RestREco

Restoring Resilient Ecosystems

Measuring stable states and resilience

Dr Will Rust + Dr Daniel Simms

Cranfield University

Will.rust@cranfield.ac.uk

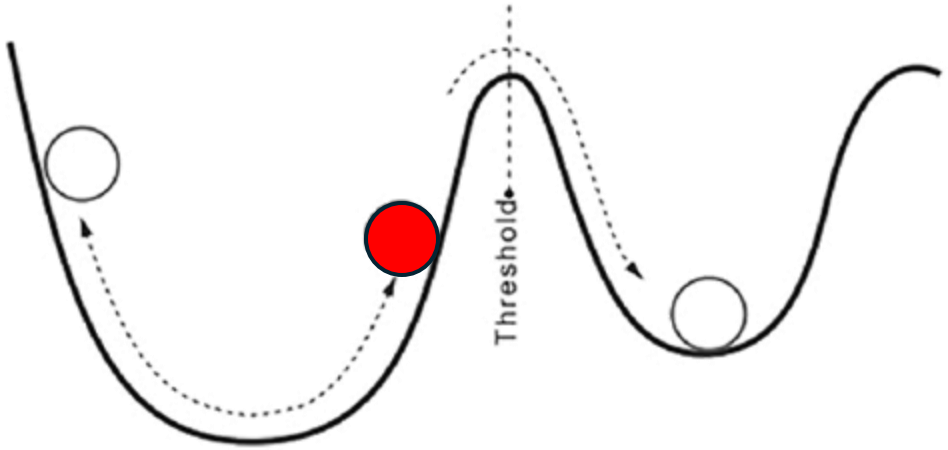
D.m.simms@cranfield.ac.uk



Ecological Ball and Cup

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- **Hollin (1973) -** Ecological Resilience as a ball in a cup
- **Loch Neigh** flipped into a eutrophied state in 2023
- Ecosystem → Tipping point = **Critical Slowing Down**
- We can model resilience and CSD by estimating system autocorrelation but need **high-frequency measurements**



Ecological resilience concept





Keane, R. E., Loehman, R. A., Holsinger, L. M., Falk, D. A., Higuera, P., Hood, S. M., and Hessburg, P. F.: Use of landscape simulation modeling to quantify resilience for ecological applications, Ecosphere, 9, e02414, 2018.
