Using a place-based ecosystem to create linked undergraduate research experiences:

Soil ecology meets molecular microbiology in the Arboretum

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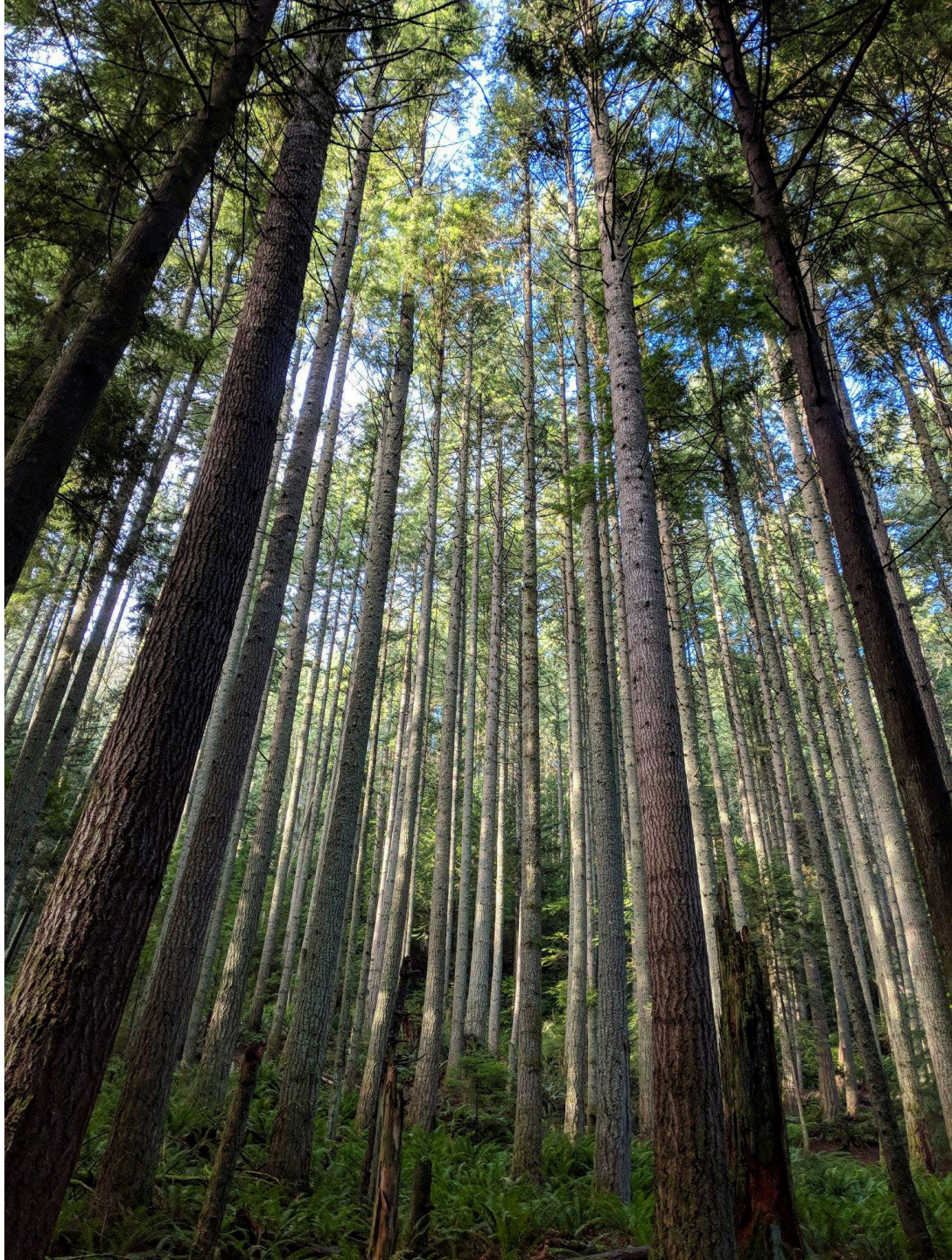


How did it all begin?

January 12, 2021: a tree falls onto a Fairhaven dorm.

- 2021 was not off to a great start
- Cause of tree = laminated root rot

The Sehome Hill Arboretum Board investigates

How much LRR is present?

Willam Cantrell MS, 1990
- Ground survey
- **31 infection centers, covering 6 acres**

Are we losing Douglas fir faster than new ones grow up?
- Liz Zimmermann, ESCI, GIS, 2022
- Aerial photographs, 1975, 2006, 2013
- **Conifer canopy decreased by 17 acres**

