# *It's time for time: Aquatic-terrestrial linkages in California vernal pools*

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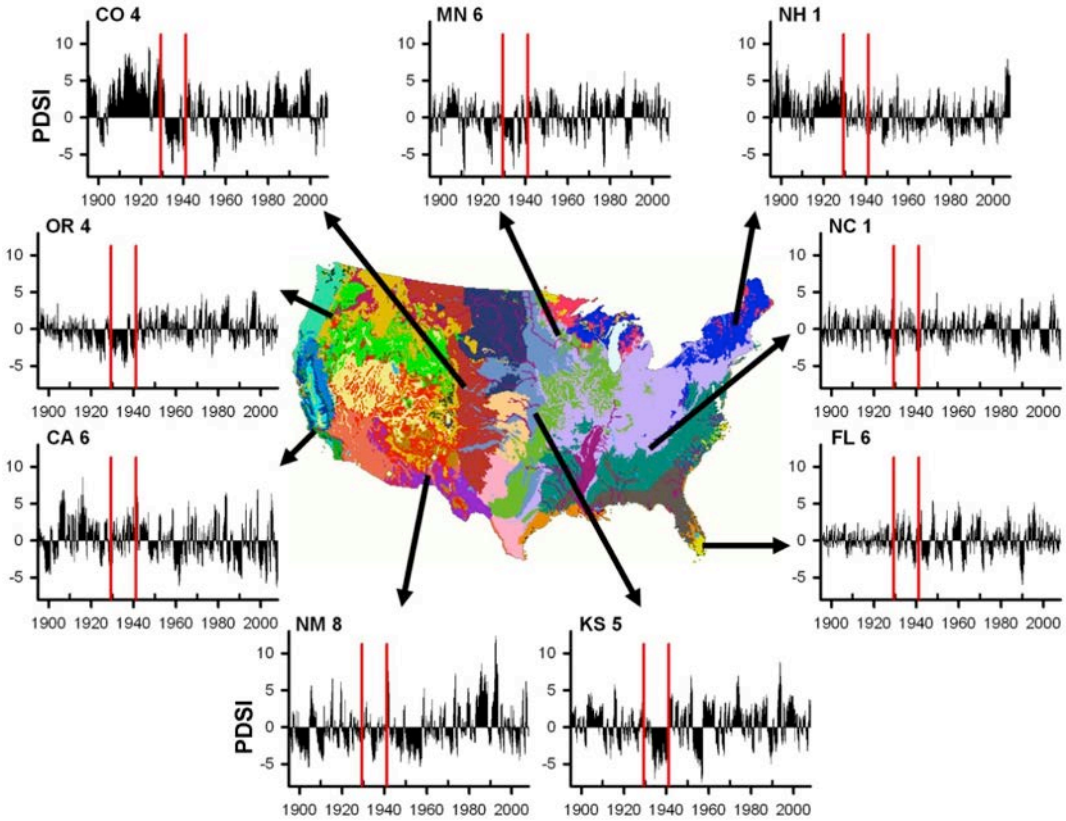
# Spatial and temporal heterogeneity

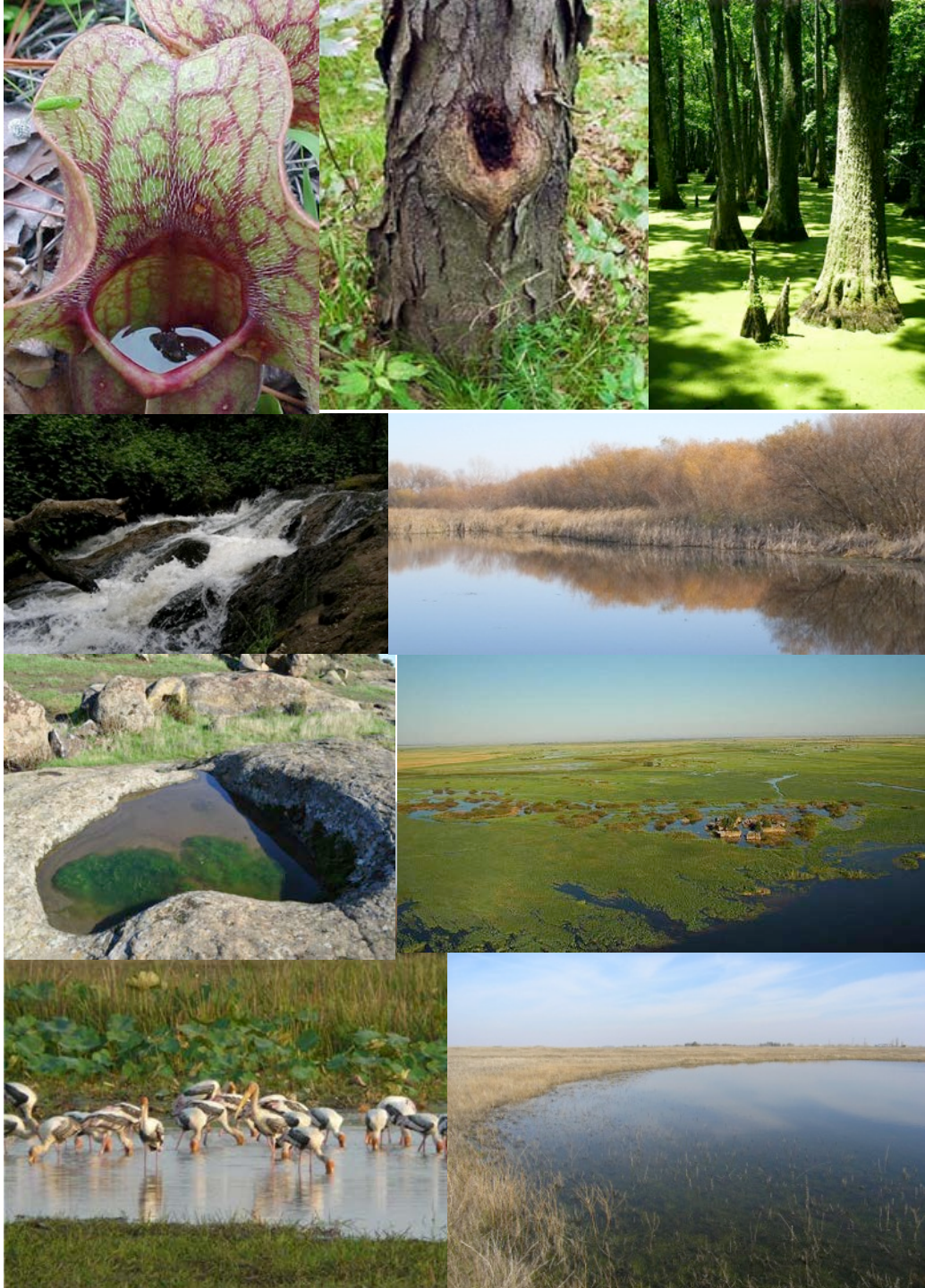
- Important in all ecosystems
- Climate variation
- Increasing focus on effects in natural ecosystems




Peters (2011)

# Temporary Waters

- Directly tied to precipitation & temperature
- Ubiquitous
- Discrete & dynamic in space and time



# Temporary Waters (*California Vernal Pools*)

- Greatly reduced habitat
- Services:
  - Groundwater recharge
  - Flood control
  - Nutrient recycling
- High levels of:
  - Biodiversity
  - Endemism
- Consistent dry phase

