Research Hypotheses and Inferences

IUFRO-SPDC

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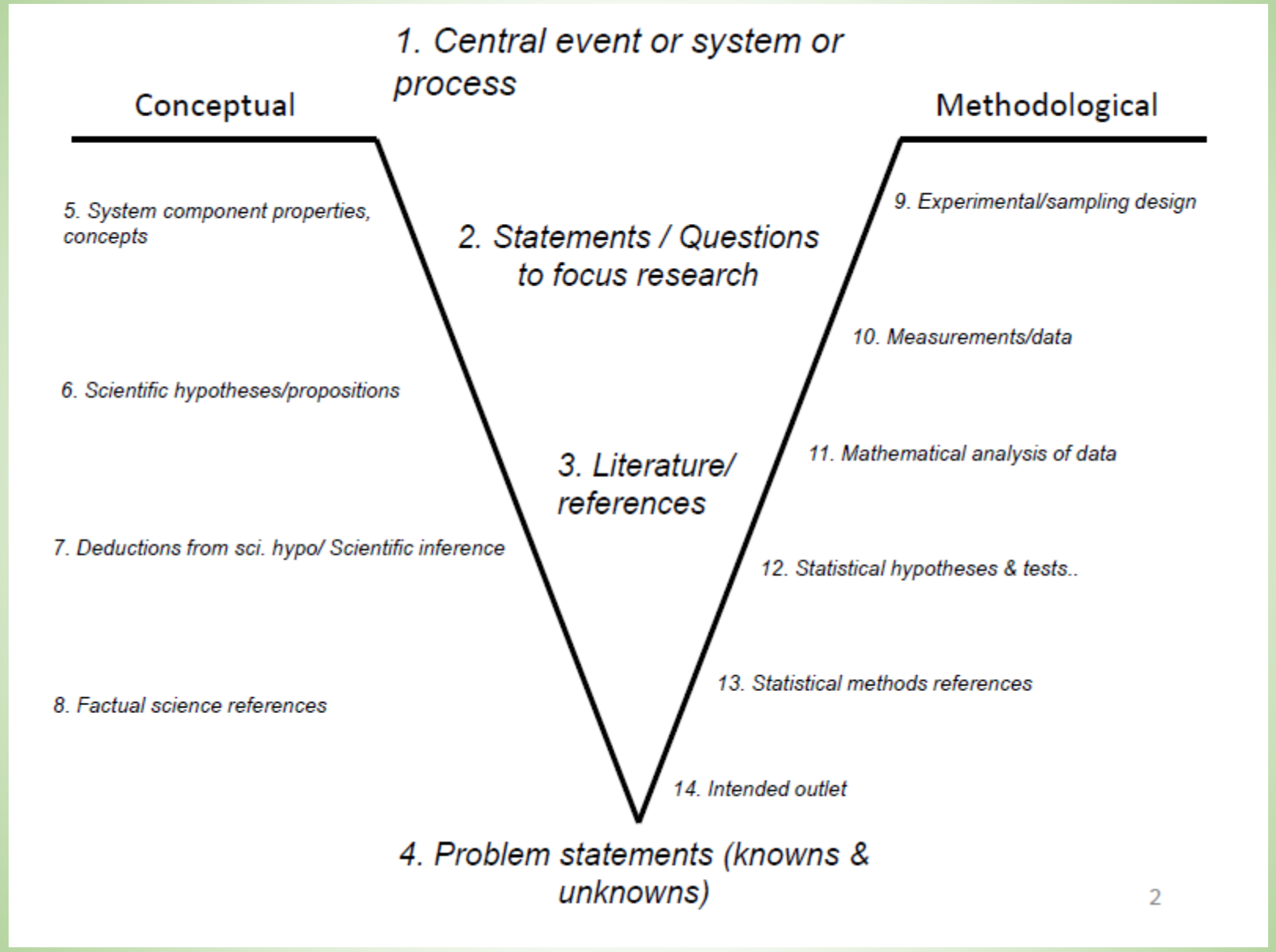

1. Central event or system or process
Conceptual
Methodological
5. System component properties, concepts
2. Statements / Questions to focus research
9. Experimental/sampling design
10. Measurements/data
6. Scientific hypotheses/propositions
3. Literature/ references
11. Mathematical analysis of data
7. Deductions from sci. hypo/ Scientific inference
12. Statistical hypotheses & tests..
13. Statistical methods references
8. Factual science references
14. Intended outlet
4. Problem statements (knowns & unknowns)

