Adapting Minnesota's Shoreland BMPs for Climate Change

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- John Chapman, University of Minnesota Erosion and Stormwater Management Certification Program Director, and
- Shahram (Shane) Missaghi, University of Minnesota Extension Water Resources Educator

Acknowledgements

Project partners:

Barb Liukkonen (PI), Camilla Correll, John Chapman, Karen Terry, Mary Blickenderfer, Prof. Miki Hondzo, and Shahram Missaghi

Project contributors:

Rob Langer, Natural Shore Technologies, Inc.--plant selection, growing locally, and plant supplies
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The Minnehaha Creek Watershed District (water quality data),

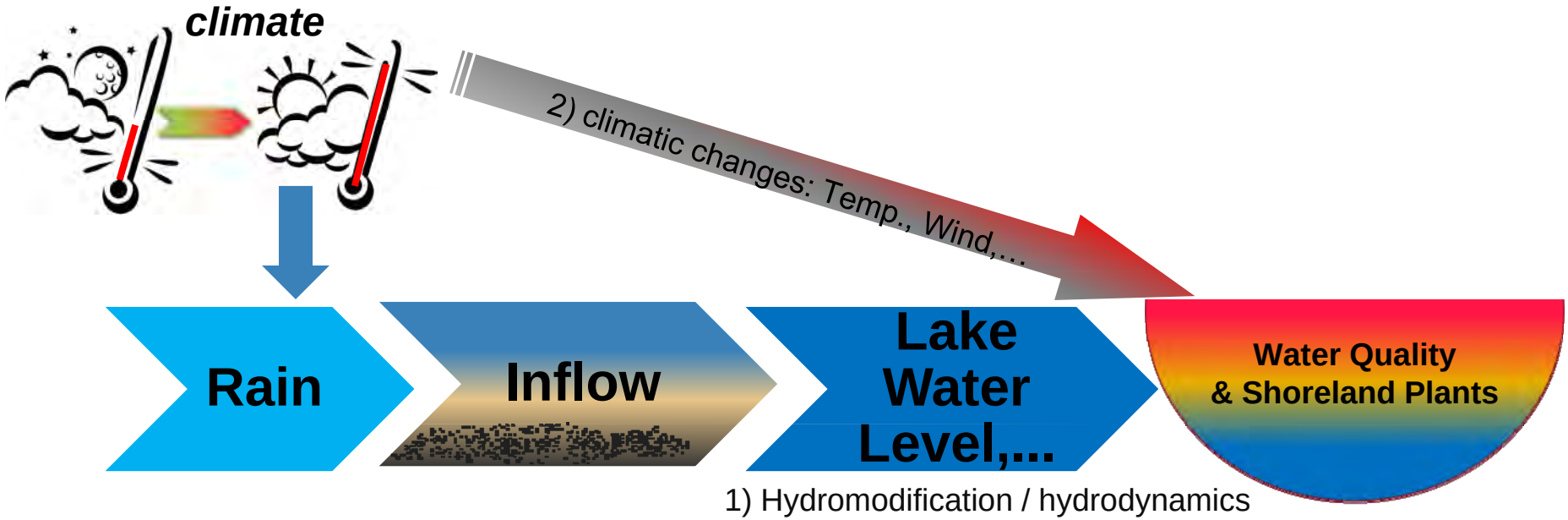
Funding: 319 Grant-**EPA** & **MPCA**

Topics

- Introductions & **Motivations**
- **Modeling** Research
- **Experimental** Research

- General **Conclusions**, **Recommendations**, Q&A

Motivation--Changes due to 1) hydromodifications & 2) climatic changes

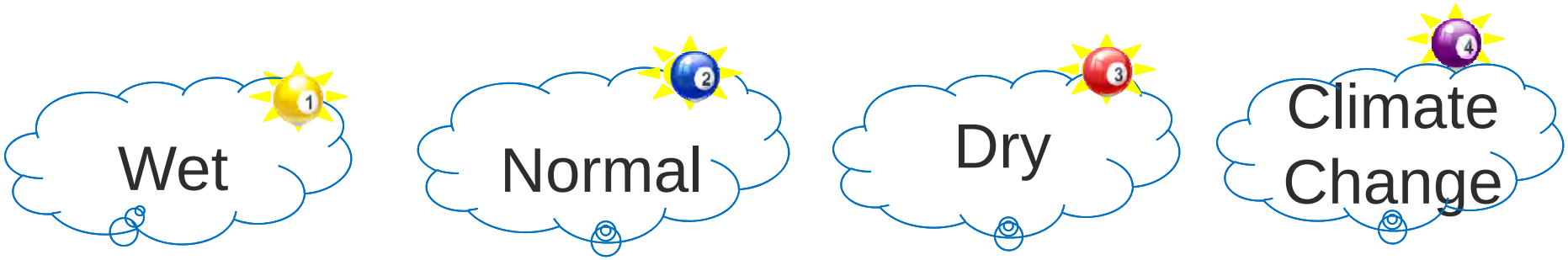


Or **Evaluate the effects of the expected water level variability on lake water quality and the littoral plant habitat (shoreline)**

Project Approach– Climate Scenarios

Study a lake **under different water level regimes** to see impact on **water quality** and **shoreline**

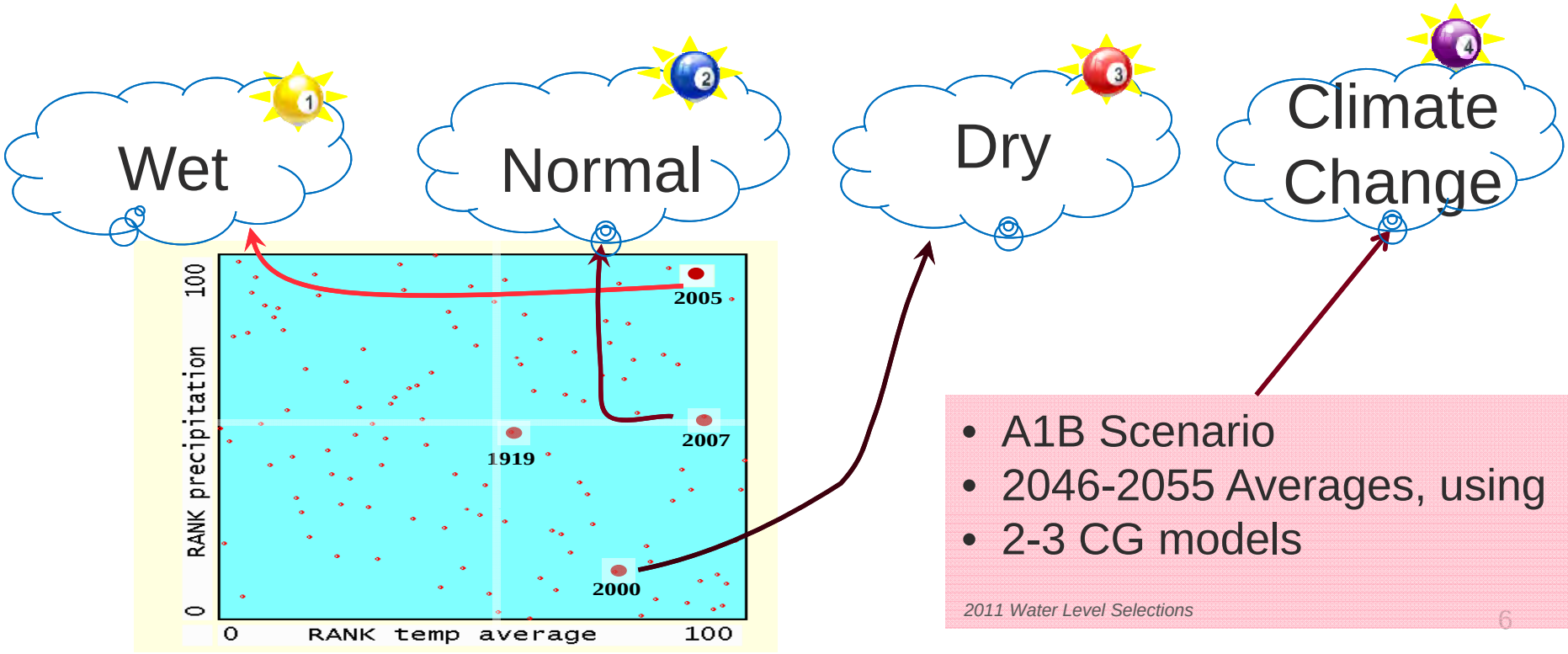
climates



10 percentile	50 percentile	10 percentile	Modeled

Project Approach– Climate Scenarios

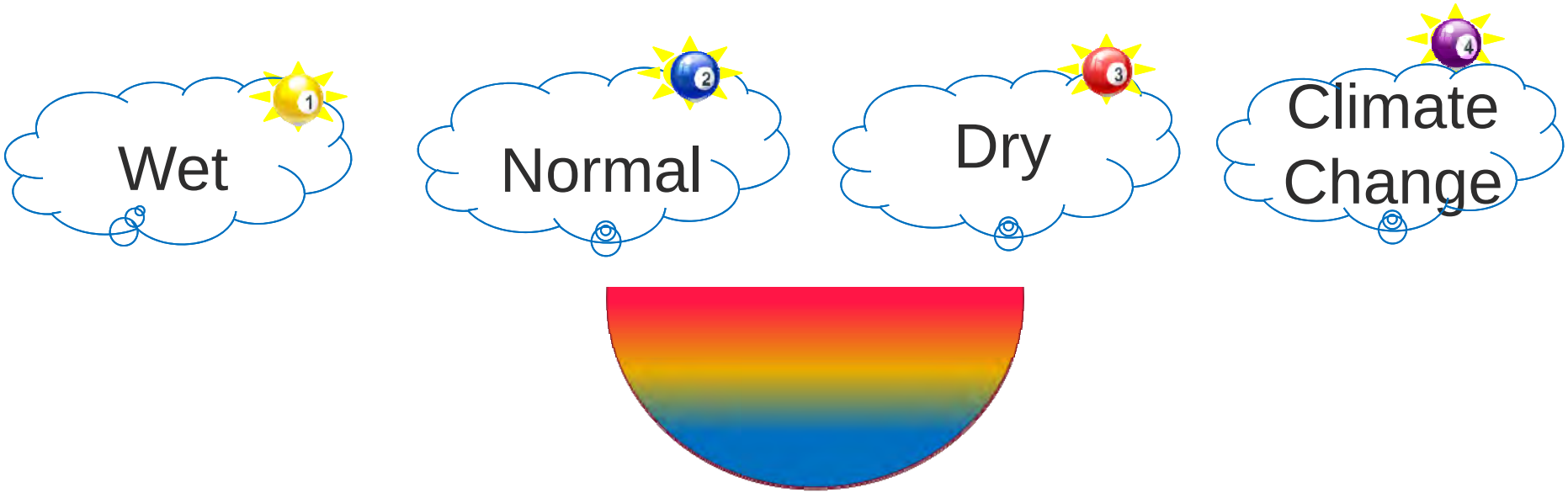
Study a lake **under different water level regimes** to see impact on **water quality** and **shoreline**



- A1B Scenario
- 2046-2055 Averages, using
- 2-3 CG models

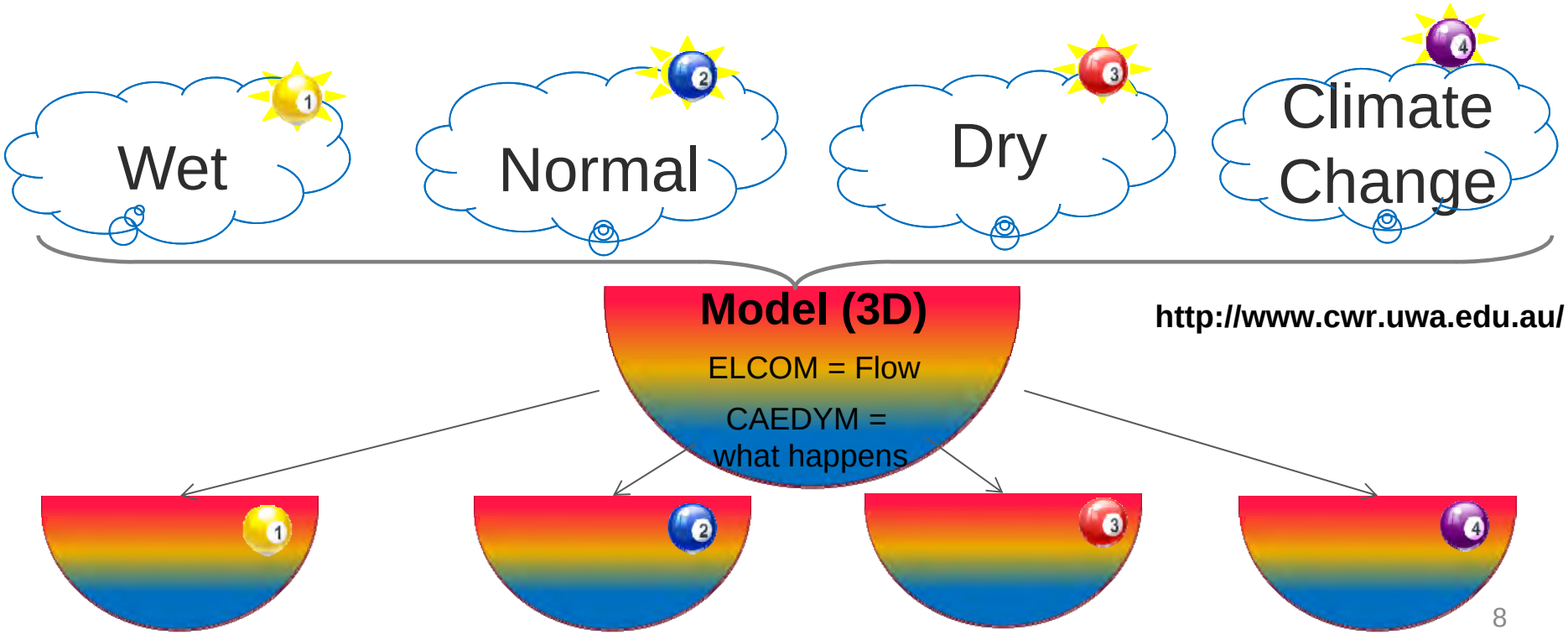
Project Approach– ?

Study a lake **under different water level regimes** to see impact on **water quality** and **shoreline**

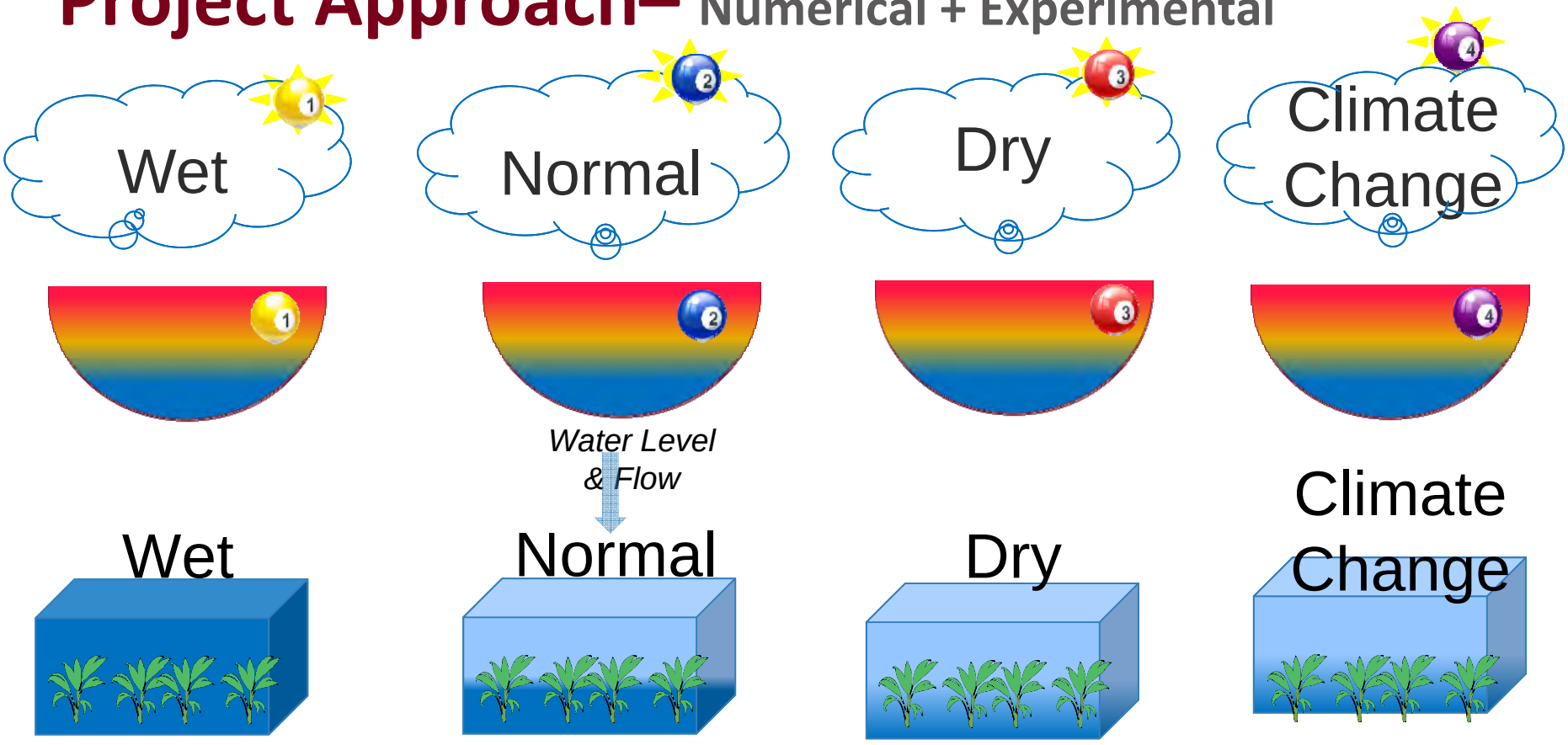


Project Approach– Numerical / modeling

Study a lake **under different water level regimes** to see impact on **water quality** and **shoreline**

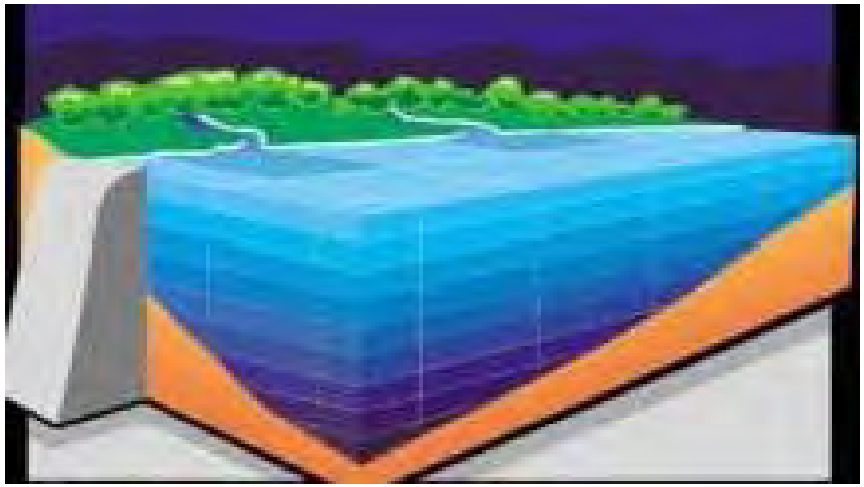


Project Approach– Numerical + Experimental

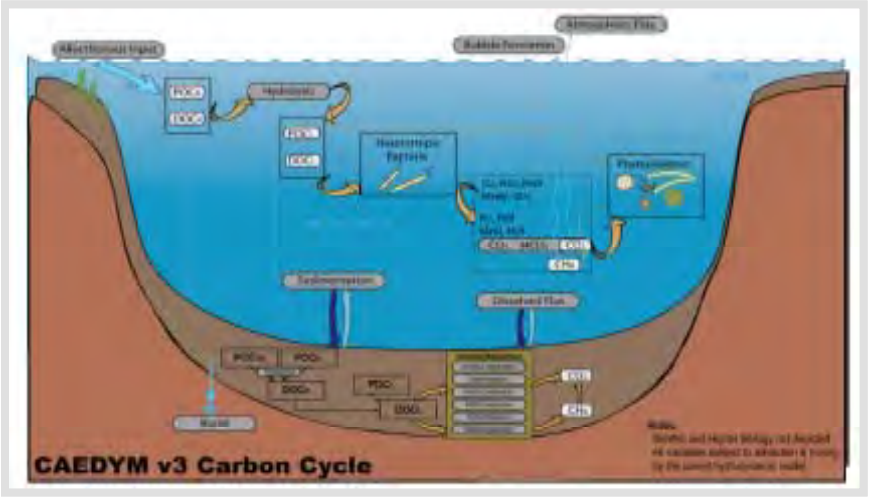


Project Approach– Model(s)

ELCOM = Flow



CAEDYM = what happens



Quiz coming next!!! Ready to type it in the chat box

Project Approach– Model

Parameters, **may be site specific**

changes

Air Temperature, Rain, wind, ……

Forcing Data

Water quality pH, TP, TN,…soils,..

