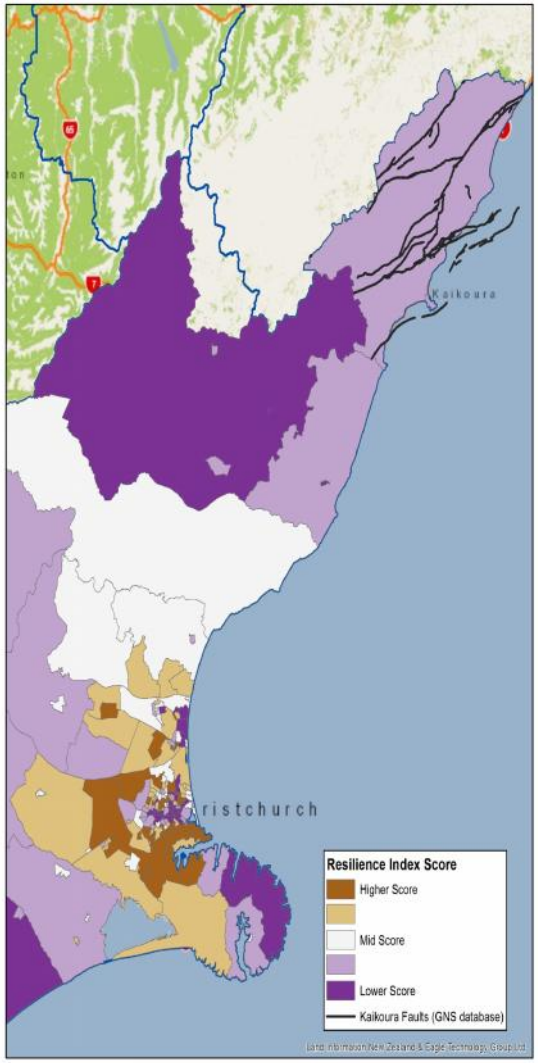
Draft National Spatial Resilience Index



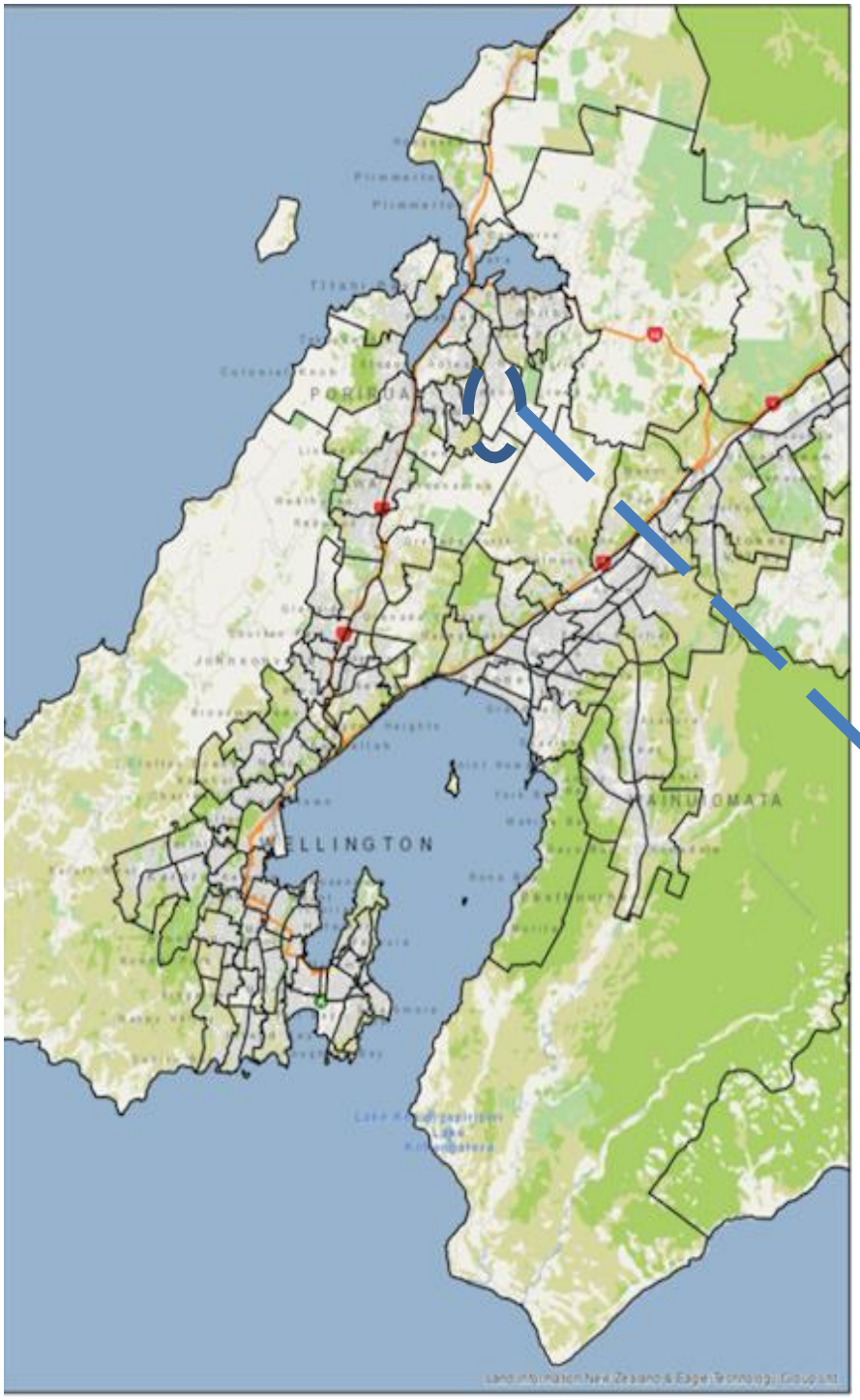
Northland



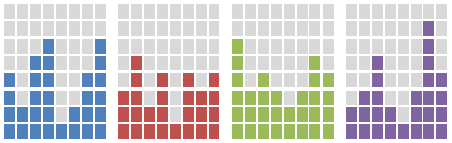
Wellington



Canterbury



Wellington Region
CAU-level Information



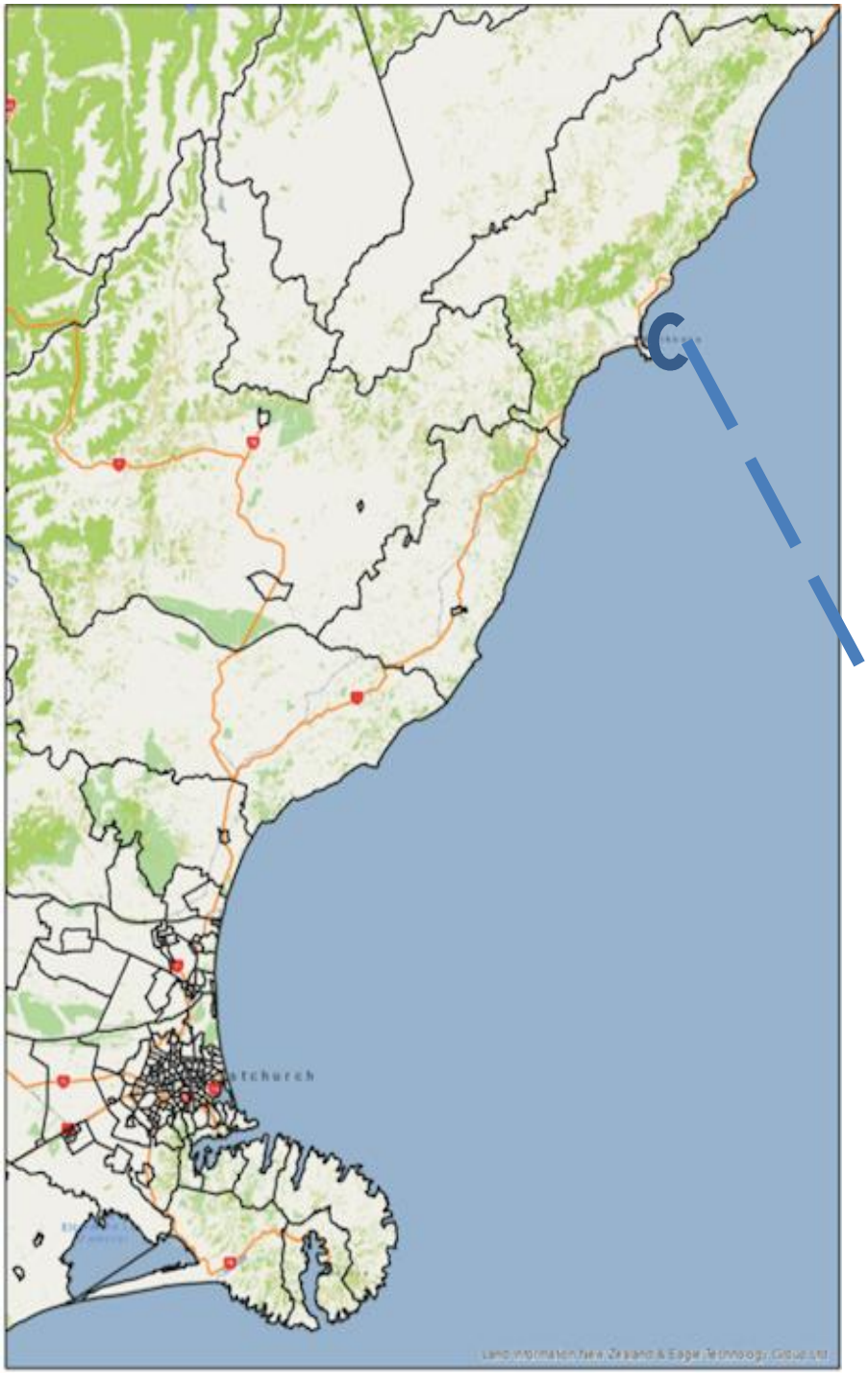
CANNONS CREEK NORTH

Mean score: 0.48

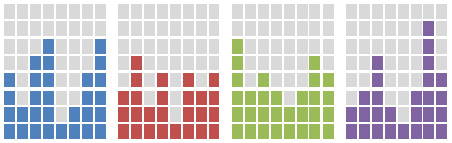
WEAKNESSES
Low life satisfaction
High loneliness
High number of renters

STRENGTHS
High proportion pre-retirement age
Relatively high basic disaster preparedness

trajectories



Canterbury Region
CAU-level Information



KAIKOURA TOWNSHIP

Mean score: 0.63

WEAKNESSES

Relatively low household income
Few large businesses
Small numbers of government/ professional sector employees

STRENGTHS

Mostly English speaking, long-term residents
Low loneliness
High life satisfaction
High self-rated health

trajectories

Growth… new contestable projects 2017-2019

National SCIENCE Challenges

RESILIENCE TO NATURE'S CHALLENGES

Kia manawaroa – Ngā Ākina o Te Ao Tūroa

Resilience to flow-on impacts to NZ Regional economies

Disaster preparation in Auckland's SE Asian communities

Electricity Distribution resilience framework

Resilience in transient worker communities

Legal framework for managed retreat

Technology in resilience citizen science

Kaupapa Maori tsunami planning

Rural value chain resilience

Lessons so far…

- Resilience to Natural Hazards is complex, different approaches needed depending on scale and circumstance
- Knowledge of hazard is not enough
- Partnerships between science-government-private sector needed
- Entrenched boundary issues between local and regional government (or between local authorities and communities must be overcome) (e.g. acceptable risk, managed retreat)
- Resilience must become “normal” for it to really function – ***Resilience as a state-of-mind***