https://wodnesprawy.pl/en/lough-neagh-lake-an-example-of-the-changes-taking-place-in-nature/
https://www.bbc.co.uk/news/uk-northern-ireland-66995187

Questions

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1. Is a system becoming unstable and when might it fail?
2. What might the system look like after a transition?

3. How do we manage this system??

Question 1

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Is a system becoming unstable and when might it fail?

Question 1 Is a system becoming unstable and when might it fail?

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Productivity / Health



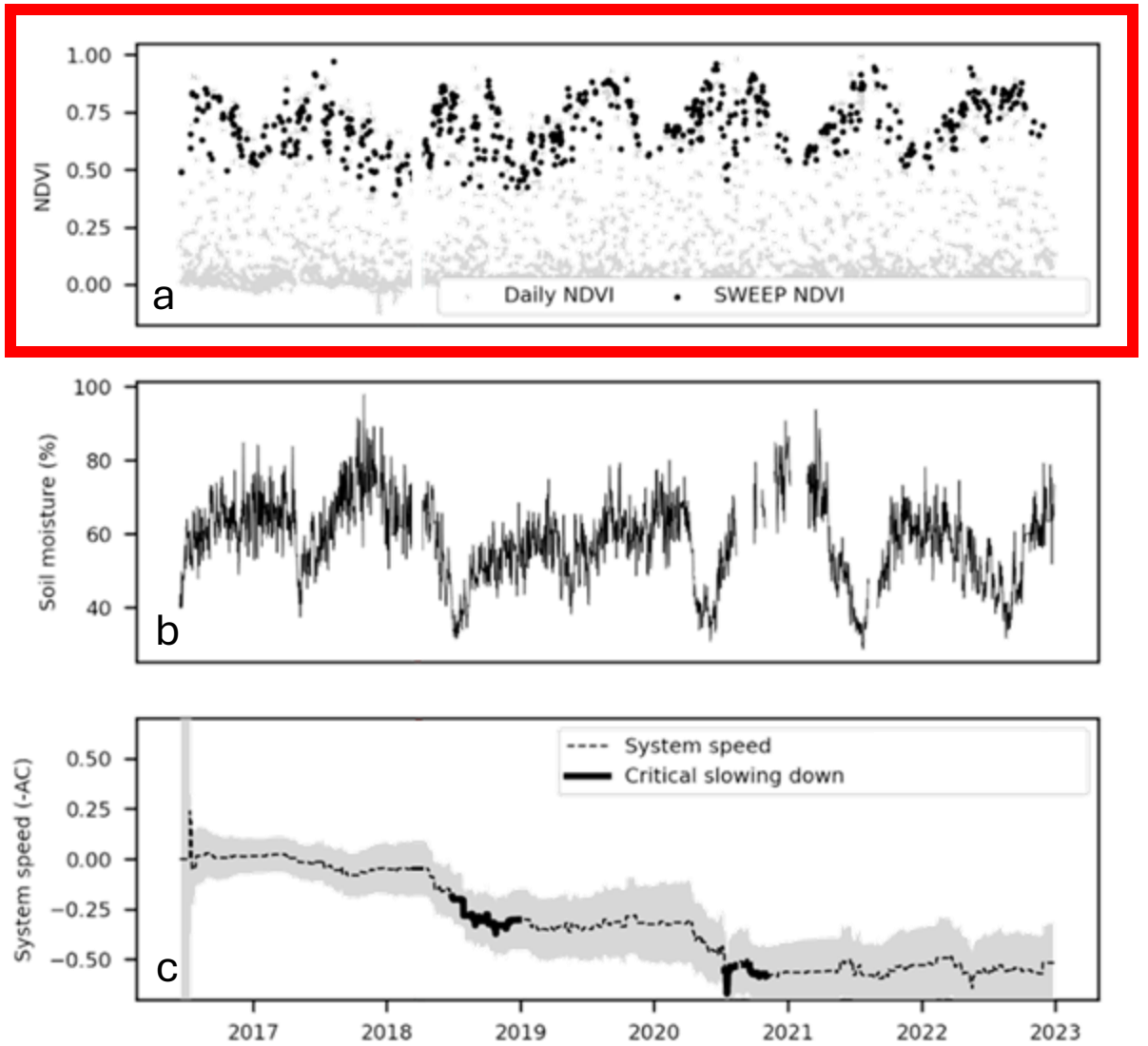
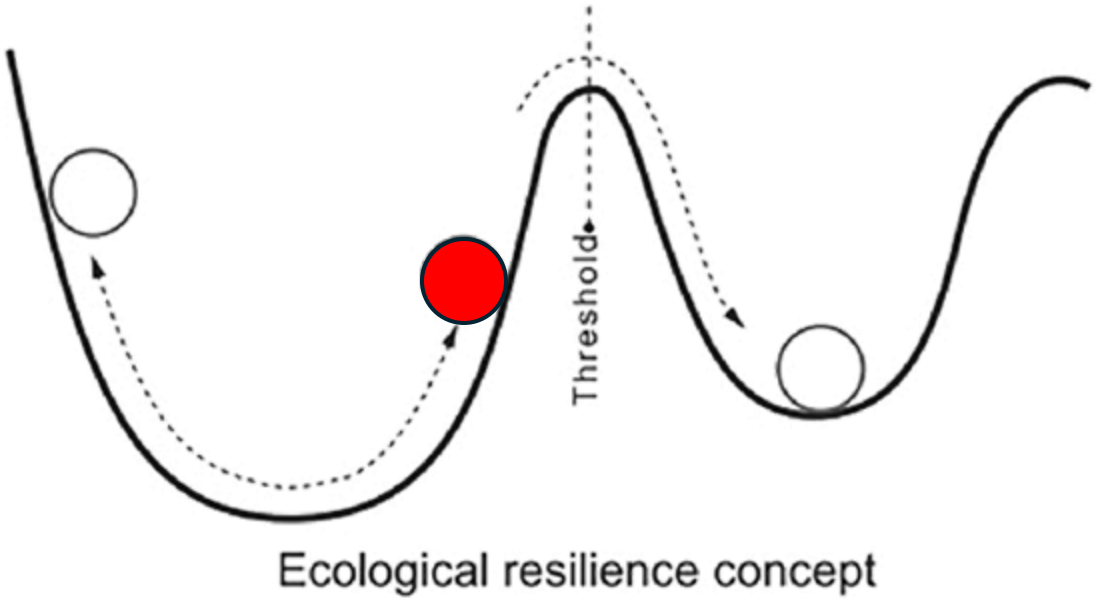


