

SpaDES : Une nouvelle librairie R pour la modélisation spatiale et la reproductibilité

Jean Marchal,

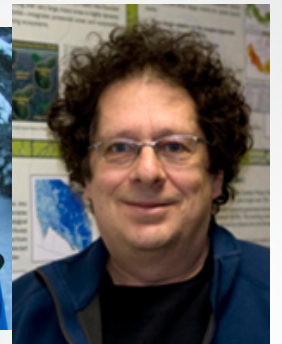
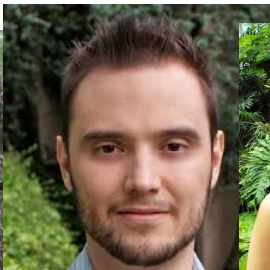


UNIVERSITÉ
LAVAL

15 mai 2019 –



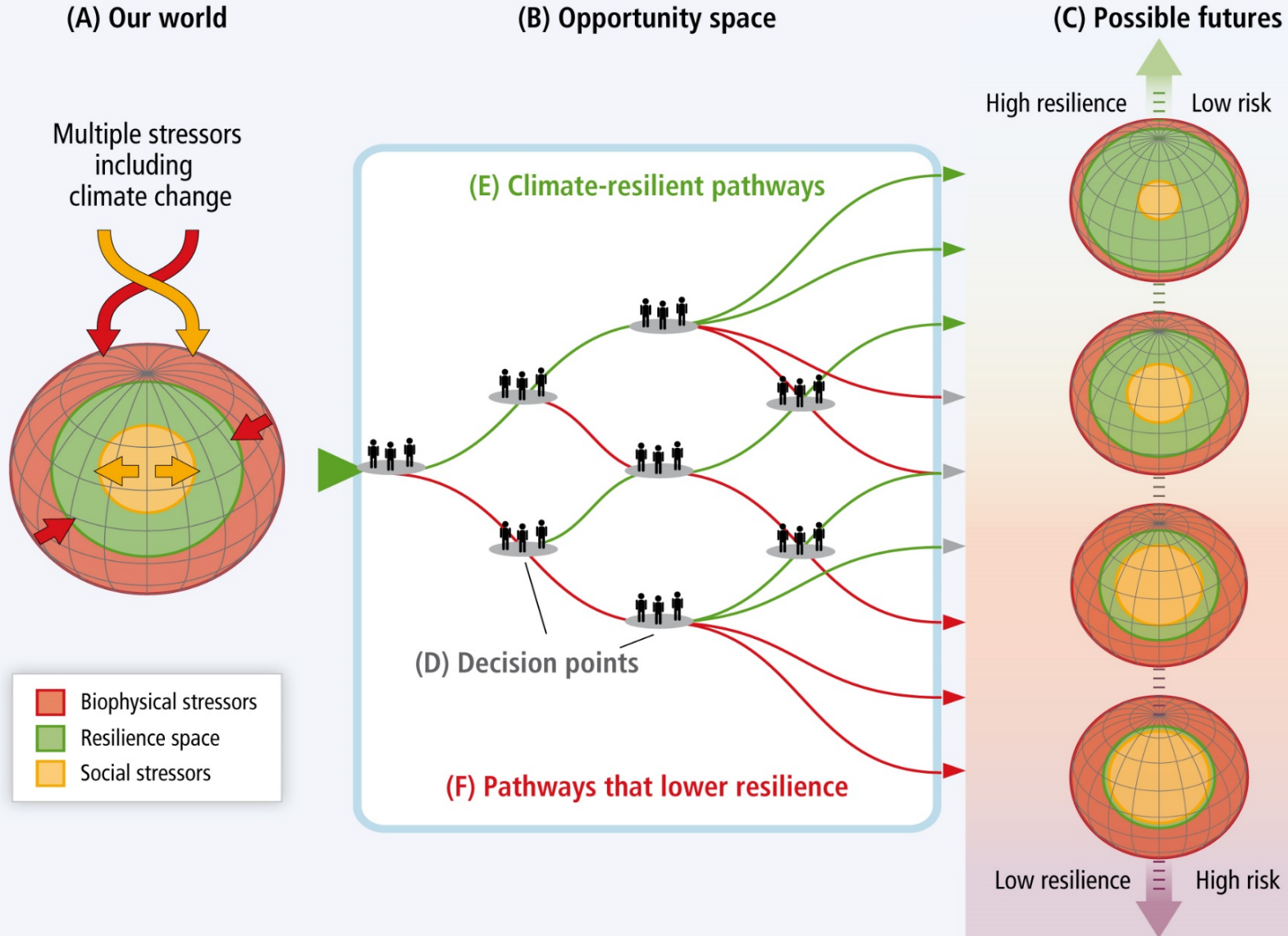
Présenté par 



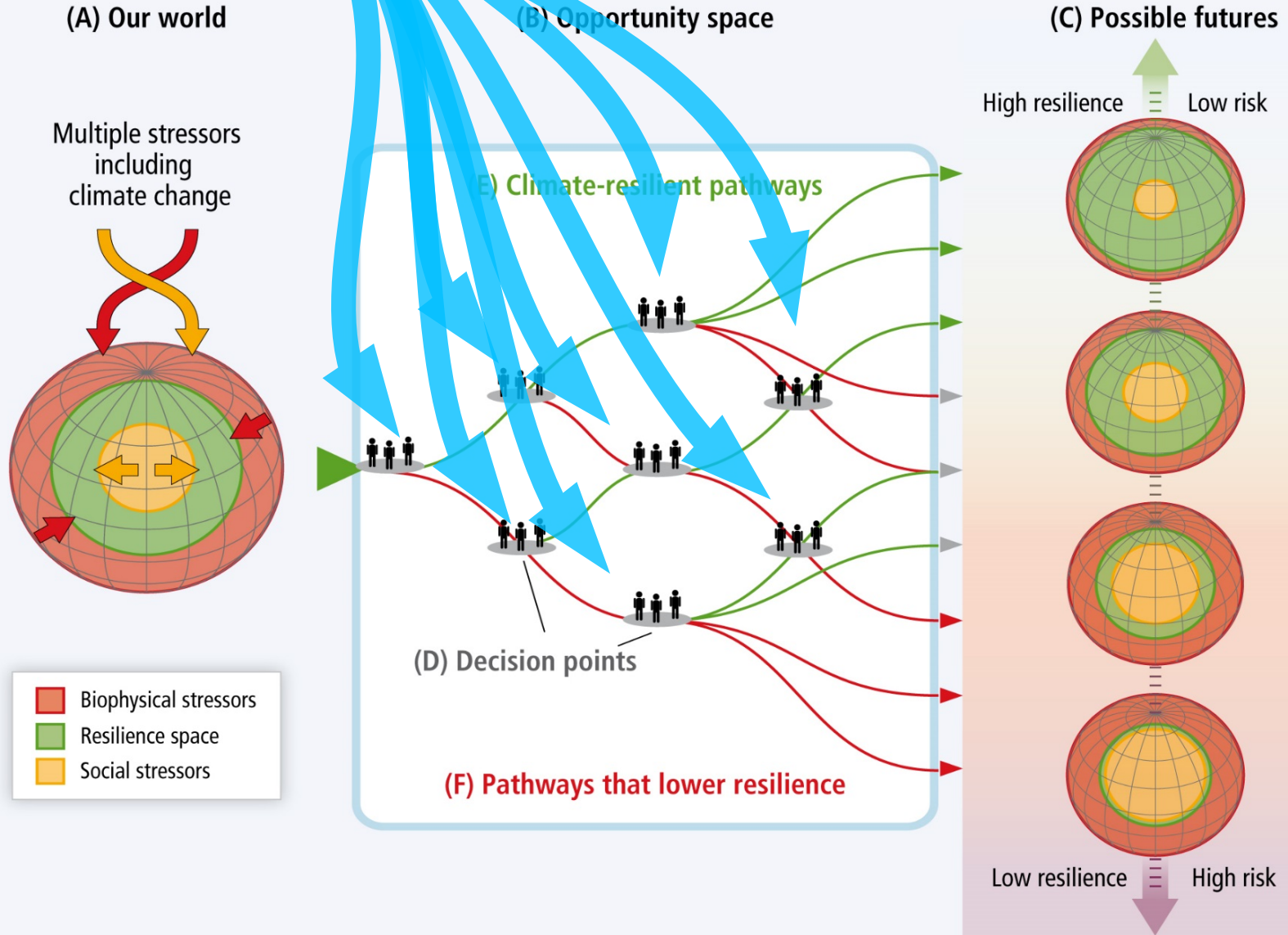
Climate change?

