Predicting Ecosystem Change in Response to Climate Change Scenarios: Plant Species and Community Responses

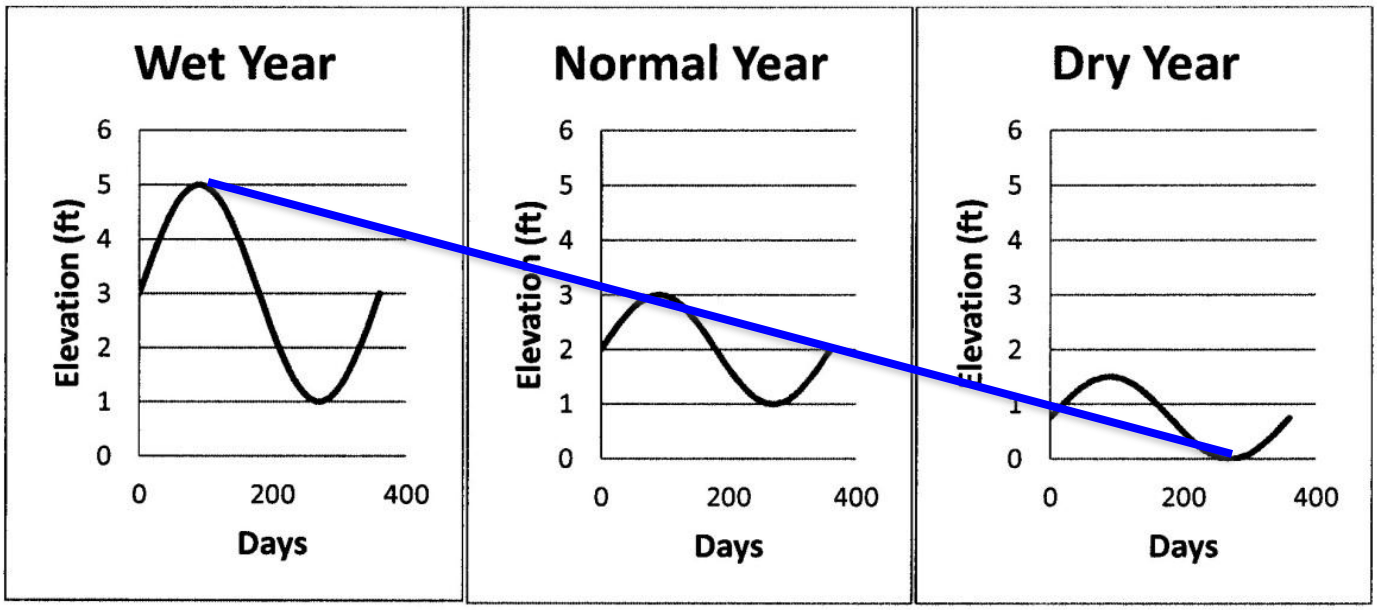
John Volin, Arnold van der Valk, Paul Wetzel

Wetland Hydrology

Annual and interannual hydroperiods (water-level fluctuations) are the main drivers that control the development of landscape features.

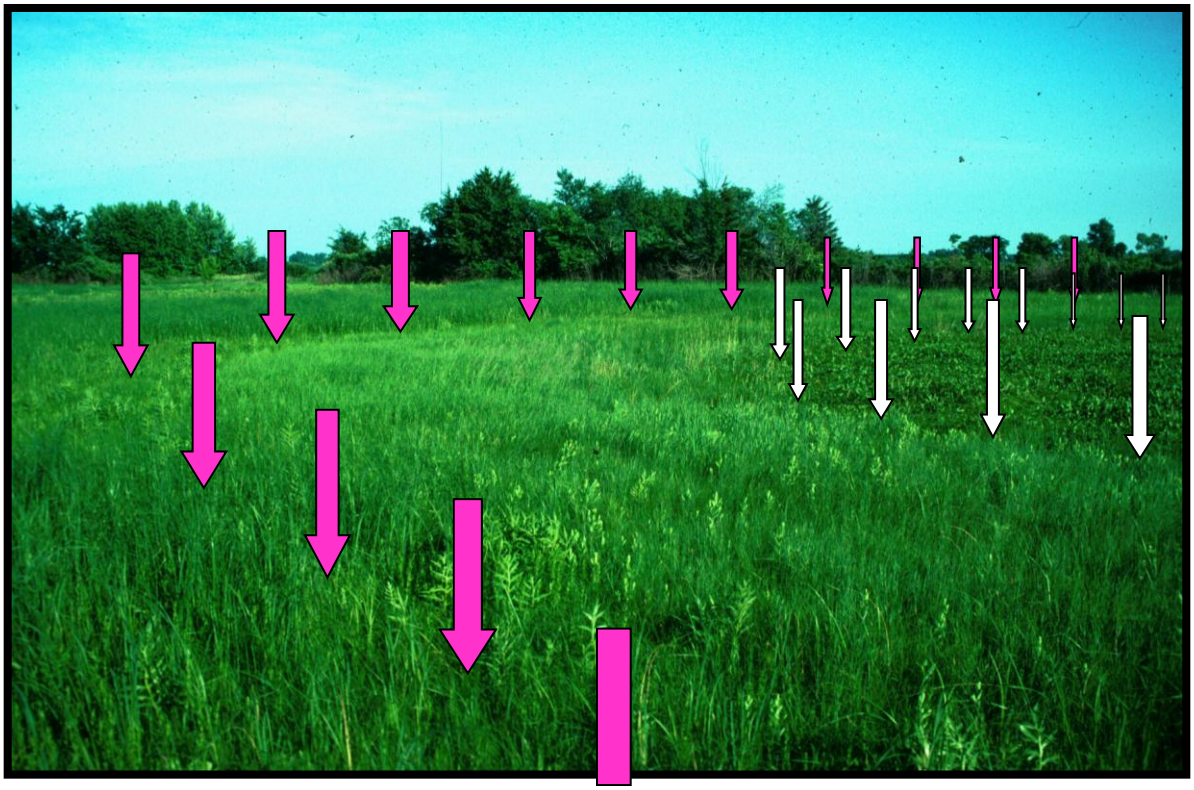
These include the composition of plant and animal communities, and the distribution and abundance of individual plant and animal species.

Hydroperiods can be described using harmonic analysis. Both the primary (annual) and secondary (interannual) harmonics of water-level fluctuations.

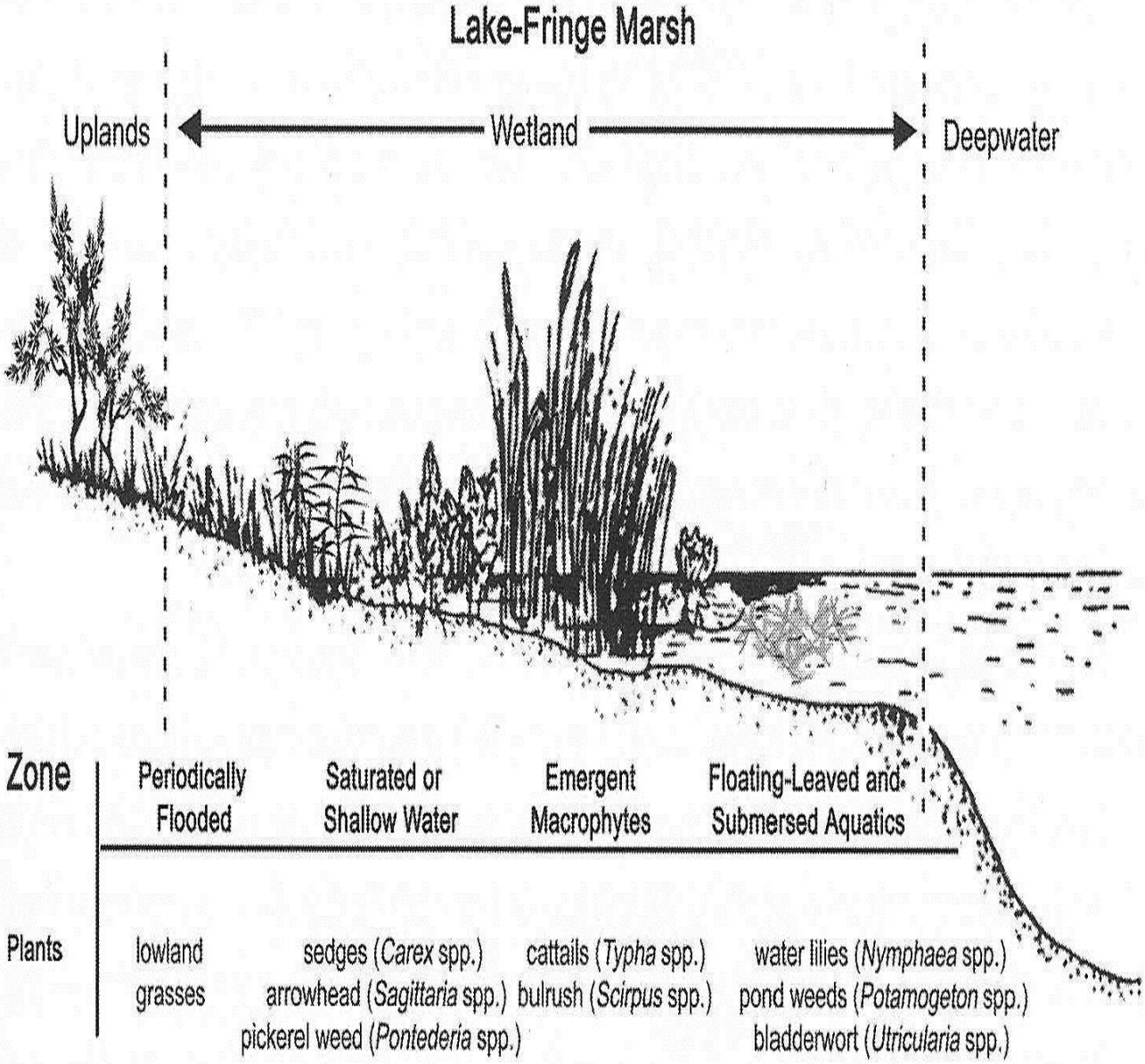


Annual Hydroperiod			
Mean	**3 ft**	**2 ft**	**0.75 ft**
Range	**4 ft**	**2 ft**	**1.5 ft**
Interannual Hydroperiod			
Mean			**2 ft**
Range			**5 ft**

The maximum range in water level over an **interannual** cycle seems to be a good indicator of the number of vegetation zones found in a wetland.