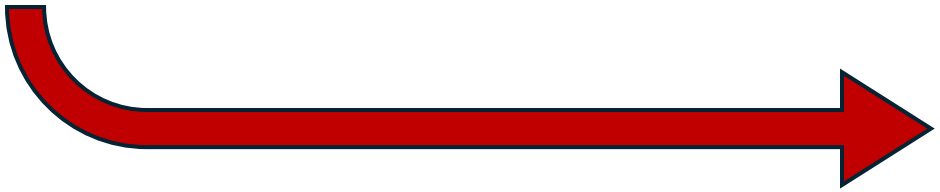
Figure 13- Glenwherry Grassland side - results from state-space model using both SWEEP and Composite NDVI

Question 1 Is a system becoming unstable and when might it fail?

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System speed, aka *recovery rate + response rate*



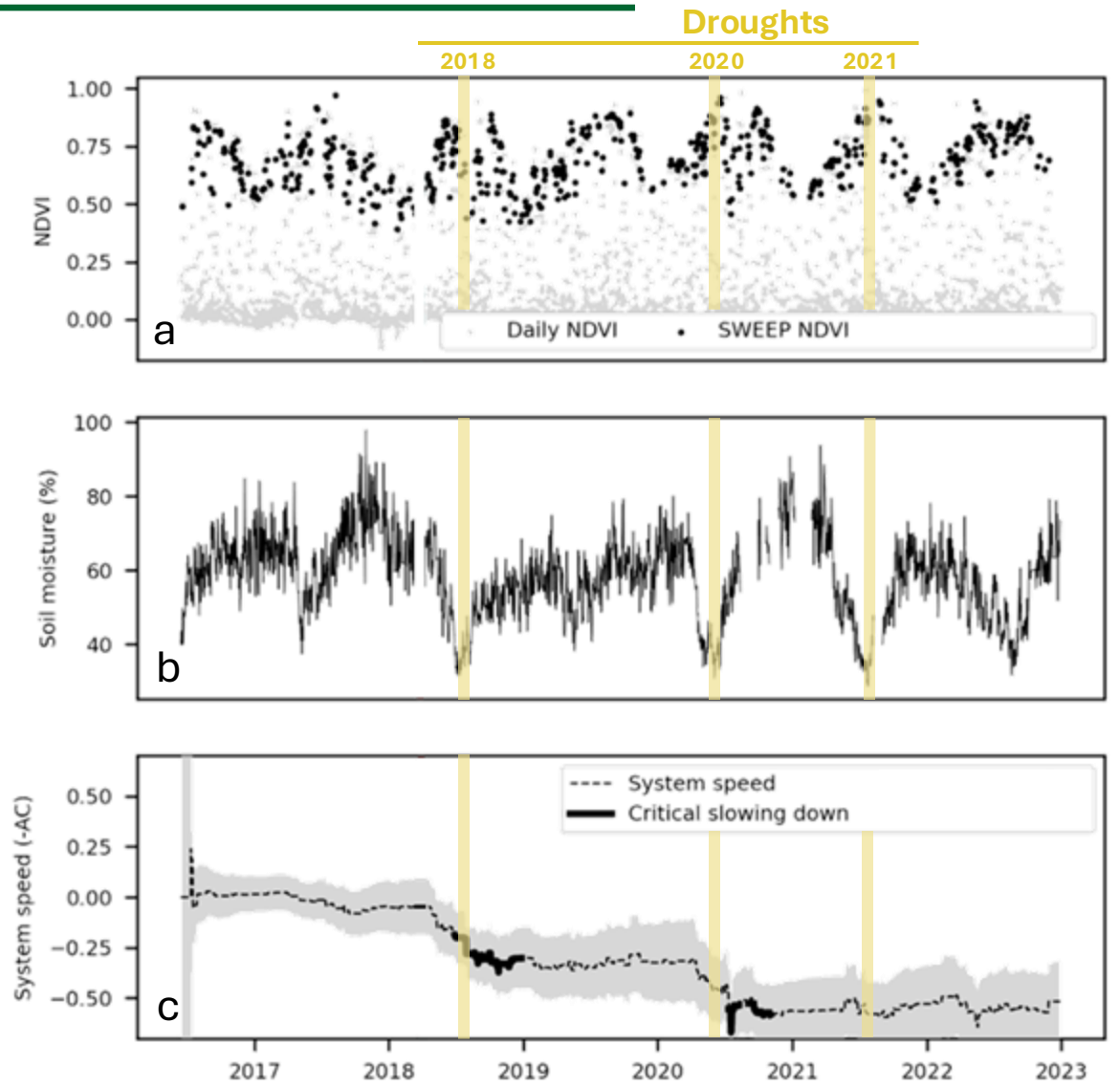


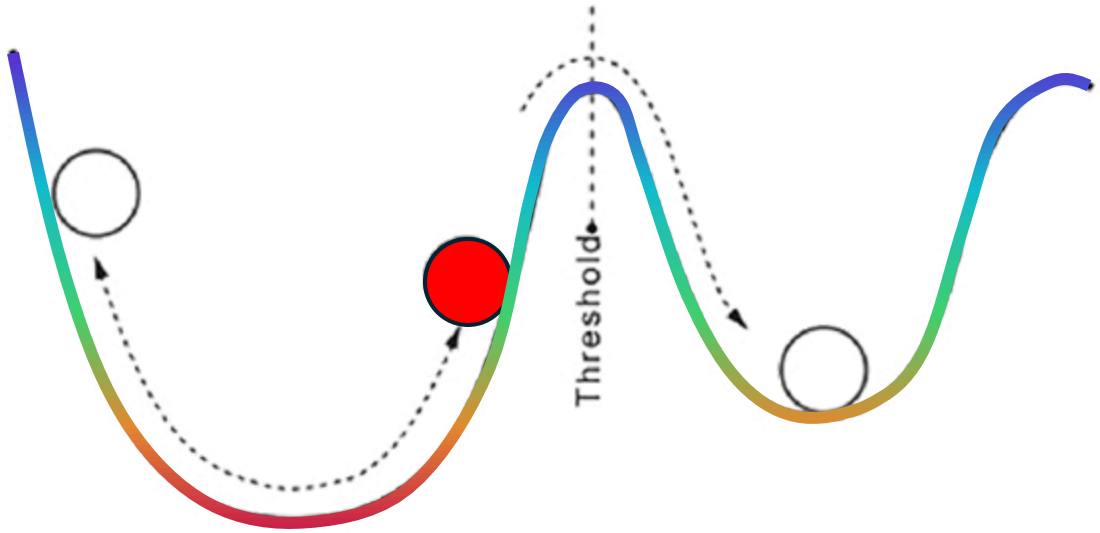
