

Wetland Plant Ecology

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Grand Island, NE
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Determining the intent of management is critical because only when the intent is clearly articulated can the outcome be evaluated to determine if management has been successful.

Holling 1978, Cairns 1989, Noss 1995

Current Management Approaches

► Often based on selecting tool/technique due to

- ❑ Management dogma (tradition)
- ❑ Acceptability (staff, public)
- ❑ Availability of resources (money, staff, equipment)

► Often fail because

- ❑ Abiotic factors not considered or have changed

Example: Sediment dynamics altered soil properties (texture, chemistry)

- ❑ Ecological processes underlying tool/technique are unknown or misunderstood

Example: Conduct drawdowns every 3 years

Current Management Approaches

► Often fail because

- ❑ Emphasis on concepts/information from single locations OR single temporal period

Example: Drawdown in late April for annual smartweeds

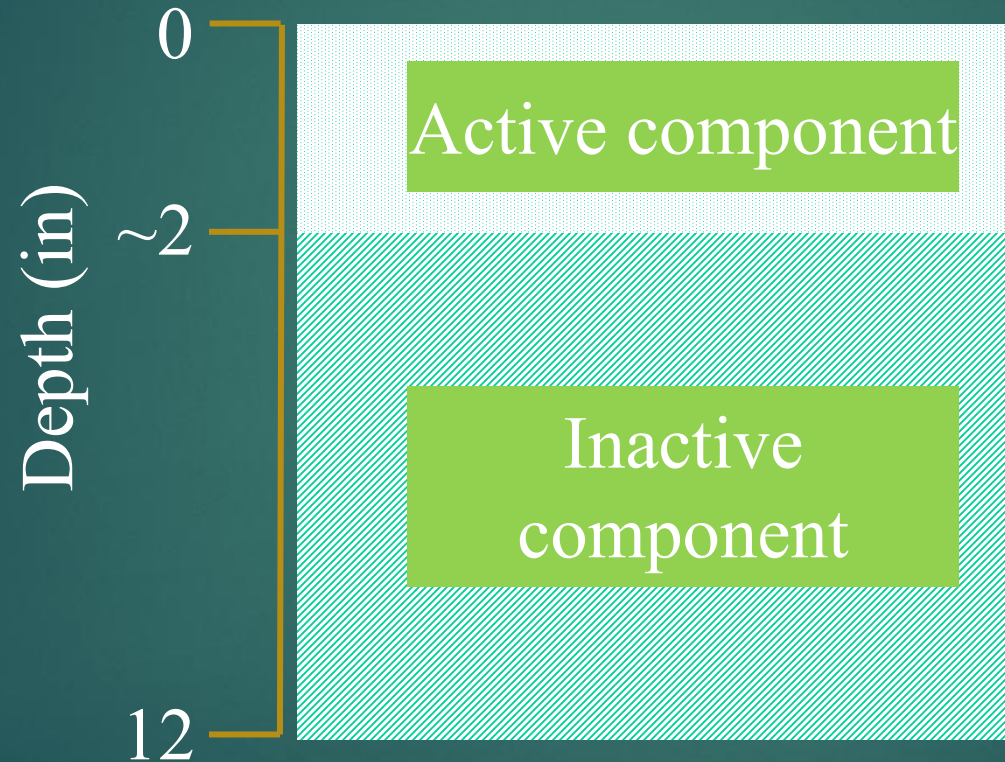
- ❑ Failure to recognize importance of abiotic factors

Example: Soil texture influence on soil moisture cycles

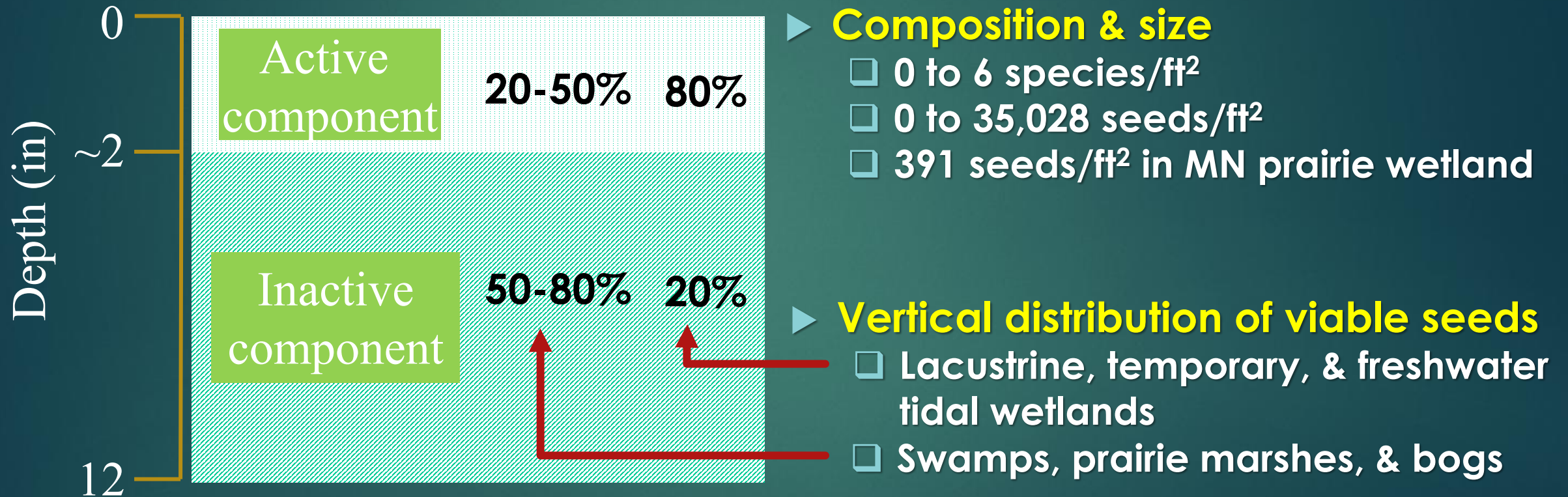
- ❑ Limited monitoring to evaluate results of management actions (i.e., learning)

Example: Growing conditions preceding & following actions

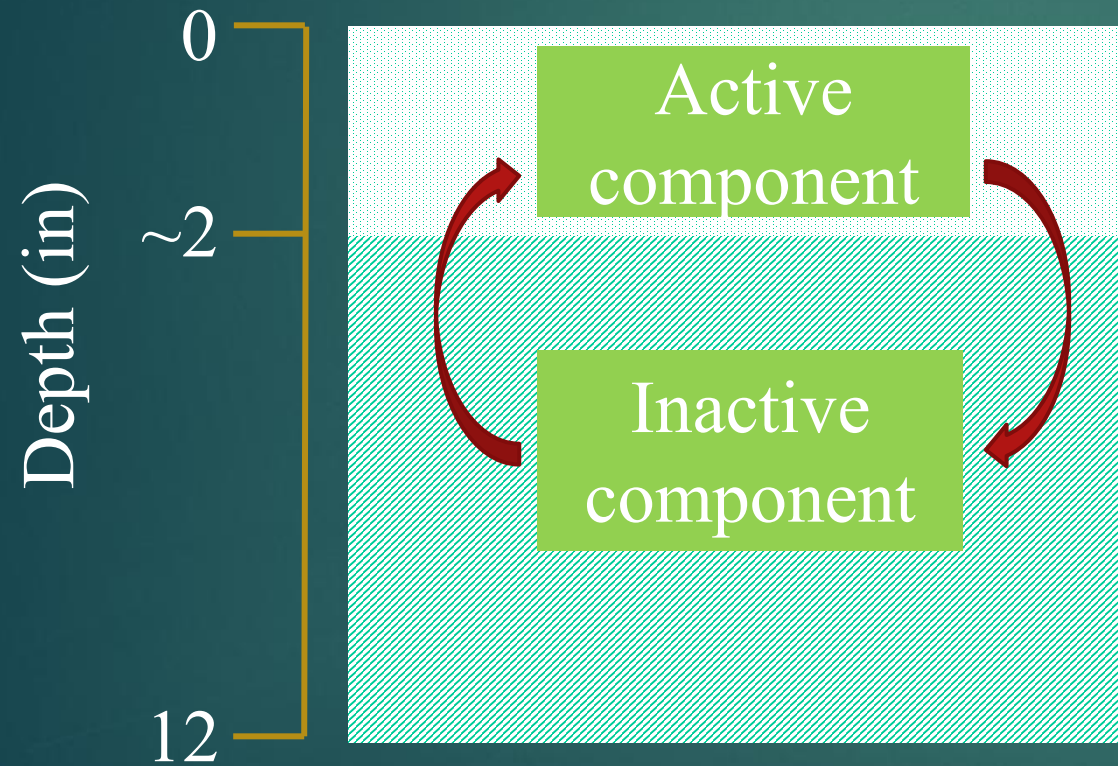
Seed Bank Dynamics (Generalizations)



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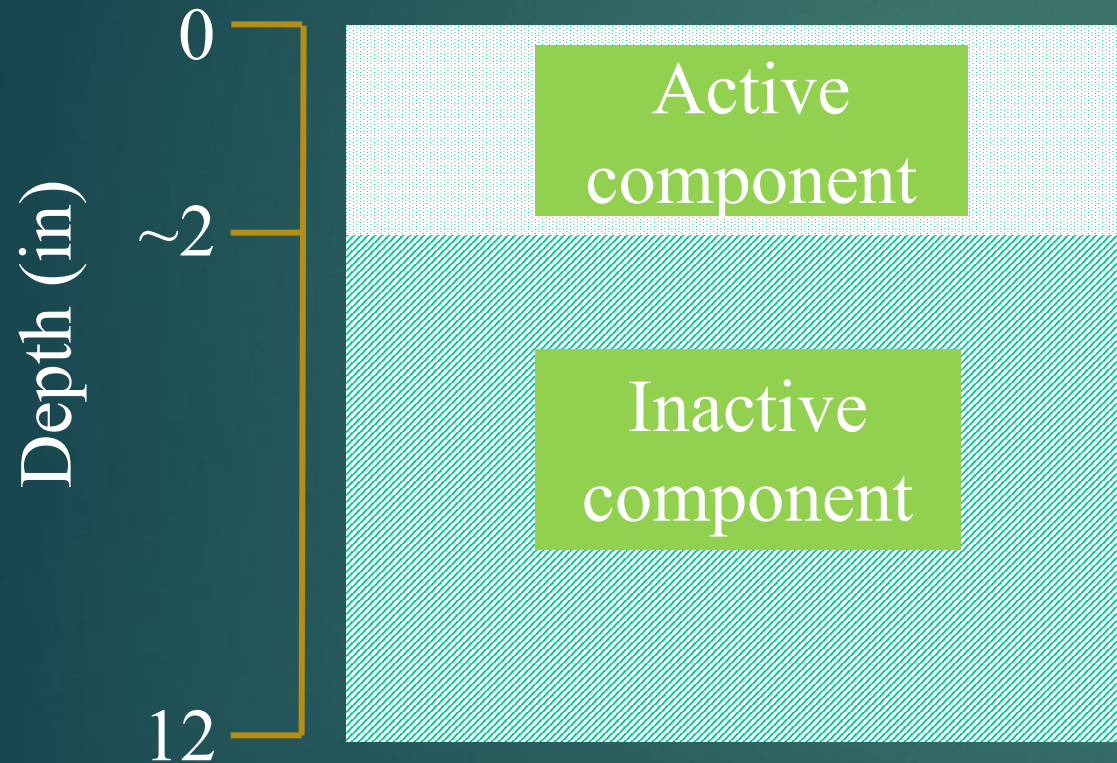
Seed Bank Dynamics