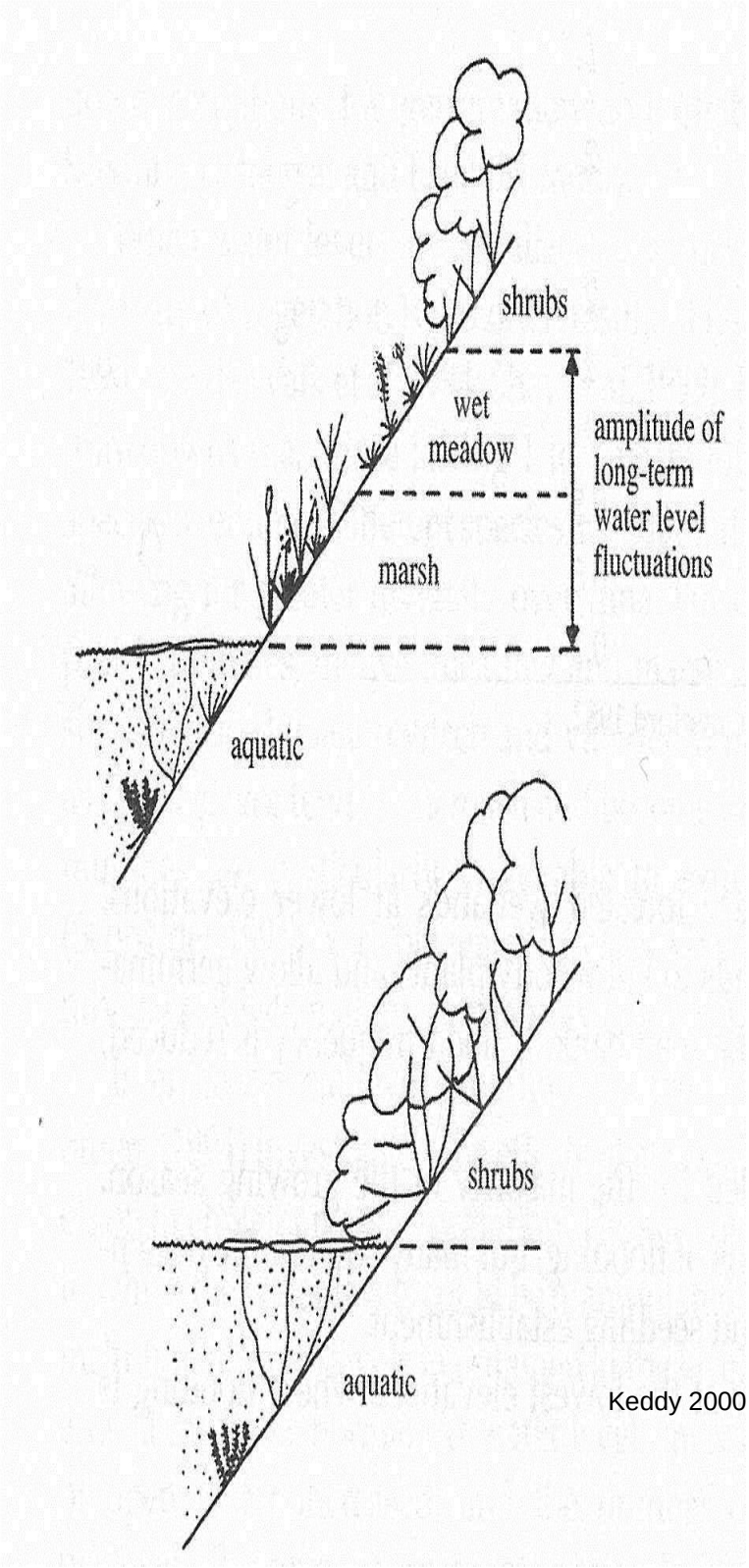
For prairie potholes, if the range is small (<50 cm), only one or two vegetation zones will be found, whereas a hydrologic range of >100 cm will create four or five vegetation zones (Stewart and Kantrud 1971, van der Valk 2005).



Sharitz & Pennings 2006

Hydrology dominates the position and composition of vegetation communities

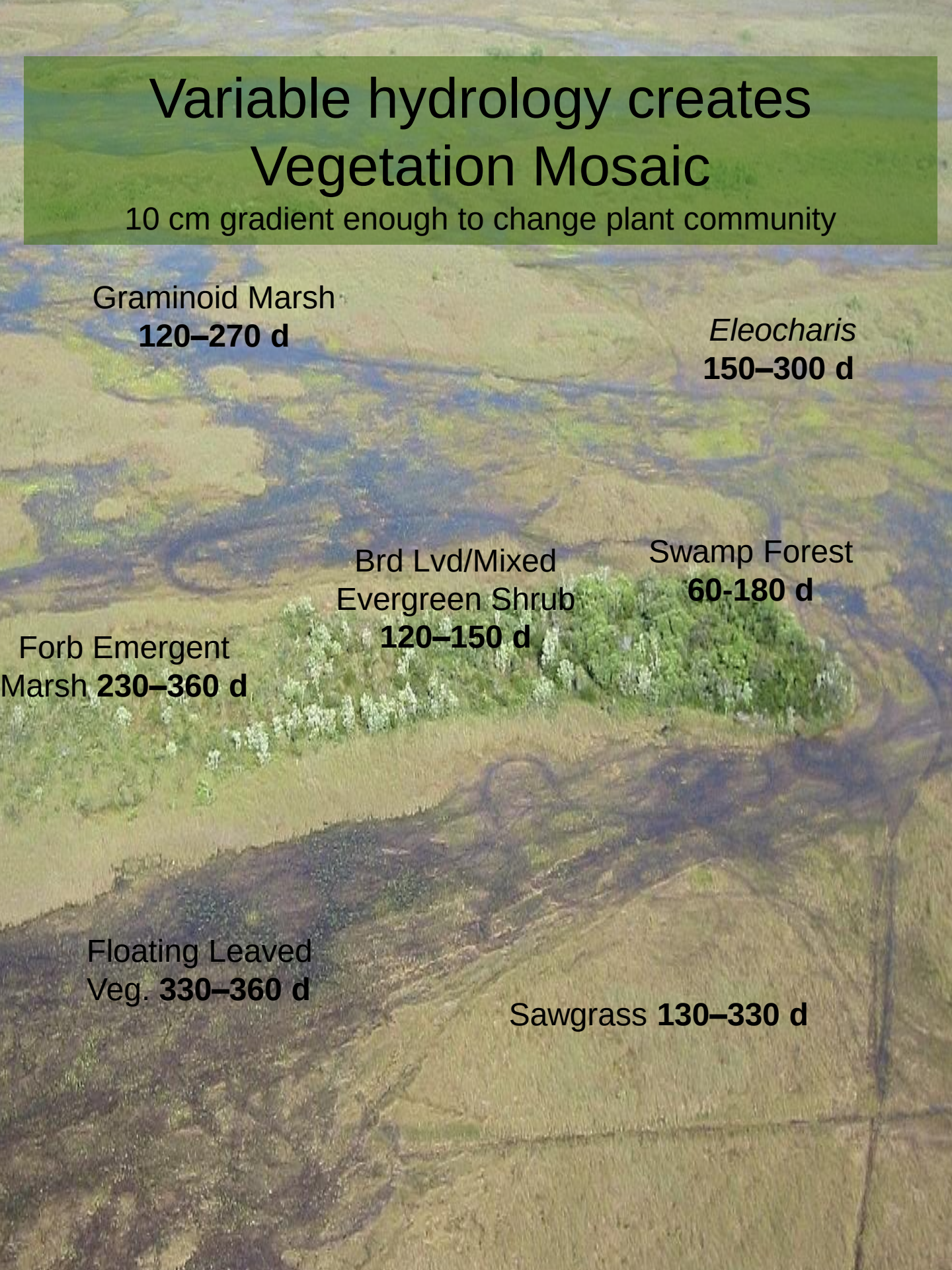
Stabilizing water levels compresses vegetation zonation



