
# Surveillance of Environmental Signals to Detect Emerging Threats

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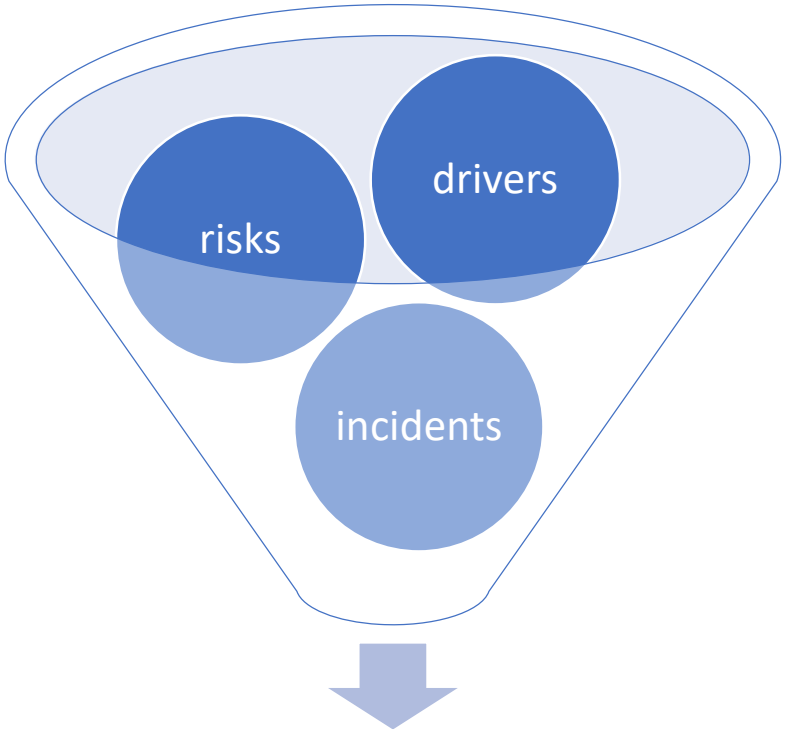
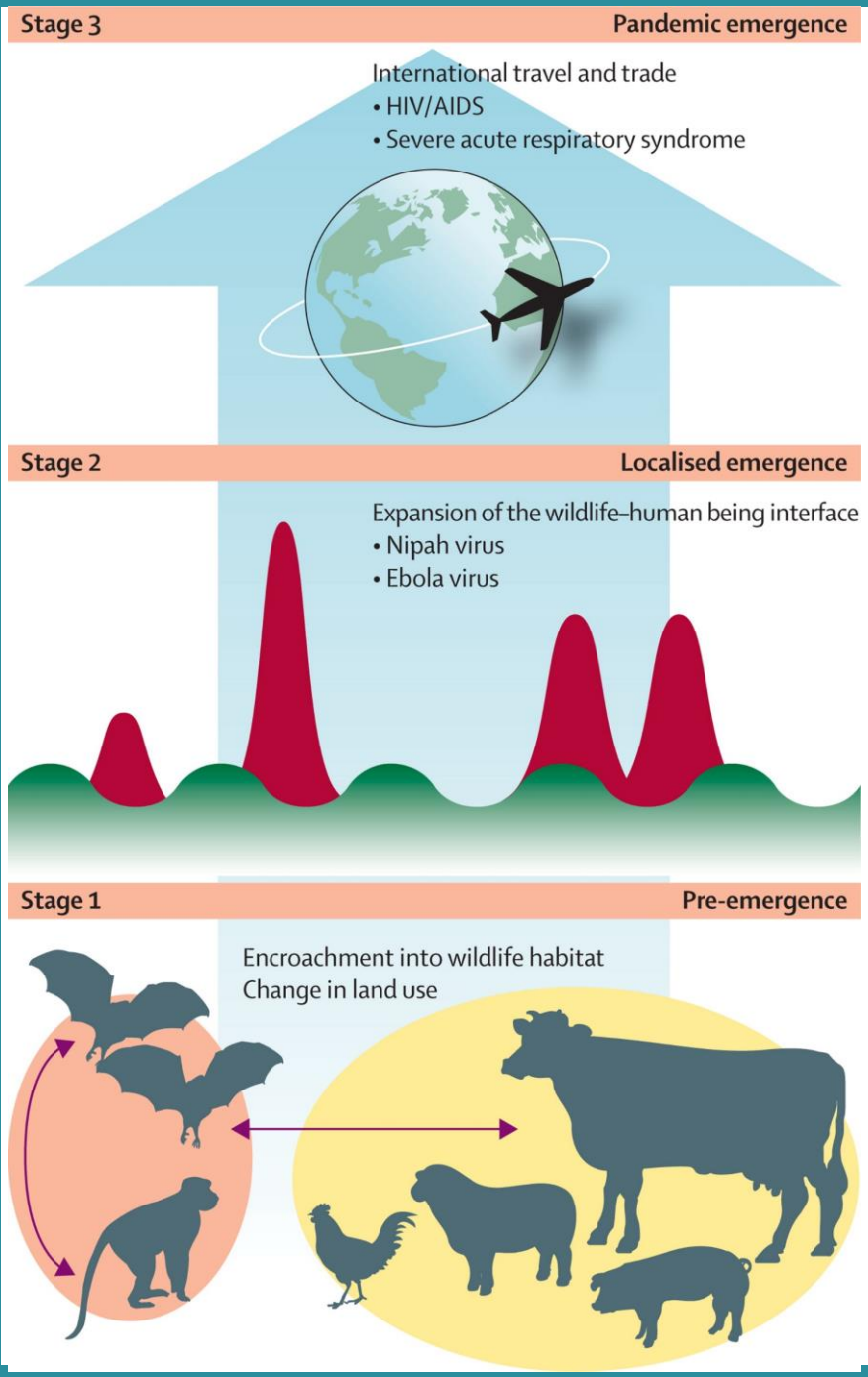
Canadian Wildlife Health Cooperative

# The hypothesis

Finding clues in advance of an outbreak provides opportunities to act to prevent or minimize harms