Research Hypotheses

- We've come down left-hand side of the Vee
- Hopefully by now we have a solid problem statement and a research question
- We may still b struggling with our research hypotheses

Research Hypotheses

- Statistical hypotheses are about facts, measurements
- Mean tail length of cat in the USA = mean tail length of cats in Europe

- Research hypothesis is about how nature is or how nature works
- Cats evolved tails because tails have a survival advantage; specifically, when cats fall from high places, tails help them right themselves, so that they land on their feet

Research Hypotheses

- Many ways to Classify them
  - Some provide explanations, some provide answers
  - Some are qualitative, some are quantitative
  - Some are simple, some mechanistic
  - Some are conceived quickly, some takes months (or longer)

Methods of Generating Research Hypotheses

- Question Method
- Subject Method
- Fact Method (Retroduction)

Question Method

- Entertain an interesting question about a condition or process observed in nature
- Be a regular questioner and, in time, good research hypotheses will come

- Jack pine (Pinus banksiana) is typically considered a dry site species
- In the upper peninsula of Michigan, some JP sites flood following harvesting
- “If JP is a dry site species, why do some sites flood following harvesting?”
- Hypothesis: Most JP stands originated in the 1930s, during a prolonged drought, everything was dry then, therefore JP can be found today on wet sites because of initial site conditions.

Subject Method

- Think about a subject and, at some point, the thinking will suggest a possible truth (a research hypothesis)

- Continuing to think about JP
- Only SOME sites flood
- If drought was the cause, why don't we see JP everywhere?
- JP appears to be found on very wet sites and very dry sites
- Hypothesis: JP grows best on very wet and very dry sites

Fact Method (Retroduction)

- “retro” means opposite to
- “retro” duction reasons in a direction opposite to deduction
- Example (deduction)
  - It rained last night; therefore, our street is wet
- Example (retroduction)
  - Our street is wet, perhaps it rained last night

Using Retroduction to conceive a research hypothesis (Romesburg 2009 after Hanson 1958)

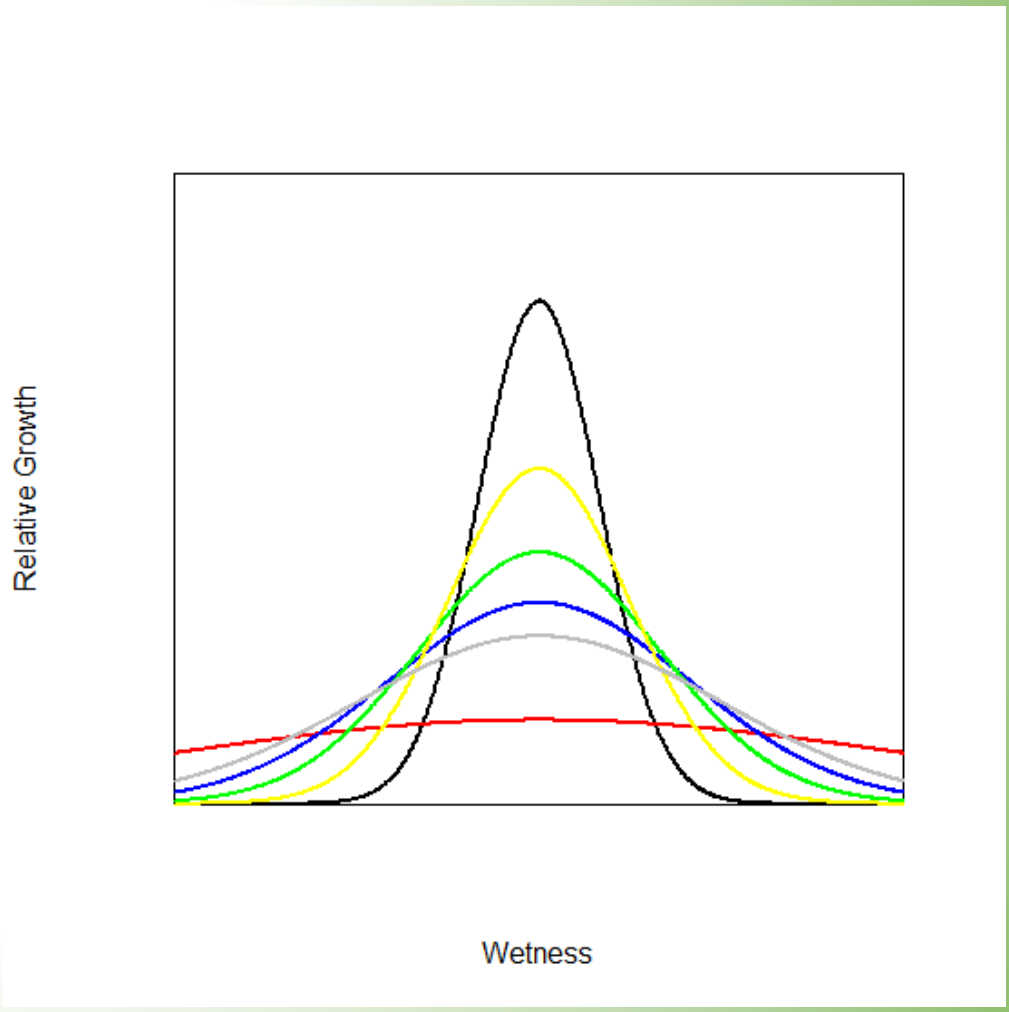
- Some interesting facts, or set of facts is observed (F)
- F would be explained if our research hypothesis (H) is true
- Hence, there is reason to think H is true

