Shifting Ground: Landscape-Scale Modeling Of Soil Biogeochemistry under Climate Change in the Florida

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UF Water Institute Symposium 2/25/2020

To plan restoration in the face of climate change:

Vulnerabilities and Resilience
Risks and Benefits

Northern Everglades
Biogeochemical Processes

Today's Talk
Three Climate Scenarios
Everglades Landscape Model
Soil Phosphorus
Methylmercury Production
Muck Fire Risk
Implications for Restoration

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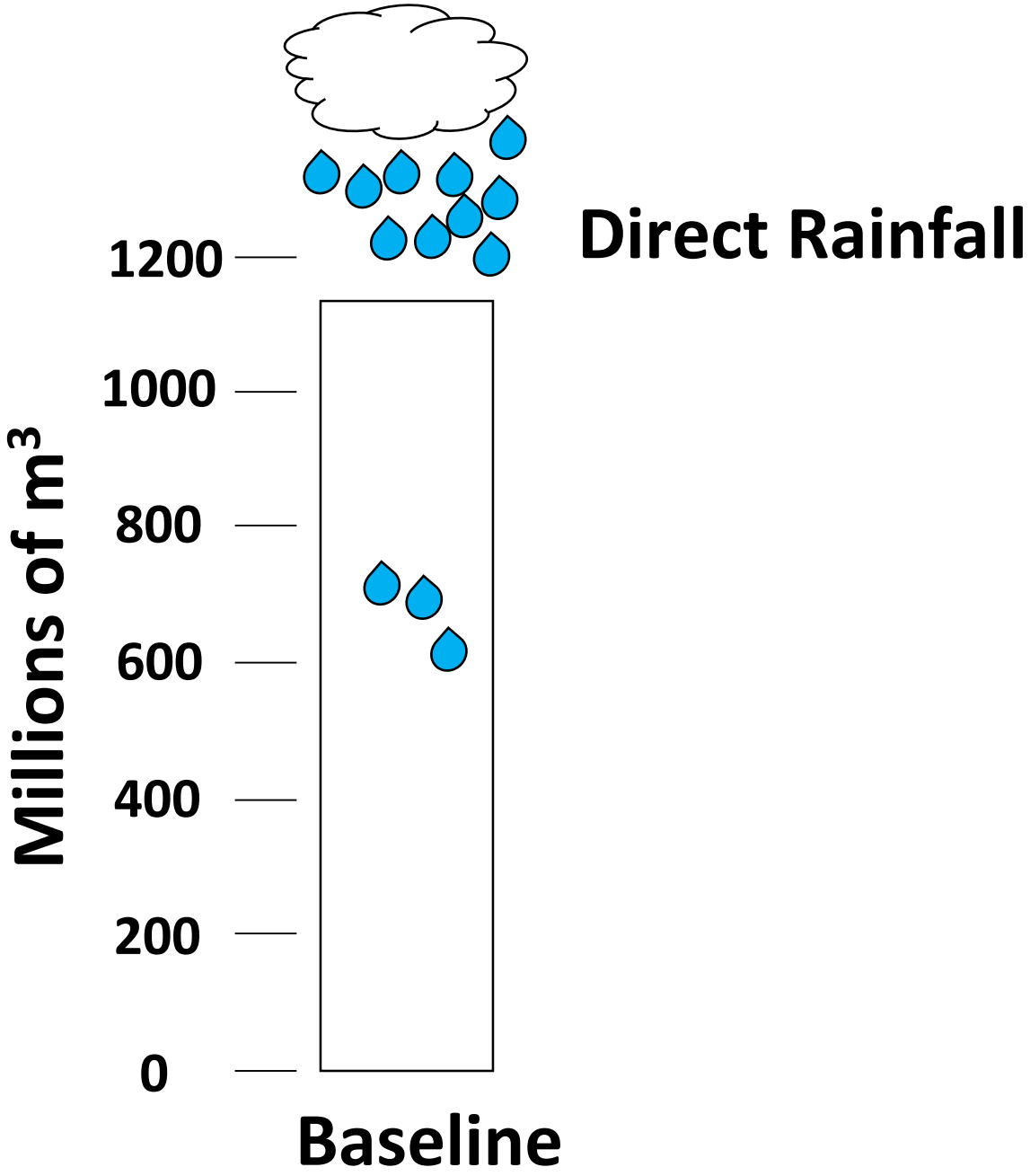
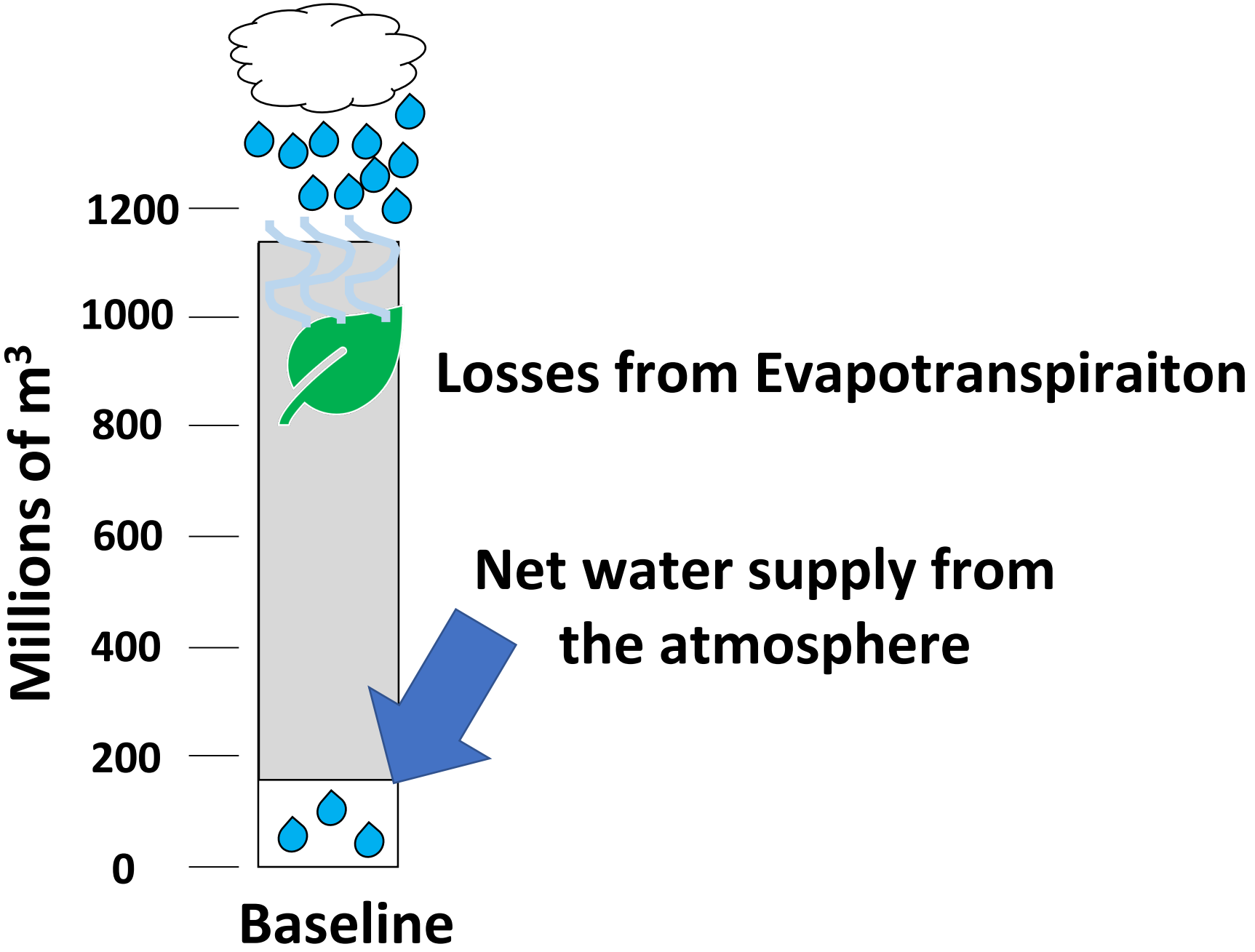
2010 Baseline +
Two climate change scenarios:

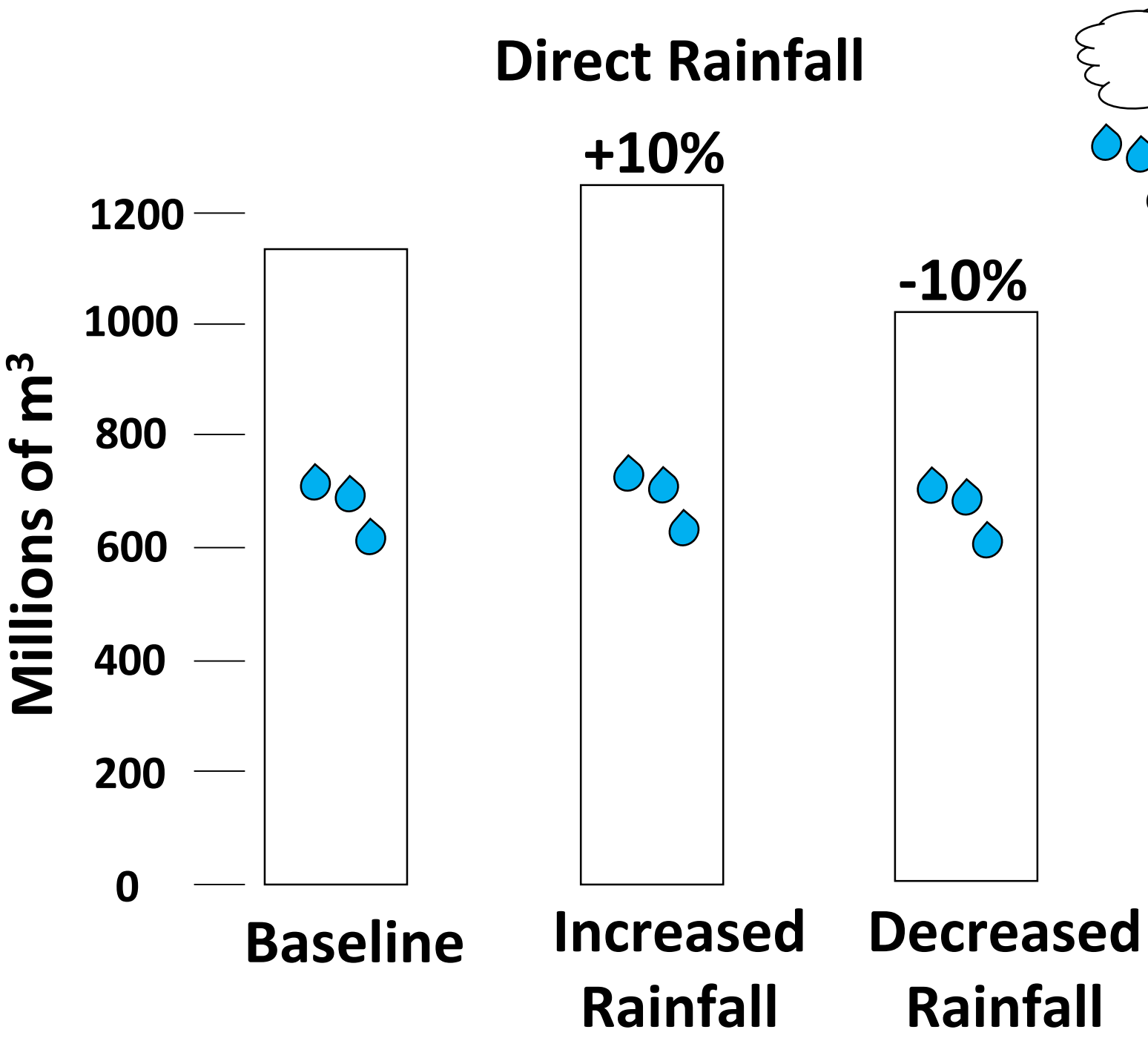
“CERP 0”