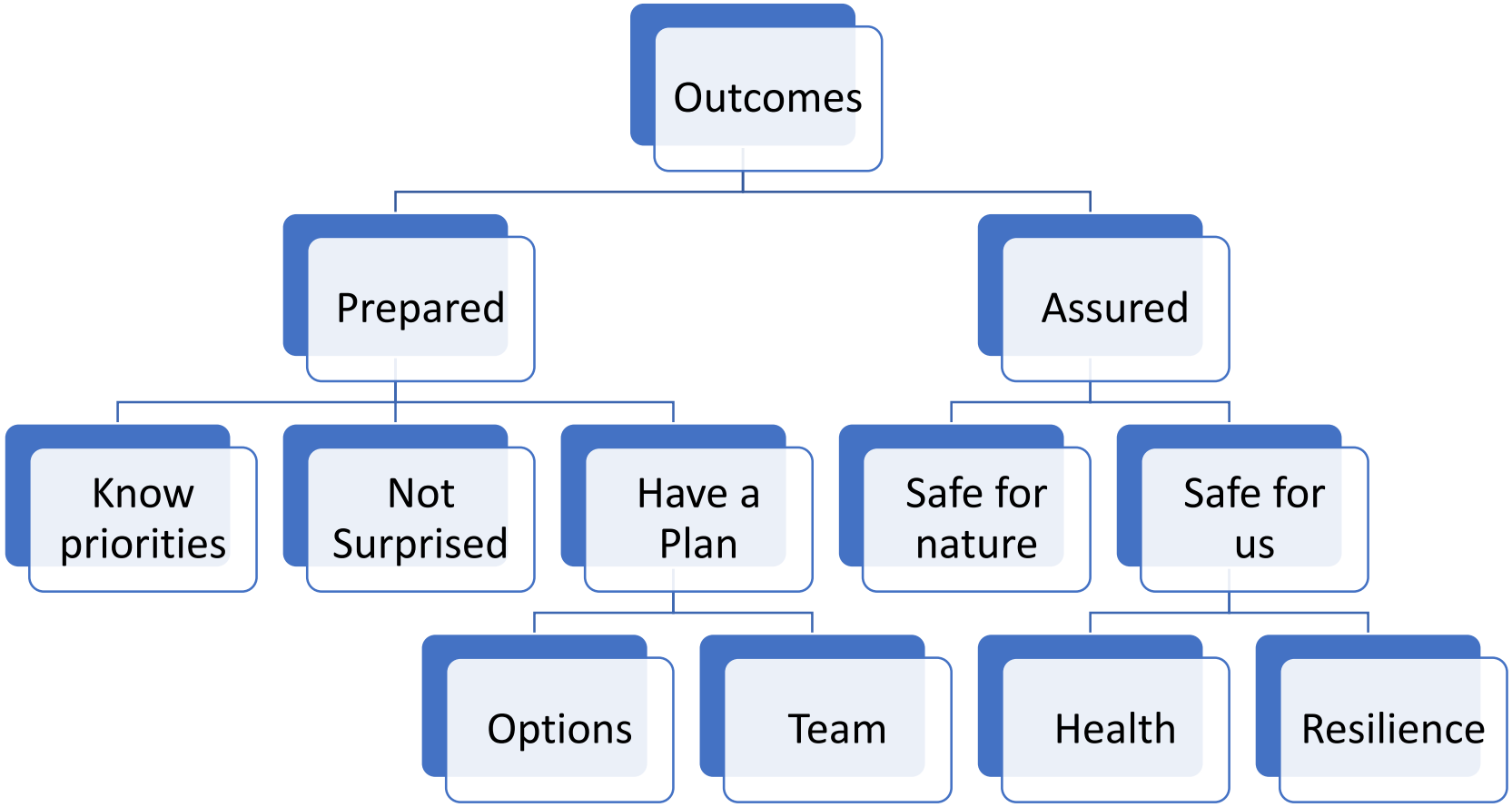





# Looking upstream for early warning

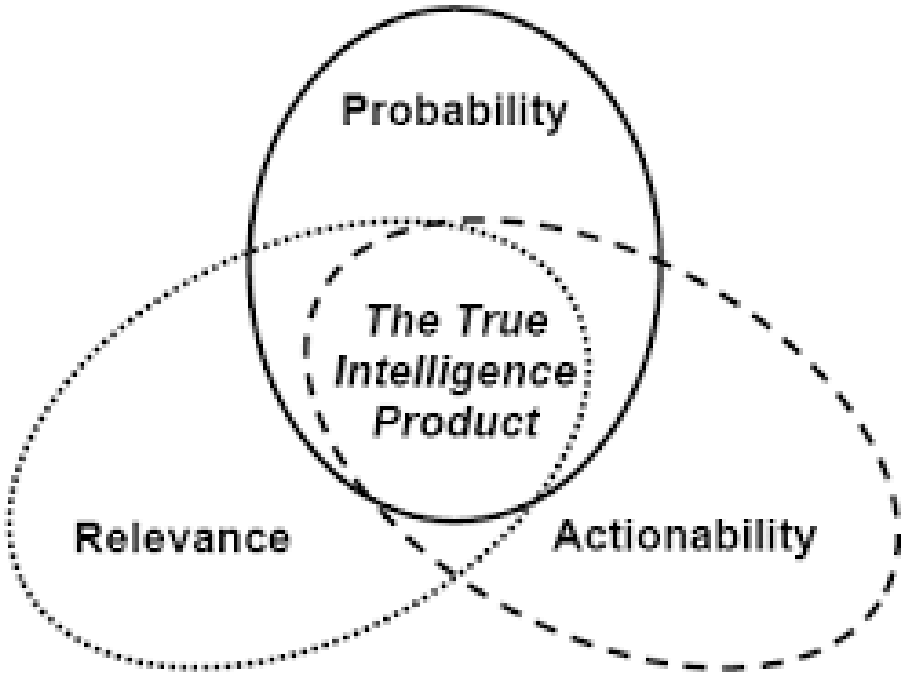
- Find the hazard
  - In animals closest to us (those we eat or live with)
  - In the wildlife source
  - In index human cases
- Track the interface
  - Changing opportunities for hazard flow
    - wildlife-agriculture contacts
    - human food consumption patterns
- Track the enabling factors affecting exposures and sensitivities
  - Habitat loss, changed agriculture practices, human travel

# What we want to produce

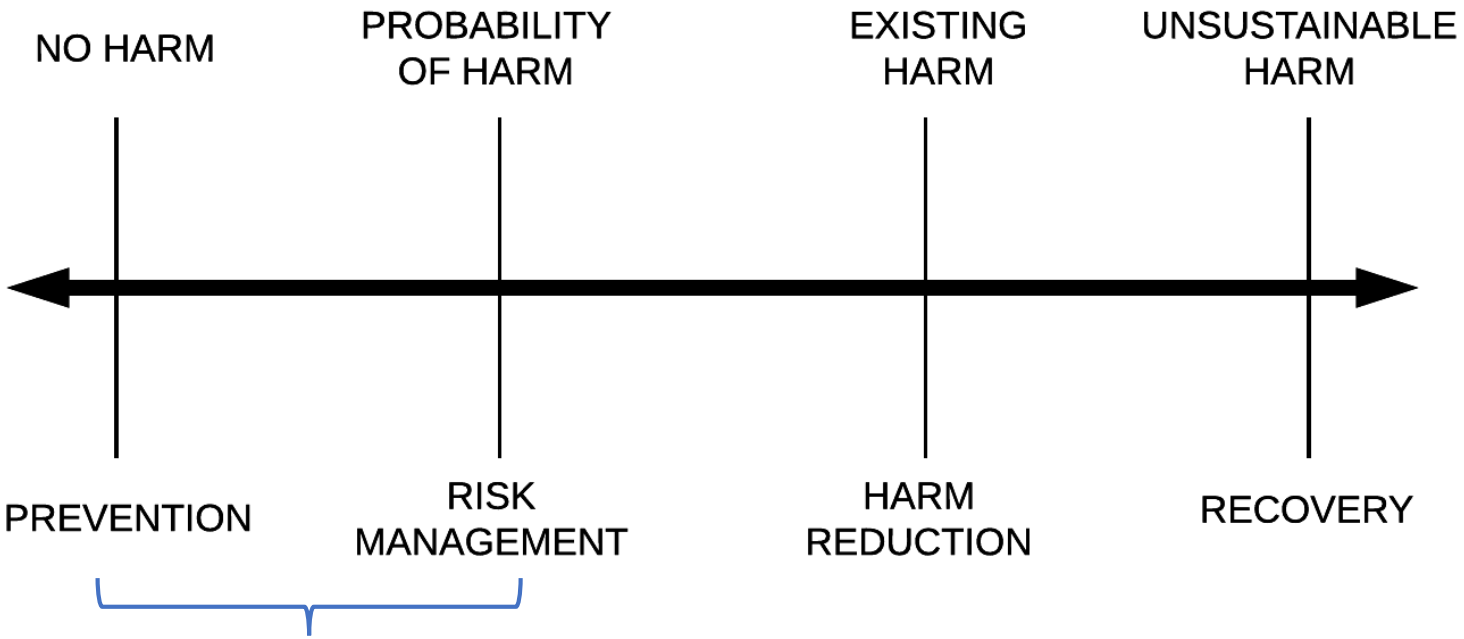


# What we usually want to know

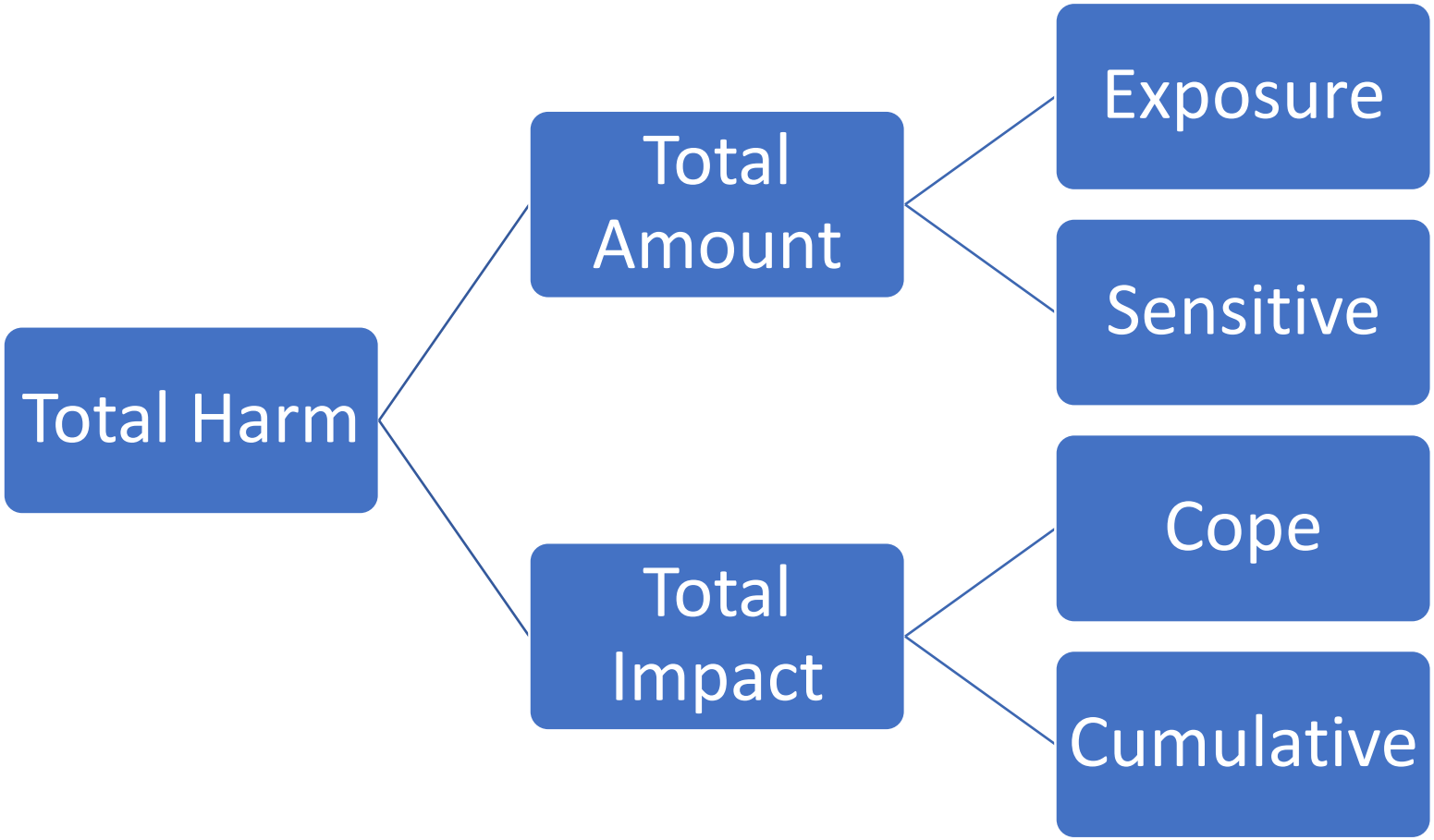
Can I find an understandable signal to inspire an action to lower the likelihood that something I care about is going to be harmed?