Figure 13- Glenwherry Grassland side - results from state-space model using both SWEEP and Composite NDVI

Question 2

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What might the system look like after a transition?
In what way is the system changing?

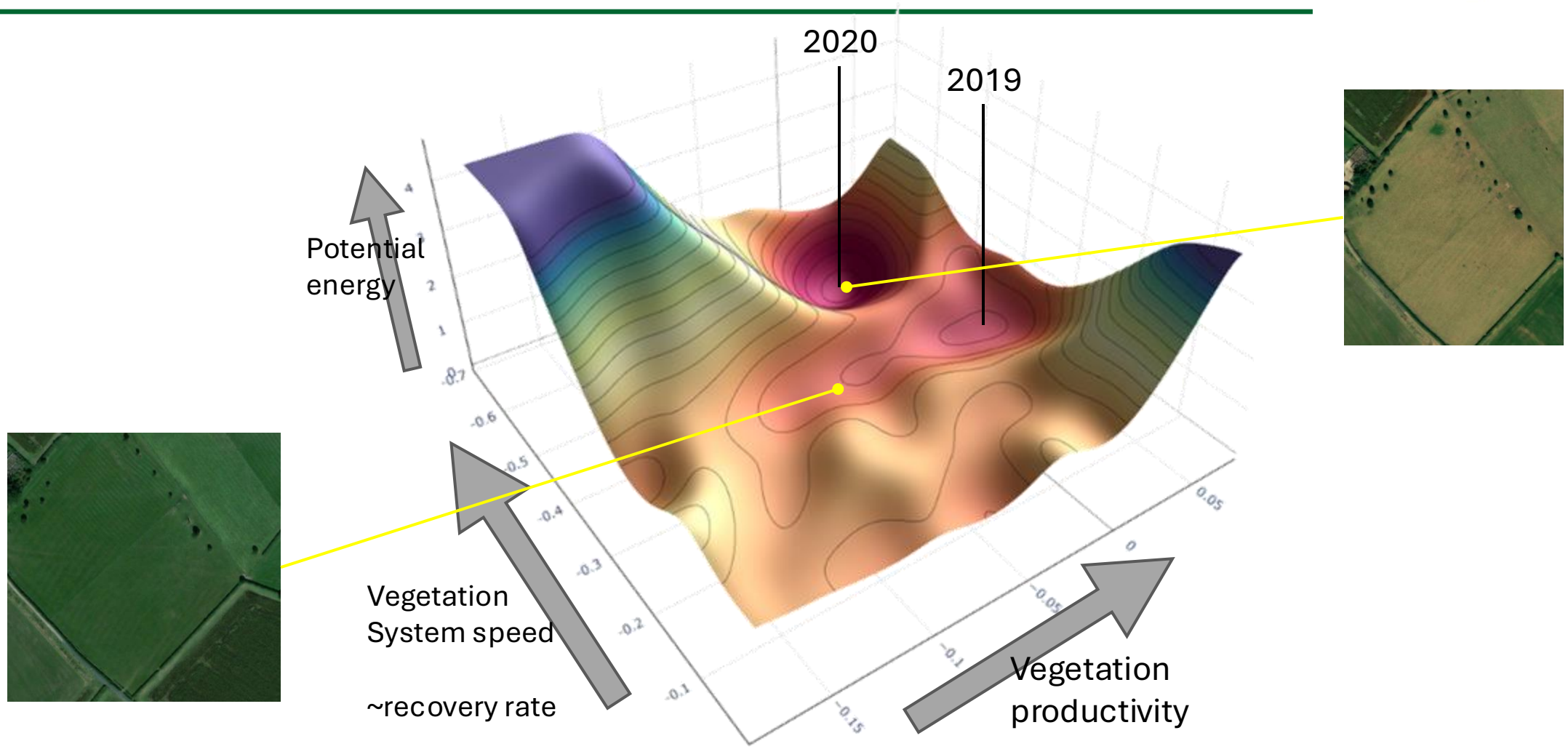
Question 2 What might the system look like after a transition?