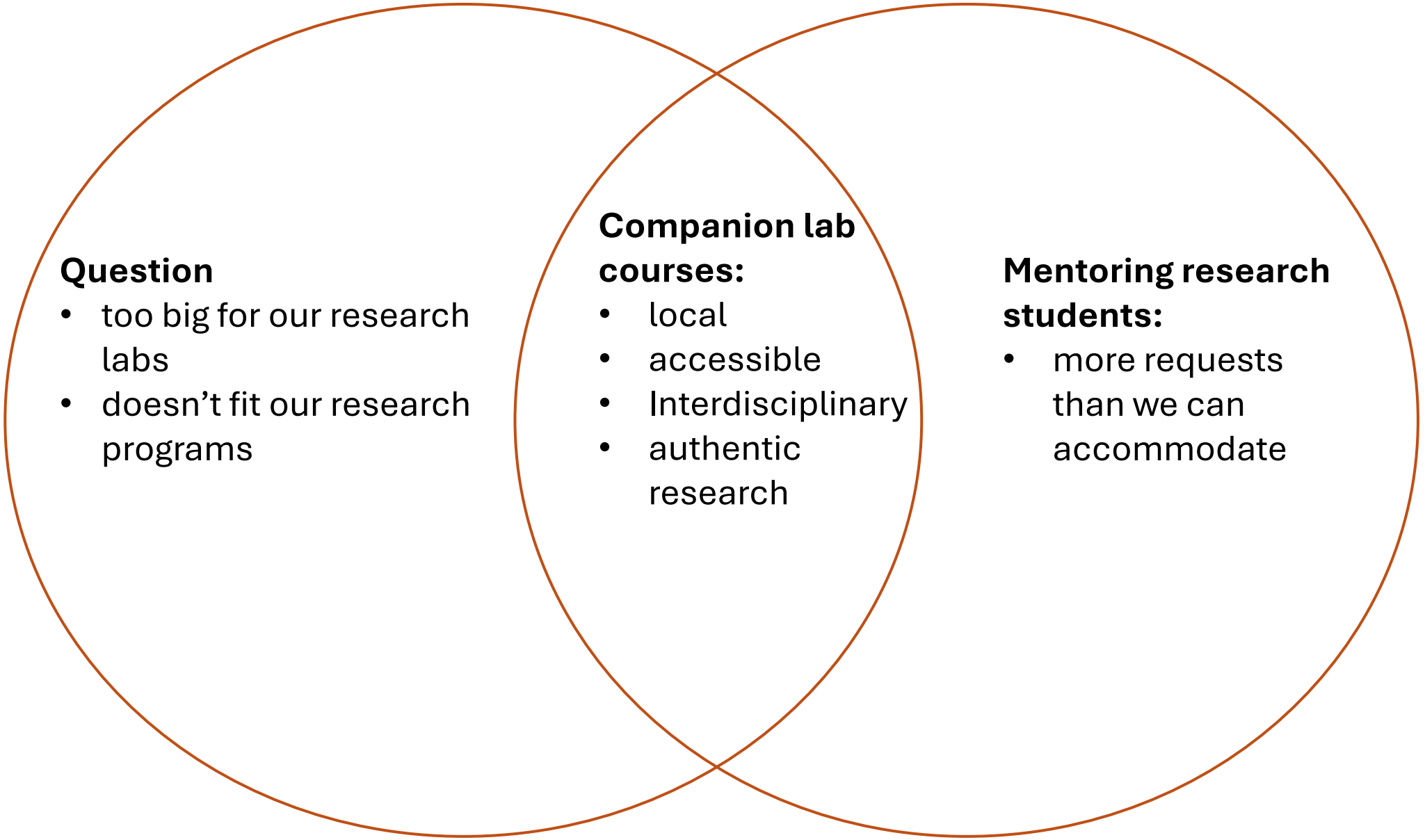
Laminated root rot

- Caused by a native fungus, *Coniferiporia sulphurascens*
- Most serious disease of Douglas fir
- Slow-growing (~10 cm/year)
- Underground: difficult to locate or control disease
- Root grafts spread disease

What can be done?

- Is management needed in the Arboretum?
- Best course of action?

Does LRR need to be managed in the arboretum?



We can ask related questions

BIOL – Does the microbial community of rhizoplane soil differ between…

- Diseased Douglas fir
- Asymptomatic Douglas fir
- Non-host (bigleaf maples)

ESCI – Do soil properties different between…

- Conifer dominant canopy
- Deciduous dominant canopy

We can increase student learning by:

Making learning accessible:

- Authentic research experience without additional cost

Motivating through ownership and agency

- Local, familiar, valued ecosystem
- Meaningful work that will have an impact

Motivating through relevance:

- Lecture content is streamlined to specific project
- Data will be used by Arboretum Board and future students
- Data is the legacy for future students

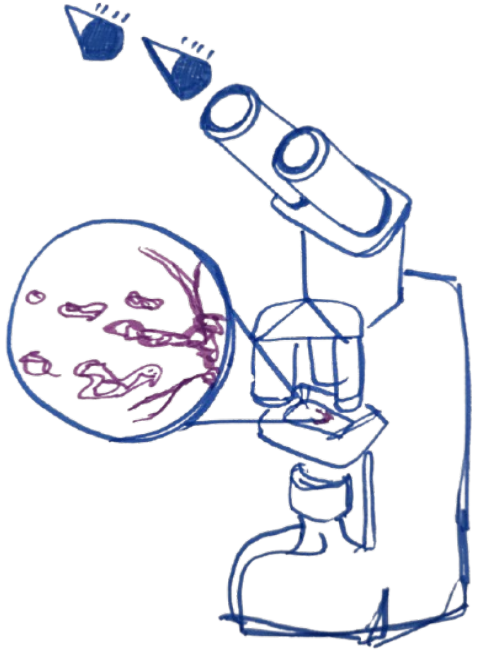
We can increase student sense of belonging by:

Investment in team success for good research outcomes:

- Better understanding of disease impact on arboretum ecosystem
- Report to Arboretum Board

Synergy: mixed BIOL/ESCI groups for entire quarter

- Community-building via multi-week exercises
- Introductory exercises to help students find connections with one another
- Fostering respect for and reliance upon one another as cross-disciplinary scientific colleagues



Other goals

Practice science communication (throughout)

Learn by peer teaching (midterm)

Broaden perspectives

- Across spatial scales, molecular to ecosystem
- Across time, human generations and tree lifespans
- Across species, considering many stakeholders in forest management

Teaching approaches:

Lectures
- individual and shared
- all directly relevant to project

Labs
- Classes separate
- different but related research questions

Multi-week collaborative exercises (~7 x 1hr structured discussion)
- larger context of research: managing an urban forest
- diverse viewpoints
- science and society
- scientific findings inform management decisions

Shared Midterm
- Classes present their work to date to each other

Shared Final Activities
- Shared presentation to Arboretum Board
- create outline of study questions for future section(s) of the course

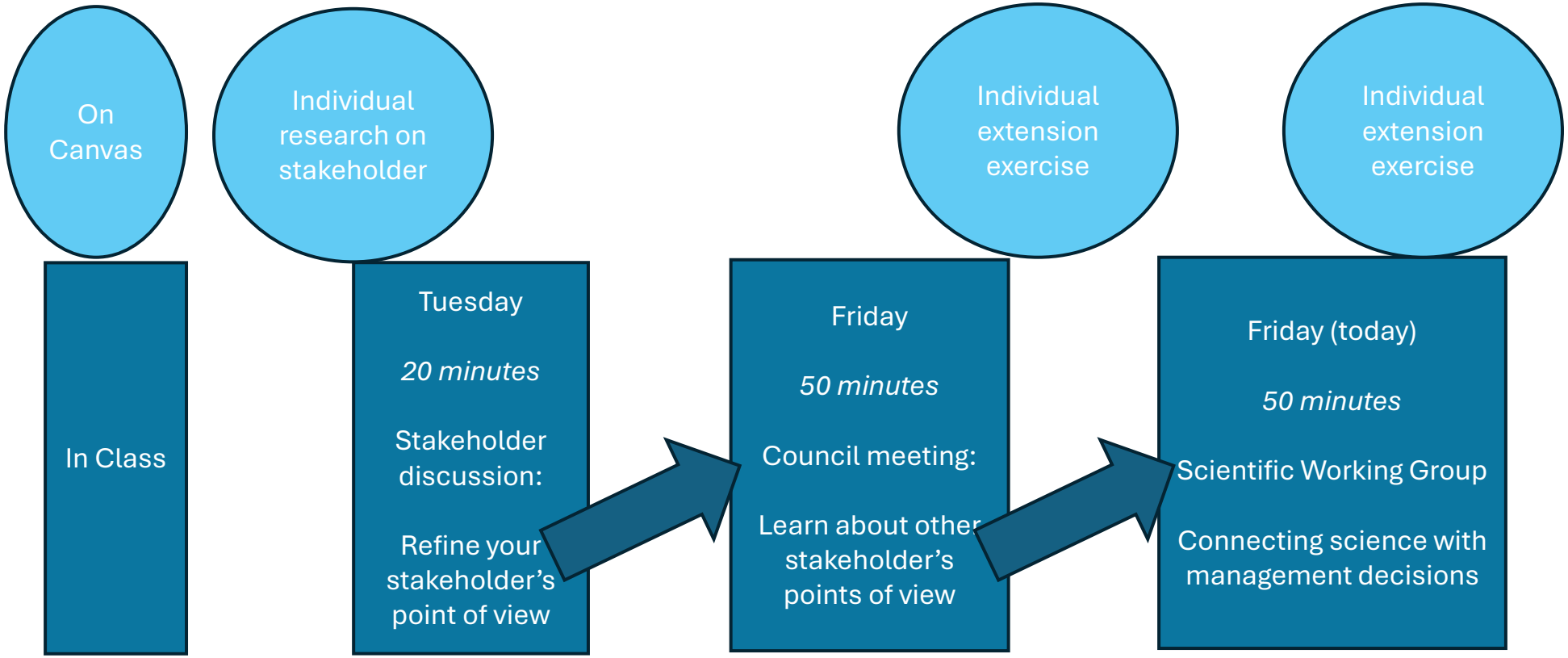
Points of View Group Exercise

Goals:

1. Gain familiarity with ecology of the arboretum.

2. Be able to consider a situation from multiple points of view, including different human

Points of View Group Exercise

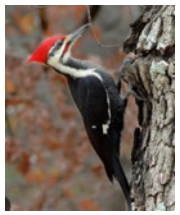


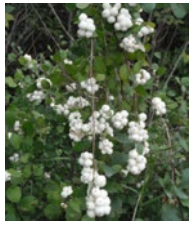
Points of View exercise

Day 1: 25 min in class – stakeholder discussion

- Pre-class individual homework: research stakeholder
- Each group is focused on one stakeholder
- Start with activities to find connections among strangers
  - Round robin
  - Think pair share
  - Choose group roles
  - Guided discussion
- Exercise goal: a unified and well thought out point of view of each stakeholder that can be delivered in 2 min to council