Initial Conditions

Boundaries Shape, slopes,

Maps, Bathymetry

Inputs

Model

Output

(State) variables, Predicted / Modeled values

Constant Values (**universal**); g

Simulation

Run

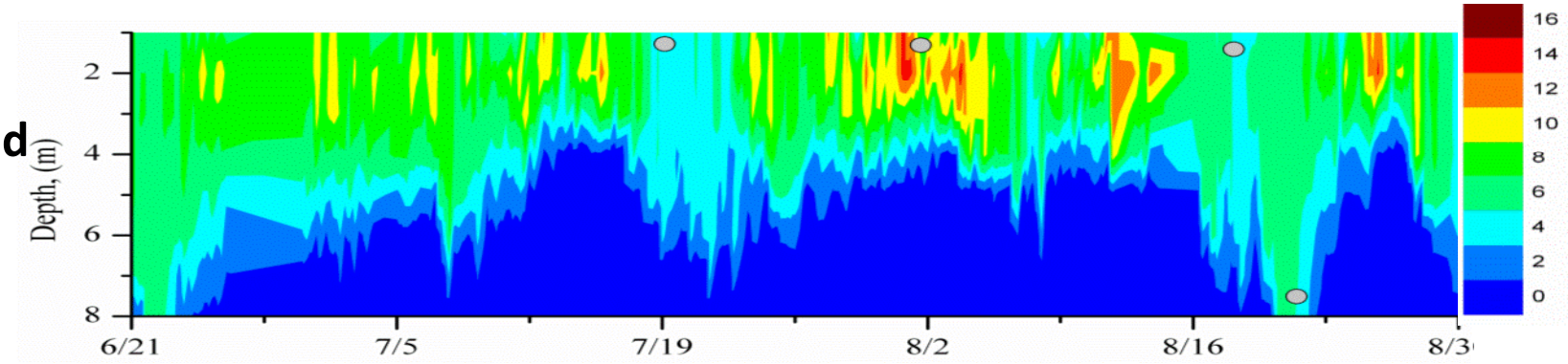
Evaluate the effects of the expected water level variability on lake water quality and the littoral plant habitat (shoreline)

Model Results—Flow & Mixing, new insight

Dissolved Oxygen , mgL^{-1}

Field Measured

2000

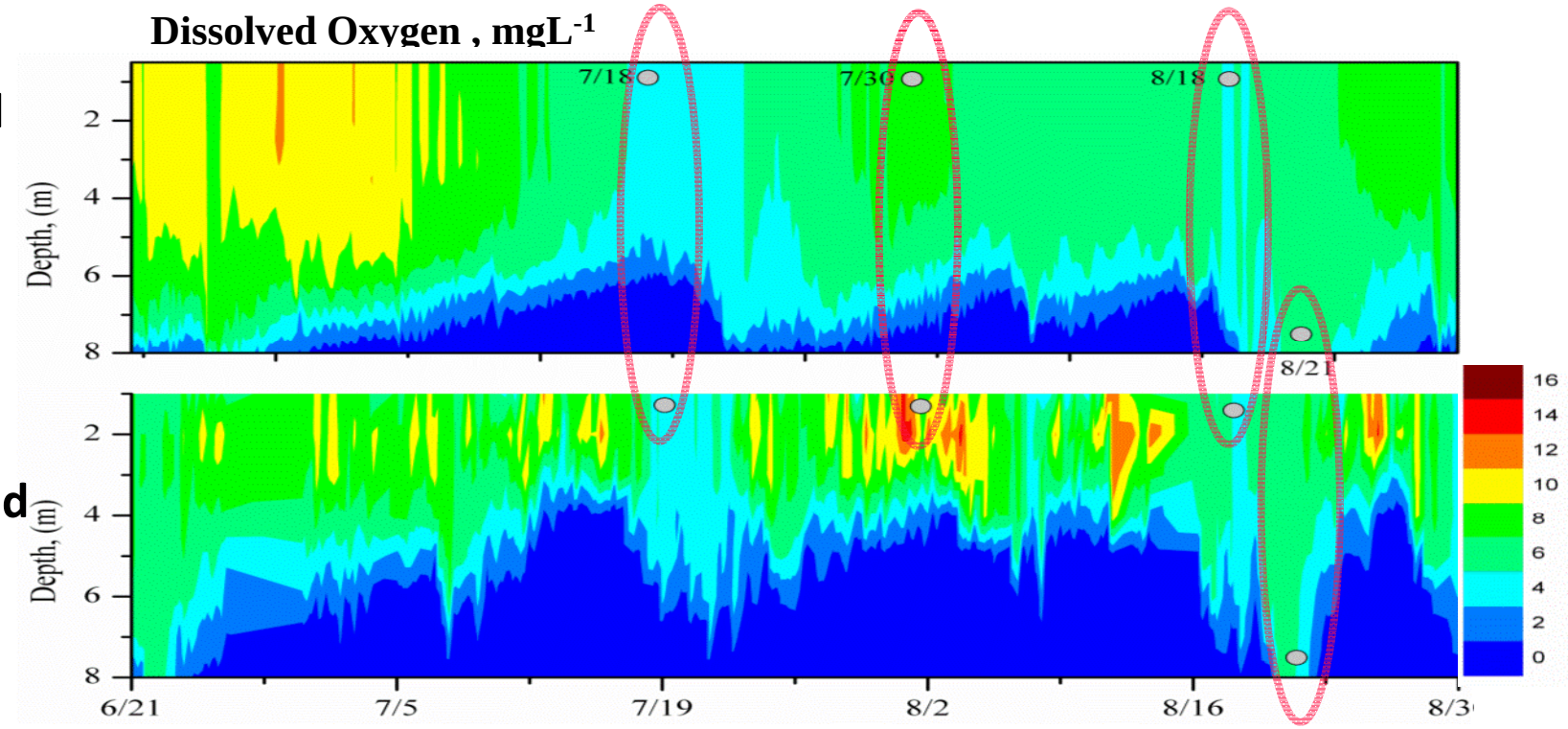


Model Results—Storm Event Mixing

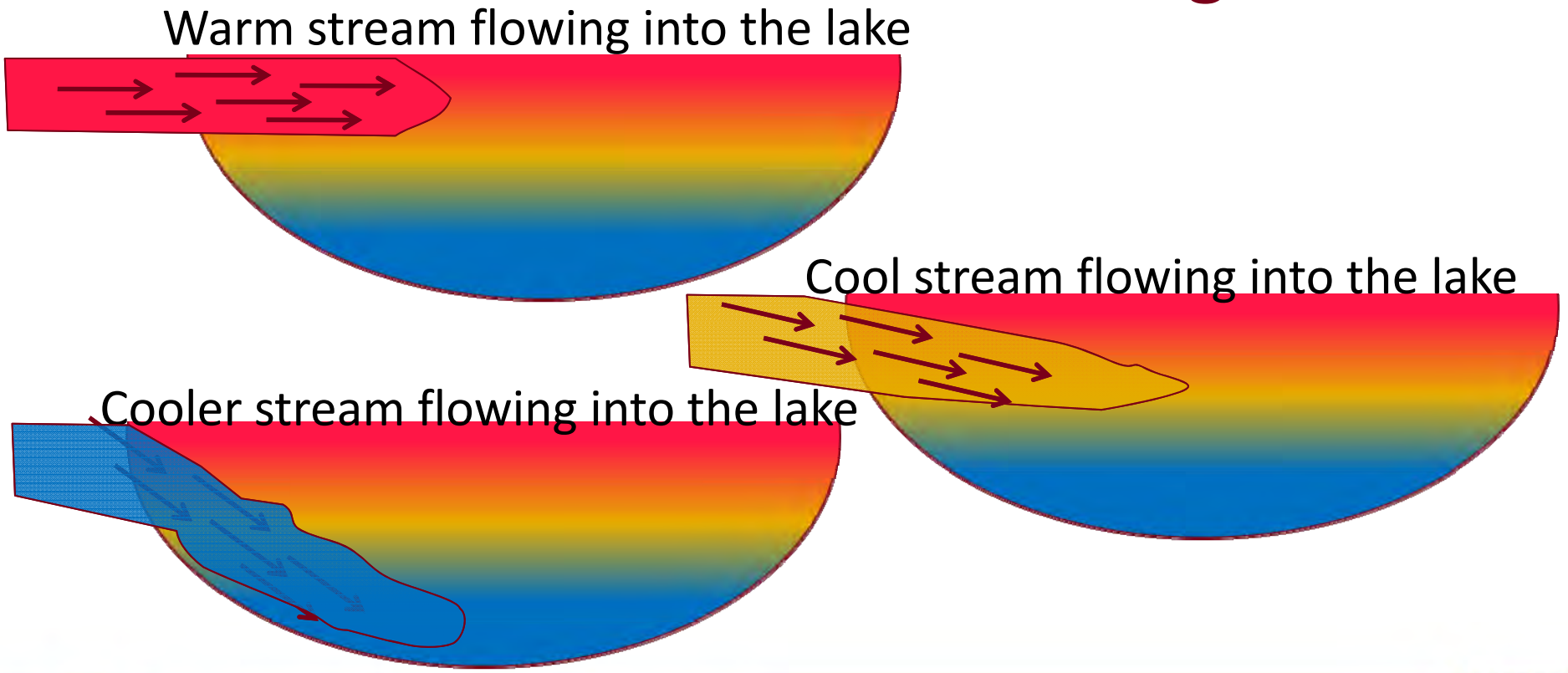
Modeled

Field Measured

2000



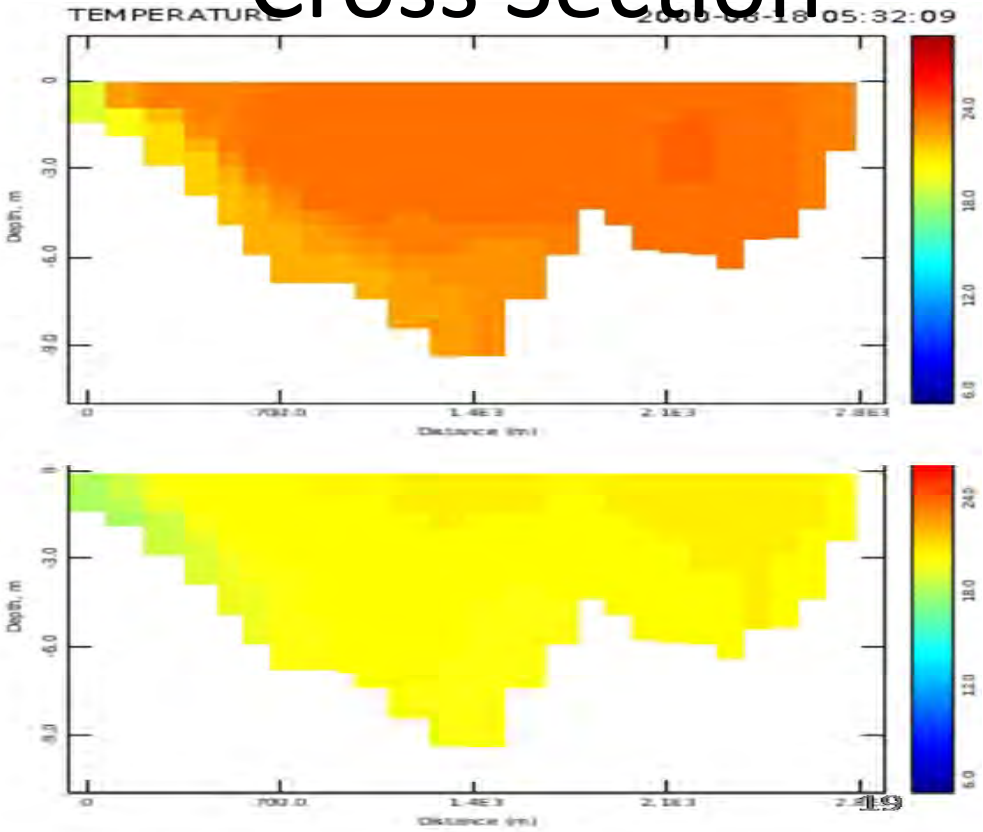
Model Results—Storm Event Mixing



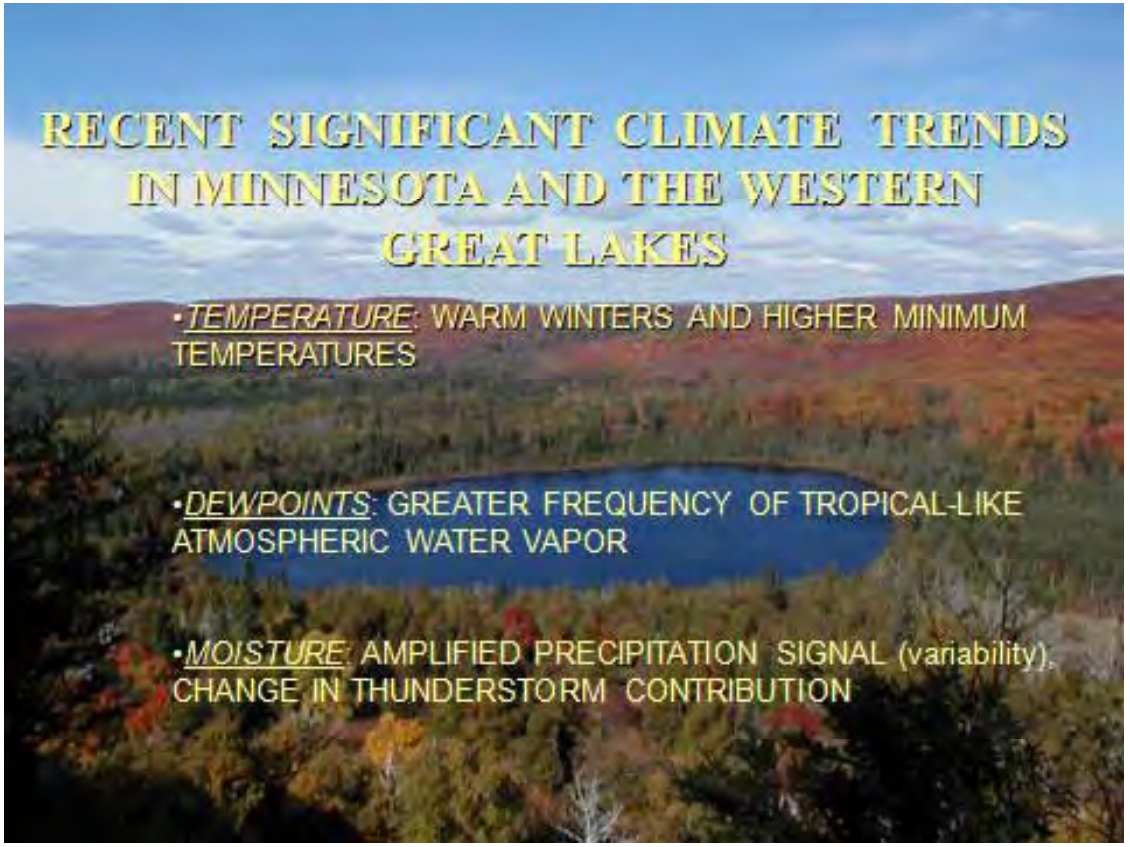
Model Results—Storm Event Mixing

Top View of Halsted Bay

Cross Section



Model Results—Flow matters & Why is it important?



Seely, M. (2011), Climate Change in Minnesota: Current Trends and Projections, http://www.climate.umn.edu/seeley/

Model Results—Temperature Implication

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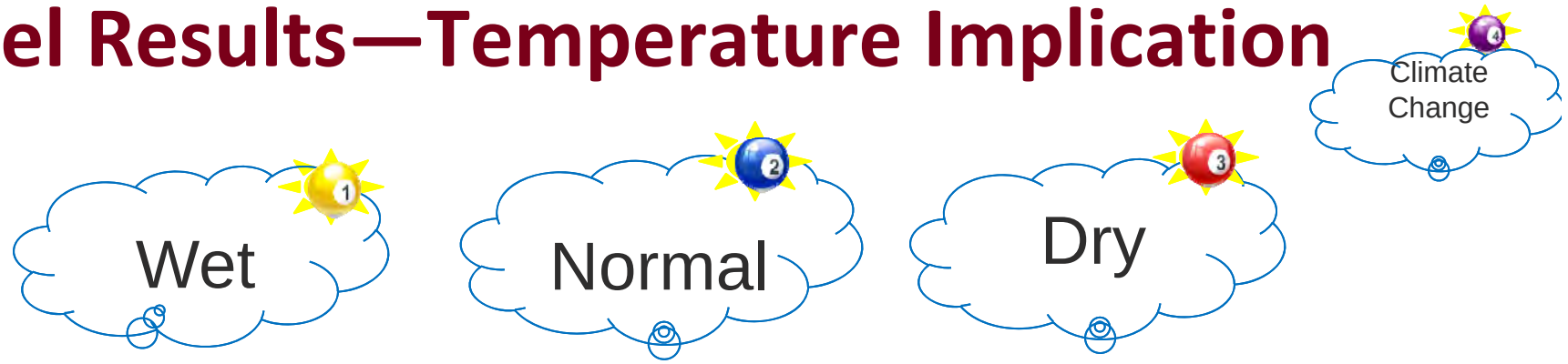
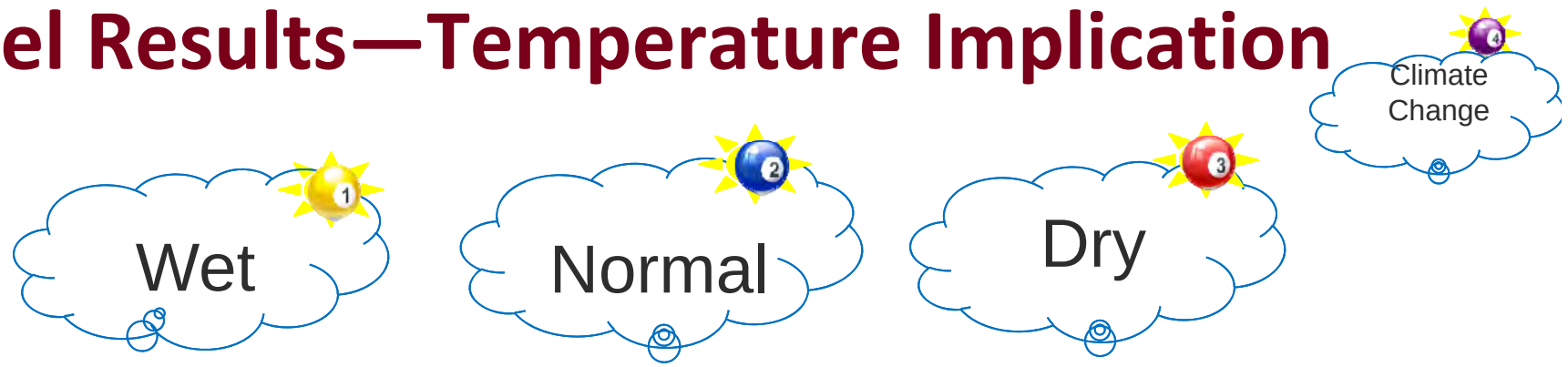
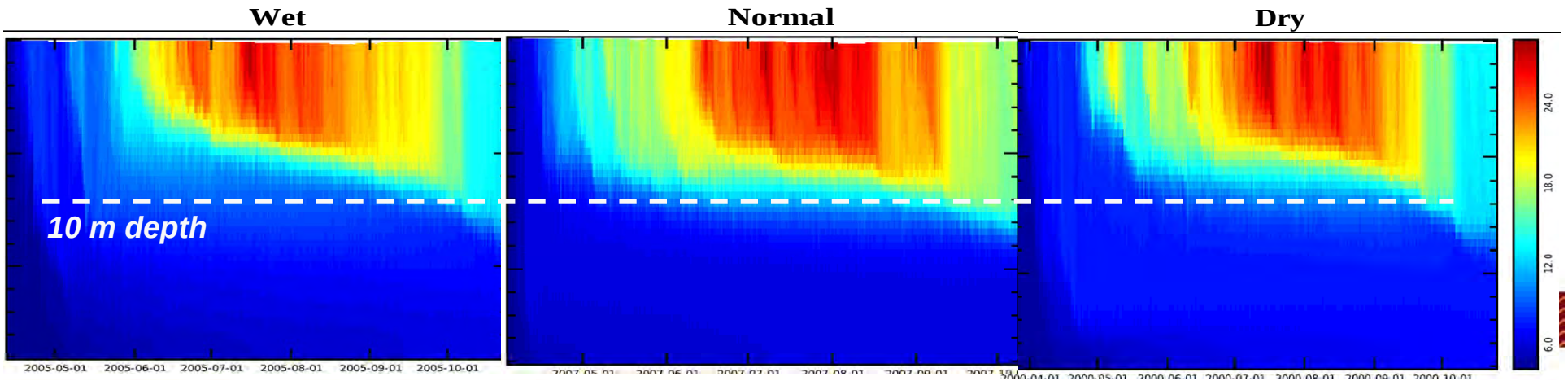
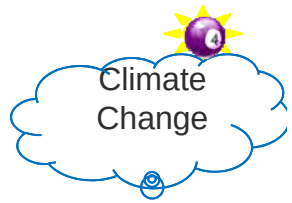