Jack Pine example

- We find JP on very wet and very dry sites
- We may initial think: JP grows best on very dry or very wet sites
- We also observe that JP goes very well on mesic sites, but we don't tend to find it there, we find Acer, Betula, and Abies species on mesic sites
- Perhaps JP is found on very wet and very dry sites because it competes best of those sites
- We could test this by looking at relative growth rates across a gradient of wetness

Jack Pine example

- Jack pine
- Black spruce
- Balsam fir
- White birch
- Red maple
- Sugar maple



Scientific Inference

- Rolfe touched on this yesterday
- For a theory to be a theory, it must be testable(Platt)
- Hypotheses are the forms by which we test theories

Components of Science

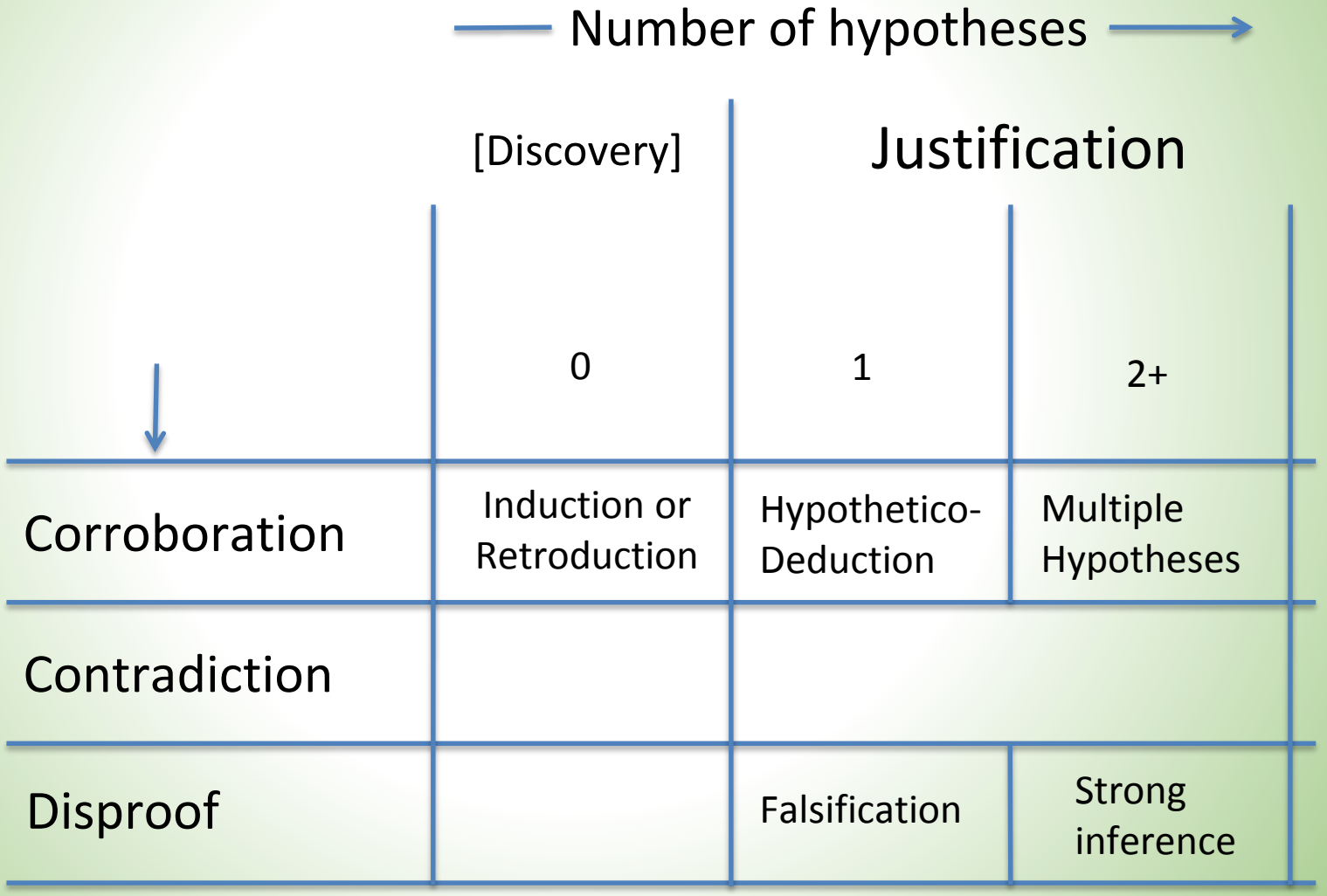
- Problem Identification
- Discovery
- Justification