# The harm continuum



# Origins of harm



# The problems for early warning

## Too early = less actionable = less warning

## Too late = less effectiveness = less valued


| Can't cope | More vulnerable | At increased risk | Morbidity, mortality, social harms |
|---|---|---|---|
| Primordial prevention is hard to sell | Problem of risk perception | | Best you can do is minimize impact |

# The new normal = surprise

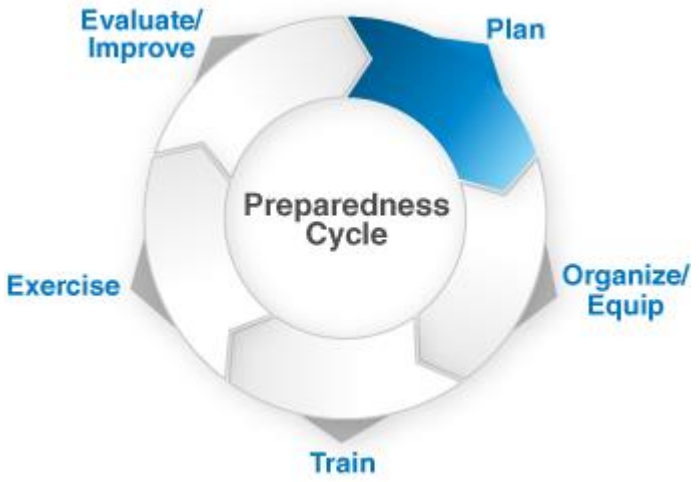
- Globalization
  - Interconnectedness = flow of hazards and susceptible
- Social change
  - Population growth and urbanization
  - Food production
- Environmental change
  - Altered food webs and ecological conditions


Does business as usual prepare us for surprise?

# Origins of surprise

- Complexity theory
  - Surprise as an event is always unanticipated
  - Surprise as a phenomenon is always expected

- Organizational theory
  - Lack of understanding
  - Lack of warning
  - Lack of response when there is ample warning



# Taxonomy of surprise 1

| Type | Example |
| --- | --- |
| Rare event with serious consequences | Post-tsunami nuclear accident in Japan |
| Common event but we didn't recognize it as a warning signal early enough | Translocated pathogens – index cases not seen as a warning (ex. West Nile virus) |
| Unexpected consequences | Moving New York's garbage to Ohio made rabies jump borders |
| Knowable consequence from an unexpected source | Aerosol cans thinning the ozone |

# Taxonomy of surprise 2

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| | Expected Process | Unexpected Process |
|---|---|---|
| Expected Issue | **Routines Surprises**<br>Can expect them at one scale but hard to pin down at another scale<br>(ex. seasonal vector-borne diseases) | **Incremental surprises**<br>Gradual changes lead to an unexpected outcome<br>(ex. ocean acidification impacting shellfish survival) |
| Unexpected Issue | **Sudden Events**<br>Something new arises from an existing phenomenon<br>(ex. El Nino shifts bird migrations leads to novel flu) | **Loss of meaning**<br>Something previously inconceivable<br>(ex. mad cow disease and prions) |

# Strategies to anticipate surprise

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| Category of Surprise | Response |
| --- | --- |
| Knowable in retrospect but **elude detection** | **Awareness and vulnerability**<br>• Connect specialized pools of knowledge to detect and assess signals<br>• Detect hazards<br>• Track exposures<br>• Sentinel outcomes |
| **Fail to recognize** actionable signal or not able to **respond** despite warning | |
| **Unanticipated** consequences of socio-ecological interactions | **Coping & Adaptation**<br>• Be aware of changing relationships<br>• Track changes in determinants of health and community capacity |
| Previously **inconceivable** events | |

# Origins of harm – drivers of surprise

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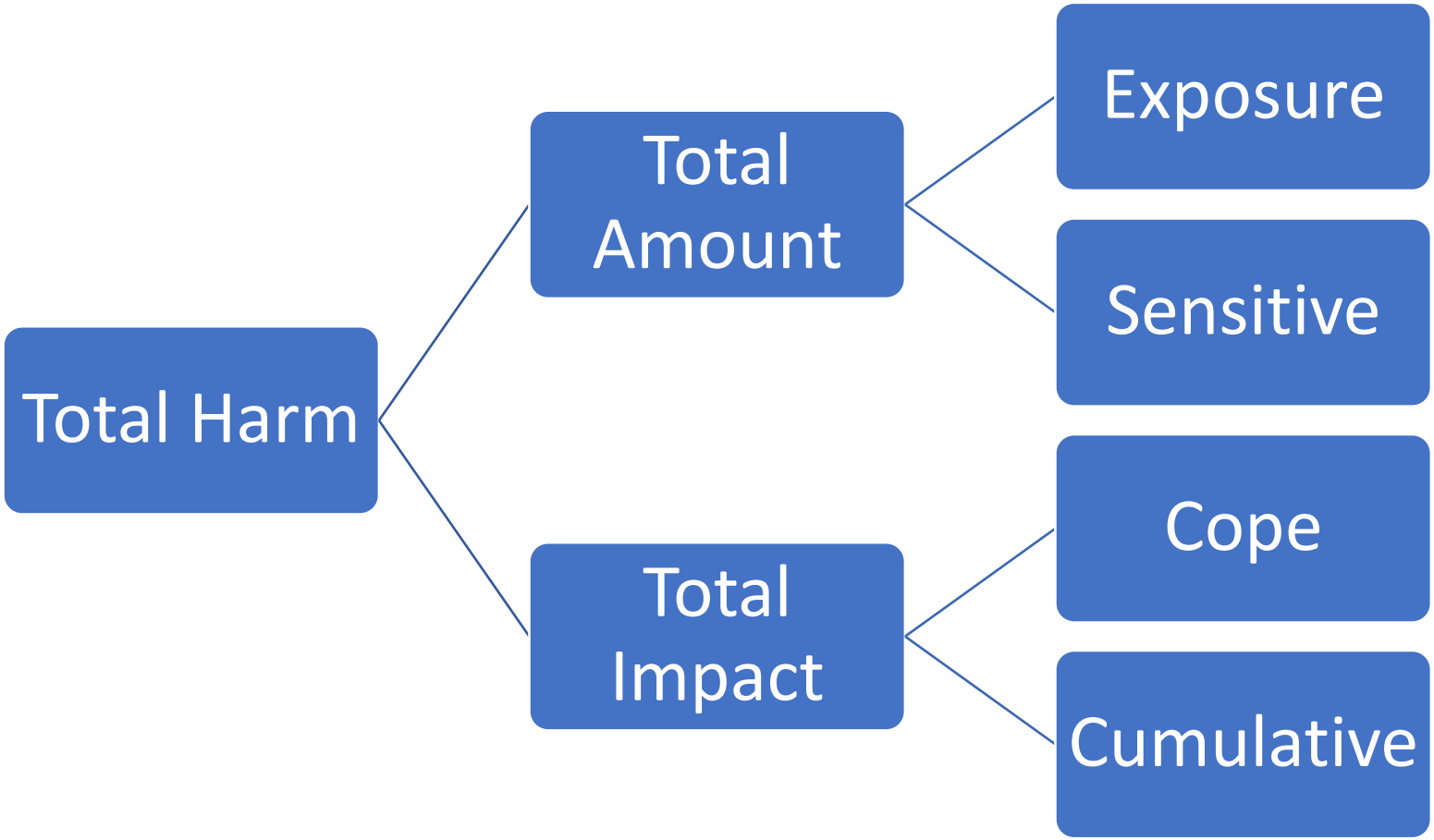
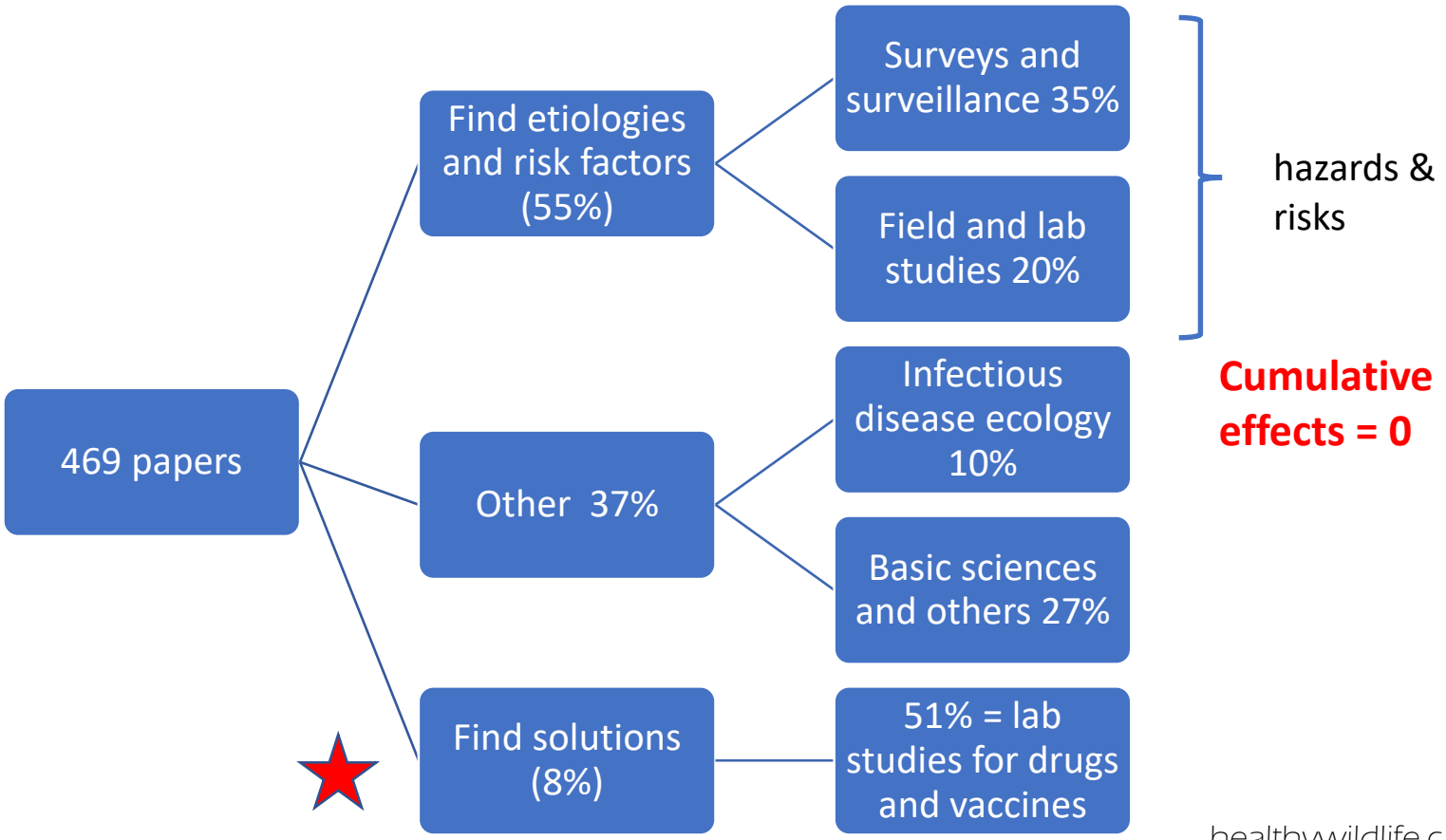


