Advancements in design of watershed scale monitoring of aquatic habitat

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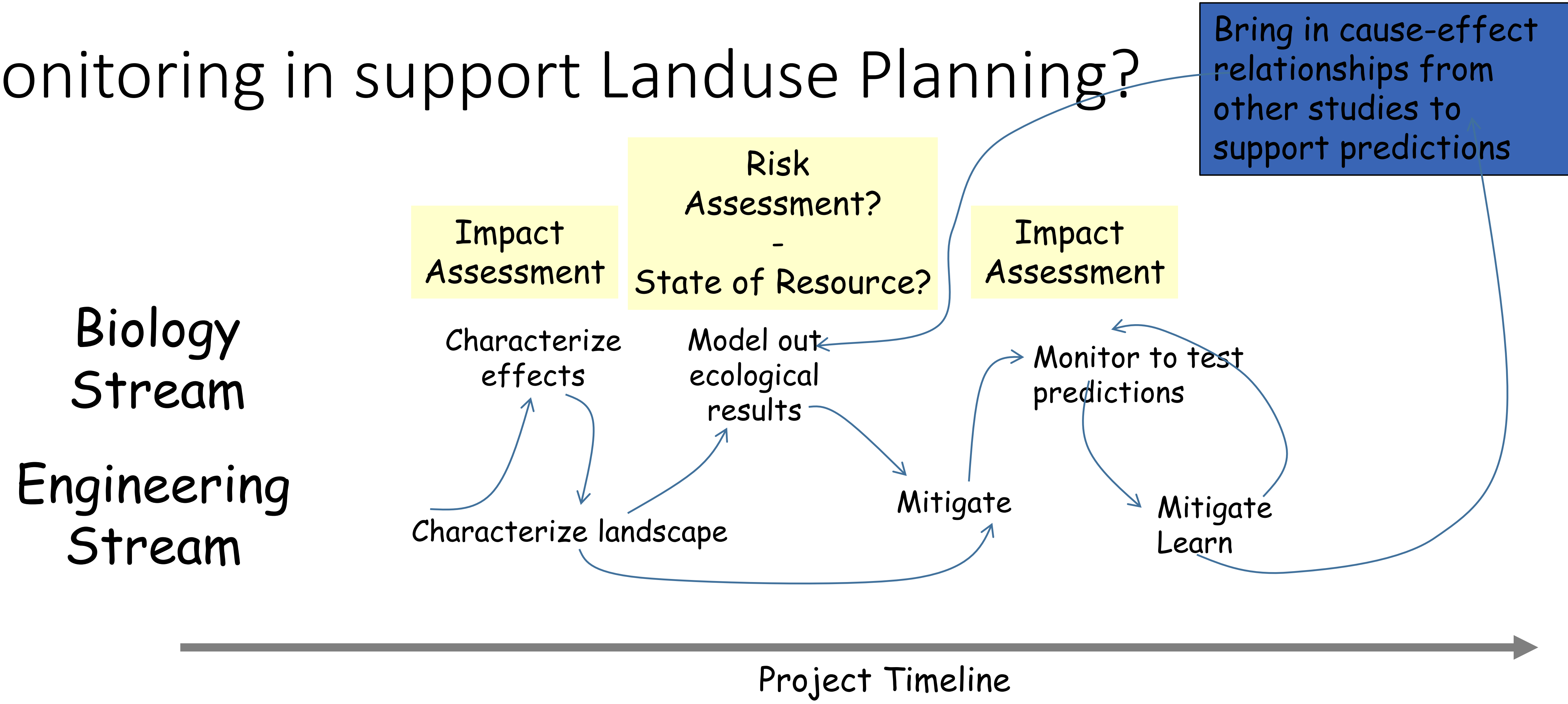
Outline

- Define the challenges and an opportunity
- Scope a solution to the need for transparency in monitoring programs
- A preliminary demonstration of how it would work
- Synopsis of benefits and concerns

…monitoring in support Landuse Planning?



Inherent truths to the monitoring cycle

1. It is adaptive
2. Decision thresholds are essential for state of resource report

Traditional State of the Resource Reporting

- A means of applying defensible and ideally standardized approaches to evaluate the state of a valued resource for a geographic area
- Ideally:
  - approaches can nest across landscapes
  - Designed to enable quantification of landscape influences
  - Are scalable
  - Can differentiate unknowns as well as knowns
  - Are amenable to adaptive approaches
  - Clear thresholds that direct study to an impact assessment design