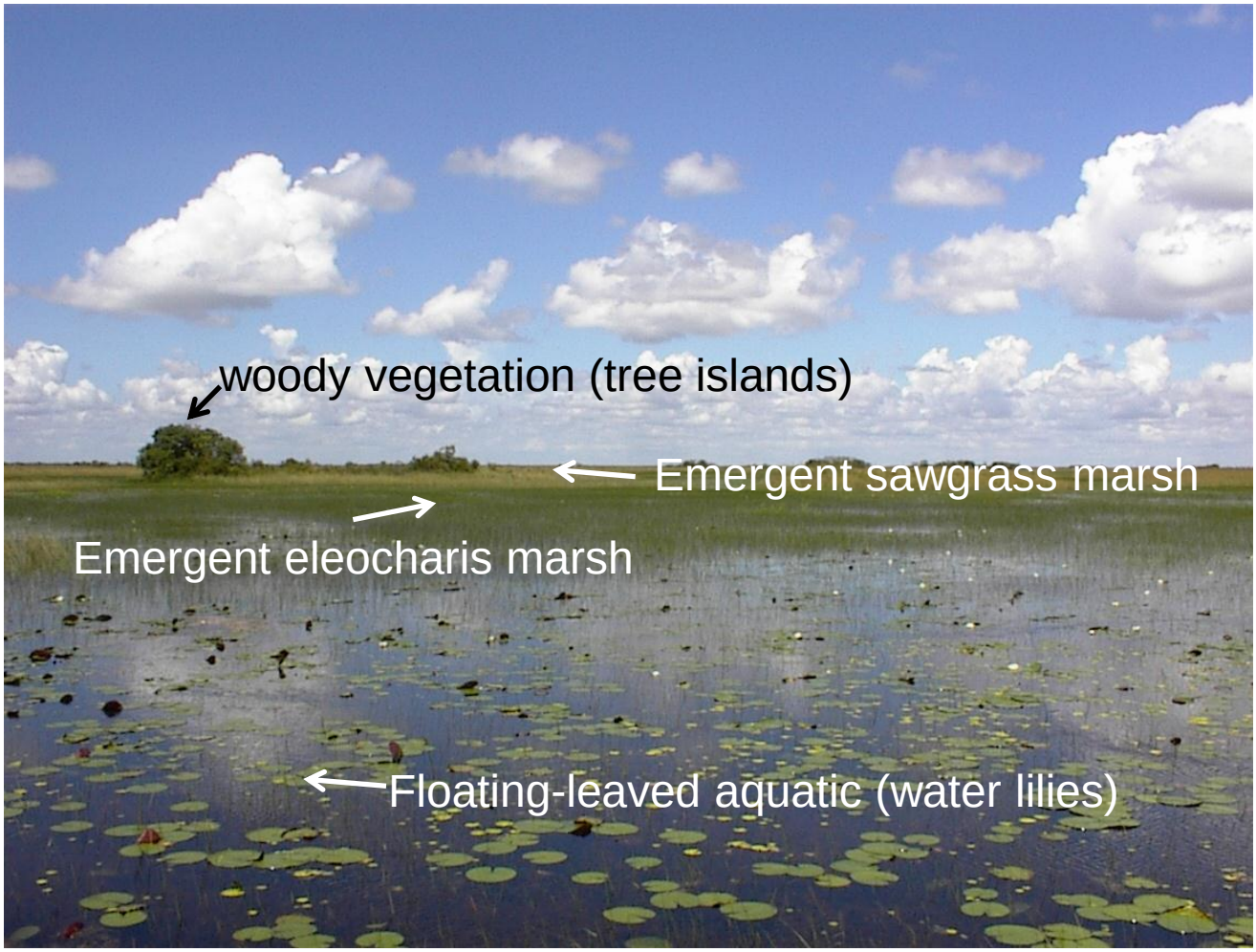
Keddy 2000

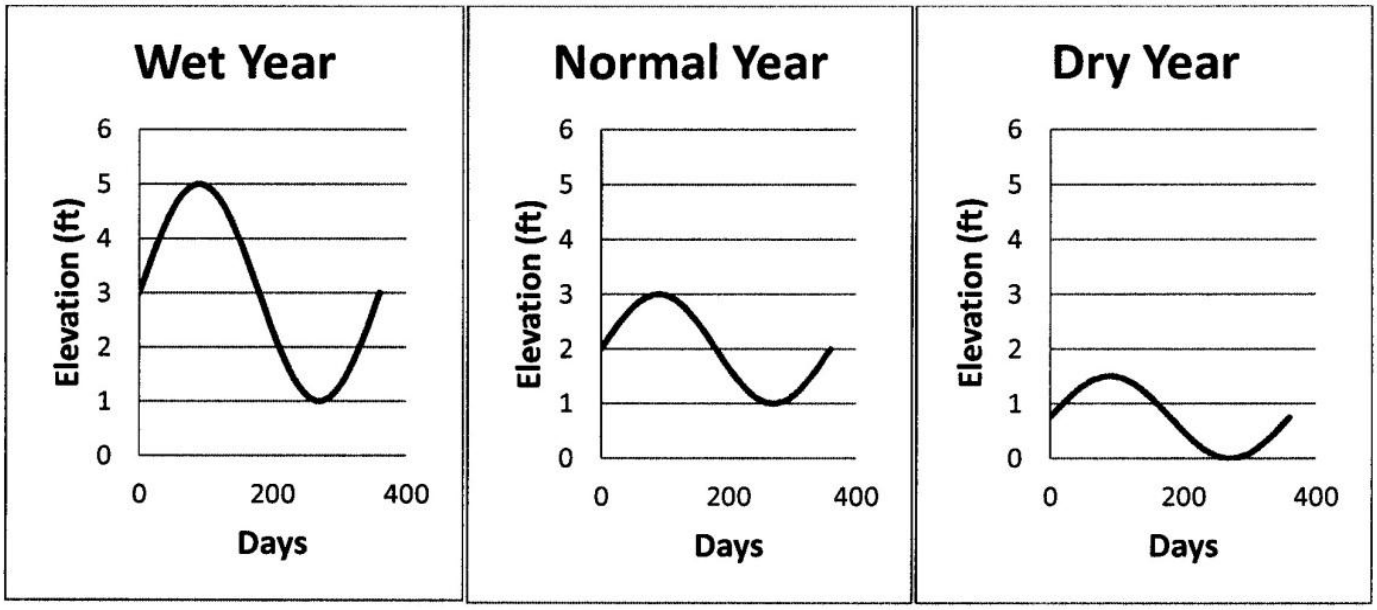
Variable hydrology creates Vegetation Mosaic

10 cm gradient enough to change plant community



Estimates of the interannual range (second harmonic) in the in ridge and slough landscapes of the Everglades is from data in McVoy et al (2011; Table 11.1, Figure 11.4, and Table A.3).





Annual Hydroperiod			
Mean	**3 ft**	**2 ft**	**0.75 ft**
Range	**4 ft**	**2 ft**	**1.5 ft**
Interannual Hydroperiod			
Mean			**2 ft**
Range			**5 ft**

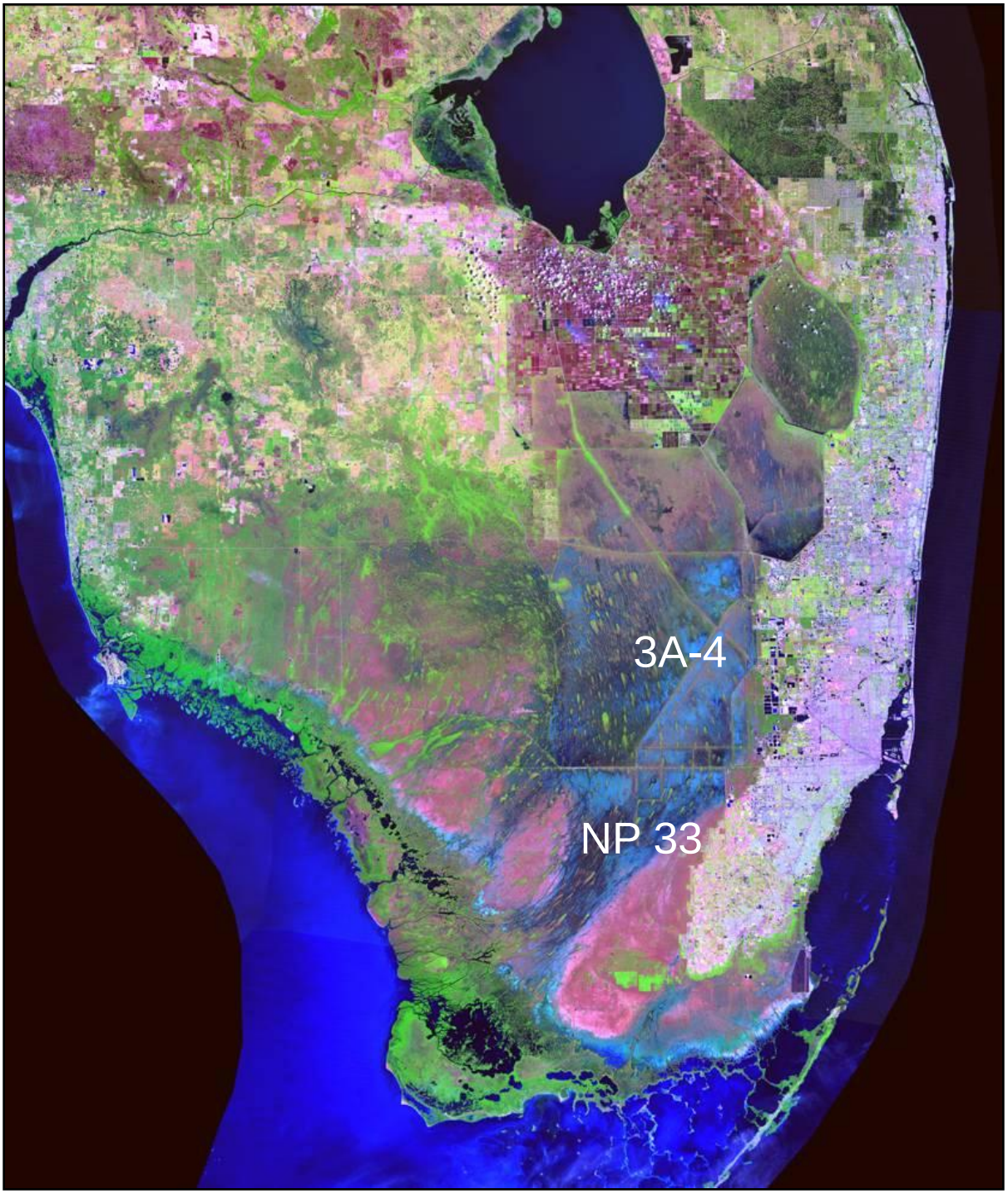
Idealized predrainage annual hydroperiods over a wet-dry cycle in the Everglades in wet, normal, and dry years.

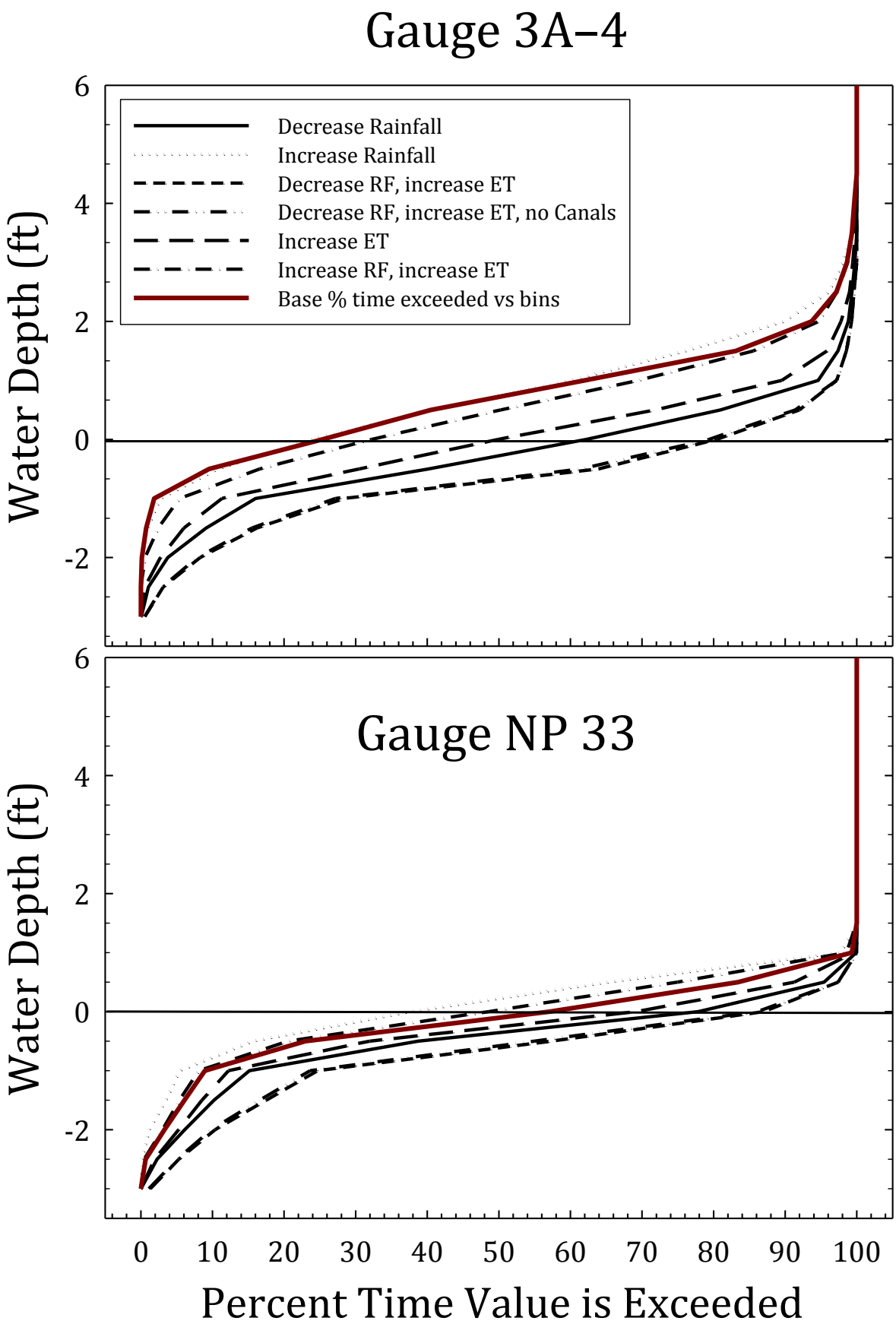
Probable responses of plant assemblages that likely characterized the pre-drainage Everglades over a wet-dry cycle.

