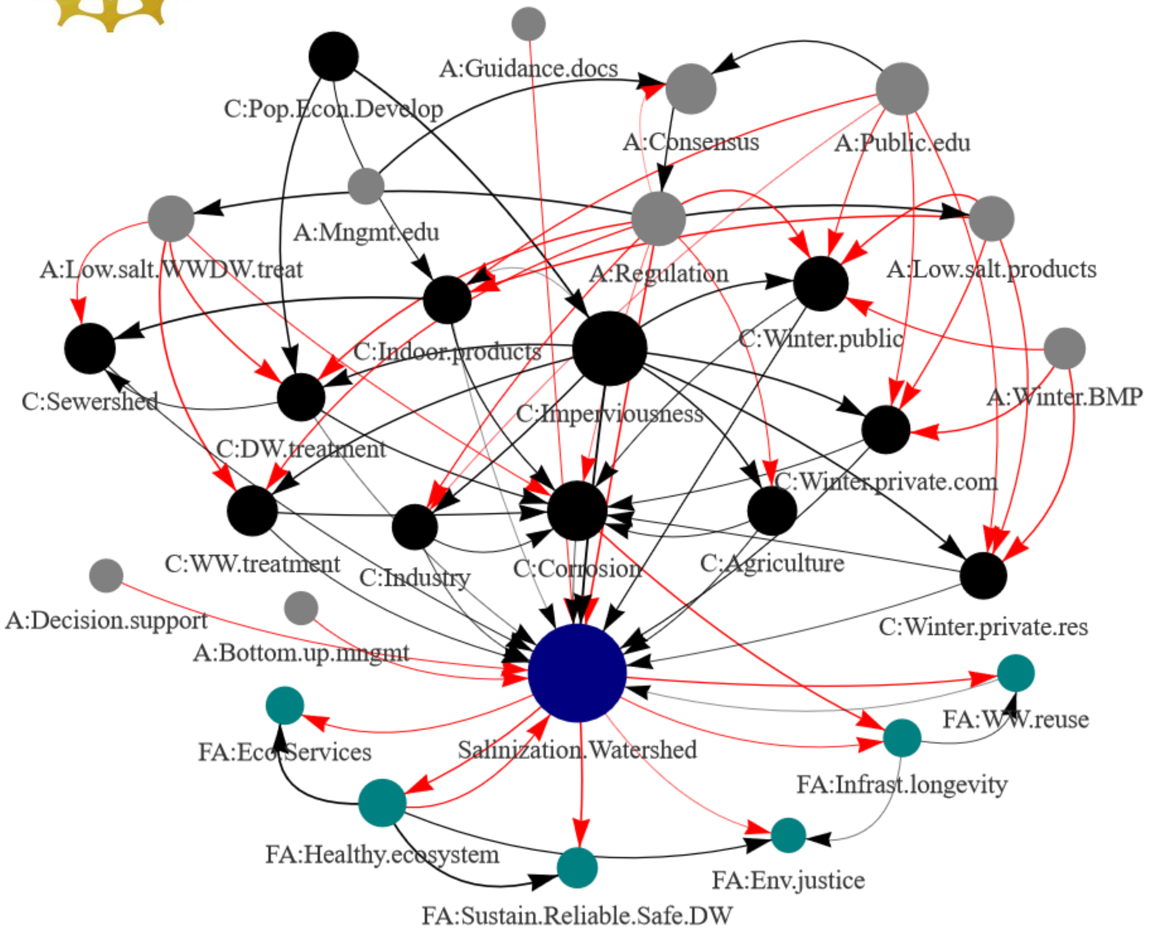
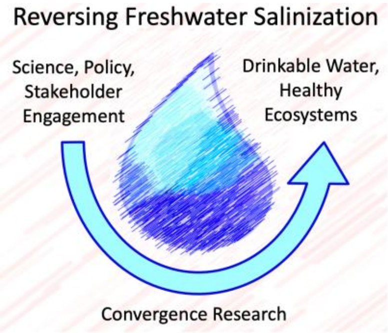
Characterizing the social-ecological-technological system for inland freshwater salinization



The human dimensions of freshwater salinization really matter



Megan Rippy, Virginia Tech

What is a wicked problem anyways?