# A harm lens to seek early warning options

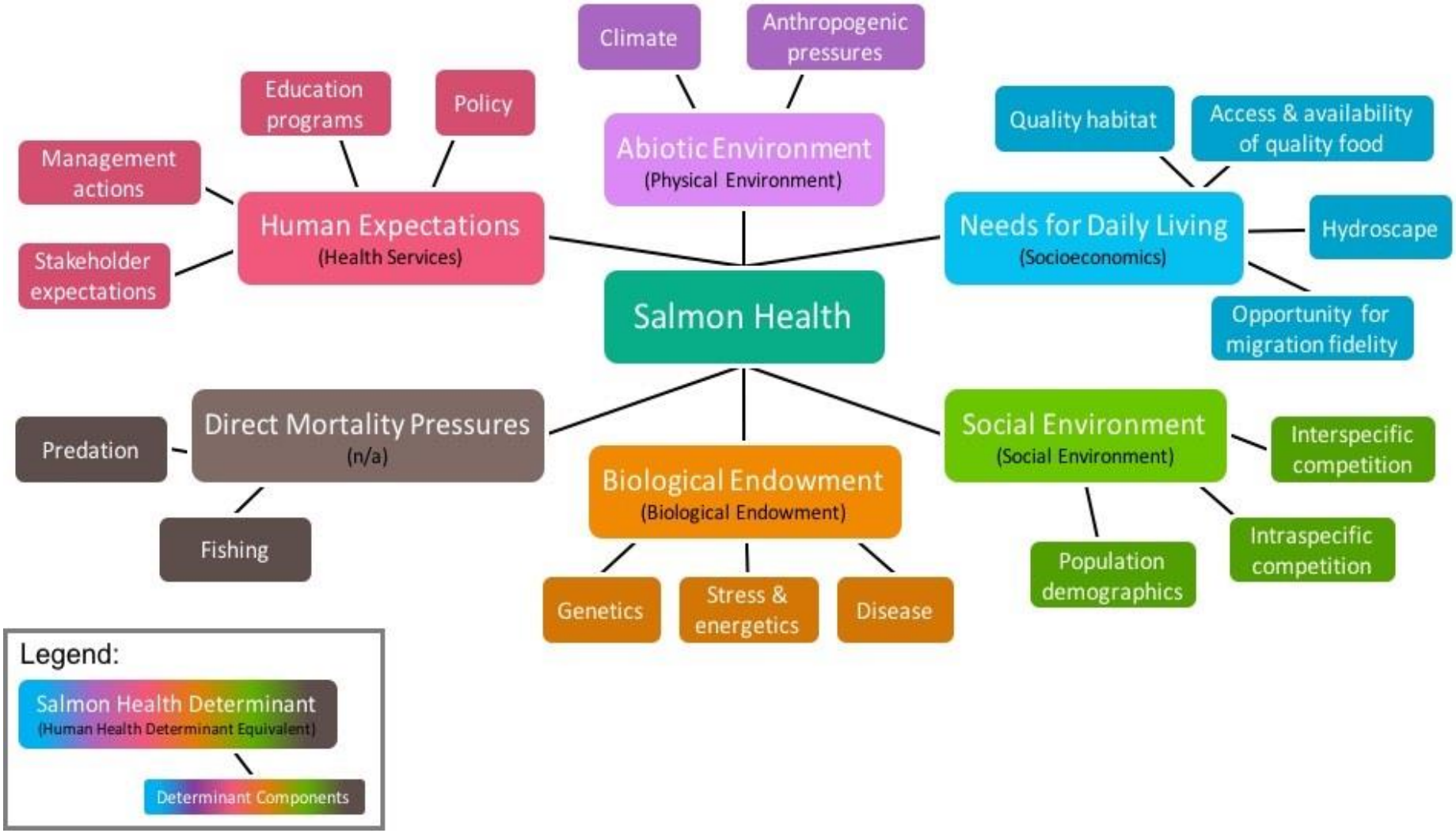
| **Total Amount of Harm** | | **Total Impact of Harm** | |
|---|---|---|---|
| Exposure | Sensitivity | Coping and adapting | Cumulative |
| • Route of exposure<br>• Amount of hazard in the environment | • Susceptibility to the harm<br>• Concurrent stressors<br>• Anthropogenic modifiers | • Ecological and biological barriers<br>• Management barriers<br>• Social barriers<br>• Drivers of resilience | • Shared drivers of concurrent harms<br>• Zero-sum management options |

# Where do we look?

Recent 10 issues J. Wildlife Disease, Ecohealth, Disease Aquatic Org

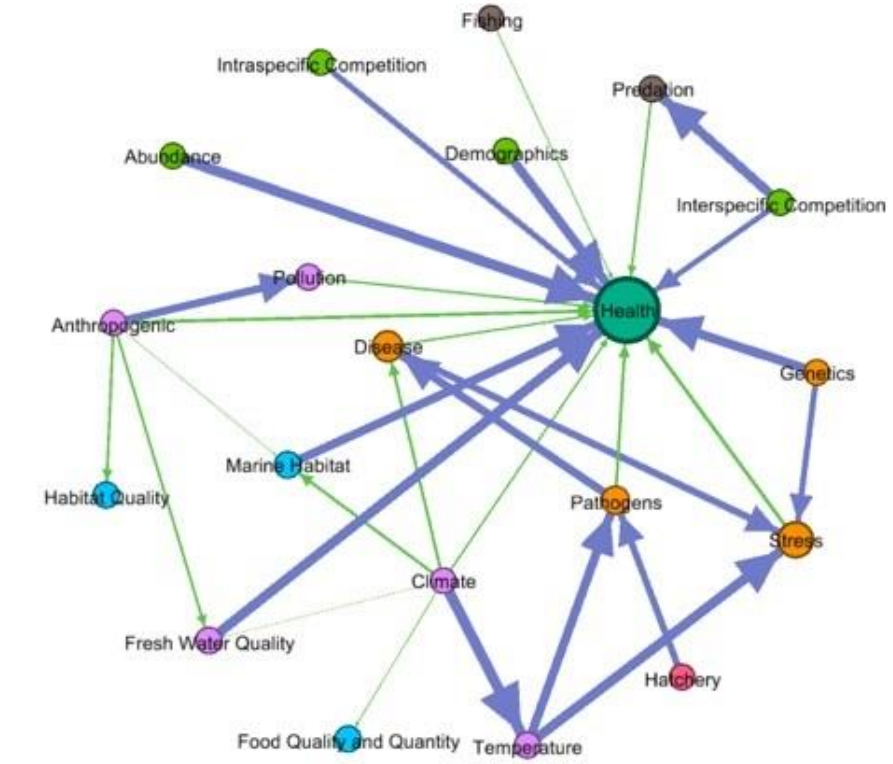


# Many drivers of health




From J. Wittrock – Doctoral research in progress

## Expert Salmon Health Network




Legend:

- Biological Endowment
- Social Environment
- Needs for Daily Living
- Direct Mortality Pressure
- Human Expectation
- Population Health – Outcome
- Abiotic Environment

- Arrow weight represents the impact of that relationship; thick arrow = large impact, thin arrow = small impact
- Arrow colour: Positive Impact Negative Impact
- Node size depicts Eigenvector centrality

**Many interacting drivers result in many ways risk can change**

**How to select targets to monitor for early warning?**

# Determinants of risk signals

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$$R = p_h x v_1 x v_2$$

- R= Risk
  - $P_h$ = probability of harm
  - $V_1$ = vulnerability to harm of the populations of concern
  - $V_2$ = value(s) at risk

# Let's be honest .....

$$R = p_h x v_1 x v_2$$

Value will drive priorities for monitoring and action

Sick kid > economic impact >sick adult > sick domestic animal > sick wildlife > sustainable wildlife > sustainable ecosystems

.....or maybe I am getting too cynical

$$R = p_h x v_1 x v_2$$

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## Probability of Harm

- Scenario 1 = We know it causes harm
  - Early warning signals
    - More likely to be exposed
    - More sensitive to adverse effects
- Scenario 2 – It is a new/emerging hazard
  - Early warning signal
    - Showing a harm is possible

# Can the presence of a hazard suggest a likely harm?

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**Sometimes it is enough**

- Food borne pathogen in a food source in a known exposure pathway
  - Ex. Vibrio in oysters
- Index case of a foreign or listed disease
  - Ex. Ebola in Juneau

**Sometimes it is not**

- HPAI in wild birds
  - Does little to change farmer biosecurity behaviour without local exposure information
- A novel coronavirus in a bat in BC
  - May raise interest, but little action

# Showing harm can occur

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## 'Silent Spring' Is Now Noisy Summer

### Pesticides Industry Up in Arms Over a New Book

### Rachel Carson Stirs Conflict—Producers Are Crying 'Foul'

By JOHN M. LEE

The $300,000,000 pesticides industry has been highly irritated by a quiet woman author whose previous works on science have been praised for the beauty and precision of the writing.

The author is Rachel Carson, whose "The Sea Around Us" and "The Edge of the Sea" were best sellers in 1951 and 1955. Miss Carson, trained as a marine biologist, wrote gracefully of sea and shore life.

In her latest work, however, Miss Carson is not so gentle,

fending the use of their products. Meetings have been held in Washington and New York. Statements are being drafted and counter-attacks plotted.

A drowsy midsummer has suddenly been enlivened by the greatest uproar in the pesticides industry since the cranberry scare of 1959.

Miss Carson's new book is entitled "Silent Spring." The title is derived from an idealized situation in which Miss Carson envisions an imaginary town where chemical pollution has silenced "the voices of spring."

# New technology

## Ex. scanning for signals of hazards rather than the hazards

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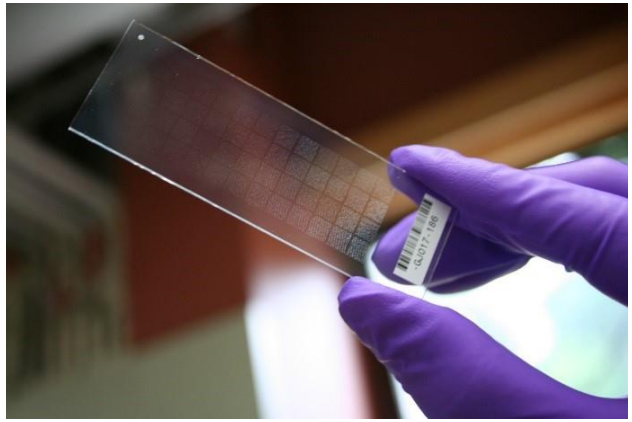
- Genomics and salmon disease
  - Major policy and political issue of interpretation



- HP Avian influenza
  - Test for genomic signals
    - Find virus signals in waterbodies

Will this inspire farmer action

Trade impacts might discourage surveillance

Can you do something about the marsh

$$R = p_h x \boldsymbol{v_1} x v_2$$

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# Vulnerability

| Exposure | Sensitivity | Adaptive Capacity |
|---|---|---|

# The exposure challenge

- Right place, Right amounts, Right pathway – before it causes harm
- If we **find it on its own** in the environment
  - Is it viable, is there enough, is there effective contact?
    - Good if we know exposure pathways and thresholds but less so for surprises and novel hazards
- If we **find it in another species, vector or fomite**
  - Are they in the same exposure pathway as us; is their mode of uptake the same?
  - How much is significant in the absence of harm
    - Ex. immunosuppressive contaminants in thriving seal populations
    - Ex. contaminated crabs

# Pros and cons of exposure signal sources. Which would make you act?

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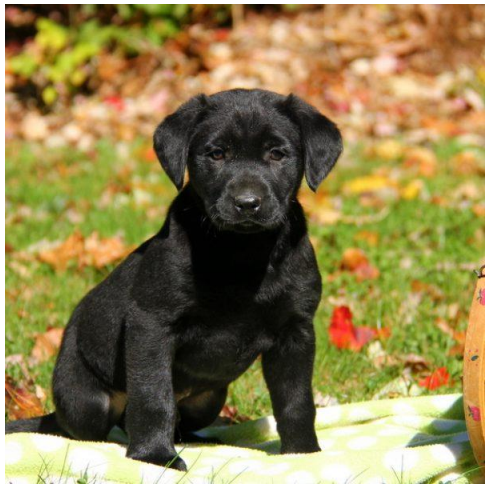
Context = Industry and air pollution



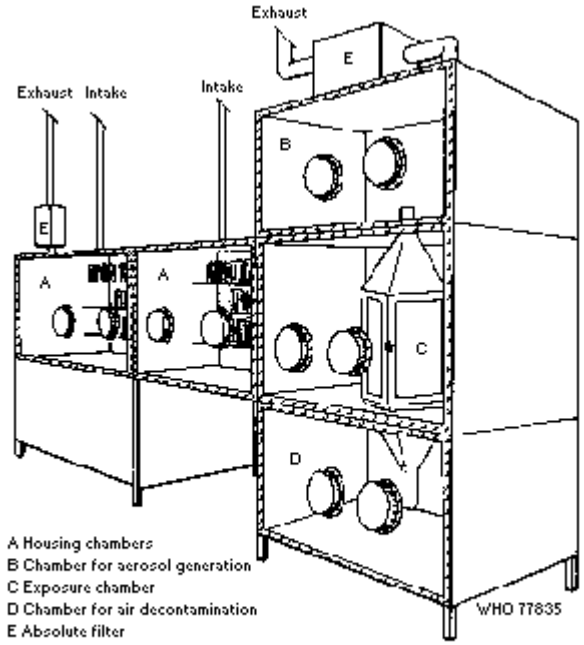
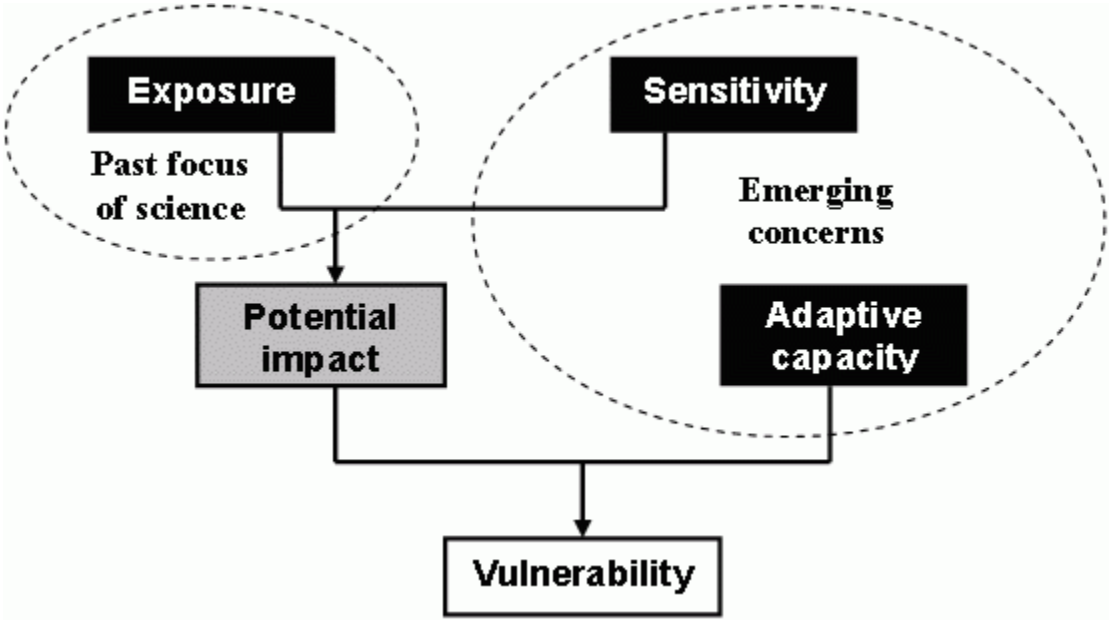