Distribution is dynamic

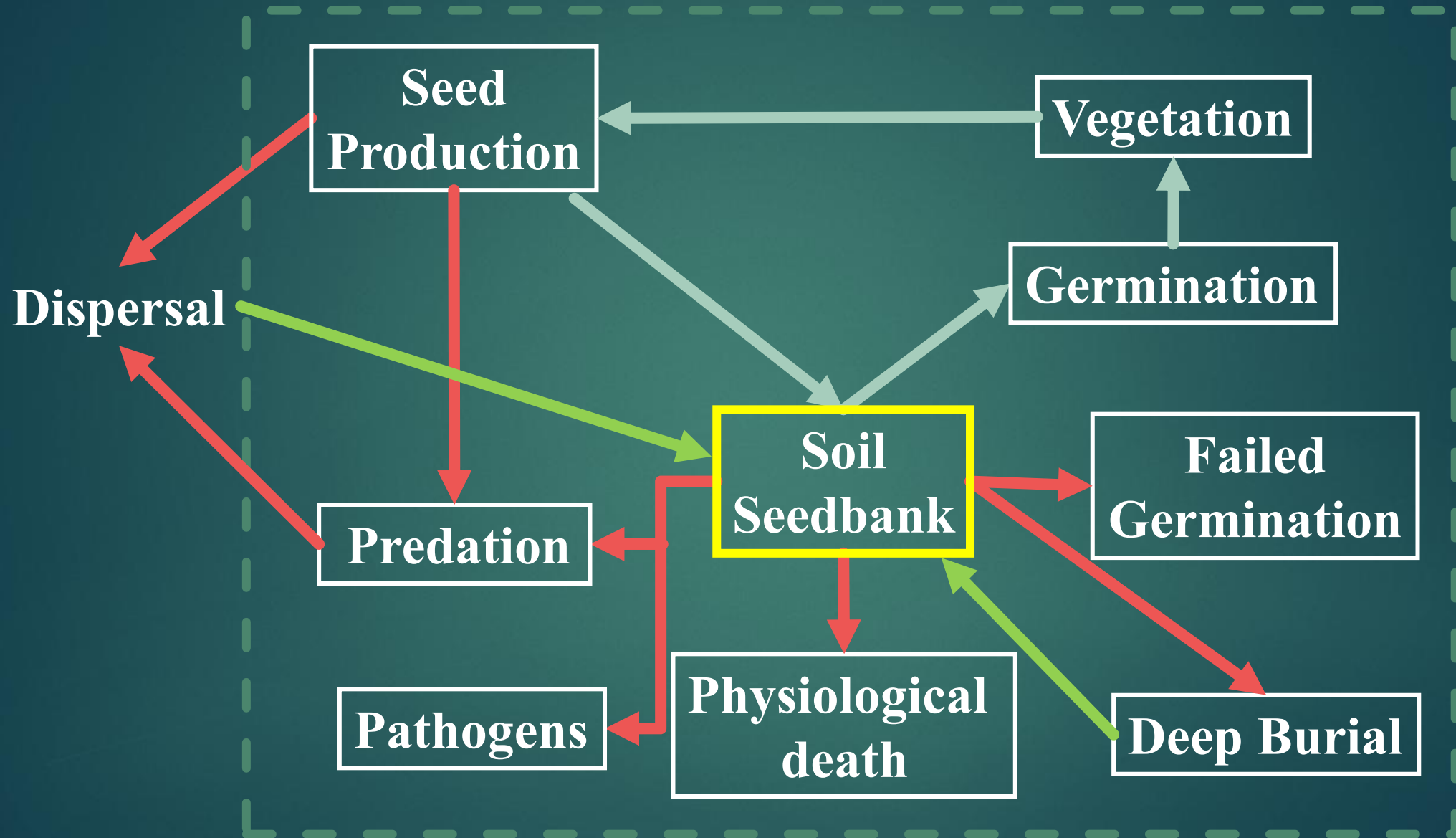
- ❑ Wind
- ❑ Burrowing
- ❑ Grubbing
- ❑ Tillage
- ❑ Sediment dynamics

Seed Bank Dynamics



Seed longevity varies

- ❑ Arctic lupin (10,000 yrs)
- ❑ Lambsquarters (17,000 yrs)
- ❑ Curly dock (80 years)
- ❑ Redroot pigweed (>30 yrs)



Successful Exploitation of Seed Banks Require:

- ▶ Presence of seeds of preferred species AND suitable conditions for germination and establishment of preferred species are met
- ▶ Seeds of undesirable species occur in low abundance OR conditions for germination and establishment of undesirable species are avoided

Plant Categories

(Annual & Perennial)

Annuals

- ▶ Complete life cycle in 1 year
- ▶ Early successional
- ▶ Reproduce by seed (often prolific)
- ▶ Lack energy storage structures
- ▶ Lack adaptations to address oxygen stress
- ▶ Tend to decompose rapidly
- ▶ Provide temporary structure

Perennials

- ▶ Life cycle is multi-year
- ▶ Late successional
- ▶ Reproduce by seed & vegetative propagule
- ▶ Have energy storage structures
- ▶ Often have adaptations to facilitate oxygen capture
- ▶ Tend to decompose slowly
- ▶ Provide robust structure

Plant Categories

(Preference & Avoidance)

Wildlife Requirements

▶ Food Production

- ❑ Type (nutrition)
- ❑ Quantity
- ❑ Size

▶ Cover

- ❑ Invertebrate substrate
- ❑ Structure (horizontal/vertical)
- ❑ Attachment sites

Management Considerations

▶ Decay Rate

- ❑ Nutrient dynamics/availability
- ❑ Seed germination potential

▶ Ability to control

- ❑ Available techniques
- ❑ Frequency
- ❑ Intensity

Seed Banks (Annual & Perennial)



Seed Germination Generalizations

- ▶ Maintaining appropriate conditions for a minimum of approximately 10 days (4 -14 days) required to break dormancy and stimulate germination of a given species
- ▶ Duration of appropriate conditions determines density of seeds of a particular species that germinates
- ▶ Range of conditions during the growing season is a major determinant of species diversity of annual vegetation
- ▶ Seed maturity of annuals requires 50 – 90 days

Breaking Seed Dormancy

Exogenous (seed coat)

► Physical

- ❑ Soil temperature (cold/fluctuating)
- ❑ Fire
- ❑ Animal digestion
- ❑ Mechanical

► Chemical

- ❑ Soil moisture

Endogenous (embryo conditions)

► Physiological

- ❑ Soil temperature
- ❑ Soil moisture
- ❑ Light

► Morphological (development required)

- ❑ Time
- ❑ Soil temperature
- ❑ Soil moisture

Seed Germination

- ▶ **Factors affecting species diversity and density of germination**
 - ❑ Extent of bare soil
 - ❑ Photoperiod
 - ❑ Soil temperature
 - ❑ Soil moisture/oxygen
 - ❑ Water quality (e.g., salinity, sediment, contaminants)
- ▶ **Most mature seeds have low moisture content (5-20% by weight) & must absorb water to activate enzymes and initiate metabolism**
- ▶ **During early germination, respiration may be entirely anaerobic but when seed coat ruptures aerobic respiration starts**

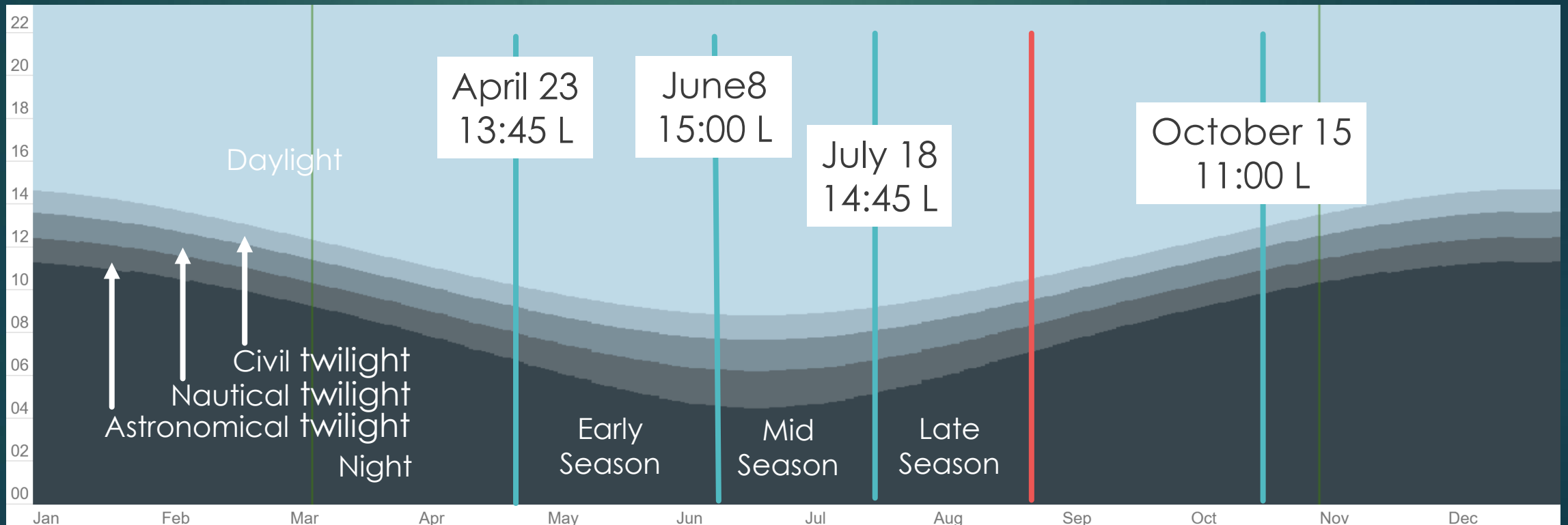
Growing Season

- ▶ **Defined as frost-free period (date of last spring frost to date of first killing frost)**
 - April 23rd to October 15th (175 days) based on long-term NOAA average for Grand Island, NE
- ▶ **Difficult to use daily values as general management guidelines for plant germination, so growing season divided into 3 seasons**
 - Early: 23 April – 7 June (first 45 days of growing season)
 - Mid: 8 June – 17 July (remainder of growing season; 40 days)
 - Late: 18 July – 15 October (last 90 days of growing season)

Photoperiod

(Daily time an organism receives illumination)

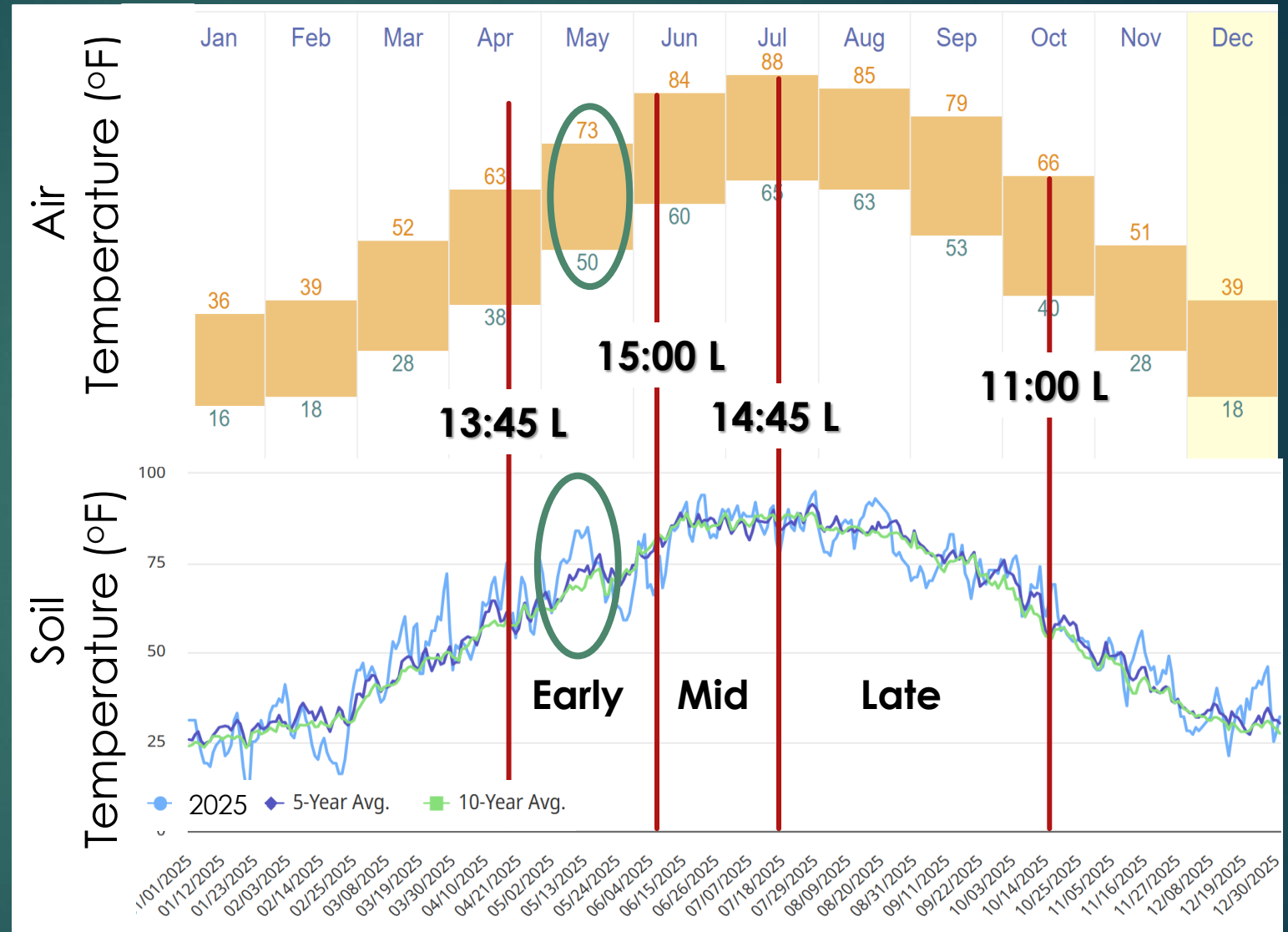
- ▶ Dormancy removal typically involves minimum light requirement
- ▶ Germination may require almost direct light (e.g., *Carex* spp.)