Species Assemblage	Wet Year	Normal Year	Dry Year
Flood intolerant tree species	Negative	Neutral	Positive[a]
Flood tolerant tree species	Neutral	Neutral	Positive[a]
Sawgrass	Negative	Neutral	Positive[a]
Slough Species	Positive	Neutral	Negative[b]
Wet prairie species	Positive	Neutral	Negative[b]

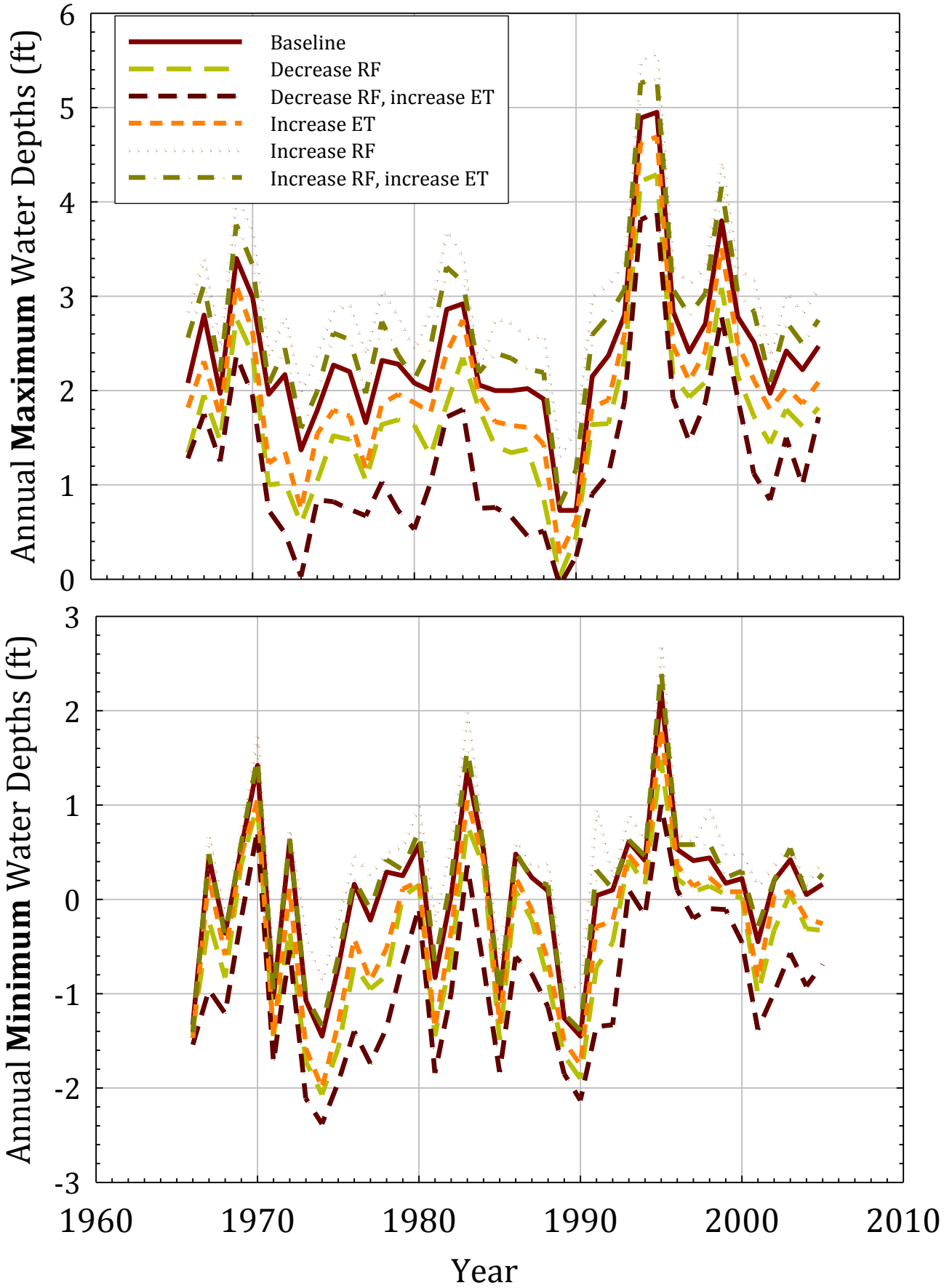
[a] Negative with respect to increased fire damage.
[b] Positive with respect to recruitment.

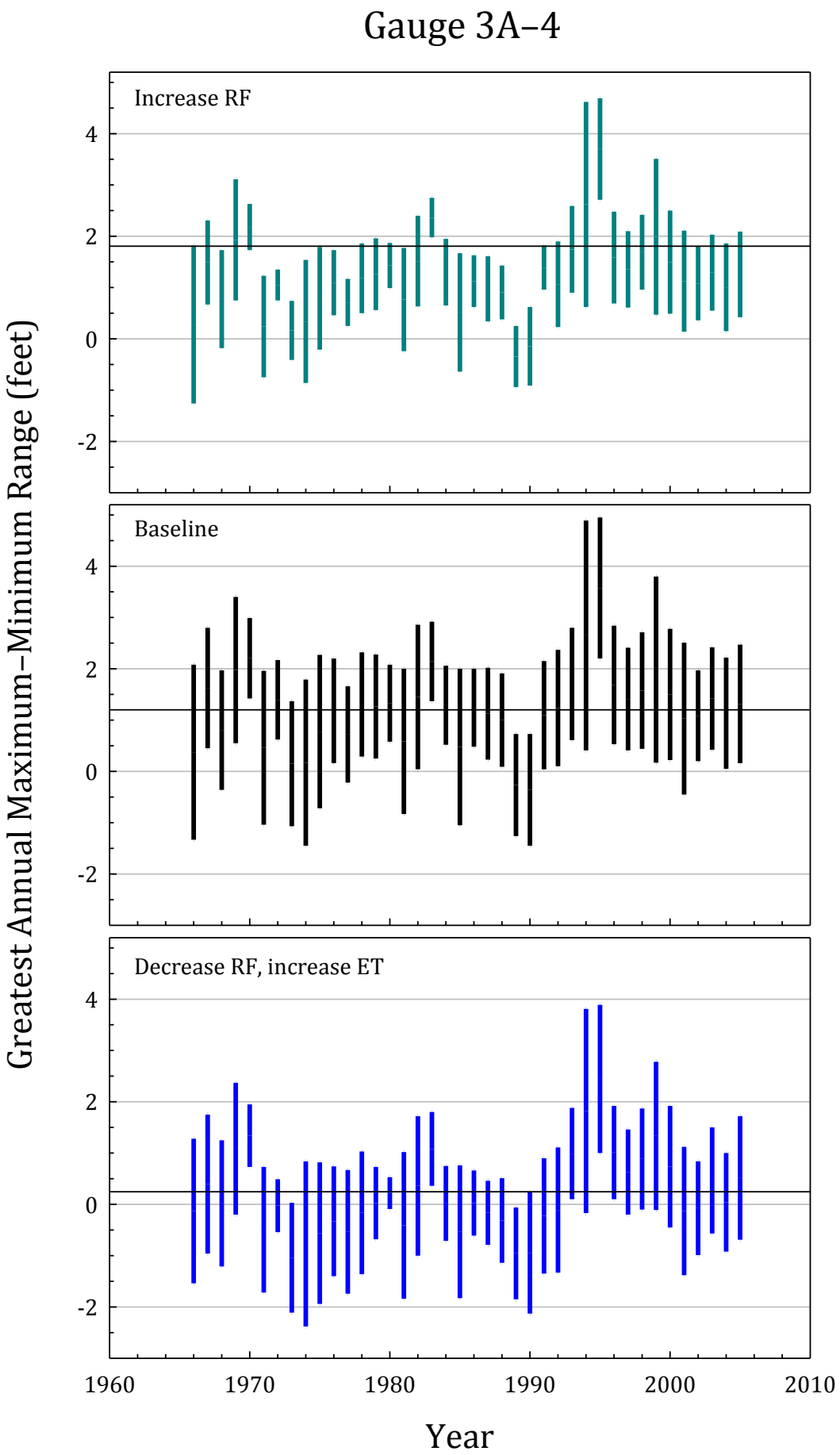
Climate Change Scenarios



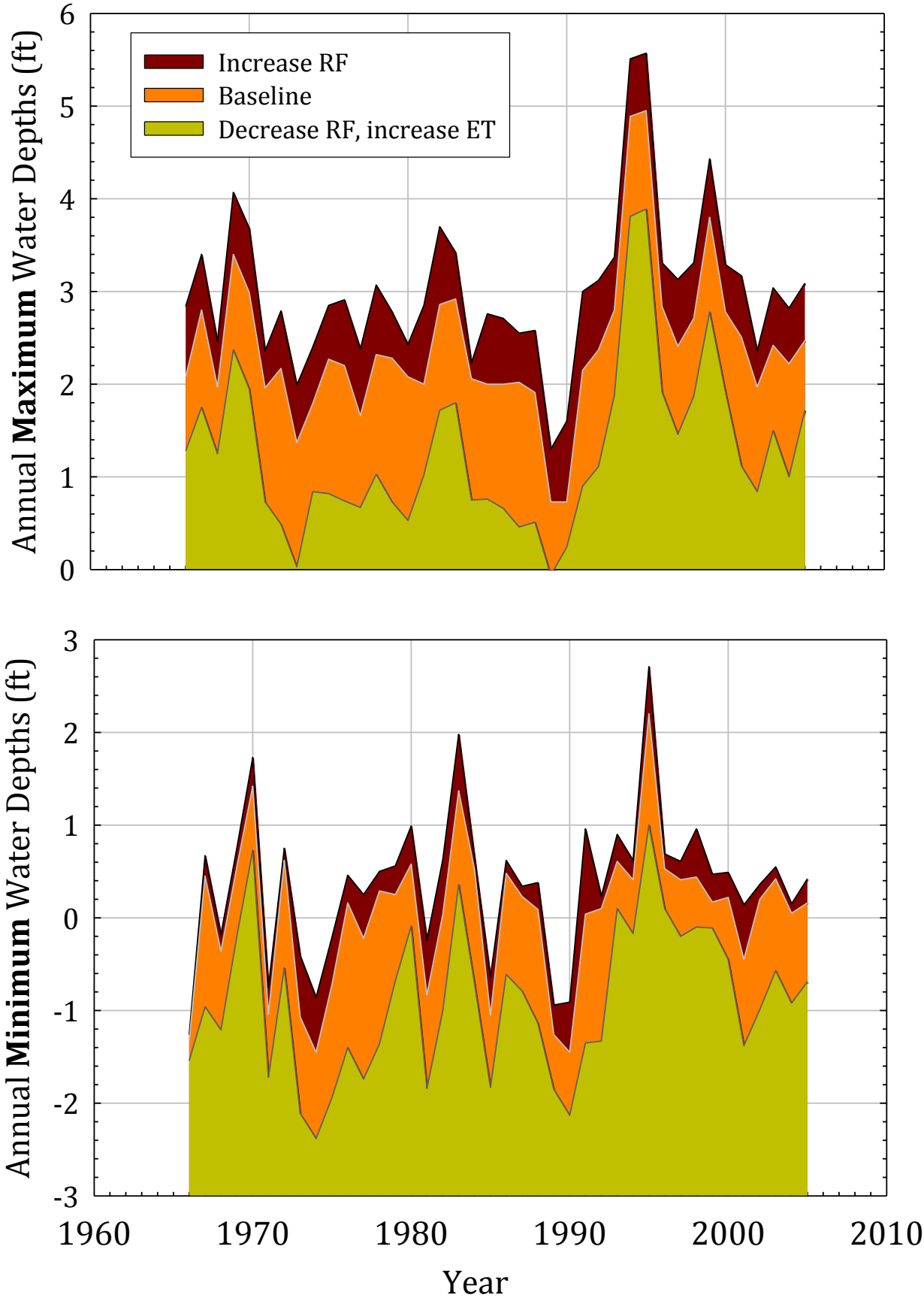

Gauge 3A–4
Decrease Rainfall
Increase Rainfall
Decrease RF, increase ET
Decrease RF, increase ET, no Canals
Increase ET
Increase RF, increase ET
Base % time exceeded vs bins
Water Depth (ft)
6
4
2
0
-2
Gauge NP 33
Water Depth (ft)
6
4
2
0
-2
0
10
20
30
40
50
60
70
80
90
100
Percent Time Value is Exceeded