Ecological resilience concept

Question 2 What might the system look like after a transition?

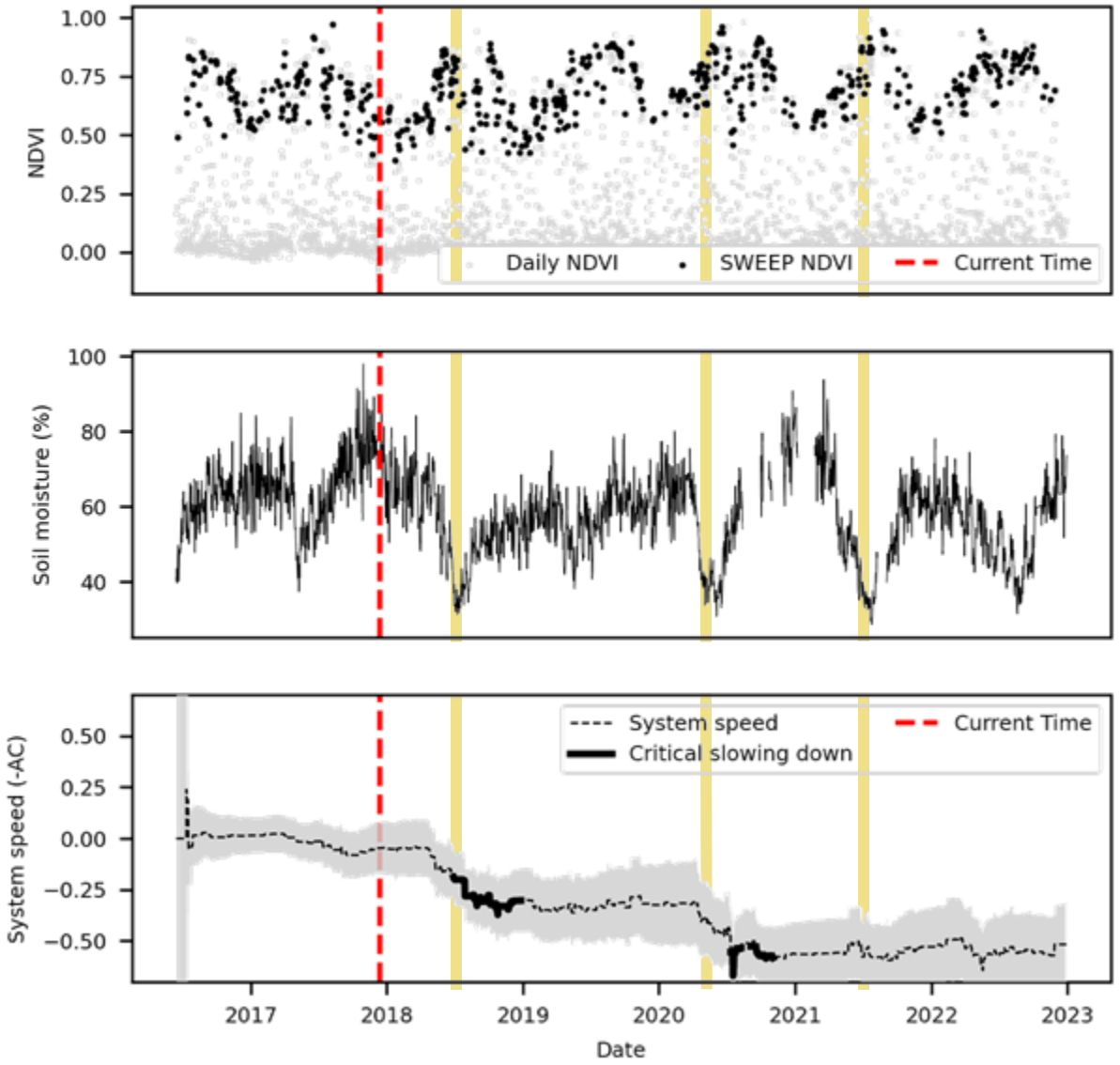
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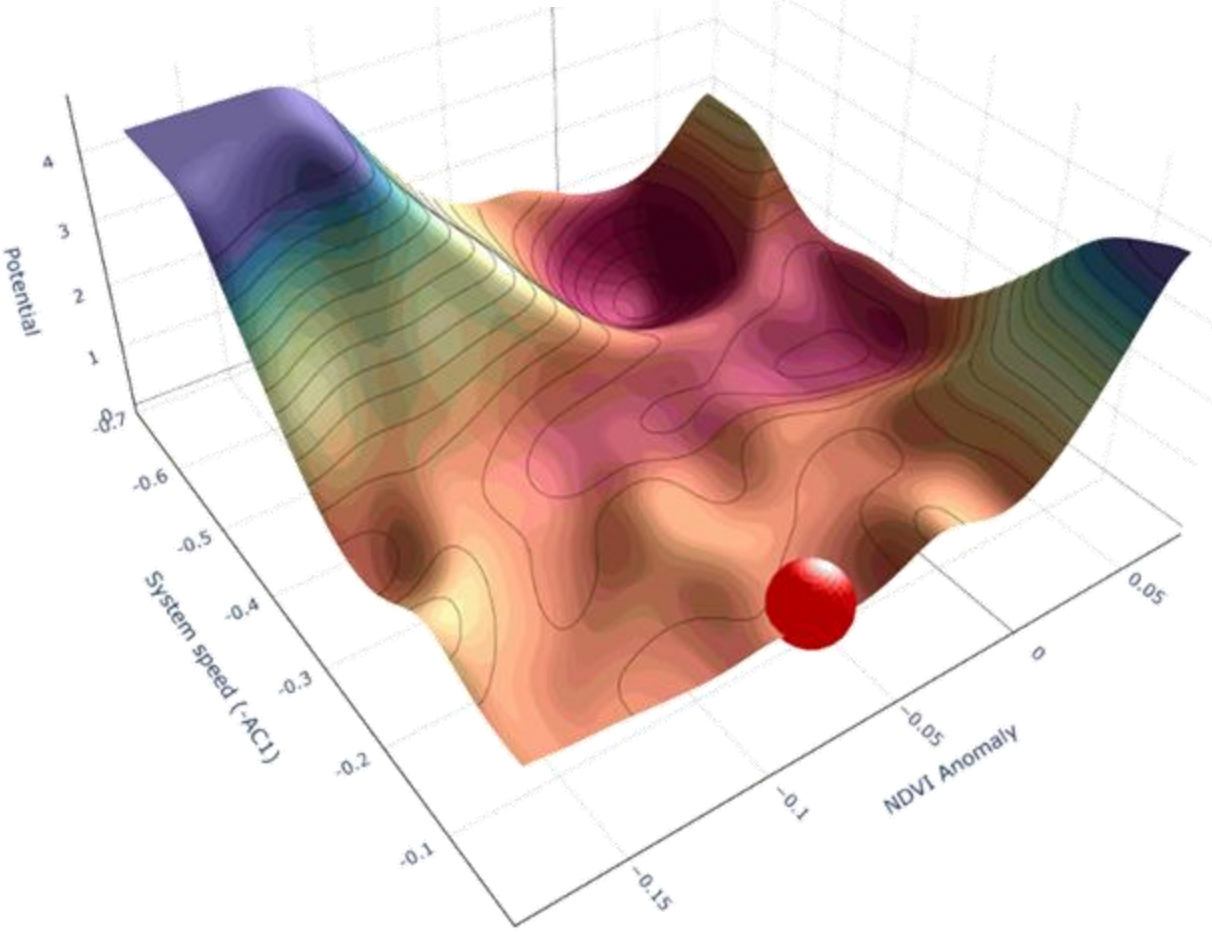
Question 2 What might the system look like after a transition?