**Fig. 6.4 Schematic drawing of New York University isolation exposure unit.**

# Sensitivity

- Extent to which a harm will result in direct or indirect effects in a unit of interest when in a viable exposure pathway



# Sensitivity factors

- Function of the species, population, systems and the external drivers acting on them.
  - **Biologic endowment** – the biological or ecological features of a unit of interest that makes them susceptible to effects
    - e.g. physiological, behavioural or life-history factors
  - **Concurrent drivers** –factors unique to the unit of interest but not related to exposure, that produce the same effect & can compound the effects of exposure the hazard
    - ex. concurrent causes of mortality when death is the effect of concern
  - **Human modifiers** –interventions that can modify the magnitude of an effect
    - ex. a vaccination program

# Emerging disease hotspots driven by socio-ecological sensitivities

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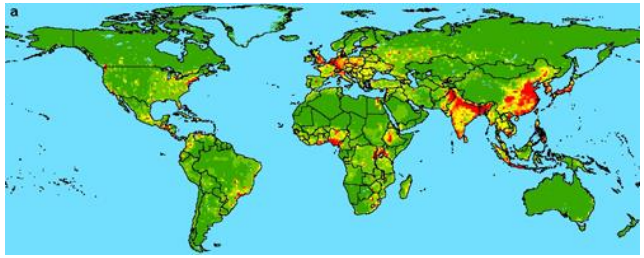

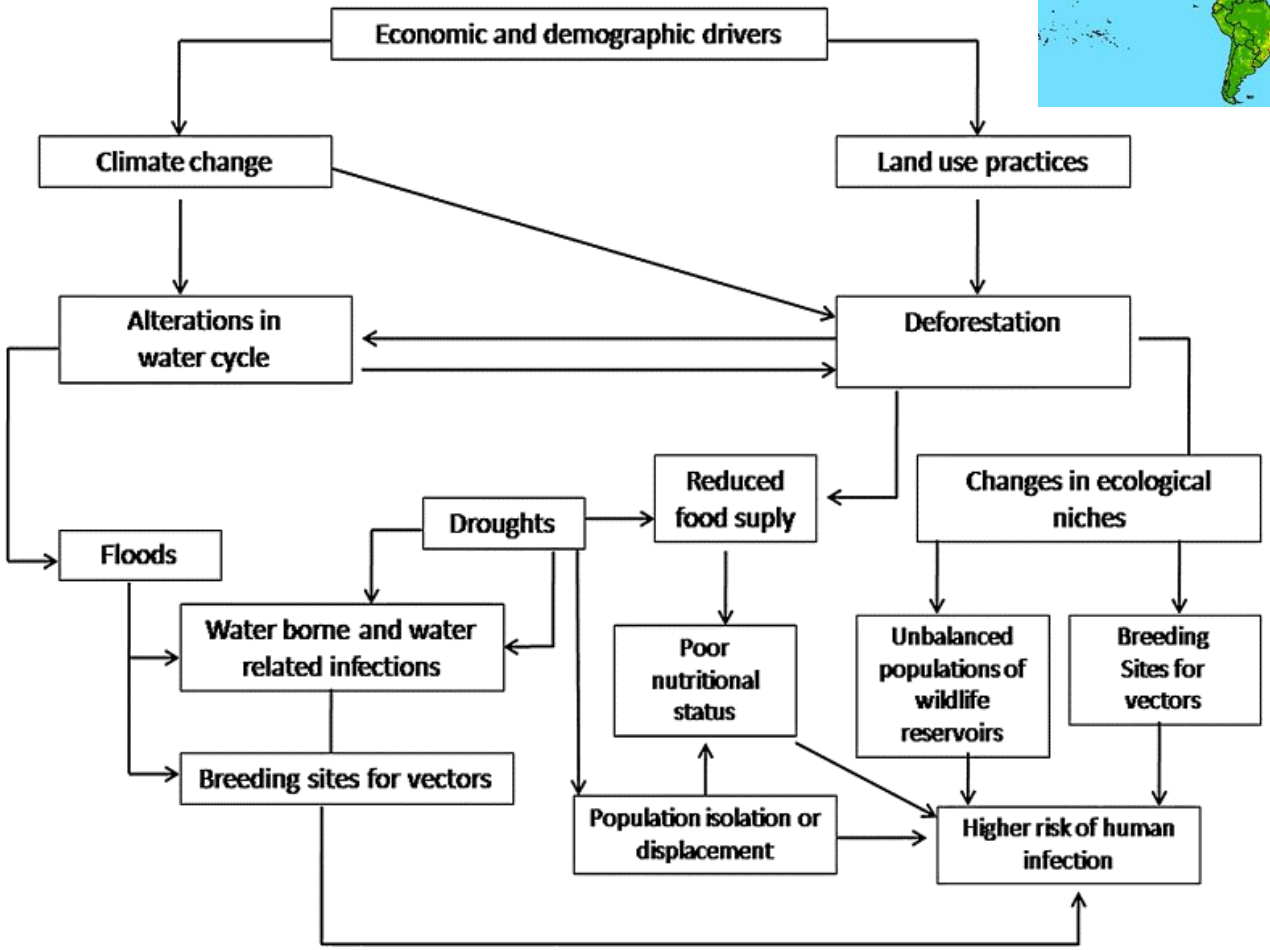

# Adaptability

- Barriers to adaptability
  - **Management barriers**
    - limits in the willingness or capacity of managers to respond to prevent or mitigate harms
  - **Social barriers**
    - cultural, political, or economic competing interests that will devalue response to prevent or mitigate harms
  - **Biological barriers**
    - concurrent factors that will affect a species or populations ability to adapt to or recover from harms?
      - Unique aspects of physiology or life history
      - Species abundance or distribution
      - Concurrent or cumulative stressors affecting recovery or coping capacity
    - habitat or landscape factors that reduce access to affected units of interest to the resources or relationships required for recovery or adaptation to harms

# Seeing vulnerability as a cumulative effect

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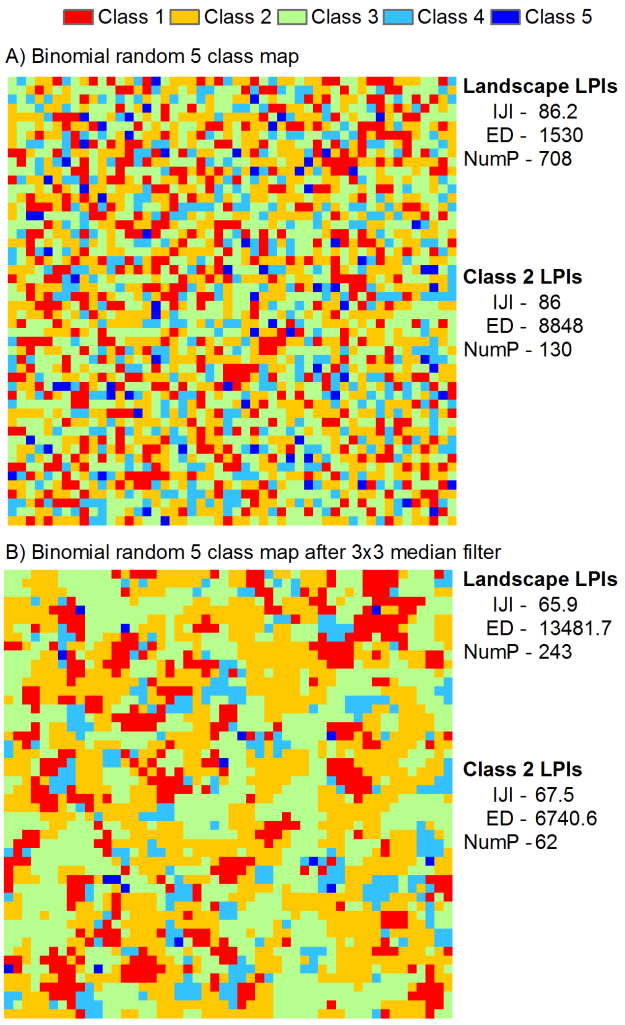
- Fragmented forests in Nepal & Japanese encephalitis
  - Increased interface of wild bird habitat and peri-urban irrigated, small-scale farming = increased exposure risks
  - Poverty and lack of health care increases sensitivity and decreases adaptability




http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0066168

# Context is everything for early warning

- Can we do sensitivity and adaptability surveillance?
- Understanding context helps you priorities signals
  - Requires a network of information
  - Intelligence vs surveillance

# Intelligence

- Information + evaluation for a context = intelligence
- Intelligence tasks
  - Understand the situation
    - The problem in the context = more than the disease trends
  - Focus further information collection
  - Guide responses in the face of uncertainty
  - Communicate complex situations in an understandable way
- Importance of human intelligence
  - Ex. Salmonellosis in BC