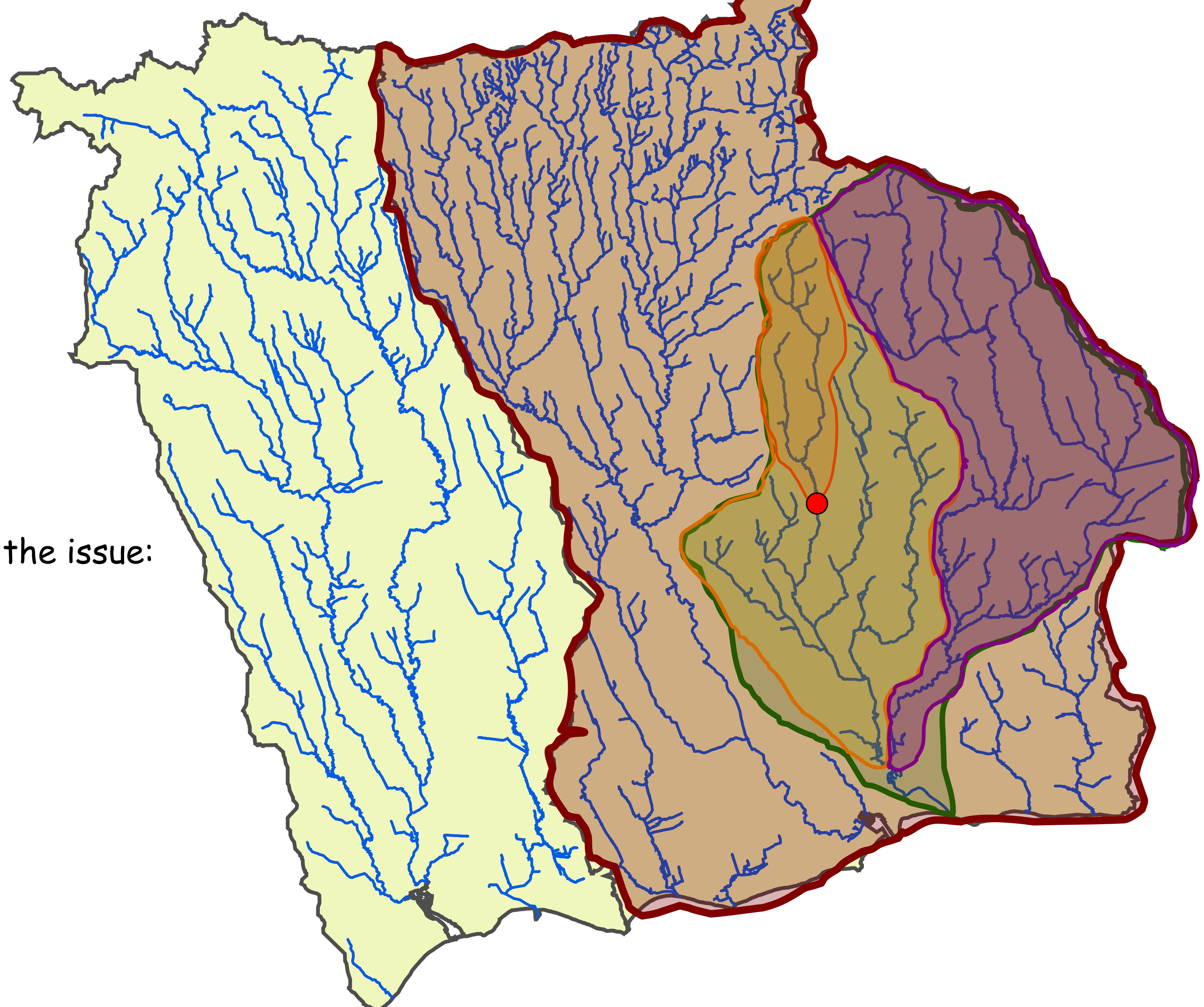
Focus for the presentation here is stream habitats; with emphasis on fish, benthic invertebrates and more generally water quality… but any metric that is influenced by landscape conditions could work