City of Bellingham WASHINGTON





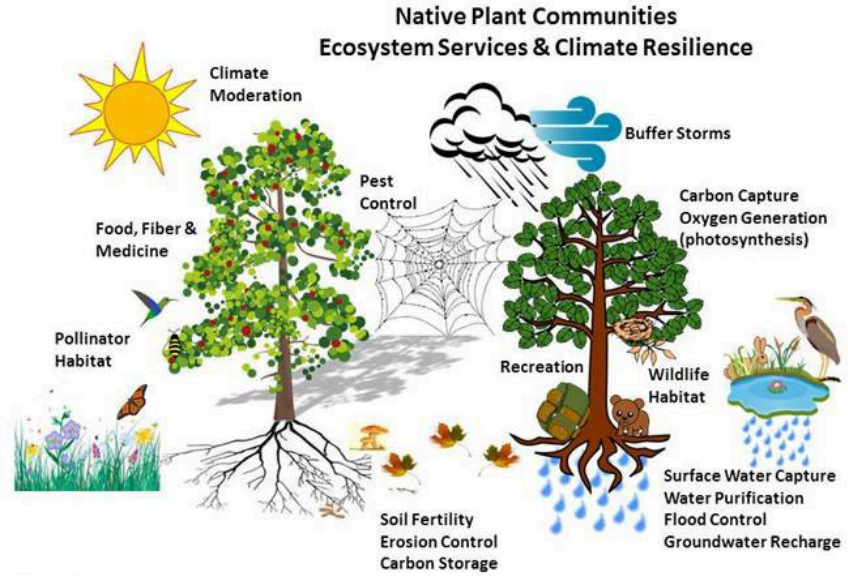
Points of View exercise

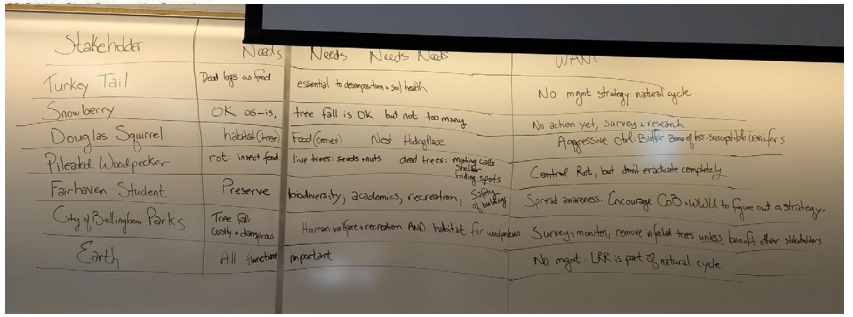
Day 2: 50 min in class – council meeting

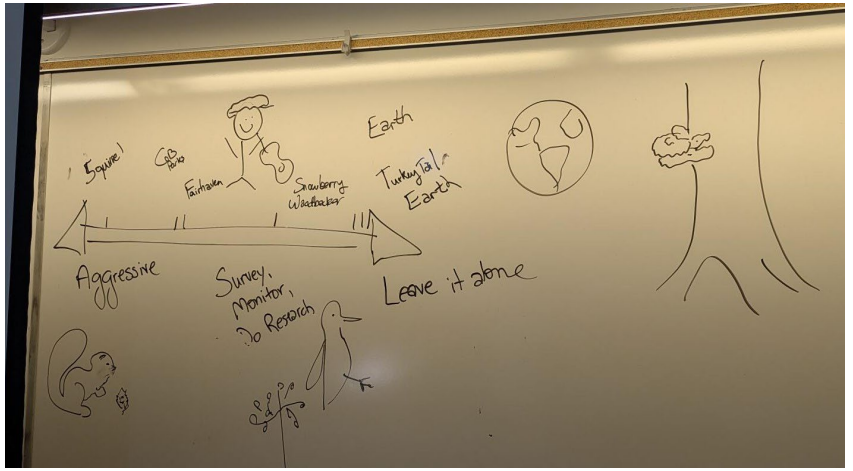
- Students take on role of one stakeholder group

- Each group presents unified point of view:
  - needs and motivations of stakeholder
  - ecosystem functions essential to stakeholder
  - impact of *C. sulphurascens* on these functions

- Exercise goal: students listen to all, and understand range of perspectives and ecosystem services needs