# The full spectrum of information needs

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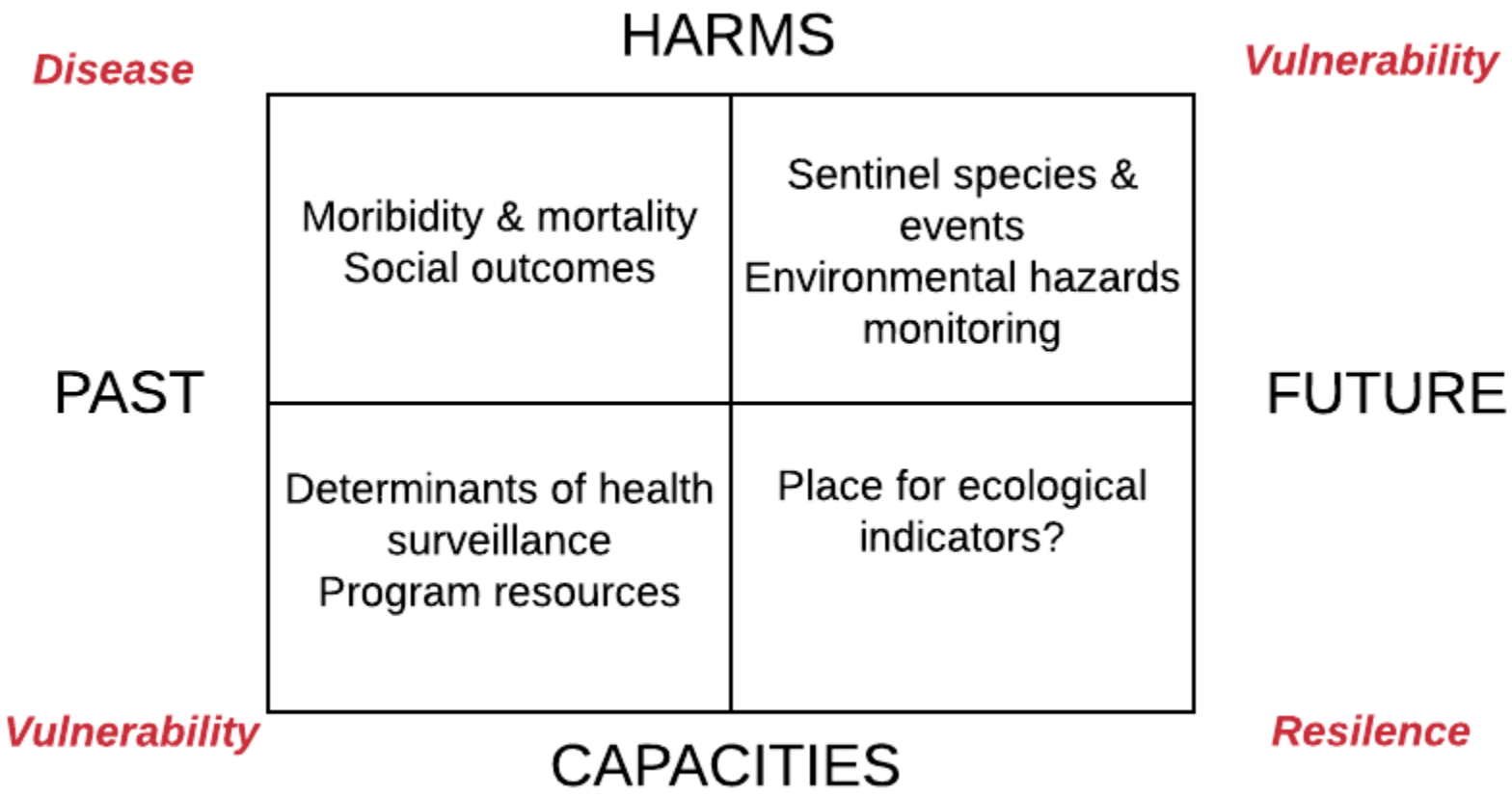
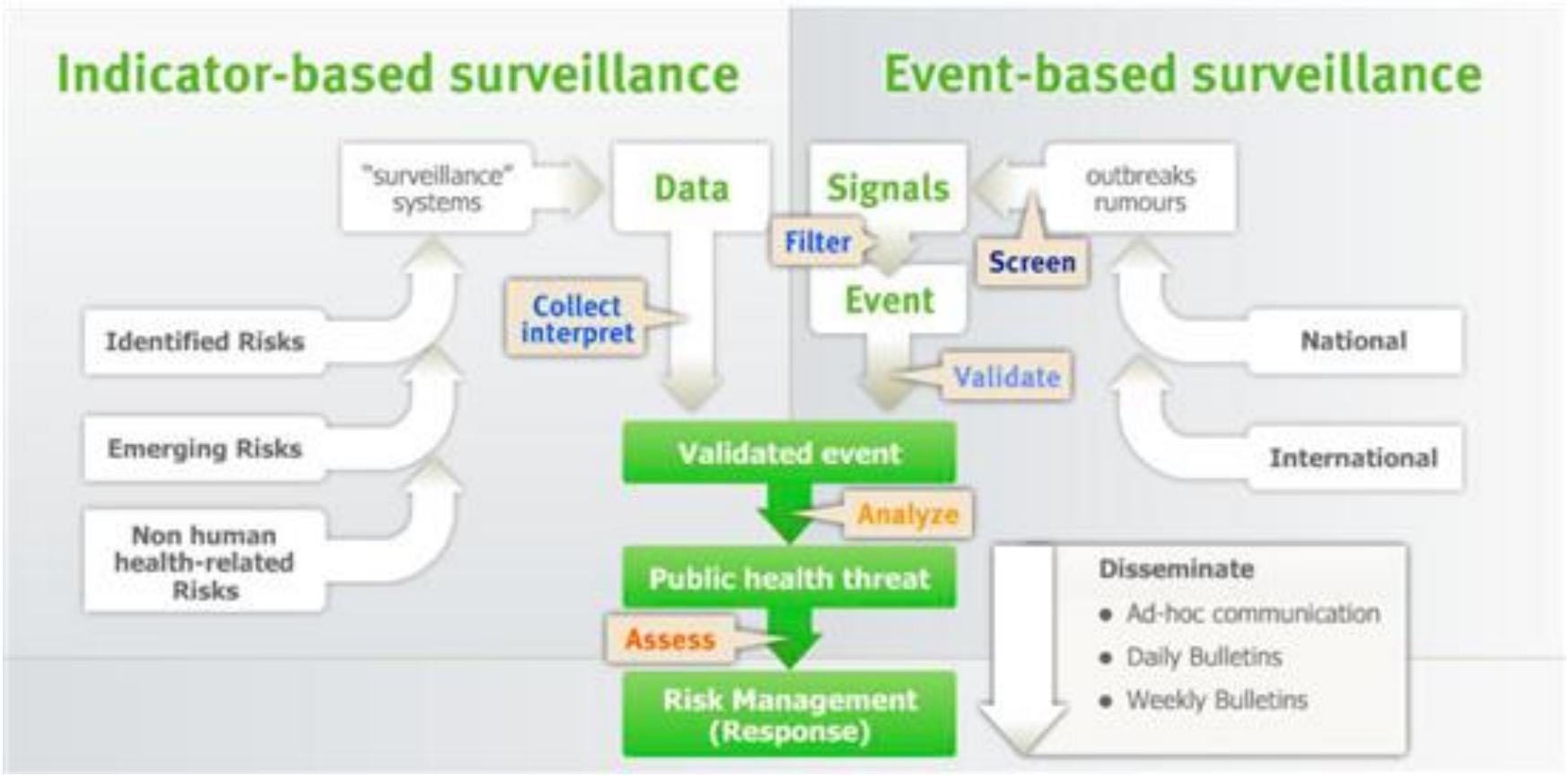