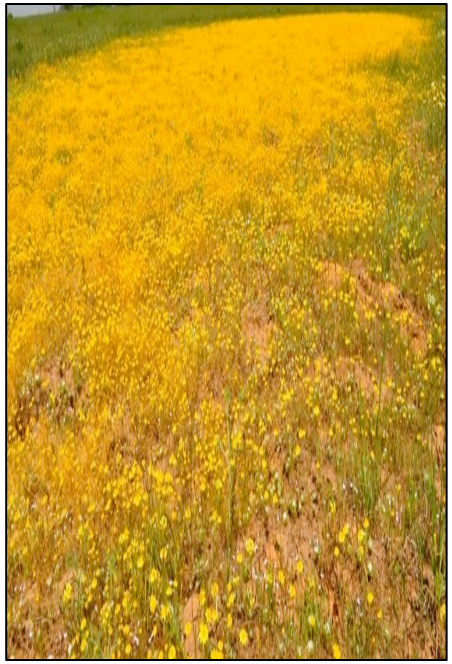
# Ecosystem Phases: Vernal Pools

Winter

**Aquatic Phase**

*-Soils saturate*

*-Standing water*



Spring

**Terrestrial Phase**

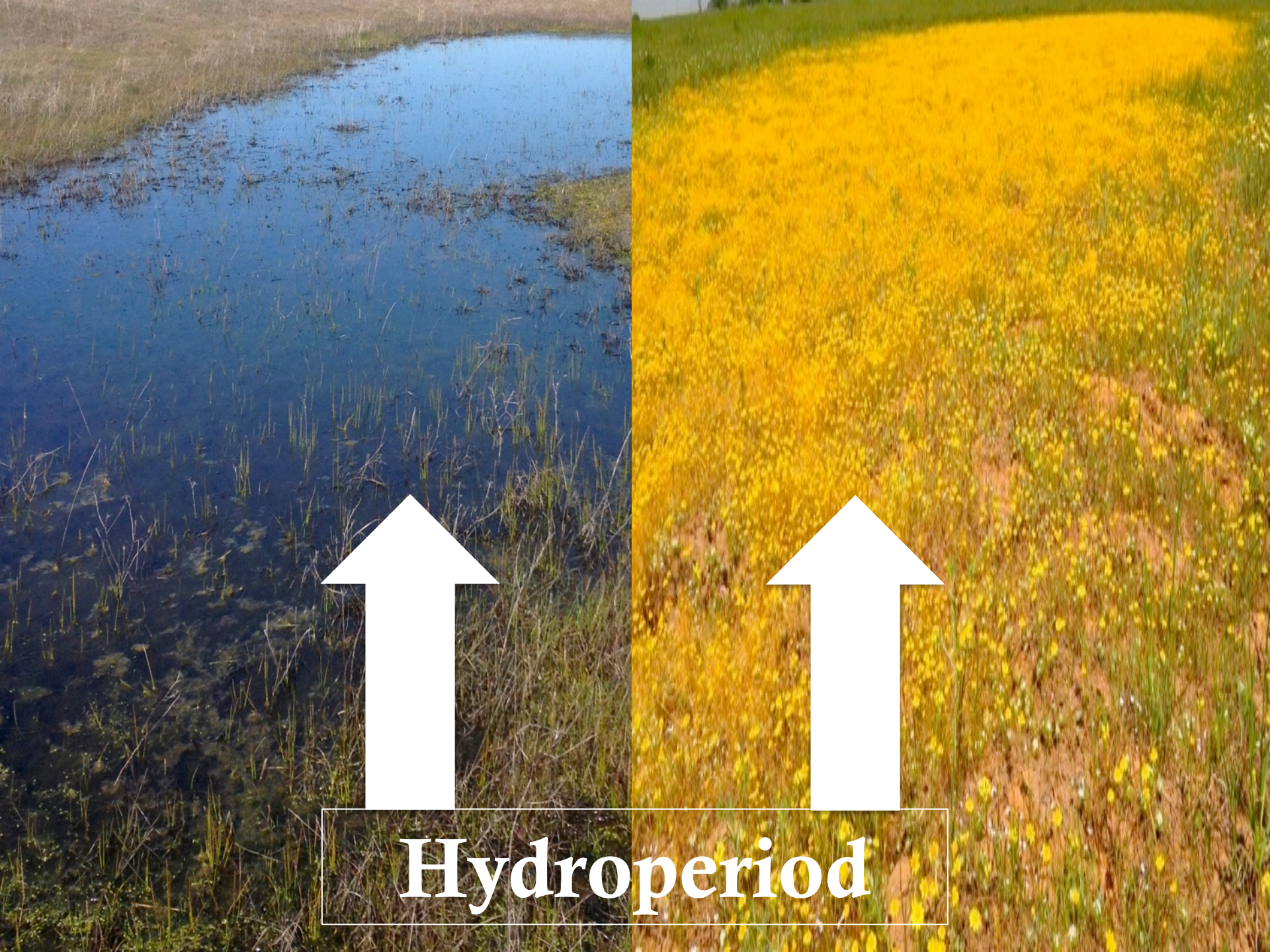
*-Soil moist*

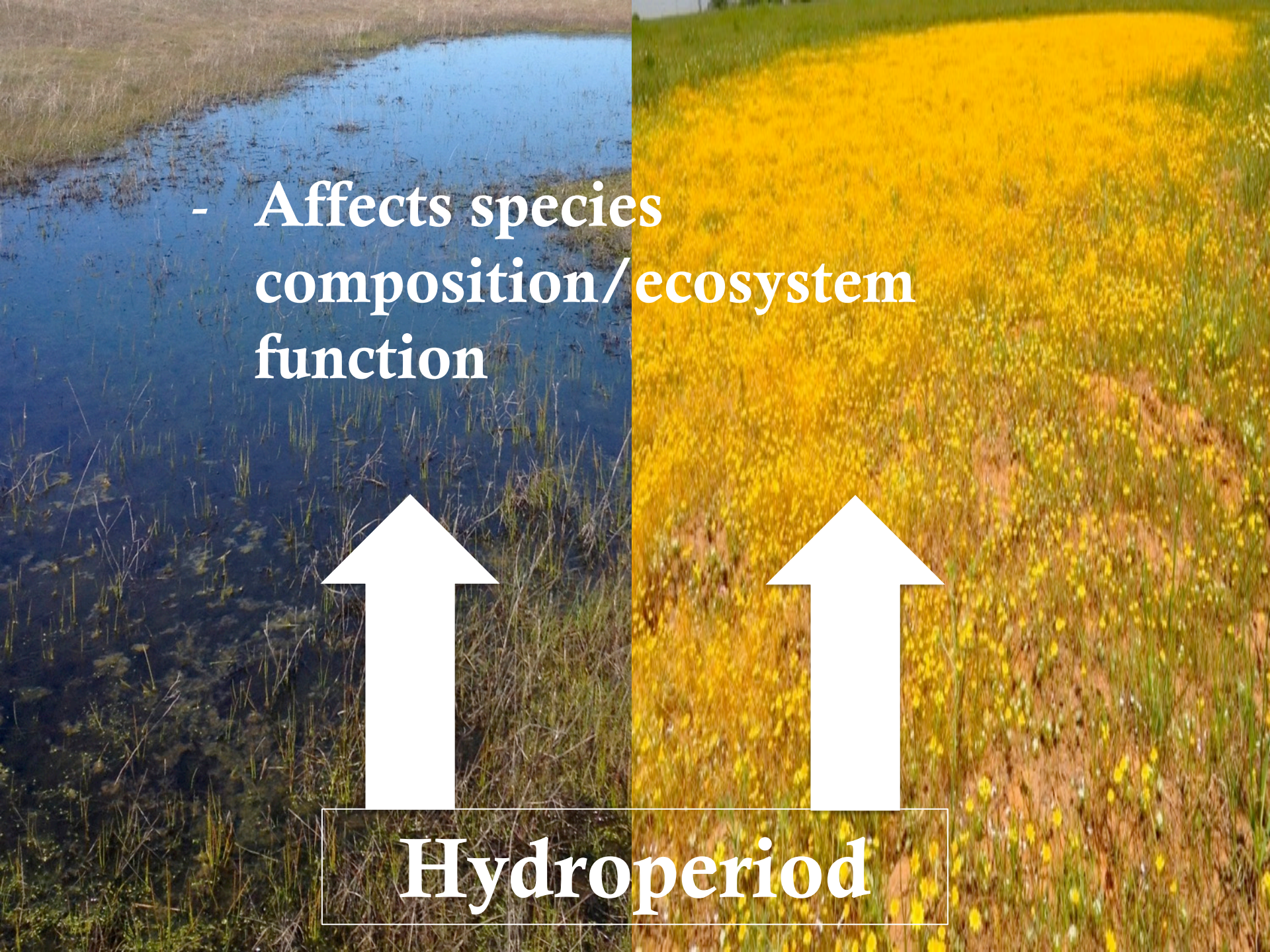
*-Drying phase*

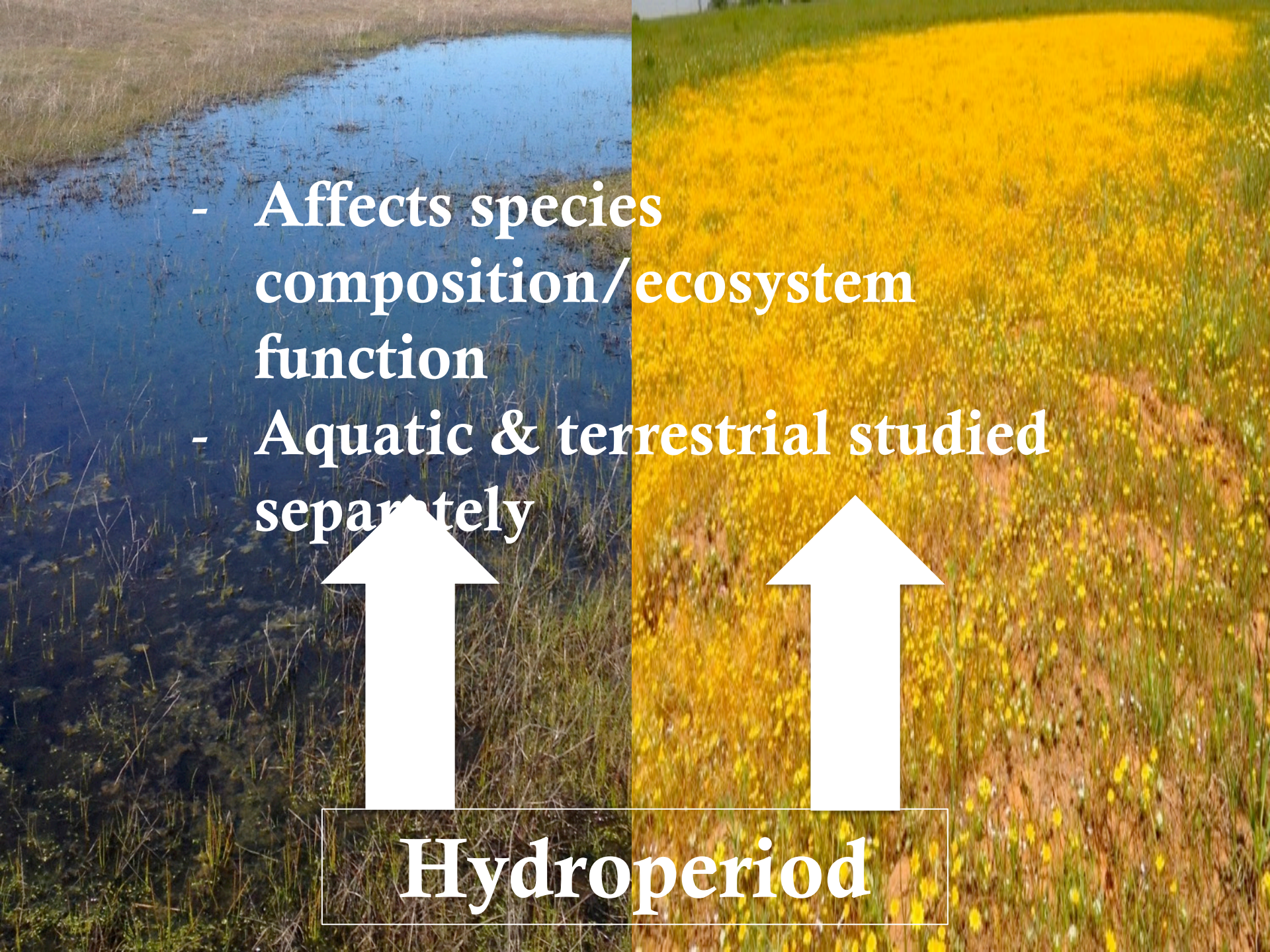
Summer/Fall

