Walking towards a cliff-edge

How might agent-based modelling complement participatory futures processes to help make tipping points feel real?

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Issues from Complexity

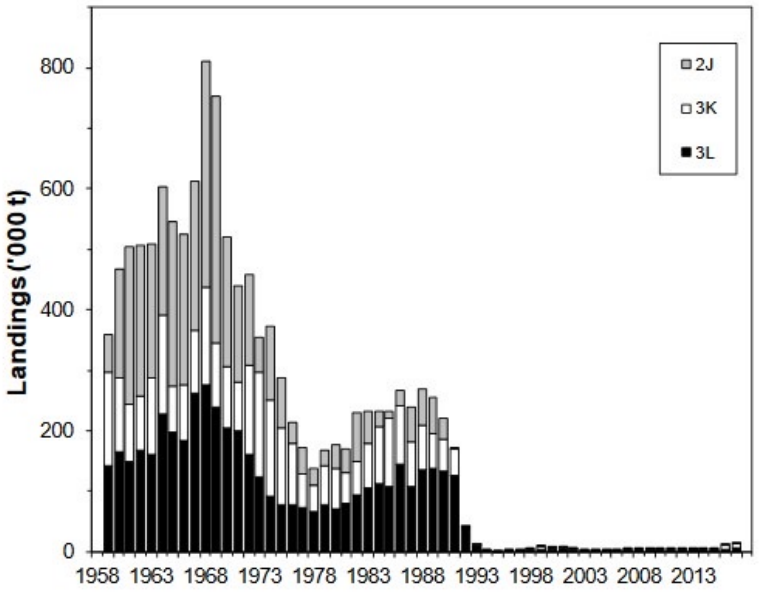
- Both social and ecological systems are complex and their combination even more so!
- Their behaviour within a phase might be very different to that in another phase
- Such systems can look to be coping right up to the moment they collapse (the “tipping point”)
- To prevent such collapse costly action often needs to be taken much earlier
- However, political will to do this is often lacking as the collapse does not seem real until it happens

A solution that does not work

- Use abstract models, that try to predict but only within the current phase where assumptions hold
- Tell people about the model and what it says
- Keep updating the model as the phase starts to change
- New versions start predicting catastrophe
- Tell people that suddenly it is an emergency
- Expect them to adapt quickly

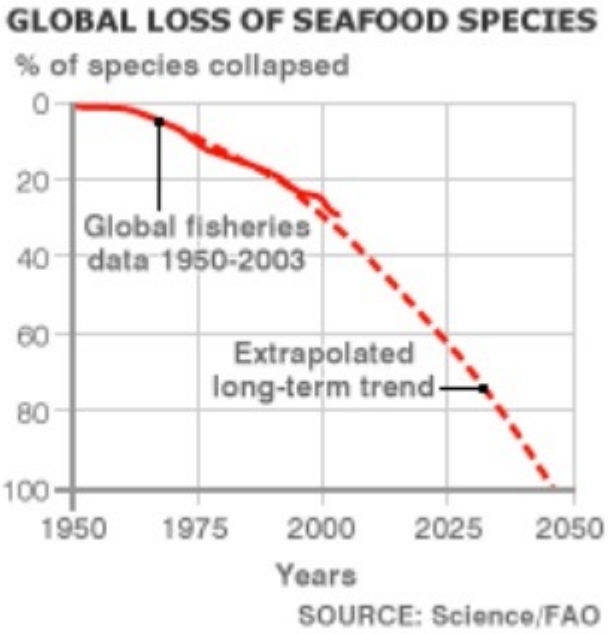
A well-known example:
the North Atlantic Cod Fishery Collapse

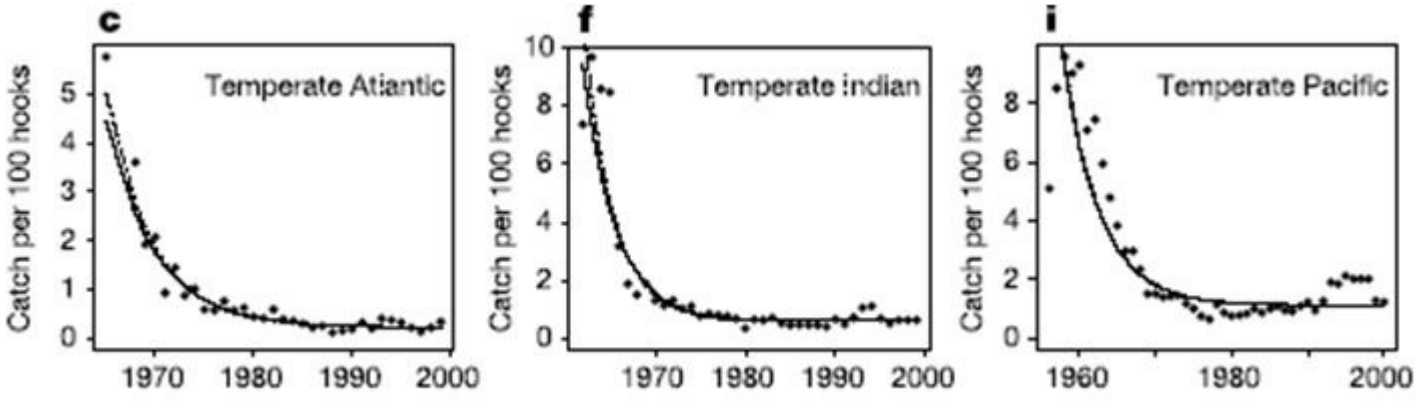
- In July 1992 Canada's fisheries minister placed a moratorium on all cod fishing off the NE coast of Newfoundland and Labrador. That day 30,000 people lost their jobs and hundreds of years fishing for cod off those coasts ended.
- Simplistic models being used predicted healthy stocks up until 1989, and hence *had made the problem worse*.
- Concerns raised by some fishermen were ignored and did not influence modelling and projections
- Policy Makers (and indeed the scientists involved!) seemed to look for signs that "business as usual" was OK