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Droughts



Glenwherry Improved Grassland

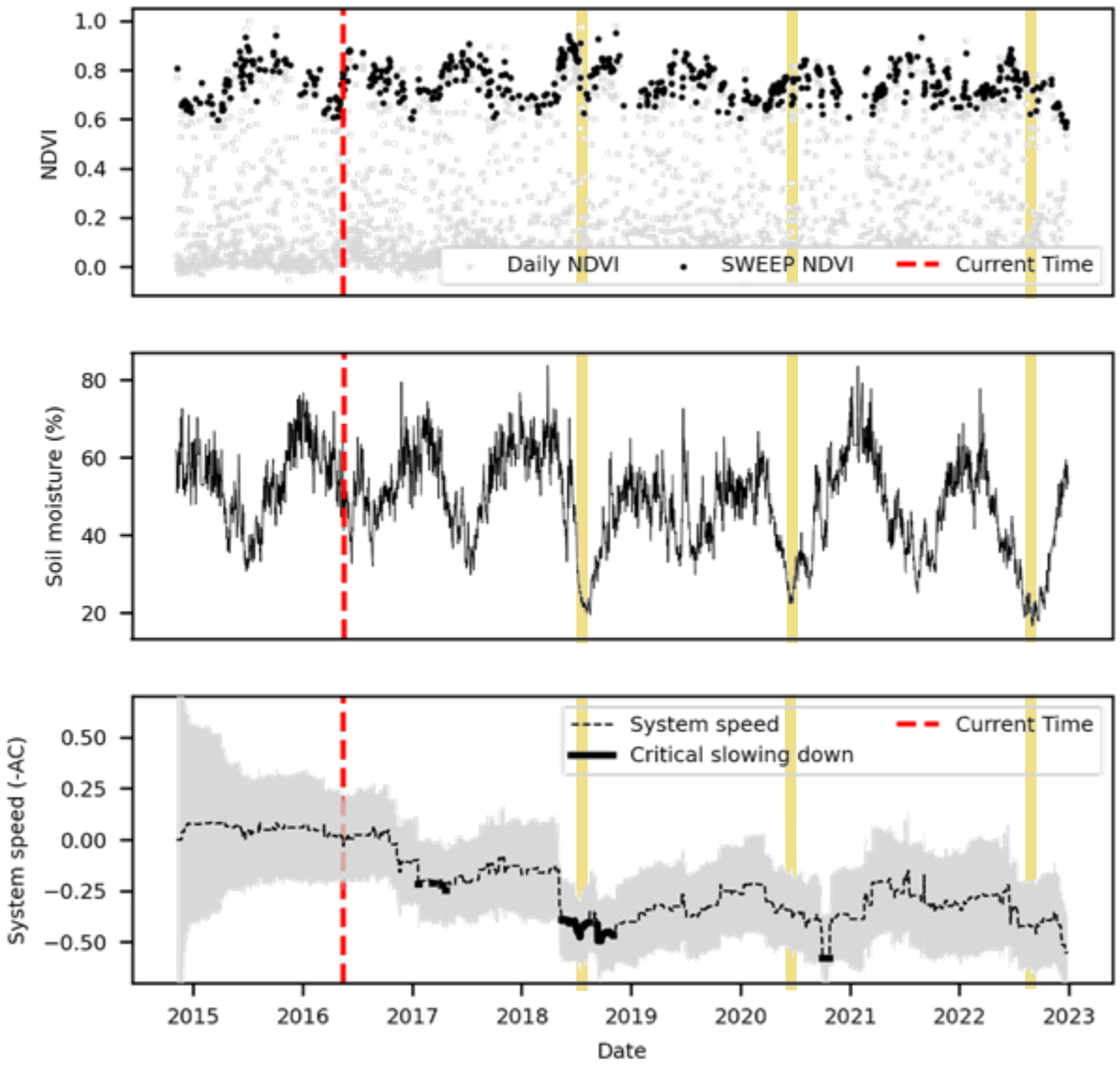


= Grassland system position

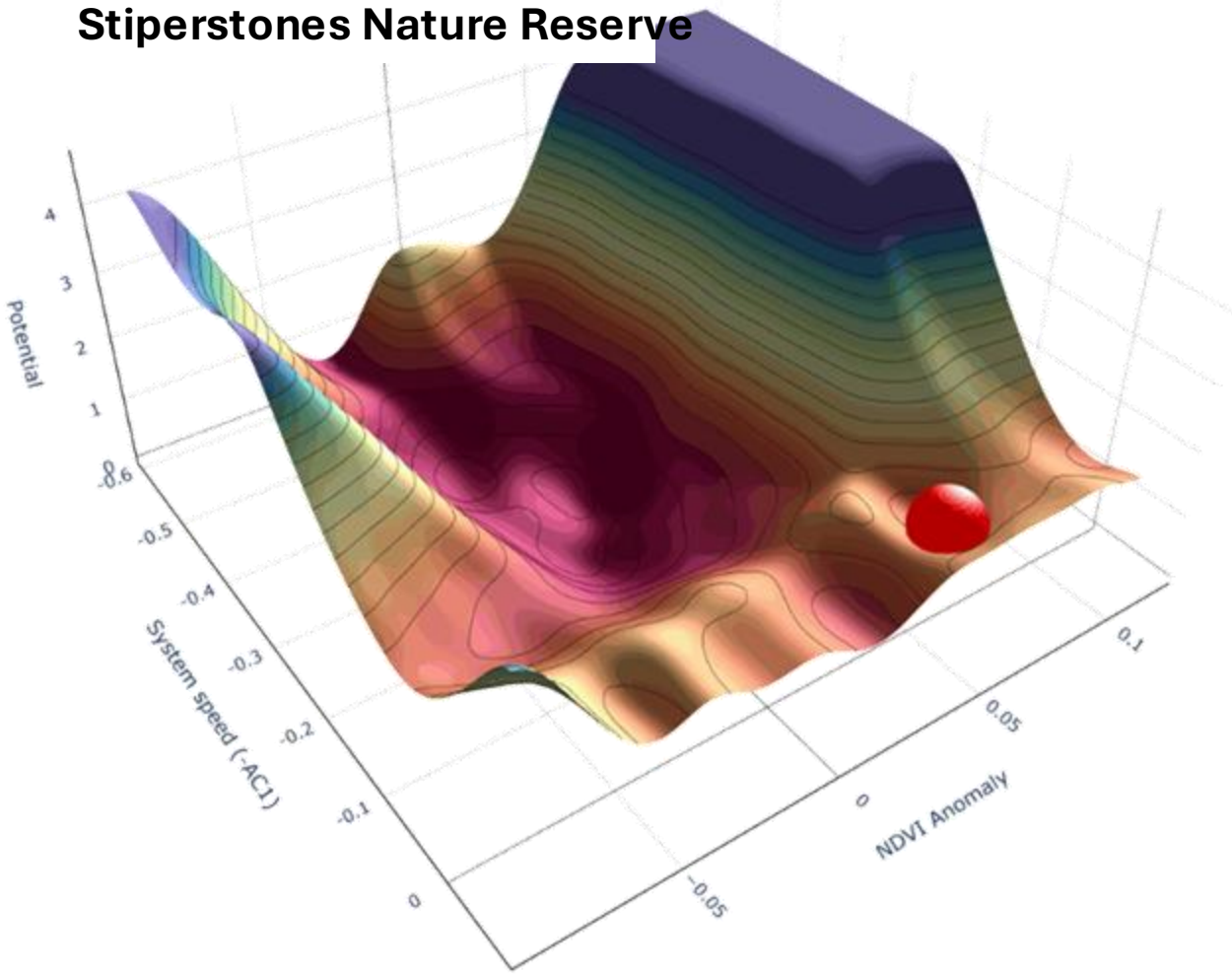
= Grassland system trajectory

Question 2 What might the system look like after a transition?