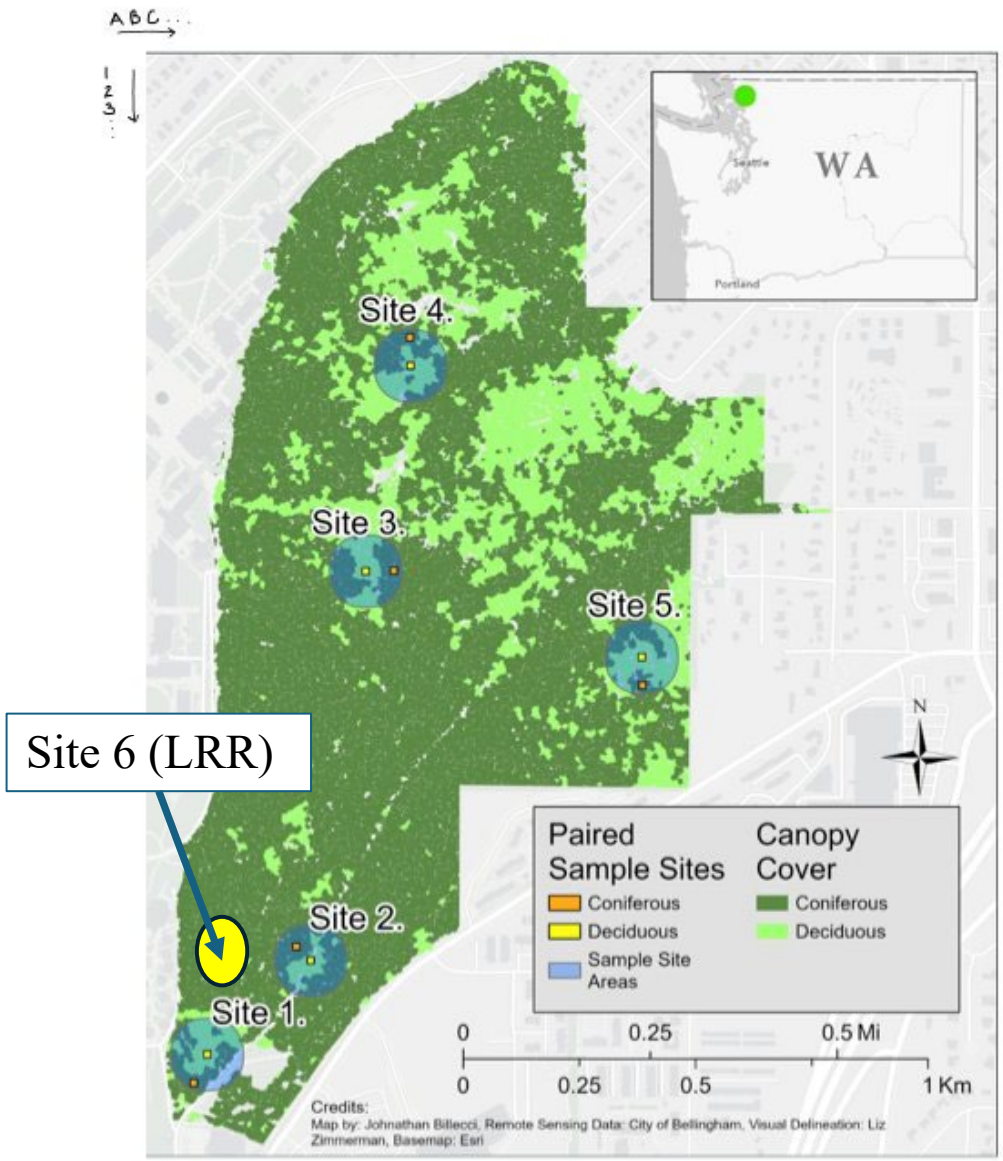






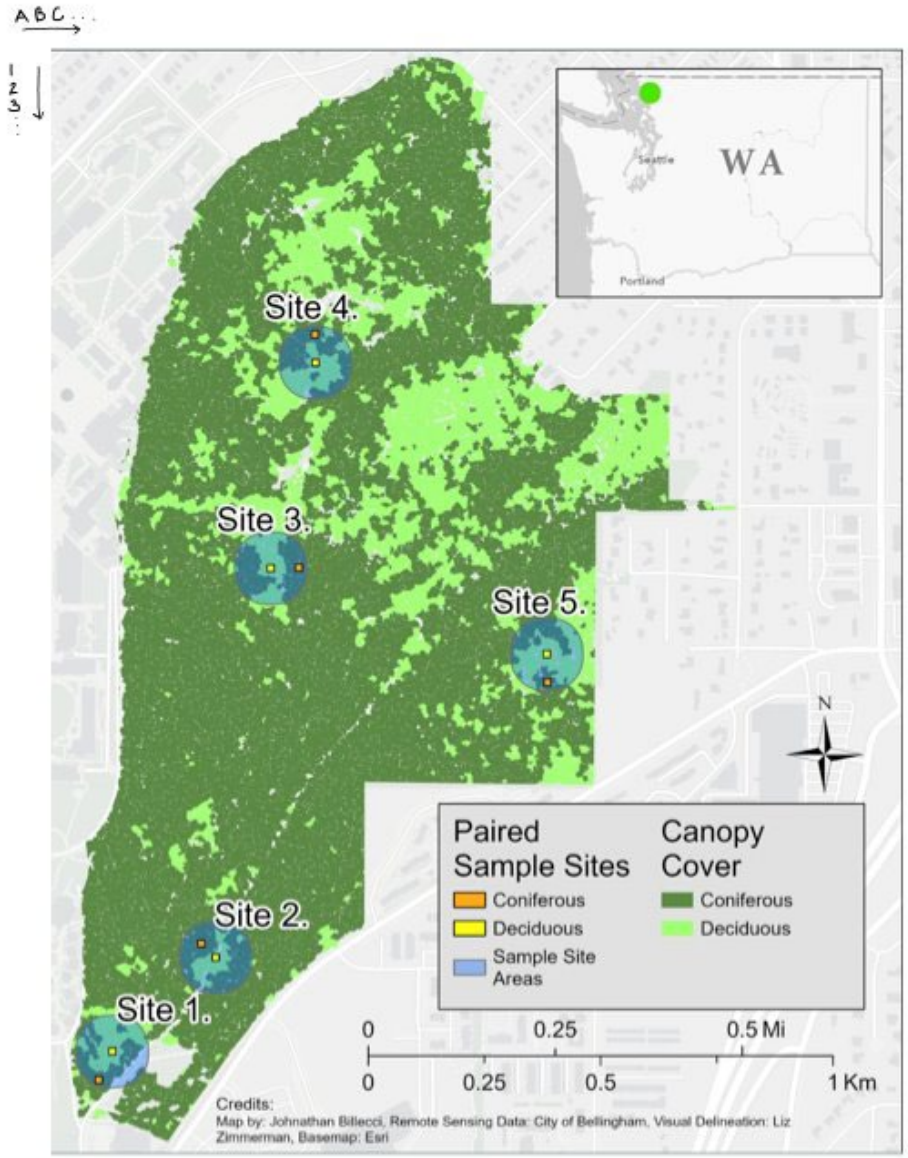
Level 1: Aggressive management

- **Where:** In LRR area that we visited during class - close to Fairhaven dorms
- **Goal:** Prevent any trees falling on dorms and stop disease in this area
- **Action:** Reduce *Coniferiporia sulpharascens* by removing colonized stumps and roots, and plant LRR-resistant species in cleared areas
- **Question:** How do we know which trees are diseased to and need to be removed? Design a method to test for LRR in healthy-appearing trees.