Global Fisheries Collapses

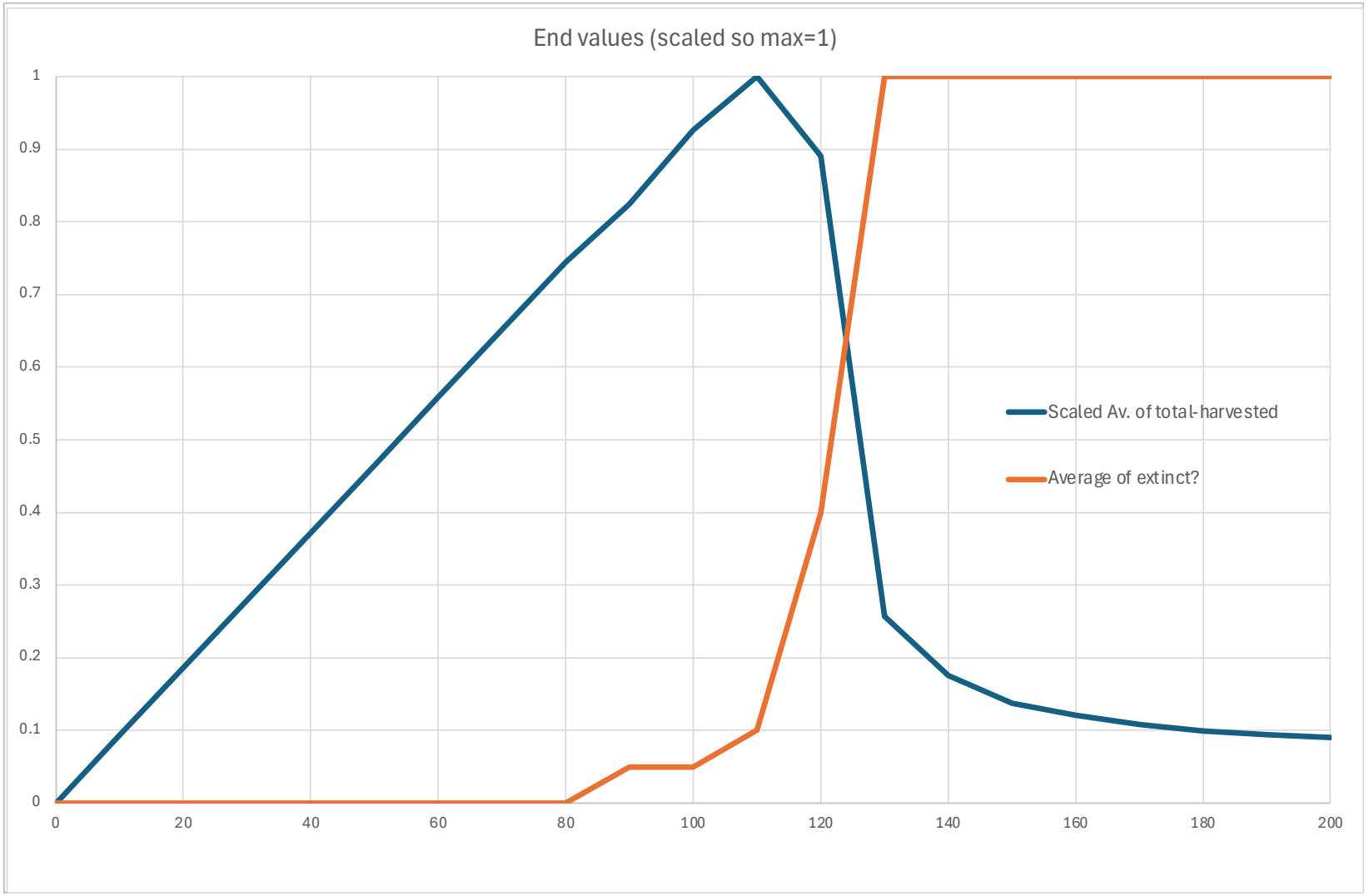
- Not limited to Atlantic Cod
- Complete lack of primary data
- Models do not capture complex inter-species interactions
- Let alone the possible consequences of fishing





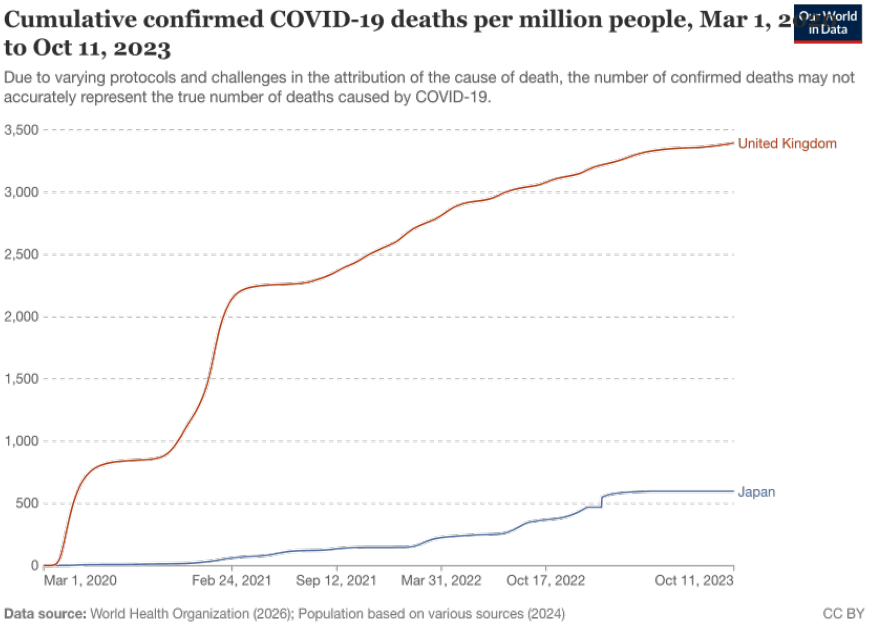
You can't re-run reality but you can in a model…

