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Resilience and environmental management

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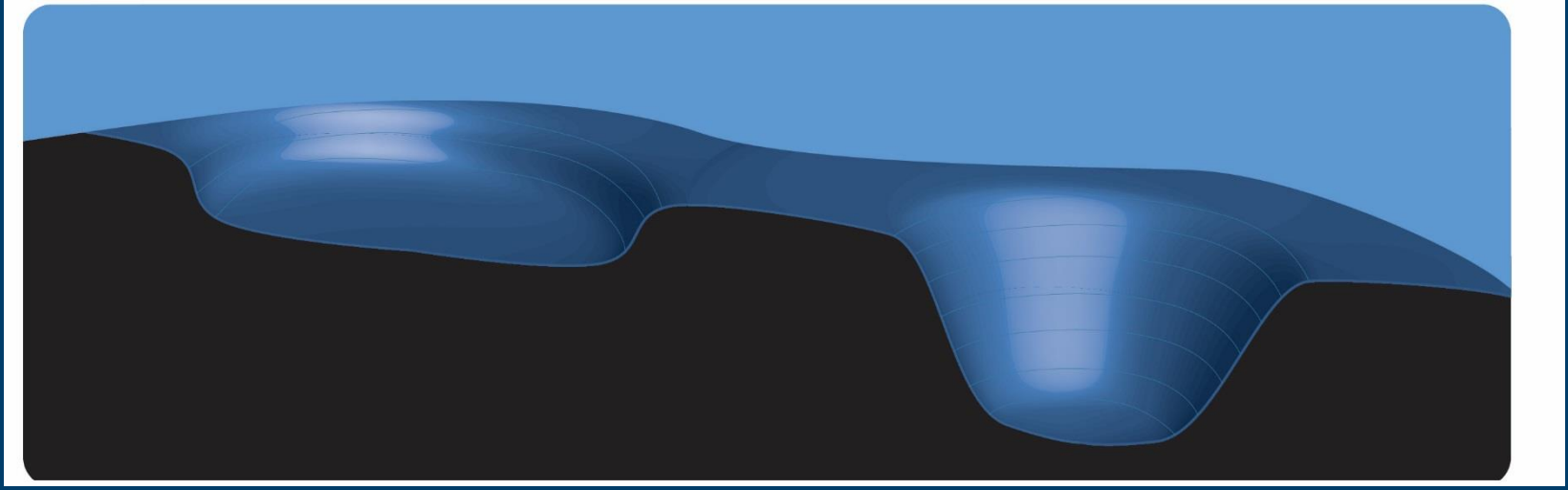
Resilience



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- Ecosystems, social systems and linked social-ecological systems may have multiple regimes
  - Resilience: amount of change a system can absorb before shifting to a different regime

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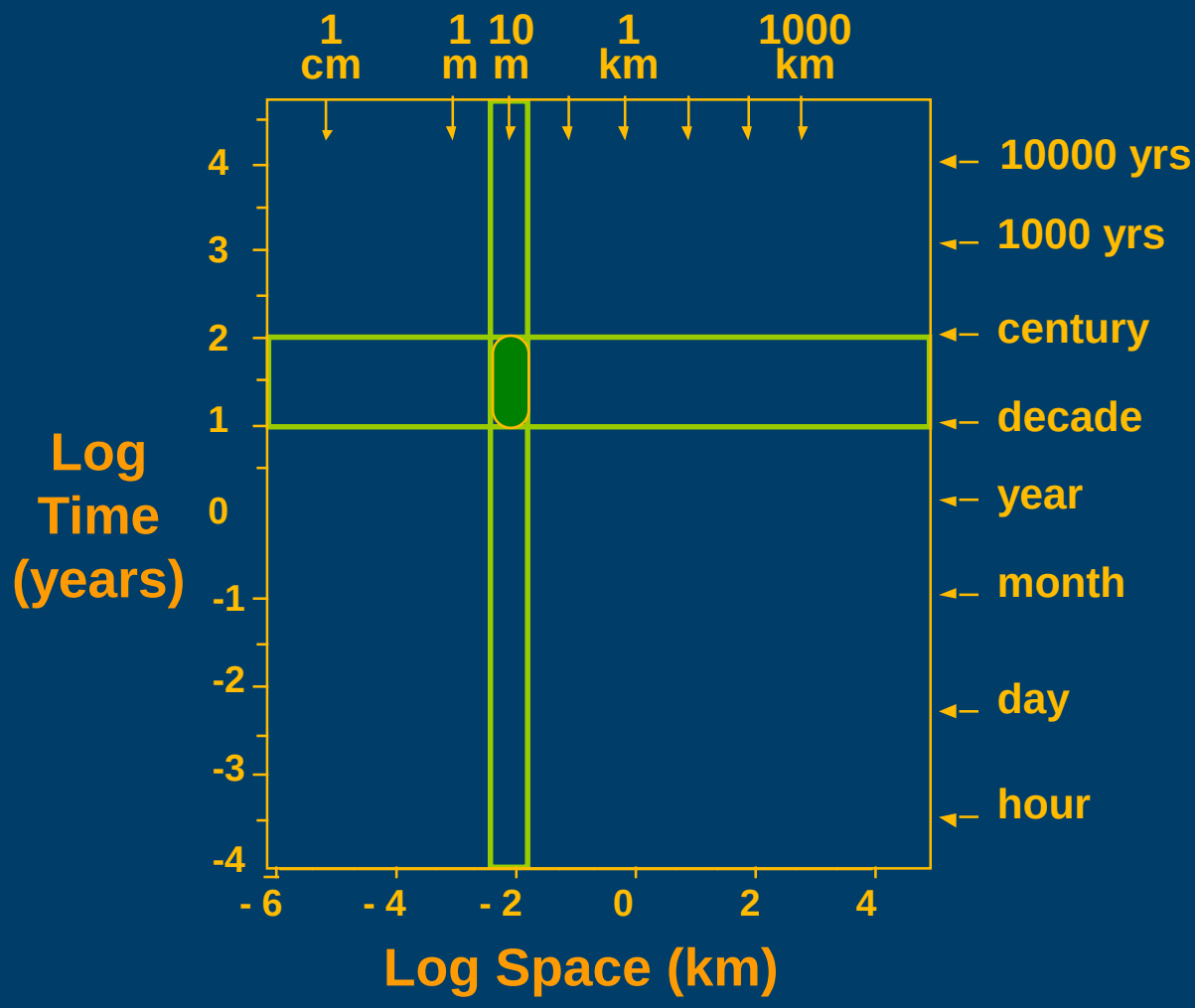
Regime shift