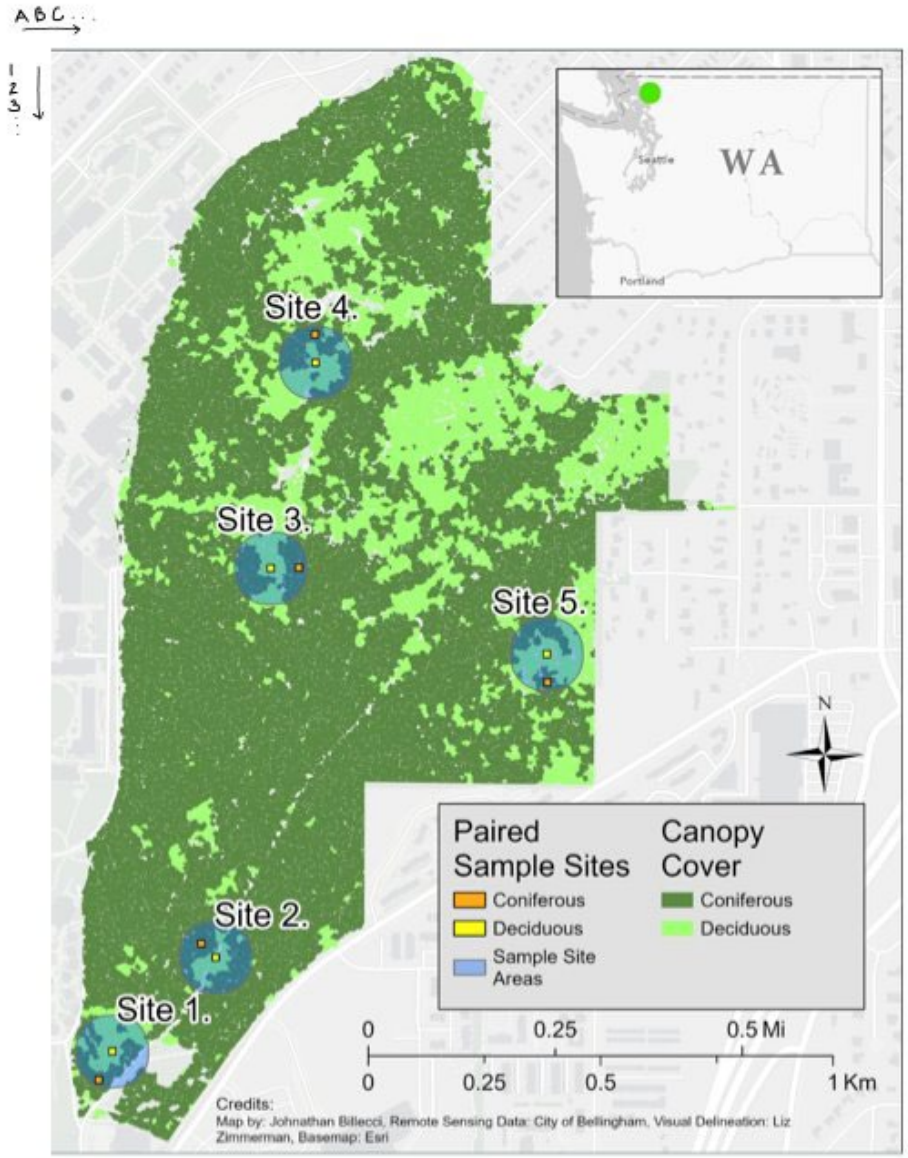
Level 2: Moderate management

- **Where:** Along most trafficked areas (main trails)
- **Goal:** Reduce risk to human users by reducing the chance of trees falling on trails and reducing disease along these corridors
- **Action:** Fell any unhealthy trees that might fall on the trail. Plant resistant trees in a buffer zone beside trails to reduce disease near trail and and improve soil quality in compacted soils
- **Question:** Which disease resistant tree species do you hypothesize would be most likely to mitigate soil degradation, primarily compaction, along trails?
    - Choose from these three species: Douglas fir bred for genetic tolerance, red alder, or bigleaf maple
    - Design a study to test your hypothesis before settling on a tree species. The study could be observational or experimental



Level 3: No management

- **Where:** Remainder of the arboretum
- **Goal:** Diversified community composition and age structure in forest.
- **Action:** Monitor forest, create a criterion for when the council should revisit the idea of managing *Coniferiporia sulpharascens* in a given area
- **Question:** When should more active management be considered?
    - Is there a level of disease that should not be tolerated? Or should change only happen in one direction?
    - What will we look for, in terms of LRR levels in the landscape, and how will we measure it experimentally? Design a method to monitor LRR.