Total Fish Harvested vs Extinction Risk of long-term fishing (scaled so max=1) *in a multi-species model*



A second example:
COVID and UK disease modelling

- Institutional memory of the Influenza pandemic 1918-1920 – the H1N1 virus infected about a third of all people and killed 50-100 million
- A previous coronavirus (SARS) did not impact the UK
- This time there was a variety of models all of which indicated the severity of the coming COVID
- But this clashed with previous experience and UK culture
- Only when the UK saw body bags being collected by the army in Italy did this seem a real threat
- And suddenly imposed severe restrictions on the population
- However, there was a backlash against the restrictions and a second wave was allowed to grow out of control before imposing them again



Problems

- The systems are very difficult to predict reliably
- Experts are as prone as others to assuming they know it all and resent new factors being introduced that do not fit how they think
- Groupthink/polarization can make this even worse working to further simplify the picture
- Abstract analysis done for central agencies can miss aspects that are important for citizens and lack the cultural saliency necessary for action
- Leaving action too late can necessitate over-severe and “yo-yoing” measures

But Humanity has survived before, *right*?

- Previously, humanity consisted of separated groups, each with different technologies/cultures etc. that inhabited different ecological niches
- If a group made fundamental mistakes there was only local population collapse – other groups survived and spread (and sometimes learnt)
- We now live in a more interconnected world where our actions are
  a) an order of magnitude greater in effect
  b) and can affect other groups in cascades
- We need a new "*technology+culture*" to cope

Model-based and Human discursive understandings are complementary

Human Discursive	Model-based
Rich semantics	Thin formal semantics
Simplifies and abstracts	Can deal with indefinite levels of detail
Can be vague	Can be precise
Can be difficult to check	Rigorously checkable
Democratically accessible	Fairly impenetrable
Can be highly persuasive	Tends not to be except in technocracies
Covers one sequence of the possible	Can explore a space of possibilities
Narrative is widely applied (analogically)	Applying a model to new targets is hard
Historically embedded	Relatively new
Can relate to different values/cultures	Can be technocratic and closed
Can be reliable and useful but…	Can be reliable and useful but…
Limitations need to be heeded	Limitations need to be heeded

(Polhill & Edmonds 2023)

It can't be left to modellers on their own…

- Whilst others may pull in lots of different directions ("Chimaera modelling")
- ATM modellers are the people that have to ensure consistency

- But they will not be aware of all the mess and complexity of the complex systems
- And they will not be inhabiting the same cultural space as all those the system impacts upon and have no right to dictate collective decisions

(Edmonds & al. 2025)

but it can't be left to citizen groups either!

- Citizens have their own domain knowledge, values, priorities that are highly relevant
- And should not have solutions "imposed" upon them, if this is at all possible
- But do a lot of directed reasoning, finding reasons for their own conclusions
- Already have a host of their own problems to deal with, without considering others
- Are suspectable to groupthink, fashions and polarisation

The proposed approach

To iterate repeatedly between:

1. Stakeholder consideration of futures in the form of narratives

2. Socio-ecological simulations that can capture some of the complexity of the systems, including their unpredictability

Goals of the iterative process

- Identify what is known and not known
- Produce the greatest possible range of future scenarios that are consistent with what is known
- Back up the scenarios with consistent details concerning how they might come about
- Identify what aspects are important about the scenarios for the participants
- Work towards identifying ways of noticing when the scenarios are starting to develop ASAP
- Identify what actors at what levels could influence/mitigate these

Some key features of ABM (agent-based modelling)

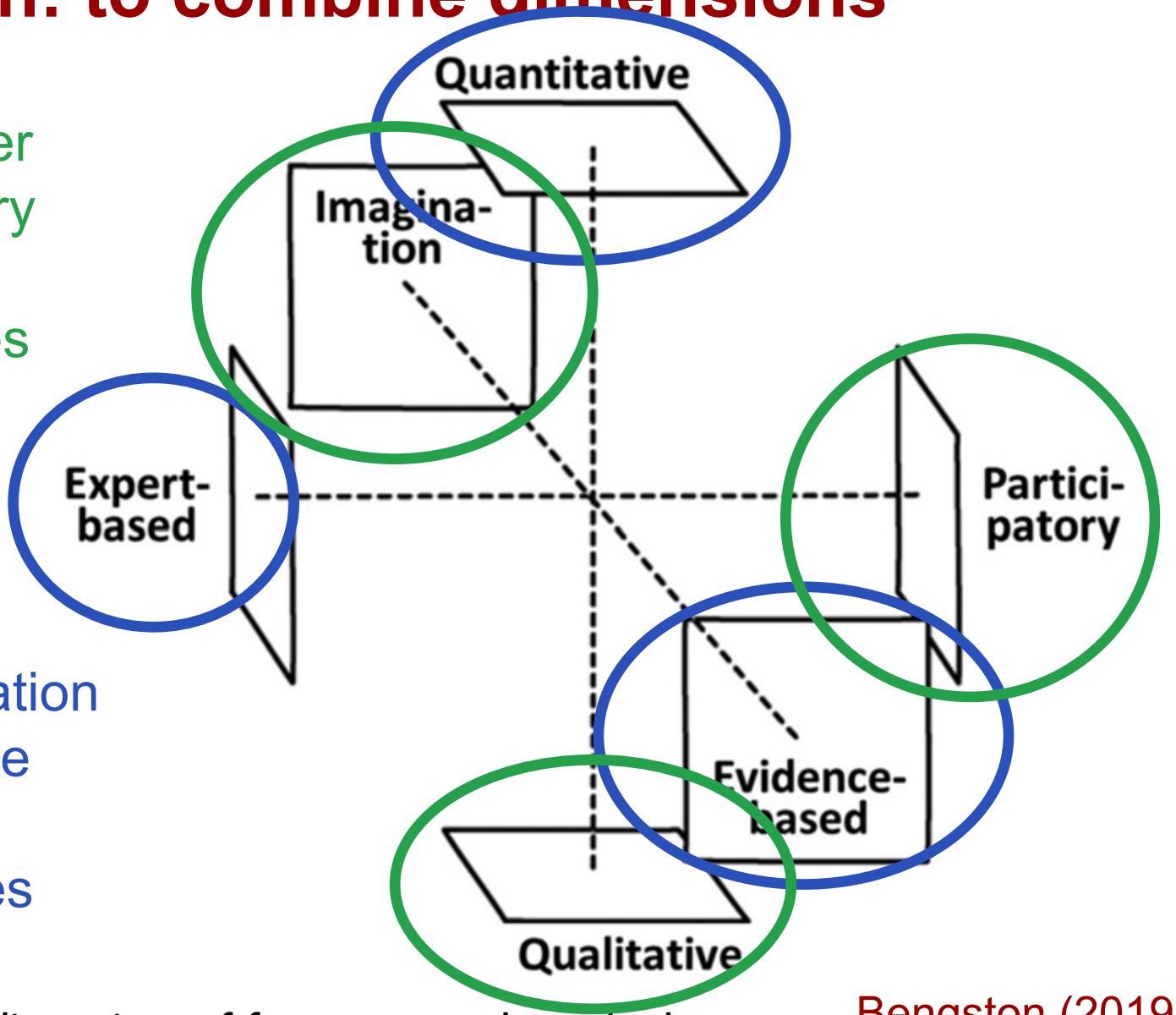
- It can include more of the complexity and mess that stakeholders observe
- It is more interpretable in common-sense ways (each person or entity is represented by corresponding entity in the simulation etc.)
- It does not predict *probabilistically* (what is likely to happen) but explores *possibilistically*
- Easier to include mechanisms that stakeholders know about in common-sense ways
- Its output is easier to relate to narrative scenarios
- Rich output which can be measured/summarised in ways relevant to different groups of people