System loses resilience

e.g., lake shifting from a clear to turbid regime; coral reefs (coral to algae)

Scale

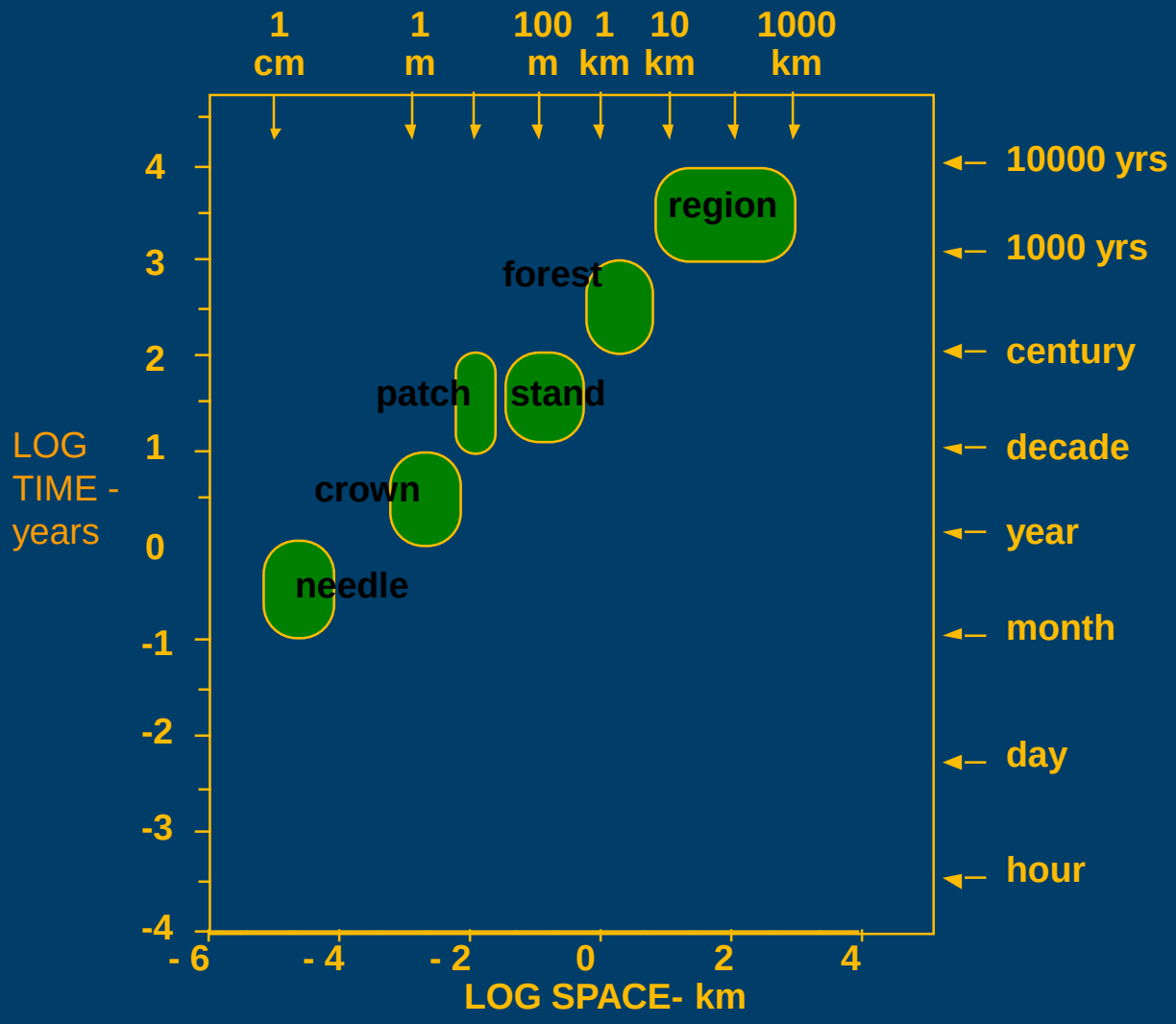
Scale is the spatial and temporal frequency of a process or structure