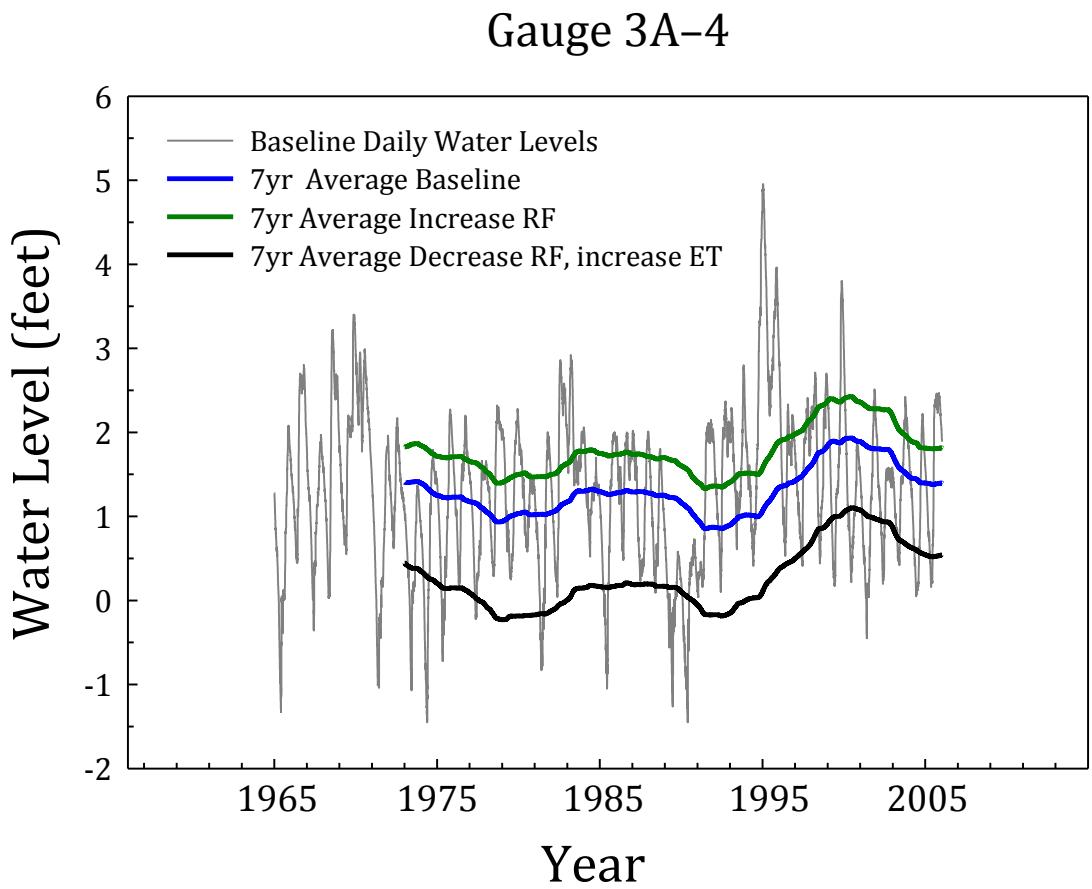
Gauge 3A–4

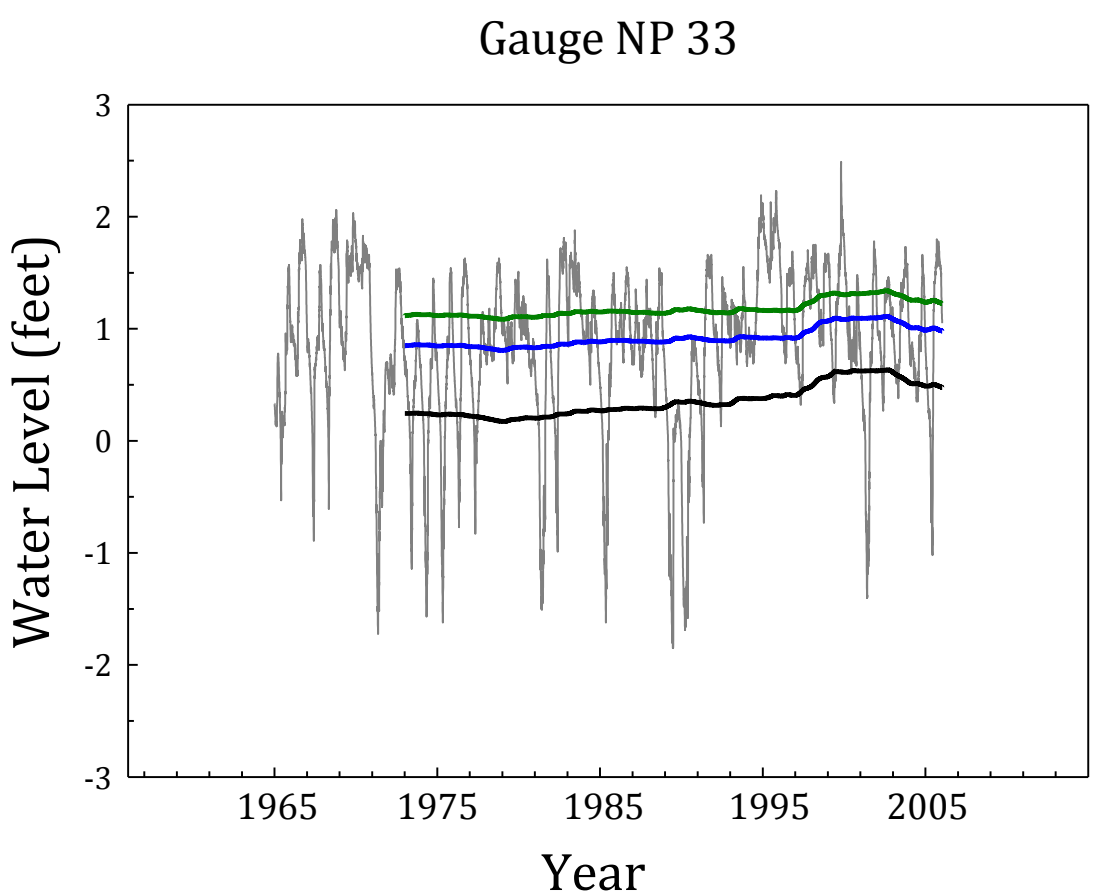

Baseline
Decrease RF
Decrease RF, increase ET
Increase ET
Increase RF
Increase RF, increase ET
Annual **Maximum** Water Depths (ft)
Annual **Minimum** Water Depths (ft)
Year
0
1
2
3
4
5
6
-3
-2
-1
0
1
2
3
1960
1970
1980
1990
2000
2010


Gauge 3A–4
Increase RF
Baseline
Decrease RF, increase ET
Greatest Annual Maximum–Minimum Range (feet)
4
2
0
-2
1960
1970
1980
1990
2000
2010
Year

Gauge 3A–4

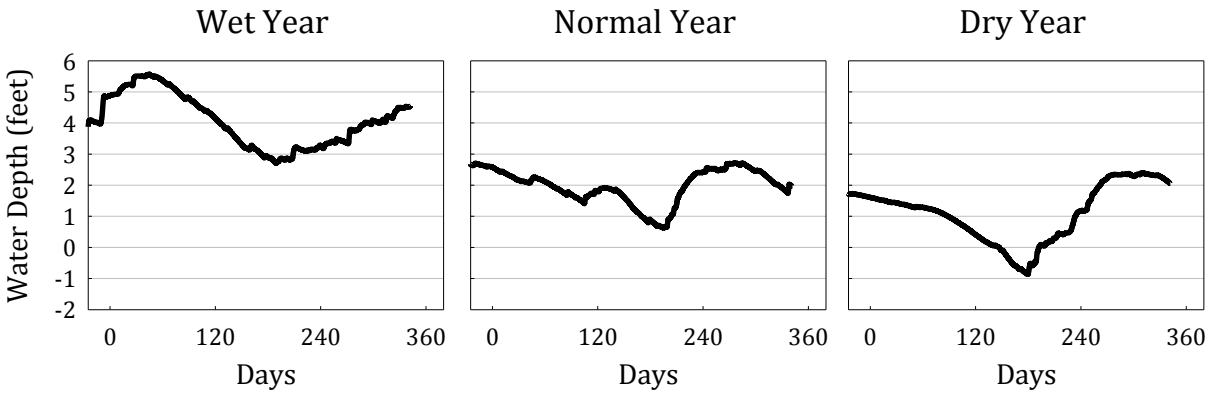

Increase RF
Baseline
Decrease RF, increase ET
Annual Maximum Water Depths (ft)
0
1
2
3
4
5
6
Annual Minimum Water Depths (ft)
-3
-2
-1
0
1
2
3
1960
1970
1980
1990
2000
2010
Year


Gauge 3A–4
Baseline Daily Water Levels
7yr Average Baseline
7yr Average Increase RF
7yr Average Decrease RF, increase ET
Water Level (feet)
6
5
4
3
2
1
0
-1
-2
1965
1975
1985
1995
2005
Year