Points of View exercise

Day 3: 50 min in class – science working group meeting

Goal: Connect human problems with scientific investigations

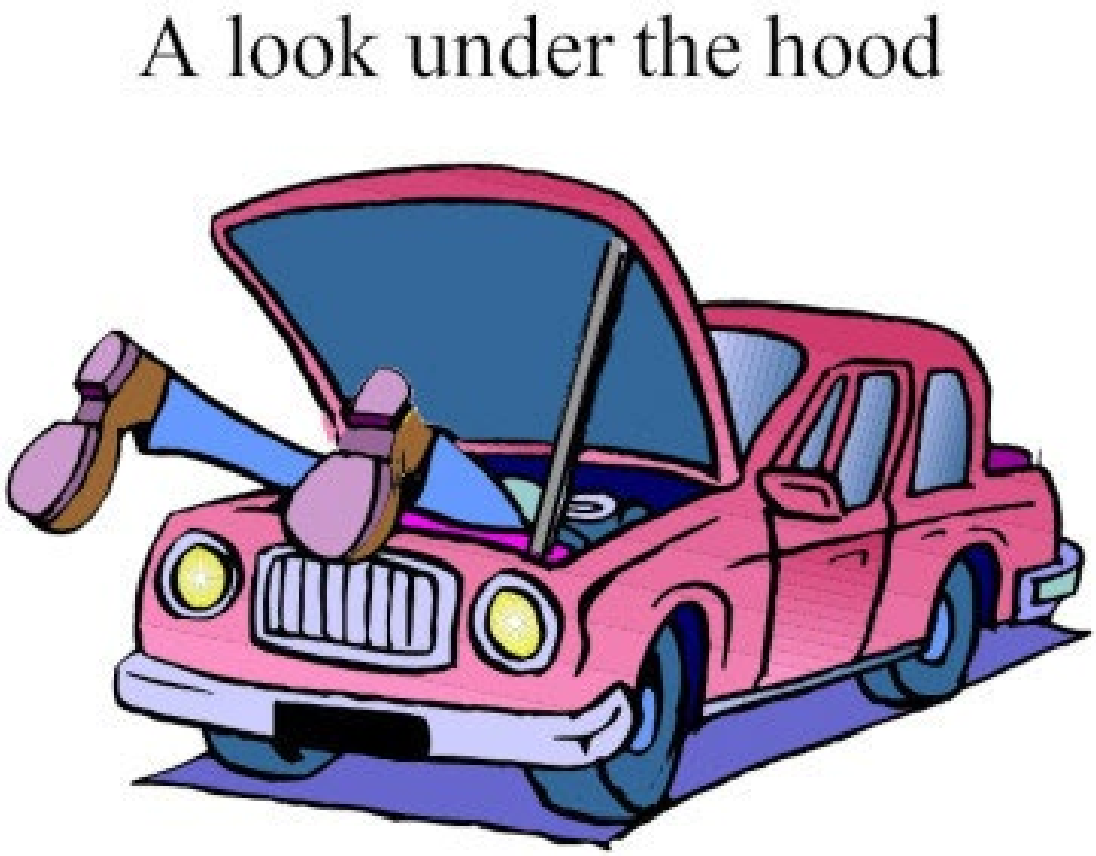
Goal: Practice the scientific process in devising experiments

Goal: See how science informs management decisions

Goal: Show that -

- Students **belong** in role of scientists
- Scientists **collaborate** across disciplines to solve problems

Here’s what we actually did:



Brainstorm- Individual- Free write!

~ 5 min

1. Read the scenario your group was assigned
2. Free write! (3 min)
   - Brainstorm ideas/thoughts about how to answer the question posed.
3. Review and decide what to share (2 min)
   - Be prepared to share your most important thoughts with your group in ~1min
4. Recall your role in the group

Brainstorm - Groups

~ 5 min

- Round robin
  - Start with the person who grew up furthest from Bellingham
  - Go round robin
  - Share your individual thoughts

Day 3: 50 min in class – science working group meeting

Brainstorm - Groups

~ 10 min

- Discussion
  - Recall group roles - Synthesizer leads (or facilitator)
  - Come to a consensus:
  1. What data would be useful in addressing these questions?
  2. How could such data be collected?
  3. Take next step…
     - What should be quantified?
     - What methods should be used?
     - Make predictions about what these data tell us

check with a Dr. B before proceeding!

Day 3: 50 min in class – science working group meeting

Individual- Free sketch!

~ 5 min

1. Recall group responses to
   - What should be quantified?
   - What methods should be used?
   - Make predictions about what these data tell us

2. Free sketch! (3 min)
   - Brainstorm ideas/thoughts about how to to display predicted data visually
   - Plot?
   - Map?
   - Other visualization?

Group Discussion

~ 10 min

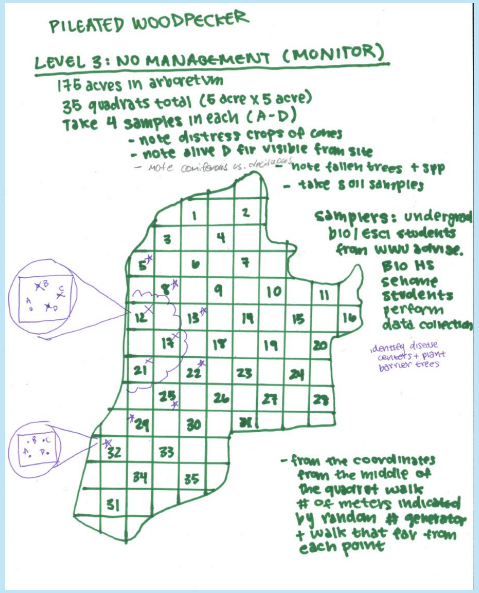
- Round robin
  - Start with the same person
  - Go round robin
  - Share your data visualizations
- Discussion
  - Come to a consensus and
  - Sketch visualization
  - Write: What data was collected? How? What does it tell us?