1) All wicked problems are unique and novel
2) The solution depends on how the problem is framed and vice versa
3) Stakeholders have radically different worldviews and different frames for understanding wicked problems (this makes them difficult to frame and solve – see 2)
4) The constraints that the problem is subject to, and the resources needed to solve it change over time
5) The problem is never solved definitively
6) Solutions are not strictly right or wrong (may be viewed positively or negatively)
7) They cannot be studied through trial and error. Every trial counts

Common examples: Climate change, homelessness, freshwater salinization

Freshwater salinization has many wicked elements

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Stakeholders have radically different worldviews and different frames for understanding wicked problems

(this makes them difficult to define and solve)

Contested consequences

"I don't know that there are any impacts [on aquatic life] right now. I haven't seen them"

"I think [the impact of salinization on aquatic life] is going to be really high, because if you exceed the threshold of whatever the species is then it can't make it"

"I don't believe that the change of salt level we are experiencing will have a meaningful impact on corrosion of the distribution system or any concrete structures"

"If you want infrastructure to last long, you want to have less salinization. Obviously, the infrastructure is not going to last long if it gets corroded faster?"

Contested causes

"Everything in the detergent aisle is salty. It is going to be heading to the sewage treatment plant and those salts will wind up in our drinking water"

"Most of the problem is private sector deicer use. Its just not regulated"

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So why does this “wickedness” matter as we start thinking about solutions

“I do ... gful impact on corros

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Recognizing freshwater salinization as a wicked problem has important implications for how it is approached

Wicked problems are not "solved" in the conventional sense but rather managed through iterative, adaptive, and participatory processes that acknowledge contested values

This requires innovative approaches that facilitate shared learning *(approaches that clarify how different actors view freshwater salinization, how those views shape perceived risks and solutions, and where opportunities exist for aligning priorities)*

If we accept that freshwater salinization is a wicked problem, then we must also accept that our ability to address it depends not only on biophysical understanding, but on our collective understanding of divergent values and why perspectives about freshwater salinization differ

Wicked problems require new, bottom-up "convergent" approaches for problem solving and salt management that we need to work towards together

Tools like fuzzy cognitive maps (mental models) that help us visualize and unpack divergent values and perspectives can help get us there

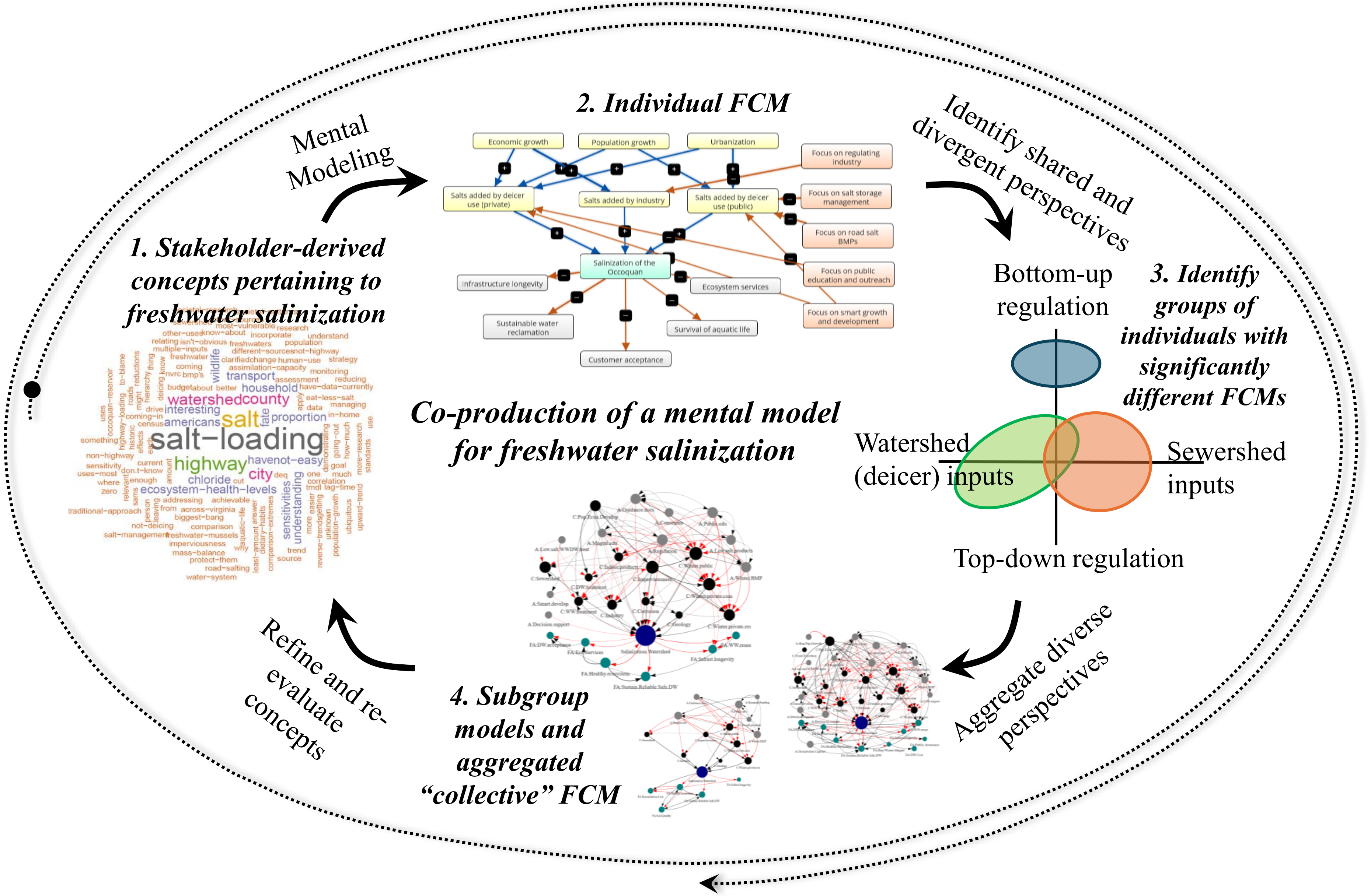
What are FCMs and how do we generate one?