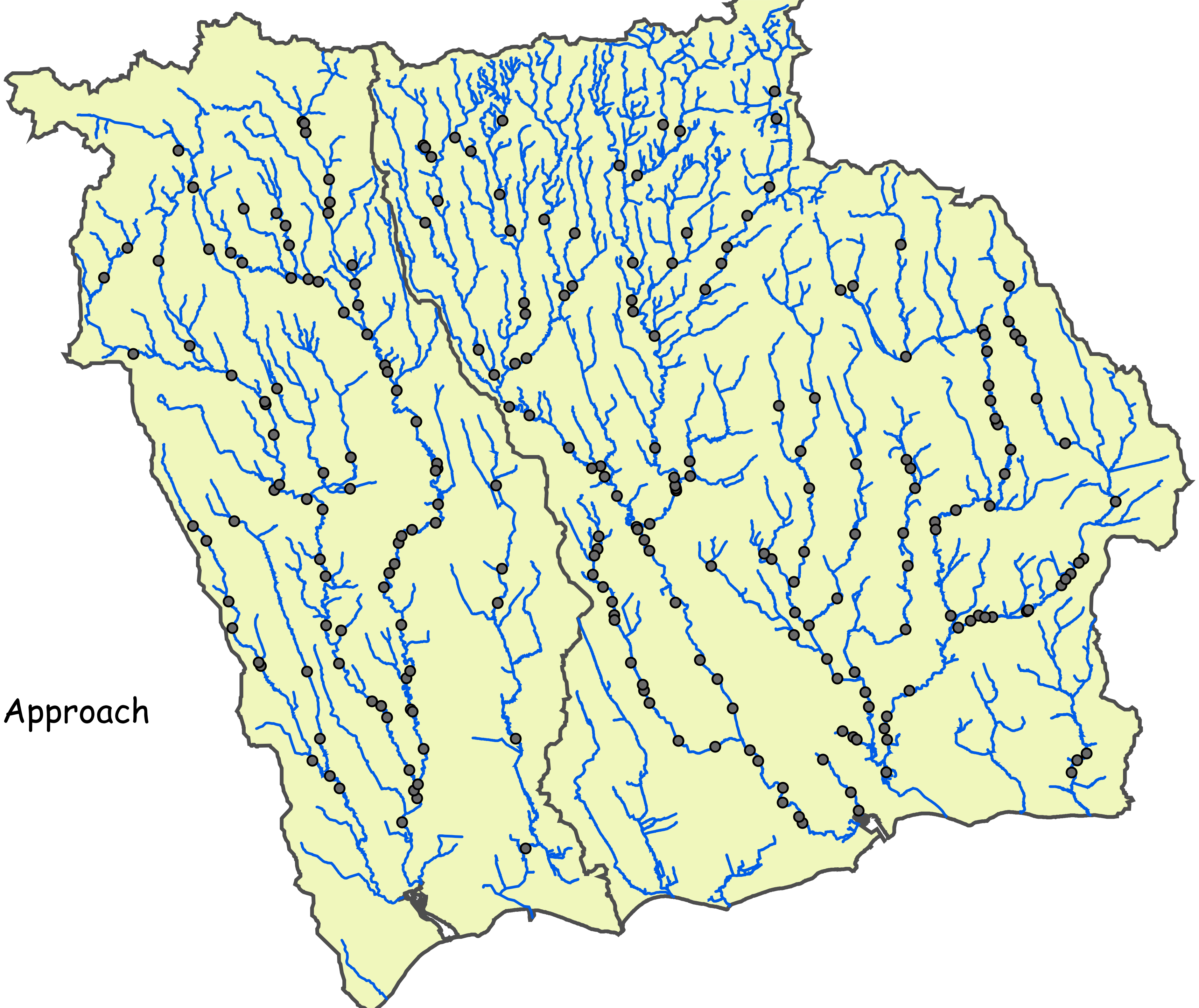
Challenges

- Monitoring at the ‘watershed’ scale has always presented various challenges:
  - There are lots of potential sampling locations; but how many do we need, and where do we put them?
  - How to (and do we?) stratify for natural influencing variables like stream order, gradient, surficial geology?
  - How to (and do we?) use the data to understand what the streams were like historically and the current level of ‘impactedness’?
  - How do you reconcile the need for more data verses resource limitations?
  - How and when do you switch to an impact assessment
- Monitoring is EXPENSIVE and an easy target for cuts due to “ ***we need more data***” thinking