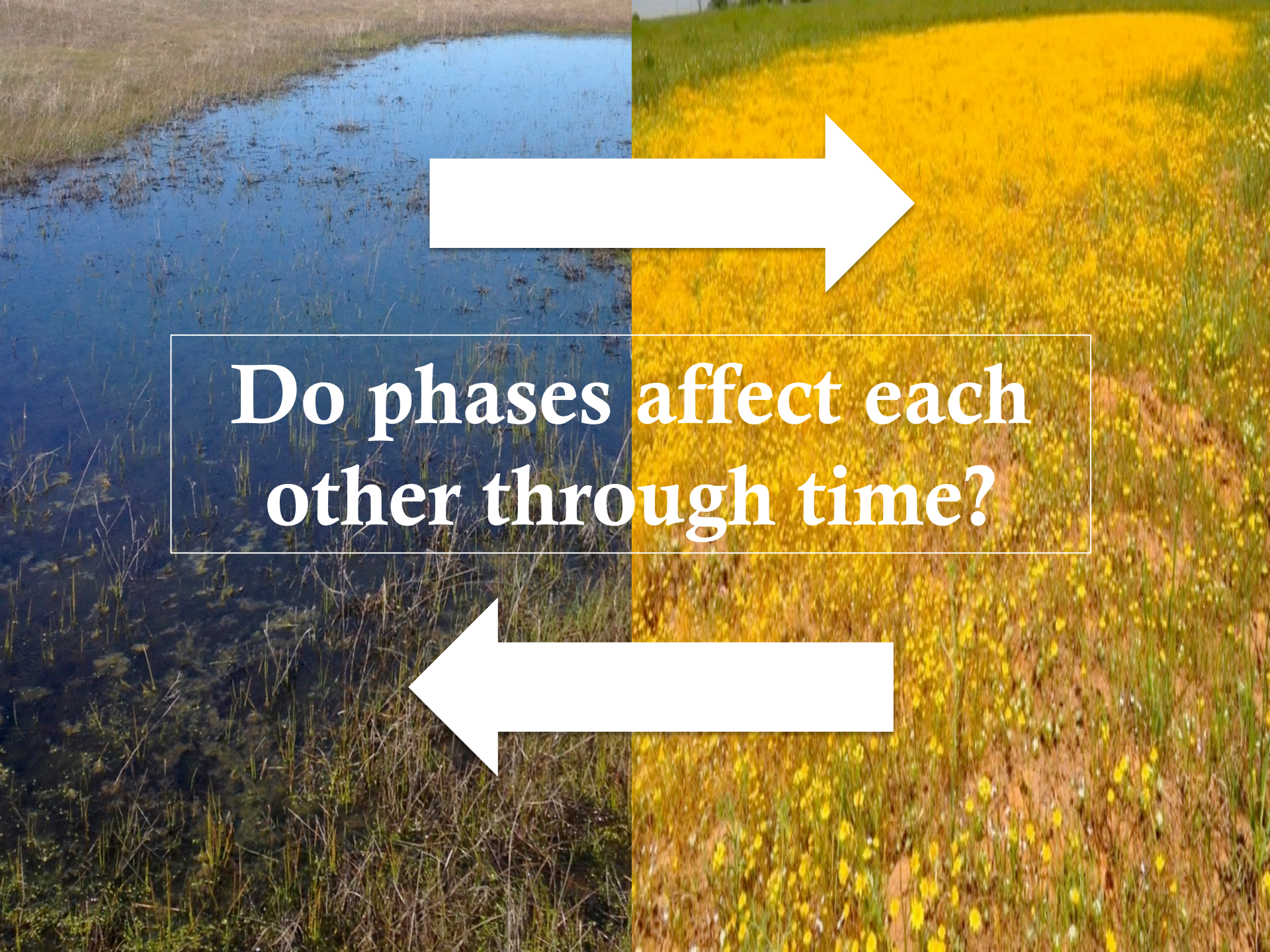
**Dry Phase**

*-Soils dry*


Hydroperiod

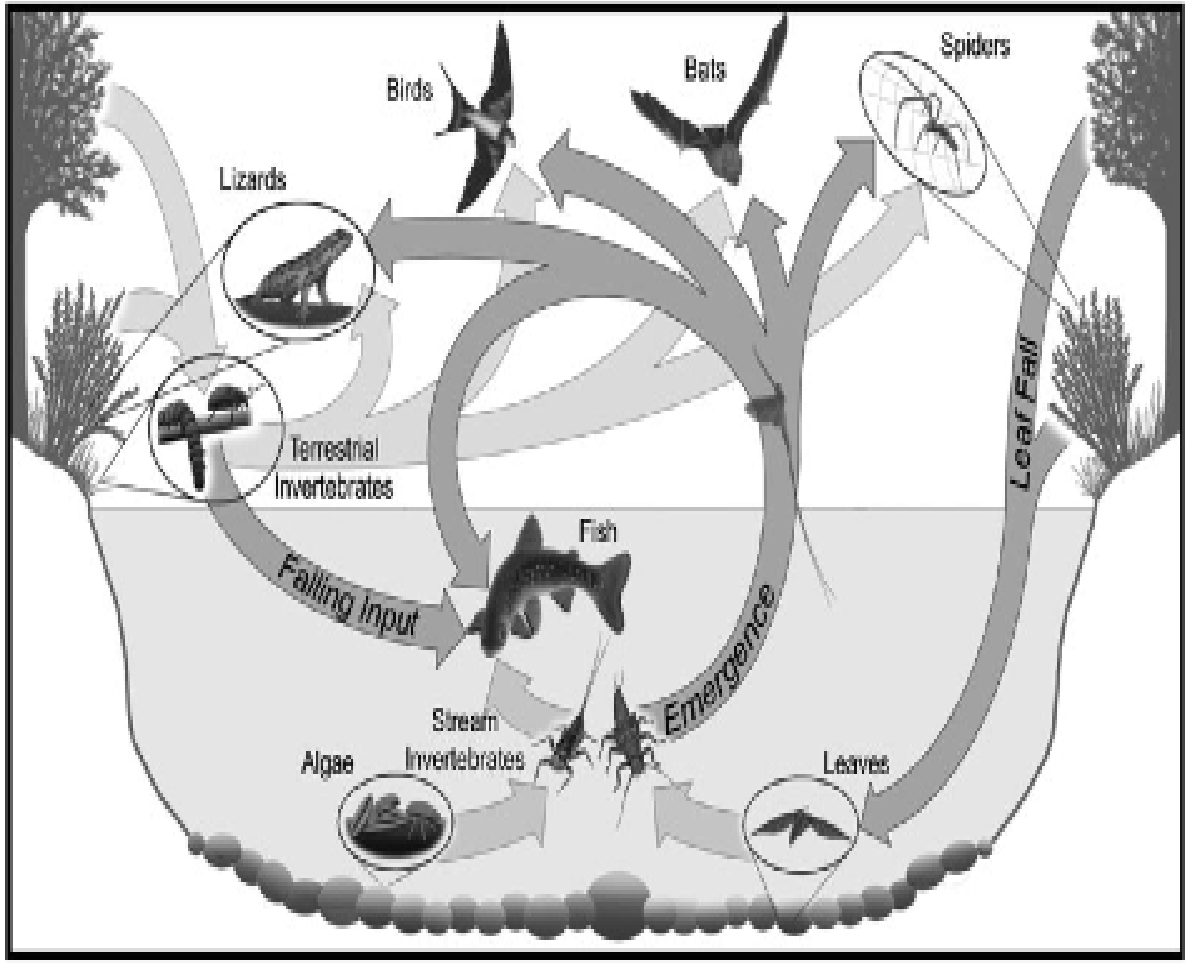

- Affects species composition/ecosystem function
Hydroperiod


- Affects species composition/ecosystem function
- Aquatic & terrestrial studied separately
Hydroperiod


Do phases affect each other through time?