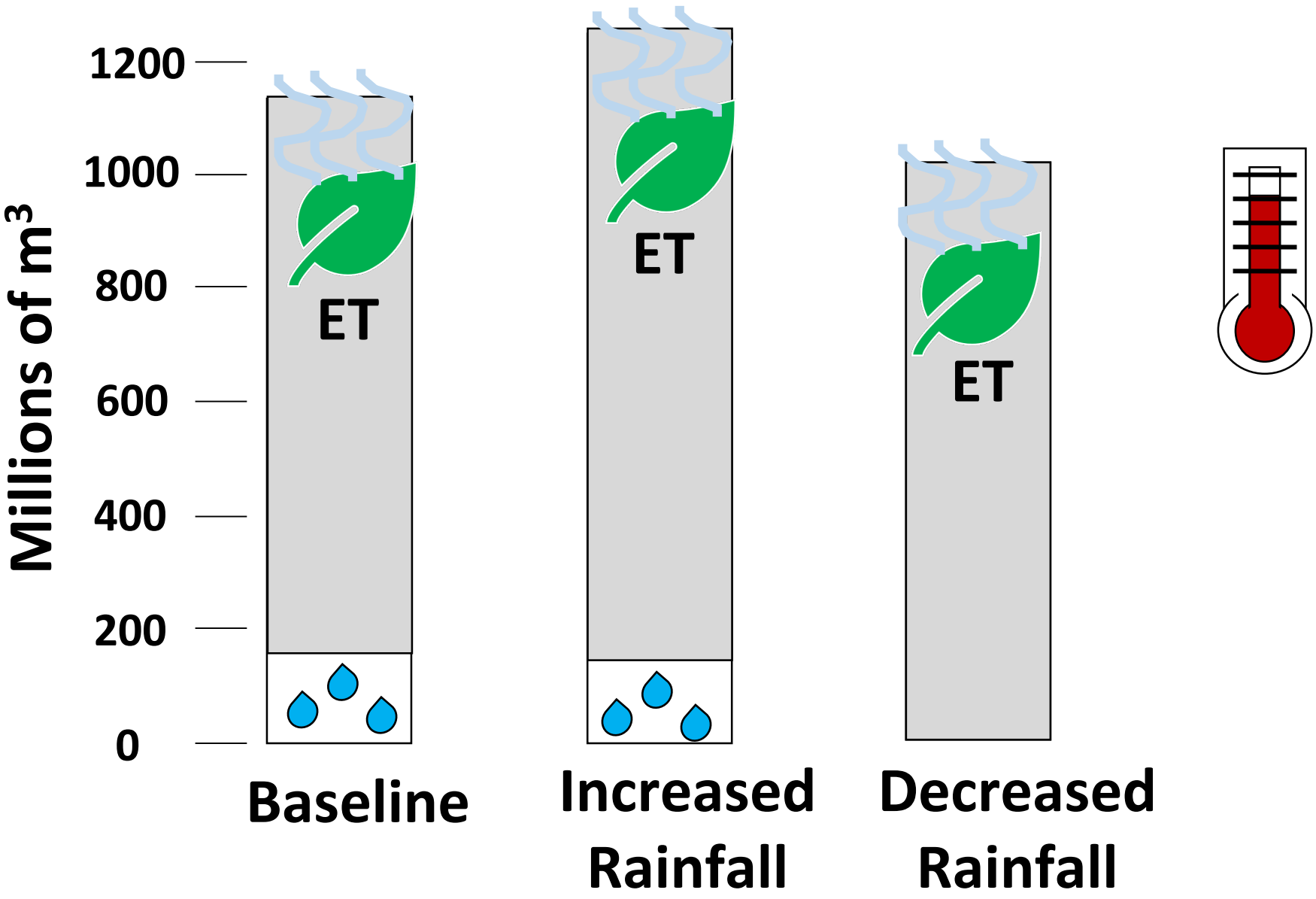
Obesekera et al., 2011
and 2015

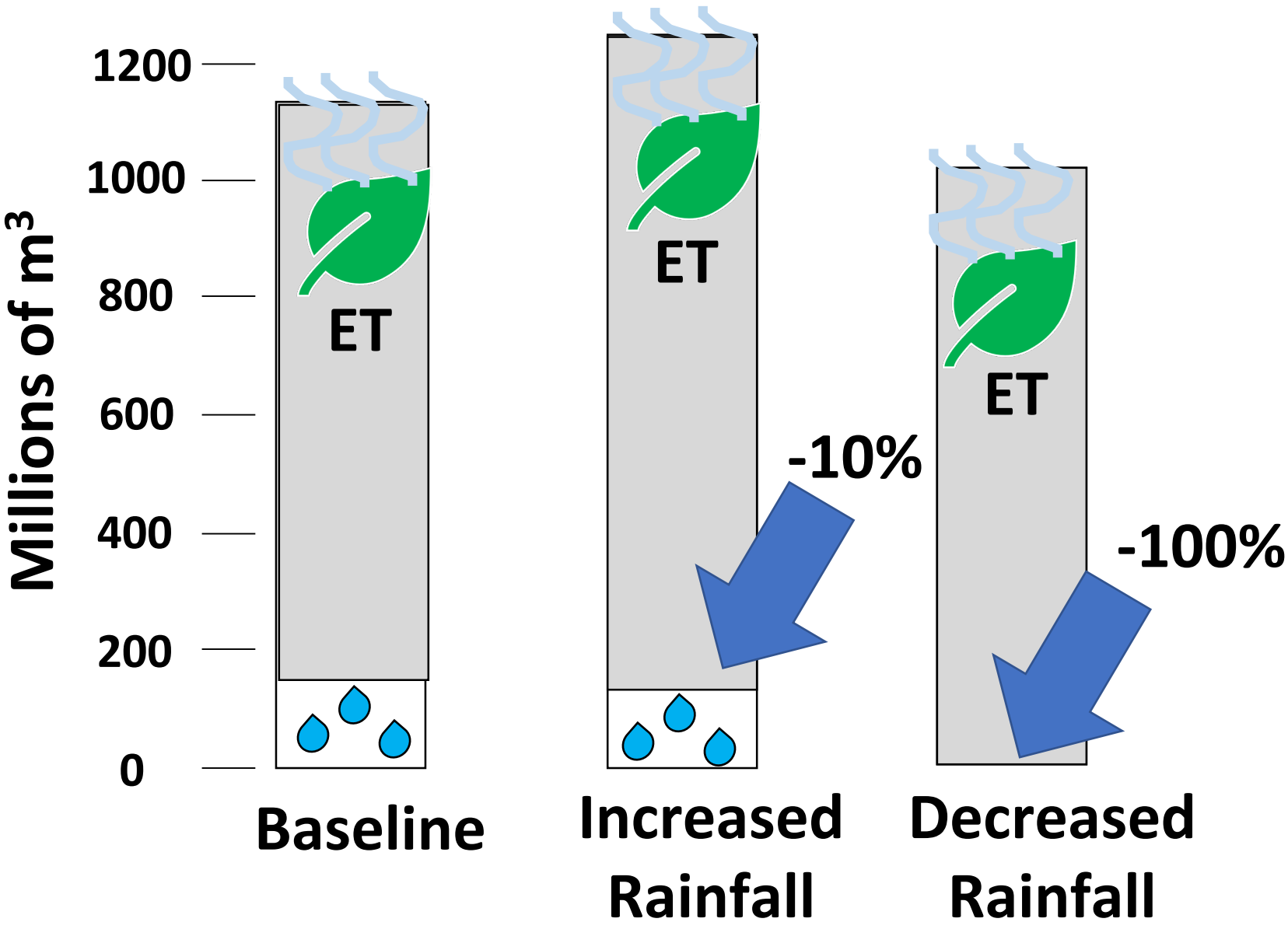
In a warming world,
in the absence of restoration,
what different trajectories
might the ecosystem take
depending on whether rainfall increases or decreases?