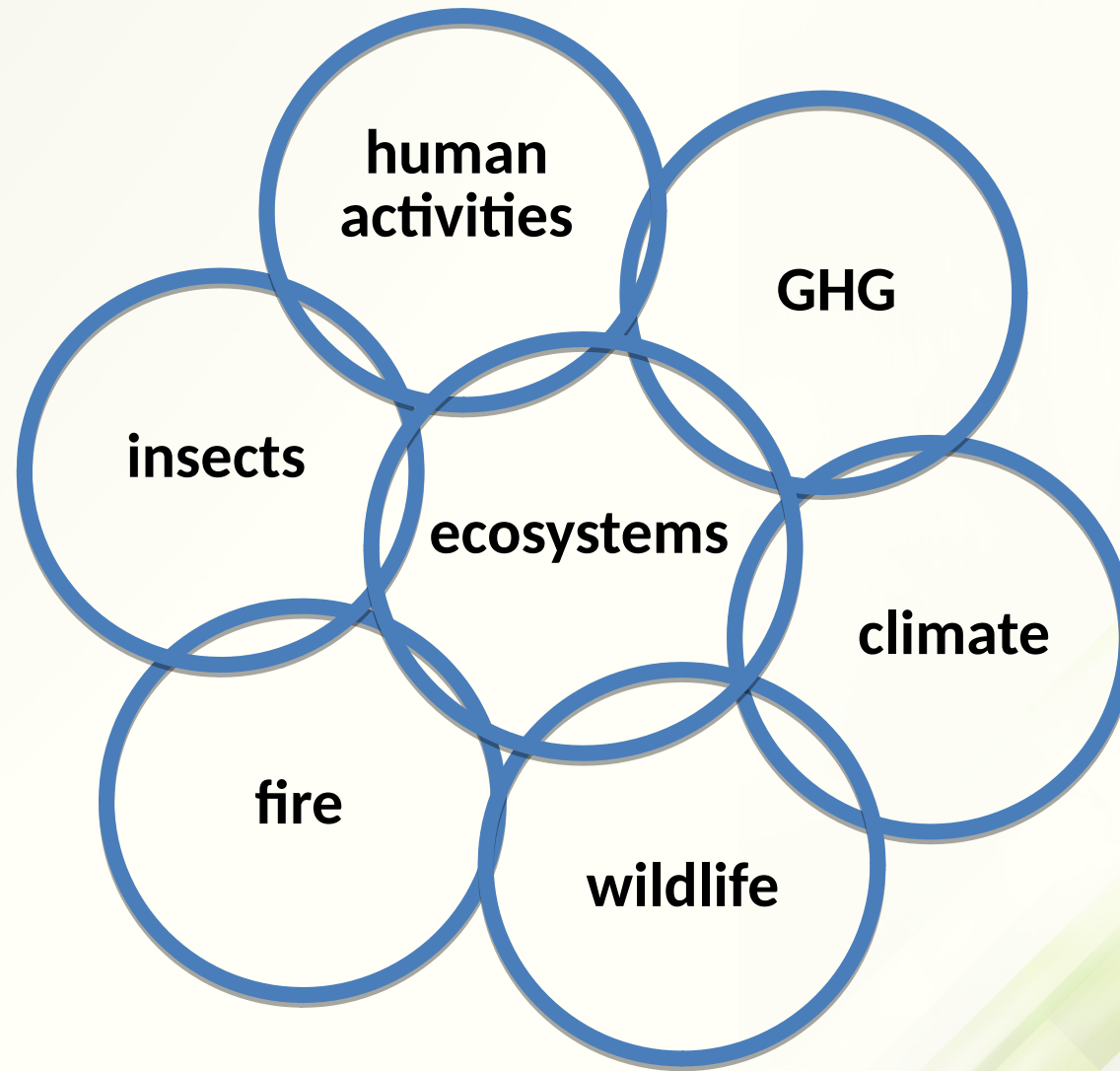


Taking the best decisions : the need for science-based policy



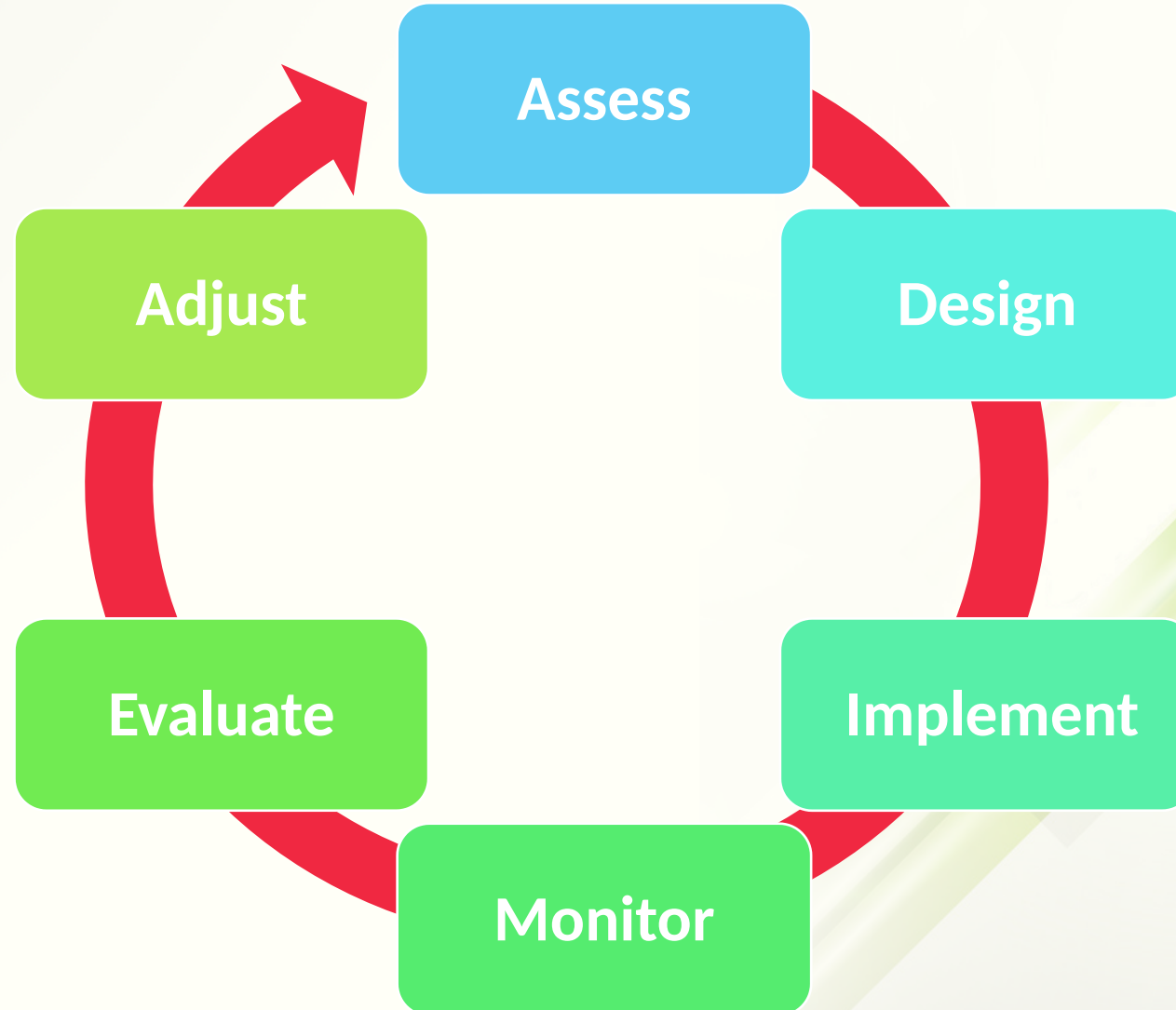
Taking the best decisions : the need for science-based policy