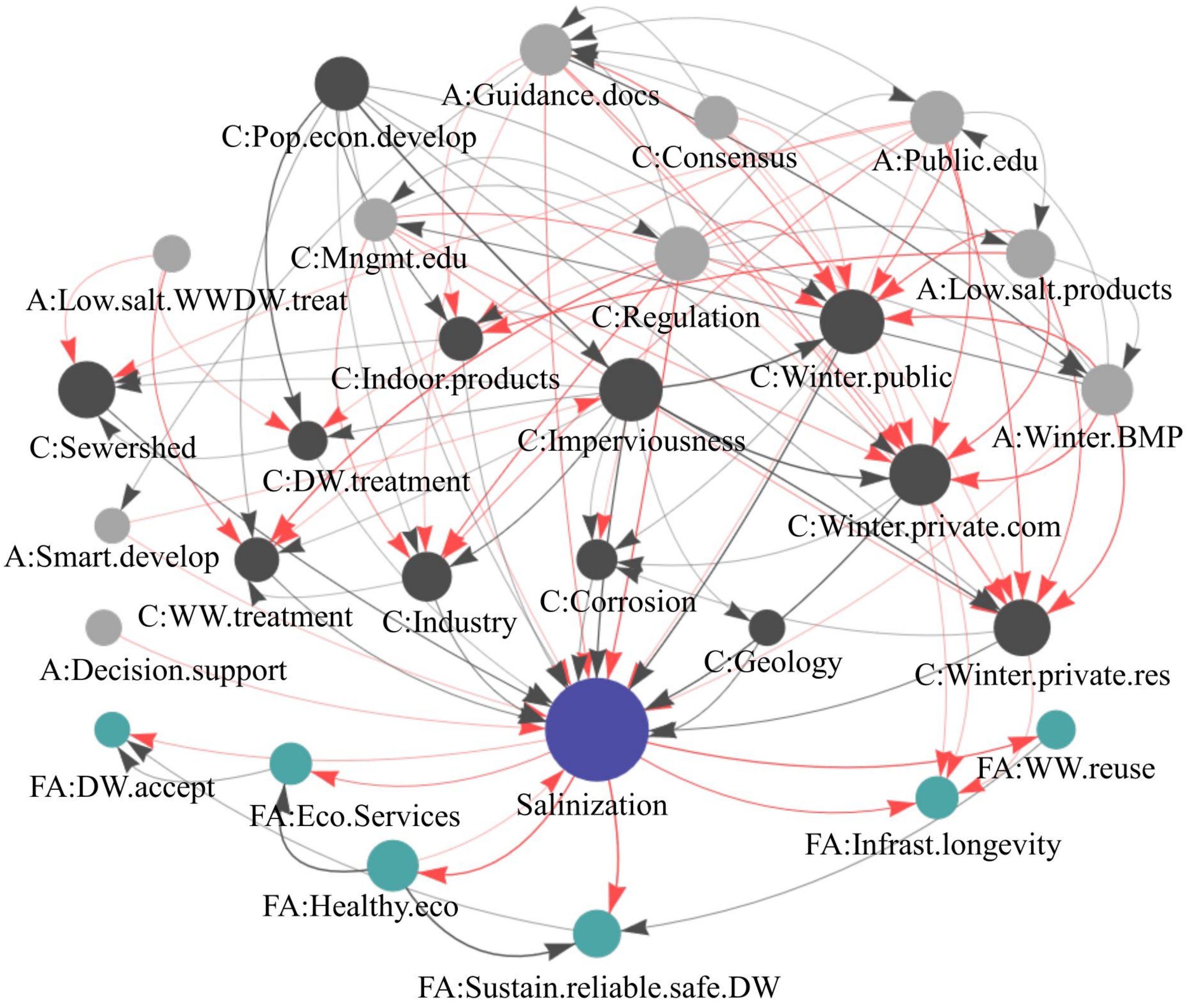
1) Elicit and express an individual expert's perceptions and knowledge of a complex problem or system *(visualize as a network with nodes representing concepts and weighted arrows representing the strength and direction of the relationships between them)*