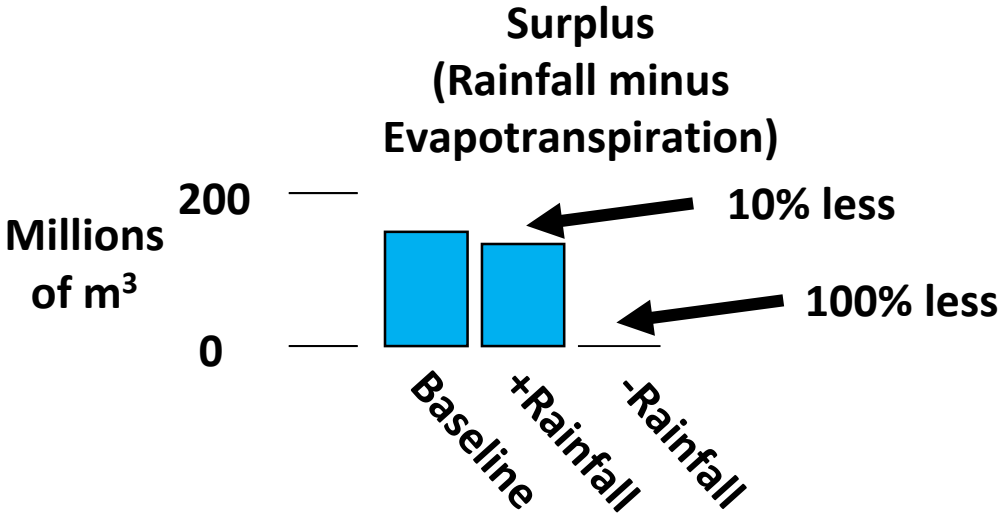

Direct Rainfall
1200
1000
800
600
400
200
0
Millions of m3
Baseline


1200
1000
800
600
400
200
0
Millions of m3
Losses from Evapotranspiraiton
Net water supply from the atmosphere
Baseline


Direct Rainfall
+10%
-10%
1200
1000
800
600
400
200
0
Millions of m3
Baseline
Increased Rainfall
Decreased Rainfall

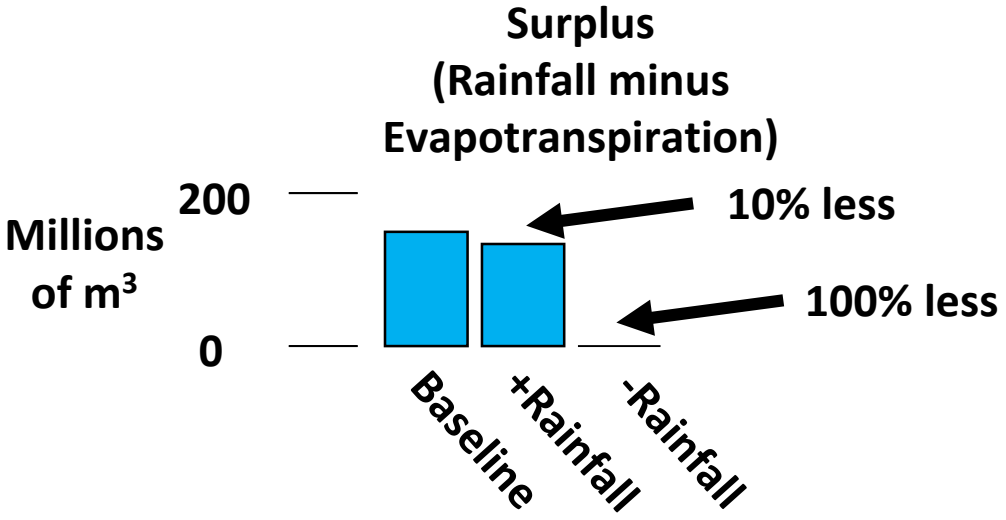

Millions of m3
1200
1000
800
600
400
200
0
ET
ET
ET
Baseline
Increased Rainfall
Decreased Rainfall