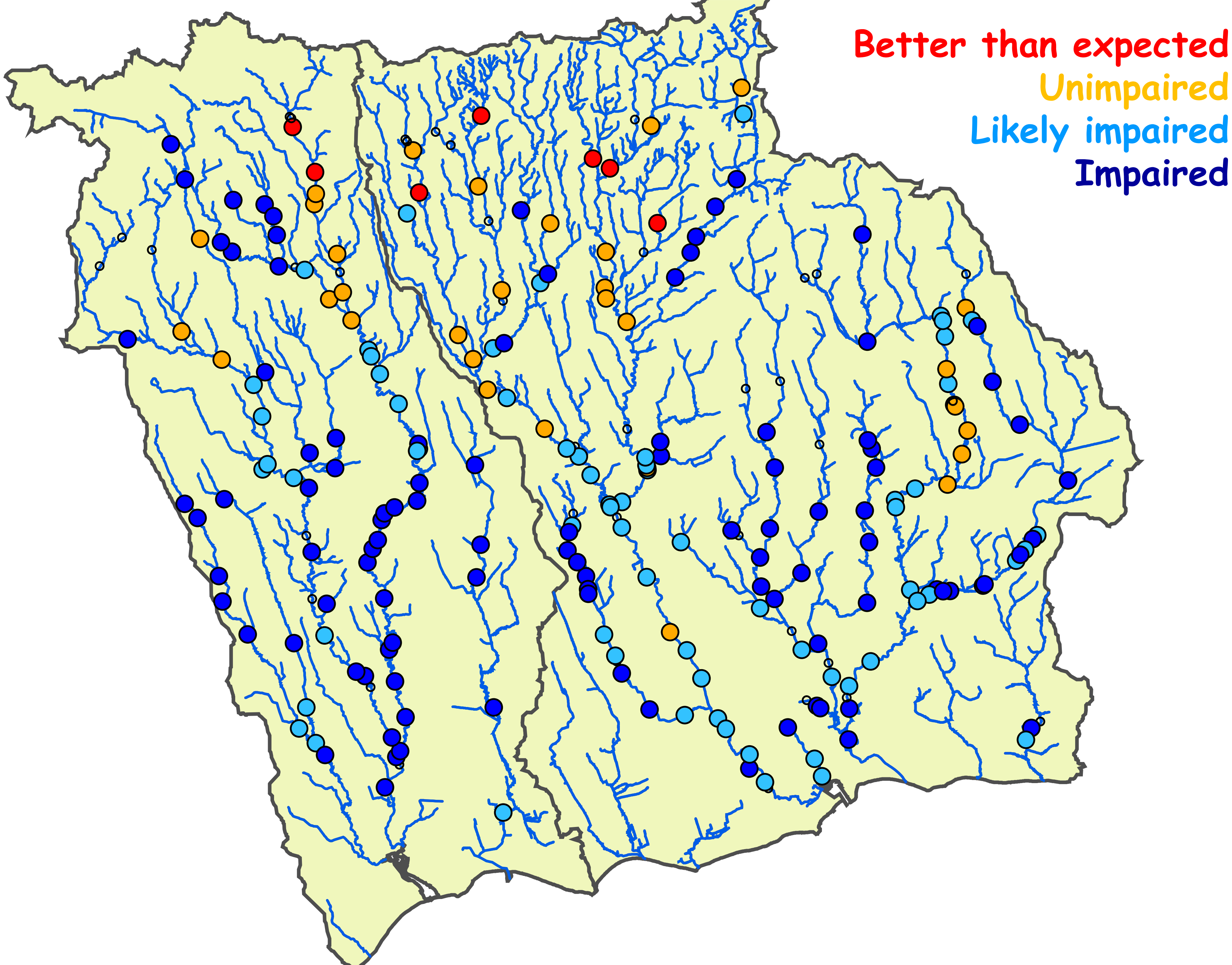
Proposal emerged through a SOSMART/OSAP sponsored study design workshop held in May 2019

To Visualize the issue:





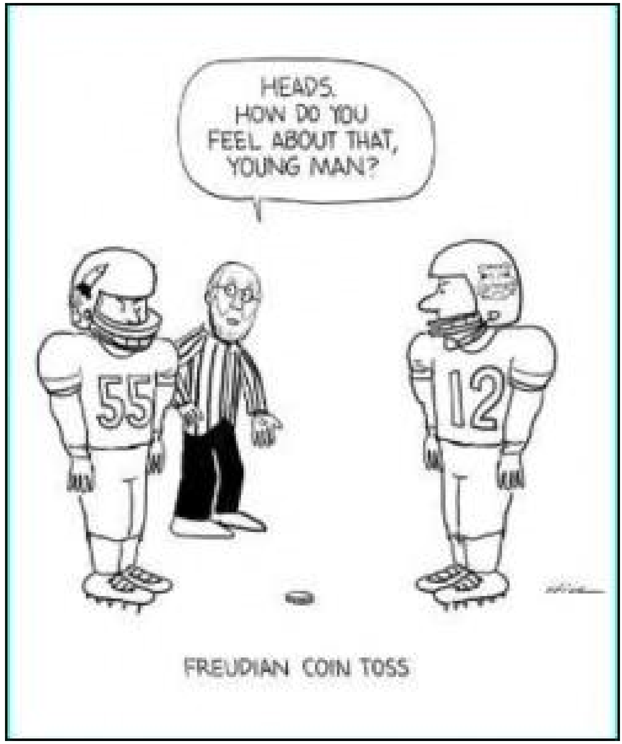
Traditional Approach



Better than expected
Unimpaired
Likely impaired
Impaired

Defining the "Opportunity"