Sunrise and sunset times in Grand Island, (timeanddate.com)

Temperature

- ▶ Correlated but variable among years
- ▶ Also depends on antecedent conditions
 - ❑ Vegetation density
 - ❑ Litter
 - ❑ Surface water
 - ❑ Soil moisture



Climate & Weather Averages in Grand Island, Nebraska (timeanddate.com)
Soil Temperature Maps | GreenCast | Syngenta (greencastonline.com)

Effects of Antecedent Conditions

► Existing vegetation/litter

- ❑ Reduces extent of bare soil
- ❑ Reduces photoperiod
- ❑ Slows soil warming in spring
- ❑ Can cause seedling mortality

► Surface water

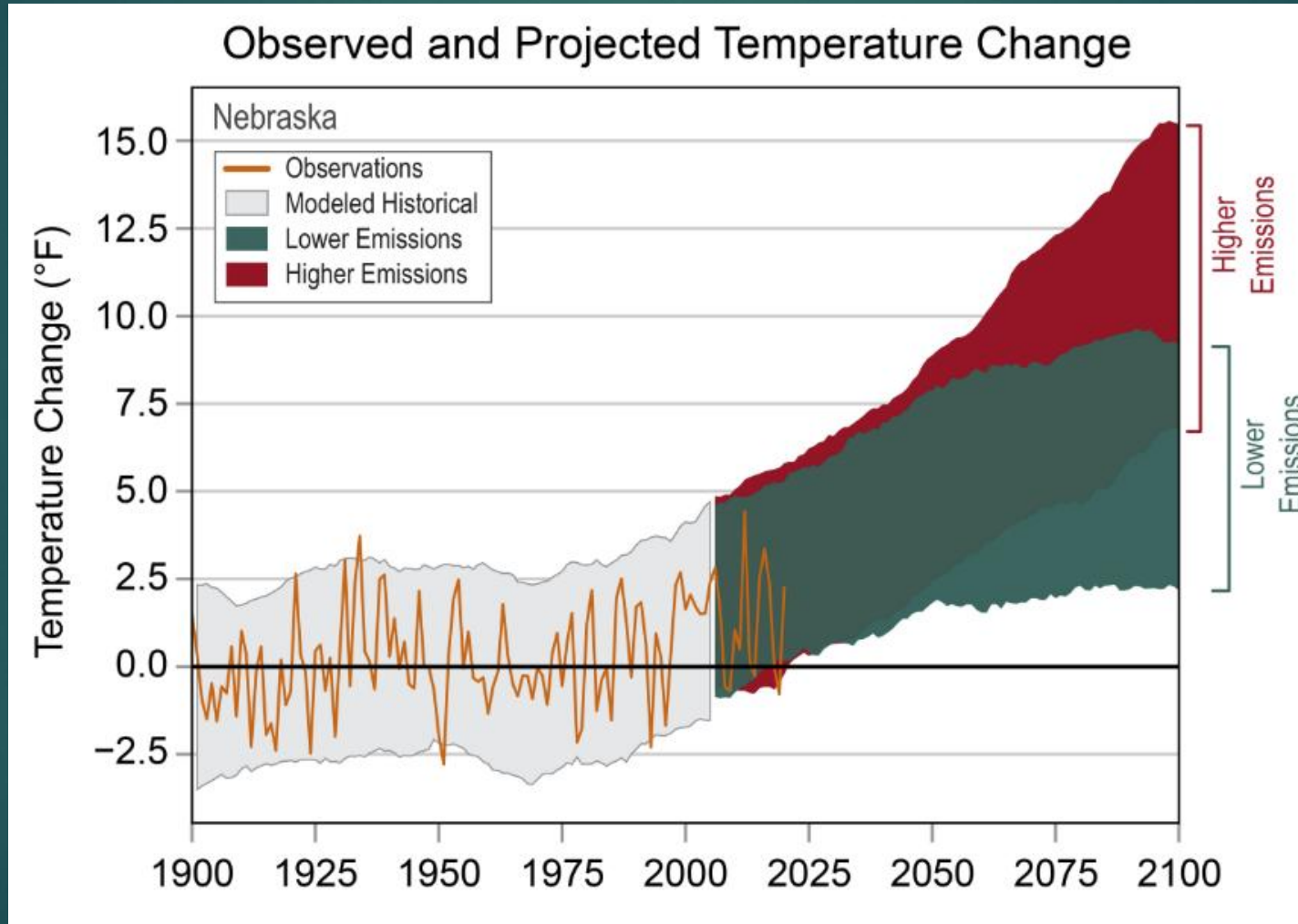
- ❑ Reduces photoperiod (turbid, algae)
- ❑ Slows soil warming in spring

► Sediment

- ❑ Can bury seeds/seedlings
- ❑ Alters soil moisture



Temperature Change (observed & projected)



[Nebraska - State Climate Summary \(ncics.org\)](http://ncics.org)

Season	Date		Soil Temp (°F)		Photoperiod	
	Begin	End	Begin	End	Begin	End
Early	4/23	6/7	63	72	13:45	15:00
Mid	6/8	7/17	72	84	15:00	14:45
Late	7/18	10/15	84	56	14:45	11:00

Grand Island, NE

Season	Date		Soil Temp (°F)		Photoperiod	
	Begin	End	Begin	End	Begin	End
Early	4/12	5/26	60	68	13:00	14:30
Mid	5/27	7/30	68	81	14:30	14:00
Late	7/3	10/28	81	56	14:00	10:45

**Duck Creek CA
(Puxico, MO)**

Season	Date		Soil Temp (°F)		Photoperiod	
	Begin	End	Begin	End	Begin	End
Early	4/7	5/22	50	65	12:55	14:30
Mid	5/23	7/31	65	80	14:30	14:10
Late	8/1	10/28	80	55	14:10	10:40

**Klamath NWR
(Klamath Falls, OR)**

Hydrology

(Soil Moisture in active Germination Zone)

► Geographic setting

- ❑ Precipitation/evaporation ratio
- ❑ Temperature

► Geomorphic setting

- ❑ Topography
- ❑ Surface soil type (texture & structure)
- ❑ Underlying lithology

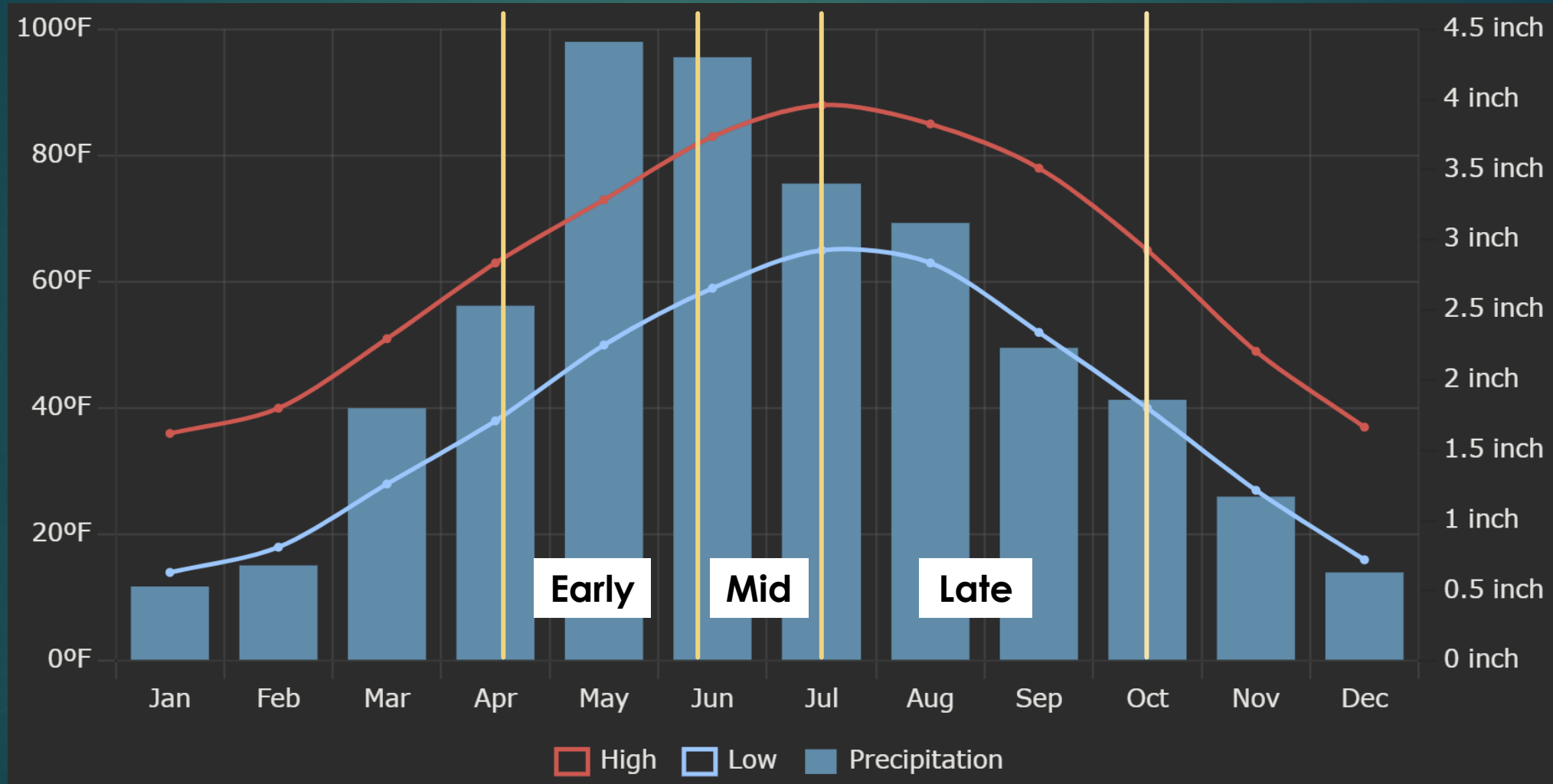
► System type (palustrine, riverine)

- ❑ Watershed area & source of hydrologic input (e.g., runoff, overbank)