Discovery

- A creative enterprise
- May not have a logical progression
- Goal is to generate testable hypotheses

- Strategies
  - Trial and error
  - Systematic search
  - Serendipity
  - Inspiration
  - Illumination
  - Analogy
  - Derivation
  - Induction
  - Retroduction

McRobert's Justification Structure



Disproof

- Most of us work in the Corroboration/Discovery Box
- We may move right into the Justification phase, developing multiple hypotheses and strategies for testing those hypotheses
- Corroboration is the accumulation of supporting facts
- Popper (1968) argues for a shift from corroboration to disproof
- Conclusive disproof is possible because it only takes one counterexample to disprove an hypothesis

Falsification

- Requires a clear state of the hypothesis
- Requires a clear statement of the conditions under which the hypothesis would be false
- Object is to acquire evidence disproving the hypothesis

Implications for designing experiments

- Corroboration designs requires resources allocated to acquiring both evidence supporting and evidence contradicting our hypothesis to satisfy the test criteria
- Falsification experiments concentrate resources to provide maximum opportunity to detect counter examples

Strong Inferences

- Disproof is a hard doctrine (Platt)
- Why would we continually want to place years of work on the cutting edge?
- When was the last time you read a negative results paper?
- Employing a method of multiple hypotheses can get around this

Strong Inferences

- Surround the problem with an exhaustive set of hypotheses whose deductions are mutually exclusive
- Arrange the hypotheses into a tree structure on the basis of similar and dissimilar features
- Perform falsification experiments at one branching points to eliminate one branch or another

Multiple Hypotheses

- The concept of multiple hypotheses dates back to 1897
- Chamberlin, T.C. (1897) The method of multiple working hypotheses. *Journal of Geology*, **5**, 837–848.
- Why haven't we adopted and employed this method more?

Testing Research Hypotheses

- The Hypothesis Step
  - Conceive or take an existing hypothesis
  - Assemble the supporting evidence for the hypothesis
- Deduction Step
  - State conditions under which the hypothesis holds
  - State conditions under which it doesn't hold
- Shunt Cause Step
  - Minimize factors that confound results
  - Establish controls to minimize confounding effects
- Experiment Step
  - Design and Implement an Experiment that minimizes random error and confounding effects
- Decision Step
  - Based on your results and the deduction step decide the outcome of your hypothesis