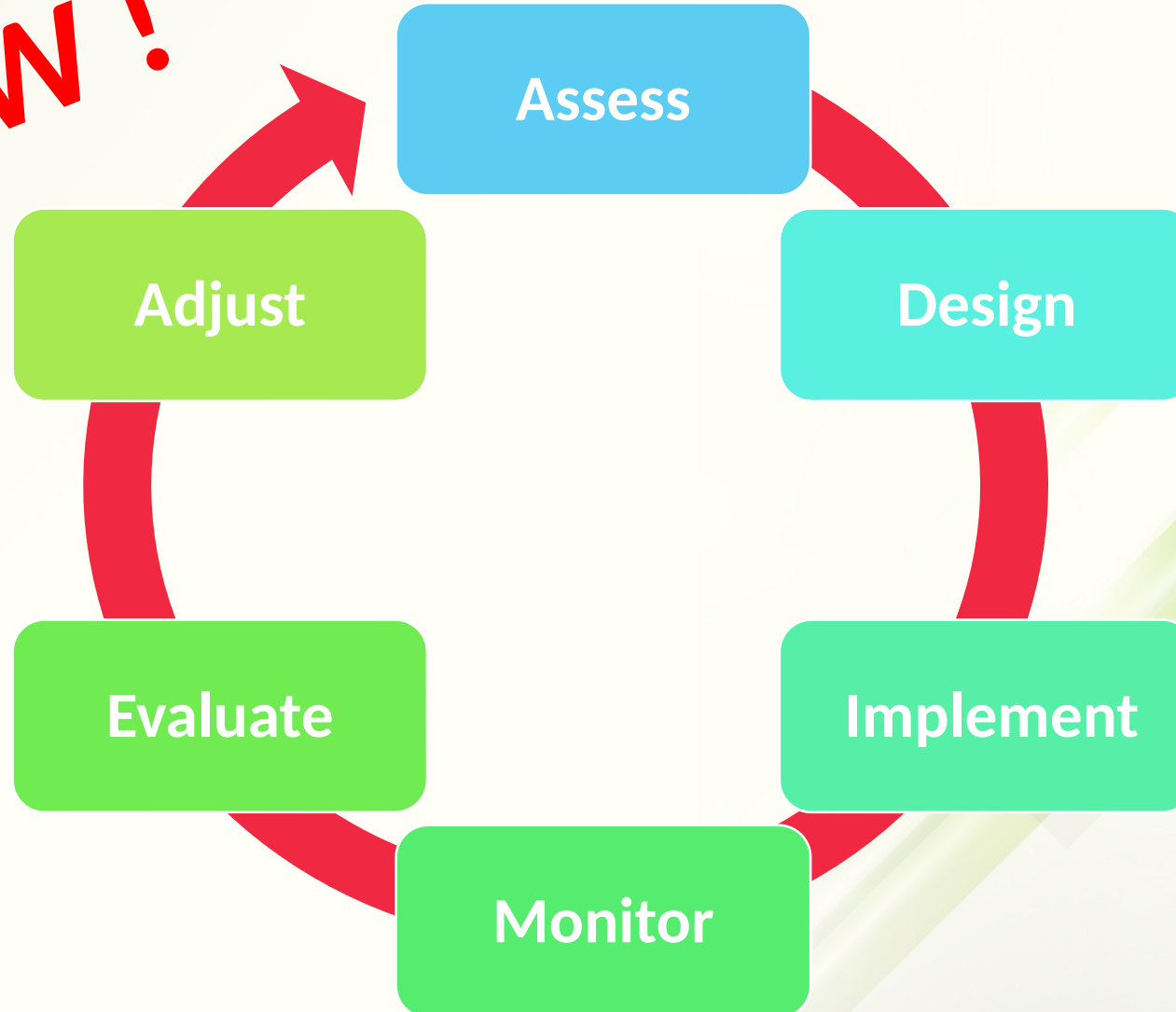
Integrated problems require integrated solutions

The answer: continuous adaptive management



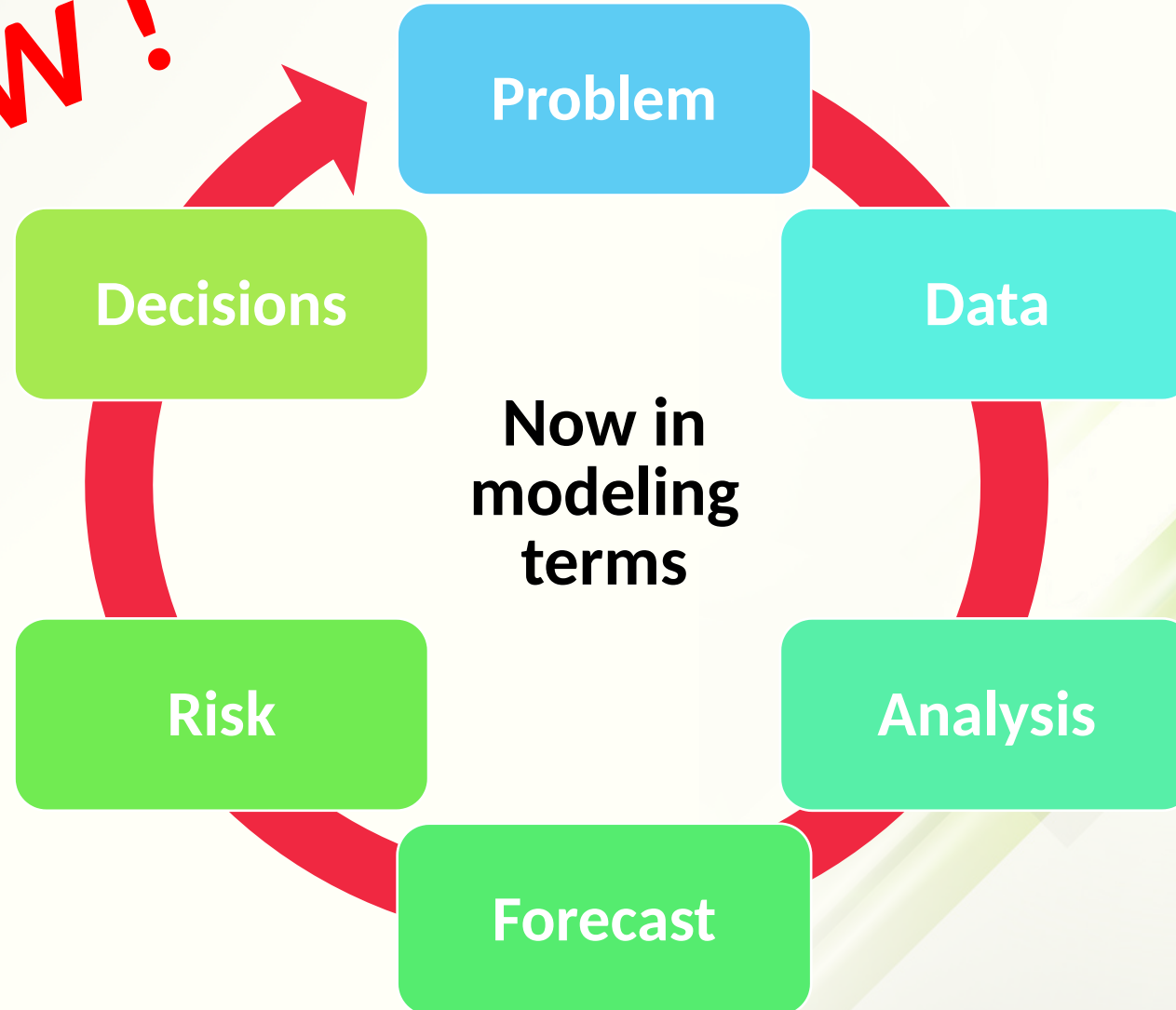
The answer **already exists**: continuous adaptive management

NOT NEW!



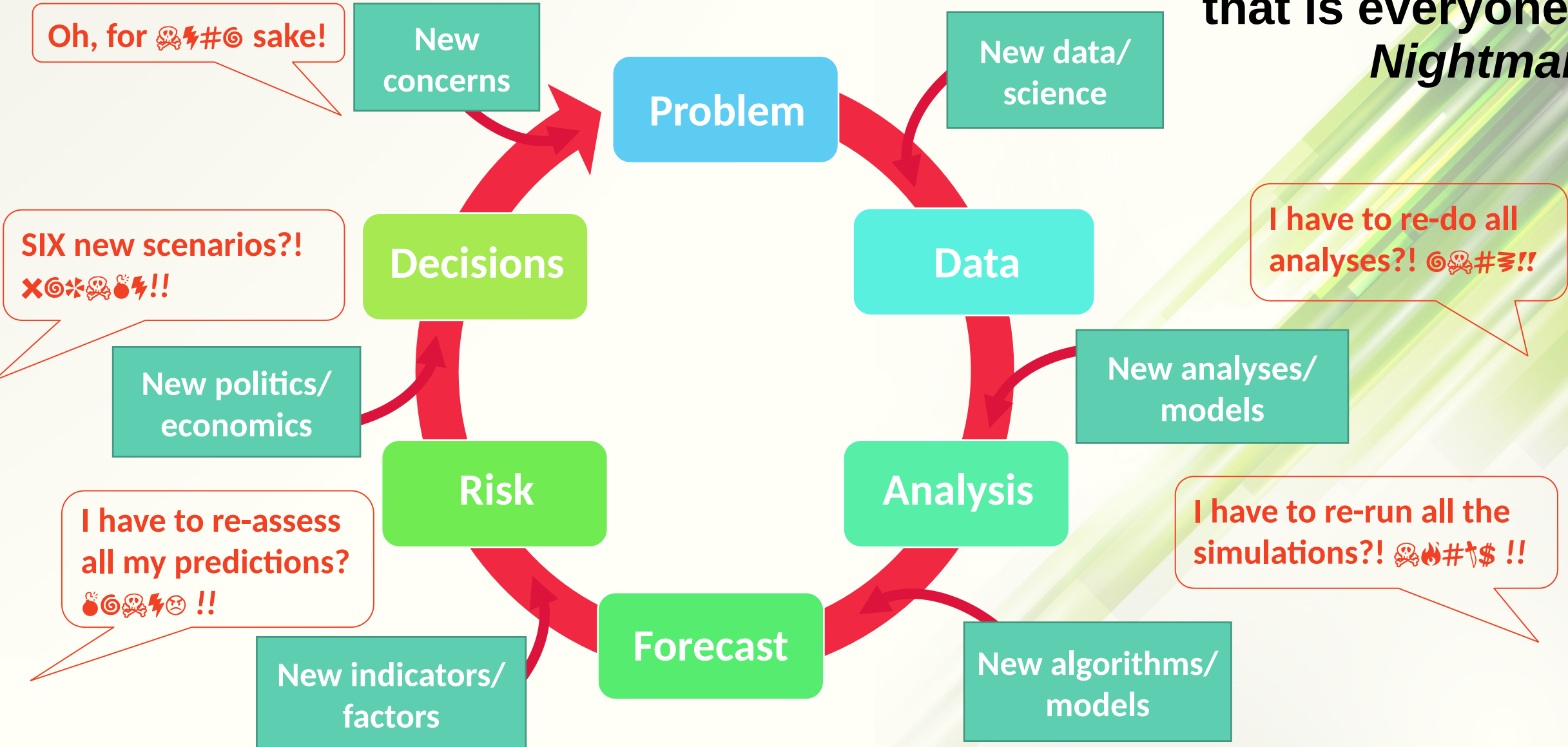
The answer **already exists**: continuous adaptive management