- **Use landscape model outputs as the State of the Resource**
  - **Measured at segment level … summarized to other scales**
- Monitoring data:
  - measures the accuracy of the predictions;
  - identifies anomalies and gaps
  - Identifies problem areas in need of impact assessment studies
- Provides transparency for monitoring needs
- Spatial and temporal sampling supports trend analysis



Flipping monitoring on its head

“Novel Study Design”

1. Model Predicts “State of Resource”
    - For particular VEC that can be predicted and is meaningful
    - Measured against a benchmark
2. Study Design Question:

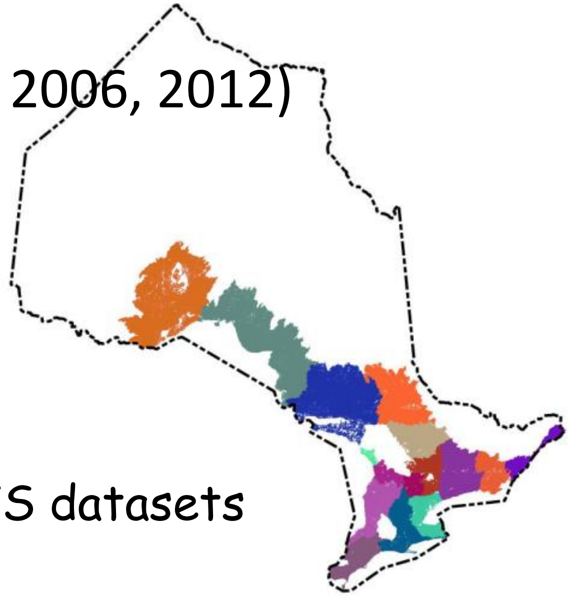
    “How effectively does the model predict VEC state in X area (e.g. watershed)”
3. Sampling targeted to the predicted conditions
    - Potentially stratified: by ….anything
4. Assess results and improve model
    - Fill gaps, refine predictions
    - Assess need to move to impact assessment
5. Repeat

Unpacking the Proposal

1. **Predict the state of stream segments in your study area from Landscape Data**
    - Segments sections of stream relatively similar hydrography and geology
        - Segment Data exists in LIO (e.g. WRIP, ALIS, or potentially the OSCS),
        - Limitations – based on MNRF so does not include headwaters
    - Or generate your own network (to include headwaters etc.)

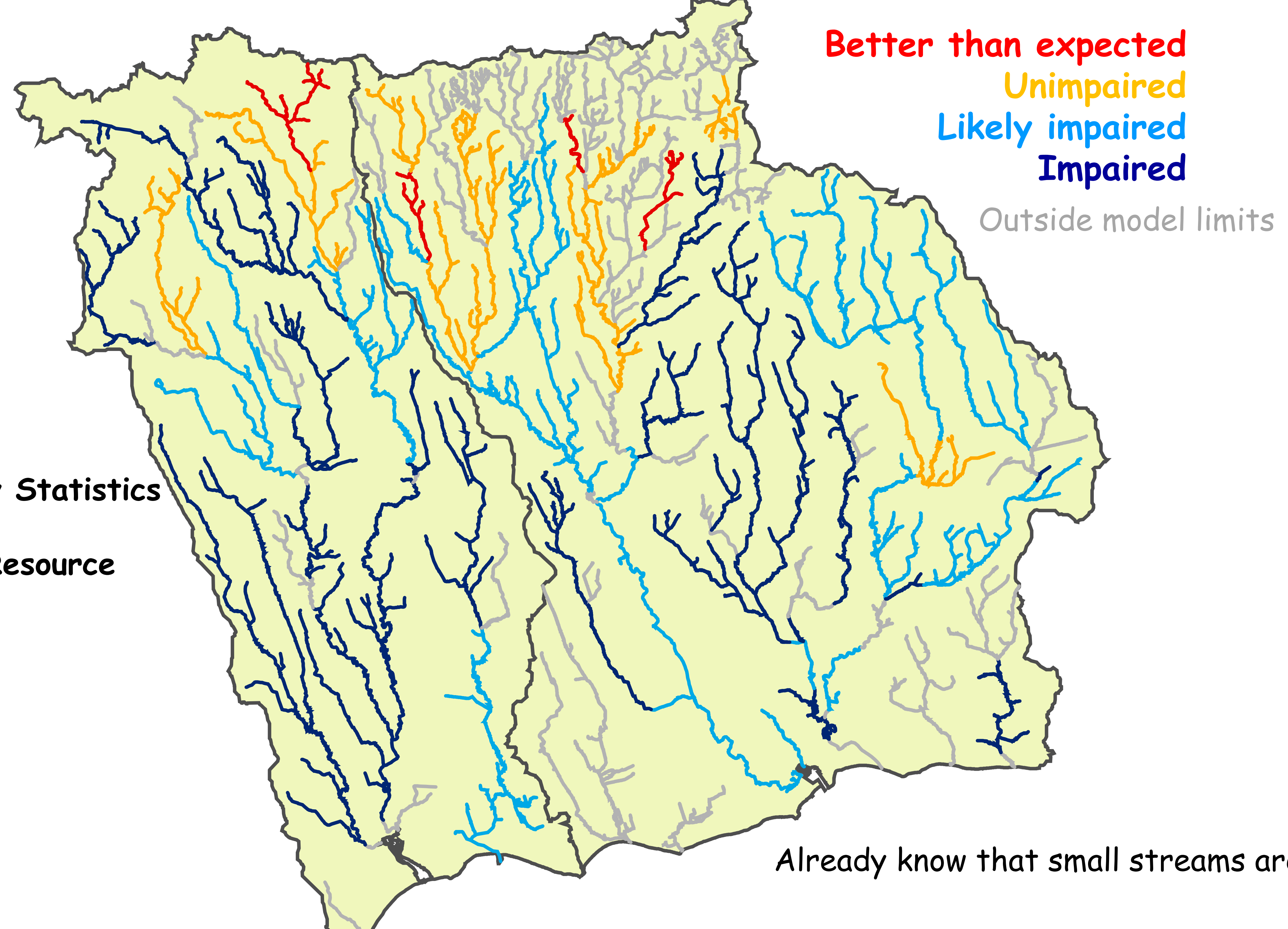
- Requires a Predictive model that correlates with an agreed Valued Ecosystem Component (VEC)
    - Many landscape models exist (C Jones et al 2017, Stanfield et al 2006, 2012)