Ambition: to combine dimensions

Stakeholder participatory Futures approaches

+

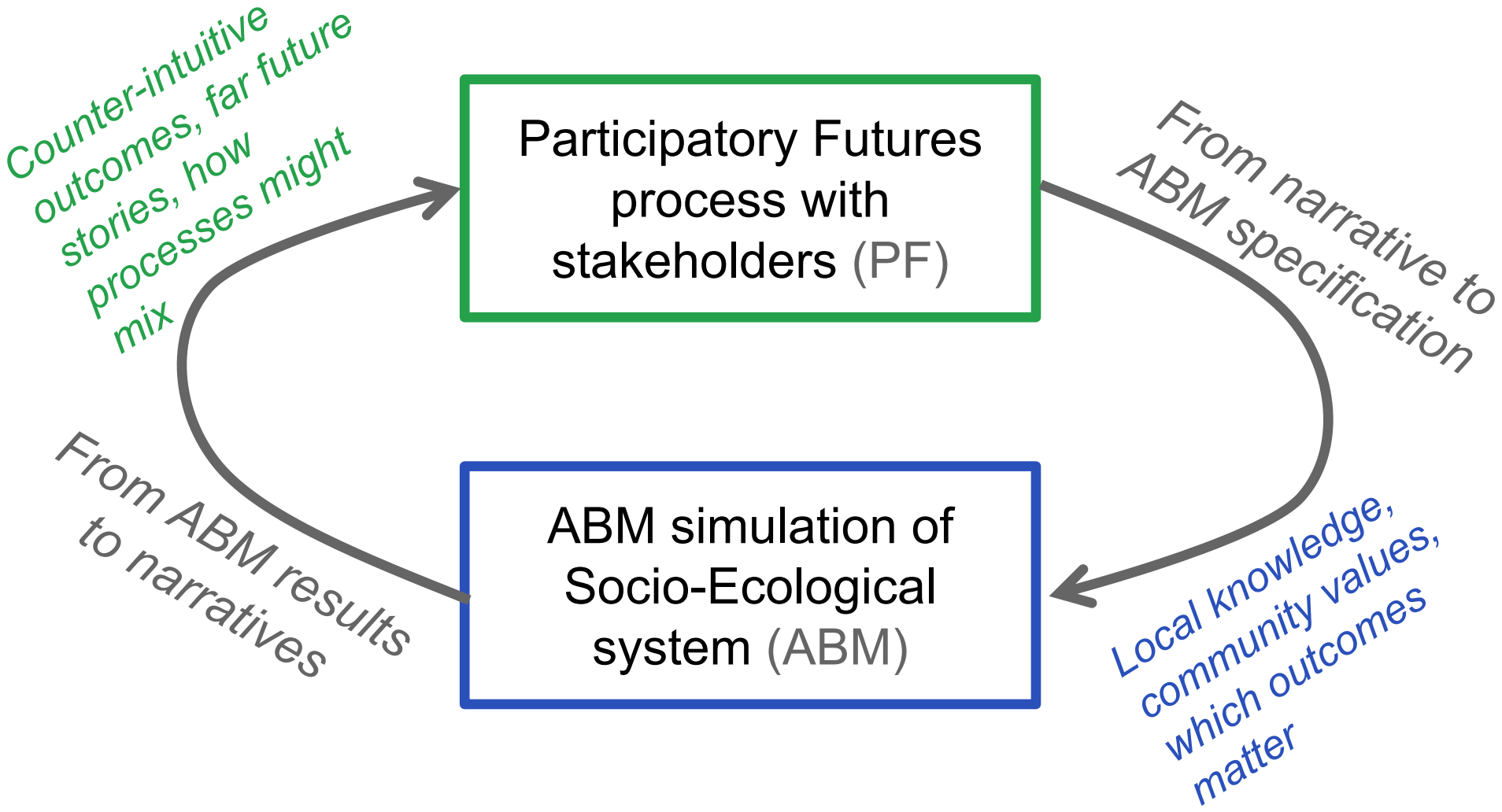
ABM exploration of possible future trajectories



Three dimensions of futures research methods.