► Type and magnitude of alteration

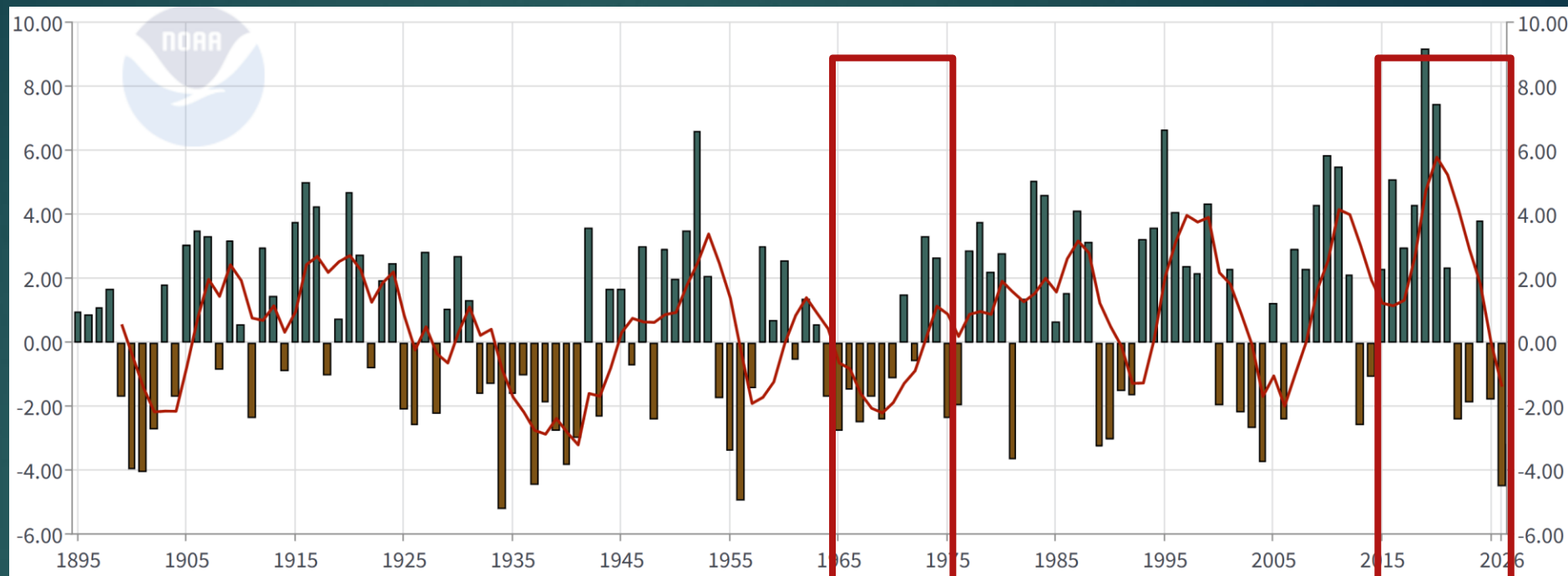
- ❑ Ditches/levees/pumping
- ❑ Water chemistry (sediment, nutrient balance, contaminants)

Geographic Setting (Precipitation & Air Temperature)