NOT NEW!



Continuous adaptive management

... Or the *dream* framework that is everyone's *Nightmare*



Continuous adaptive management

... Or the *dream* framework that is everyone's *Nightmare*

Time consuming, frustrating and costly



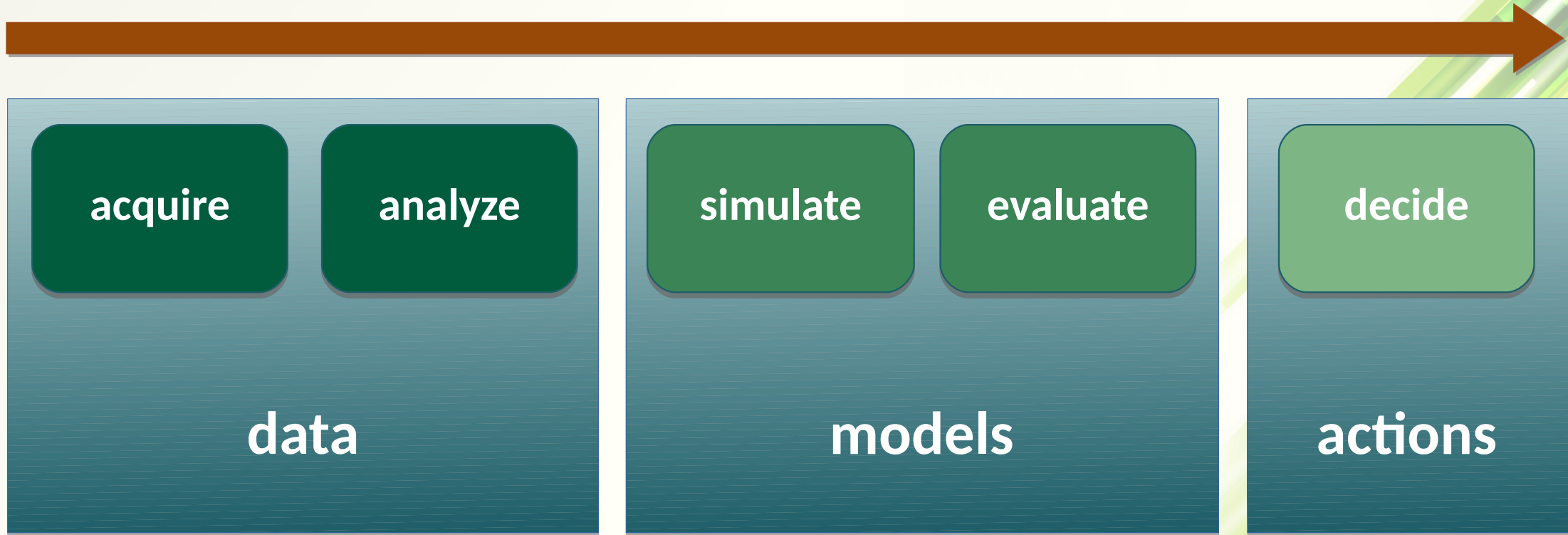
How did we get there?



Silos, Data, Cumulative, Decision Support

How did we get there?

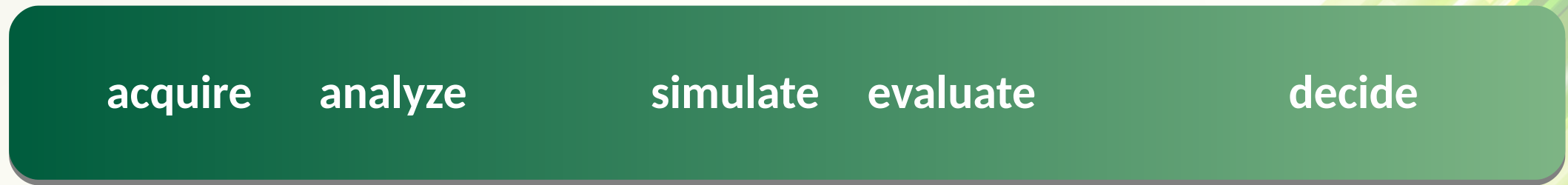
> Silos beget interrupted workflows



Even good collaborative research programs rely on interrupted workflows

How did we get there?

> **Solution: integrate our workflows**



data

models

actions

How did we get there?

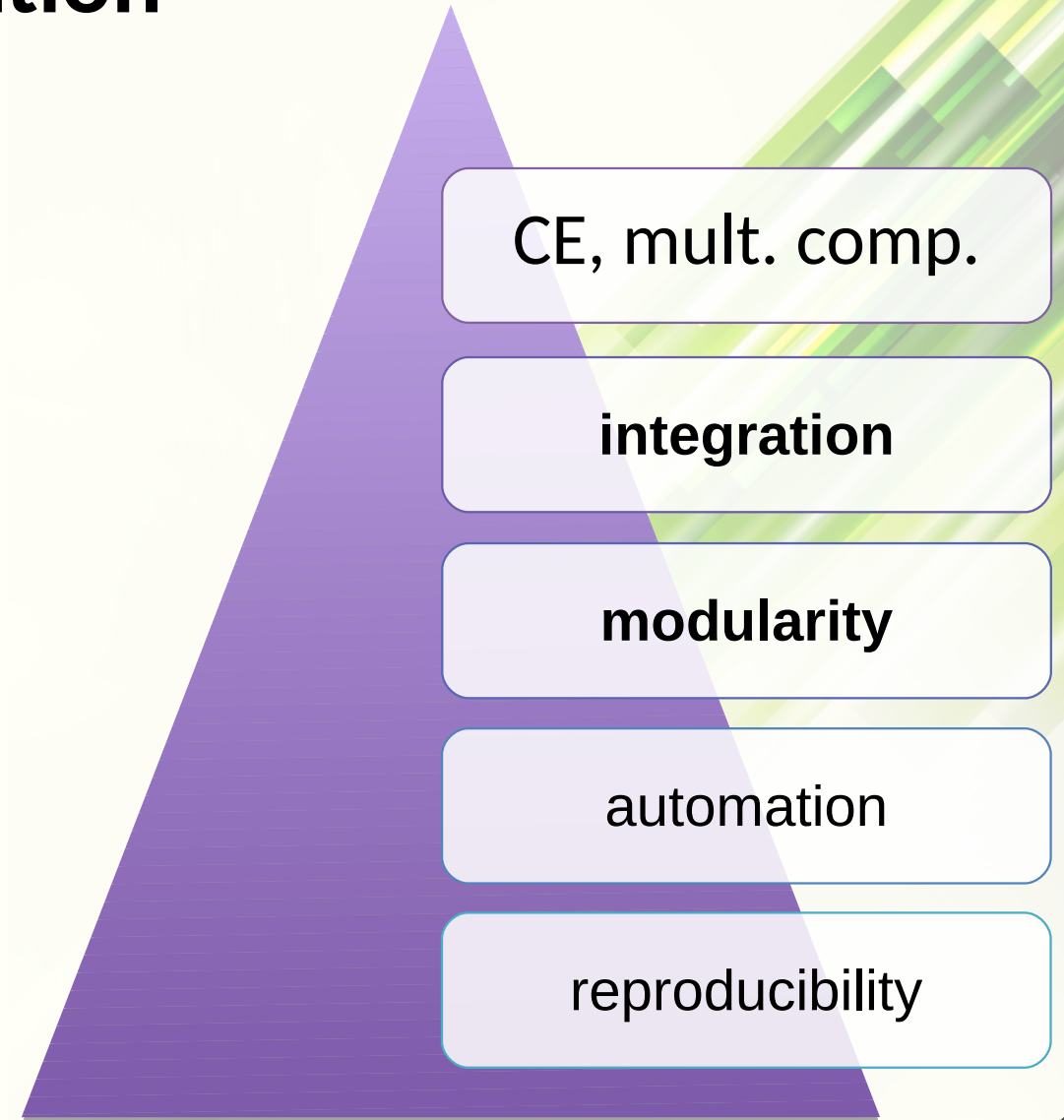
> Reproducibility is key to integration

Reproducible workflows enable:

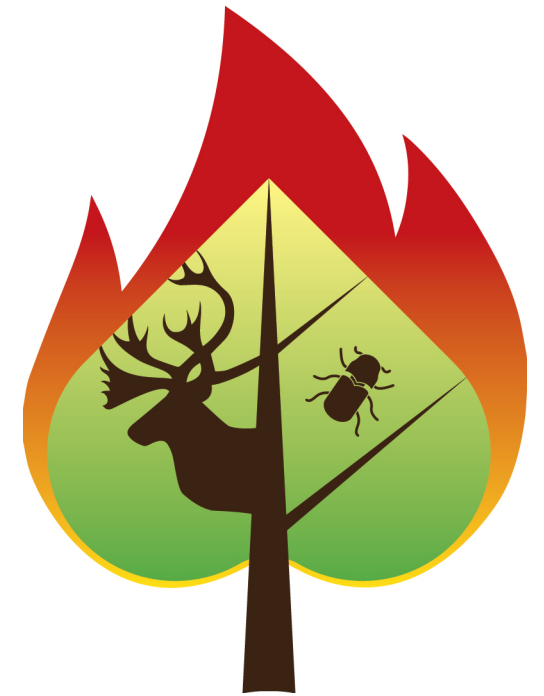
- ✓ Model comparisons
- ✓ Model integration
- ✓ Modeling cumulative effects



**Modularity
(composability) is key**



Where do we go from here?

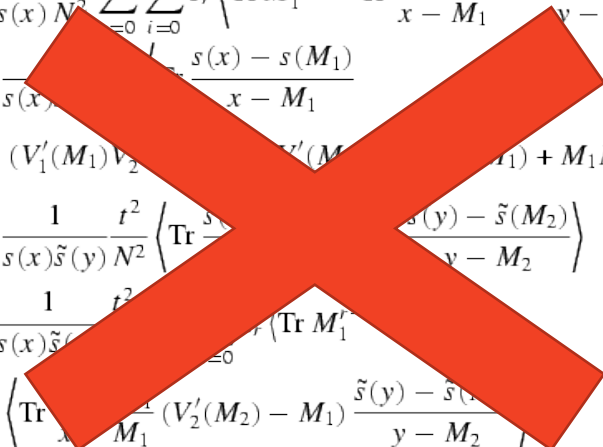




‘Is it a[nother] model?’ NO

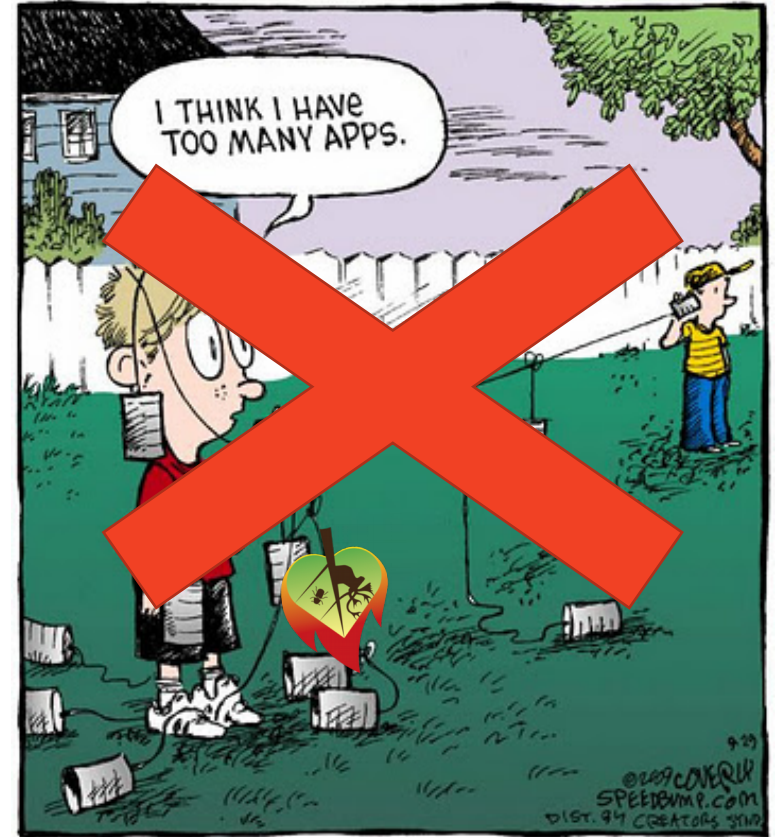


$$\begin{aligned}
 &= (V_2'(y) - x)(V_1'(x) - y) - P(x, y) + t \\
 &\quad - \frac{1}{\tilde{s}(y)} \frac{t}{N} \left\langle \text{Tr} \frac{V_1'(x) - V_1'(M_1)}{x - M_1} (V_2'(M_2) - M_1) \frac{\tilde{s}(y) - \tilde{s}(M_2)}{y - M_2} \right\rangle \\
 &\quad + \frac{1}{\tilde{s}(y)} \sum_{s=0}^{K_2} \sum_{j=0}^{s-1} \tilde{s}_s \frac{t}{N} \left\langle \text{Tr} M_2^{s-1-j} \right\rangle \frac{t}{N} \left\langle \text{Tr} \frac{V_1'(x) - V_1'(M_1)}{x - M_1} \frac{y^j - M_2^j}{y - M_2} \right\rangle \\
 &\quad - \frac{1}{s(x)} \frac{t}{N} \left\langle \text{Tr} \frac{s(x) - s(M_1)}{x - M_1} (V_1'(M_1) - M_2) \frac{V_2'(y) - V_2'(M_2)}{y - M_2} \right\rangle \\
 &\quad + \frac{1}{s(x)} \frac{t^2}{N^2} \sum_{r=0}^{K_1} \sum_{i=0}^{r-1} s_r \left\langle \text{Tr} M_1^{r-1-i} \text{Tr} \frac{x^i - M_1^i}{x - M_1} \frac{V_2'(y) - V_2'(M_2)}{y - M_2} \right\rangle \\
 &\quad - \frac{1}{s(x)} \frac{t^2}{N^2} \sum_{r=0}^{K_1} \sum_{i=0}^{r-1} s_r \frac{s(x) - s(M_1)}{x - M_1} \\
 &\quad \times (V_1'(M_1) V_2'(M_2) - V_1'(M_1) M_2 + M_1 M_2) \frac{\tilde{s}(y) - \tilde{s}(M_2)}{y - M_2} \\
 &\quad - \frac{1}{s(x) \tilde{s}(y)} \frac{t^2}{N^2} \left\langle \text{Tr} \frac{s(x) - s(M_1)}{x - M_1} \frac{s(y) - \tilde{s}(M_2)}{y - M_2} \right\rangle \\
 &\quad + \frac{1}{s(x) \tilde{s}(y)} \frac{t^2}{N^2} \sum_{r=0}^{K_1} \sum_{i=0}^{r-1} s_r \left\langle \text{Tr} M_1^{r-1-i} \right\rangle \\
 &\quad \times \left\langle \text{Tr} \frac{s(x) - s(M_1)}{x - M_1} (V_2'(M_2) - M_1) \frac{\tilde{s}(y) - \tilde{s}(M_2)}{y - M_2} \right\rangle \\
 &\quad + \frac{1}{s(x) \tilde{s}(y)} \frac{t^2}{N^2} \sum_{s=0}^{K_2} \sum_{j=0}^{s-1} \tilde{s}_s \left\langle \text{Tr} M_2^{s-1-j} \right\rangle \\
 &\quad \times \left\langle \text{Tr} \frac{s(x) - s(M_1)}{x - M_1} (V_1'(M_1) - M_2) \frac{y^j - M_2^j}{y - M_2} \right\rangle \\
 &\quad - \frac{1}{s(x) \tilde{s}(y)} \frac{t^3}{N^3} \sum_{r=0}^{K_1} \sum_{i=0}^{r-1} \sum_{s=0}^{K_2} \sum_{j=0}^{s-1} s_r \tilde{s}_s \left\langle \text{Tr} M_1^{r-1-i} \right\rangle \\
 &\quad \times \left\langle \text{Tr} M_2^{s-1-j} \right\rangle \left\langle \text{Tr} \frac{x^i - M_1^i}{x - M_1} \frac{y^j - M_2^j}{y - M_2} \right\rangle
 \end{aligned}$$