# Aquatic-terrestrial linkages *(Subsidies)*

- Movement of organisms and materials
  - Resources
  - Prey
  - Habitat
  - Predators

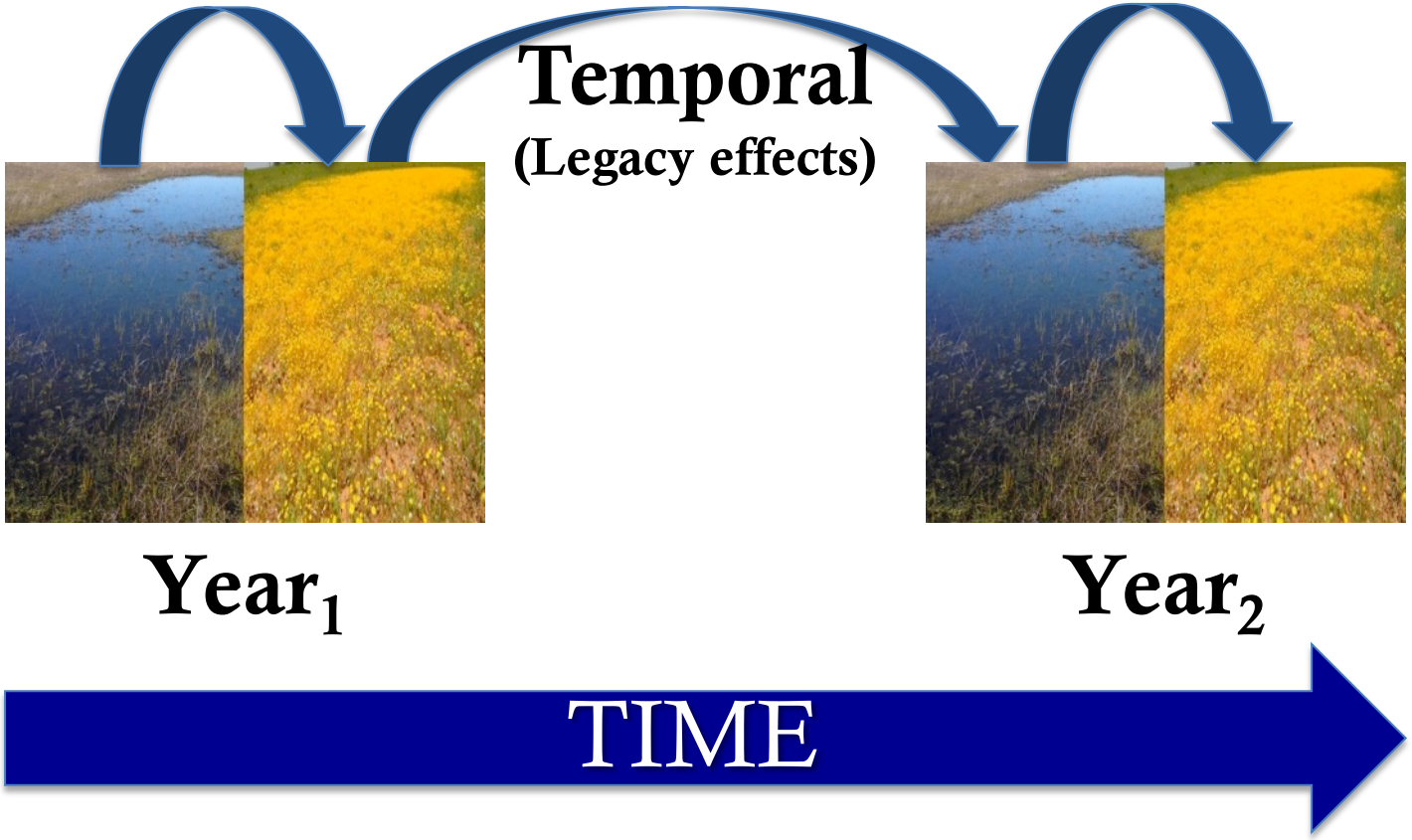



Baxter et al. (2005)

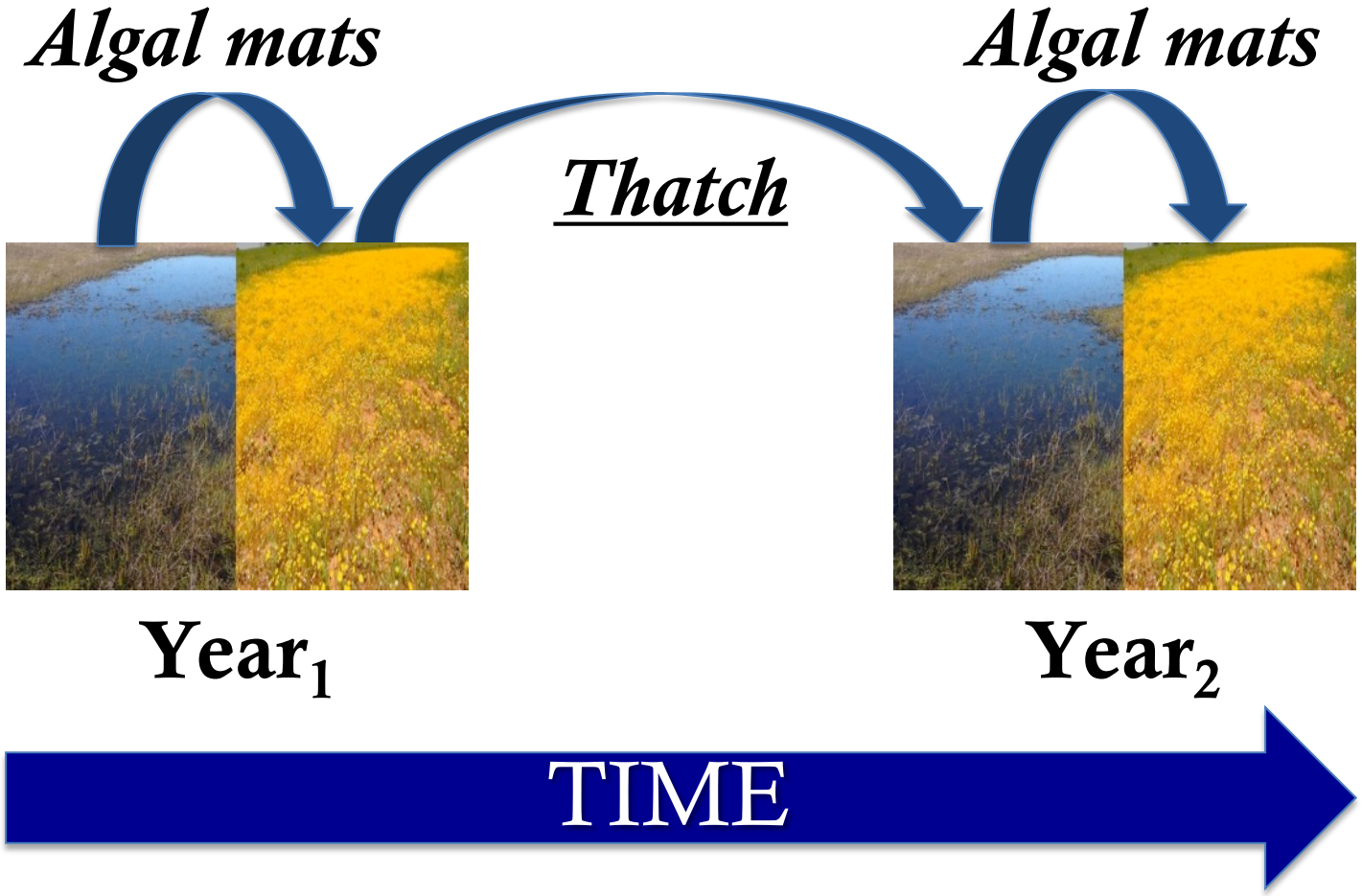
# Spatial Linkages

- Insect Dispersal
- Nutrients

# Temporal Linkages



# Temporal Linkages



# Question

Does **hydroperiod** interact with spatial (**nutrients**) and temporal (**thatch**) linkages?