Bengston (2019)

Two key translation processes
involved in the iteration



But for this to work well…

- Both PF and ABM need feed ideas/information to the other…
- …without limiting each of their strengths (much).
- One possible goal for this is: *to identify some of the realistically possible ways that things could go wrong (before they happen)*
- In this case, we should maximise the plausible variety output by both (varymaxxing 😉) …
- …and work out ways of reducing the filtering of what can be input to both (from the other)

What inputs to the ABM and from where?

- Data from anywhere if it is solid and uncontested
- Include processes for which there is evidence including from experts and the literature (but parameterise their strength and interactions)
- Use common-sense and discussions with stakeholders to identify relevant contexts

Discuss with participants about:

- the range of strategies they use in each context
- what is important to them about the situation
- how they talk about the situation
- what kind of outcomes they care about

What outputs from the ABM for what?

- Lots of multi-aspect, multi-level traces from the simulation to check/validate/understand it (animated maps, networks, traces etc.).
- Monitor each aspect/agent the participants care about and produce pseudo-stories about them
- Make outputs about what happens in each of the contexts
- Only use graphs occasionally for measures of what the participants most cared about
- Broad narratives about each kind of scenario
- Questions arising from the simulation process

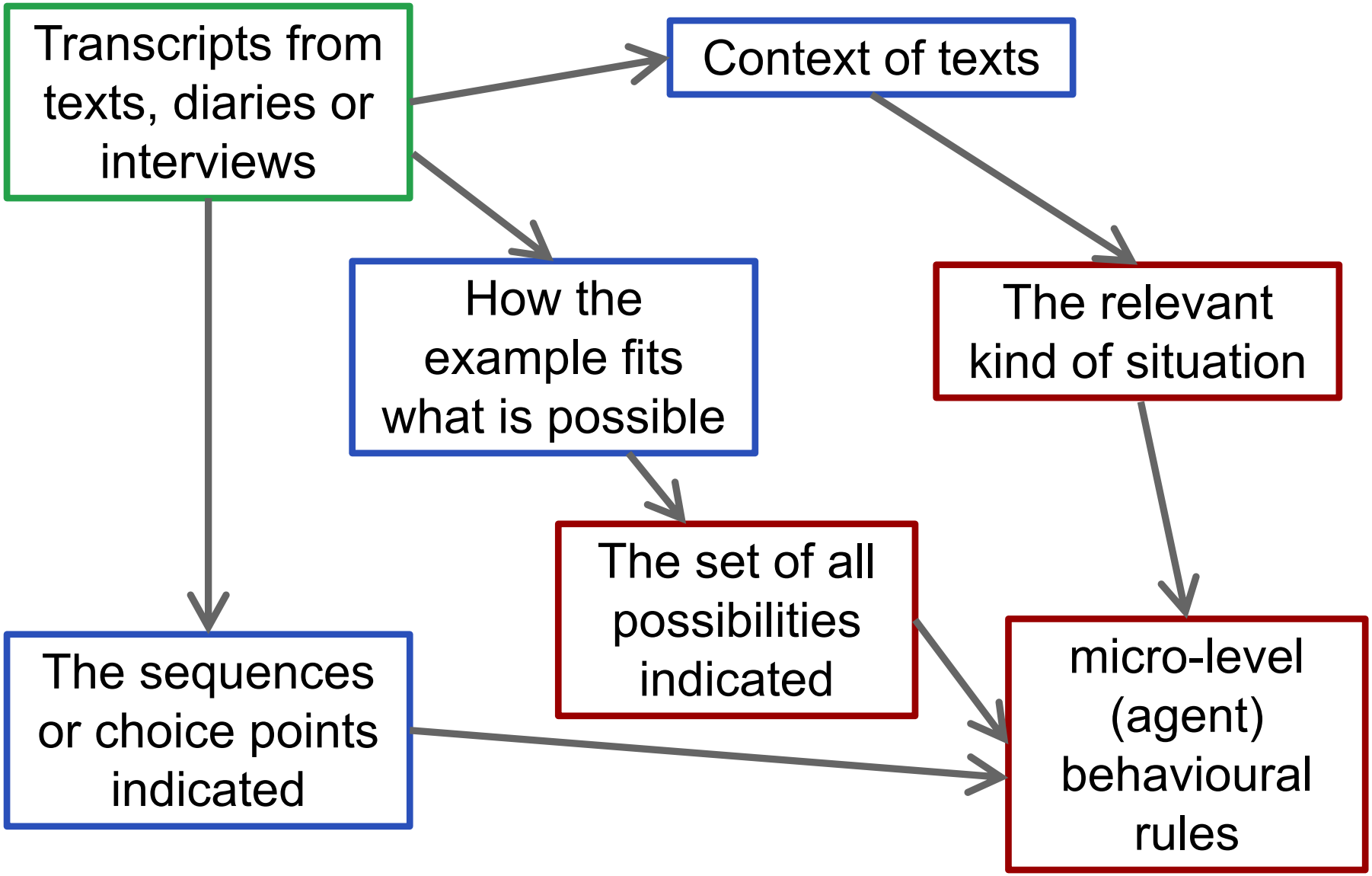
What inputs into the PF and from where?

- The relevant contexts of concern
- The aspects cared about (e.g. by authorities) and why they do for adding to by participants
- Broad accounts of the micro- and meso-processes that come from the literature/simulation
- Narratives about future scenarios from elsewhere/previous PF for discussion and the reasons why they were thought to come about
- A comparison of these narratives with simulation derived narratives about scenarios