‘Is it a[nother] model?’ NO

‘Is it a[nother] modeling software?’ NO



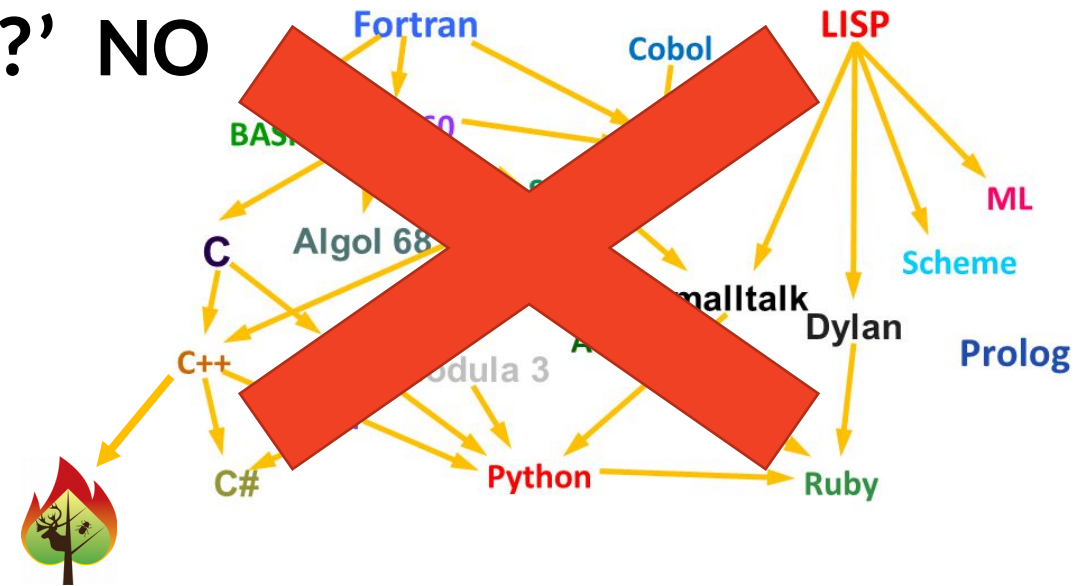
‘Is it a[nother] model?’ NO

‘Is it a[nother] modeling software?’ NO

‘Is it a[nother] programming language?’ NO

A family tree of languages

Some of the 2400 + programming languages



‘Is it a[nother] model?’ NO

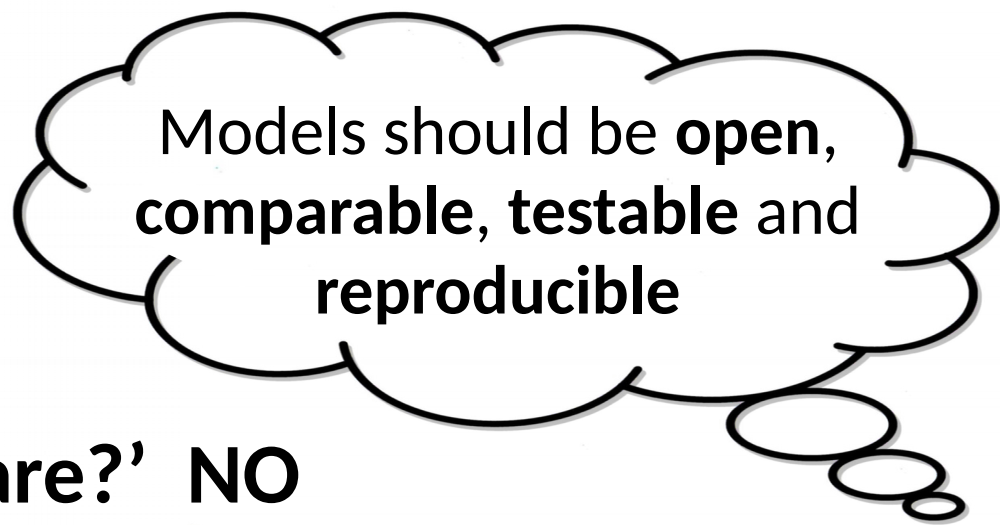
‘Is it a[nother] modeling software?’ NO

‘Is it a[nother] programming language?’ NO

‘Is it a[nother] coffee machine?’ NO



‘Is it a[nother] model?’ NO



‘Is it a[nother] modeling software?’ NO

‘Is it a[nother] programming language?’ NO

No... it’s a modeling tool/framework!

(almost a modeling philosophy really...!)



Spatial Discrete Event Simulator

✓ Suitable for a wide-range of modeling approaches (incl. process-based)

✓ Modular by design

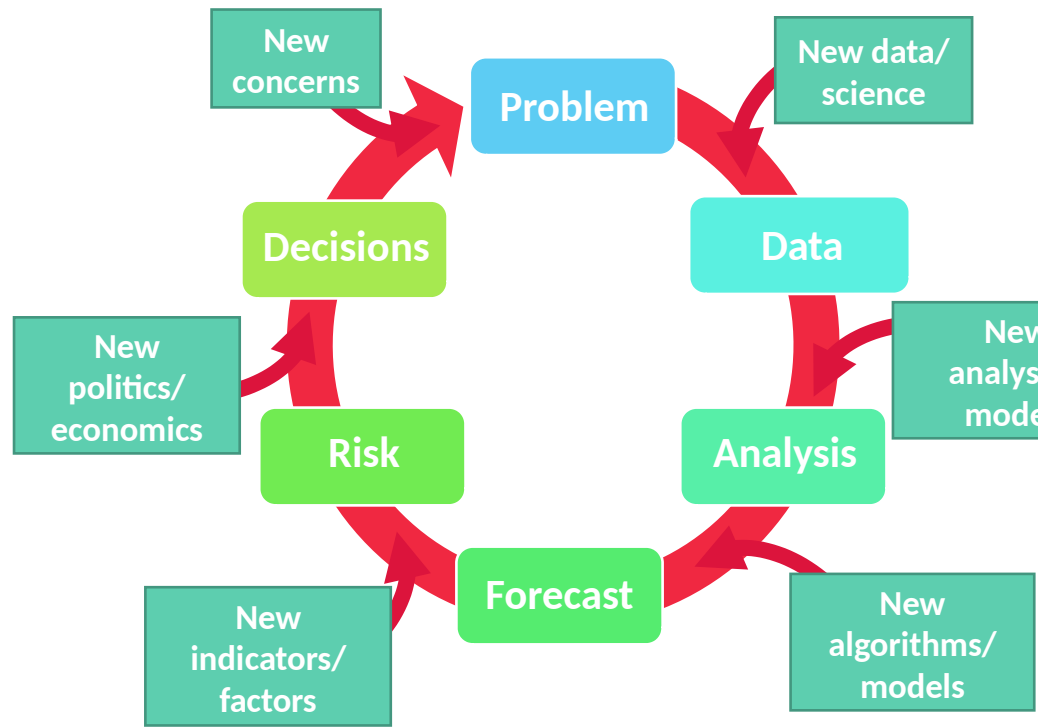
Shareable model components

Integrate components across domains

“Make your own” model



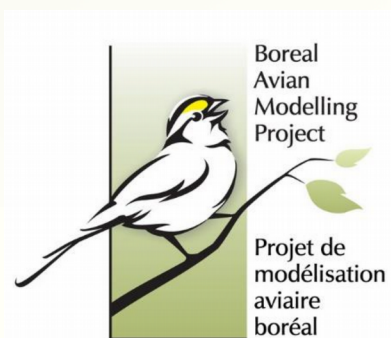
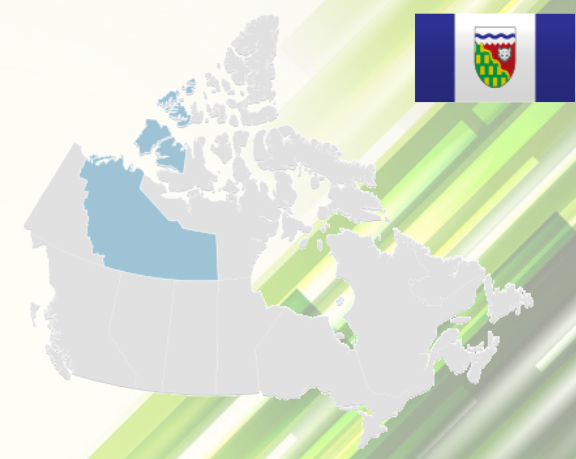
SpaDES : modularity?