Model Results—Temperature Implication





Model Results—predication of water T



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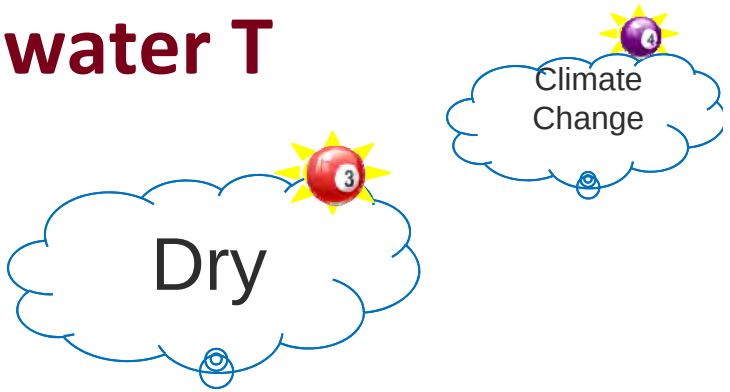
Model Results—predication of water T



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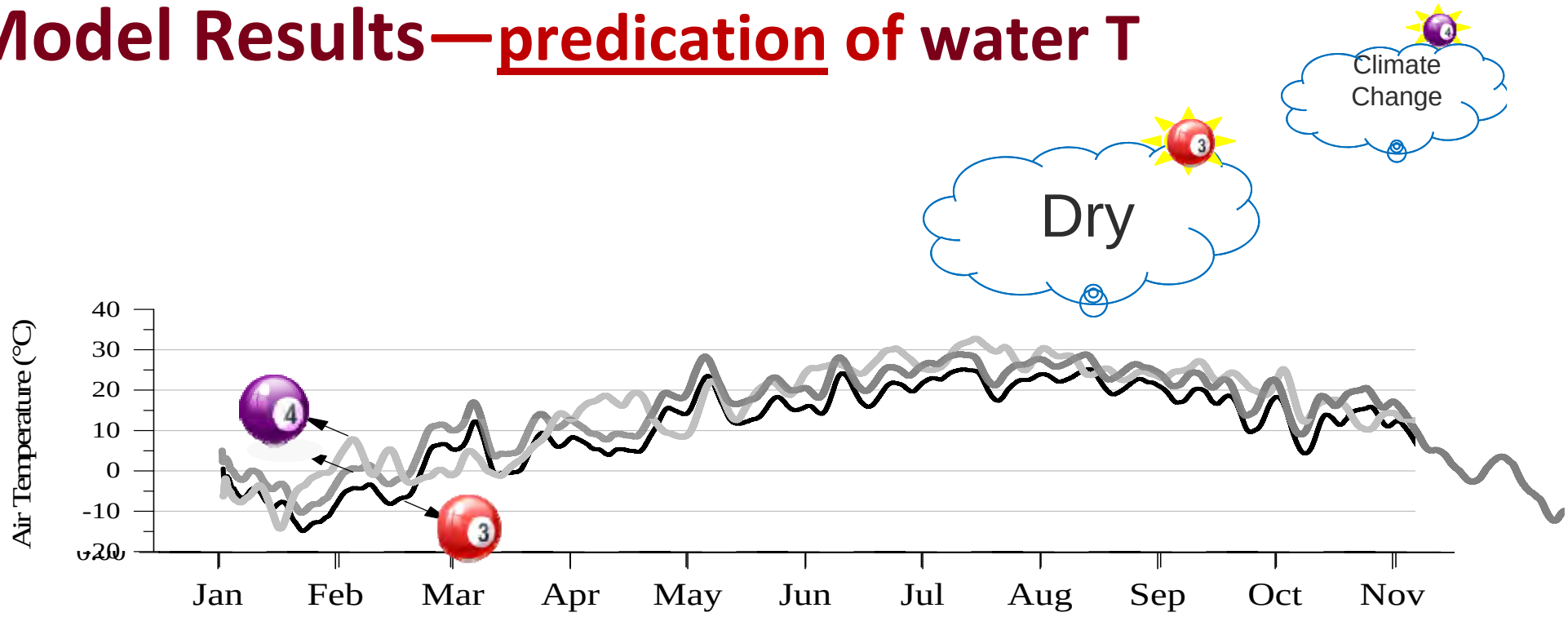
Model Results—predication of water T



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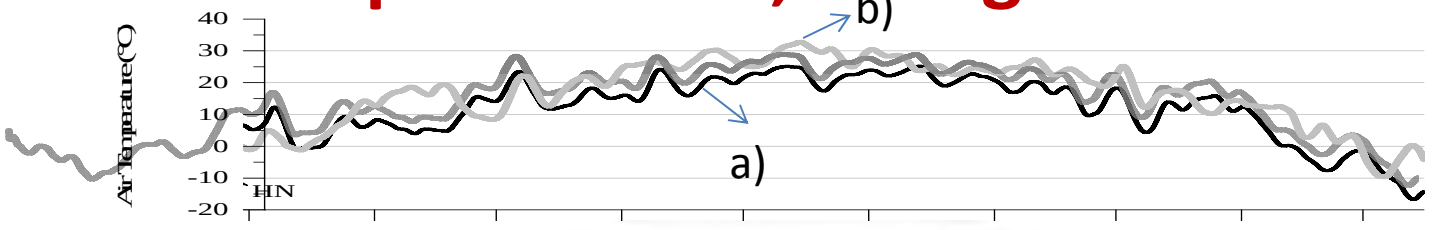
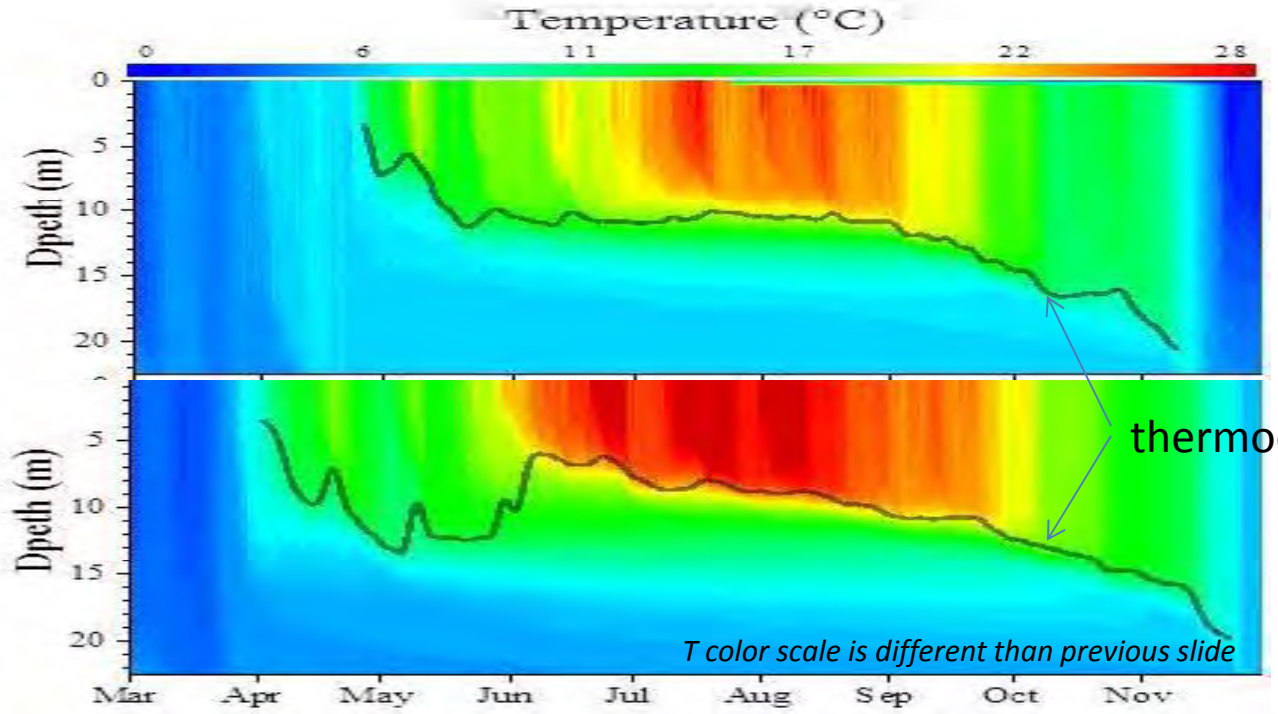
Model Results—predication, changes in water T





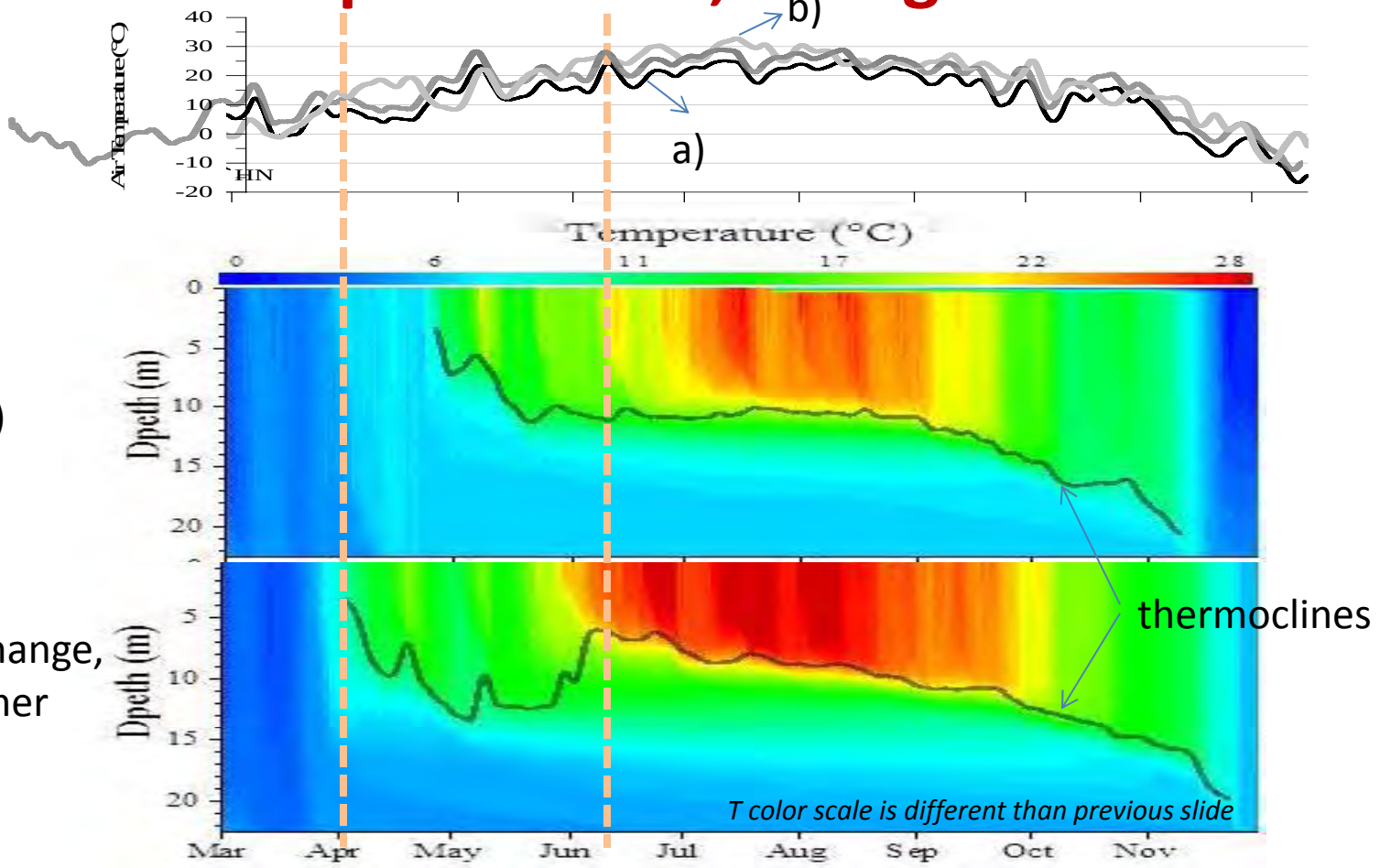
a) Dry (2000)

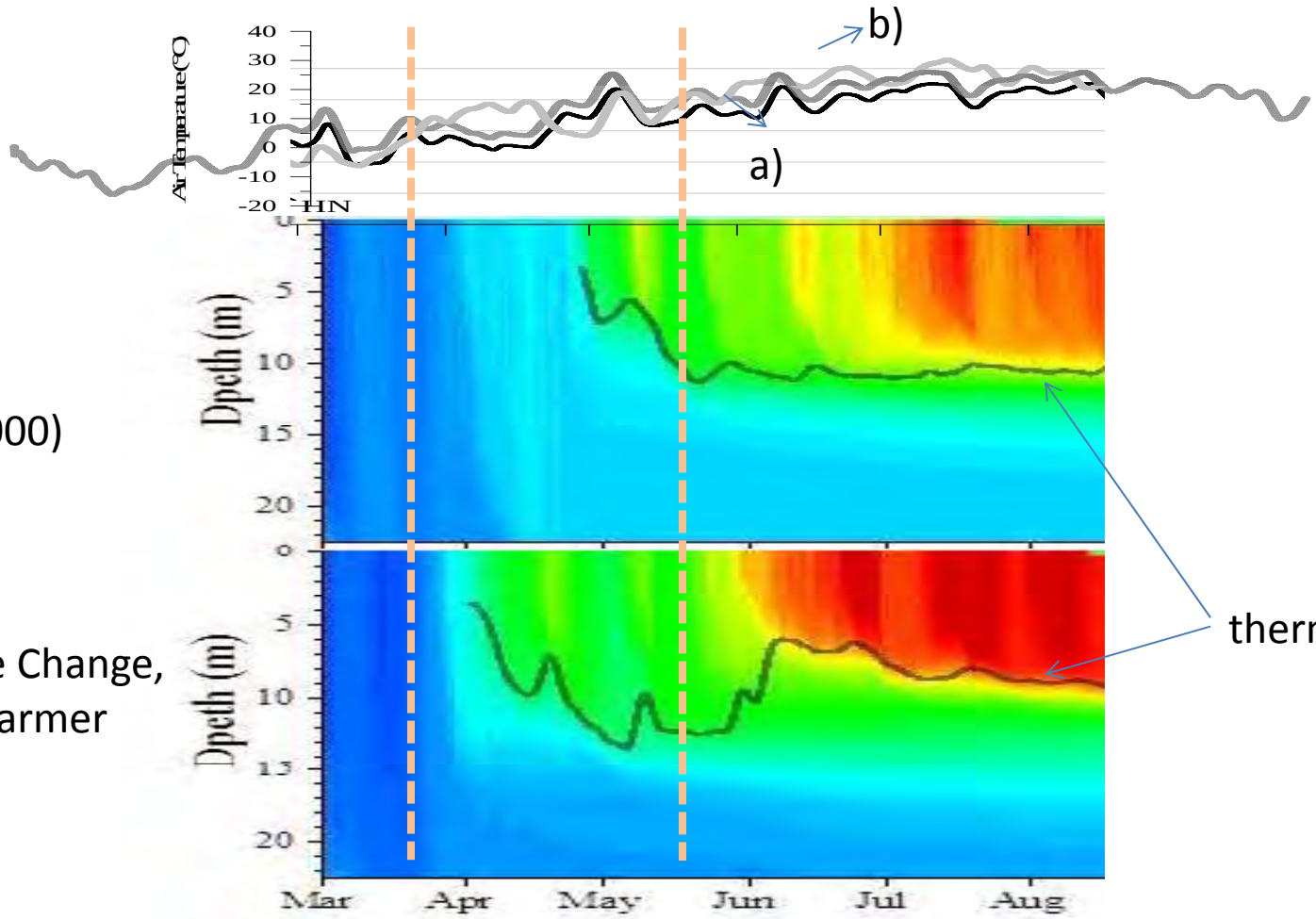
b) Climate Change, Wet & Warmer

Model Results—predication, changes in water T

a) Dry (2000)

b) Climate Change, Wet & Warmer





a) Dry (2000)

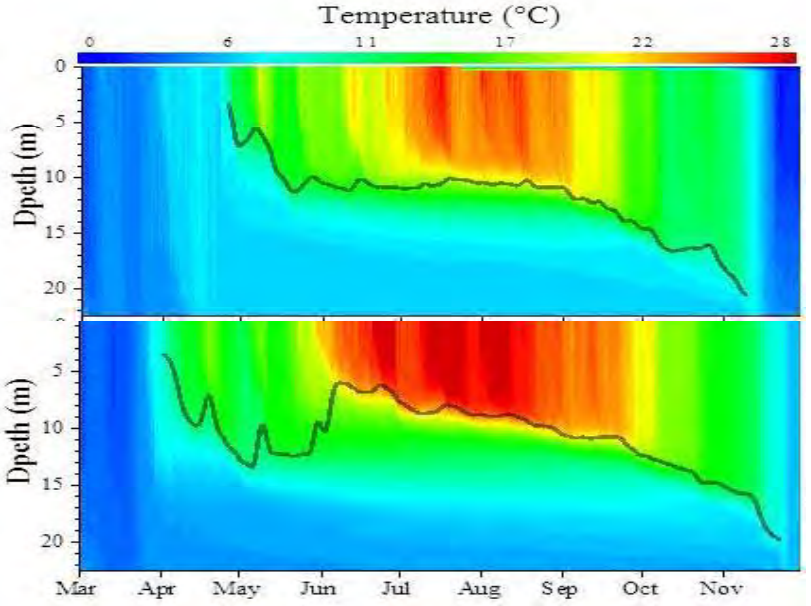
b) Climate Change, Wet & Warmer

thermoclines

Model Results—Temp. matters & Why is it important?