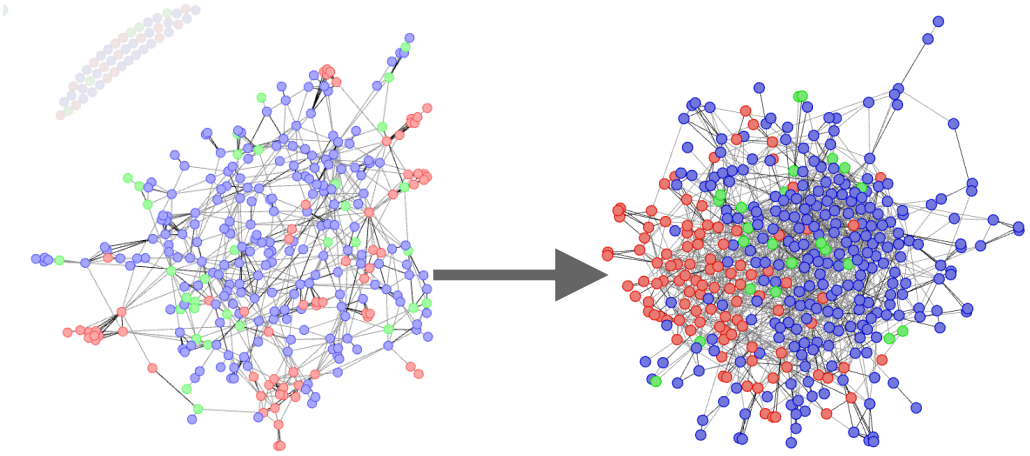
What outputs from the PF and for what?

- Broad narratives characterising future scenarios that are imagined/feared/hoped-for etc.
- Micro-level narratives concerning these about key causation and how they matter to the participants
- Critiques/explanations about these, including where participants differ or agree
- Aspects/questions that the participants want to know more about
- What evidence they know about and what data seems to be missing/unknown