Gauge NP 33
Water Level (feet)
3
2
1
0
-1
-2
-3
1965
1975
1985
1995
2005
Year

Gauge 3A–4

Increase RF



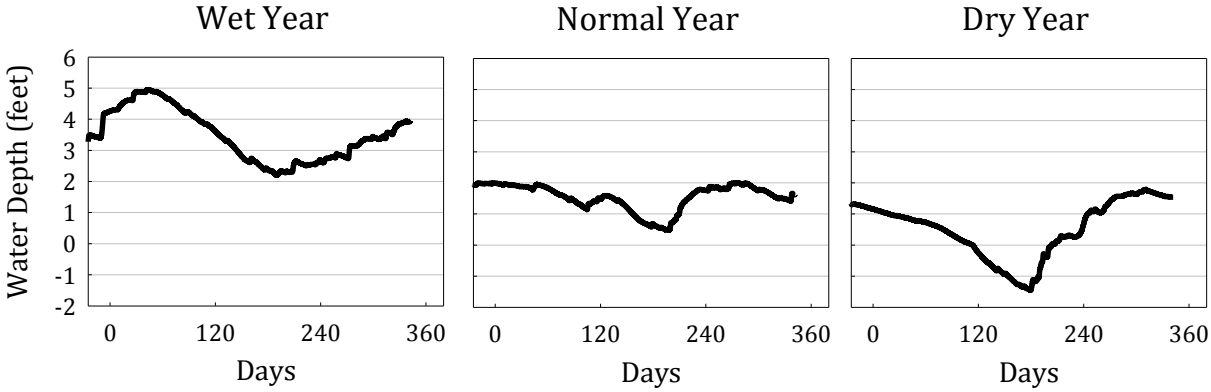
Annual Hydroperiod

Mean	4.2 ft	1.7 ft	–0.5 ft
Range	2.8 ft	2.2 ft	2.9 ft

Interannual Hydroperiod

Mean	**2.3 ft**
Range	**6.5 ft**

Baseline



Annual Hydroperiod

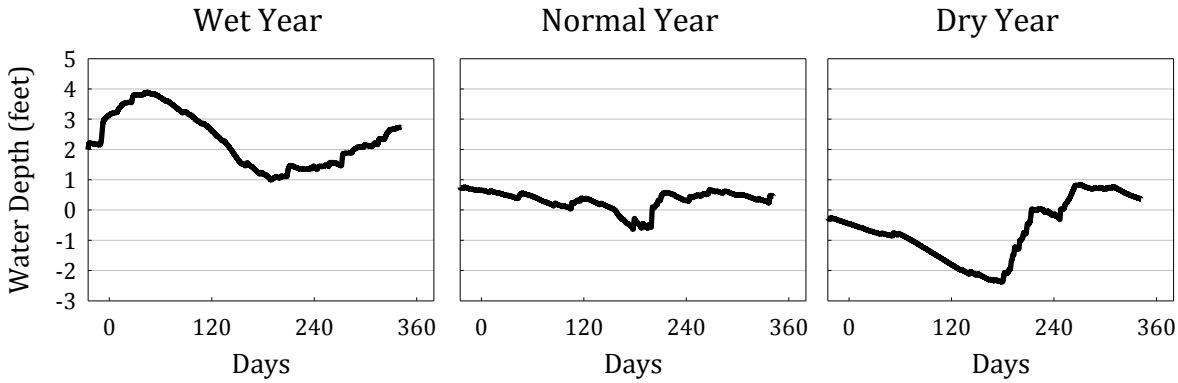
Mean	3.5 ft	1.3 ft	0.0 ft
Range	3 ft	1.5 ft	3.0 ft

Interannual Hydroperiod

Mean	1**.8 ft**
Range	**6.5 ft**

Gauge 3A–4

Decrease RF, increase ET



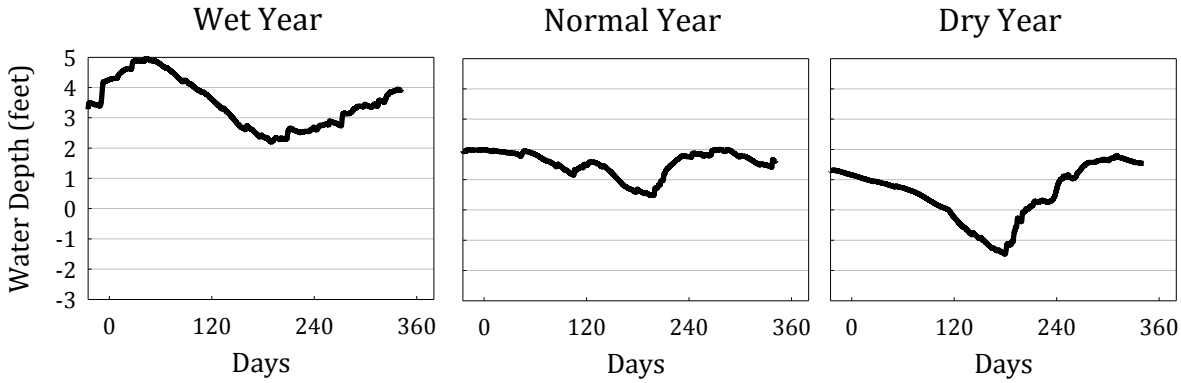
Annual Hydroperiod

Mean	2.5 ft	0.1 ft	–1.3 ft
Range	3 ft	1.4 ft	2.6 ft

Interannual Hydroperiod

Mean	**0.8 ft**
Range	**6.4 ft**

Baseline



Annual Hydroperiod

Mean	3.5 ft	1.3 ft	0.0 ft
Range	3 ft	1.5 ft	3.0 ft

Interannual Hydroperiod

Mean	**1.8 ft**
Range	**6.5 ft**

Summary

(1) All of the climate change scenarios will result in little change in the range of water levels over interannual cycles.

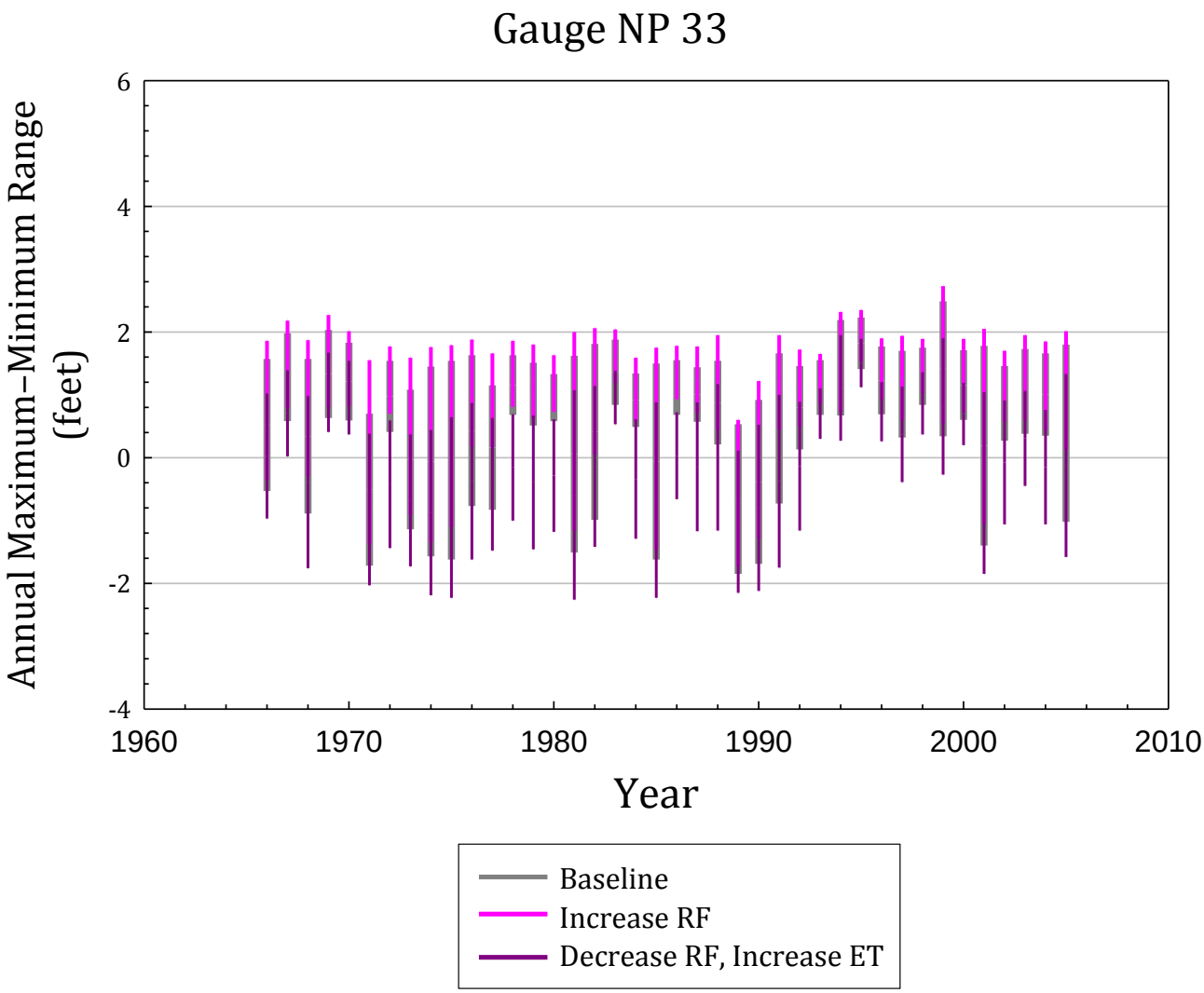
(2) This suggests that climate change driven changes in hydrology will not alter the number of vegetation zones in the Everglades. climate change per se will have little impact on the distribution and composition of vegetation types in the Everglades.

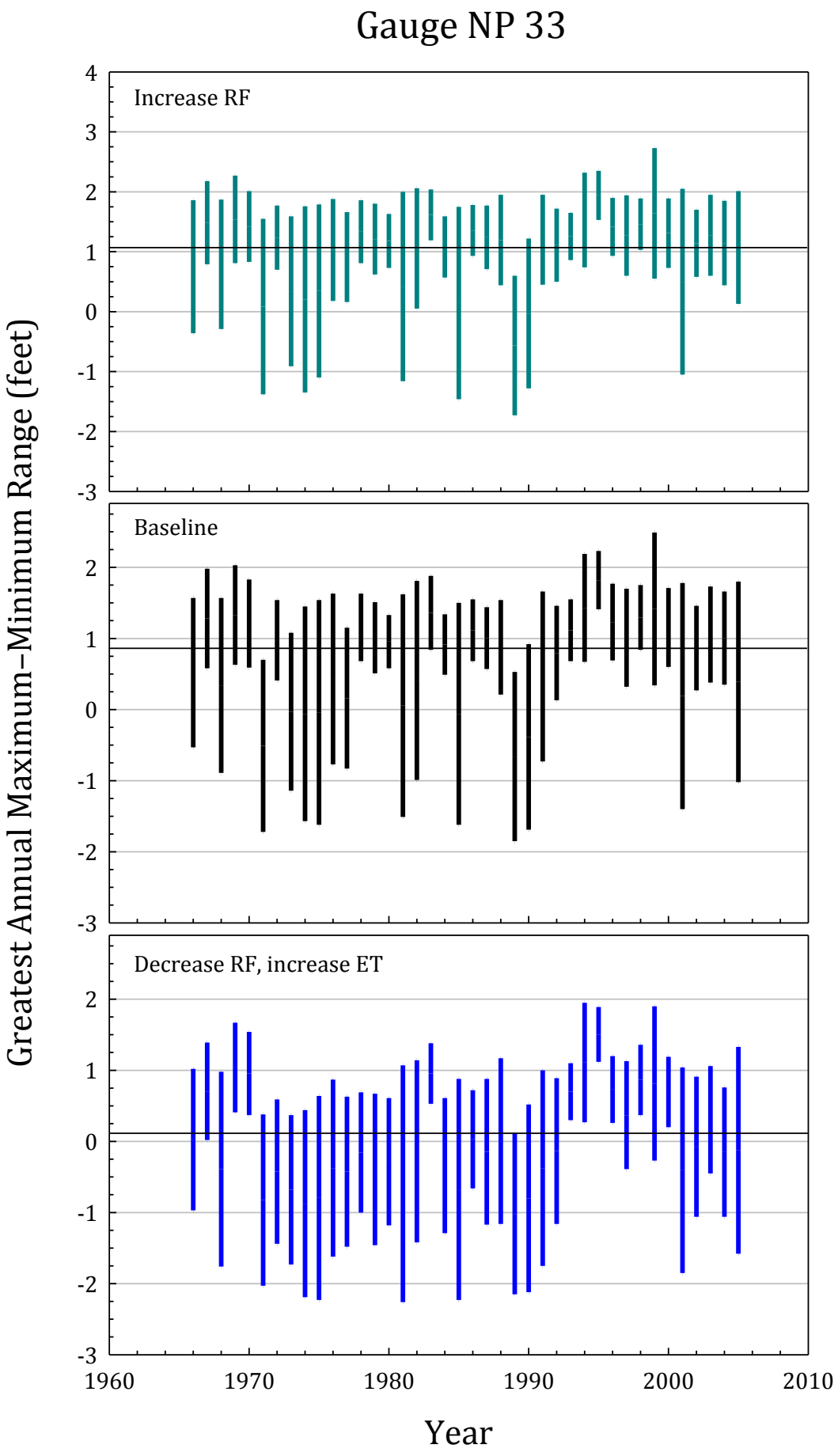
(3) The length of interannual cycles may shift, mostly to longer dry phases in some scenarios. Other ecosystem features such as fire frequency could be affected.