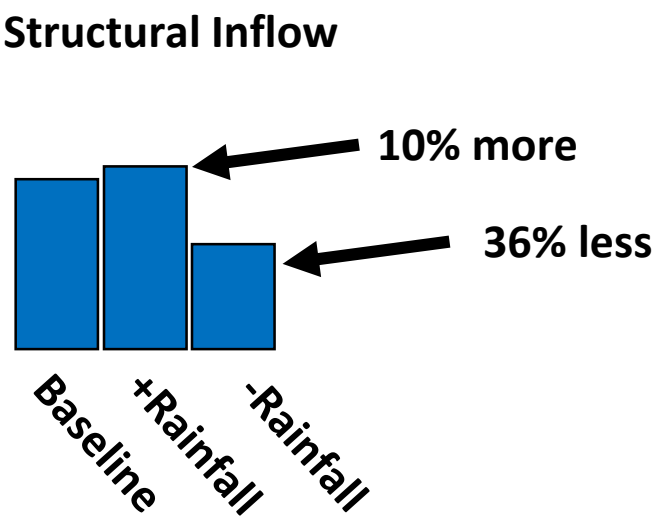

Millions of m3
1200
1000
800
600
400
200
0
ET
ET
ET
-10%
-100%
Baseline
Increased Rainfall
Decreased Rainfall


Surplus
(Rainfall minus
Evapotranspiration)
200
Millions
of m3
0
10% less
100% less
Baseline
+Rainfall
-Rainfall

Water management rules in the SFWM Model

? Structural Inflow





Today's Talk

Three Climate Scenarios

Everglades Landscape Model

Soil Phosphorus

Methylmercury Production

Muck Fire Risk

Implications for Restoration

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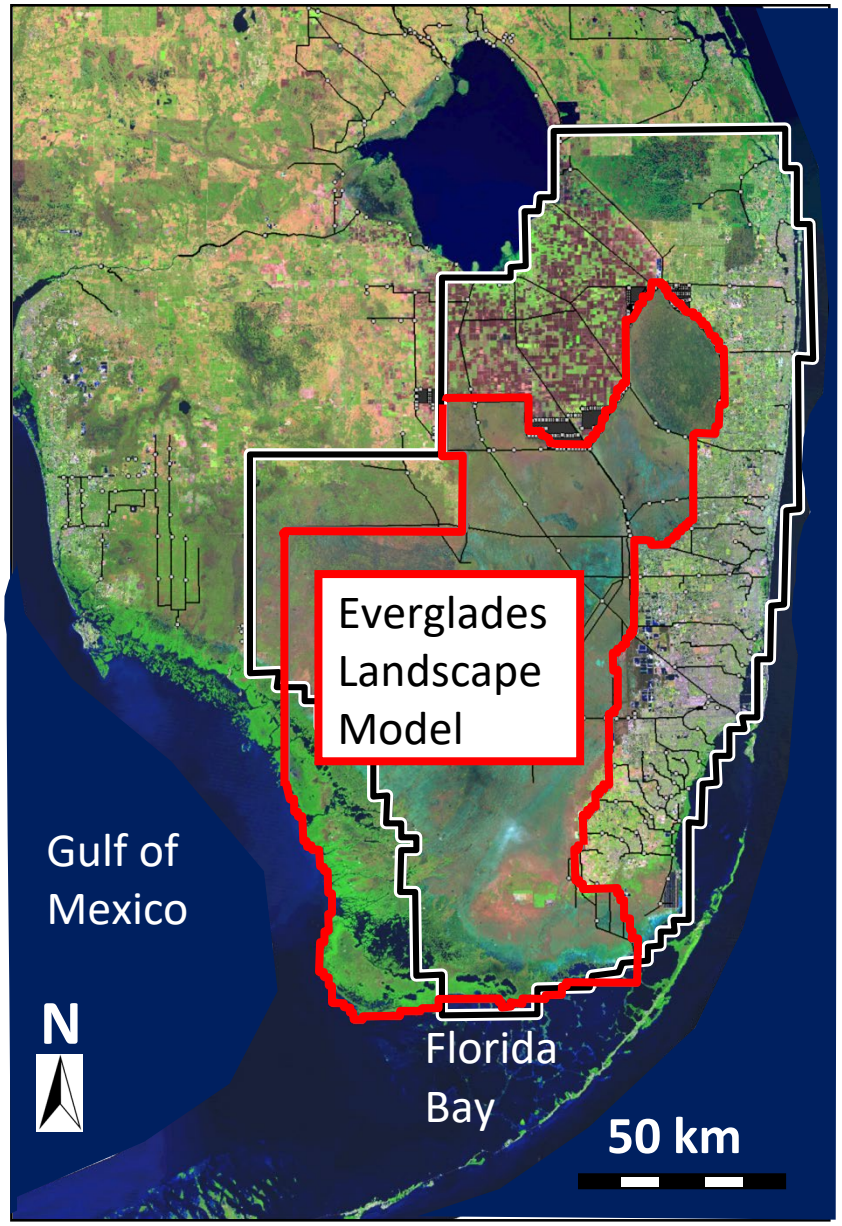
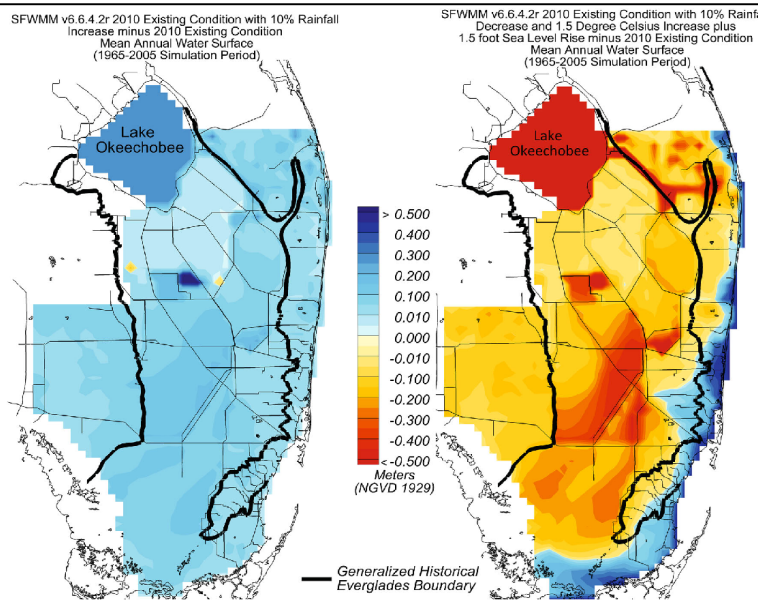
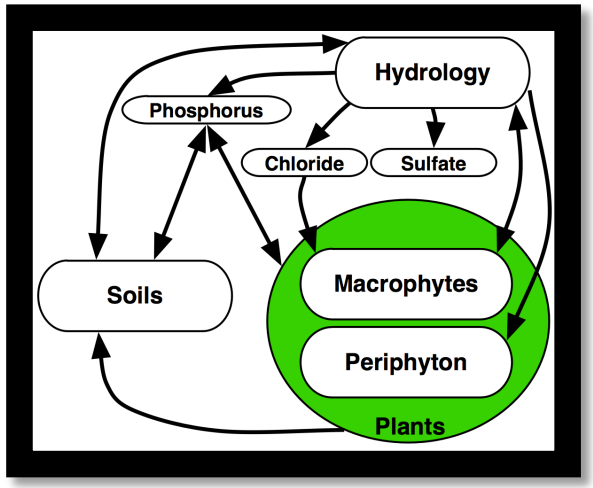
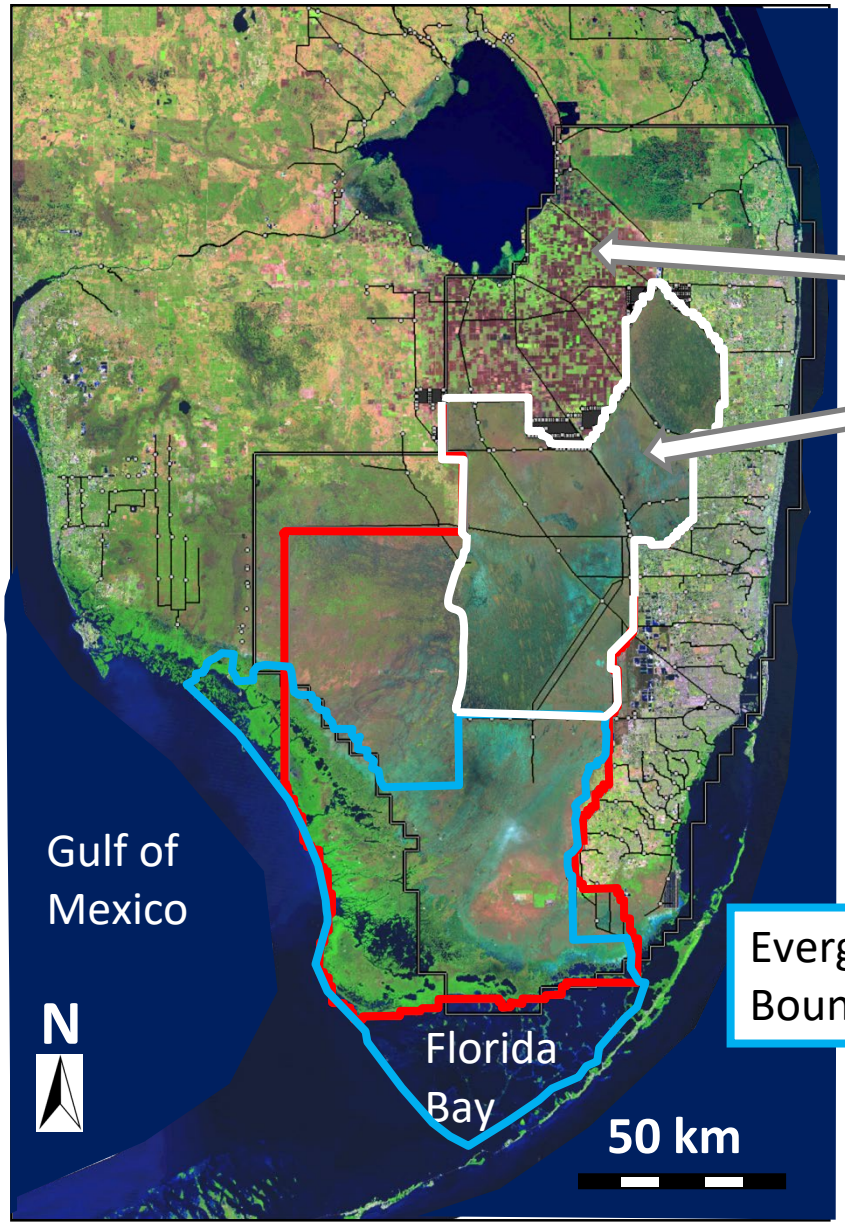