    - Data can be summarized to provide sub basin states
    - Recommend a conversation with decision makers about confidence needs (i.e., agreement criteria, spatial extent)



ALIS datasets

Map &Summary Statistics
are
A State of a Resource



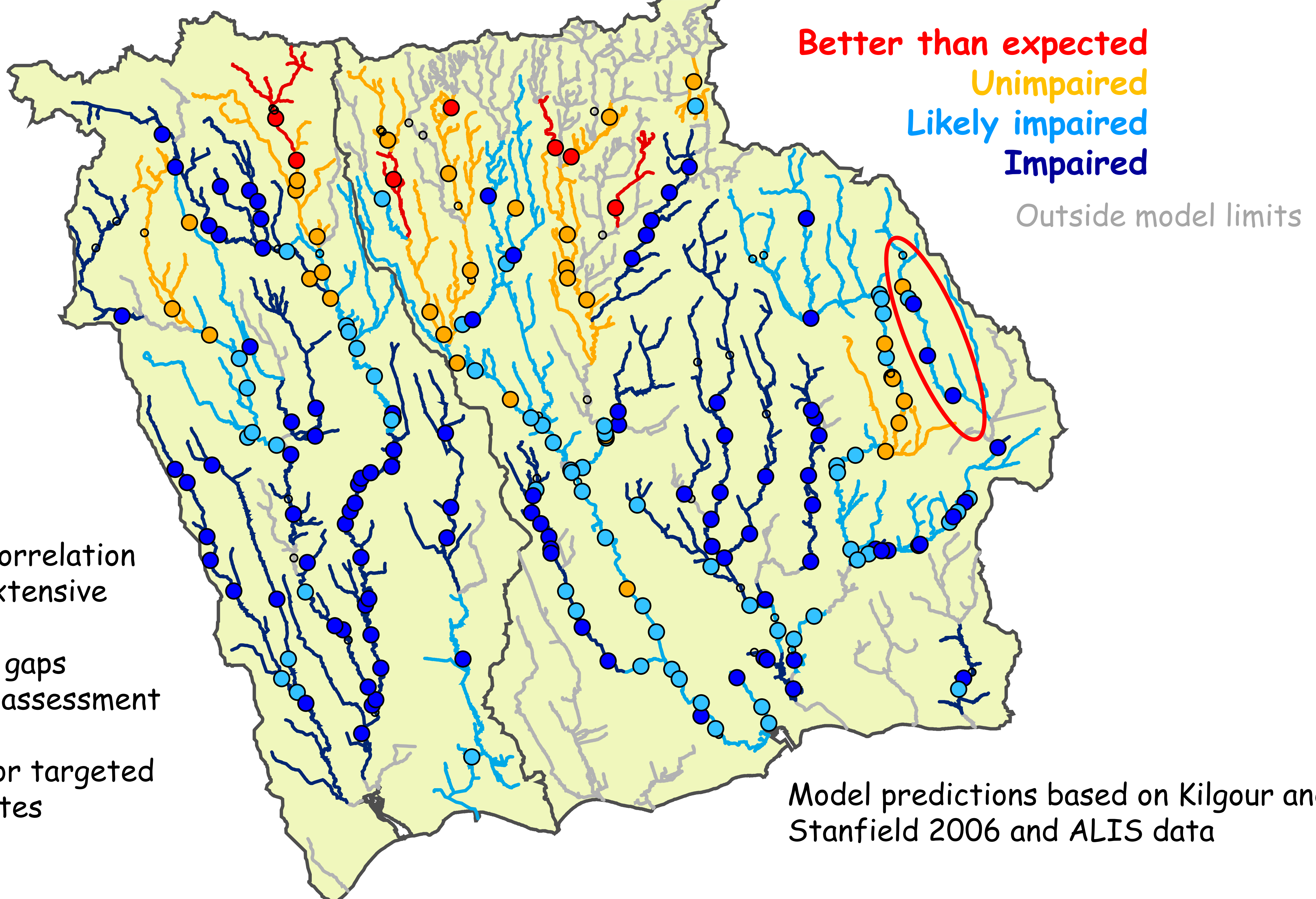
Already know that small streams are a gap