- Aquatic phase
- Terrestrial phase

# Methods

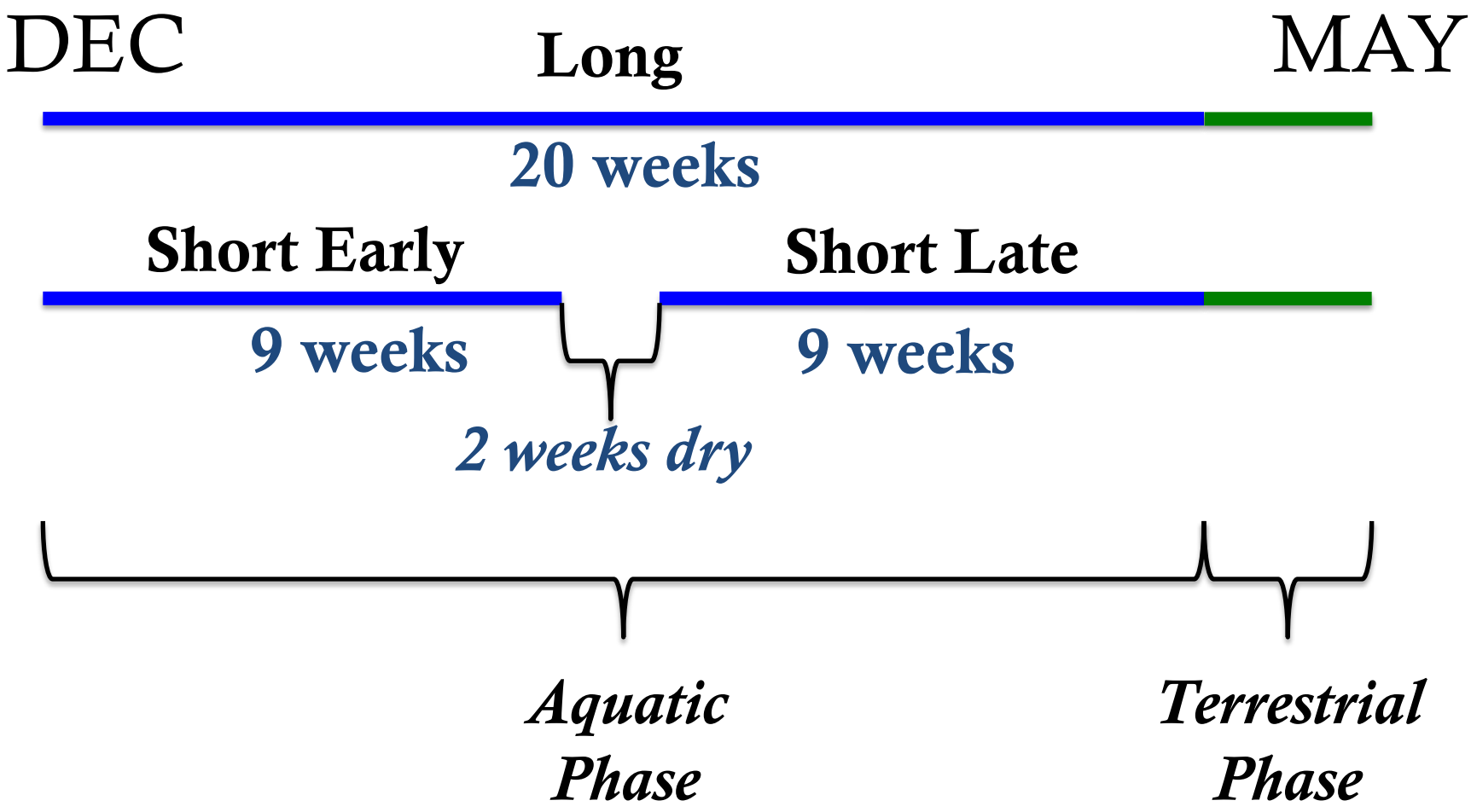
## *Independent variables*

Hydroperiod:
- *Short*
- *Long*

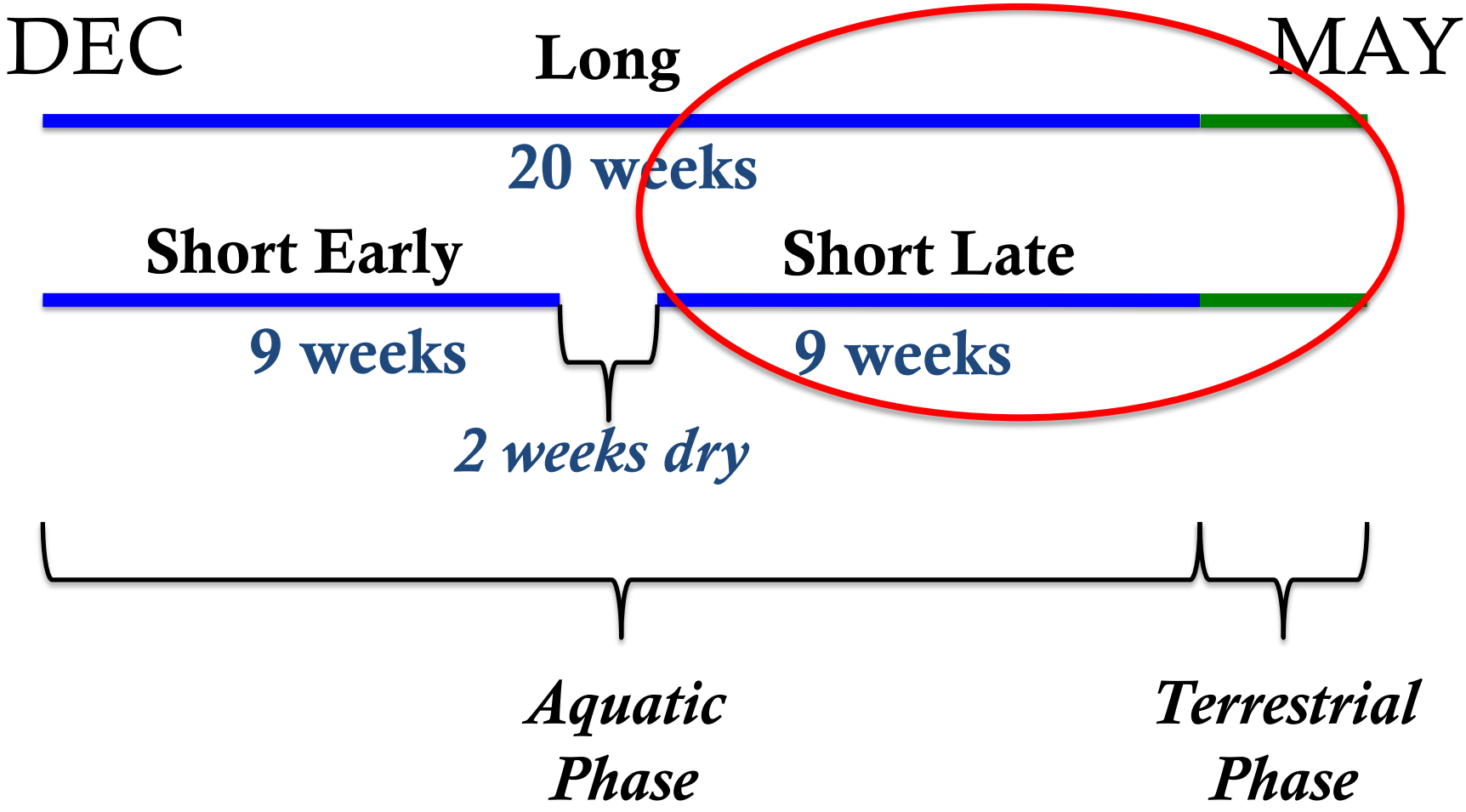
Nutrients:
- *Control*
- *Addition*

Thatch:
- *Control*
- *Addition*

# Experimental Design



# Experimental Design



# Methods
## *Dependent variables*

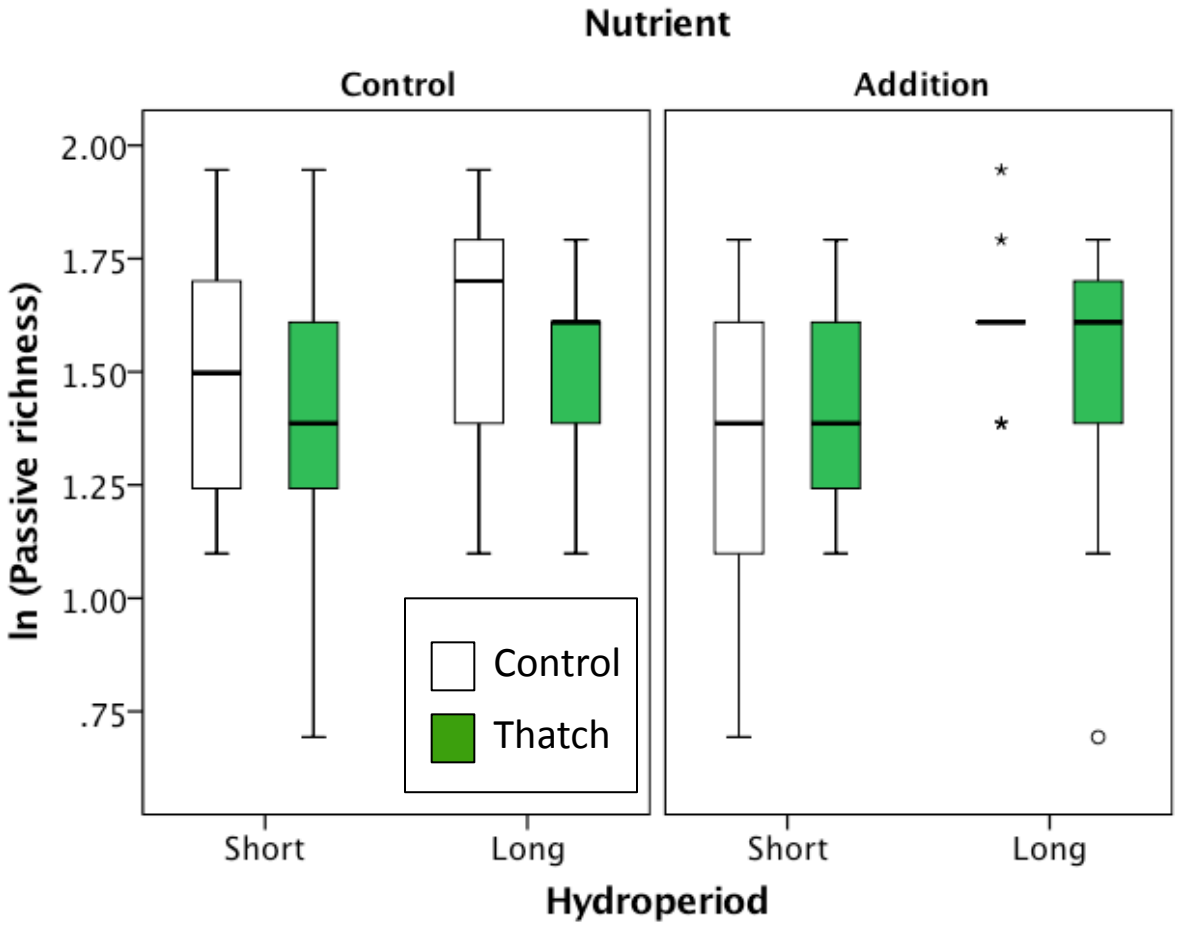
**Aquatic**:
- *Invertebrates*
  - *Passive*
  - *Active*
- *Algal mats*