Change in stratification timing / thermocline

- Change of habitat
- Impact on fish habitat
- Impact on algae
- Impact on plants (warmer surface water)



Take away

Our system (water quality) is susceptible to

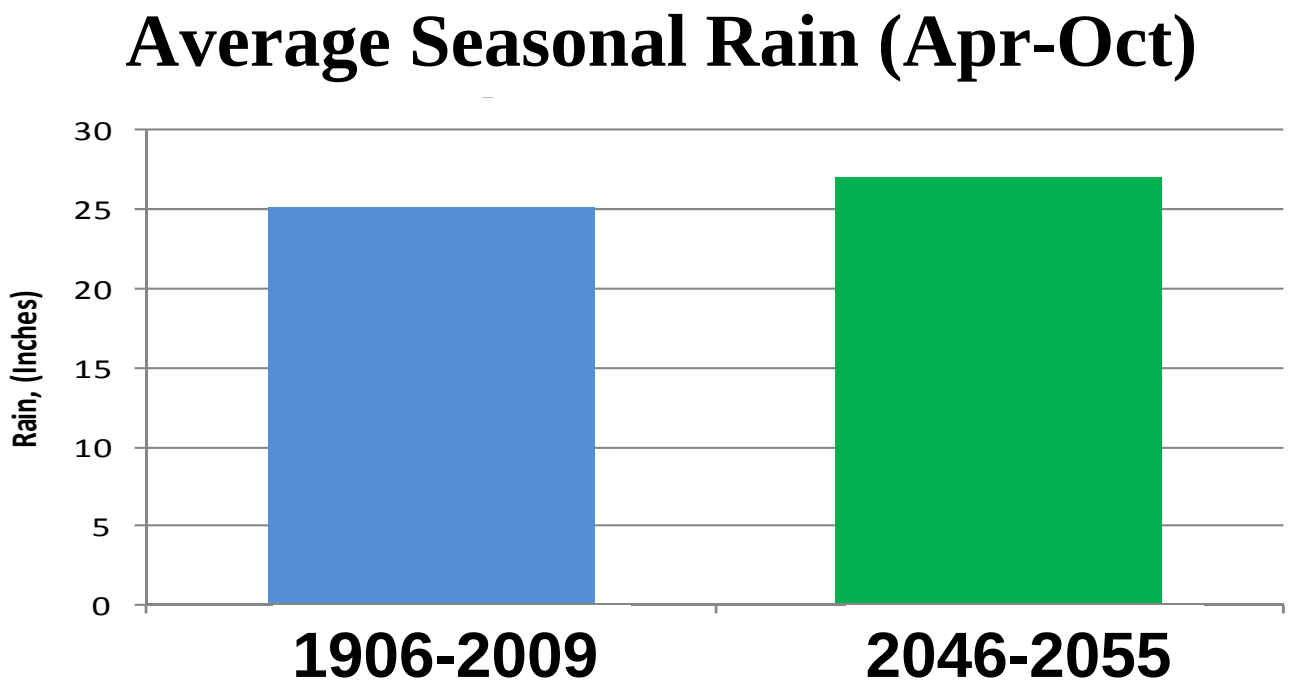
- Hydrodynamics (precipitations, flow, rain patterns)
- Temp. and wind

Thank You

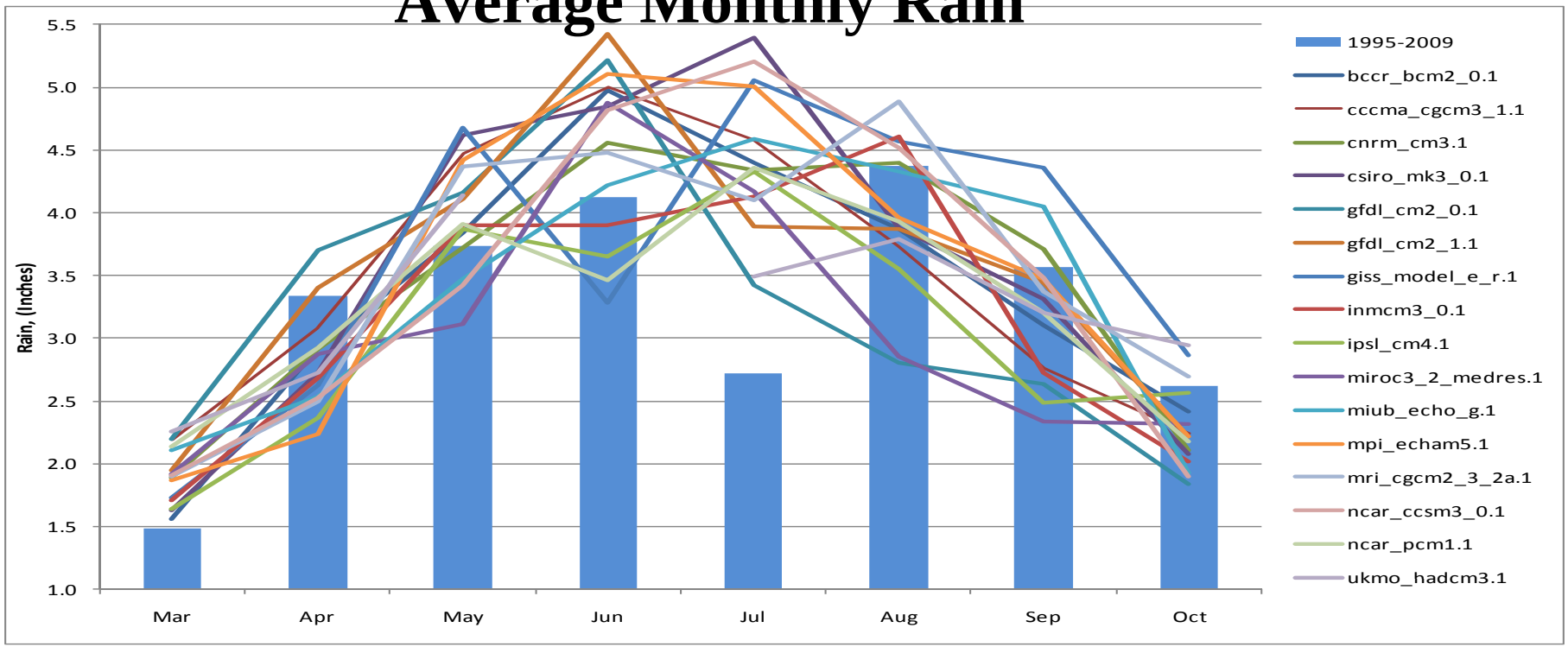
Shahram (Shane) Missaghi
miss0035@umn.edu

http://www.extension.umn.edu/

Model Results—Flow matters. Total Rain won't change much

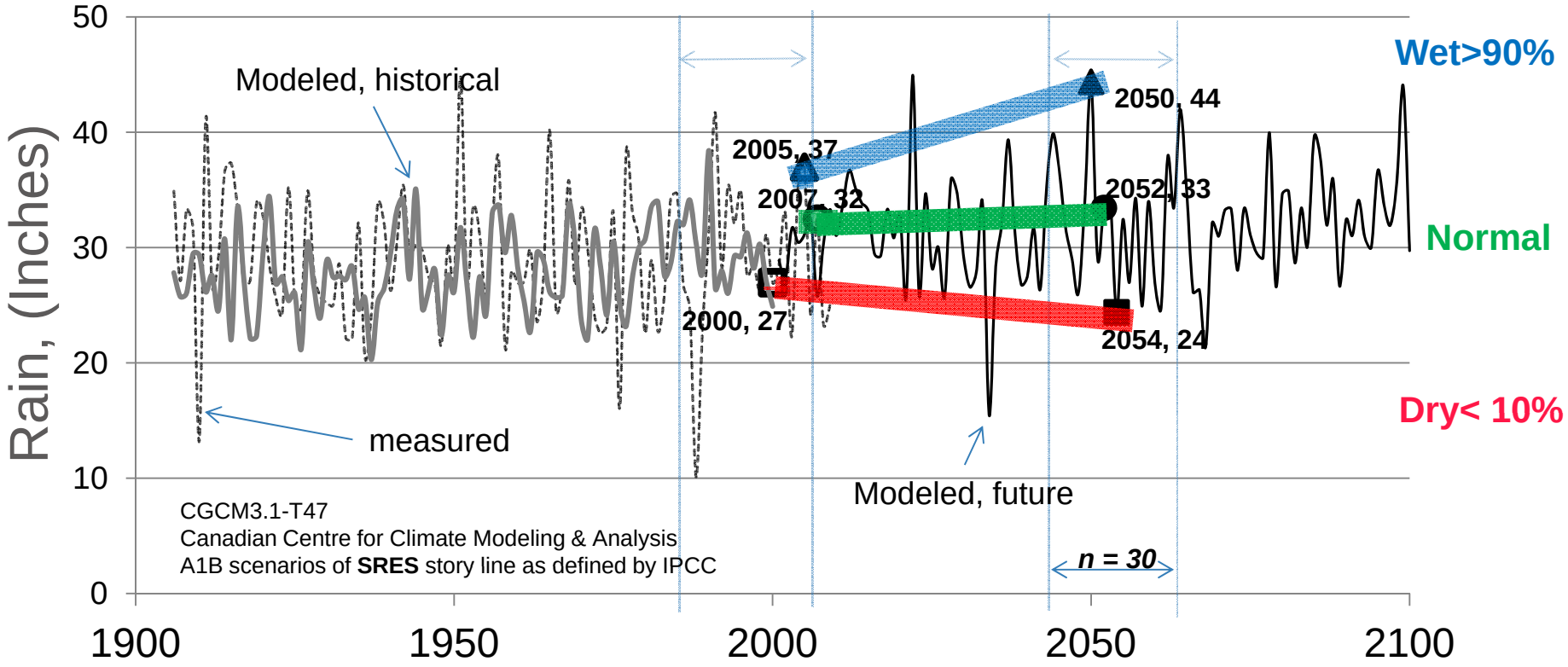


Model Results—Flow matters-But rain patterns will change



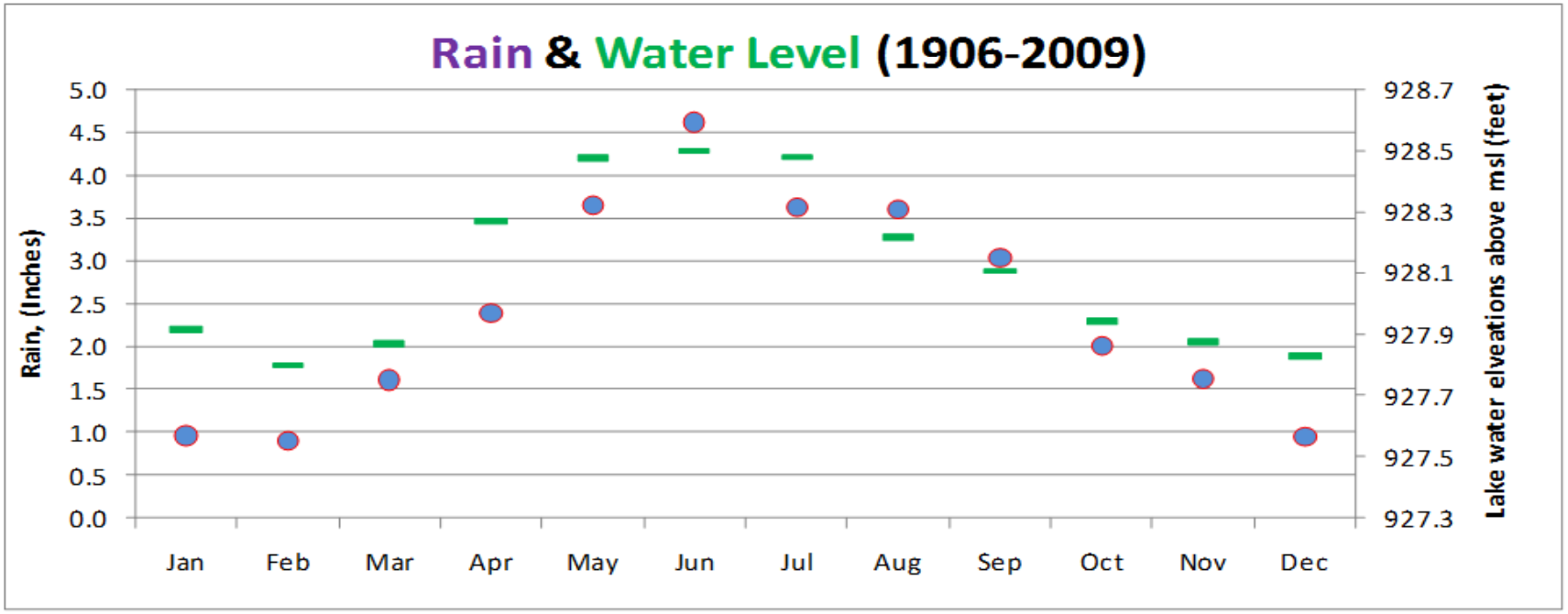
Project Approach– Climate Scenarios--*annual precipitation*

Study a lake **under different water level regimes** to see impact on **water quality** and **shoreline**



CLIMATE CHANGE IMPACT ON LAKES?

RAIN → INFLOW → LAKE WATER LEVEL

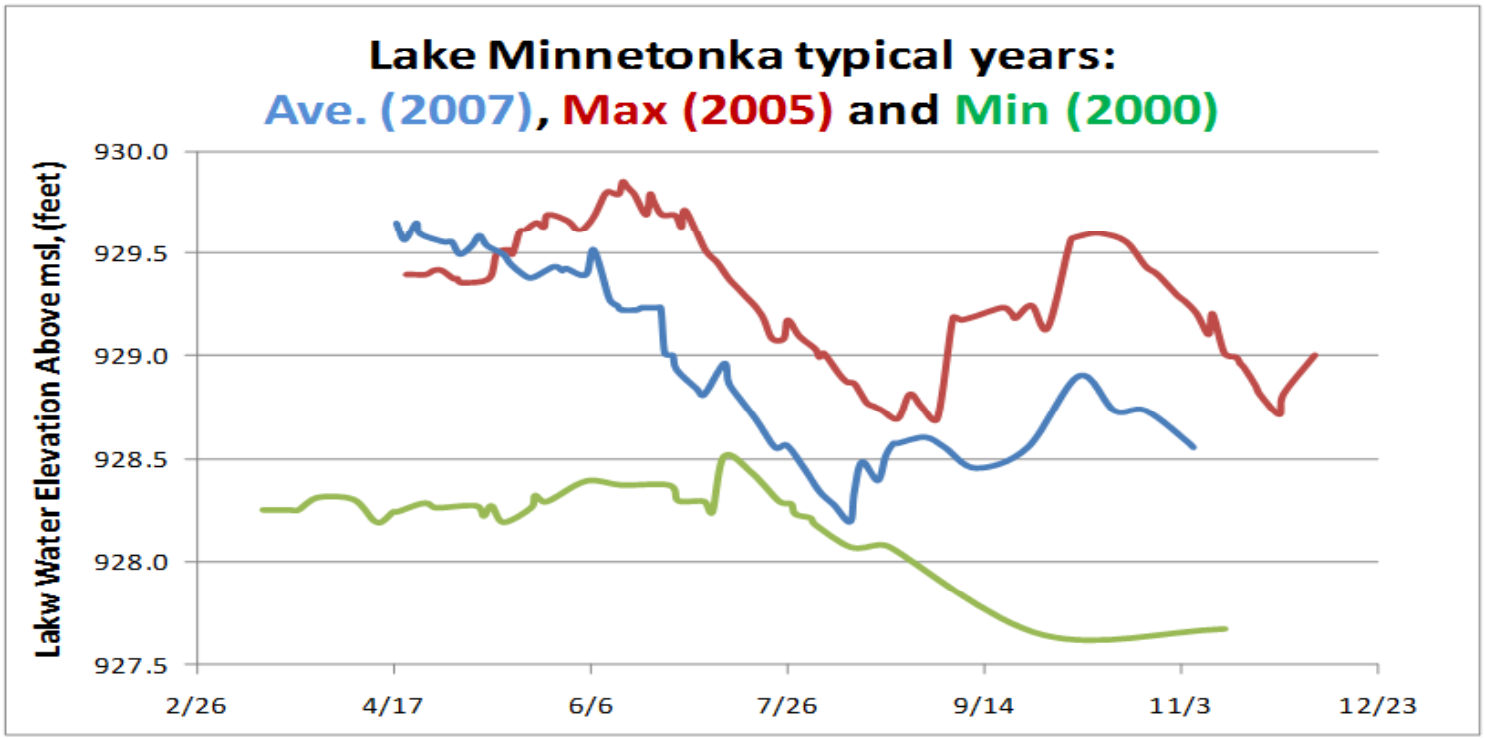


Lake Minnetonka, MN

Study Area

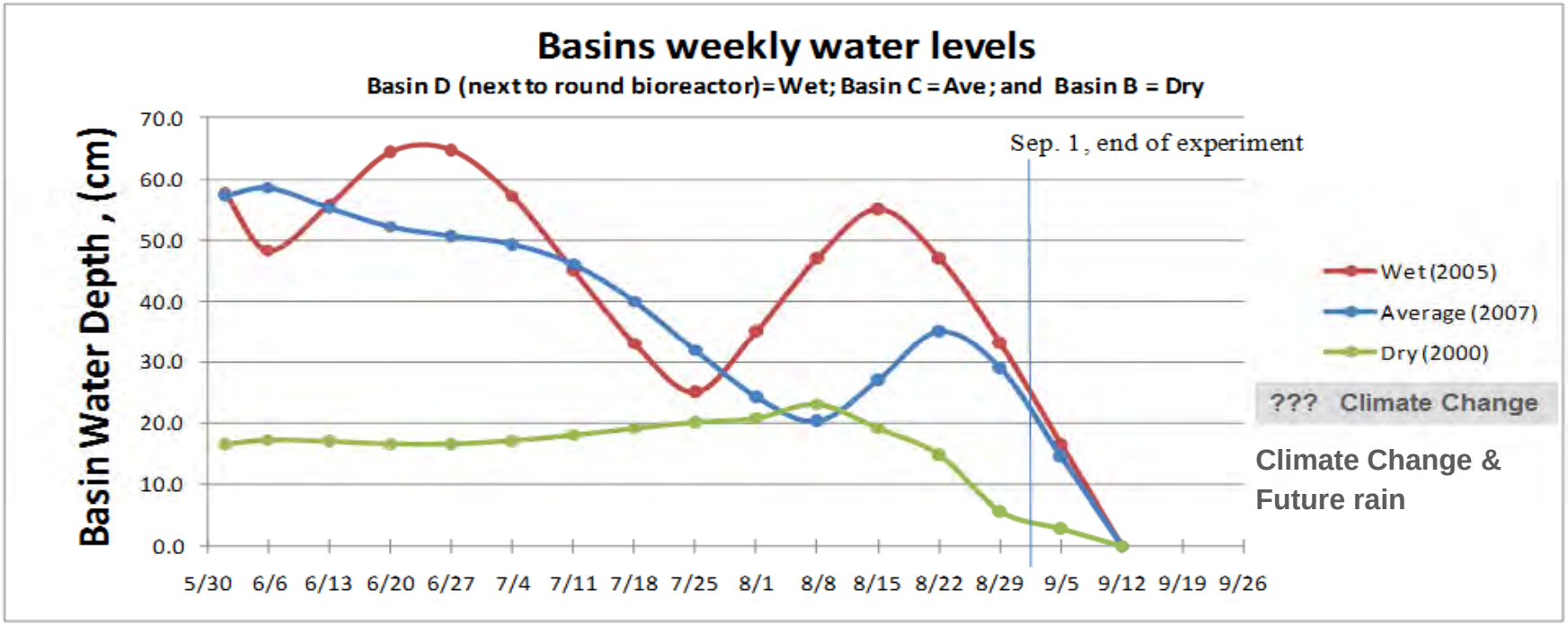
PROJECT APPROACH

Basin Design & Construction: Water Levels



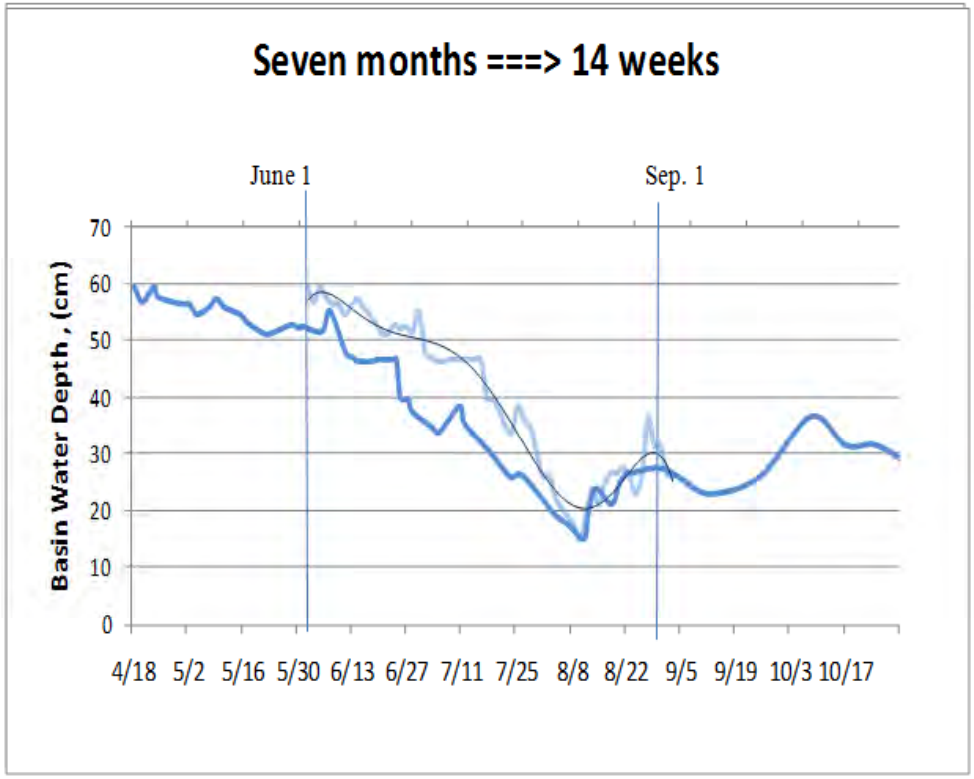
PROJECT APPROACH

Basin Design & Construction: Water Levels (2011)