(4) The Everglades are currently declining because of a compression in the range of water-level fluctuations over a wet-dry cycle. Climate change will not reverse the compression, but it may be exacerbated by a decline in rainfall and increase in ET.

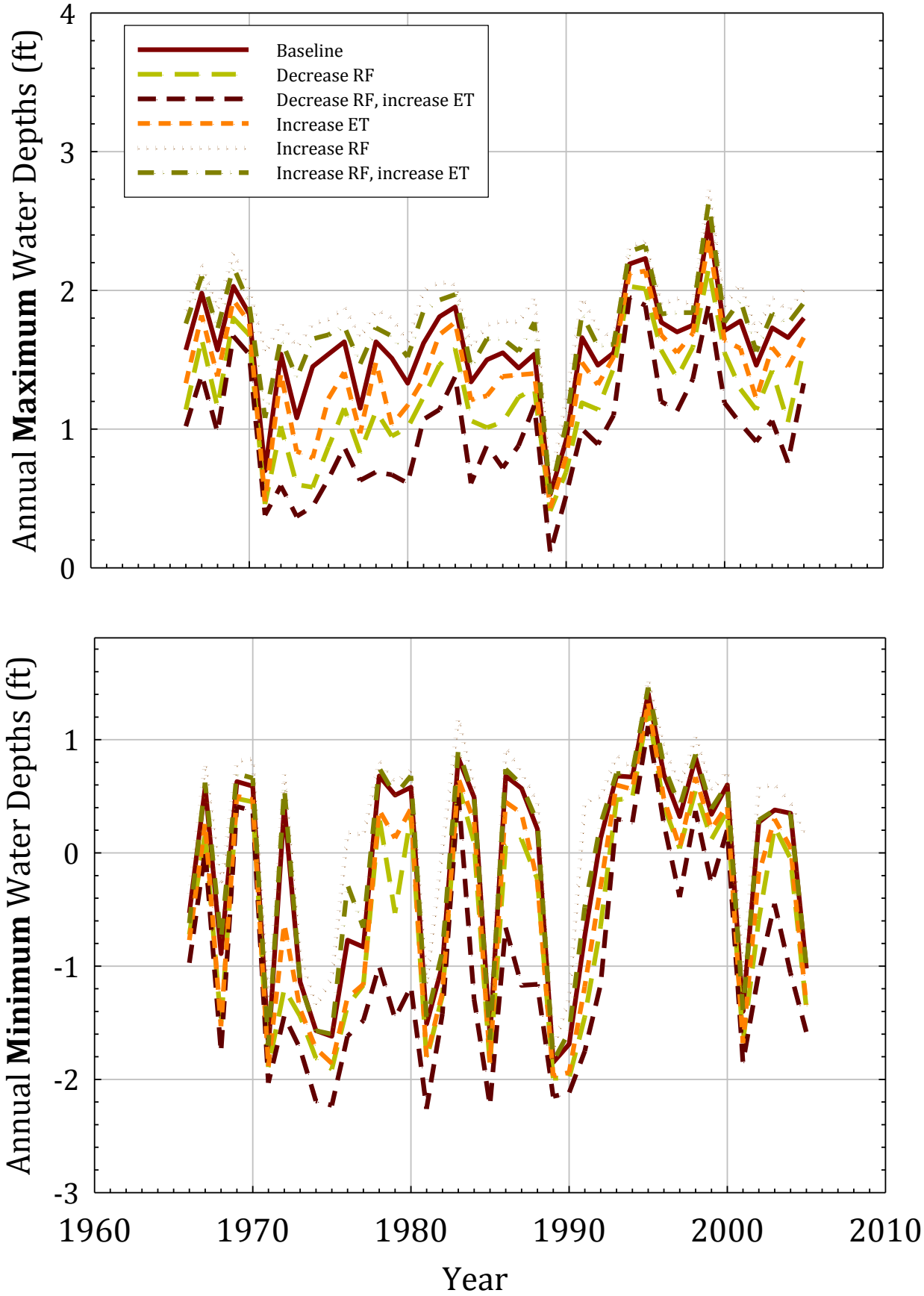
(5) The scenarios of increases and decreases in rainfall seem unrealistic. Increases in rainfall are more likely to occur in the wet season.

Questions?

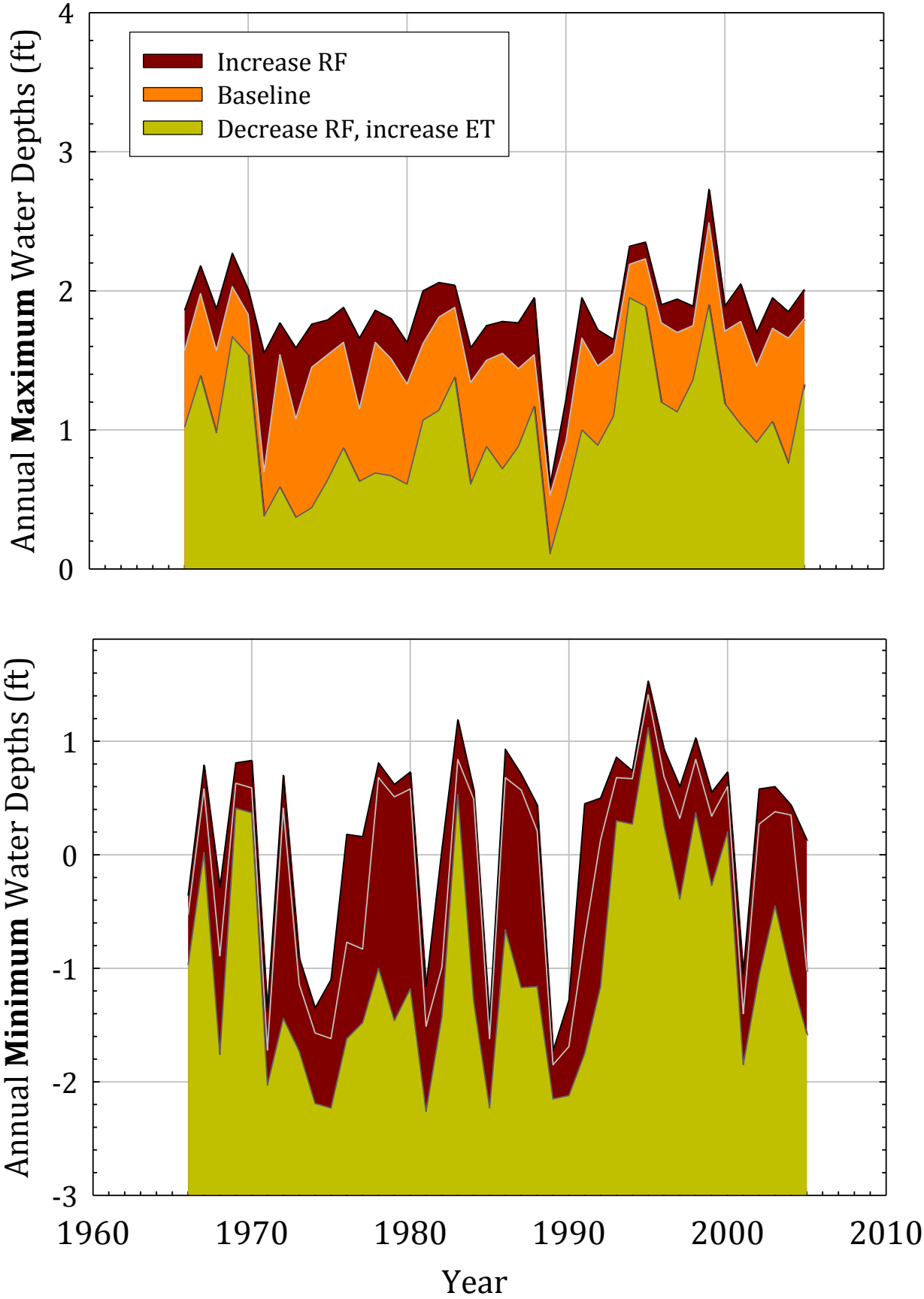

Gauge NP 33
Annual Maximum–Minimum Range (feet)
6
4
2
0
-2
-4
1960
1970
1980
1990
2000
2010
Year
Baseline
Increase RF
Decrease RF, Increase ET


Gauge NP 33
Increase RF
Baseline
Decrease RF, increase ET
Greatest Annual Maximum–Minimum Range (feet)
Year
4
3
2
1
0
-1
-2
-3
1960
1970
1980
1990
2000
2010

Gauge NP 33

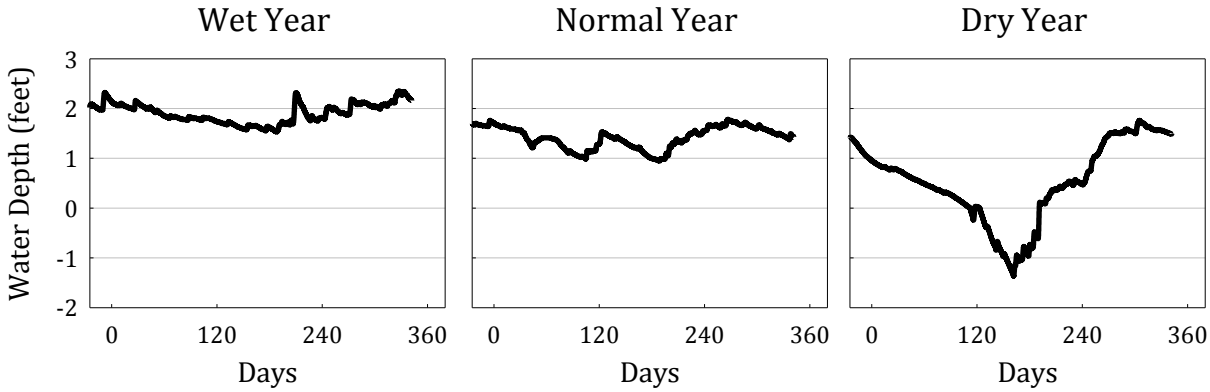

Baseline
Decrease RF
Decrease RF, increase ET
Increase ET
Increase RF
Increase RF, increase ET
Annual **Maximum** Water Depths (ft)
4
3
2
1
0
Annual **Minimum** Water Depths (ft)
1
0
-1
-2
-3
1960
1970
1980
1990
2000
2010
Year