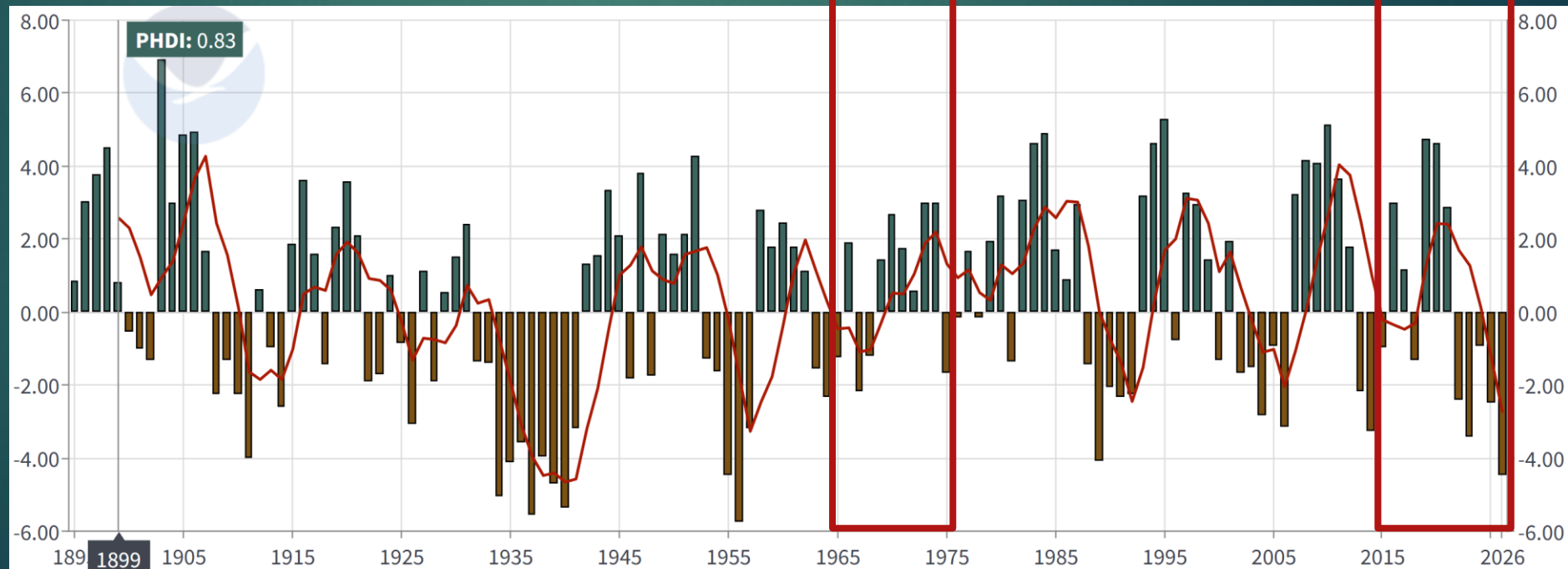


**North
Central**

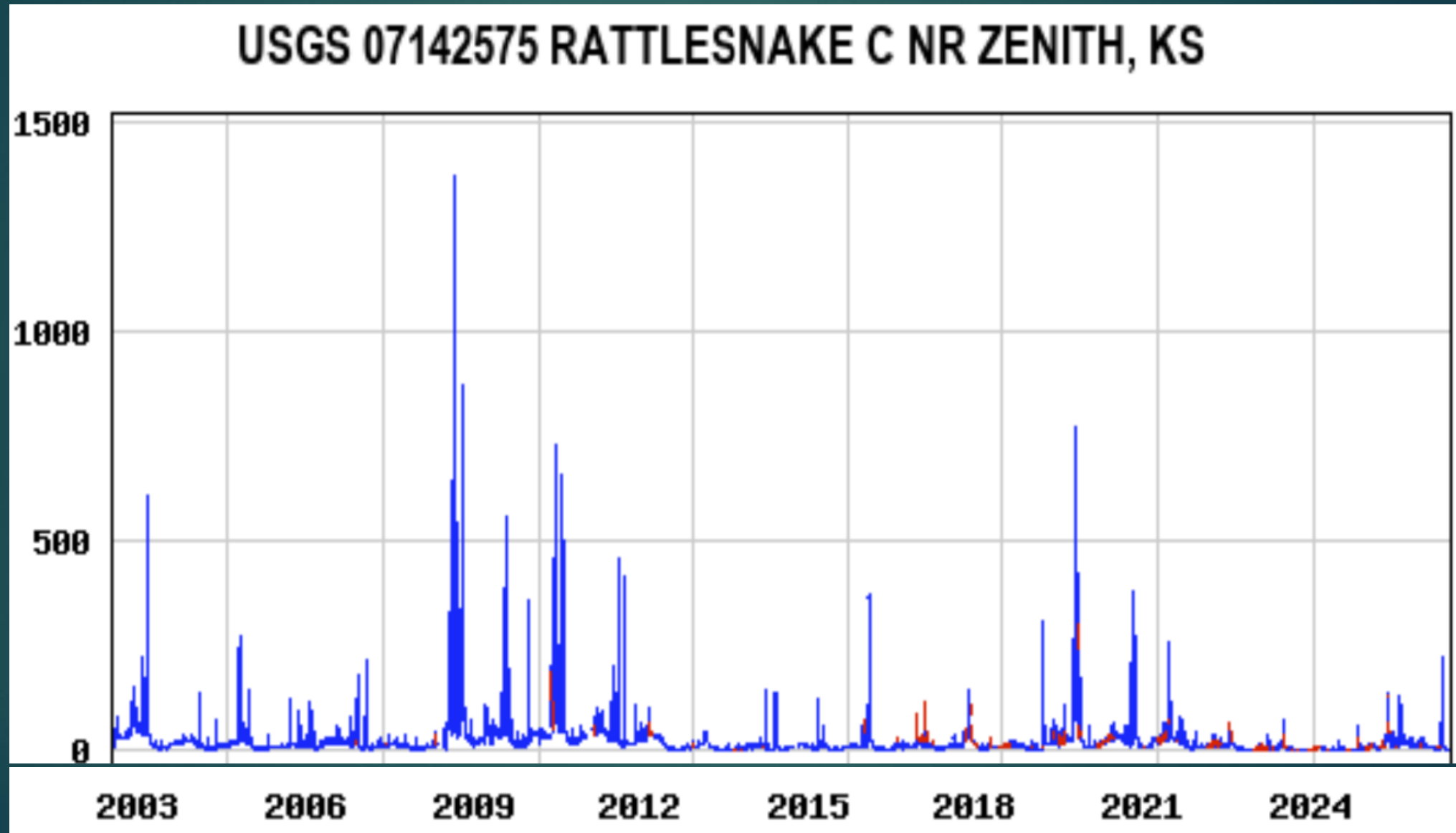
**NE PHDI
(May)**



**South
Central**



Geomorphic Setting



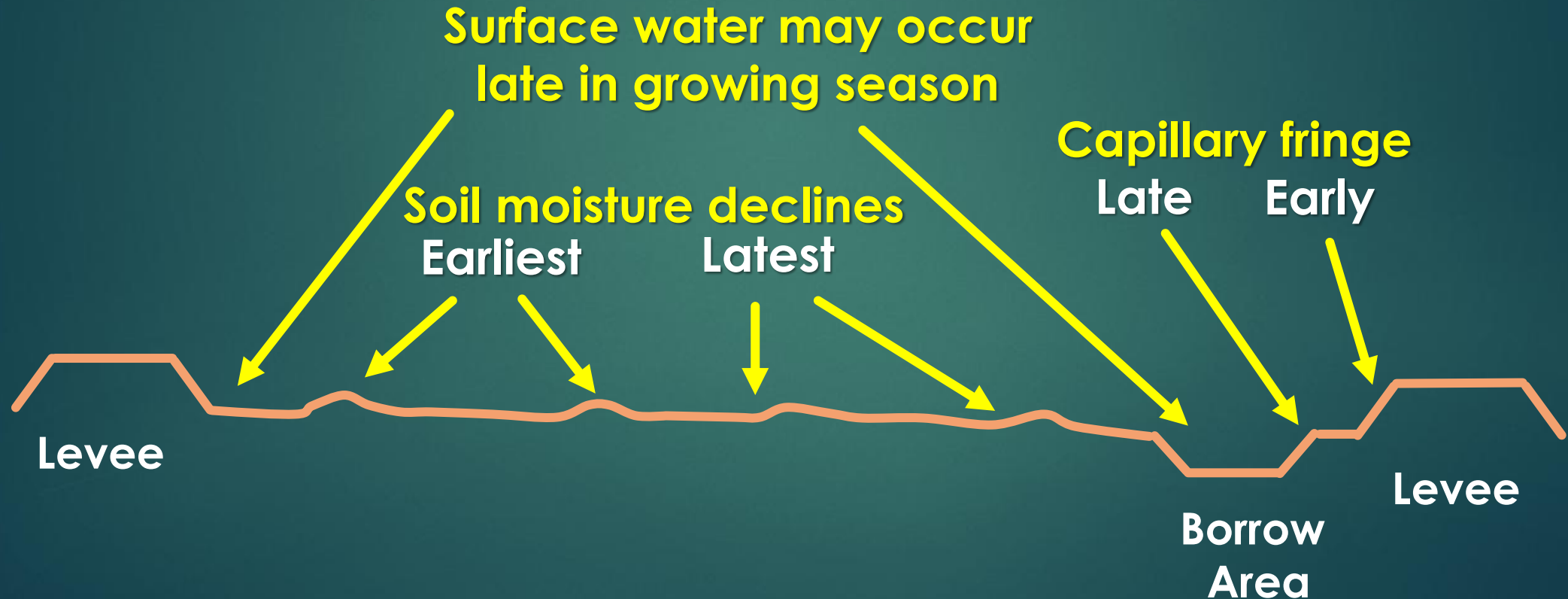
Geomorphic Setting

topography
soils



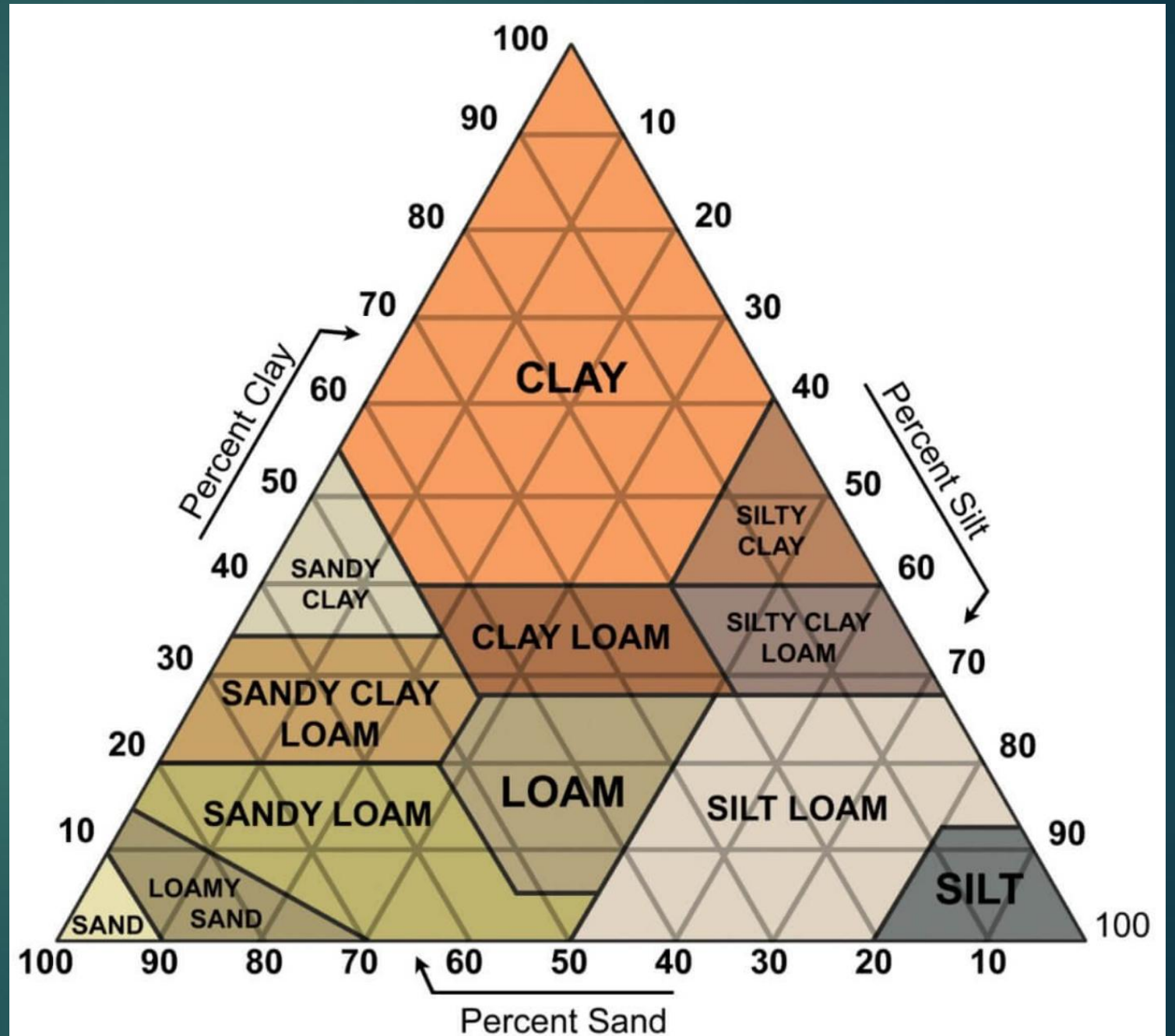
Geomorphic Setting (Topography)

- Soil moisture (as well as temperature and photoperiod) can be influenced by gradient and aspect



Geomorphic Setting (Soil texture)

Class	Diameter (mm)	Texture
Sand	2.00 to 0.05	Gritty
Silt	0.05 to 0.002	Smooth
Clay	< 0.002	Sticky

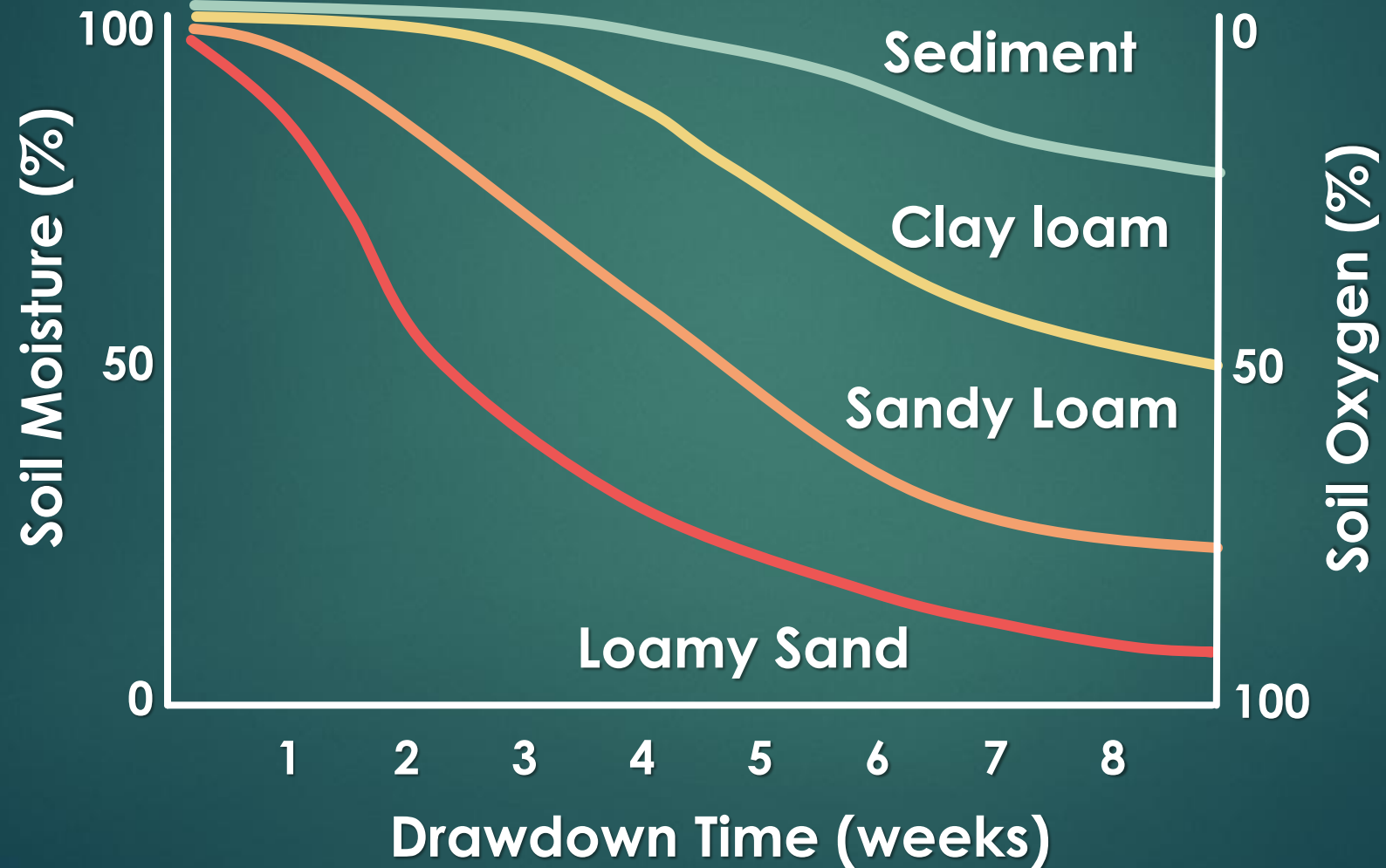


Geomorphic Setting (Soil texture)