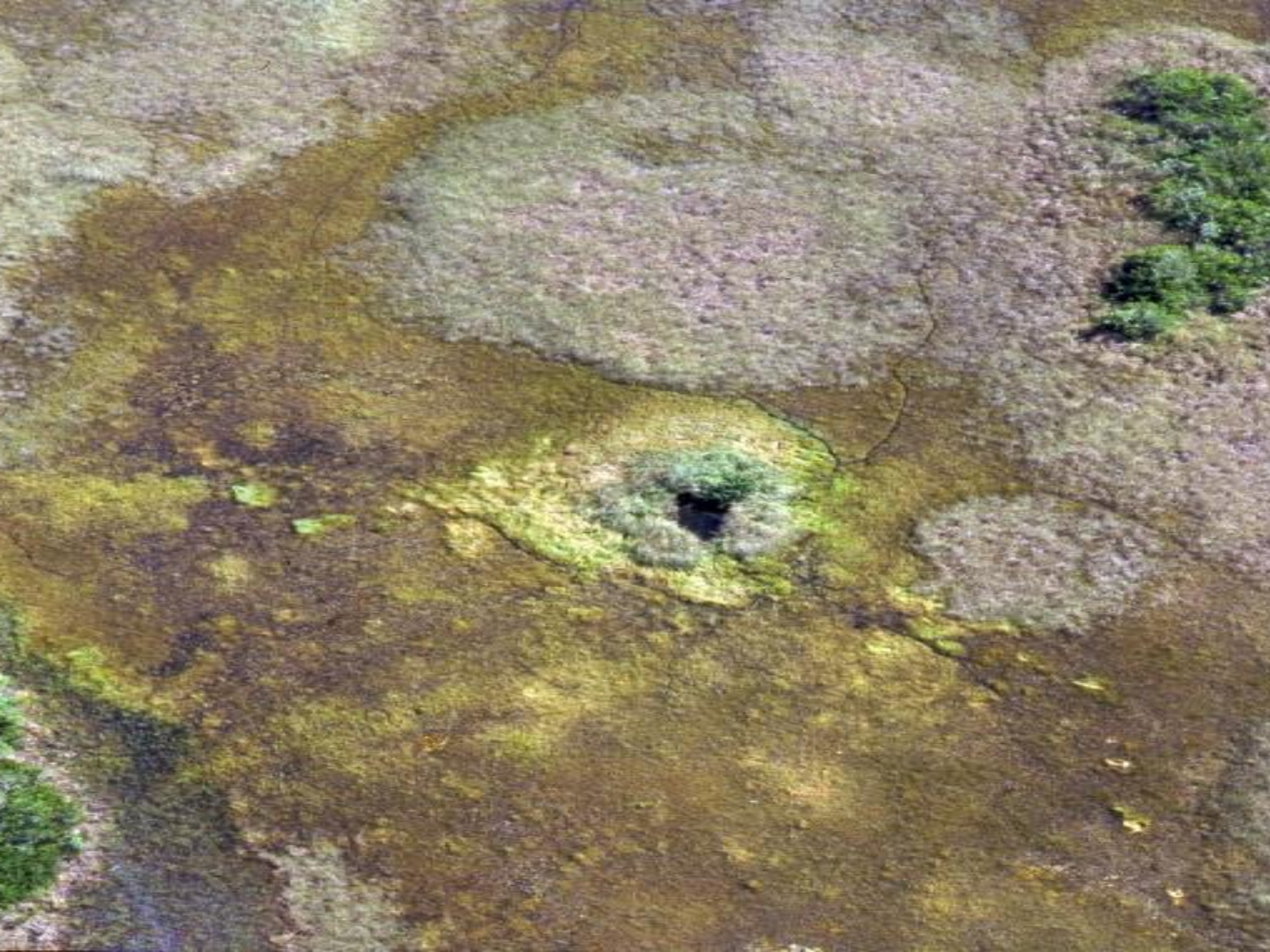


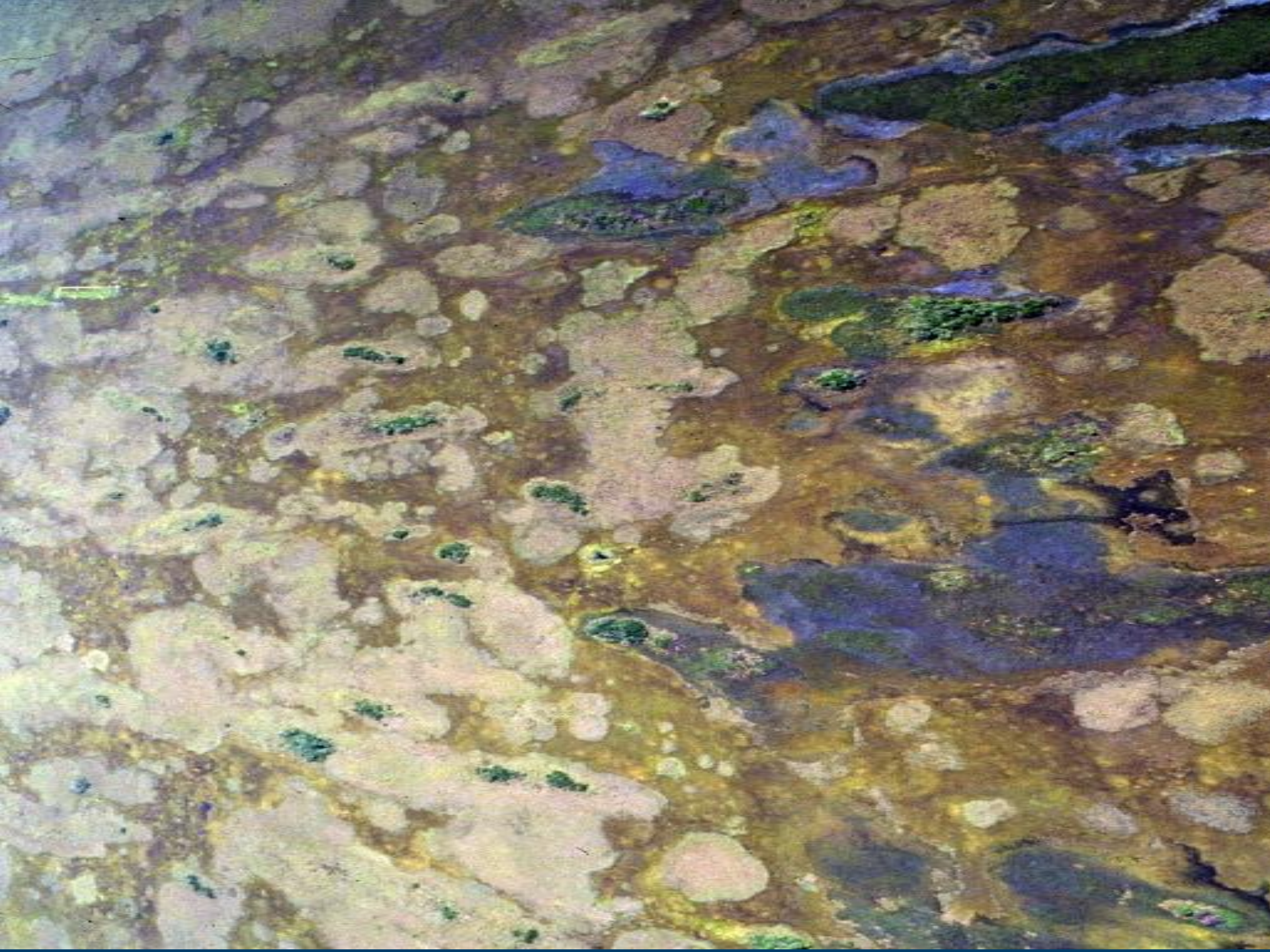
Scale

Boreal forest, for example, is patterned across a range of scales.

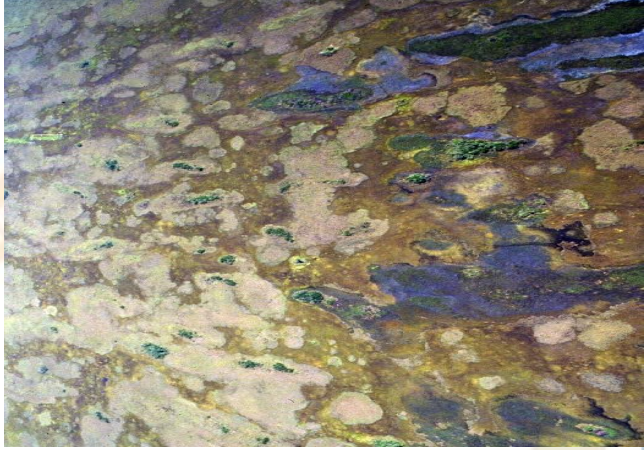
Larger slower structures usually constrain the behavior of faster smaller scales, but "surprise" can happen via cross-scale cascading.

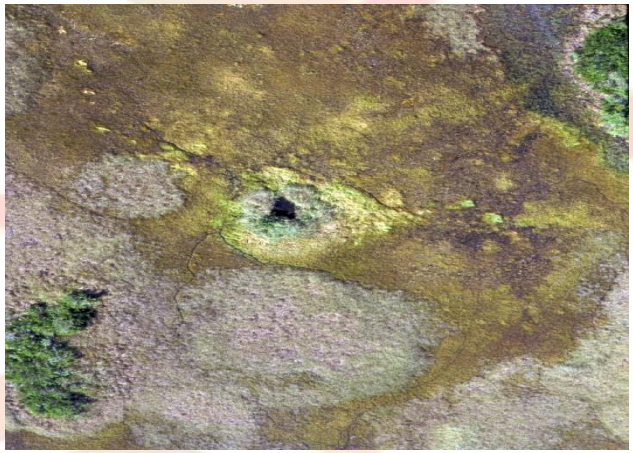






large
and slow





small
and fast

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Panarchy

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Panarchy is based upon hierarchy

Hierarchy

Rank-order of variables (or scales)

Each subordinate to one above

Control is top-down

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Panarchy

Rank-order of variables (or scales)

“Bottom up” change is common

“Surprise”