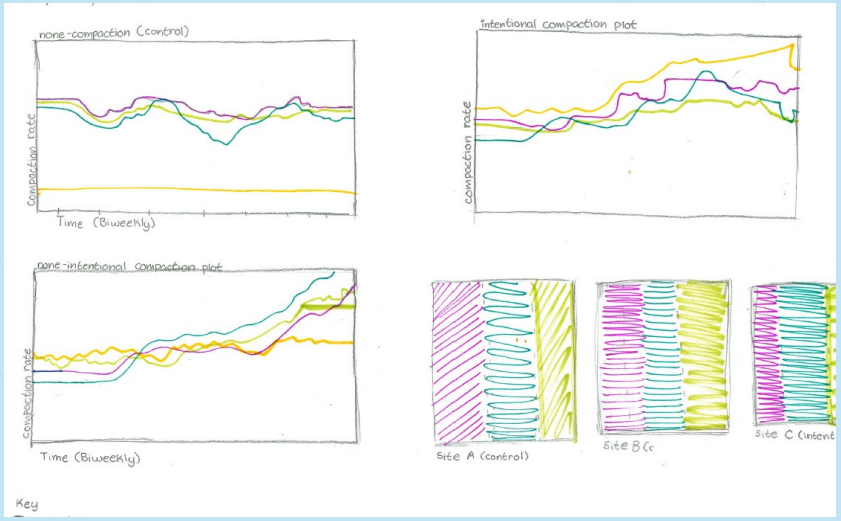
Day 3: 50 min in class – science working group meeting

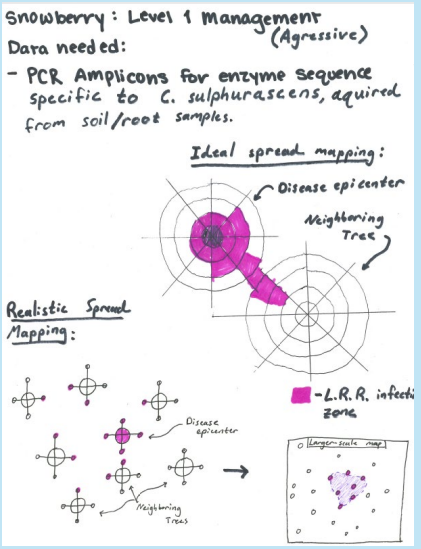
Class Synthesis

~30 min

Share experiment sketches







Group Discussion

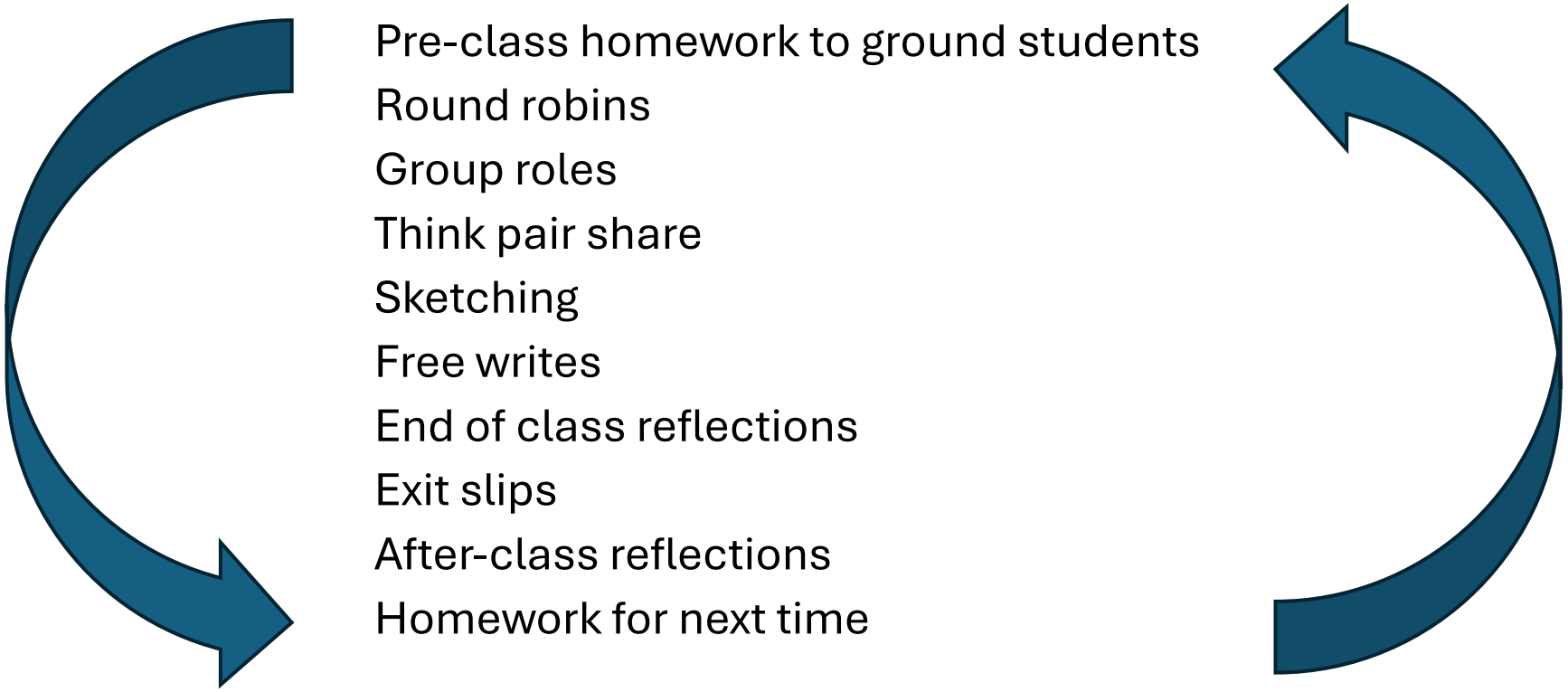
~ 5 min

- Did you like any of the other suggestions even better than your own?
- Are there are any limitations or concerns you have about the suggested data collection?
- Any last thoughts?

Reflection assignment on Canvas

Points of View exercise:

Structure creates positive, productive group work.
Positive groups create community and connection.
Connections foster **belonging**.



Thank you!

- John Tuxill
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