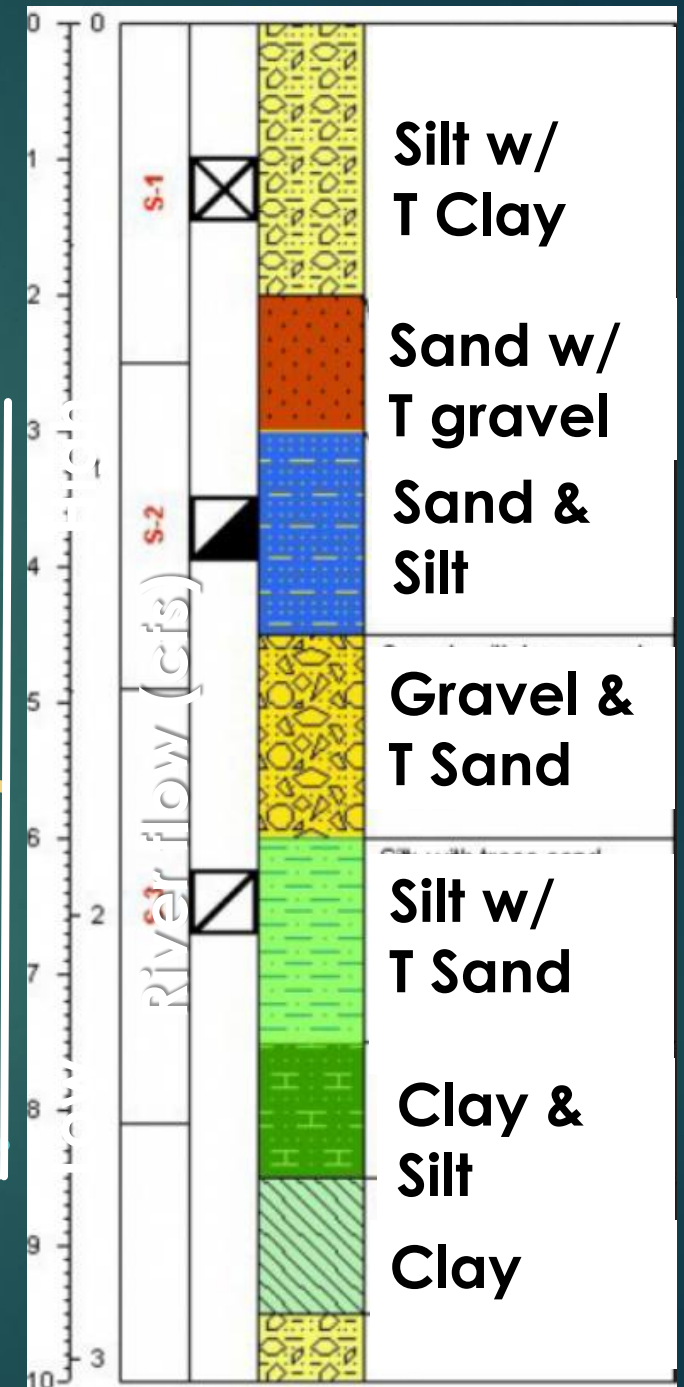
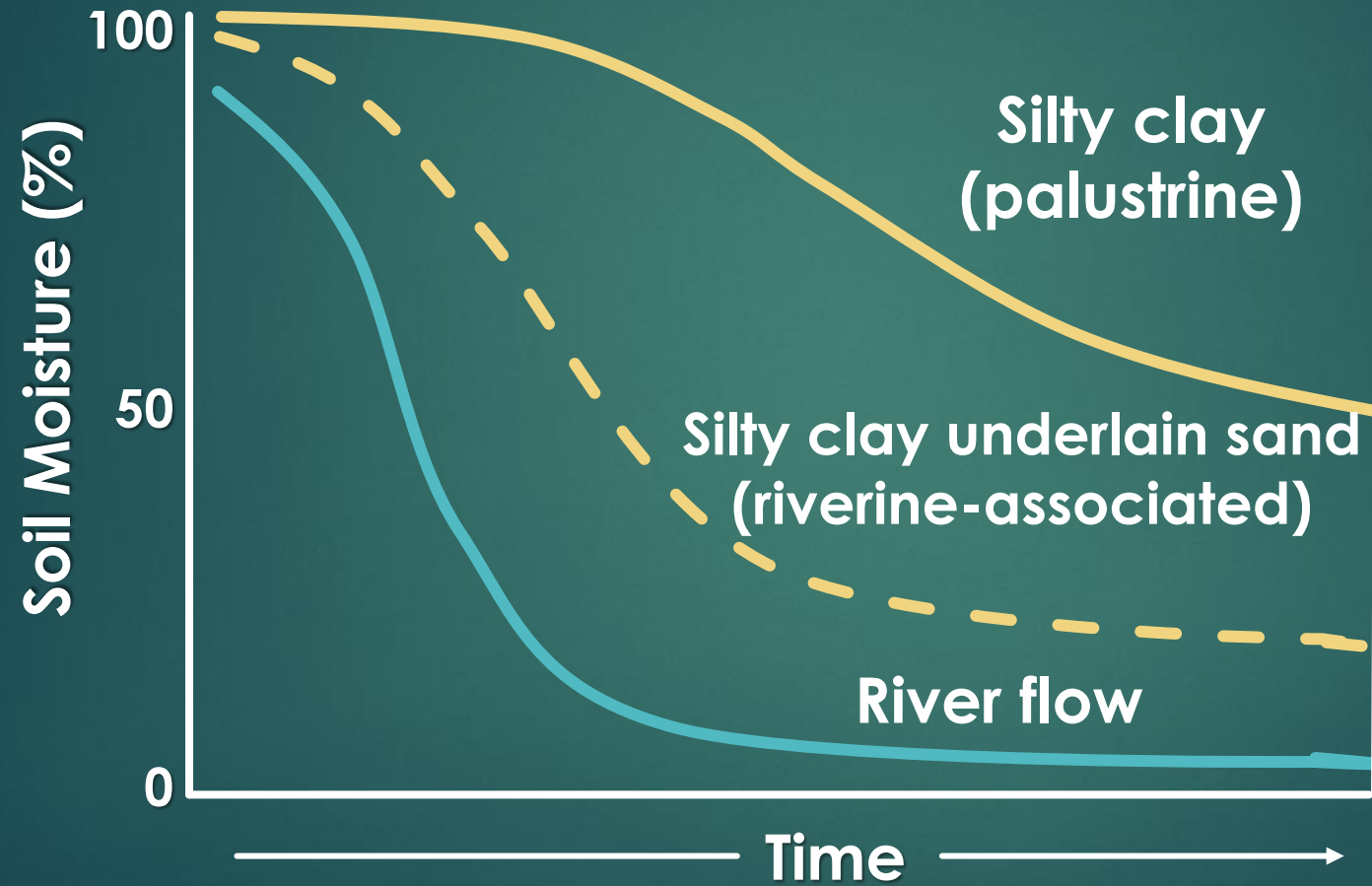
Texture class	Organic matter (%)	CEC (cmol/kg)	Moisture retention	Nutrient retention ¹	Shrink/swell
Fine (e.g., clay)	>4	> 20	High	High	High
Medium (e.g., loam)	2-3	16 - 18	Medium	Medium	Medium
Coarse (e.g., sand)	<1	3 – 12	Low	Low	Low

¹ Nutrients include calcium, potassium, sodium, magnesium

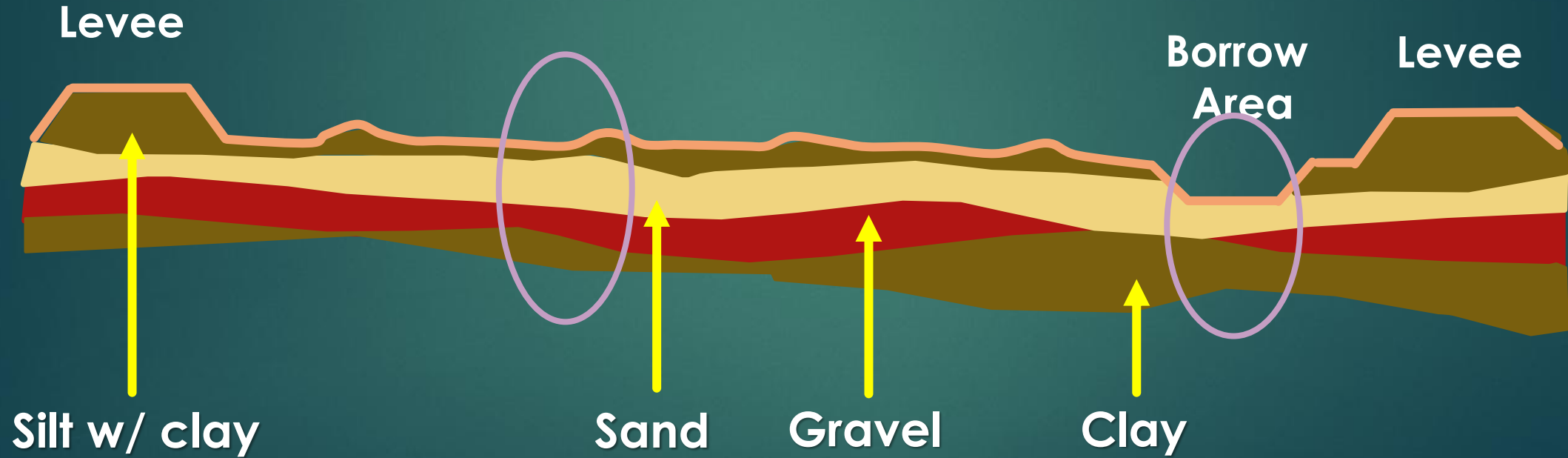
Geomorphic Setting (palustrine wetland)



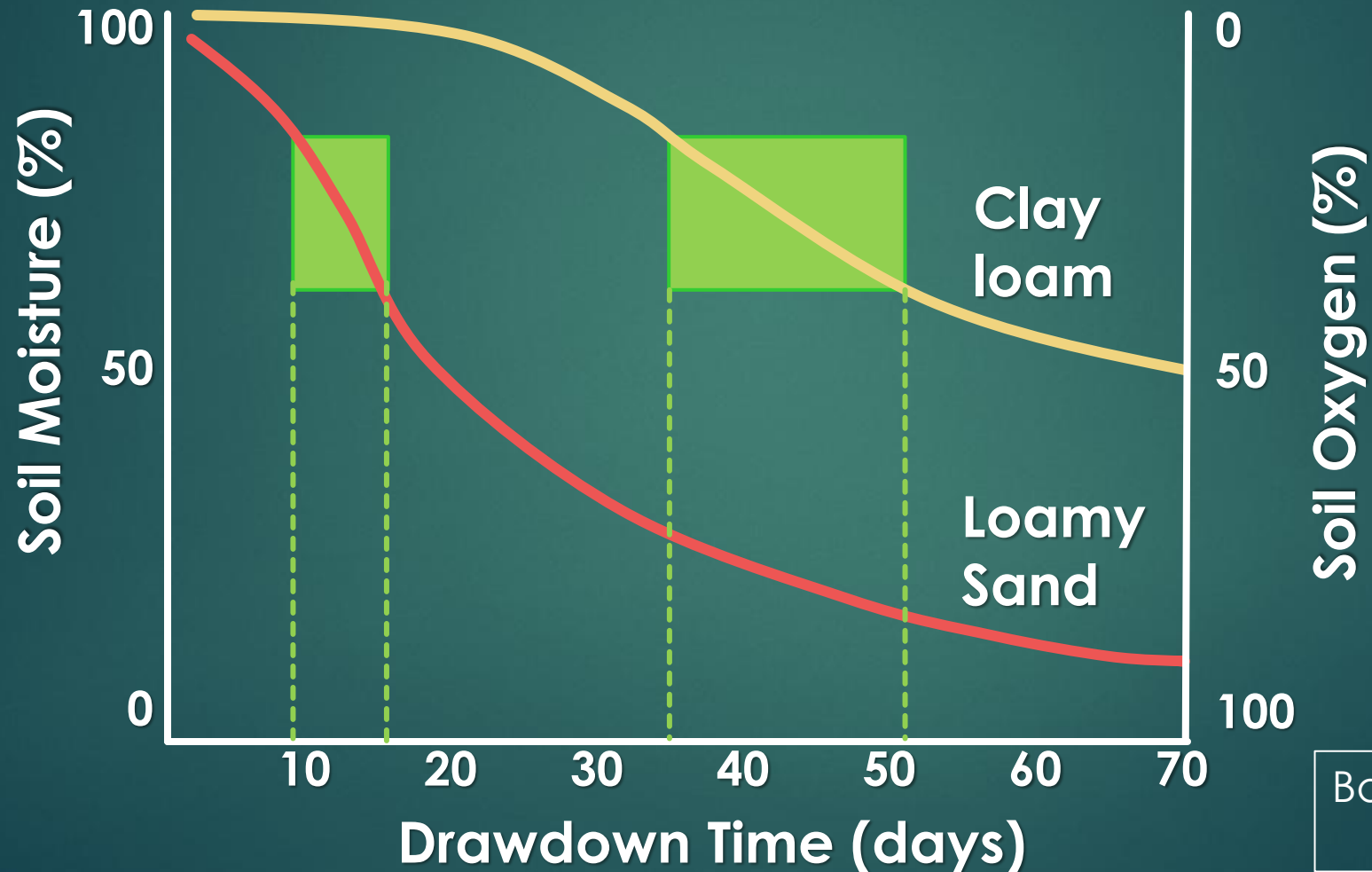
Geomorphic Setting (influence of lithology)



Geomorphic Setting (Lithology)