Unpacking the Proposal

2. Test model reliability using existing monitoring data

- Classified using model prediction comparisons
  - Deviation from expected condition (Observed condition – model prediction) or some other metric
  - Requires some GIS work to measure the landscape state at each monitoring site….
  - Analysis offers both statistical and spatial interpretation for confidence in state conclusions

- Transparent conversation about spatial and temporal sampling needs



An Example

- Excellent correlation
- Spatially extensive dataset
- Headwater gaps
- Ids impact assessment segments
- Guidance for targeted temporal sites

Model predictions based on Kilgour and Stanfield 2006 and ALIS data

Unpacking the Proposal

3. Targeted sampling to fill gaps in segment categories

- Strata become classified segments, informed by gaps
    - Random samples within the cumulative length of each predicted strata
- Additional stratification is encouraged:
    - e.g. equal sampling in each sub watershed
    - Strata not well predicted from the model
    - Gaps (e.g. segments outside model parameters

- Transparent conversation informed by confidence needs, resources and thresholds

Unpacking the Proposal

4. Annual assessment and model refinement

- Use new data to refine model predictions, identify new issues etc..,
- Revised report and maps on state and accuracy of predictions
- Revise sampling needs to address issues and continued gaps
- Develop impact assessment plan where necessary
    - I.e. where sampling and model predictions indicate consistent impacted zones
    - Strategic sampling for recovery
- Refinement of models for smaller spatial areas where appropriate…

Unpacking the Proposal

5. **Adapt and Repeat**

- It is an adaptive process
- Monitoring results provide thresholds and trend analysis that provide direction to impact assessment
- Model & monitoring improvements may change state classifications but reasons will be transparent …. Adapt monitoring accordingly
- Approach is readily transferable across landscapes to provide consistent approaches