South Florida Water Management Model





Everglades Landscape Model



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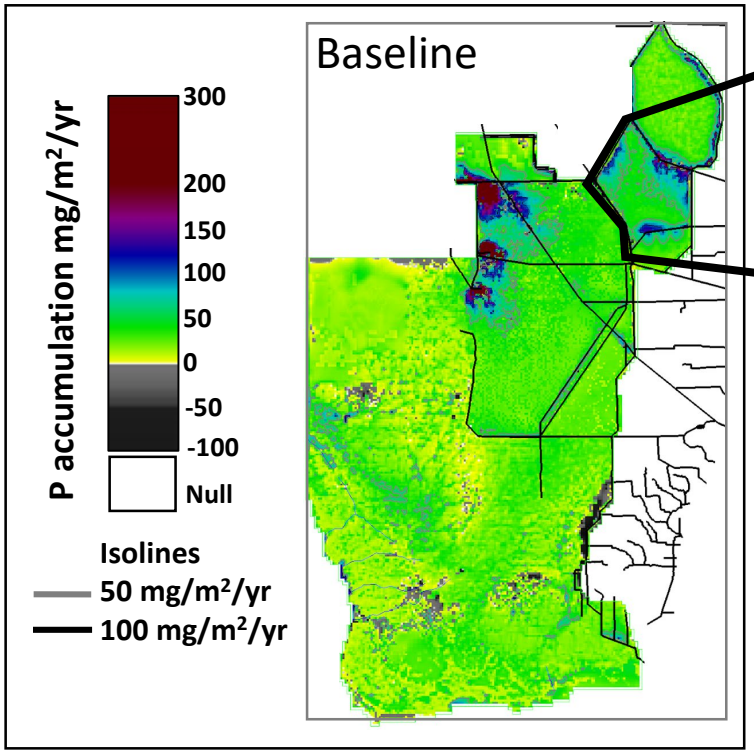
Phosphorus-limited ecosystem