**Terrestrial**:
- *Plants*

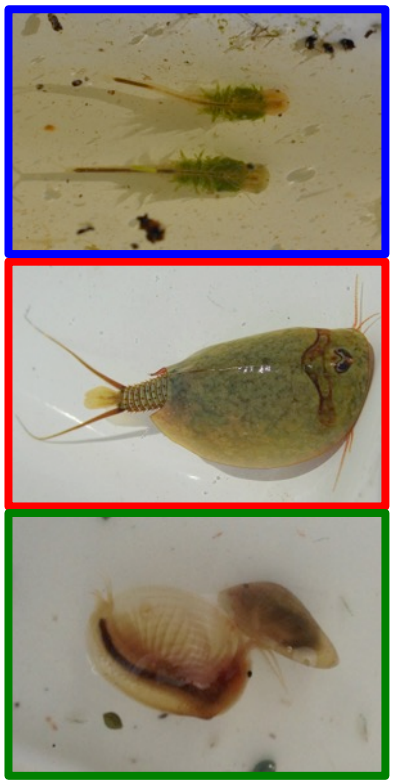
# Results: Aquatic

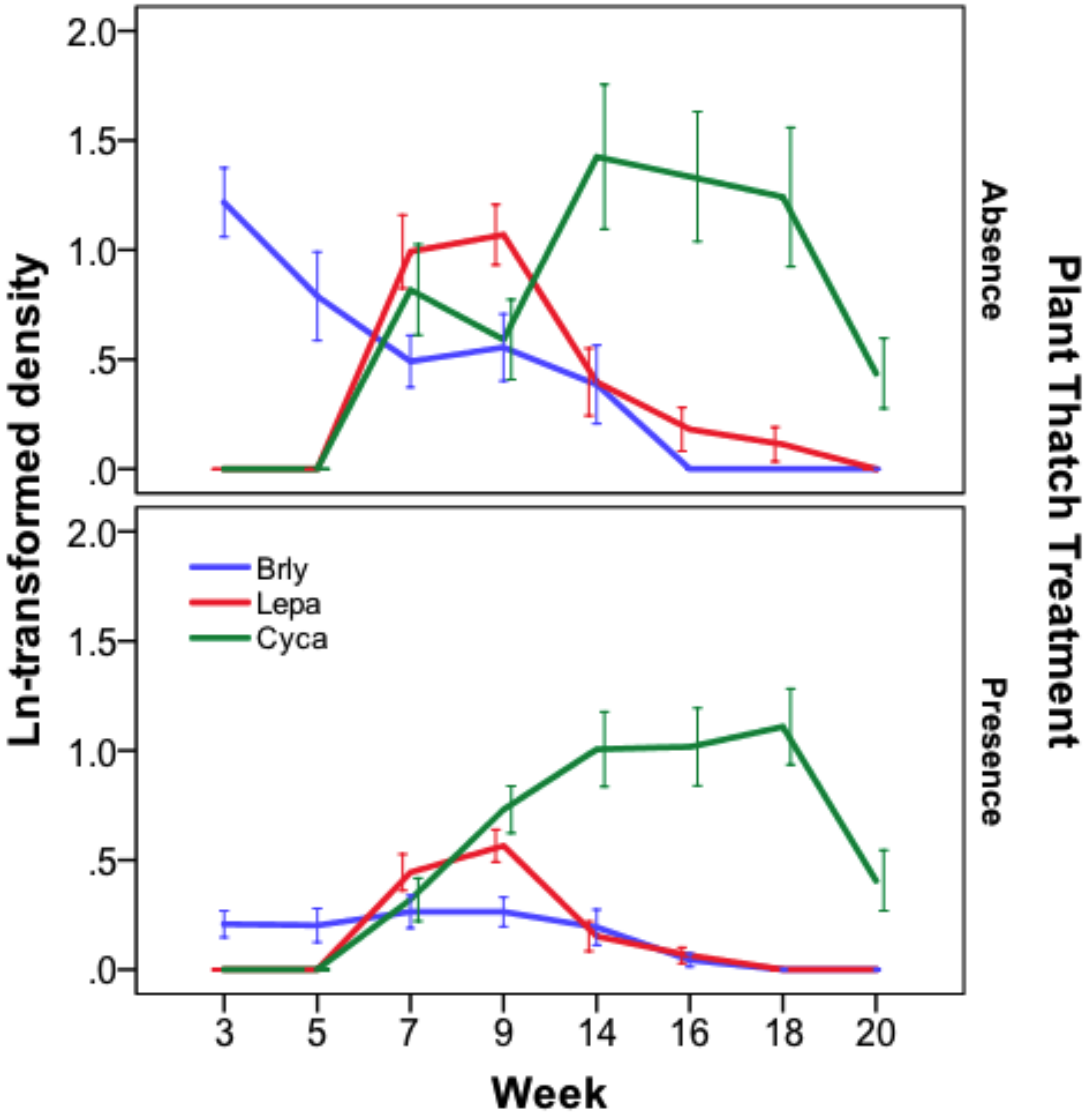
## *Passive species richness*

- Hydroperiod: ↑
- Litter: ↓
- Nutrients: **ns**
- H x L x N



# VP Endemics

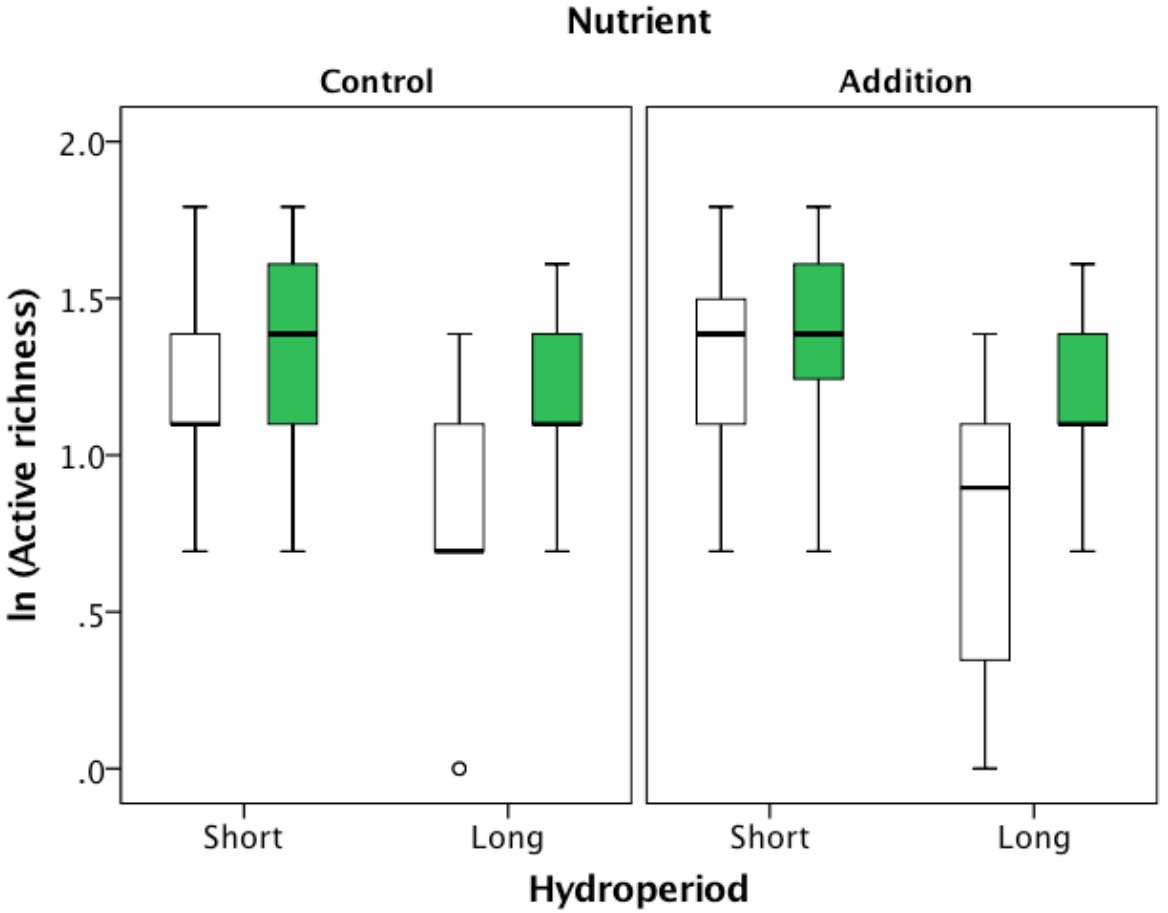



Ln-transformed density
2.0
1.5
1.0
.5
.0
Absence
Presence