Requires a diversity of knowledge & partners

# Triangulating multiple signals




Epidemic Intelligence

# Collective Intelligence Systems

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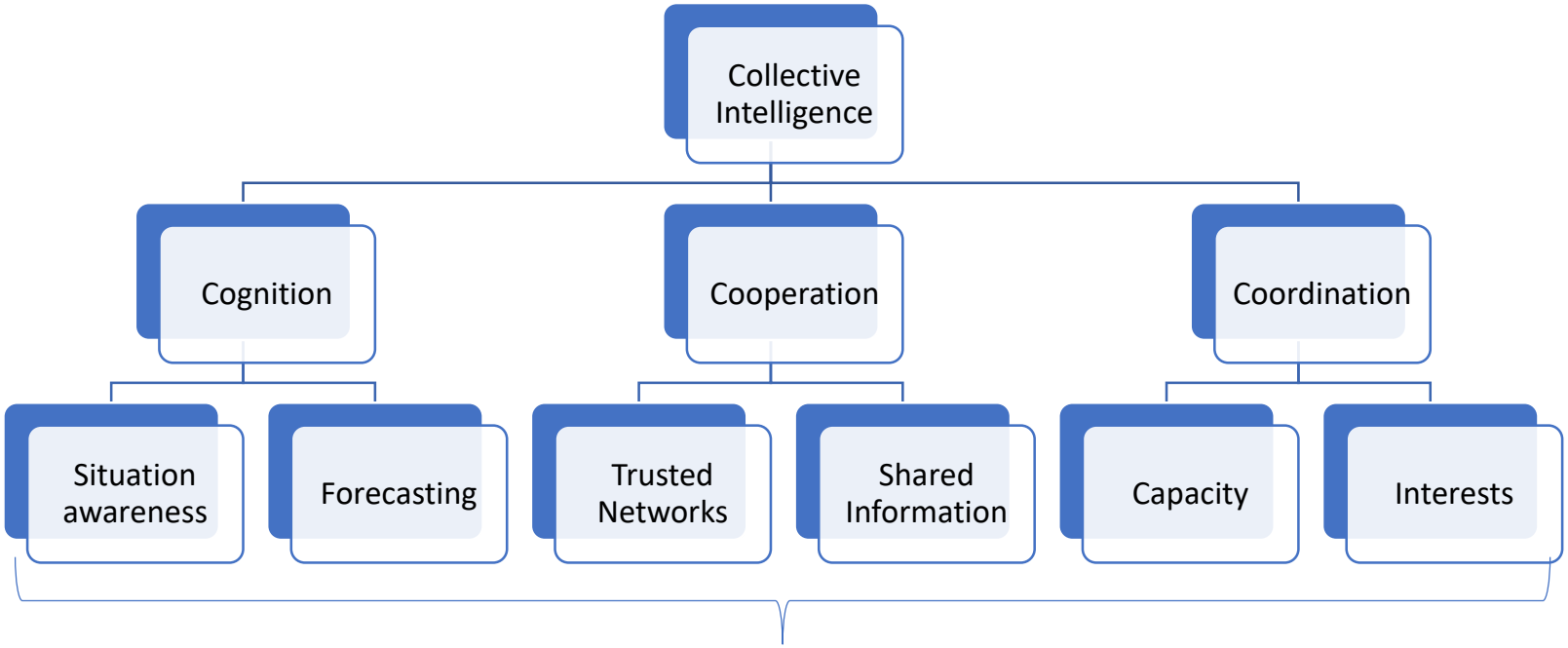
Emerges from the collaboration, collective efforts, and competition of many individuals




Assembled from the Network

# Triaging via surprise intelligence = different than predicting outbreaks

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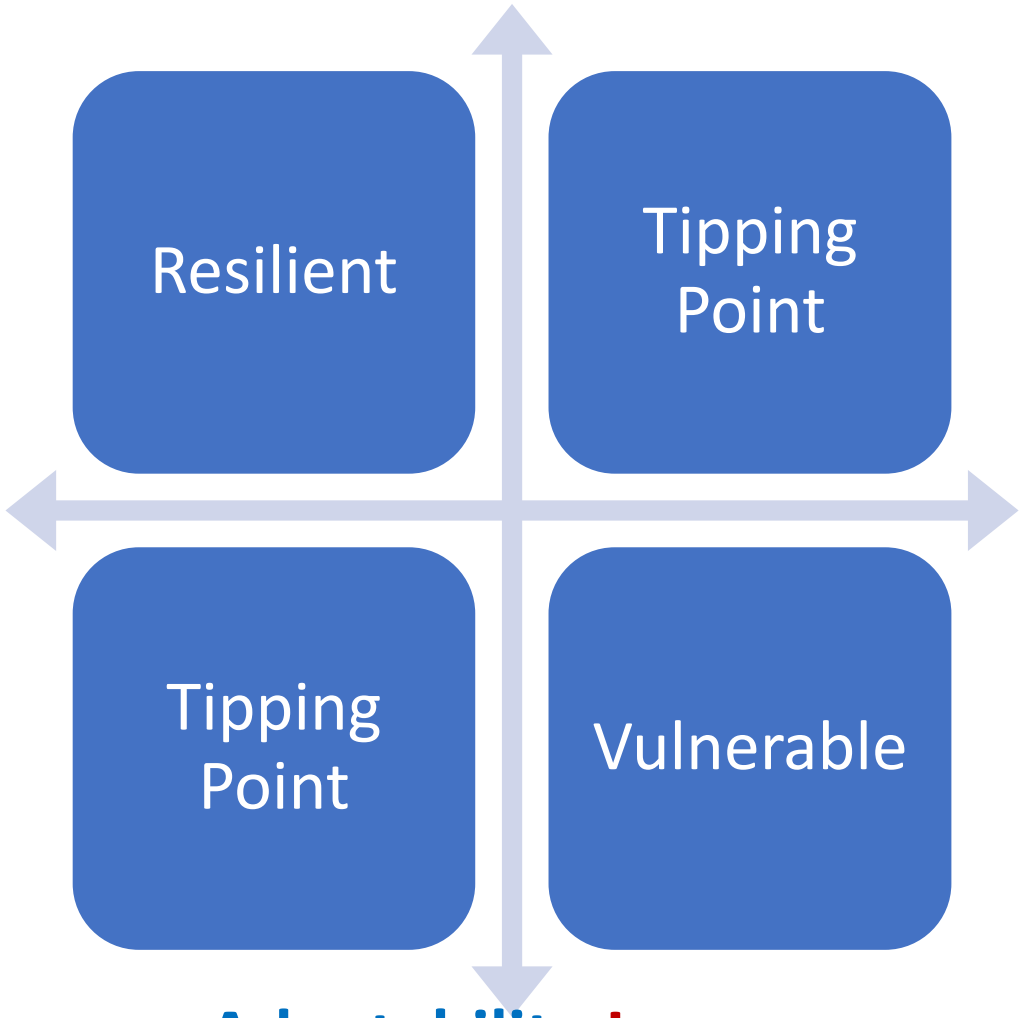

# Limited options to act on risk drivers

- Standard disease control interventions can't be done in wildlife
- Economic drivers and social values affect willingness and ability to act in domestic animals
- Causal pathways from ecosystems functions too complex to predict risk reduction from ecosystem management
- So….. we need to find opportunities to build resilience
  - Part of the harm reduction ethic

# The surveillance cycle

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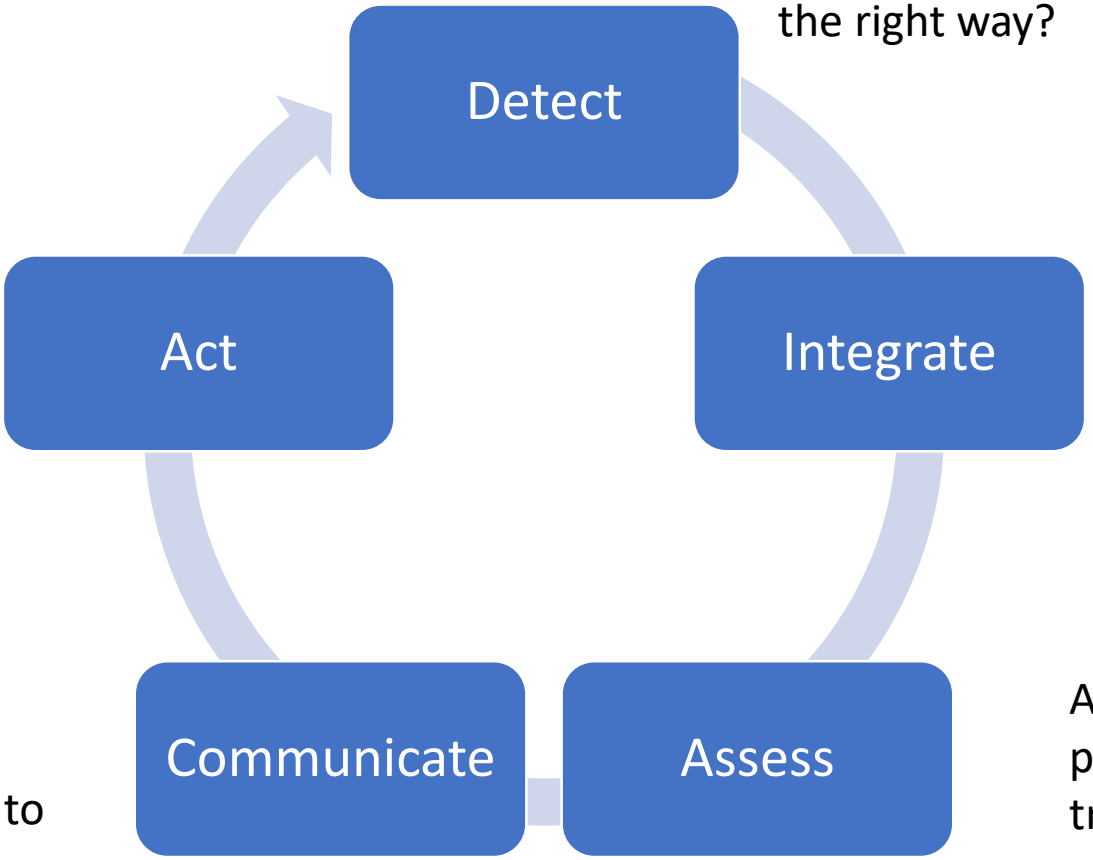

# Conclusions

- Detection is only a small part of surveillance
  - If we want to provoke preventive action, we need to see environmental signals in their socio-ecological context

- Move to harm focussed intelligence
  - Can't wait for perfect signals and perfect knowledge
  - Can't focus on infectious hazards alone
  - Knowing context turns signals into information
  - Need to inspire action "where we are now" to maintain health "where we want to be"


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Thank-you
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