Phosphorus accumulation in soil



Cattail occurrence (Lagerwall et al. 2012)

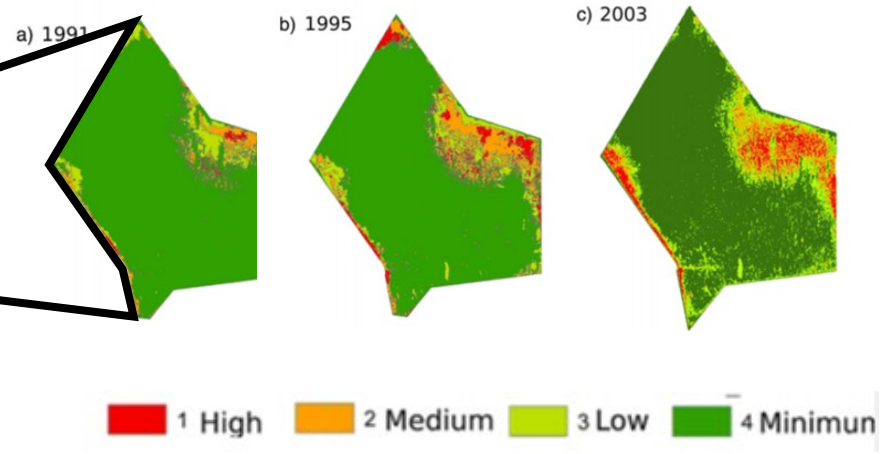
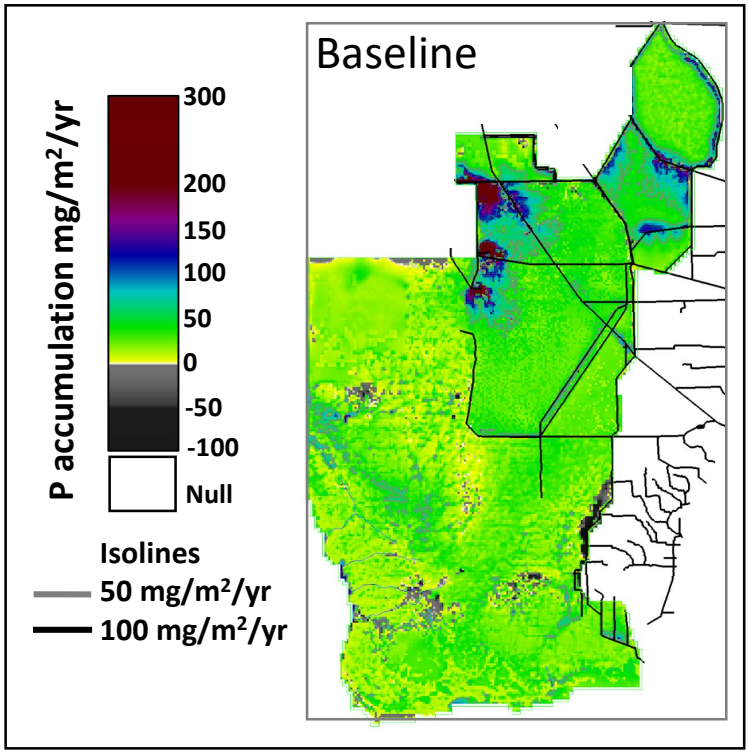


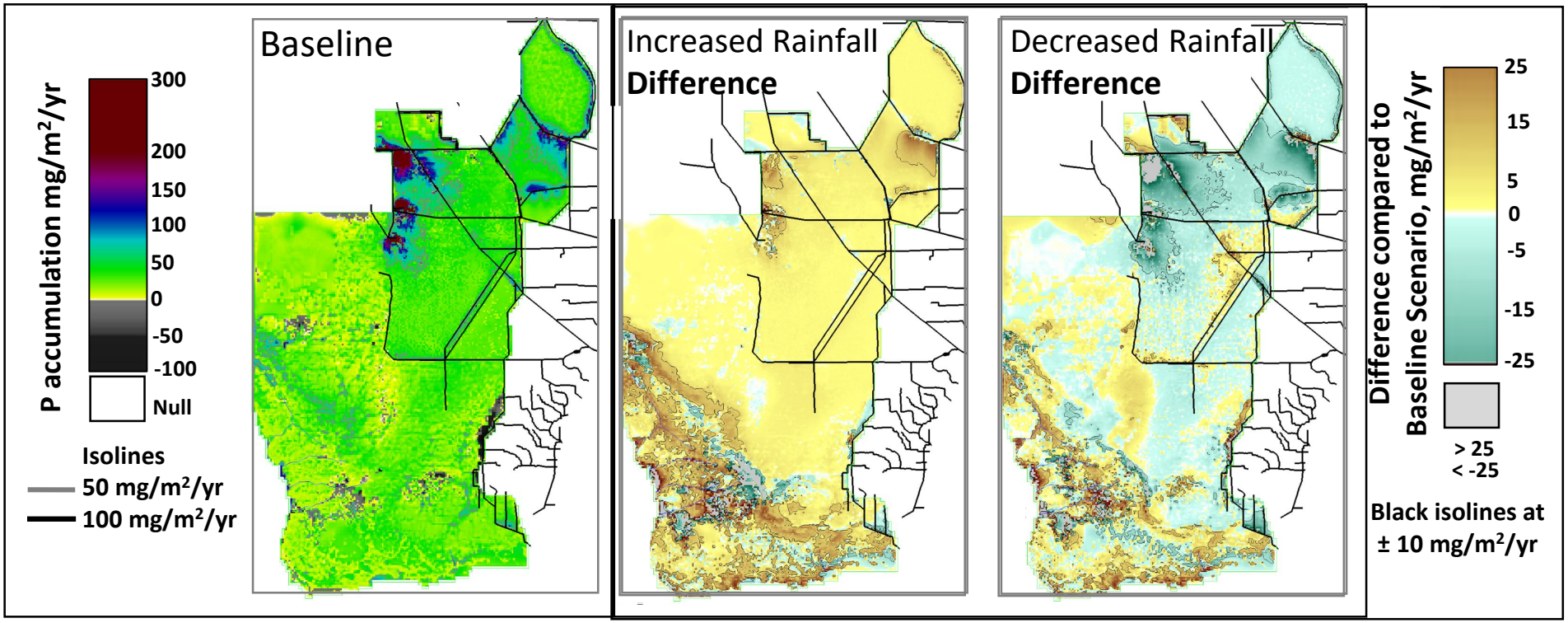
Photo: Ben Wilson

Reference: Lagerwall, G., Kiker, G., Muñoz-Carpena, R. et al. Ecol Process (2012) 1: 10. https://doi.org/10.1186/2192-1709-1-10