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Stiperstones Nature Reserve

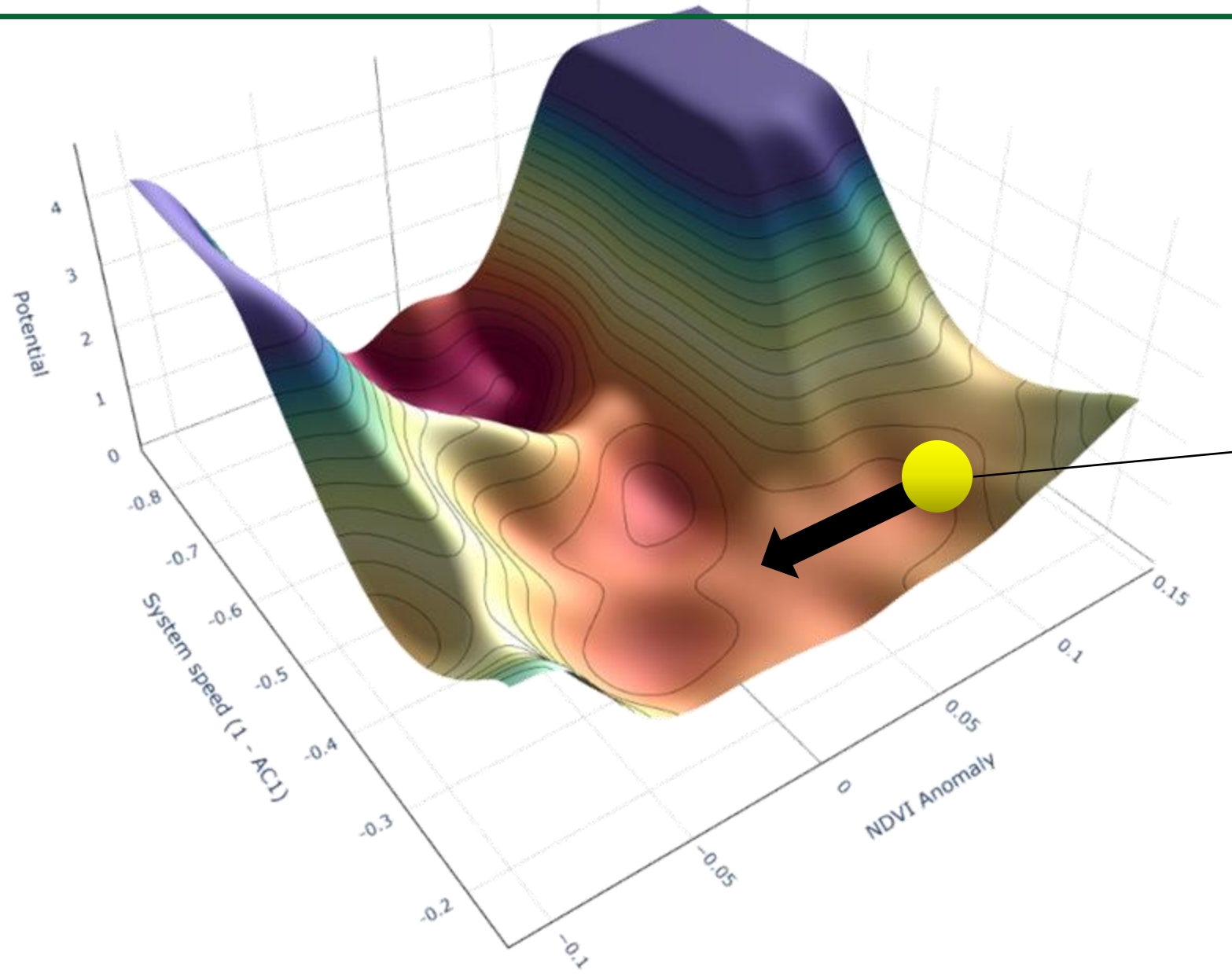


= Grassland system position

= Grassland system trajectory

Example Use Case

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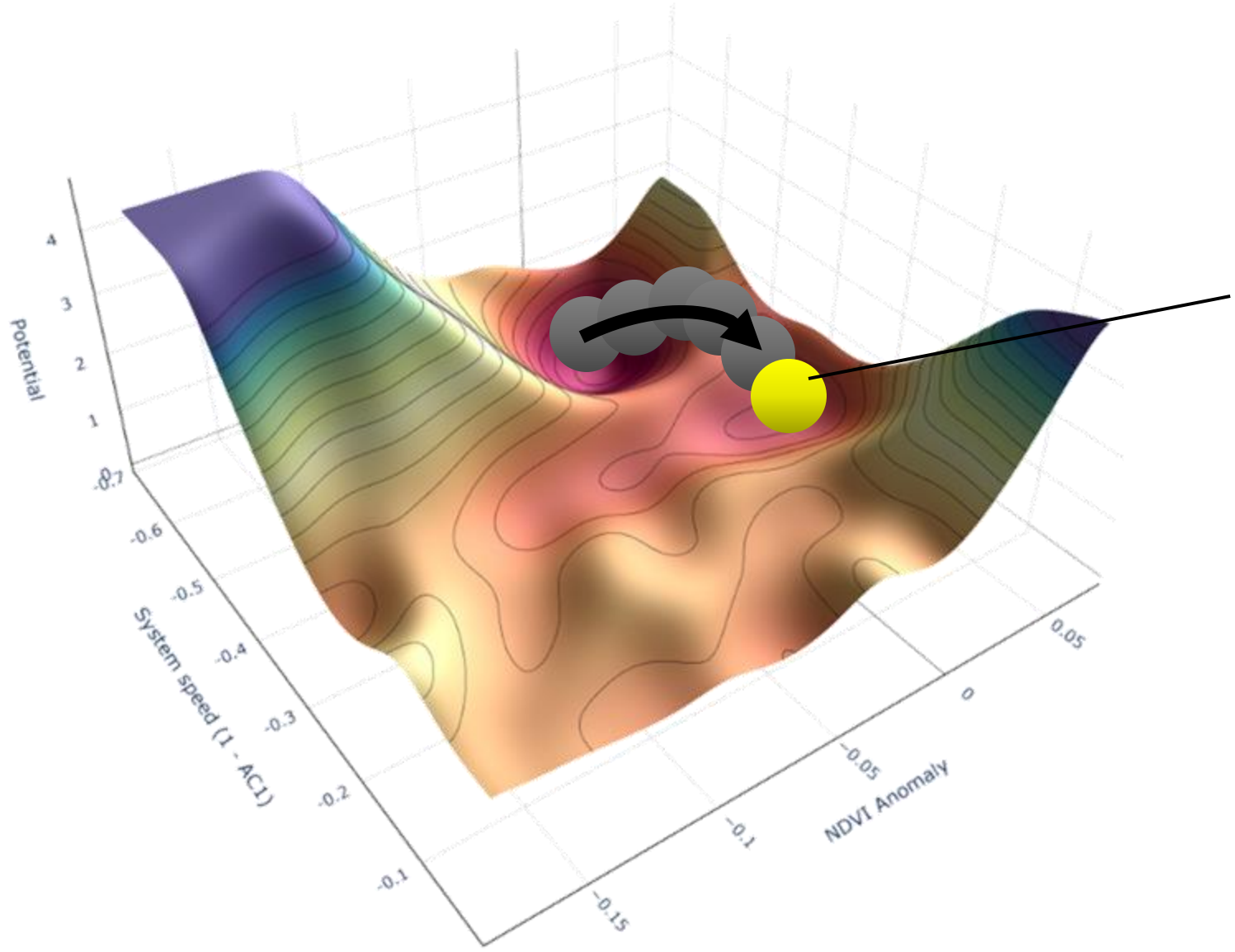