PROJECT APPROACH

Basin Design & Construction: Water Levels

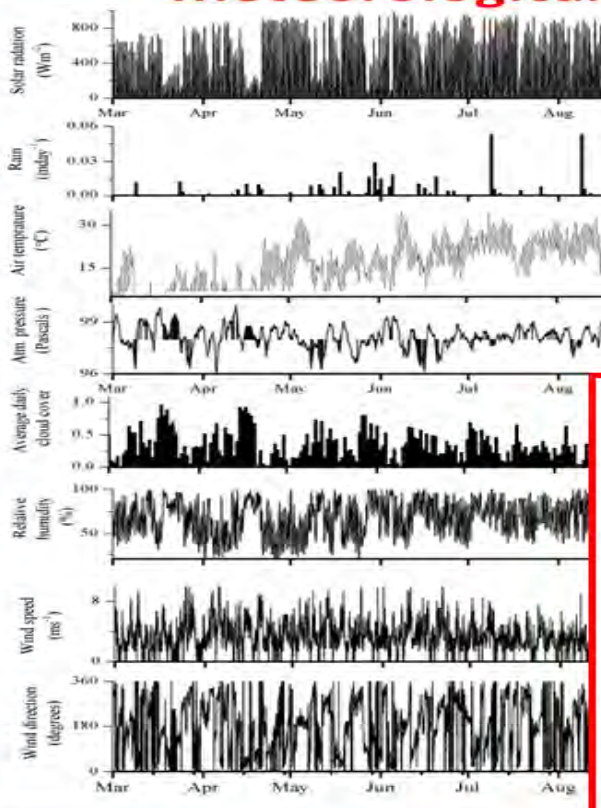


	2007
Intercept	57.17312
B1	0.92959
B2	-0.17644
B3	9.53E-03
B4	-2.31E-04
B5	2.49E-06
B6	-9.76E-09
R2	*0.98*

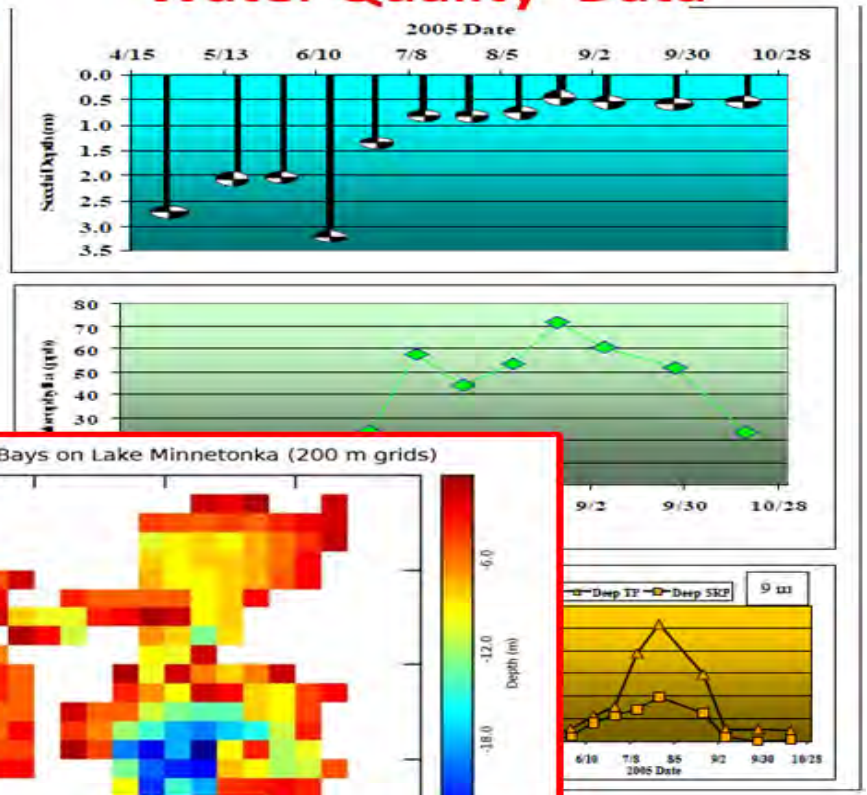
	cm
	2007-Ave
Jun, 01	57.2
Jun, 06	58.5
Jun, 13	55.2
Jun, 20	52.1
Jun, 27	50.7
Jul, 04	49.3
Jul, 11	46.0
Jul, 18	39.9
Jul, 25	31.9
Aug, 01	24.3
Aug, 08	20.3
Aug, 15	22.0
Aug, 22	27.8
Aug, 29	29.0

Model Setup:

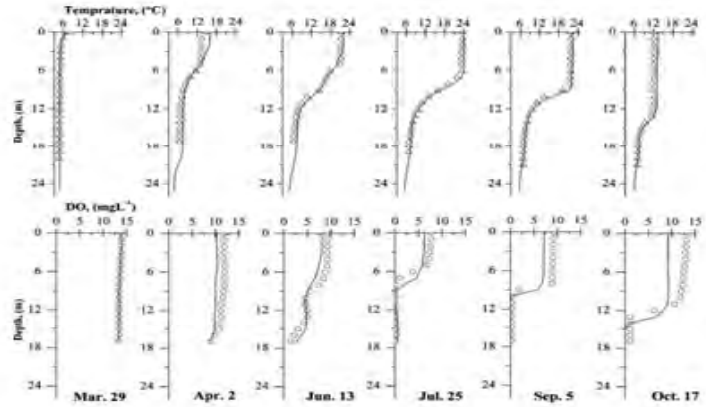
Meteorological Data



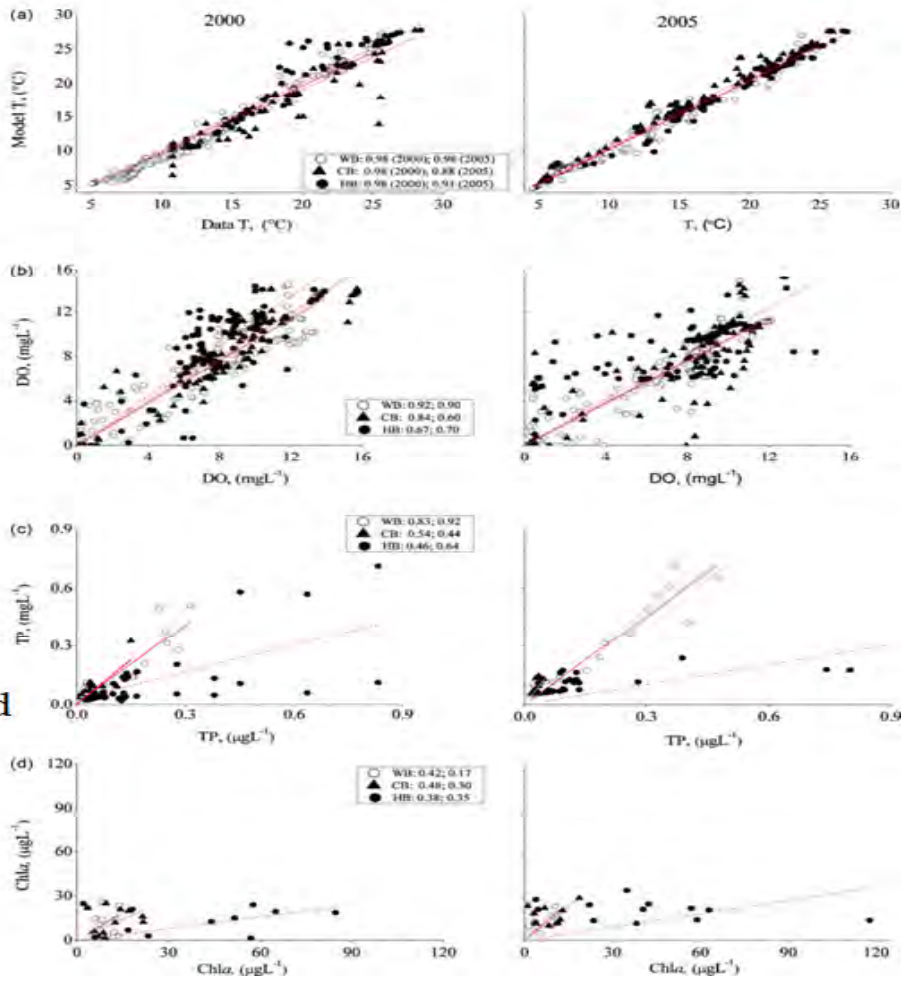
Water Quality Data



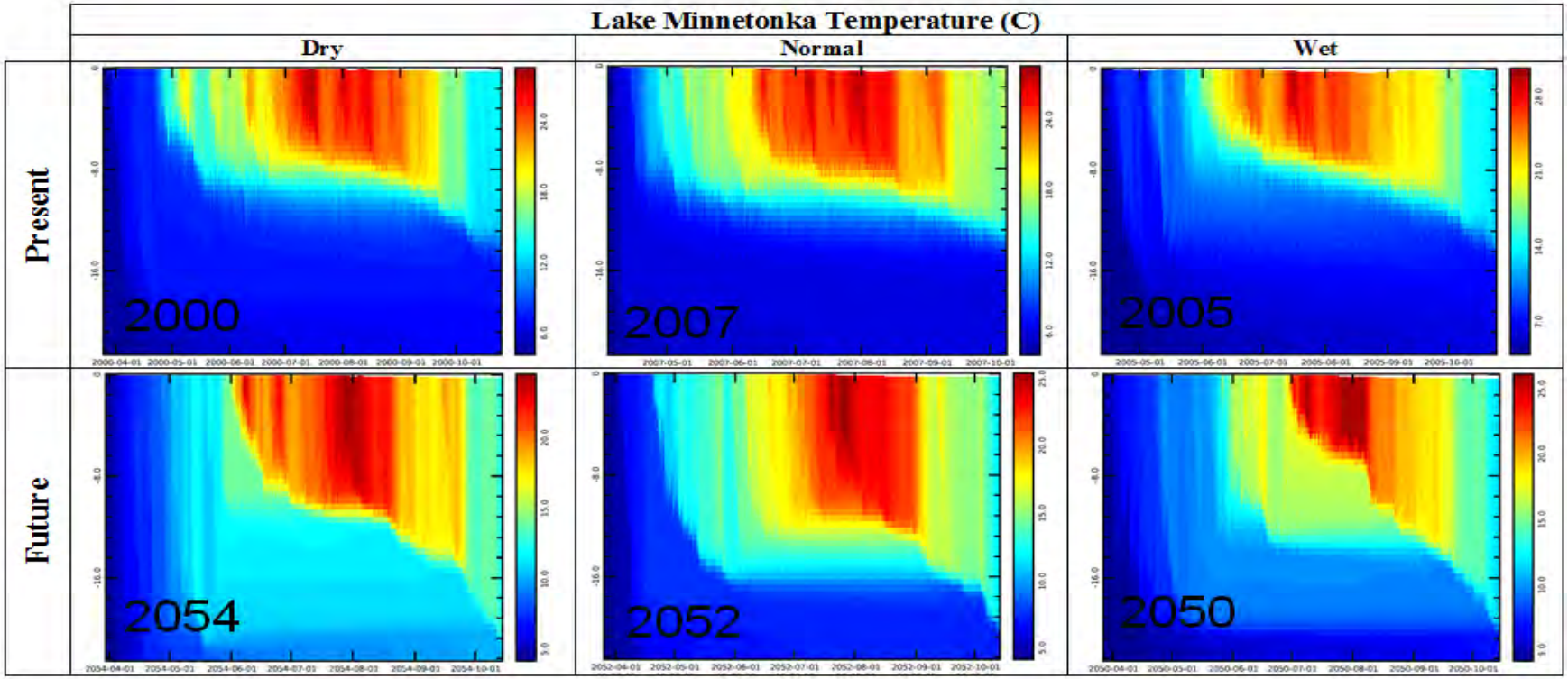
MODEL RESULTS:



ELCOM-CAYDEM modeling was able to captured the system's physical, chemical and biological temporal and spatial heterogeneity.



Climate Change Scenarios Simulation Results:



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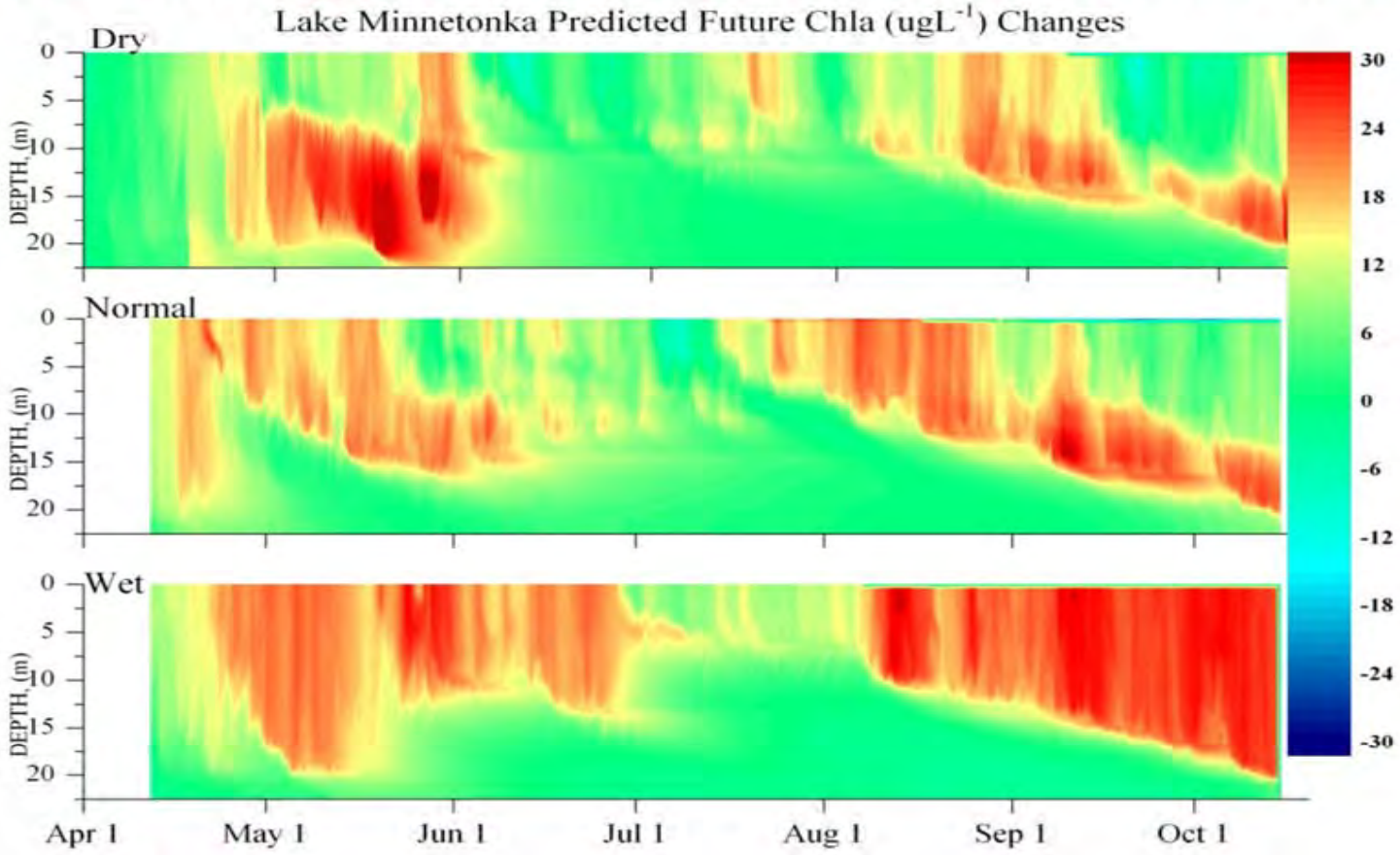
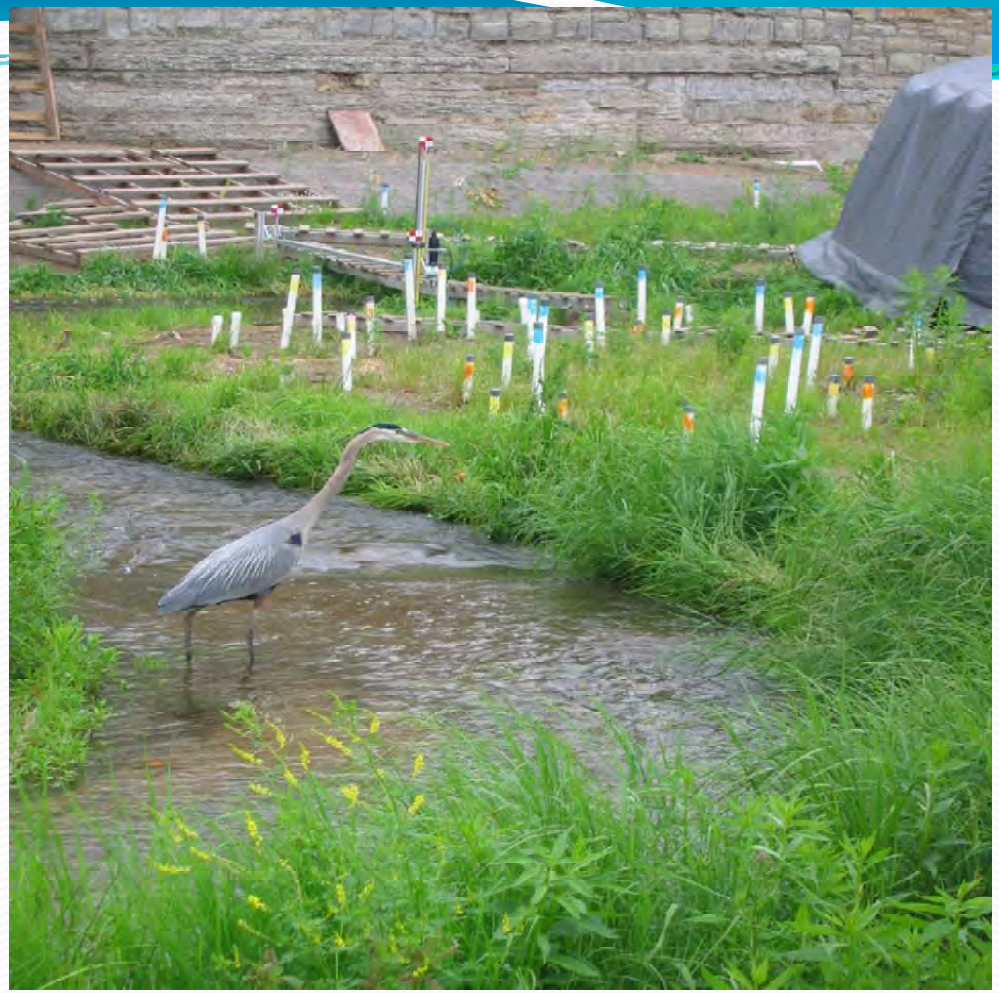



YouTube
0:00 / 0:00

The Experiment Site

U of MN Saint Anthony Falls Outdoor Stream Laboratory



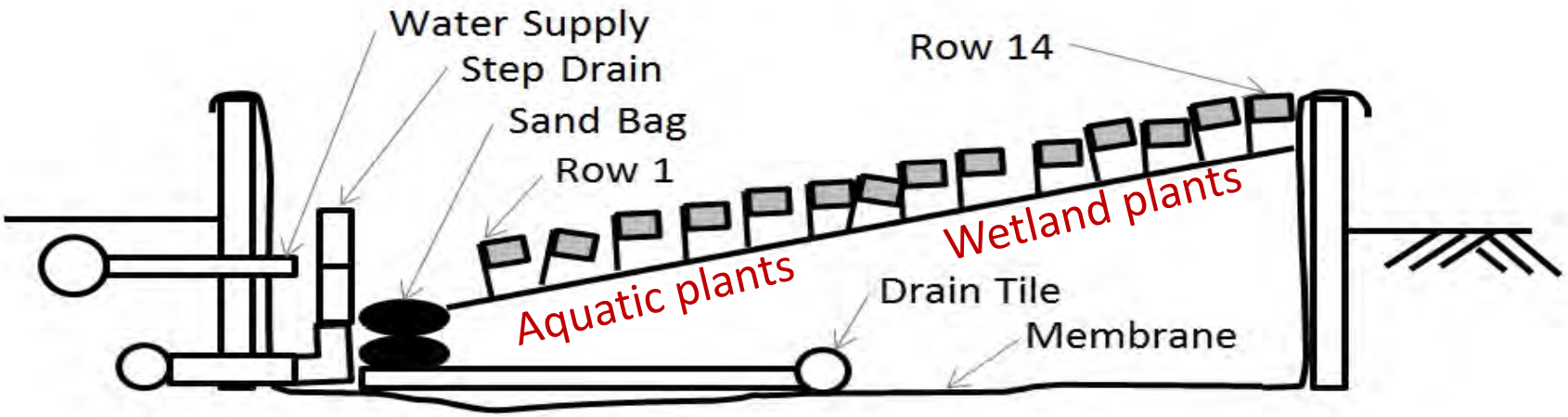
Premise of Experimental study

More healthy herbaceous vegetation leads to better water quality.