2) Combine the models of multiple experts to obtain a more wholistic (community) representation of that problem/system that captures diverse perspectives and makes those perspectives transparent to everyone else

3) Interrogate the resulting collective model (and submodels) to explore divergent perspectives and their systems implications (many approaches)

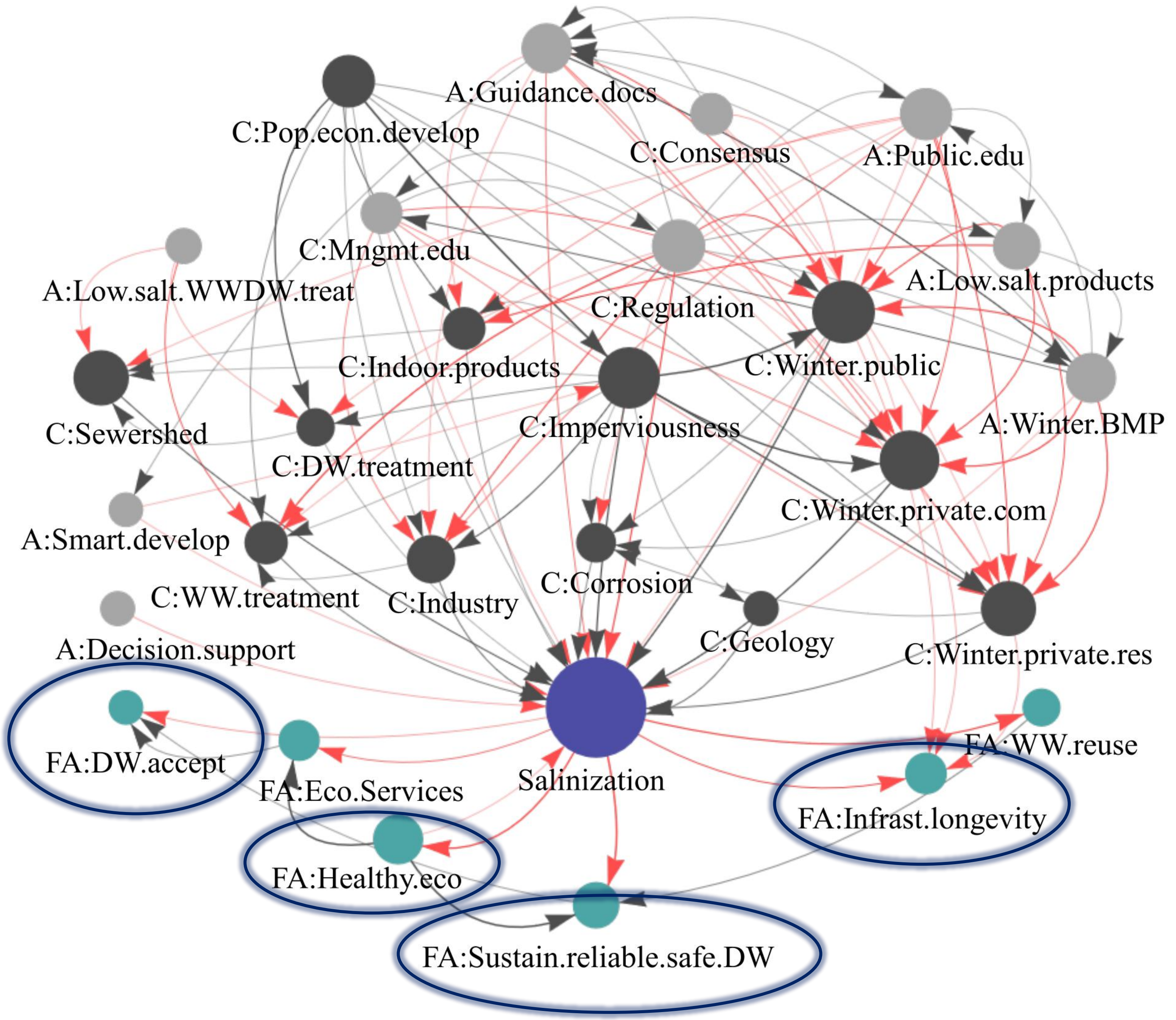
The process can be iterative (knowledge and perceptions evolve)





The conceptual models that are produced are a rich source of information that integrate different perspectives about freshwater salinization & provide a basis for understanding them

Collective mental model produced by 35 expert stakeholders, including representatives from utilities, counties, state and federal government, research agencies, transportation authorities, etc.