Example Site A state as of 01/01/2025

- Potential ~ 2.5 (not stable)
- Nearest stable state = lower productivity

Example 2

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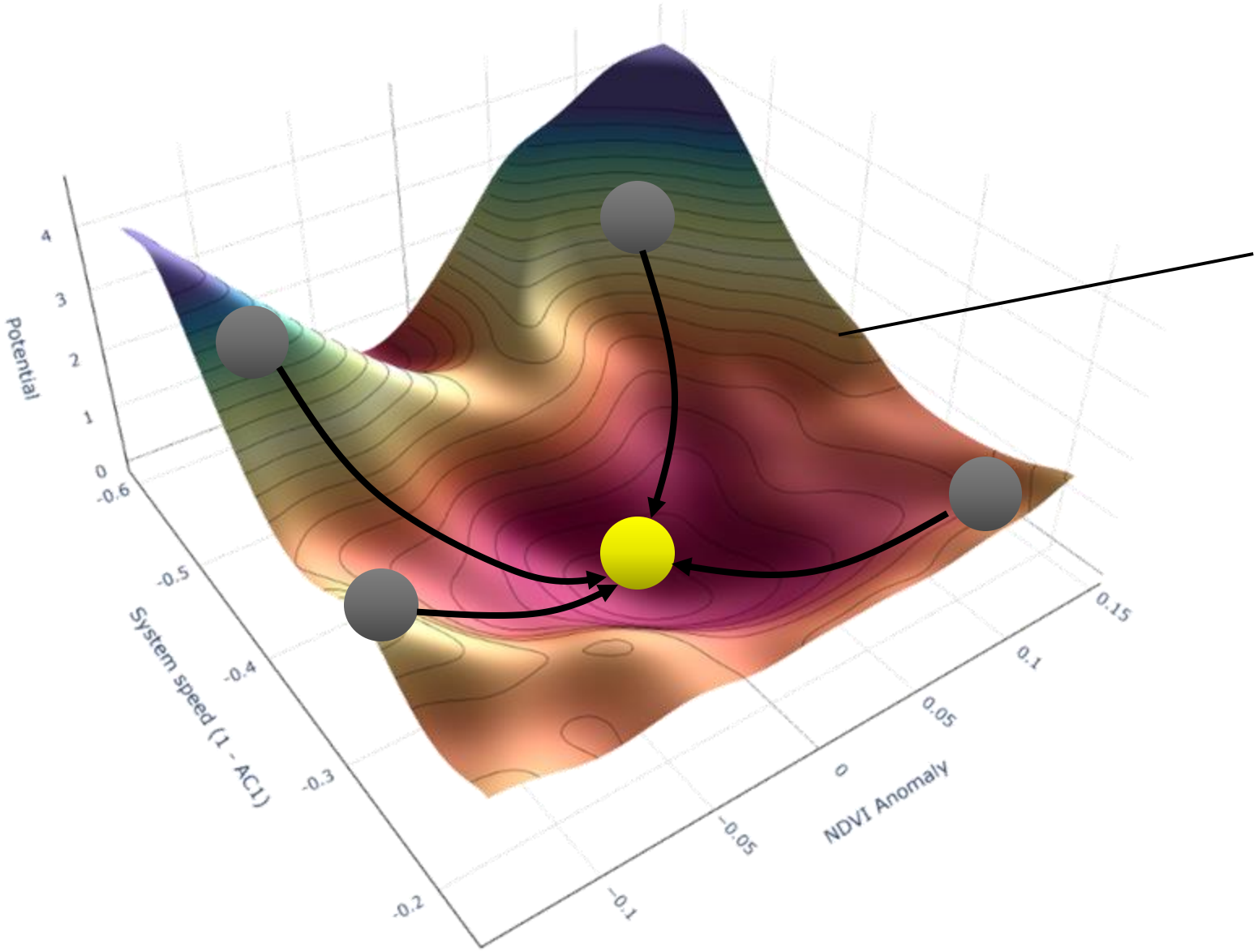


Example Site B with known restoration efforts

- Can we track the journey of the site out of its degraded state into a new state of higher function

Example 3

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Example Site C

No matter how the site has been perturbed historically, it always returns to a stable state

- Either a very resilient state or we have insufficient data

Conclusions

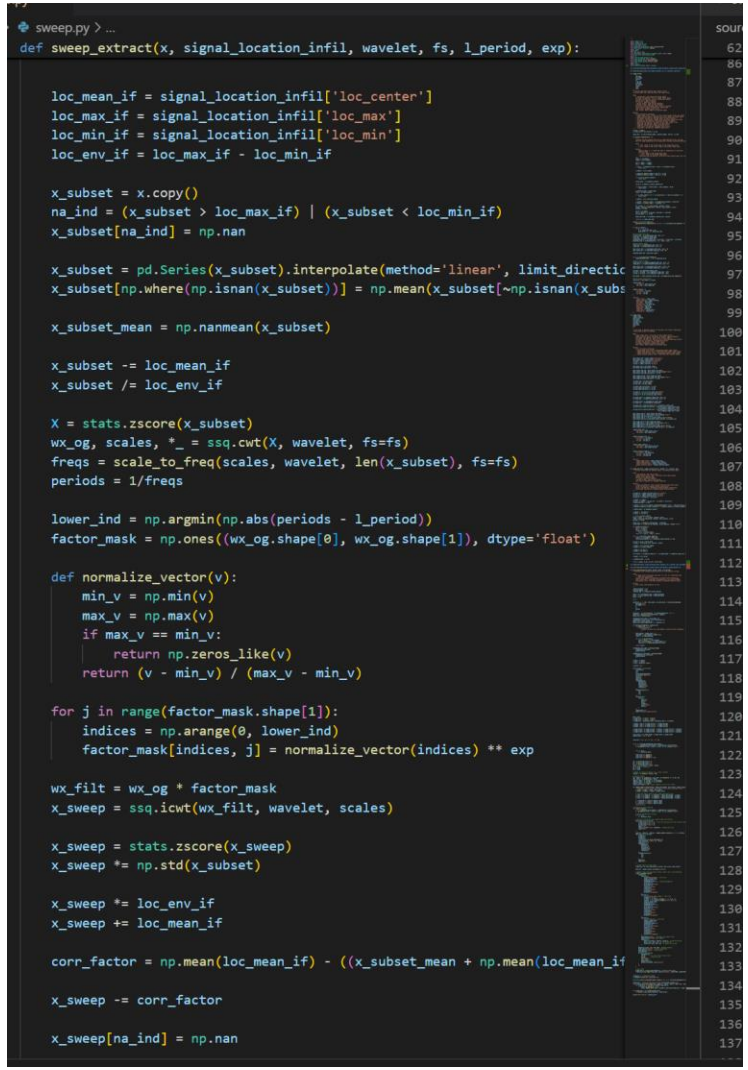
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1. Day-to-day system stress and failure warning signs (CSD) can be monitored by satellite

2. Stable states can be observed using probabilistic stability landscapes

3. These systems can exhibit multiple, stable, functional states.

4. Landscapes tell us which configurations have been stable in the past, where the system is now and indicate where the system may be in the future



WP Team:
Will Rust
Marko Stojanovic
James M. Bullock
Ron Corstanje
Jim A. Harris
Daniel M. Simms



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How stable we do want our ecosystems to be?

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