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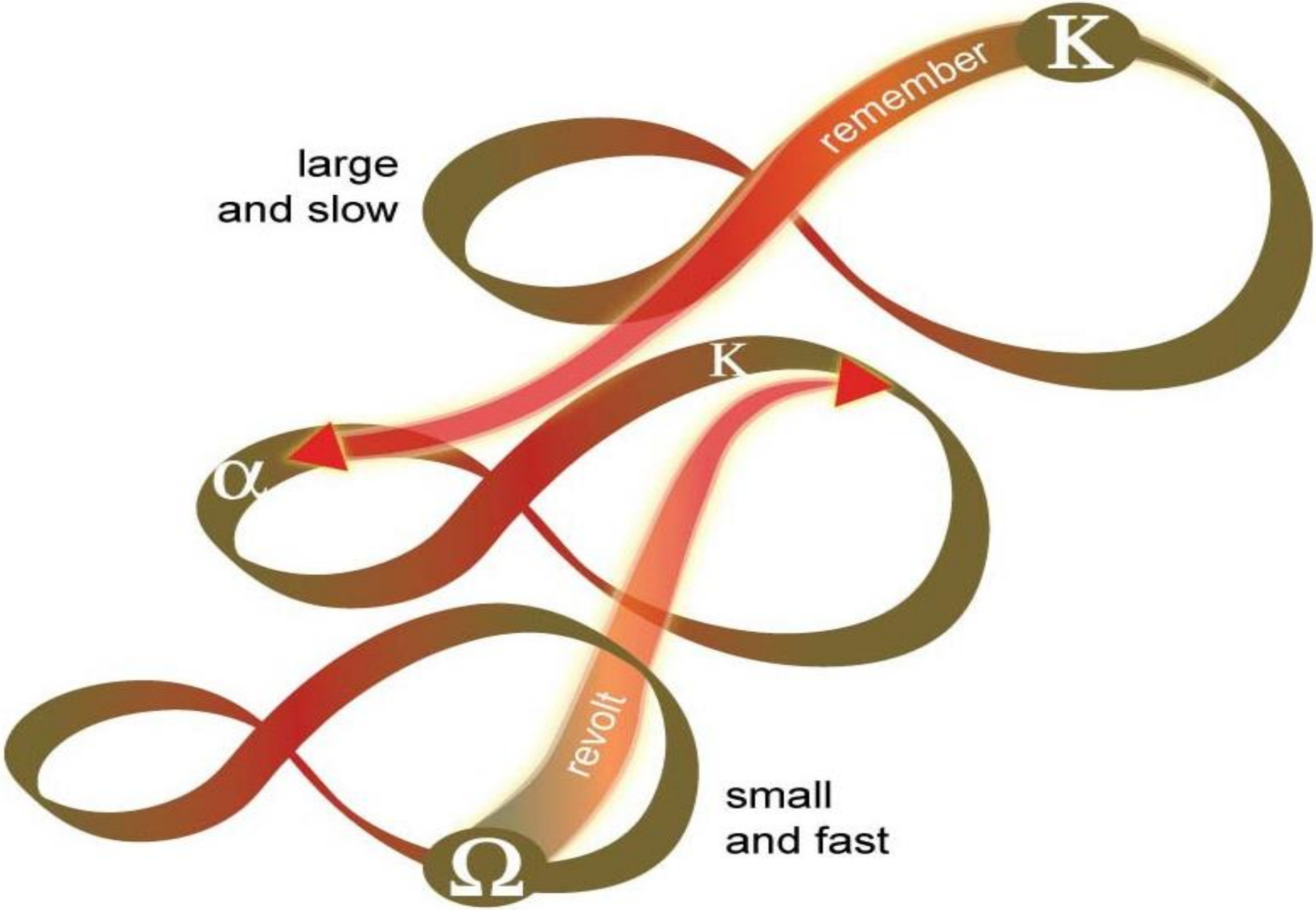
Panarchy

- Levels are not static
- Resilience
  - Dependent upon cross-scale dynamics and structure


remember
K
large
and slow
K
α
revolt
small
and fast
Ω

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Resilience

- Measure of system resilience = sustainability index
- How do we quantify?
  - 1) Cross-scale resilience (Discontinuity analysis)
  - 2) Early warning signals

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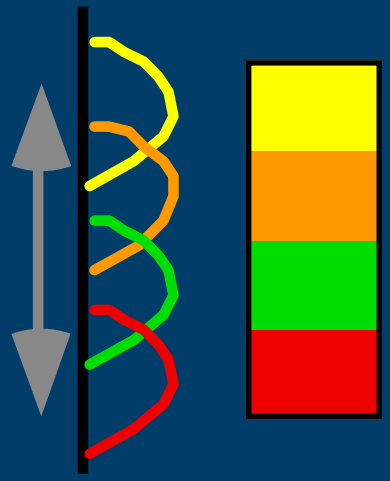
Functional Richness

Use of different resources at same scale



Function A

Function B

Function C

Function D

At the same scale species from different functional groups specialize in the use of different resources, but each function can use other resources at lower efficiencies.

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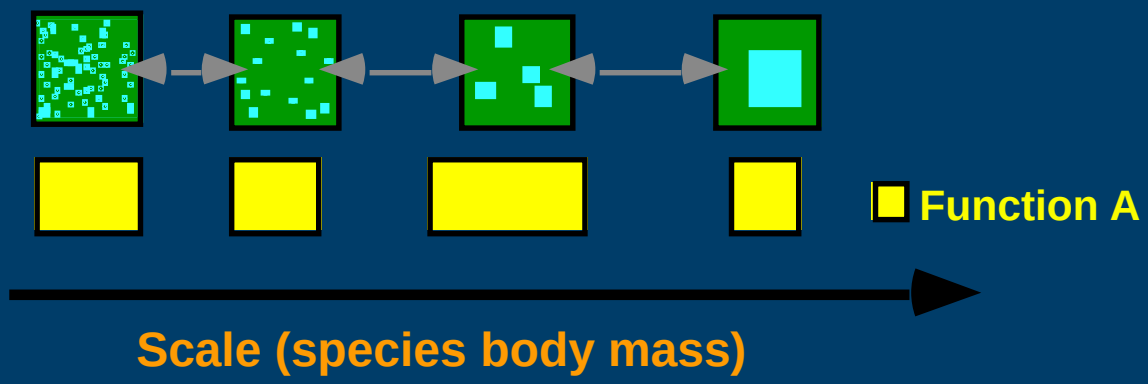
Functional Redundancy



Species with the same function can utilize the same resource at different scales. Resources that are more dispersed can be utilized by a large animal, but with a decrease in efficiency. Species are performing similar functions at different scales.