The Experiment

- Four 16'x16' basins
- 50 sand/50 compost mix; 10% slope
- 4 wetland (transition) plant species and 4 emergent aquatic species in each basin
- Each basin mimicked lake water level fluctuations for a wet, dry, normal, or fluctuating precipitation year
- 2010 field data (one season)

Basin Cross-section



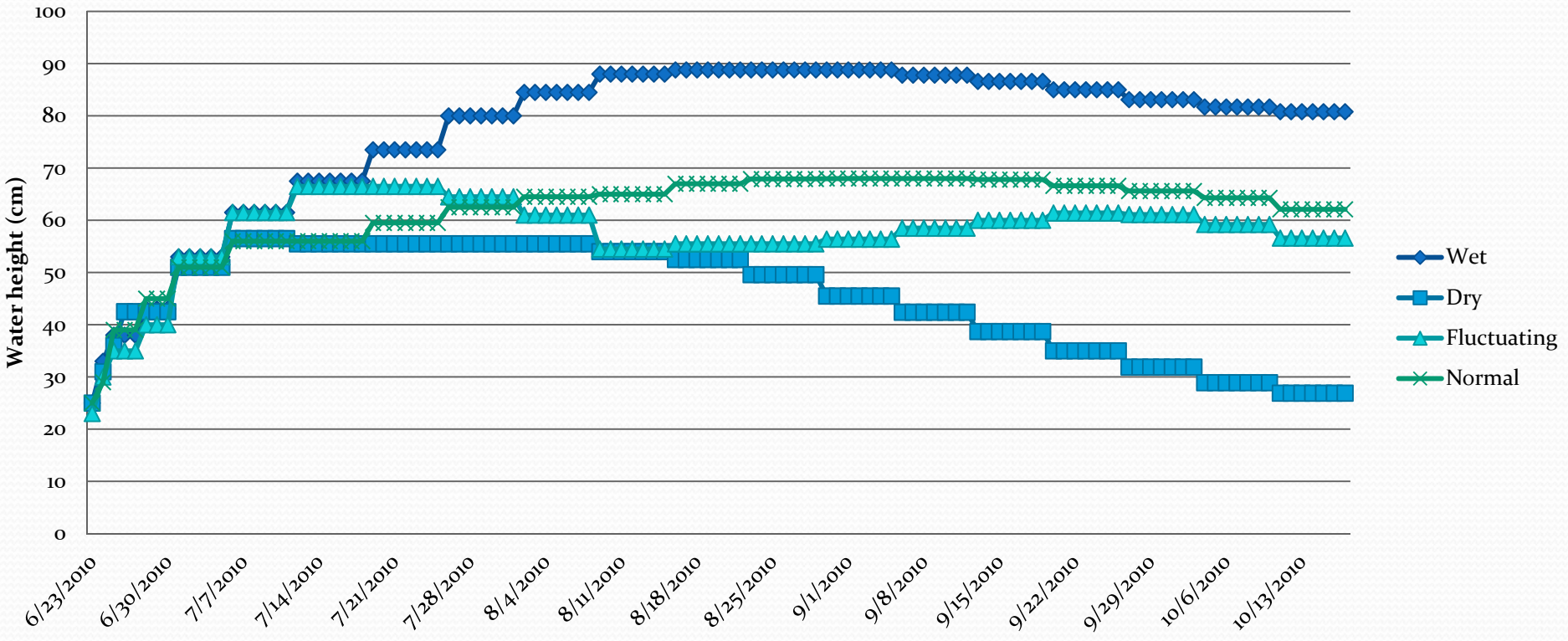
Basin Construction

2010 Measurements

- Above-ground biomass (Oct.)
- Water Levels (weekly)
- Photos (weekly)

Water Level Regimes - based upon Lake

Minnetonka water levels (historic and predicted from model)



Plants

Plant species

Shore Zone	Common name (Scientific name*)	Growth form	Abbreviation
Wetland or Transition	Fox sedge (*Carex vulpinoidea*)	Caespitose	FS
	Bottlebrush sedge (*Carex comosa*)	Caespitose	BB
	Common rush (*Juncus effusus*)	Caespitose	CR
	Prairie cordgrass (*Spartina pectinata*)	Rhizomatous	PC
Emergent Aquatic	Giant bur-reed (*Sparganium eurycarpum*)	Rhizomatous	GB
	River bulrush (*Bulboschoenus fluviatilis*)	Rhizomatous	RB
	Softstem bulrush (*Schoenoplectus tabernaemontani*)	Rhizomatous	SB
	Lake sedge (*Carex lacustris*)	Rhizomatous	LS

* Nomenclature according to *Flora of North America*: http://fna.huh.harvard.edu/

Fox Sedge (*Carex vulpinoidea*)

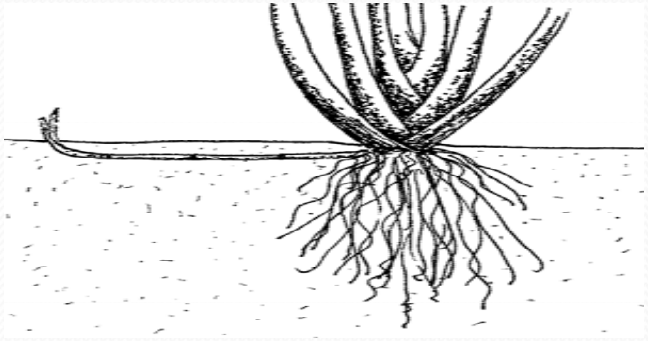
Bottlebrush, Bristly or Longhair Sedge (*Carex comosa*)

Common Rush (*Juncus effusus*)

Prairie Cordgrass (*Spartina pectinata*)

Giant Burreed

(*Sparganium eurycarpum*)



Softstem bulrush (*Schoenoplectus acutus*)

Lake Sedge (*Carex lacustris*)

River Bulrush (Bolboschoenus fluviatilis)

The Plants – 18” height

Planting-

1 ft spacing

June 29, 2010: starting level

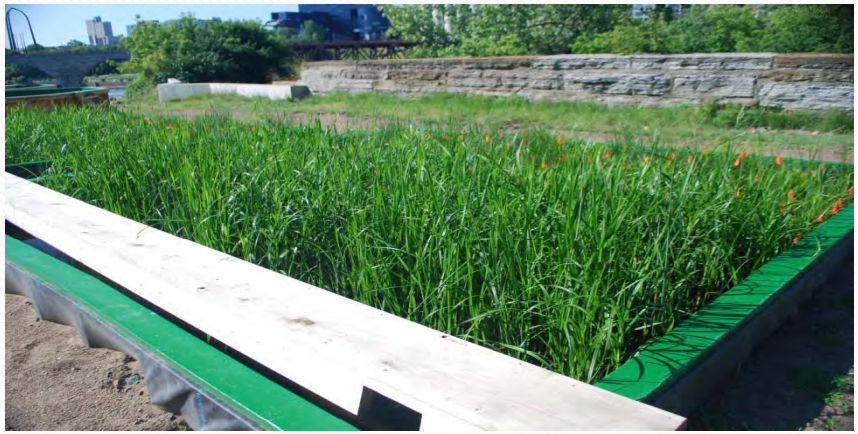
Wet Basin

Fluctuating Basin
(Dry and Normal Basins similar)

July 26, 2010

Wet Basin

Fluctuating Basin
(Dry and Normal Basins similar)



August 23, 2010

Wet Basin

Fluctuating Basin
(Dry and Normal Basins similar)

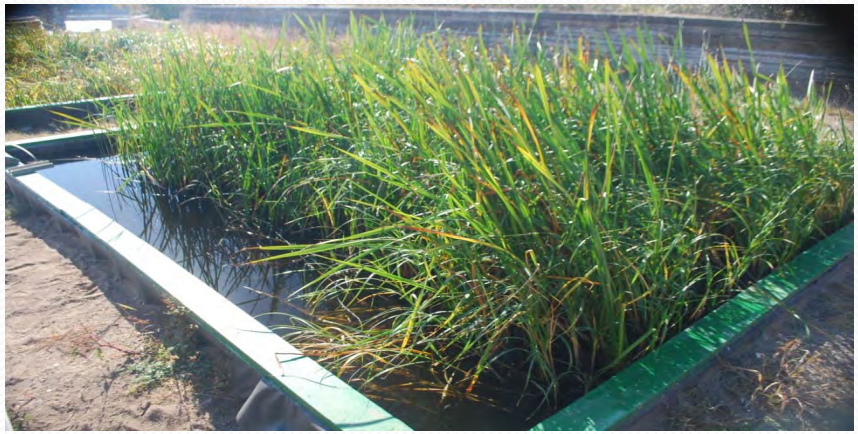
September 27, 2010

Wet Basin

Fluctuating Basin
(Dry and Normal Basins similar)

October 11, 2010

Wet Basin



Fluctuating Basin
(Dry and Normal Basins similar)

October 11, 2010 – wetland perspective

Wet Basin

Dry Basin
(Fluctuating, Normal Basins similar)

October 29, 2010 - harvest

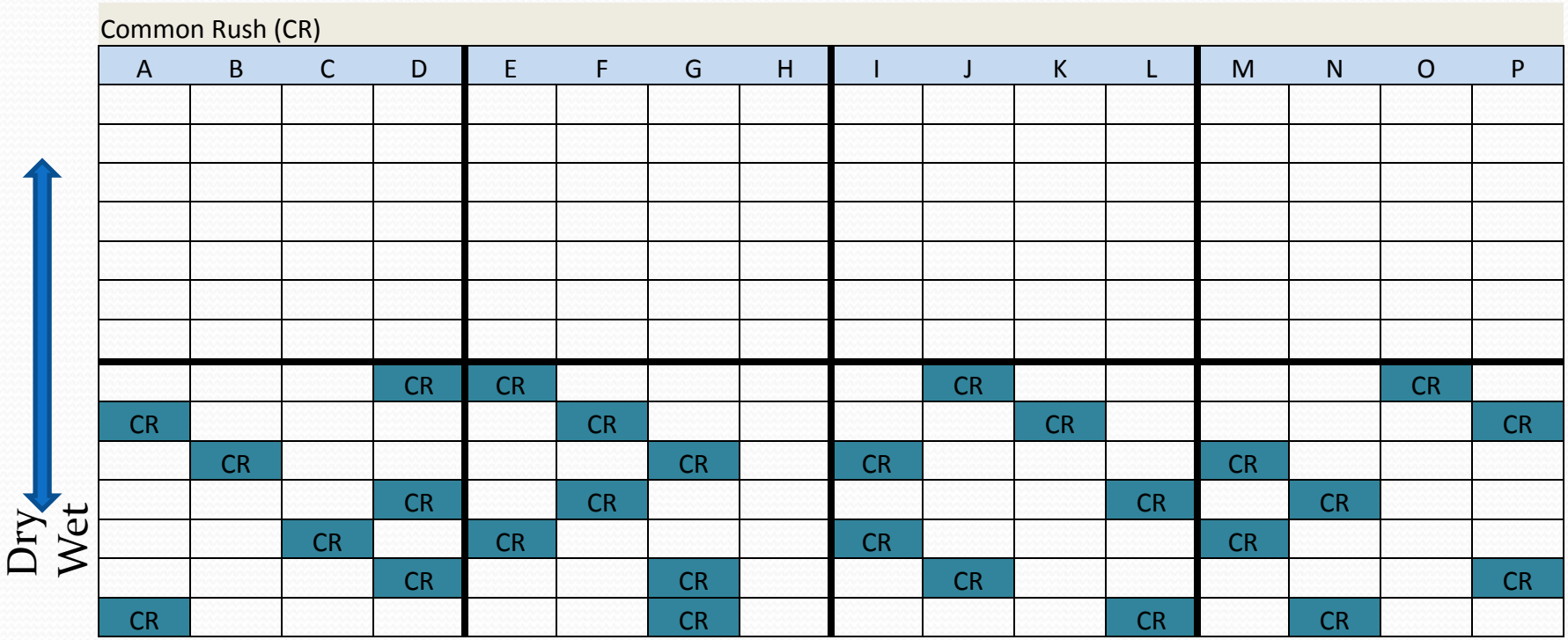
Used a grid

Almost done!

Results

Common Rush

Common Rush - Fluctuating Regime



Fox Sedge (*Carex vulpinoidea*)

Fox Sedge - Fluctuating Water Regime

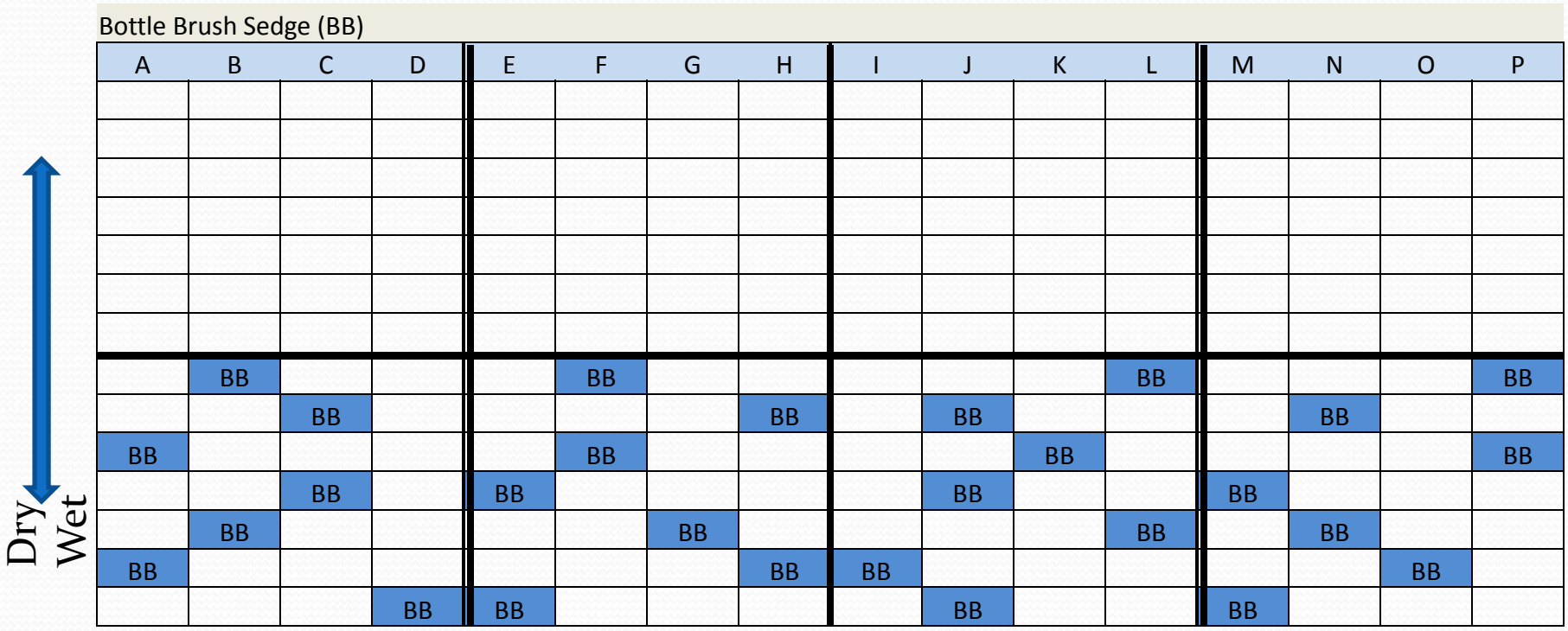
Fox Sedge (FS)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
FS						FS				FS		FS			
	FS					FS		FS						FS	
			FS	FS					FS					FS	
	FS						FS	FS						FS	
FS					FS				FS						FS
	FS			FS						FS		FS			
		FS					FS	FS						FS	

Dry
Wet

Bottlebrush, Bristly or Longhair Sedge (*Carex comosa*)

Bottlebrush Sedge – Fluctuating Regime



Prairie Cordgrass (*Spartina pectinata*)

Prairie Cordgrass - Fluctuating Regime

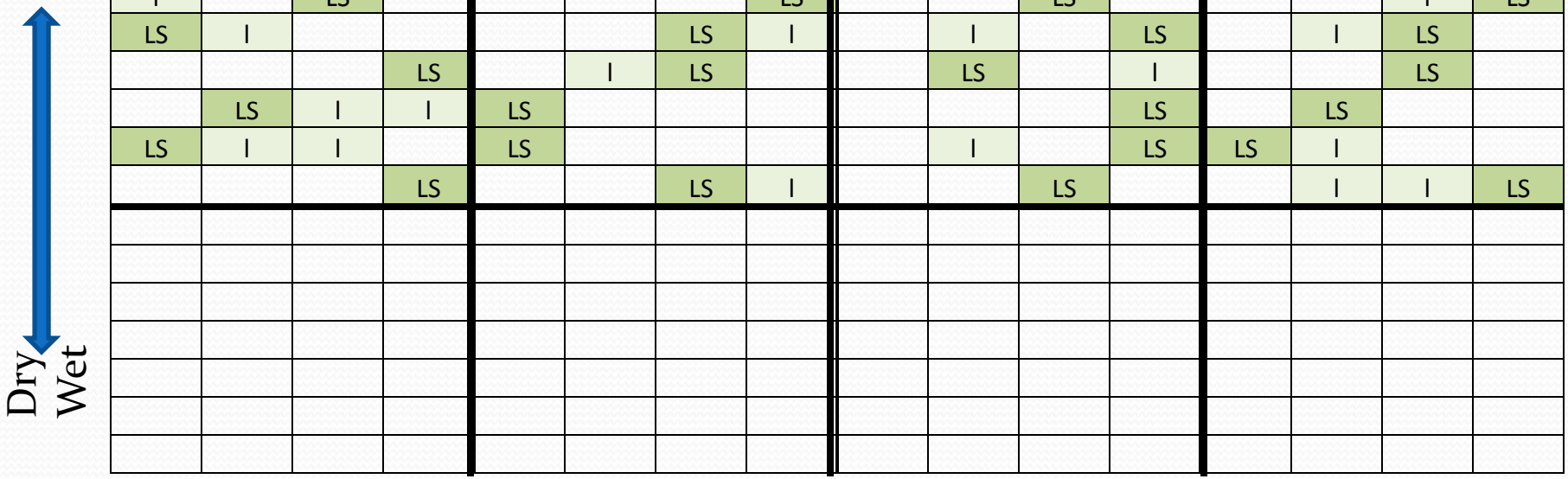
Prairie Cordgrass (PC)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		PC					PC	PC					PC		
			PC	PC							PC	PC			
p		PC	p				PC				PC	p	PC		
PC	p					PC			p	PC	p				PC
p			PC				PC			PC				PC	
		PC			PC						PC	p	PC		
	PC				PC					PC					PC

Dry
Wet

Lake Sedge (*Carex lacustris*)