Maps like this can be used in many different ways, but I want to use this one today as a springboard to talk about consequences of salinization people are concerned about

What are the early warnings of salt in SETS? What might people start to notice first?

There is no one answer to this question (perceptual issues are often highly variable)

Taste (pertinent to public acceptance of drinking water) is a case in point

- **Age**: the number of tastebuds we have can decrease as we age. So does the functioning of taste receptors within taste buds, reducing taste sensitivity *(salty tastes are more susceptible to this than sweet tastes; Weiffenbrach et al., 1986)*
- **Gender**: Women tend to be more sensitive than men to many taste stimuli (*Pepino & Mennella, 2007*)
- **Smoking** can reduce sensitivity to certain taste stimuli *(Tjahajawati et al., 2020)*
- **Stress** can reduce sensitivity to salty and sweet tastes (Ileri-Gurel et al., 2013)

Burlingame, G., Doty, R., Dietrich, A. 2017. Humans as sensors to evaluate drinking water taste and odor: a review. American Water Works Association. 109

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People begin to be able to detect salty tastes anywhere between 30 mg/L Na^+ and 460 mg/L Na^+

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Given this variability, if we want to think about public acceptance of drinking water (taste) we'd need to look across a range of sodium levels

Public health guidelines have also been developed for sodium (safety)

If we want to bring in other impact measures that involve other ions we can look at molar equivalents

- Molar equivalents of chloride can be used to connect criteria for taste and health to criteria for aquatic life
- Molar equivalents of sulfate can bee used to connect criteria for taste and health to criteria for infrastructure longevity
- We can also estimate TDS equivalents (other criteria for taste)

What might be noticed first?

What might we notice first? – this is really a mixtures question, start with end members

Na (mg/L)	Cl if all NaCl	SO_4 if all Na_2SO_4	TDS if NaCl	TDS if Na_2SO_4	Public Health	Taste	Aquatic Life	Infrastructure
14	22	**30**	36	43				Sulfate supports sulfide generation under anoxic conditions, corroding concrete sewer pipes
20	42	42	51	62	EPA sodium advisory value for individuals on a very restricted sodium diet			
30-60	46-92	63-125	76-153	93-185		Lower end of EPAs reported sodium taste range (30 is lower taste sensitive; 60 is upper taste sensitive)		
120	185	**251**	305	371		EPA secondary drinking water level for sulfate		
149	**230**	311	412	460			EPA freshwater aquatic-life chronic chloride criterion (4-day average)	
162-197	303	338	**500**	**500**		EPA secondary drinking water level for TDS		
239	368	**500**	608	740	EPA sulfate health advisory (to avoid acute laxative effects)			
460	709	961	1169	1421	High sodium levels (~400 mg/L) have strong associations with preeclampsia	Upper end of EPAs reported sodium taste-threshold range (above this most people taste)		
558	**860**	1166	1418	1724			EPA freshwater aquatic-life acute chloride criterion (1 hour average)	

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Impact order:
Corrosion > public health > taste > aquatic life

Summarize and Conclude

Freshwater salinization has many characteristics of a wicked problem, which has implications for how we work together to address it

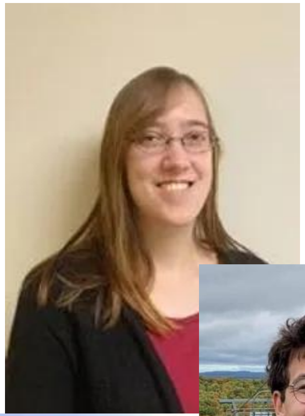
- Perceptual models that daylight and integrate divergent views like fuzzy cognitive maps can play an important role in that process

FCMs allow us to perform all manner of analyses, but are also simple visual boundary objects that can help us identify common concerns about salinization

- I used them that way today to structure my assessment of common salinization concerns and which might be triggered first (corrosion > health > taste > aquatic life)

The true value of tools like these is their ability to put social considerations on a level playing field with biophysical considerations where quantitative models and data are more available

When we are thinking about freshwater salinization, we mustn't forget the social systems that influence and are influenced by it








Thank you!

Any Questions?





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