Plant Thatch Treatment
Brly
Lepa
Cyca
3
5
7
9
14
16
18
20
Week

# Results: Aquatic

## *Active species richness*

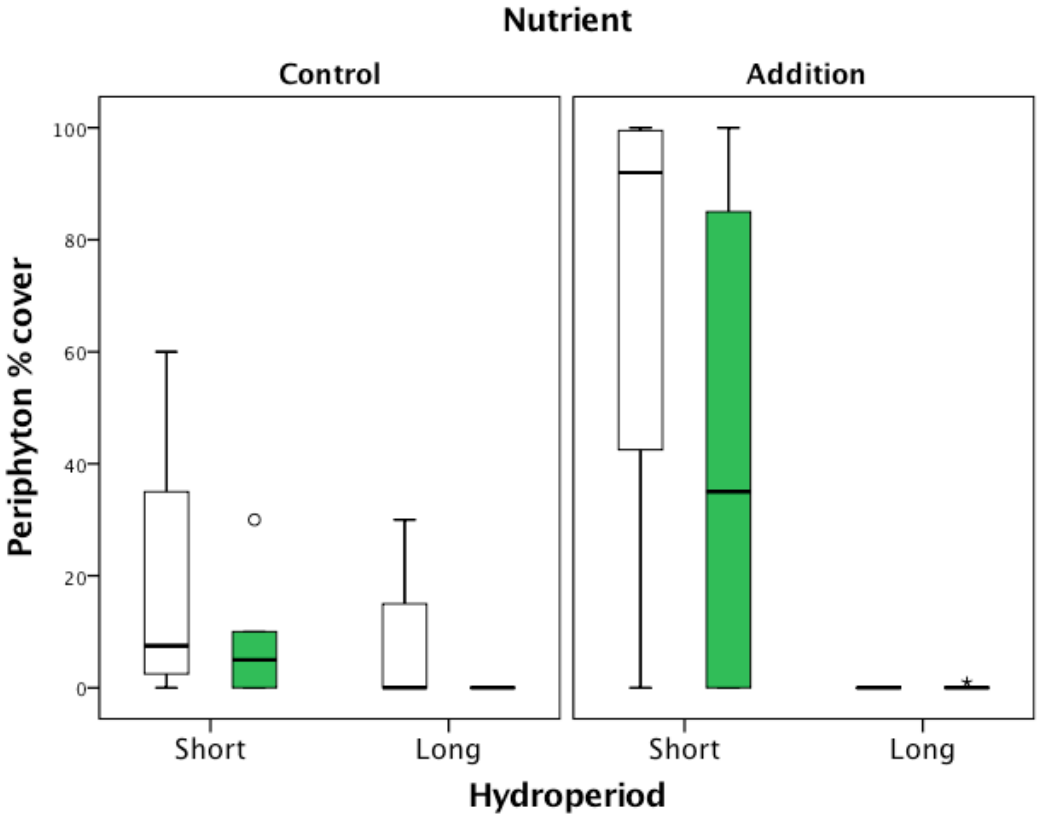
- Hydroperiod: ↓
- Litter: ↑
- Nutrients: **ns**
- H x L



# Results: Aquatic

## *Algal mat cover*

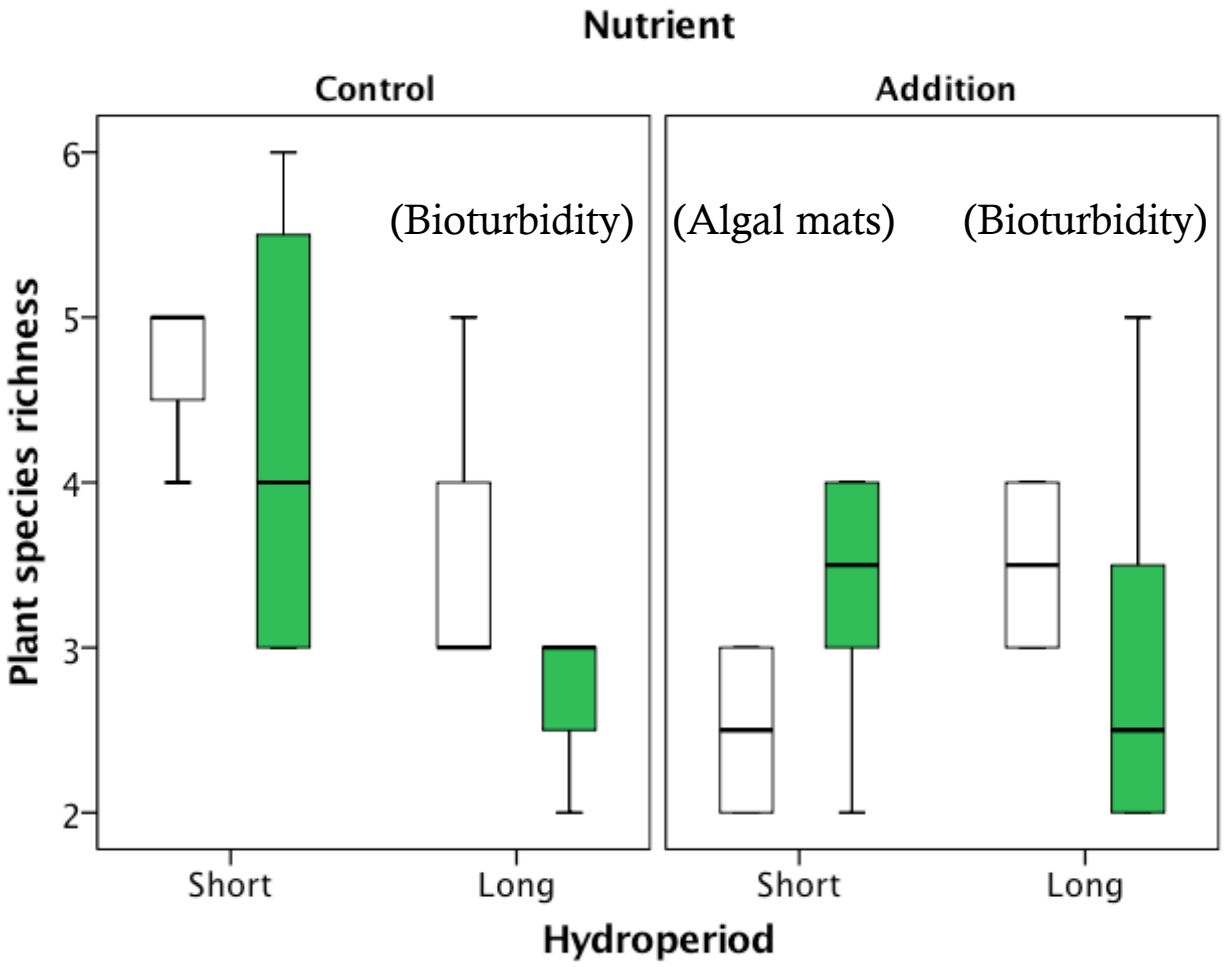
- Hydroperiod: ↓
- Litter: ↓
- Nutrients: ↑
- H x N