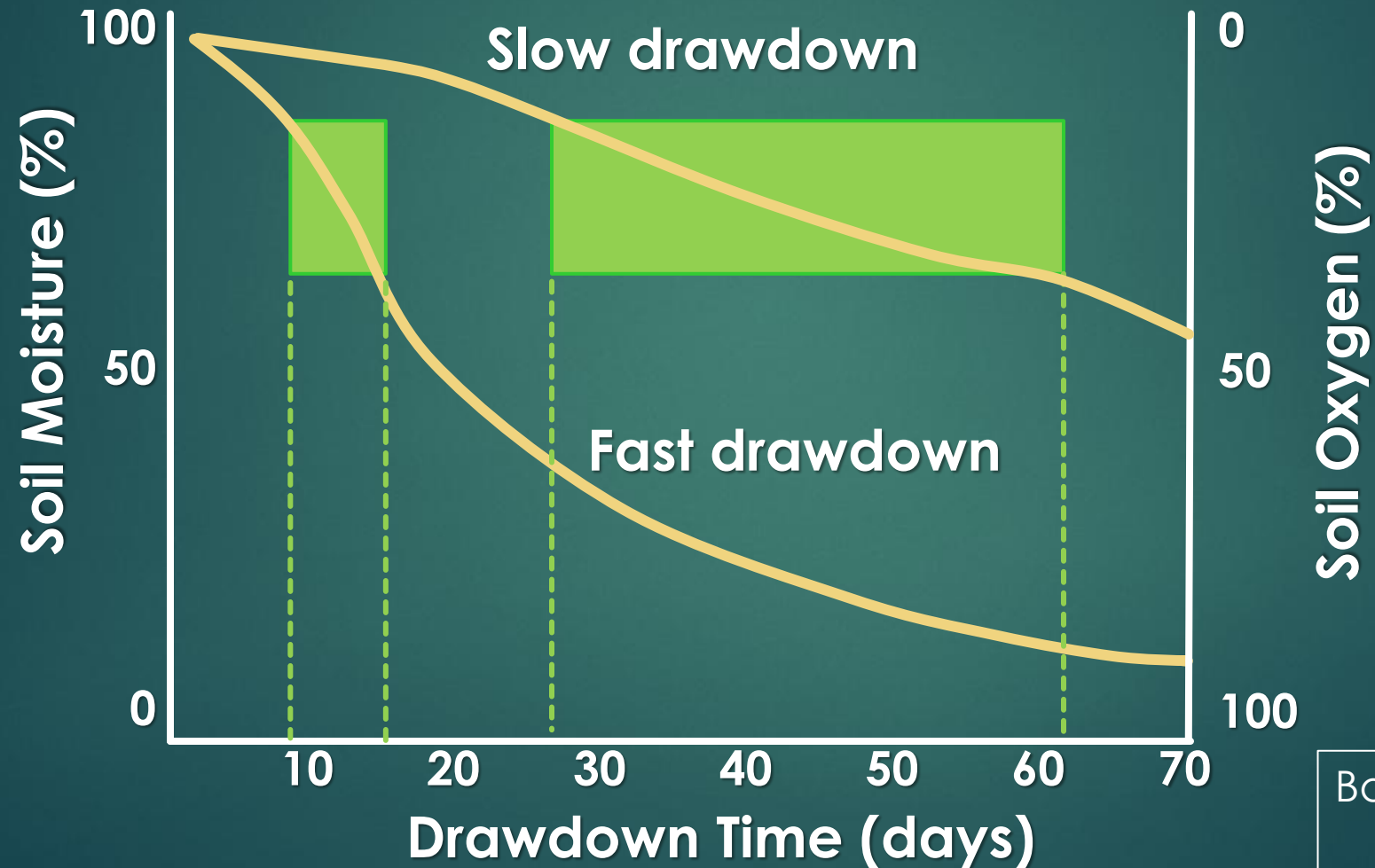


Germination Potential (same drawdown date & rate)



Barnyard grass (*E. muricata*)
70-80% soil moisture

Germination Potential (same soil type; different drawdown rate)



Barnyard grass (*E. muricata*)
70-80% soil moisture

Geomorphic Setting

(Soil structure)

► **Maintain biological (microbial) activity**

- ❑ Increase/maintain organic matter content
- ❑ Facilitate nutrient transformations (redox)
- ❑ Provide nutrients to plant roots (fungi/bacteria)

► **Maintain continuous network of pore spaces**

- ❑ Vertical movement/retention of water & nutrients
- ❑ Free movement of oxygen & gases
- ❑ Unrestricted growth of roots



Good condition

No significant clodding
Fine aggregates (>80%)
Many pores



Moderate condition

Coarse clods (50%)
Fine aggregates (50%)
Few pores



Poor condition

Coarse, firm clods
Few fine aggregates
Few/no pores

Geomorphic Setting

(Soil structure cont.)

- ▶ Aggregate size affects seed germination potential also by influencing seed location and soil moisture curves
 - ❑ Large benefits large-seeded species (e.g., cocklebur)
 - ❑ Medium benefits mid-seeded species (e.g., millet)
 - ❑ Small benefits small-seed species (e.g., sedges)



Soil & Water chemistry

► pH

- ❑ Affects chemical transformations and nutrient cycling
- ❑ Typically not an issue unless extreme conditions occur

► Salinity & Conductivity (total dissolved solids)

- ❑ Impacts ability of seeds to imbibe (absorb) water
- ❑ Diversity of seed germination declines as salinity increases
- ❑ As plant growth occurs, salinity has lesser impact

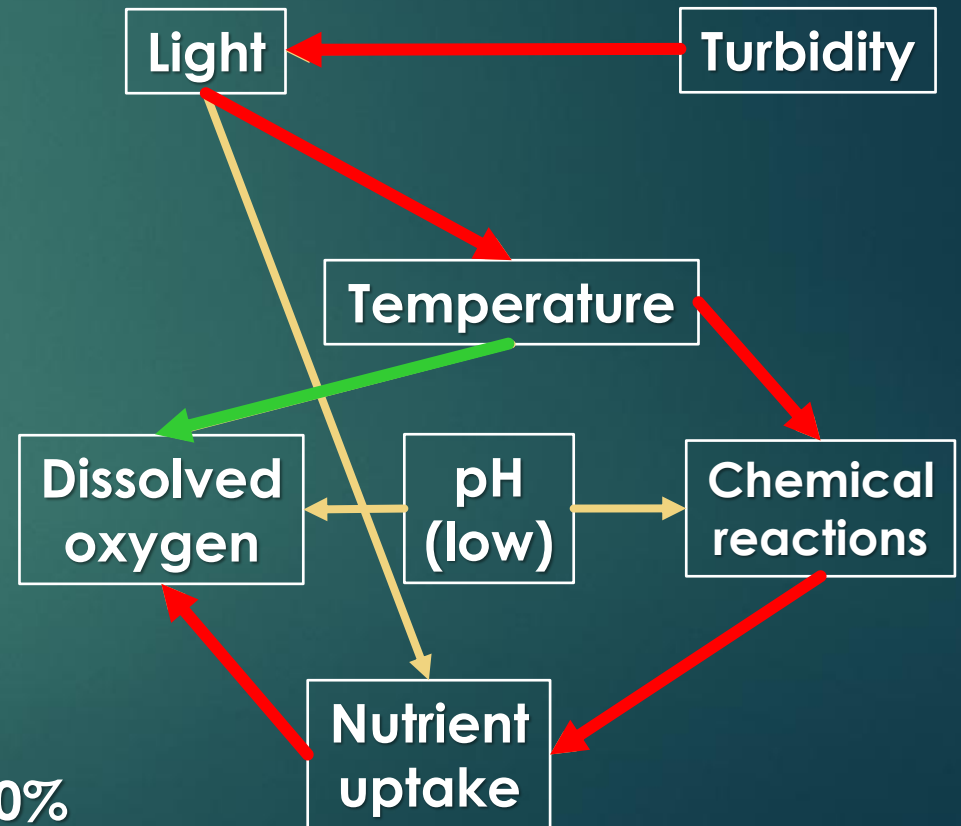
► Dissolved oxygen

- ❑ Affects nutrient cycling via reduction/oxidation
- ❑ Required to maintain microbial community diversity (although some species are adapted to anoxic environments)

Soil & Water Chemistry

► Nutrient availability governed by complex interactions

- ❑ Nutrients must be in specific form for uptake
 - Nitrogen (primarily NH_4 & NO_3 ; NH_3 toxic)
 - Phosphorus (primarily PO_4)
- ❑ Chemical transformation rates decrease at
 - Low light (e.g., turbid)
 - Low temperature
 - Low pH
- ❑ pH can change affinity
 - Low pH – PO_4 tends to bind with Fe & Al
 - High pH – PO_4 tends to bind with Ca & Mg
 - High pH – >9 can increase NH_3 -N fraction to 50%



Water chemistry (cont.)

► **Nutrients**

- ❑ Necessary for plant growth following germination
- ❑ High concentrations of nutrients (e.g., N, P) can
 - Stimulate algal blooms that form mats & prevent/reduce germination
 - Stimulate rapid growth (cocklebur) & expansion (reed canarygrass) of some species
 - Reduce/eliminate dissolved oxygen

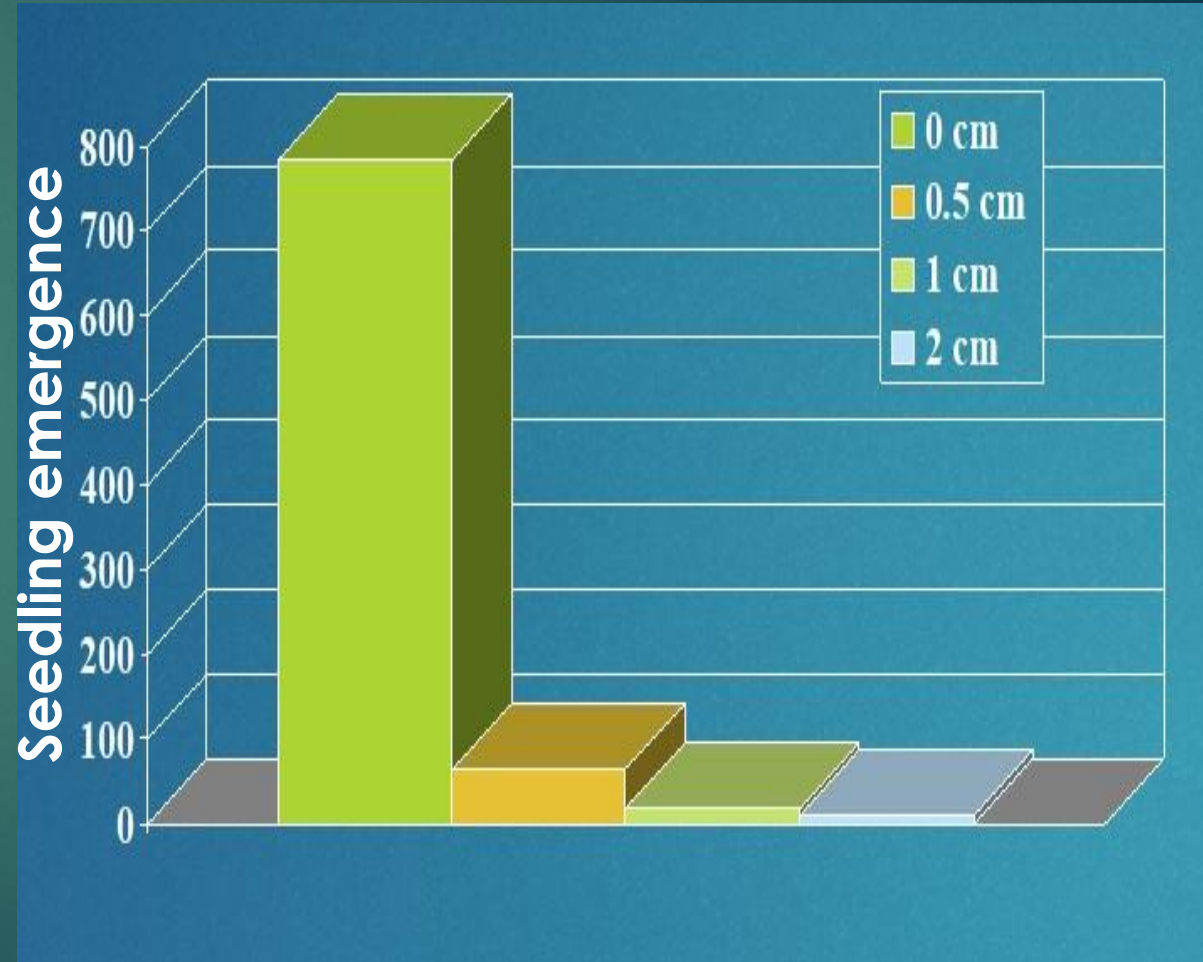
► **Contaminants (neonics, ag chemicals, etc.)**

- ❑ Disrupt nutrient cycling (microbial/invertebrate community)
- ❑ Can reduce/prevent germination of some species

Water chemistry (cont.)