Lake Sedge - Fluctuating Water Regime



Softstem bulrush (*Schoenoplectus acutus*)

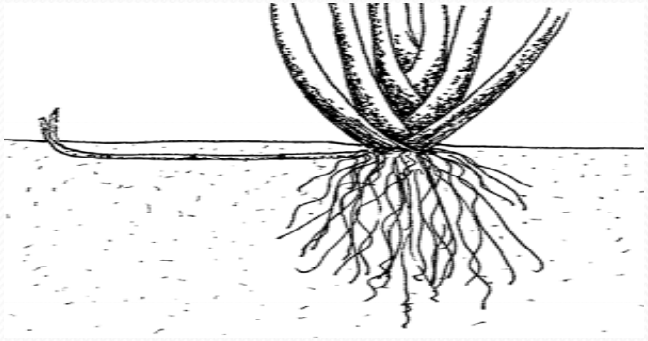
Softstem Bulrush - Fluctuating Water Regime

Softstem Bulrush (SB)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
	SB					SB		SB	s				s	SB	s
SB					SB				SB				SB		s
s	SB	s			SB	s		SB	s					s	SB
SB				SB	s			s		SB		s	SB	s	
s	s	SB	s		SB	s		SB	s			s		s	SB
	SB					SB	s		SB					s	SB
		SB				s	SB	s			SB	s	s	SB	s
		s				s								s	

Dry
Wet

Giant Burreed (*Sparganium eurycarpum*)



Giant Bur-reed - Fluctuating Water Regime

Giant Bur-reed (GB)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
g		GB		g	g		GB	g	g	g	GB		GB		
g	GB	g	g	GB	g	g	g	g	g	g	GB	GB	g	g	g
g	g	g	GB	g	g	g	GB	g	g	GB	g	g	GB		g
g	g	GB	g	g	GB	g		g	g	g	GB	GB	g	g	g
g	g	g	GB	g	g	g	GB	g	GB	g	g	g	g	GB	g
g	g	GB	g	g	GB	g	g	g	g	GB	g	g	GB	g	g
g	GB	g	g	g	GB	g	g	GB		g	g	GB	g	g	g
g	g	g	g	g	g	g			g	g					g
g	g	g	g	g	g	g	g					g	g	g	g
g	g		g	g					g			g		g	
g							g			g					

Dry
Wet

River Bulrush (Bolboschoenus fluviatilis)

River Bulrush - Fluctuating Water Regime

River Bulrush (RB)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
RB	r	r	r	r	RB	r	r	r	r	RB	r	RB	r	r	r
r	r	r	RB	r	r	RB	r	RB	r	r	r	r	r	RB	r
r	r	RB	r	RB	r	r	r	r	RB	r	r	RB	r	r	r
r	RB	r	r	r	r	r	RB	RB	r	r	r	r	r	r	RB
RB	r	r	r	r	r	RB	r	r	r	RB	r	RB	r	r	r
r	r	r	RB	r	r	r	RB	RB	r	r	r	r	r	RB	r
RB	r	r	r	RB	r	r	r	r	RB	r	r	r	RB	r	r
r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
r	r	r	r	r	r	r	r	r	r	r	r	r	r	r	r
			r	r	r	r	r	r	r	r			r	r	r
r					r	r	r	r	r	r	r	r	r	r	r
													r		r
														r	

Dry
Wet

Plant Mortality of Eight Species Under Four Climate Regimes

	2010 MORTALITY (# non-survivors/28 plants)			
"Aquatic" Species	**Wet**	**Dry**	**Fluctuating**	**Normal**
River Bulrush (RB)	0	0	0	0
Giant Burreed (GB)	0	0	0	0
Softstem Bulrush (SB)	0	2	0	0
Lake Sedge (LS)	8	3	0	1
“Wetland" Species				
Fox Sedge (FS)	18	0	3	2
Bottlebrush Sedge (BB)	5	0	0	0
Prairie Cordgrass (PC)	1	0	0	0
Common Rush (CR)	0	0	0	0

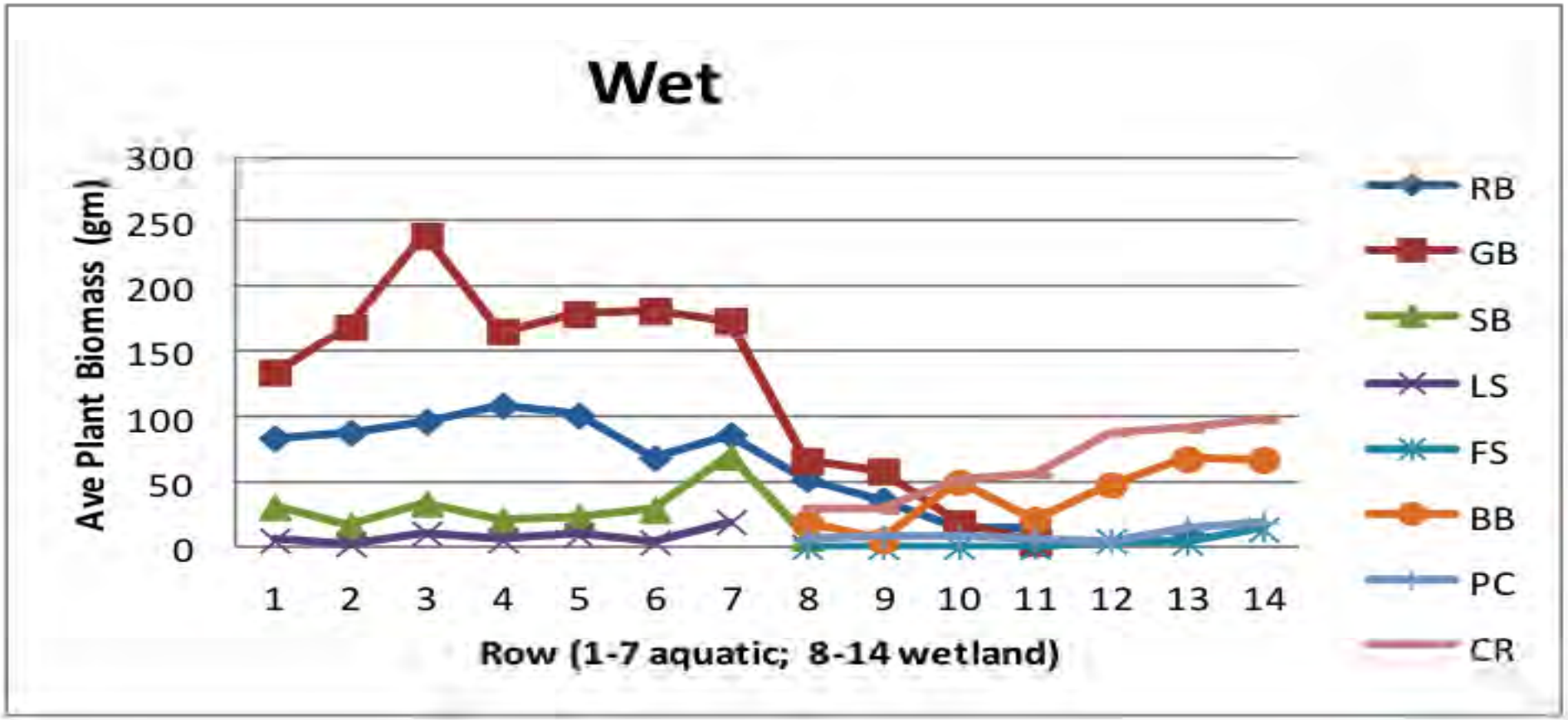
High mortality

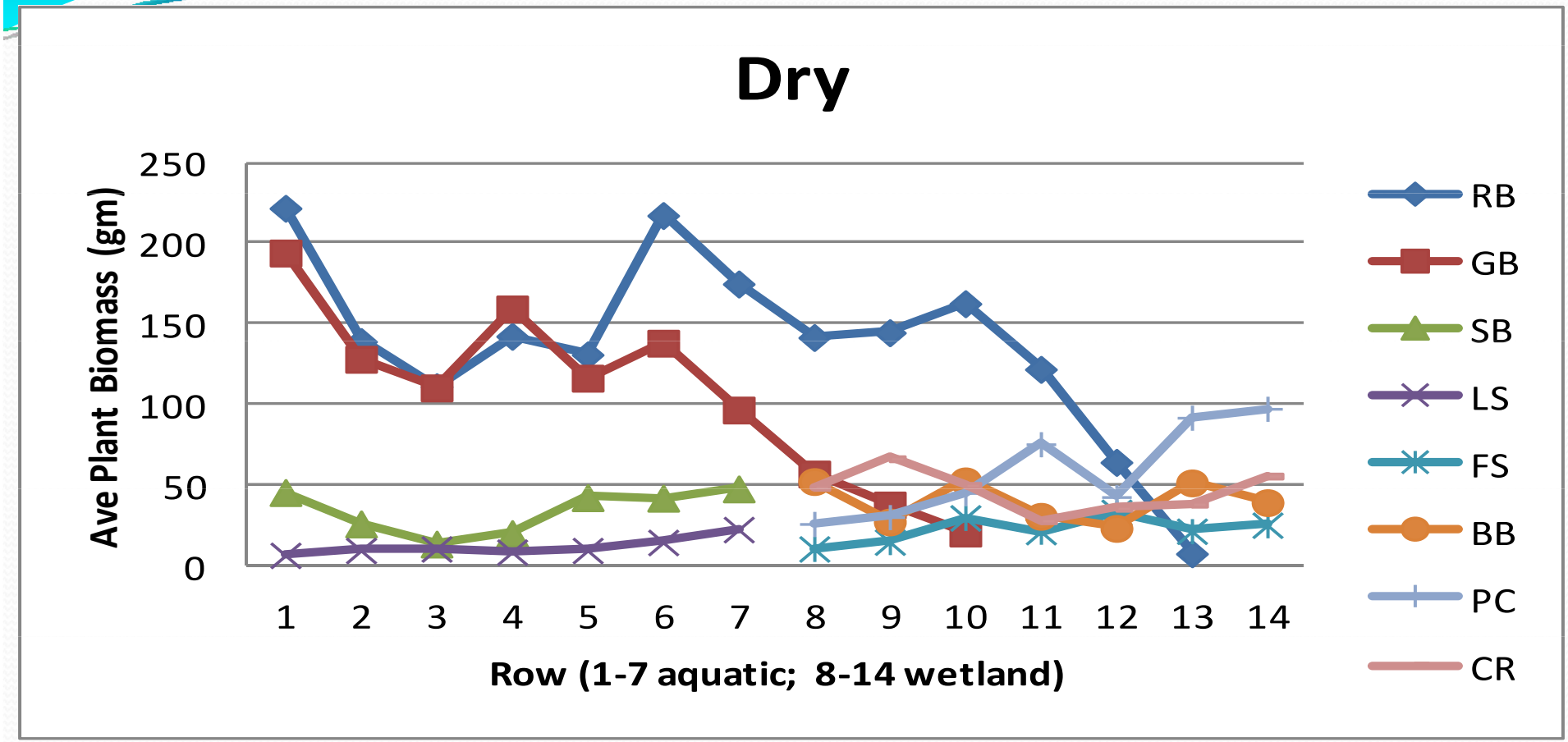
Plant Biomass of Eight Species Under Four Climate Regimes

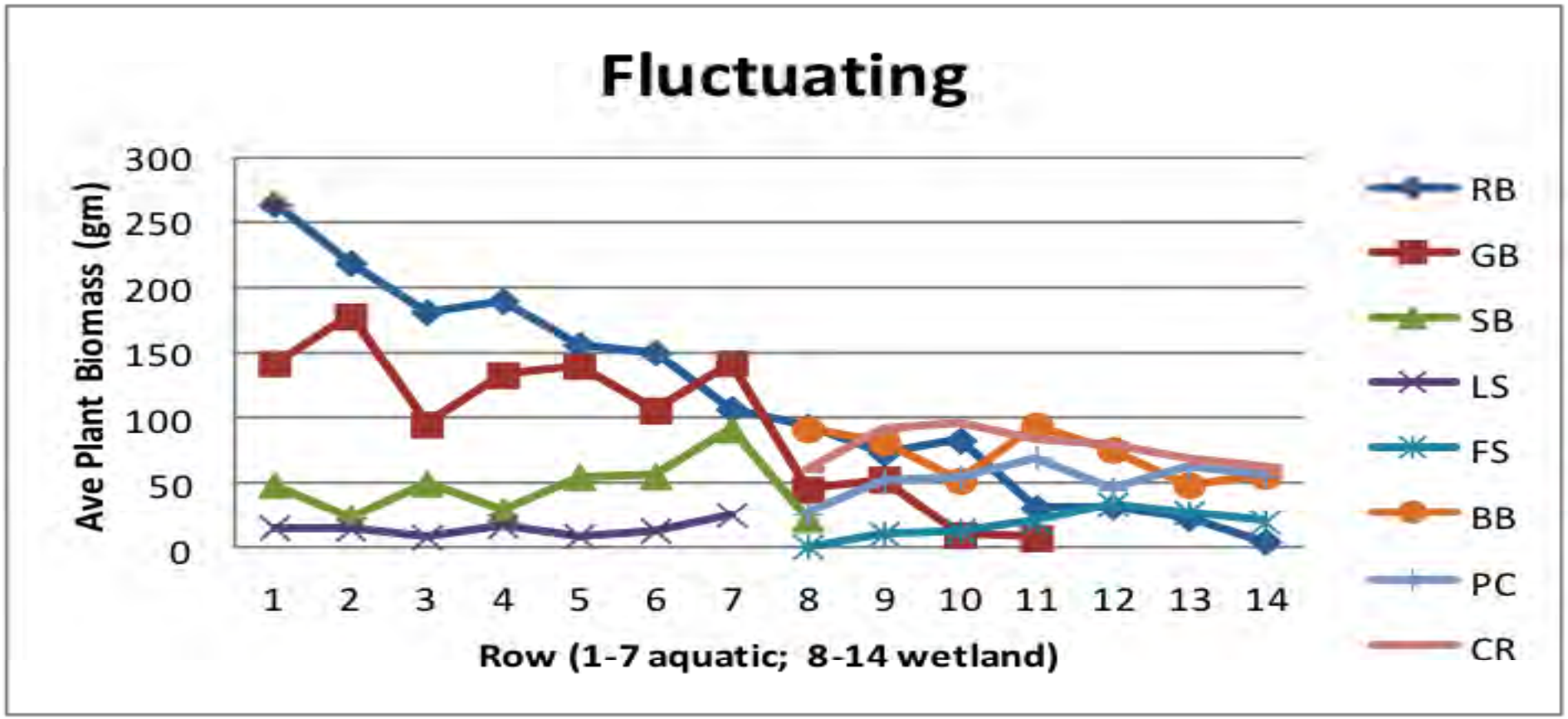
	2010 TOTAL BIOMASS (gm)			
"Aquatic" Species	**Wet**	**Dry**	**Fluctuating**	**Normal**
River Bulrush (RB)	2955	7126	6348	5787
Giant Burreed (GB)	5316	4216	4143	4935
Softstem Bulrush (SB)	891	906	1482	1753
Lake Sedge (LS)	214	326	419	431
“Wetland" Species				
Fox Sedge (FS)	84	625	512	478
Bottlebrush Sedge (BB)	1105	1056	1996	1917
Prairie Cordgrass (PC)	260	1637	1465	1520
Common Rush (CR)	1759	1292	2104	2370