Birds and Budworms

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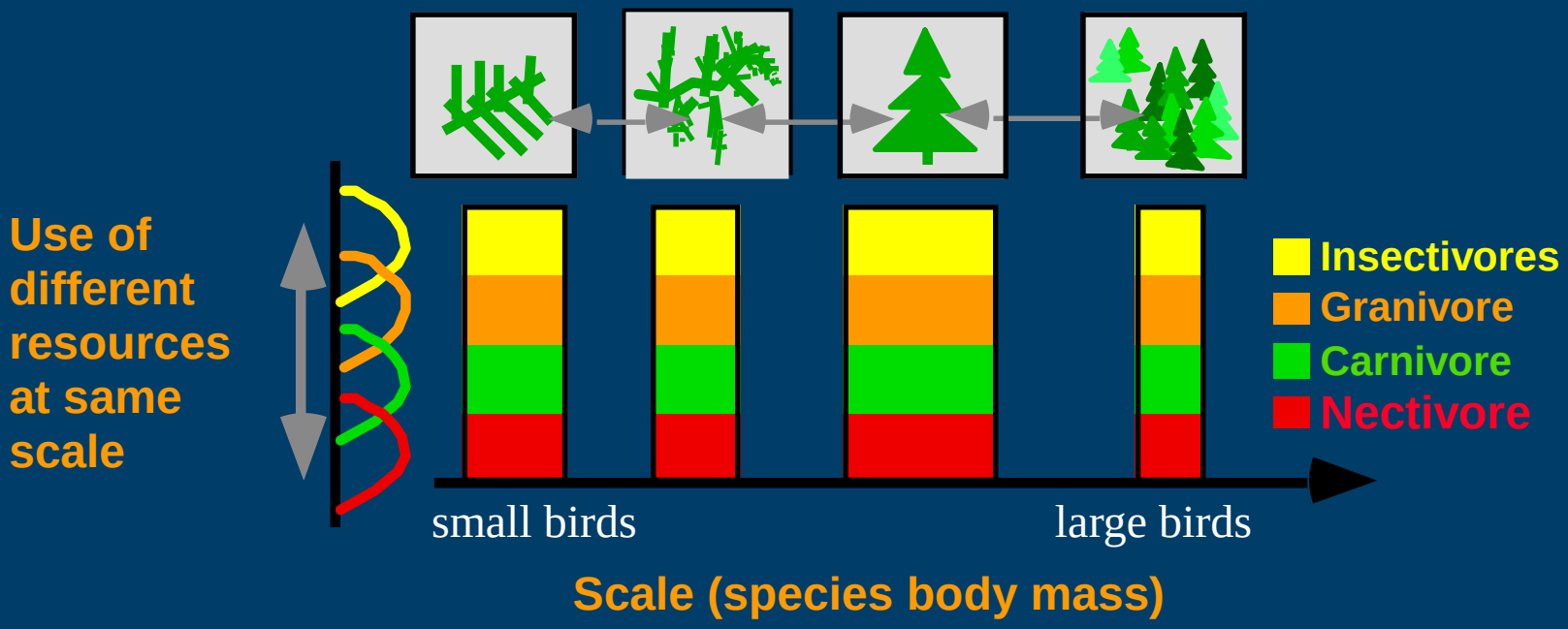
Predation of budworms at different aggregations



As budworm populations increase, larger aggregations of both larger birds and birds that would not normally consume budworms switch to the use of budworms.

This process provides robust control of budworm populations over a wide range of budworm densities.

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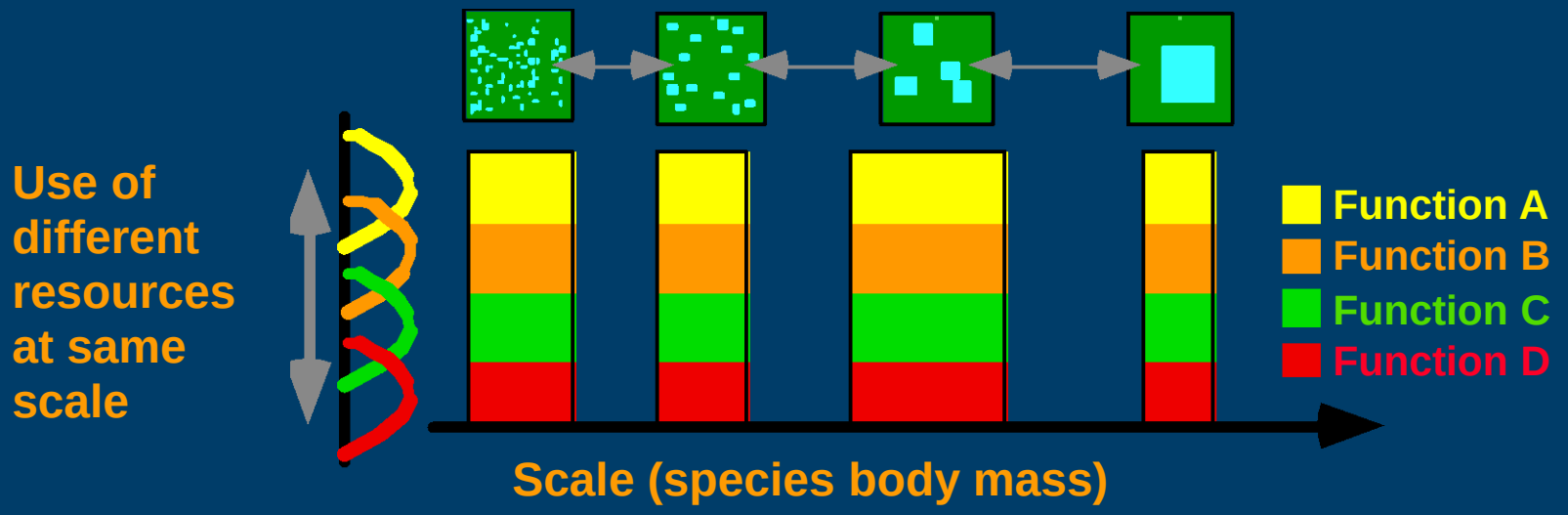
Cross-Scale Resilience