# Results: Terrestrial

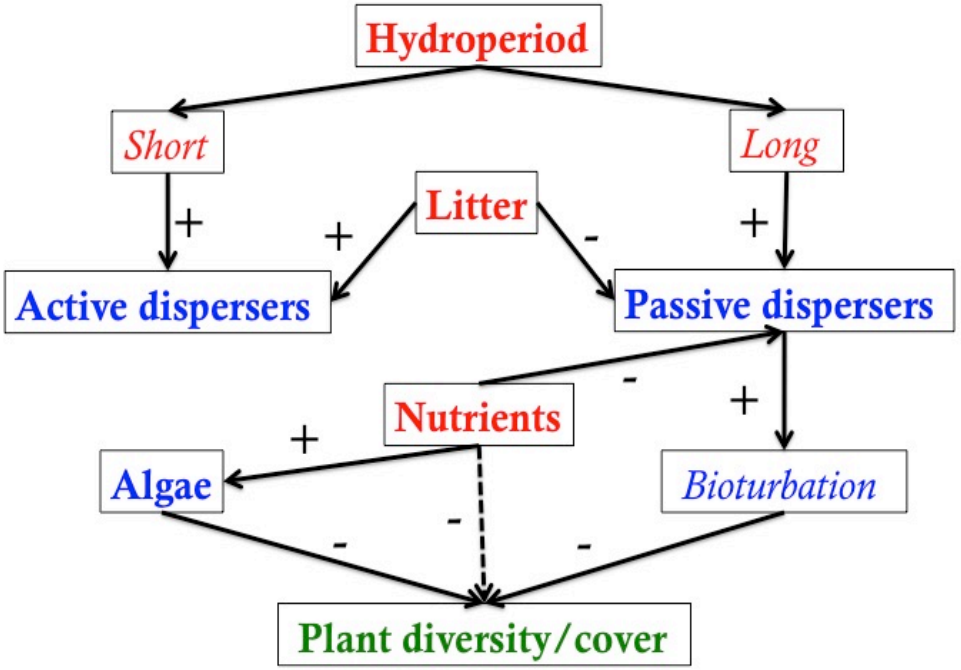
## *Plant richness*

- Hydroperiod: ↓
- Litter: ↓
- Nutrients: ↓
- H x L; H x N



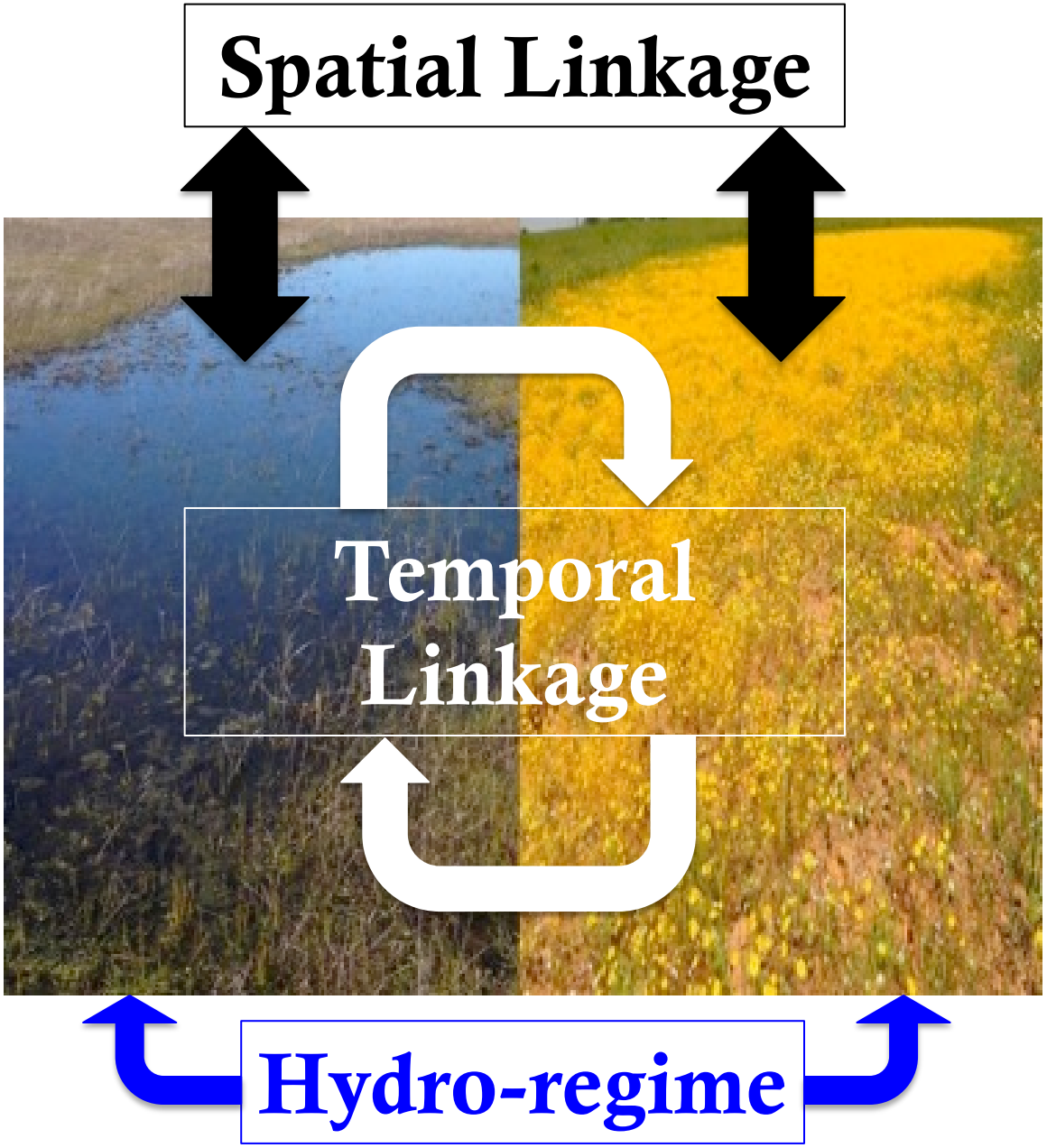
# Conclusions

- Hydroperiod interacted with spatial (nutrients) and temporal (litter) subsidies
  - Aquatic and terrestrial phases
- Complex direct and indirect interactions within and among years



# Conclusions

- Framework for seasonal ecosystems
- Management/restoration
- Future directions:
  - Field
  - Diversity-function
  - Generalizable



# *Acknowledgements*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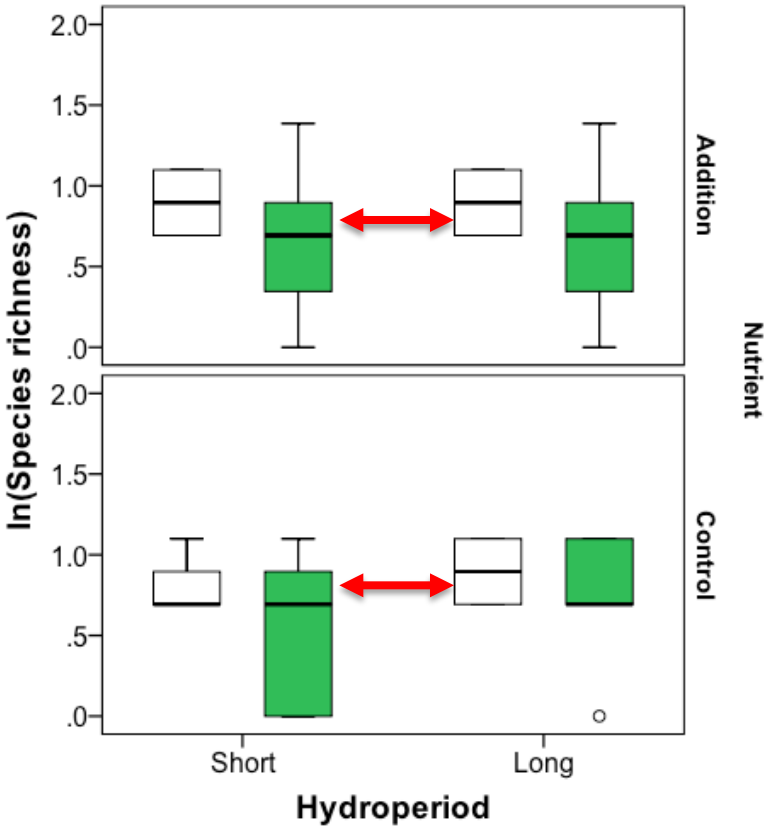
# Inter-annual Results

***Year 1** (Week 3)*




***Year 2** (Week 3)*