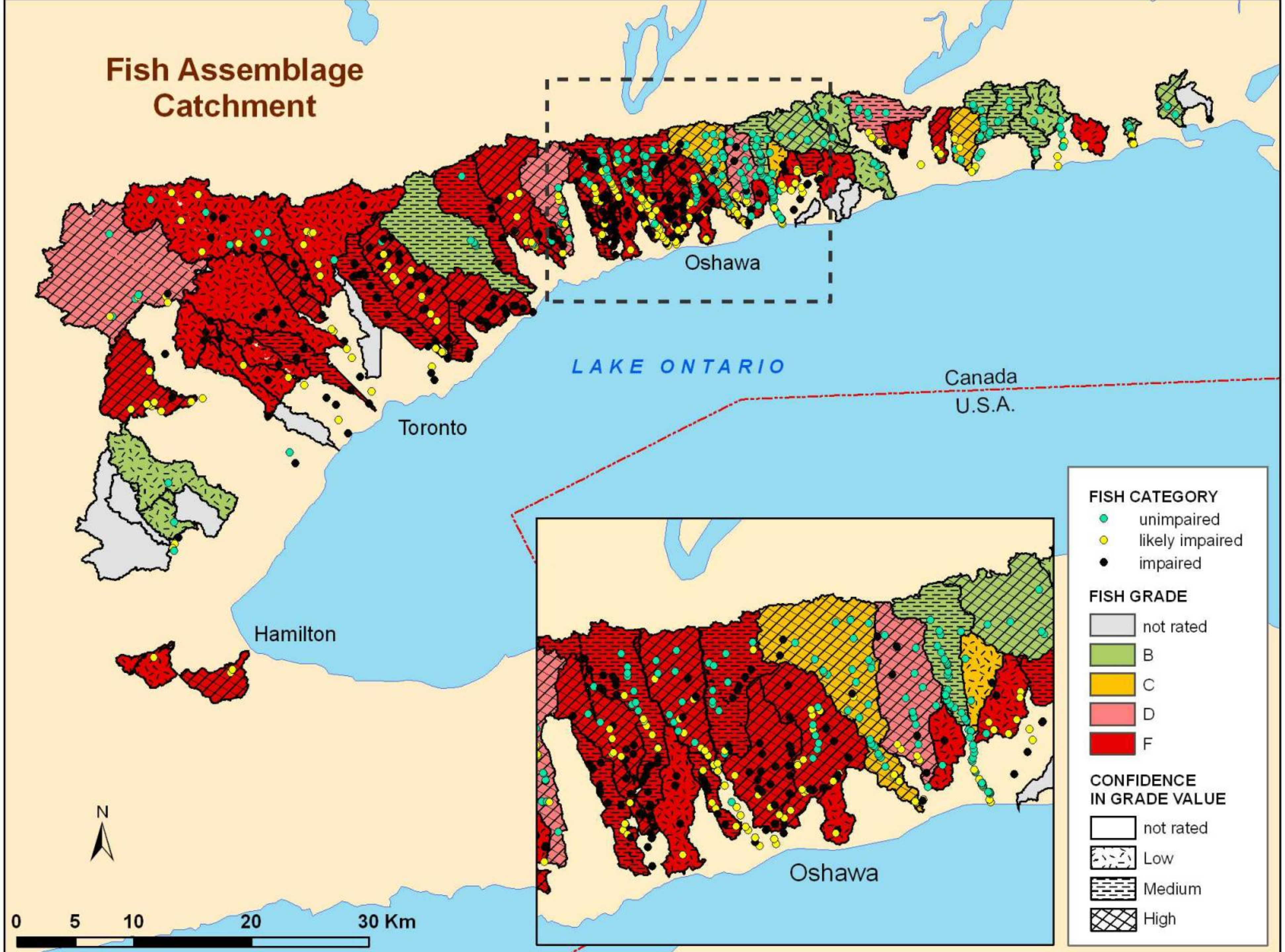
Study Outputs

1. Informed landuse planning decisions (capacity, effectiveness, problem areas)
2. Clear and transparent decision thresholds
3. Percent agreement in predictions by strata which informs additional sampling needs
4. Observed condition by strata
5. Scaled up reporting (including maps)
6. Gaps in sampling for future targeted sampling (e.g. headwaters, non-wadeable etc..)
7. Patterns where model predictions are erroneous
8. Adaptive loop to fill gaps and improve model predictions

Study Outputs Cont'd

9. Can apply rating criteria to "scale up" results
10. Combine with confidence rating
11. Stanfield 2012 compares approaches

Stanfield, L. W. 2012. Reporting on the condition of stream fish communities in the Canadian tributaries of Lake Ontario, at various spatial scales. Journal of Great lakes Research.38:196-205



Fish Assemblage
Catchment
Oshawa
LAKE ONTARIO
Canada
U.S.A.
Toronto
Hamilton
N
0 5 10 20 30 Km
Oshawa
FISH CATEGORY
unimpaired
likely impaired
impaired
FISH GRADE
not rated
B
C
D
F
CONFIDENCE
IN GRADE VALUE
not rated
Low
Medium
High

Concerns

- Requires a “model” to make initial predictions…
- Strong requirement for GIS mapping and some analysis
  - lengths of streams in each state
  - agreement in classification by strata
- Model refinement is required
  - With R scripts could be automated… but that requires R skills
  - Open Source GIS and analysis tools are widely available
  - Community of Practice can assist

Key Messages

- Focuses reporting at the segment – where predictions work best
  - But incorporates ability to identify local impact areas
- **Provides a means to assess all segments in a watershed**
  - Regardless of the magnitude of resources
- Adaptive loop is inherent in process (i.e. ability to evaluate state improves over time)
- Flexible to accommodate new data and problem areas
- Facilitates clear decision threshold for moving to impact assessment study (i.e. thresholds) and recovery success

Key Messages Continued

- Confidence levels in state measures/predictions provide transparent needs assessment for sampling
- Facilitates spatial and temporal scale analysis
- Ease of communication (i.e. colour coded maps and sites)
- Provides a template for reporting across broad landscapes
- Adaptive analysis and modeling can be automated using R scripts and data dashboards (e.g. MARS)
- Amenable to nested sampling approaches

  (e.g., rapid assessment vs diagnostic)

Thank You and Acknowledgements

- 20 students at the study design workshop…

Questions?

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