Functional richness within and functional redundancy across scales.



At the same scale species with different functions specialize in the use of different resources. Species of the same function utilize the same resource, but at different scales.

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Cumulative impacts

- "Scale up"
- Wetlands degradation
  - Numerous small conversions ("Death by a 1000 cuts")
  - Cumulative effect of small conversions manifests in large-scale degradation
  - Loss of ecosystem services associated with wetlands

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Legal certainty

Does not mesh well with environmental unpredictability

Aspects of a society that make it free (e.g., certainty of law)

- don’t mesh with ecological realities (e.g., multiple regimes, non-linear systems and responses)

Cross-scale dynamics

- Tremendous challenges for the management of ecological systems and ecosystem services

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The crux of the issue

- Rigidity of current environmental law
  - Successful at protecting the environment for many years
  - Aspect of the law that makes it difficult to confront emerging, cross-scale and cross-boundary challenges

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Adaptive Management

- Integration of resilience theory into natural resources management
- Alter management in response to monitoring

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- Adaptive Management (AM) Framework
    - AM = Iterative process
        - incorporates citizen and stakeholder input
    - AM: critical aspect of Adaptive Governance

Adaptive Governance

1) Legislation and Accountability

***Adaptive Management**

2) “Intermediaries”

***Bridging organizations and networks**

3) Matching organizations to the appropriate scale

***Panarchy**

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Adaptive Governance

Bridging organizations:

- Resolve conflicts
- Monitor management
- Facilitate rapid communication

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The critical elements:

- Monitor implementation and management of interventions as rigorously as the initial formation of interventions

- Adaptively assess responses in order to improve management or policy

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Adaptive management

Constraints to adaptive management:

- Current state of administrative law (*but see* Craig and Ruhl 2014)
- Interventions evaluated on the “front-end” (due to public and legal scrutiny)

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What does this mean?

- Tension between law and science:
  - Certainty required for socio-political stability makes it difficult to apply novel approaches to environmental management (that require some flexibility)

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Adaptive management

How to reconcile the conflict?

Karkkainen argues that administrative law should proceed on two trajectories:

(1) a fixed rule track that will apply, unless an agency can justify:

(2) an adaptive management track, where a new set of administrative law standards specific to adaptive management

Proposed process is rife with bureaucracy, which is a negative, but this type of system may be the best we can do to reconcile science and law (***see Craig and Ruhl 2014***)

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Panarchy

Management should occur at the appropriate scale

- Nested set of organizations
- Exert influence upon the corresponding scale of social-ecological system

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“Surprise”

Develop numerous policy options in order to prepare for a variety of potential “surprises”

- Policy options (i.e., scenarios) explore the inherent uncertainty in social-ecological systems

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Policy

"Window of opportunity"

- Policy can be implemented, monitored, assessed and replaced (if necessary)
- Reduce uncertainty and maximize learning

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Panarchy

Variety of scenarios in place that are scale-specific

- Interventions
    * Account for cross-scale interactions associated with the management of social-ecological systems
- Interventions should be treated as hypotheses and put at risk with monitoring data

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Panarchy

Adaptive capacity is critical, as well as open and frequent lines of communication between organizations at multiple scales

How will this happen?

One of the most critical aspects in the framework:

Bridging organization

- Monitors status of the social-ecological system, and manifest rapid change (if conditions are deteriorating)

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Bridging organizations

Bridging organizations serve to facilitate cross-scale linkages for management entities operating at discrete scales

- Improve communication
- Build trust
- Create opportunities for collaboration

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Bridging organizations

Examples:

- Assessment team: comprised of actors across sectors in a social-ecological system
- NGOs: arena for trust-building, learning, conflict resolution and adaptive co-management
- Scientific community: can act as a “watchdog”, as well as a facilitator for adaptive management

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Ecomuseum Kristianstads Vattenrike (EKV)

Successful bridging organization in southern Sweden (watershed management)

Organizational flexibility that allowed for EKV to respond quickly to “surprise”

- Leadership
- Core inter-disciplinary staff
- Facilitate connections between individuals and organizations (i.e., the panarchy of organizations)

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Ecomuseum Kristianstads Vattenrike (EKV)

- Improved capacity to respond to “surprise”
- Built trust
- Improved adaptive management of resources