Timber supply
Fire
Climate
Carbon
Caribou
Birds

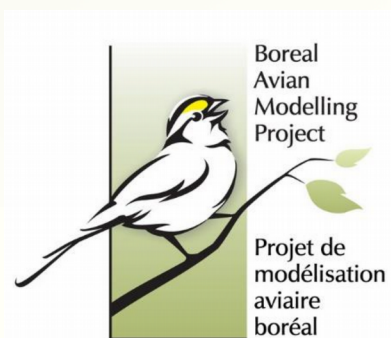
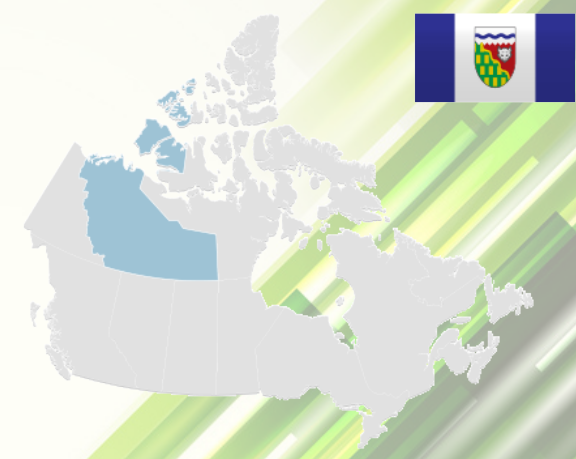


Data to actions: a multi-species approach case study for Northwest Territories

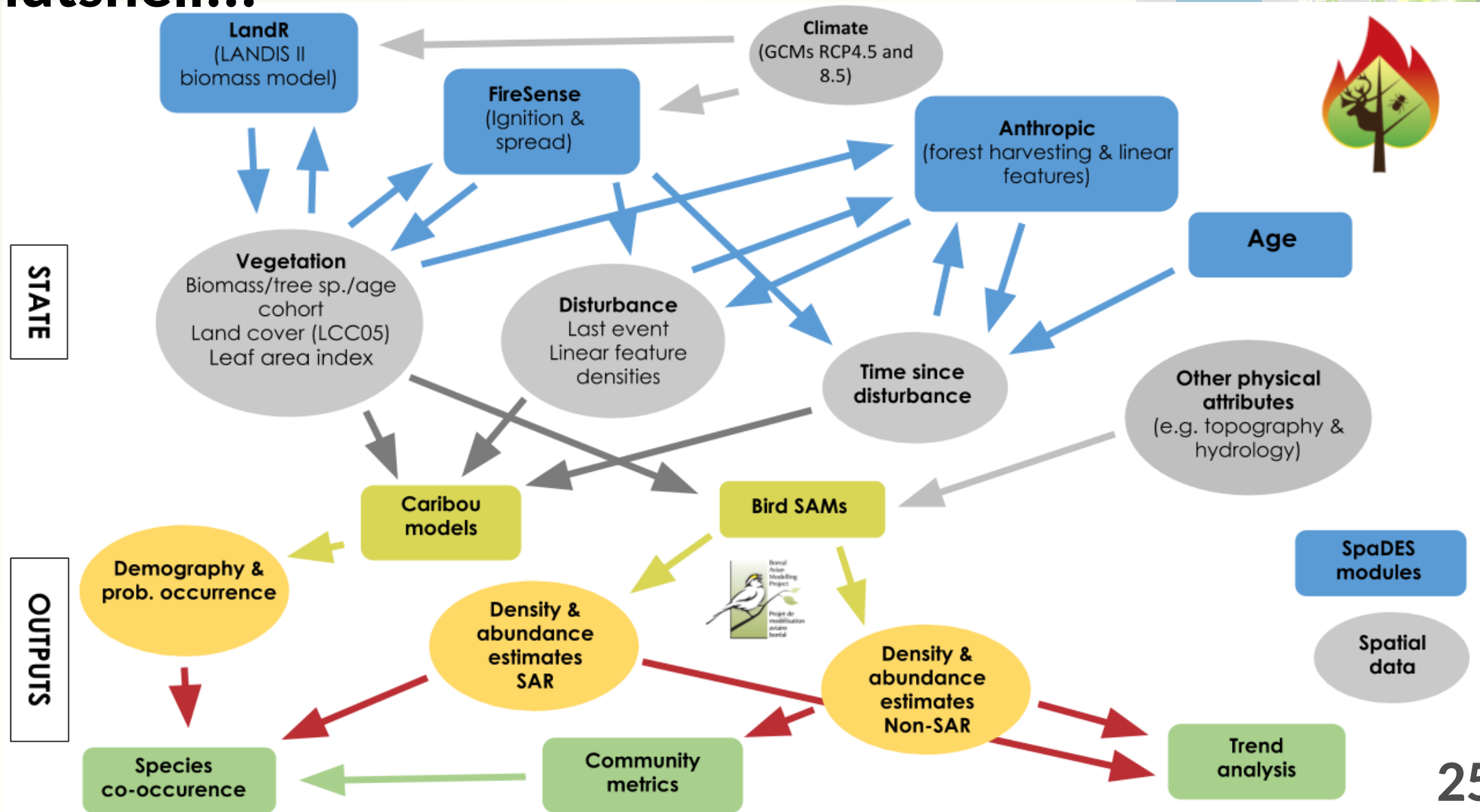
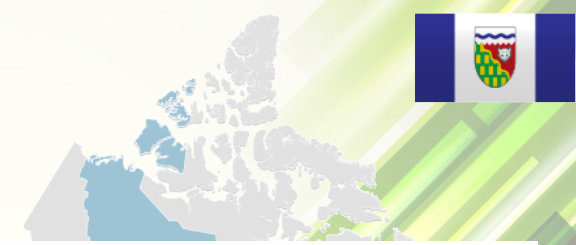


Data to actions: a multi-species approach case study for Northwest Territories

integrating (state-of-art) simulation models
to promote trade-off analyses on
human development,
caribou,
and birds



The NWT project in a nutshell...



The NWT project in numbers

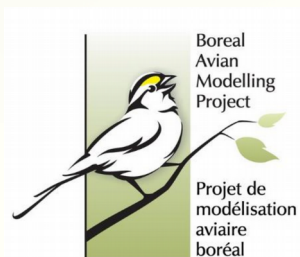
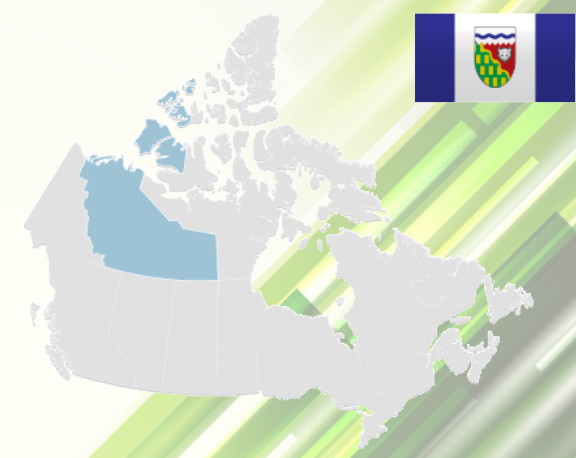
1 coordinator

3 different teams / research groups

7 different disciplines

15 different peoples involved in coding (7 ♀, 8 ♂)