Meaningful narratives → ABM spec



ABM outputs → meaningful narratives



Social Network Visualisations

Animations on maps

Following single agents over time

```
1953: (person 191) (aged 9) started at (school 1)
1961: (person 191) (aged 17) moved from (patch 1 14) to (patch 11 6) due to
1961: (person 191) (aged 17) stops going to nobody
1961: (person 191) (aged 17) started at (school 0)
1962: (person 191) (aged 18) stops going to (school 0)
1963: (person 191) (aged 19) moved from (patch 11 6) to (patch 7 9) due to
1963: (person 191) (aged 19) partners with (person 142) at (patch 7 9)
1964: (person 191) (aged 20) voted for the blue party
1966: (person 191) (aged 22) voted for the blue party
1967: (person 191) (aged 23) started at (activity2-place 13)
1969: (person 191) (aged 25) moved out of area.
1973: (person 651) (aged 5) started at (school 1)
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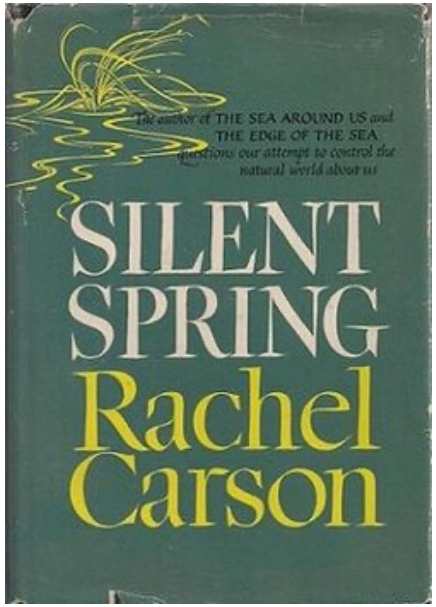
Using the social, spatial and temporal contexts to inform creation of stories

Outlook

- More work done on the Narrative → ABM than on ABM → Narrative processes so far
- Also need to iterate these quickly, naturally and often to achieve results



But science-derived narratives, even longer-term narratives, can be a very powerful focus for political and social change

The Extended Mind

- Thinking is not limited to the brain but…
- ..extends out via the ways we perceive and act.

These can include:

- Other parts of our body
- The social systems we inhabit
- Technical systems such as sensors and machines
- Computational systems

As we grow with these, they become part of us

(Clarke & Chalmers 1998)

We are already Cyborgs

- As well as the many machines that extend our physical abilities, the system of writing extends our mental abilities – allowing mathematics, extensive literature, academia, large organisations etc.
- Humans are natural cyborgs, we adapt so well to the systems (social, computational, mechanical) through which we perceive and act, that quickly we do not have to think about it and it feels 'natural'.
- Computer models (AI, complex simulations etc.) are next, enabling us to deal with the detail of data and complex inference in a way not possible before.
- Transitions take time and adaptation (think how long global literacy took) but it is not to be feared….
- *…we are **good** at this!*

Some References and Resources

Special Interest Group on using qua. evidence with ABM: https://essa.eu.org/sig/sig-qual2rule/

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The End!

These slides at: http://cfpm.org/slides

Bruce Edmonds' Publications: http://cfpm.org/~bruce/pubs.html

About Narrative and Context

About narrative

- The human brain seems to be ‘engineered’ to think in and communicate via stories
- This mechanism seems to evolved to facilitate our social organisation…
- …to pass down culture/knowledge/warnings etc. to others in their group
- …that allow groups to survive in their niche
- It must be communicable and memorable…
- …so they tend to simplify and dramatise.

What do we know about narratives?

- They occur within a (mutually understood) context that is usually implicit
- They delineate one possible string of events (they can imply others but not many)
- They assume lots of background knowledge (e.g. what is/is not possible in that context)
- They are usually sequenced in time
- They concern causation (this happened as a result of having chosen that etc.)
- They can include choice points

But (human) narrative is bound up with the ego viewpoint

- We can understand the actions and motivations of others through narrative
- …but we also employ narrative to make sense of ourselves
- …helping define our identity
- Thus narrative is more than just subjective, it is bound up with the ego
- However, we are the experts of ourselves and our accounts of what we do and why can be more accurate than those of theory

CSNE Analysis Framework

CSNE Aspect	Corresponding Property
Context	Relevance
Scope	Applicability
Narrative Element	Local: cause-effect pairs, decision points, sequences, alternatives etc.

1. Context: the kind of situation one is in that determines the 'bundle' of knowledge that is relevant to that kind of situation
2. Scope: what is and is not possible given the current situation and observations
3. Narrative Elements: the narrative elements that are mentioned assuming the context and scope

(Edmonds 2015)

Context

- The kind of situation is recognised in a rich, fuzzy, complex and unconscious manner
- Knowledge, habits, norms etc. are learnt *for* that kind of situation and are retrieved *for* it
- Context allows for the world to be dealt with by *type of situation*, and hence makes reasoning/learning etc. feasible (e.g. which norms, expectations, etc. are relevant)
- Context can be difficult to pin down – it is usually implicit
- However, encultured people have a natural ability to identify the relevant context (but not necessarily to name it)

About Scope

- By “scope” I mean *what is possible* if the present circumstances
- For example, if all the seats are taken in a lecture, then some of the norms, habits and patterns as to where one sits might not apply
- Reasoning about scope can be complex and is done consciously
- However once judgments about scope are made then they tend to be assumed (i.e. are fixed), *unless* the situation changes critically

Scope vs. Context

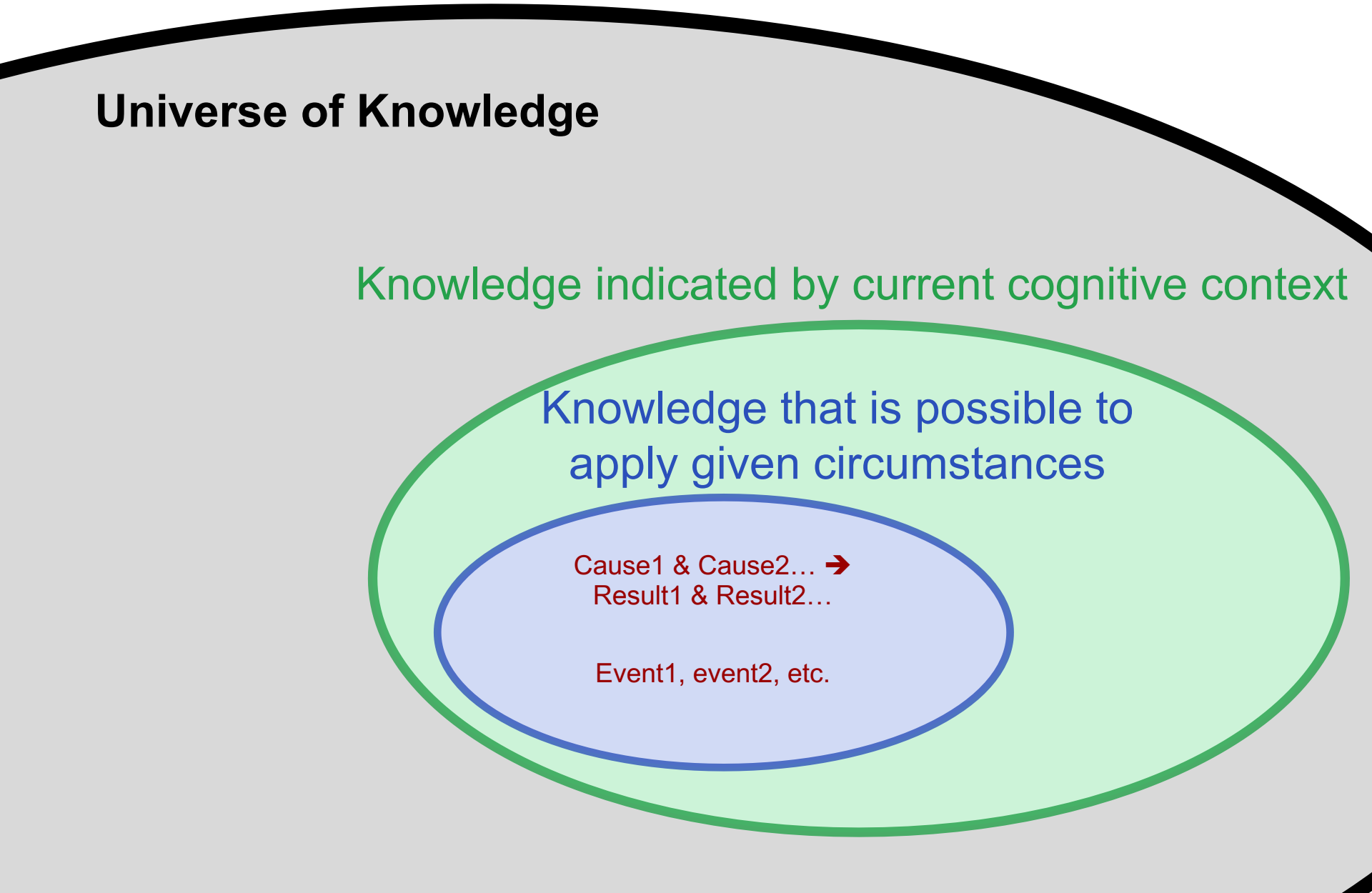
- Both scope and cognitive context determine which knowledge is useful for any particular situation that is encountered
- However, they play *different* roles:
  - Cognitive Context is learnt using pattern recognition over a long time, but then is largely a ‘given’, is almost impossible to change once learnt, is quick and automatic and is socially rooted
  - Scope is reasoned about, taking effort to do so, is possible to re-evaluate but only if needed, and is more individually oriented

Narrative Elements

A variety of narrative structure elements are possible, including:

- Causal stories: A … resulted in … B
- Sequences: A … then … B … then C
- Choices: had to choose between … A and B
- End points: which resulted in A which was a disaster/really good/…
- Parallelism: A … happens at the same time as ….B

Different Aspects Illustrated



Narrative → ABM

The process (version 0.0)

Context: Use innate expertise to label relevant kinds of situation explicitly and which apply to which parts of this narrative

Scope: Map out the relevant set of possibilities and situate narrative within this

Narrative Elements: look for…

- Branch points/choices/alternatives
- Sequencing (necessary order of events)
- Causation (links with a past event)
- Underlying processes (assumed in account)

Consider…

- How what is mentioned in a narrative relates to those in other narratives
- Are there alternative accounts of the same processes
- What values/goals/power structures etc. are assumed in the narrative
- The contingency of the narrative – what are other trajectories if things were different

Example Analyses

using narrative examples from:
(Bhawani 2004)

Hypotheses about relevant contexts for the interviewed stakeholder