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Bridging organizations

- Millennium Ecosystem Assessment
  - Supports neither centralization nor decentralization
    - - Encourages multi-layered governance to enhance adaptive capacity
  - Trust-building is viewed as critical to ecosystem management

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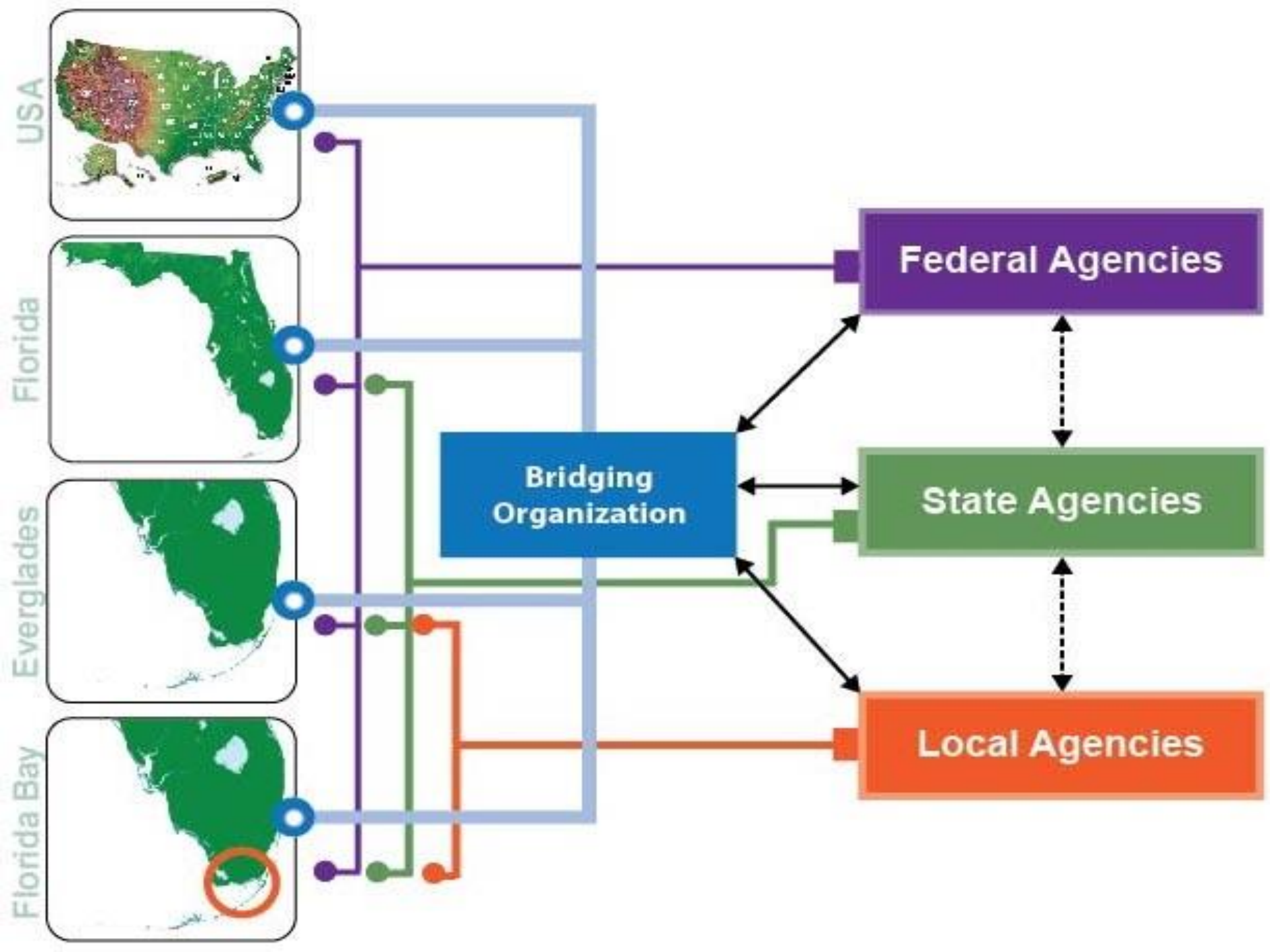
Bridging organizations

- Unique role in the management of social-ecological systems
- Foment AM and AG
- More flexible and reflective of the panarchy of linked SESs


USA
Florida
Everglades
Florida Bay
Federal Agencies
Bridging Organization
State Agencies
Local Agencies

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Synthesis

The key is for a bridging organization to operate within the context of a panarchy of management entities and ecological systems, and for monitoring to generate the most current data on that system's dynamics

- Framework could serve as one possibility to manage for resilience

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Conclusion

Social-ecological systems have traditionally been managed via anticipatory management

- Based on the belief that it's possible to collect enough information on the system to essentially reduce uncertainty to zero

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Conclusion

*Our understanding of social-ecological systems has led us to understand that these systems are characterized by an inherent degree of unpredictability

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Conclusion

*Given the capacity for “surprise” in ecosystems, monitoring becomes critical to developing a read on system behavior and the need for new interventions associated with the system of interest

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Conclusion

The type of analysis needed to deal with social-ecological systems, is an ongoing, open process of deliberation, experimentation and further deliberation

*Scale-dependent management

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"Panic", a word derived from the "pan" in panarchy, comes closer to capturing nature as it is: characterized by unpredictability

*Thus, sustainability is not an end, but rather a journey, a journey that requires an acceptance of a degree of unpredictability……no easy task for *Homo sapiens*