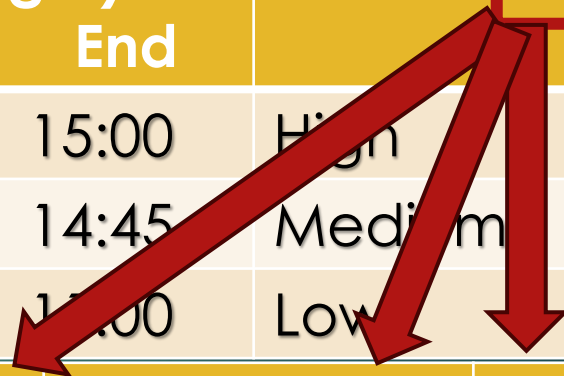
► Sediment

- ❑ High colloidal sediment can
 - Affect moisture availability
 - Bind nutrients/contaminants
- ❑ Distribution often is uneven
- ❑ Small volume can have large impact



Summary

Season	Date		Soil Temp (°F)		Photoperiod (Light)		Soil Moisture	
	Begin	End	Begin	End	Begin	End	Natural	Managed
Early	4/23	6/7	63	72	13:45	15:00	High	Variable
Mid	6/8	7/17	72	84	15:00	14:45	Medium	Variable
Late	7/18	10/15	84	56	14:45	15:00	Low	Variable
Species		Dorm	Soil Temp (°F)		Photoperiod (hours light)		Soil Moisture (%)	
Pond sedge (C. acutiformis)		Cold	72/50 Flux		>10		60-85	
Bristly sedge (C. comosa)		Cold	60/40 Flux		>10		65-85	
Hardstem bulrush (S. acutus)		Cold	95/82 Flux		>13		>70 to 1"	
Barnyard grass (E. muricata)		Dark	68 – 86		>12		70-80	
Broadleaf cattail (T. latifolia)		None	77 – 86		>12		< 3"	
Cocklebur (X. strumarium)		None	91/77 Flux		None		55 kPa (<70)	



Perennial plants



Perennials

(After initial establishment from seed)

► Invest significant resources in belowground structures

❑ Rhizomes (e.g., cattail, phragmites)

- Continuously growing horizontal underground stem
- Generates lateral shoots & adventitious roots



❑ Stolon (e.g., cattail, phragmites)

- Stem that grows horizontally along the ground
- Gives rise to roots & aerial branches



Perennials

(After initial establishment from seed)

► Invest significant resources in belowground structures

▣ Tuber (e.g., chufa)

- Thickened underground part of stem or rhizome
- Serves as reserve for carbohydrates & nutrients



▣ Turion (e.g., sago pondweed)

- Wintering bud that becomes detached



Perennials

(belowground structures)

▶ Rhizomes & stolons

- ❑ Enable rapid growth and expansion
- ❑ Withstand periods of environmental stress

▶ Tubers & turions (plus similar structures)

- ❑ Storage of energy and nutrients for future use
- ❑ Enable regrowth under broader environmental conditions compared to seeds (e.g., hypoxia, anoxia)
- ❑ Enables fall germination and growth the following spring

▶ Seeds produced, but often limited

- ❑ Long-distance dispersal
- ❑ Re-establishment following significant disturbance events

Biomass of Select Perennial Plant Species

Plant species	Biomass (lbs/ac)		Total
	Above	Below	
Common reed (Phragmites)	9580	64060	73640
Cattail (Typha)	7580	16060	23640
Yellow cow lily (Nuphar)	5400	10225	15625

Perennials (aboveground adaptations)



- ▶ **Aerenchyma (tissue with large intercellular spaces)**
 - ❑ Enable tissue transfer of gases (CO_2 , ethylene, methane)
 - ❑ Facilitate movement of oxygen from stem to roots in flooded environments (anoxia, hypoxia)
 - ❑ Helps maintain leaf buoyancy (e.g., duckweed)
 - ❑ Some invertebrates use plant aerenchyma for respiration
 - Coleoptera larvae (e.g., aquatic leaf beetles [*Donacia* sp.])
 - Diptera larvae (e.g., mosquito [*Mansonia* sp.])

Species	Anoxia Endurance (days)	Shoot Elongation
Beaked sedge	4	None
Common rush	4-7	None
Common spike rush	7-12	None
Umbrella sedge	7-14	None
Reed switchgrass	7-21	Occasional
Common reed (<i>Phragmites</i>)	>28	None
Broadleaf cattail	>28	Frequent
Three-square bulrush	>28	Frequent
Soft-stem bulrush	>90	Frequent
Hard-stem bulrush	>90	Frequent

Perennials (summary)

- ▶ **Morphological and physiological characteristics increase tolerance of environmental conditions**
 - ❑ Growth during current season
 - Extension of growing season
 - Range of moisture (surface flooding to moisture stress)
 - Increased capacity for nutrient processing (e.g. N, P)
 - ❑ Regrowth in subsequent years
 - Conditions for breaking dormancy of buds (e.g., turions, tubers) are less stringent than seeds

After Germination/Regrowth

- ▶ Time for seed production varies, but >50 days for most species
- ▶ Individual plant survival & final plant community determined by
 - ❑ Soil moisture
 - Age
 - Drought/flood tolerance
 - ❑ Subsequent management treatments
 - Irrigation
 - Mechanical (e.g., mowing, disking)
 - Fire
 - Herbicide

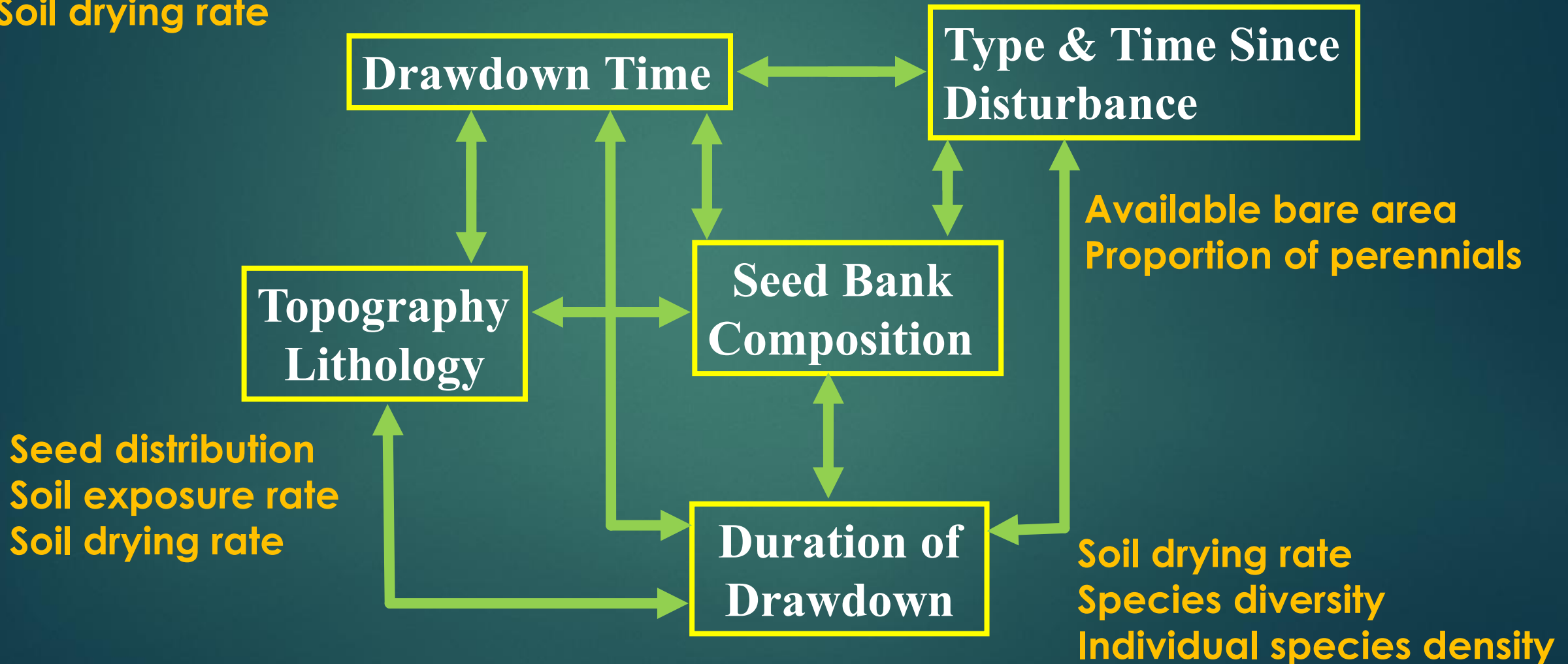
Wetland Plant Ecology (summary)

- ▶ **Abundant information on ecology of many species available, but**
 - ❑ Lab studies often do not directly translate to field application (e.g., highly controlled, sterile soil)
 - ❑ Field studies often do not report critical factors necessary for correct interpretation (e.g., location, soil, climate)
- ▶ **Improving management certainty (i.e., practical ability) requires investment in learning that includes**
 - ❑ Using available information to formulate strategies in context of site conditions relative to plant ecology
 - ❑ Recording plant response & abiotic factors during growing season

Summary

(managed wetlands)

Seed dormancy/germination
Soil drying rate



Wetland Plant Ecology

(summary)

- ▶ **All abiotic factors in constant flux**
- ▶ **Rate and direction of change varies depending on**
 - ❑ Site characteristics (geographic, geomorphic)
 - ❑ Intactness of natural processes
 - ❑ Influence of human infrastructure (on- & off-site)
- ▶ **Periodically need to evaluate status to understand changes**
 - ❑ Site conditions (e.g., soils)
 - ❑ Processes (e.g., hydrology, nutrient cycling)

Nutrition

Species	Energy (kcal/g)		Weight (%)				
	Gross	TME	Fat	Fiber	Ash	NFE	Protein
Beggarticks	5.17		15.0	19.7	7.2	27.5	25.0
Barnyardgrass	3.90	2.61	2.4	23.1	18.0	40.5	8.3
Bulrush, alkali	4.40	0.65	1.9		2.7	86.3	9.1
Bulrush, California	4.70		2.5		2.7	86.5	
Bulrush, river (rhizomes)	4.01						
Cattail (male flower)	5.20		3.4		4.7	74.4	17.5
Chufa flatsedge (tubers)	4.26		6.9	9.0	2.5	55.4	6.7
Curly dock	4.28	2.68	1.2	20.4	6.9		10.4
Duck potato	4.74		9.0	10.8	4.9	55.5	20.0
Duckweed	4.24		3.5	11.3	10.7	49.8	25.7
Fall panicum	4.00	2.75	3.1	16.8	16.1	50.1	12.3
Hairy crabgrass	4.38	3.09	3.0	11.1	9.7	59.4	12.6
Rice cutgrass	3.98		2.0	10.6	9.5	57.8	12.0
Saltwort	2.10		1.0		37.4	51.9	9.6
Smartweed, Ladysthumb	4.42	1.52	2.8	22.0	7.5		9.7
Smartweed, Pennsylvania	4.32	1.08	2.3	21.8	4.9	65.3	9.0
Sloughgrass			6.5	20.0		59.6	7.0
Spikerush		0.50					
Whitetop			1.9	16.1		67.9	8.8
Wild rice		3.47					

Species	Energy (kcal/g)		Weight (%)				
	Gross	TME	Fat	Fiber	Ash	NFE	Protein
Beggarticks	5.17		15.0	19.7	7.2	27.5	25.0
Barnyardgrass	3.90	2.61	2.4	23.1	18.0	40.5	8.3
Bulrush, alkali	4.40	0.65	1.9		2.7	86.3	9.1
Chufa flatsedge (tubers)	4.26		6.9	9.0	2.5	55.4	6.7
Fall panicum	4.00	2.75	3.1	16.8	16.1	50.1	12.3
Hairy crabgrass	4.38	3.09	3.0	11.1	9.7	59.4	12.6
Rice cutgrass	3.98		2.0	10.6	9.5	57.8	12.0
Smartweed, Ladysthumb	4.42	1.52	2.8	22.0	7.5		9.7
Smartweed, Pennsylvania	4.32	1.08	2.3	21.8	4.9	65.3	9.0
Pecan	7.88		40.8	19.0	12.6	35.1	8.4
Pin oak	5.06	2.60	18.9	14.7	1.6	58.6	6.4
Willow oak	5.30	2.60	20.6	14.0	1.7	55.3	5.1
Corn	4.44		3.8	2.3	1.5	79.8	10.8
Common soybean	5.45		20.5	5.4	6.2	27.1	39.6
Milo	4.23		3.1	6.0	3.5	72.2	10.2