Different perspectives from which the narratives seem to be told:

- "survival" – things are continually getting worse and the primary goal is to keep in farming, battle against nature etc. to avoid bankrupcy
- "comfort" – conditions are comfortable with no immediate survival threat, one could stop worrying so much and take things a little easy
- "entrepreneur" – one is looking for big profit, taking risks if necessary

Quote 1 (p. 113) and CSNE Analysis

"The one conundrum here is that there are more people in the East who want to … upgrade to more wheat allied products, that may alter the value of the end product to us. You see the worst thing that has happened to us worldwide is the collapse of the Eastern economy... but it is coming back again now and that actually may help us again. It is a great shame because we were getting into the Eastern markets and it was beginning to grow and suddenly it collapsed."

Context	Scope	Narrative Elements
Survival	*No "killer" profit available*	• Prices for wheat may increase in near future • Price increases can be followed by a sudden collapse

Quote 3 (p. 112)

I… would imagine that if the summers were warmer and the autumns were wetter you would have an earlier harvest, and therefore all that would happen is that the harvest would come early and your drilling… would come early so that you would still be able to establish your winter crops before the rain really started. If the rains were really early then we would have to resort to spring sown varieties... The net effect would be that you would be drilling as soon as you possibly could which may be later than normal, but because the weather is warmer that would make up for lost time, so harvest would still be about the same time… If the autumn was continuously wet … and we were under water… If it was like this year every year, then yes there could be a problem.

CSNE Analysis of Quote 3

Context	Scope	Narrative Elements
Survival	*Summers warmer and autumns wetter*	• Harvest comes early • Therefore drilling needs to be early
	Summers warmer and autumns wetter + rains really early	• Need spring sown variety • Therefore drilling as soon as possible • Probably harvest at the same time due to warmer weather
	Summers warmer and autumns wetter + autumn was continuously wet and we were under water	• If wet like this every year then there is a serious problem

Quote 3 (p. 127) and CSNE Analysis

"…we have often had this conversation around this table. Some people don't want to maximize profit.... They are happier to take a slightly easier, lower level approach and have an easier life, and not make quite so much money.... And I can relate to that... But because I'm a tenant I don't own my own land... Everything we farm is rented and therefore we have an immediate cost, the first cost we meet is to our landlord and that tends to go up."

Context	Scope	Narrative Elements
Comfort	*Does not have to maximise profit to survive*	• Can take life easier • Does not make quite so much money
Survival	*Has immediate cost (rent) which tends to go up*	• Has to maximise profit to survive

Difficulties

- Context is implicit and not usually labelled
- People envisage one context when telling a story, if you want stories from others you need to set this up by prompting them
- Each story focusses on one of the possibilities, to get others one needs to explore the branch points and what could have happened differently
- People abstract to a level of personal significance and ignores the habitual
- Stories are always bound up with issues of personal status, power and identity

ABM → Narrative

Narratisation

- Unlike the art and science of “visualisation” there is no existing field of “narratisation”
- Simulation work is often going from informal→formal and micro→macro due to the social framing & history of modelling and so the output has tended to be macro-level graphs and other statistical projections
- But with the involvement of stakeholders, narrative outputs concerning individuals might well be desirable for consultation etc.

Comments

- For specific, applied simulations, the context for events represented are clear
- For abstract, more theoretical, simulations a relevant context needs to be decided upon
- Unlike going from narrative to ABM, when going from ABM to narrative the simulation can be used to trace out possibilities
- Instead of removing detail the simulation can not cope with, we are adding this in – it can help here to use synthetic population data for more realism in terms of these details

The Process (version -0.000)

- Explore and understand the possible trajectories inherent within a simulation
- Choose one (at a time) and follow an agent through, noting the events that happen to it, including when it could have branched
- Add in (or decide) contextual information, e.g. using the same contexts as the evidence the ABM was specified using
- Add in specific, but arbitrary, names and details to make this less abstract
- Turn the events into a more fluid narrative

An example raw simulation output

(family 20)@0: is new family needing DA services ([female]) and characteristics: 56 "august" 1936 "female" "white" "white br" "dudley" "inapplic" "inapplic" "divorced" "gce o le" "3c:low s" "2a:middl" "employed" "junior n" "routine" "skilled" 4115

(family 20)@0: finds and rings help line

(family 20)@0: is provided with Contact Advice by (contact-agent 17)

(family 20)@1: is taken on by provider coordinator (family 20)

(family 20)@1: is moved to refuge provider: (provider 3) by (coordinator 13)

(family 20)@1: asks around for help on Counselling and Therapy

(family 20)@1: learns that (provider 4) provides Counselling and Therapy

(family 20)@1: (provider 3) tells (family 20) that (provider 4) provides service Counselling and Therapy

(family 20)@1: is provided with Counselling and Therapy by (provider 4)

...

(family 20)@7: asks around for help on Housing-related Support

(family 20)@7: learns that (provider 1) provides Housing-related Support

(family 20)@7: (provider 3) tells (family 20) that (provider 1) provides service Housing-related Support

(family 20)@7: is provided with Housing-related Support by (provider 1)

(family 20)@7: is moved to permanent accommodation with all their needs met

Reanimation process from raw output

- Context: a victim/survivor of domestic abuse
- Is 56, white British, divorced, no children, with basic education, in Calderdale, born Dudley
- Already knows about the domestic abuse help line and so quickly makes contact
- Is lucky that there is a place in the refuge
- Finds out about the services for her needs from her proactive case worker and accesses these rapidly
- Is also lucky to quickly find permanent accommodation to move into afterwards

Use cases for narratisation

- Very specific stories for presentation back to the stakeholders who provided input so they can give more input and comment on whether what is of value to them is there
- More generalised stories (encapsulating a particular range of possiblities) as input to discussions about a collective future
- Example stories for illustration of the complex processes for a wider public or for press releases