3 months

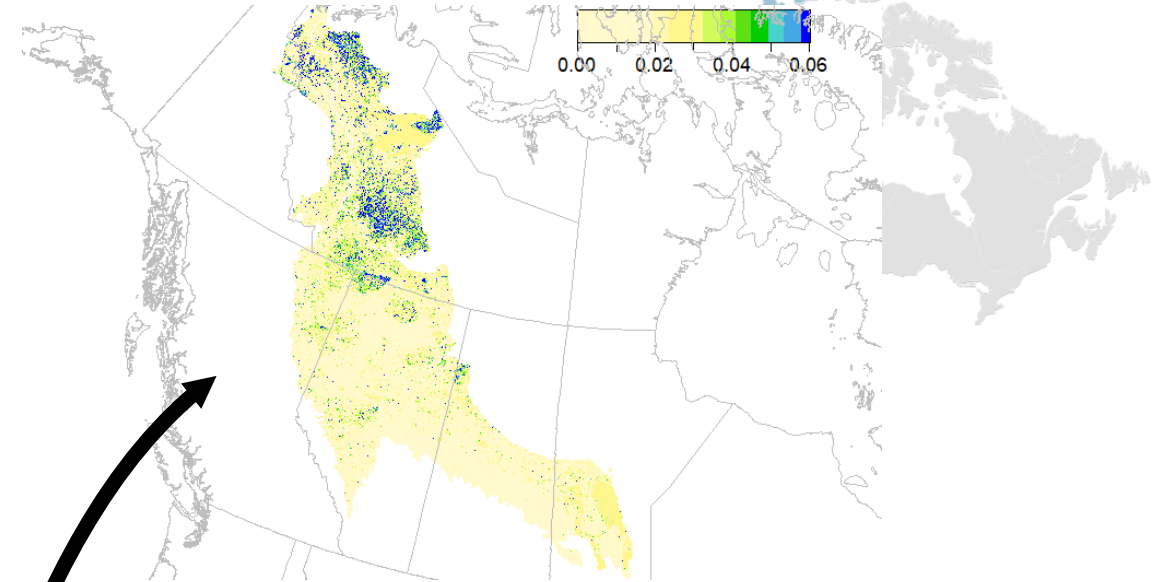


The NWT project

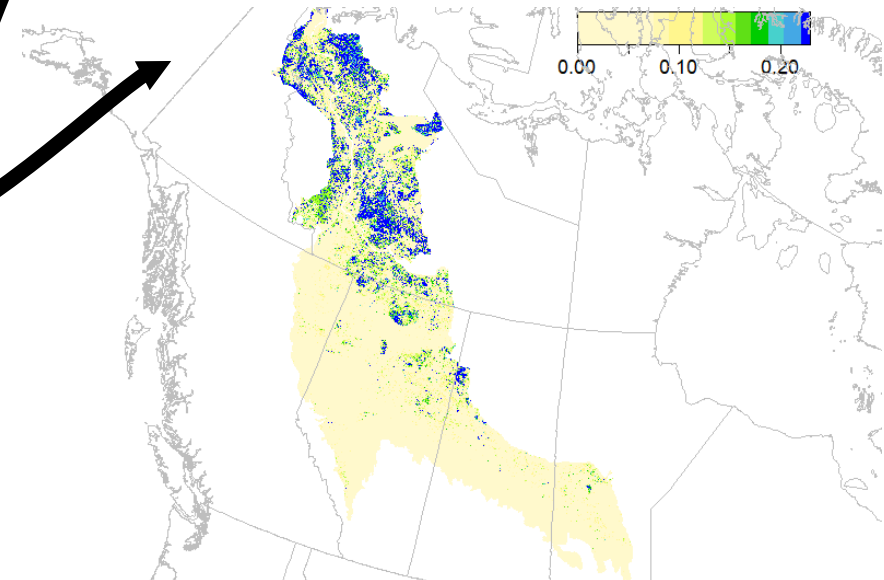
some preliminary results



OSFL current



OSFL 2100



Fire

Climate

Anthropogenic

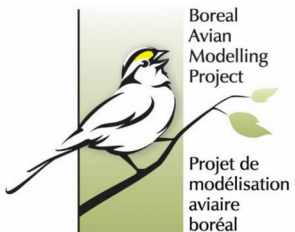
Vegetation

Bird diversity

Bird occurrence

Caribou occurrence

Caribou populations



The NWT project

some preliminary results



Fire

Climate

Anthropogenic

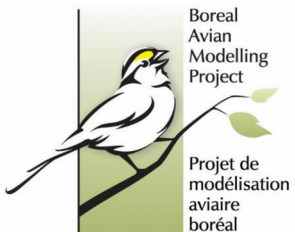
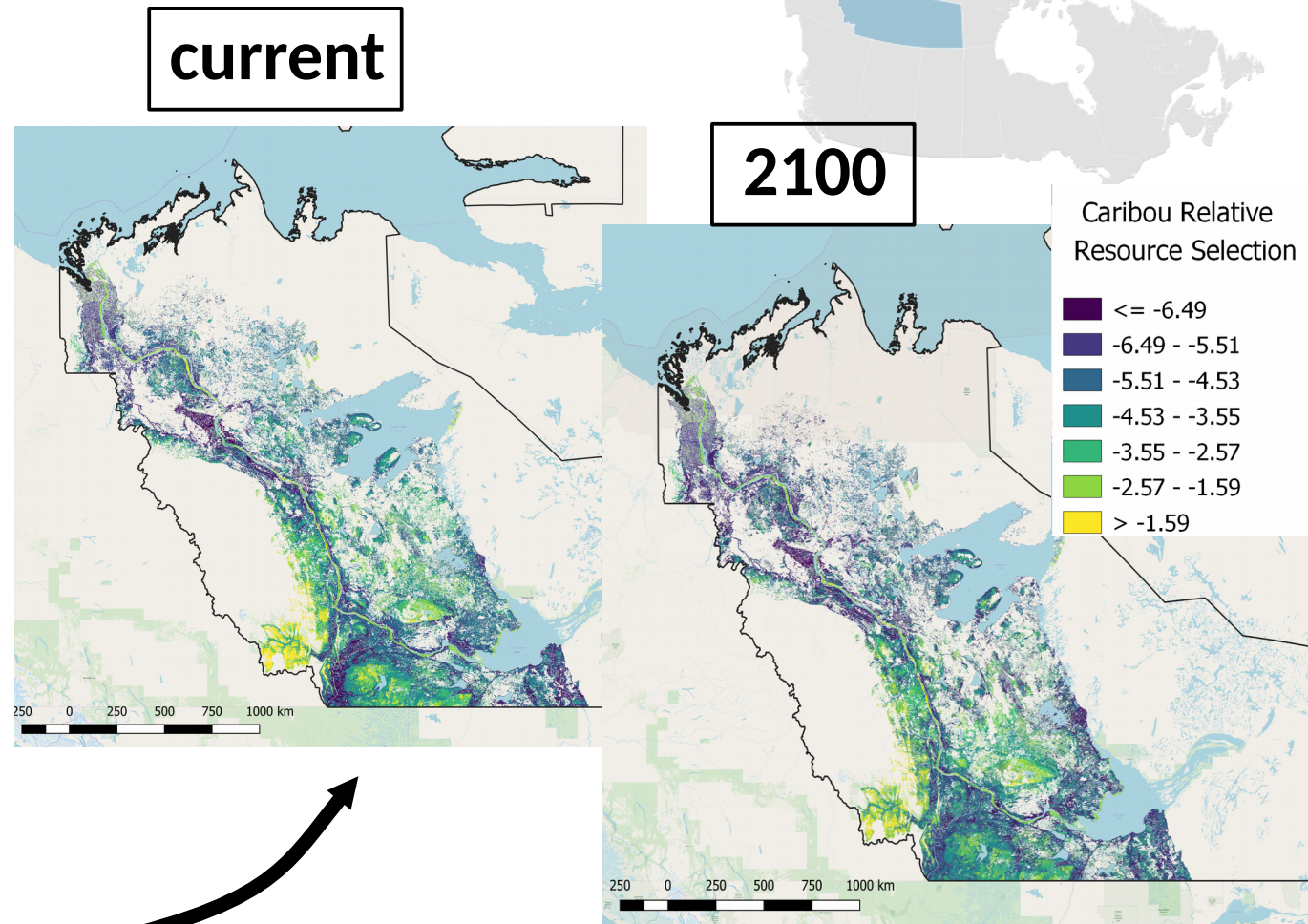
Vegetation

Bird diversity

Bird occurrence

Caribou occurrence

Caribou populations

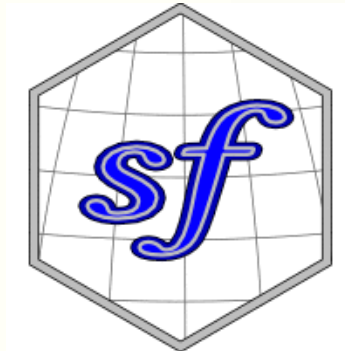
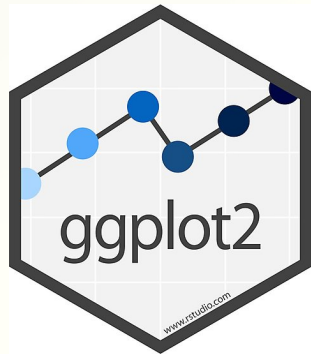




written in



Rtoolbox: graphics, rmarkdown, spatial, statistics



Want to know more?

<http://predictiveecology.org/SpaDES/>

<https://github.com/PredictiveEcology/SpaDES>

eliot.mcintire@canada.ca