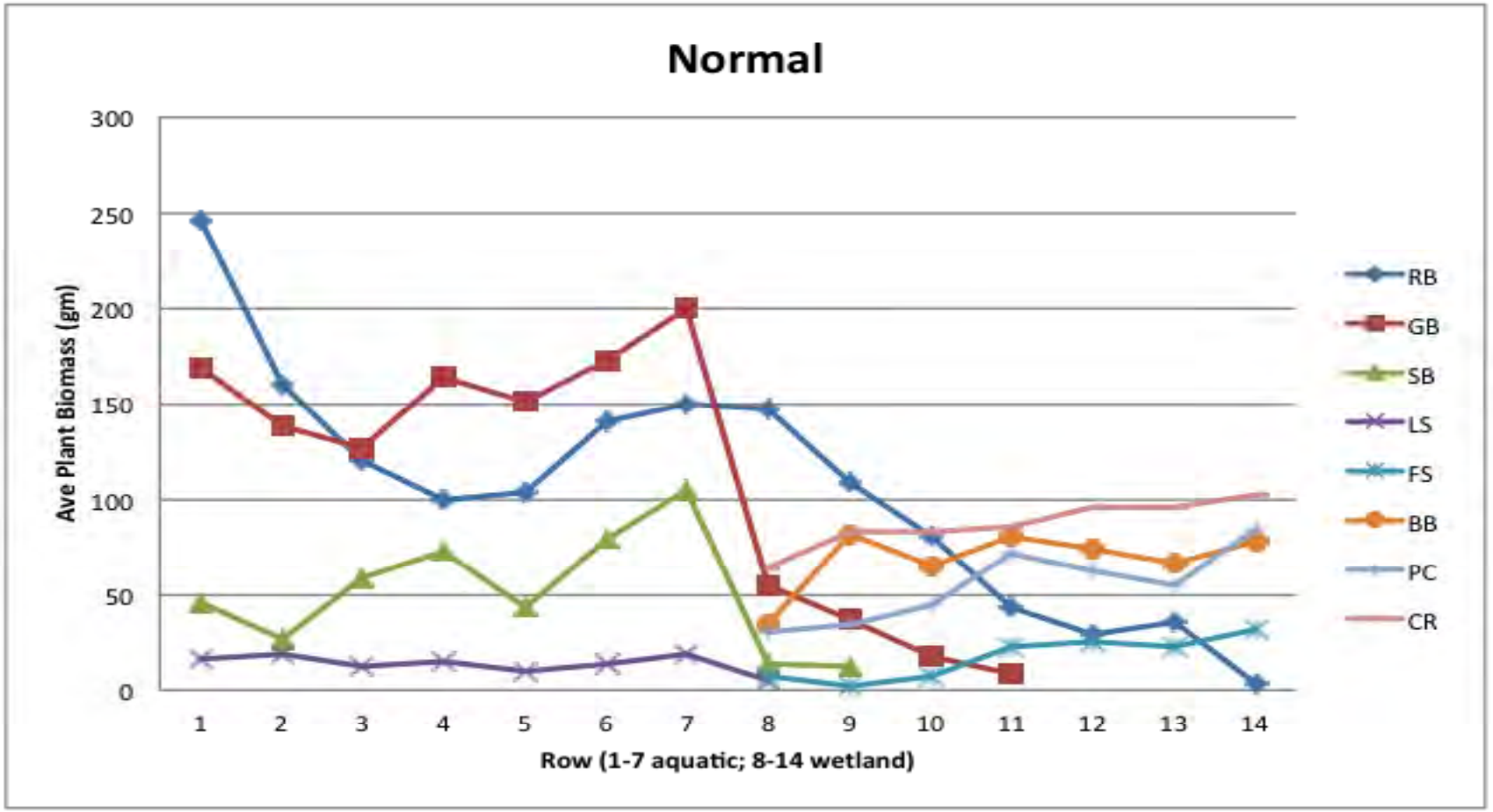
= lowest biomass of species

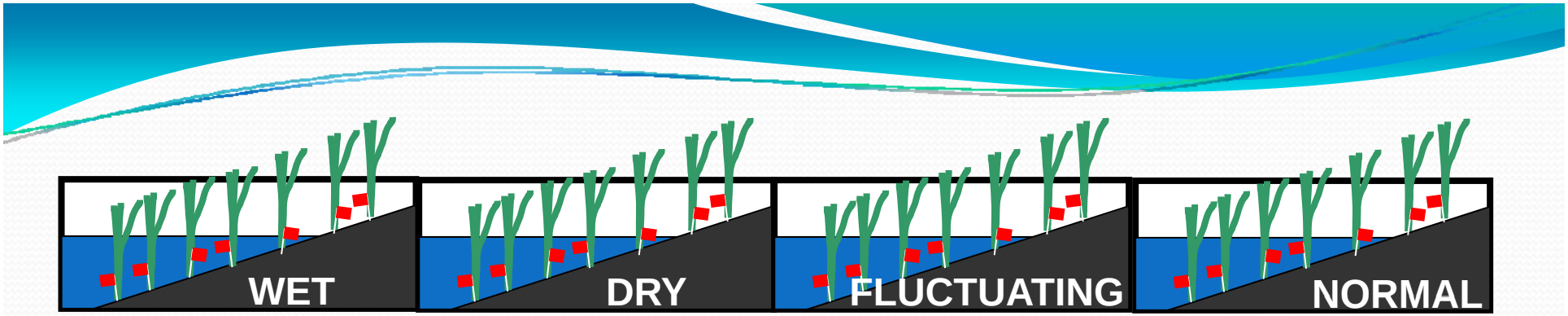
= highest biomass

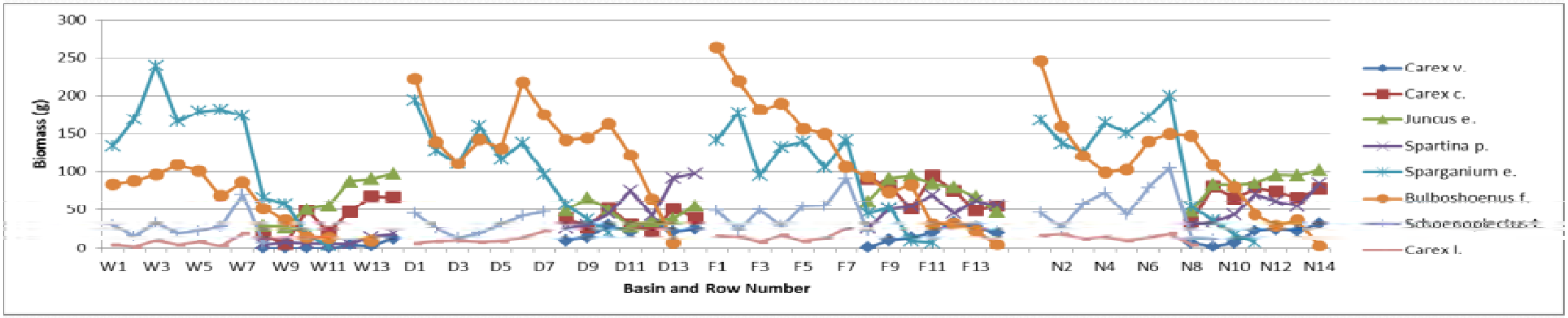


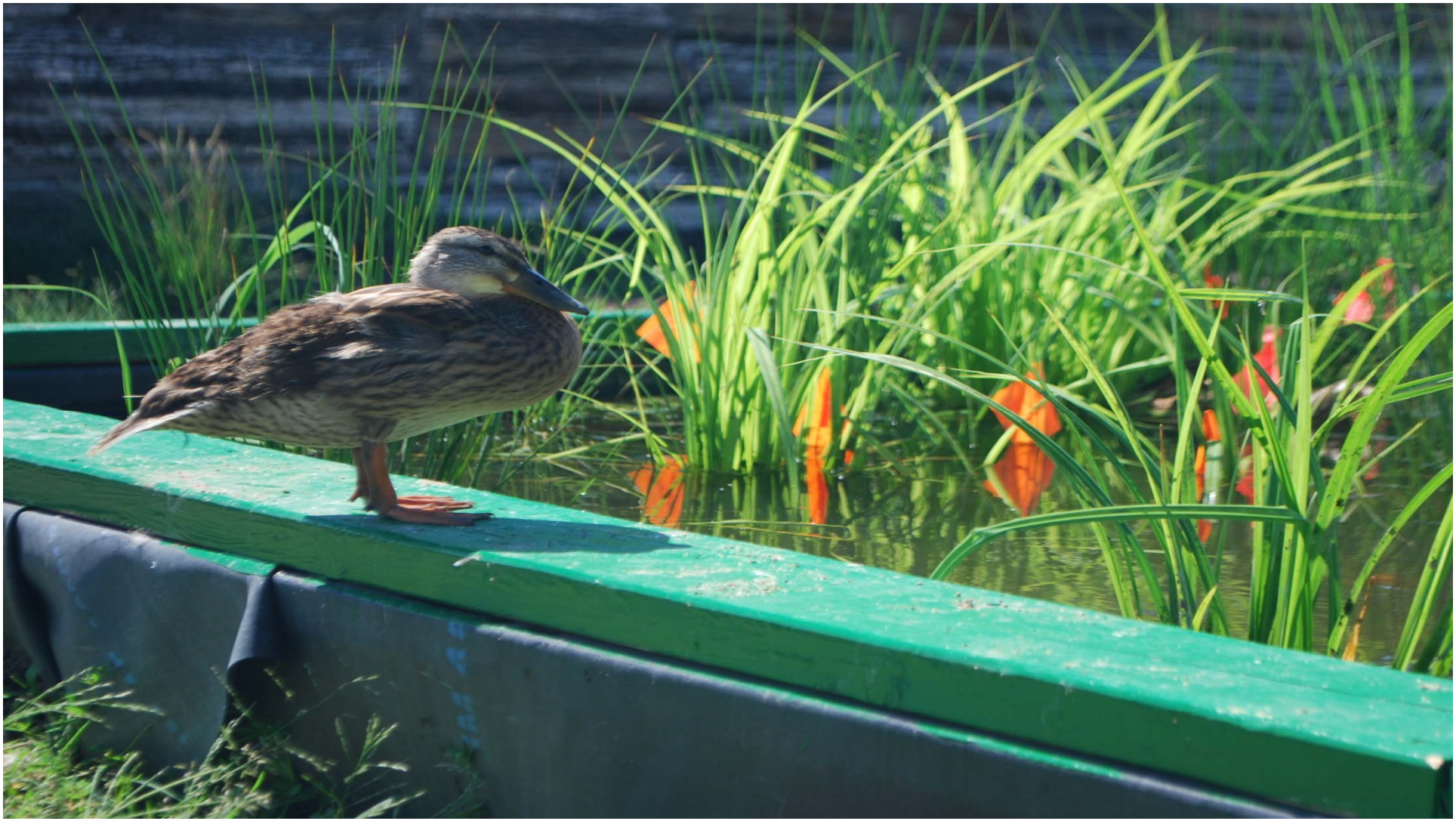


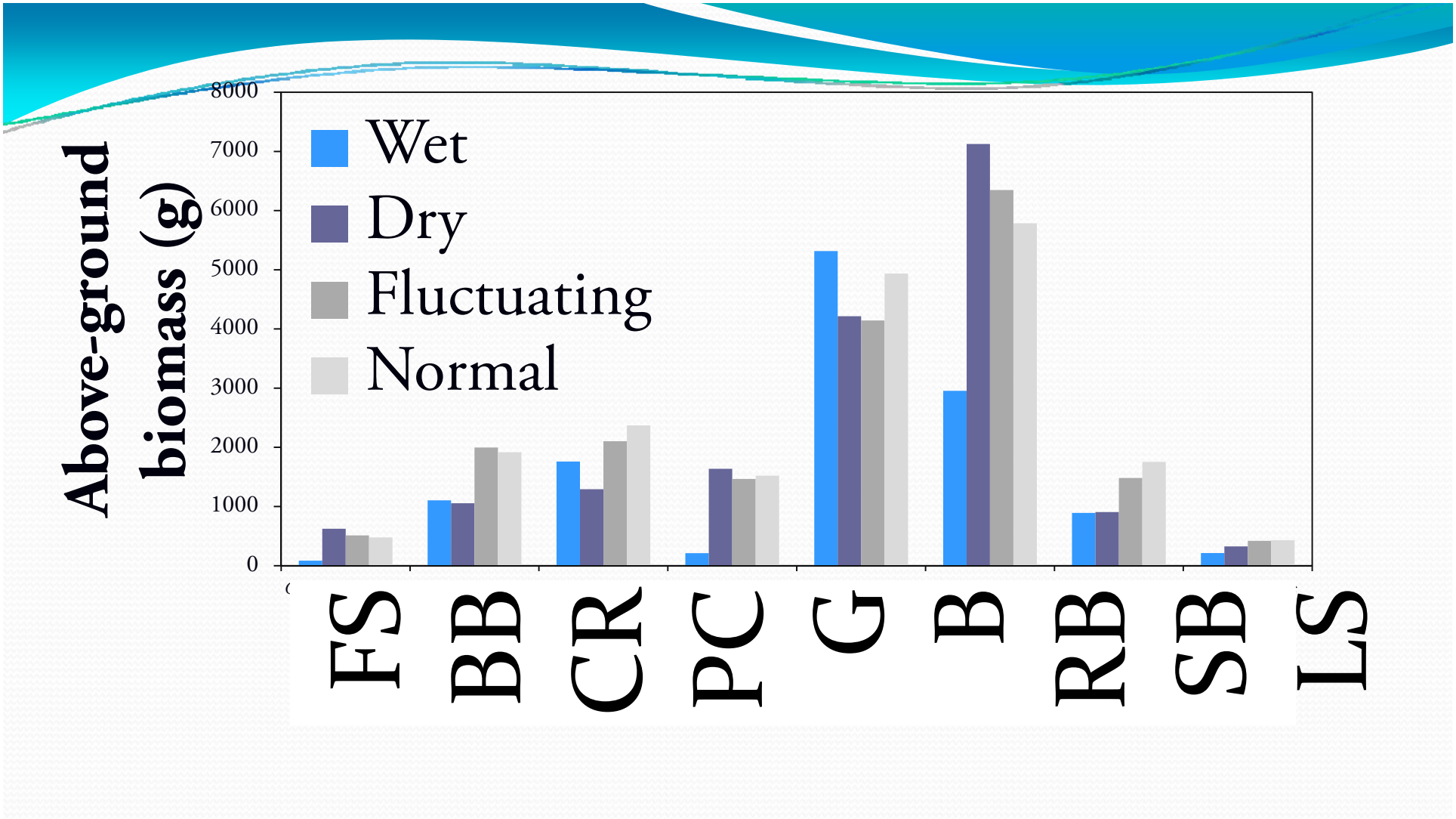

Fluctuating
Ave Plant Biomass (gm)
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Row (1-7 aquatic; 8-14 wetland)
RB
GB
SB
LS
FS
BB
PC
CR


Normal
Ave Plant Biomass (gm)
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Row (1-7 aquatic; 8-14 wetland)
RB
GB
SB
LS
FS
BB
PC
CR

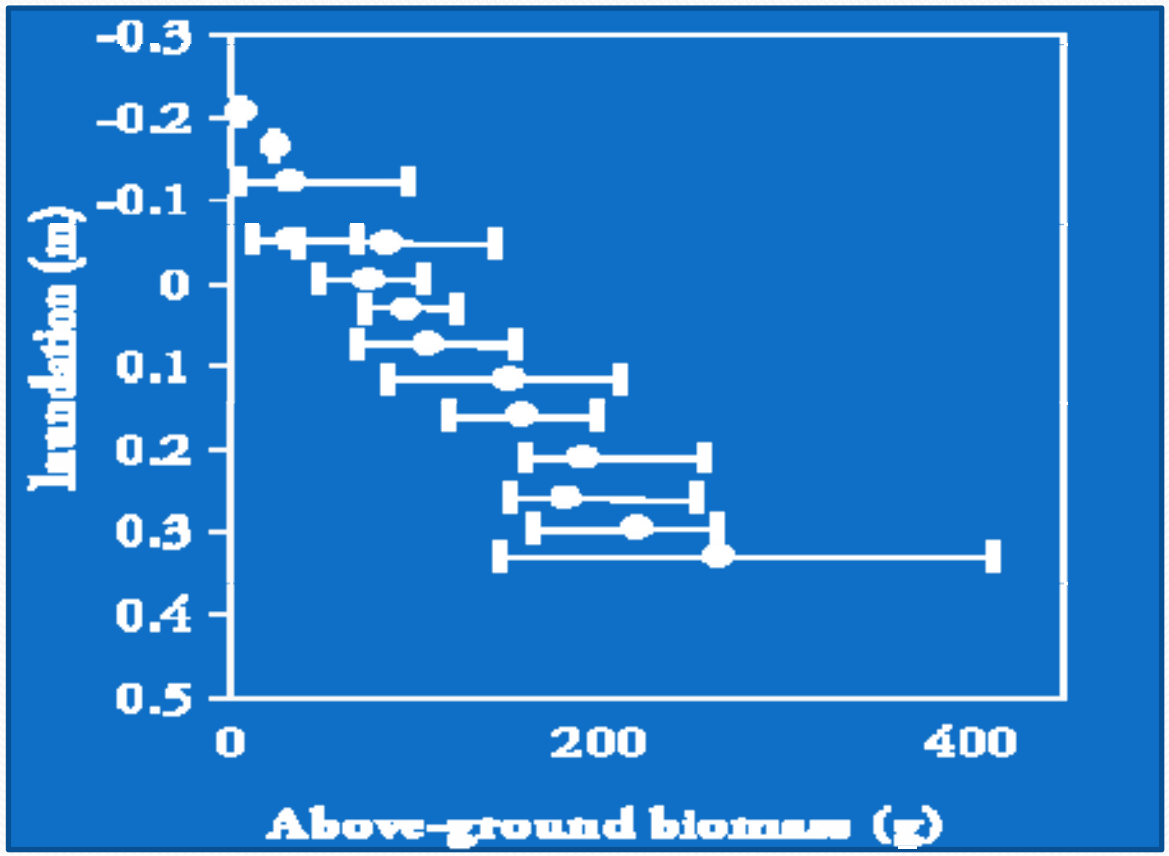


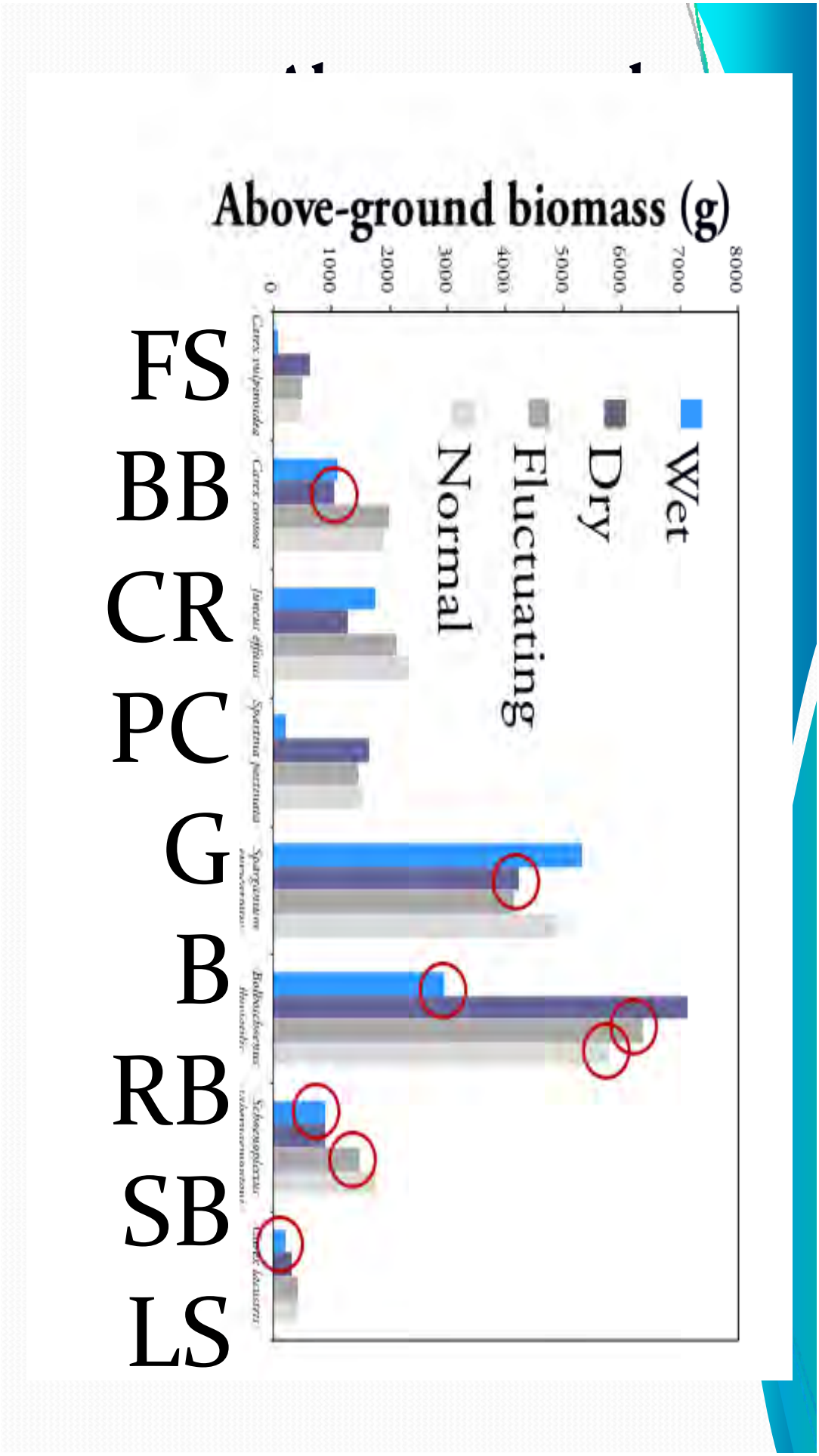






River Bulrush in fluctuating water conditions





FS
BB
CR
PC
G
B
RB
SB
LS

Plant Diversity

Water Regime	Shannon-Weiner Index of Diversity
Wet	3.78
Dry	4.84
Fluctuating	4.69
Normal	4.87

Soil Erosivity

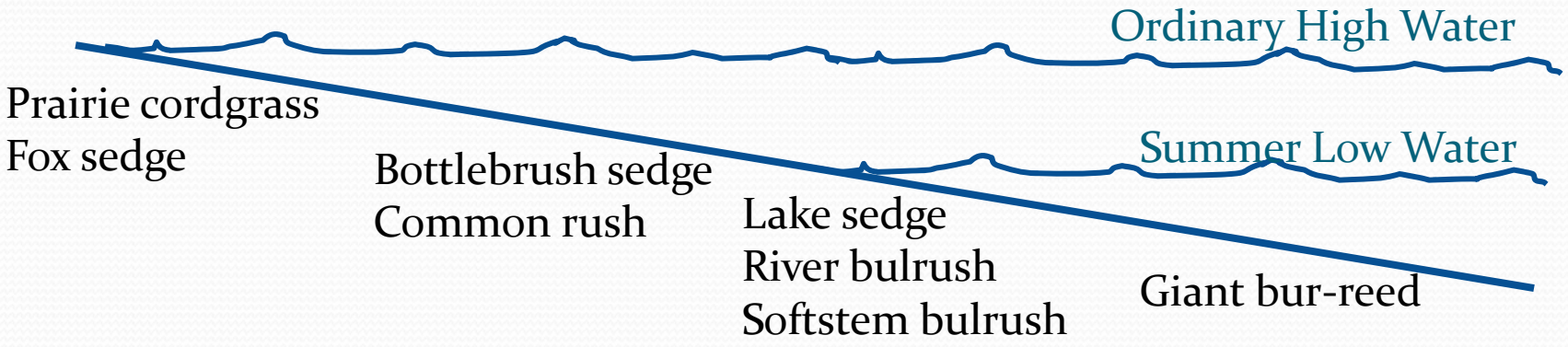
- No statistical difference in erosion potential between basins (ANOVA)
- There is significant difference in erosion potential between vegetated and non-vegetated samples (ANOVA)
- Unable to determine differences in erosion potential of single plant species due to the “jungle” of plants.

Implications for Practice

- Care should be taken when choosing plants in a fluctuating water environment, as it can impact project success.
- Water level fluctuation of 200 mm (8 in.) to 400 mm (16 in.) does not appear to impact these 8 species significantly.
- Long duration of inundation of 400 mm or more appears to limit biomass production of 7 of these species (giant bur-reed increased its biomass).
- Consider rhizomatous plant species for restoration and erosion control in near-shore areas.
- Rhizomatous plant species can dominate a plant community. Good for erosion control, but this could limit biodiversity and be ecologically less stable over time than a diverse plant community.

Implications for Practice (cont.)

Placement of plants along the shoreline:



- NOTE: These same species may behave differently under different conditions (e.g., soil texture and fertility, wave action, temperature, sun exposure, herbivory).

Recommendations for Minnesota

- Common Rush, Prairie Cordgrass and Giant Bur-reed should grow well, except that Giant Bur-Reed will likely dominate
- Fox Sedge, Bottlebrush Sedge and Lake Sedge will not likely grow as well in these communities
- Sites with River Bulrush will do well but may support a monoculture, unless a strong competitor such as Giant Bur-reed is also planted.