Gauge NP 33


Increase RF
Baseline
Decrease RF, increase ET
Annual **Maximum** Water Depths (ft)
4
3
2
1
0
Annual **Minimum** Water Depths (ft)
1
0
-1
-2
-3
1960
1970
1980
1990
2000
2010
Year

Gauge NP 33

Increase RF



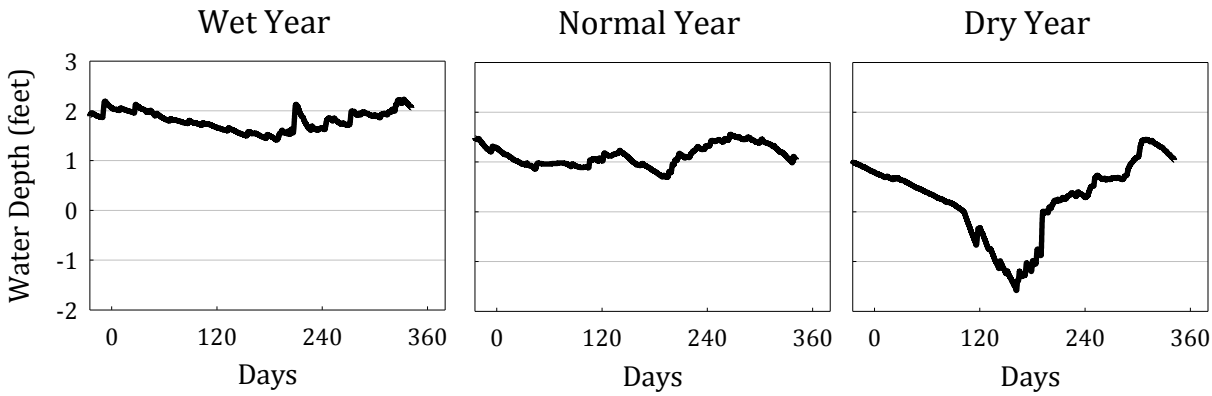
Annual Hydroperiod

Mean	2.0 ft	1.4 ft	0.0 ft
Range	0.7 ft	0.7 ft	3.0 ft

Interannual Hydroperiod

Mean	**0.4 ft**
Range	**3.8 ft**

Baseline



Annual Hydroperiod

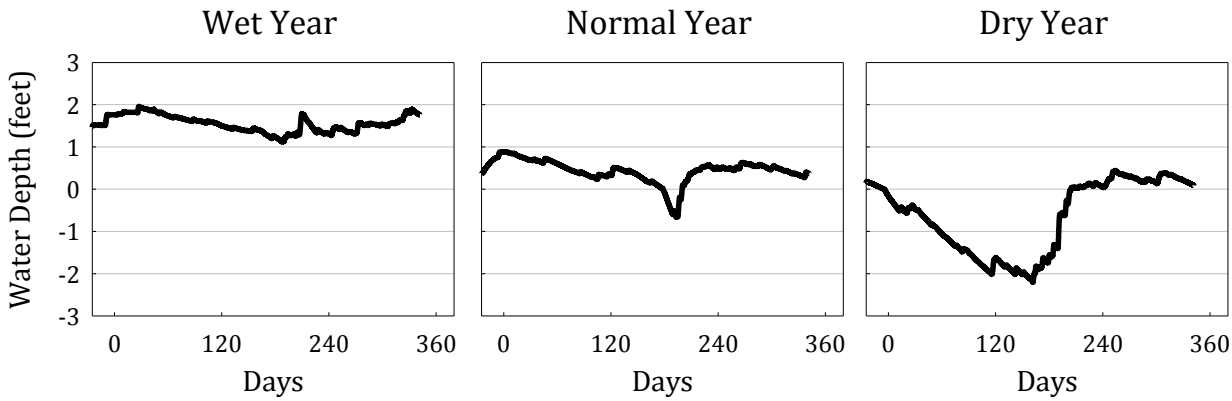
Mean	1.9 ft	1.1 ft	–0.3 ft
Range	0.7 ft	0.8 ft	2.5 ft

Interannual Hydroperiod

Mean	**0.7 ft**
Range	**3.7 ft**

Gauge NP 33

Decrease RF, increase ET



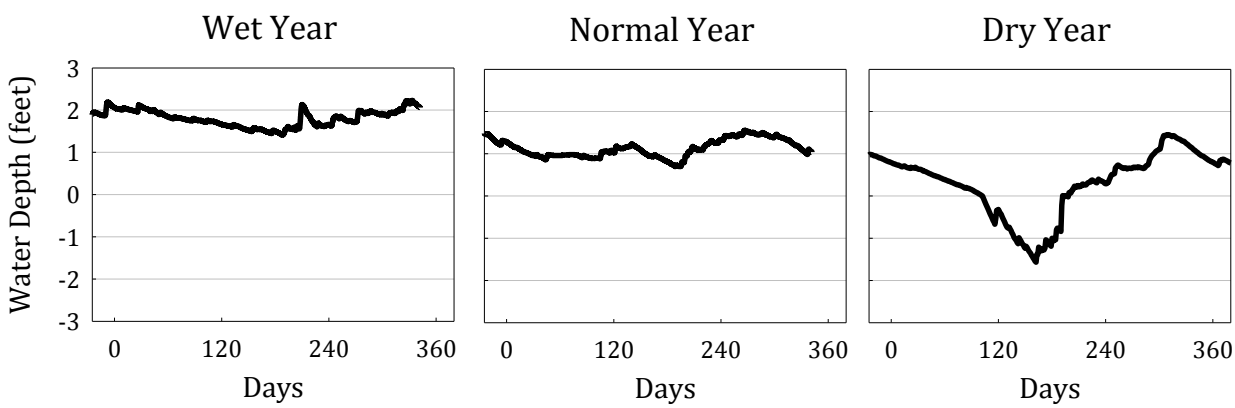
Annual Hydroperiod

Mean	1.5 ft	0.1 ft	–1.0 ft
Range	1 ft	1.8 ft	2.2 ft

Interannual Hydroperiod

Mean	**0.0 ft**
Range	**4.1 ft**

Baseline

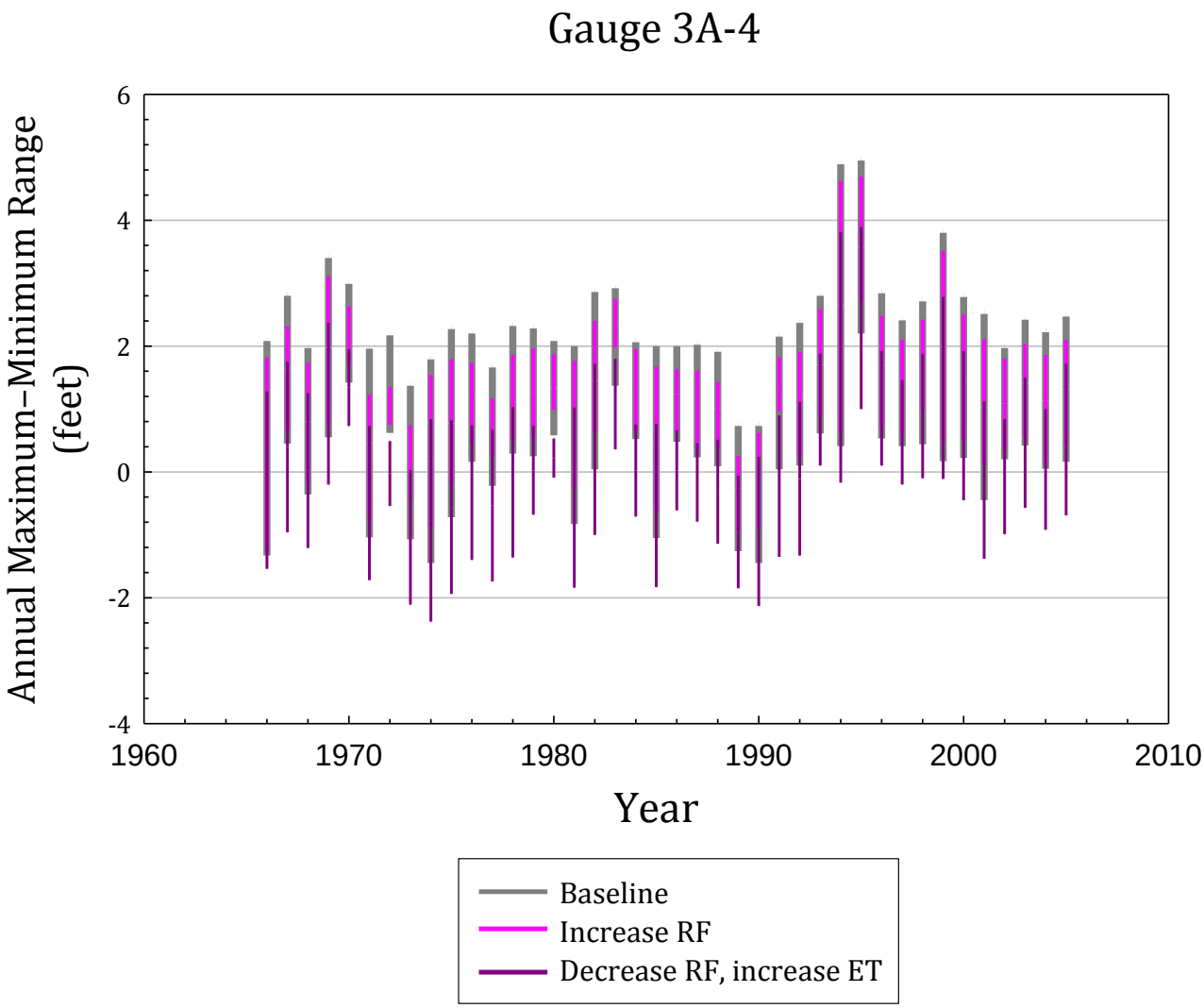


Annual Hydroperiod

Mean	1.9 ft	1.1 ft	–0.3 ft
Range	0.7 ft	0.8 ft	2.5 ft

Interannual Hydroperiod

Mean	**0.7 ft**
Range	**3.7 ft**


Gauge 3A-4
Annual Maximum–Minimum Range (feet)
6
4
2
0
-2
-4
1960
1970
1980
1990
2000
2010
Year
Baseline
Increase RF
Decrease RF, increase ET