Phosphorus accumulation in soil



Phosphorus accumulation rate in soil



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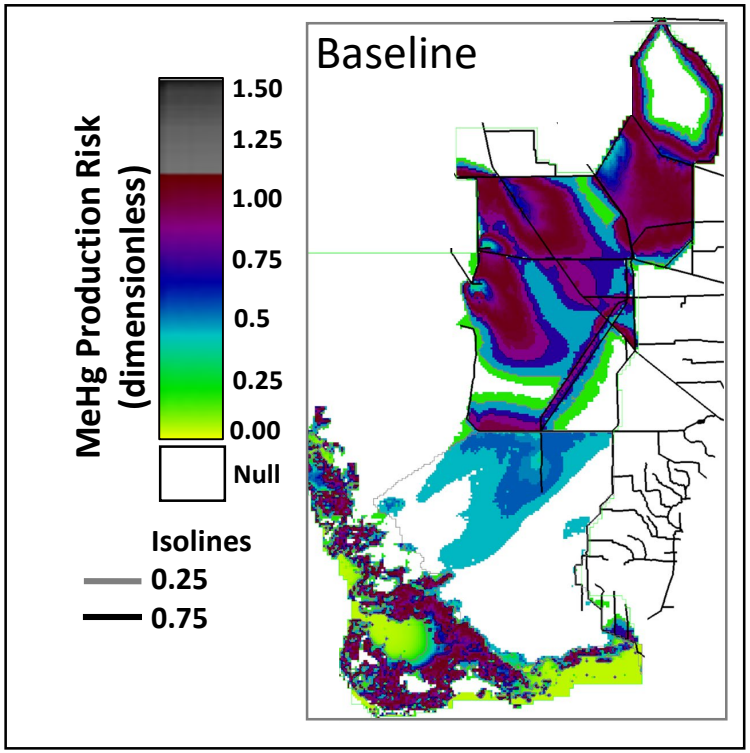
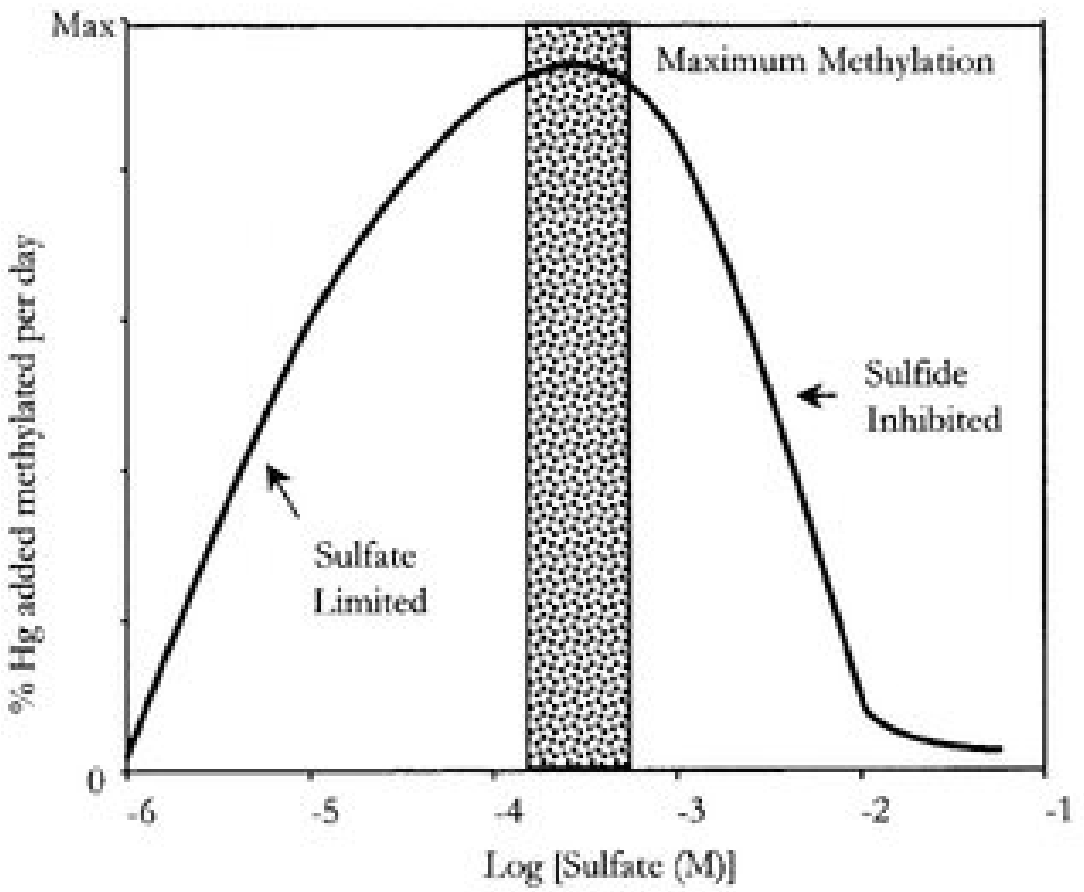
WARNING
HEALTH HAZARD
DO NOT EAT MORE THAN ONE BASS PER WEEK, PER ADULT
DUE TO HIGH MERCURY CONTENT.
CHILDREN AND PREGNANT WOMEN SHOULD NOT
EAT BASS.
AVISO
PELIGRO CONTRA LA SALUD

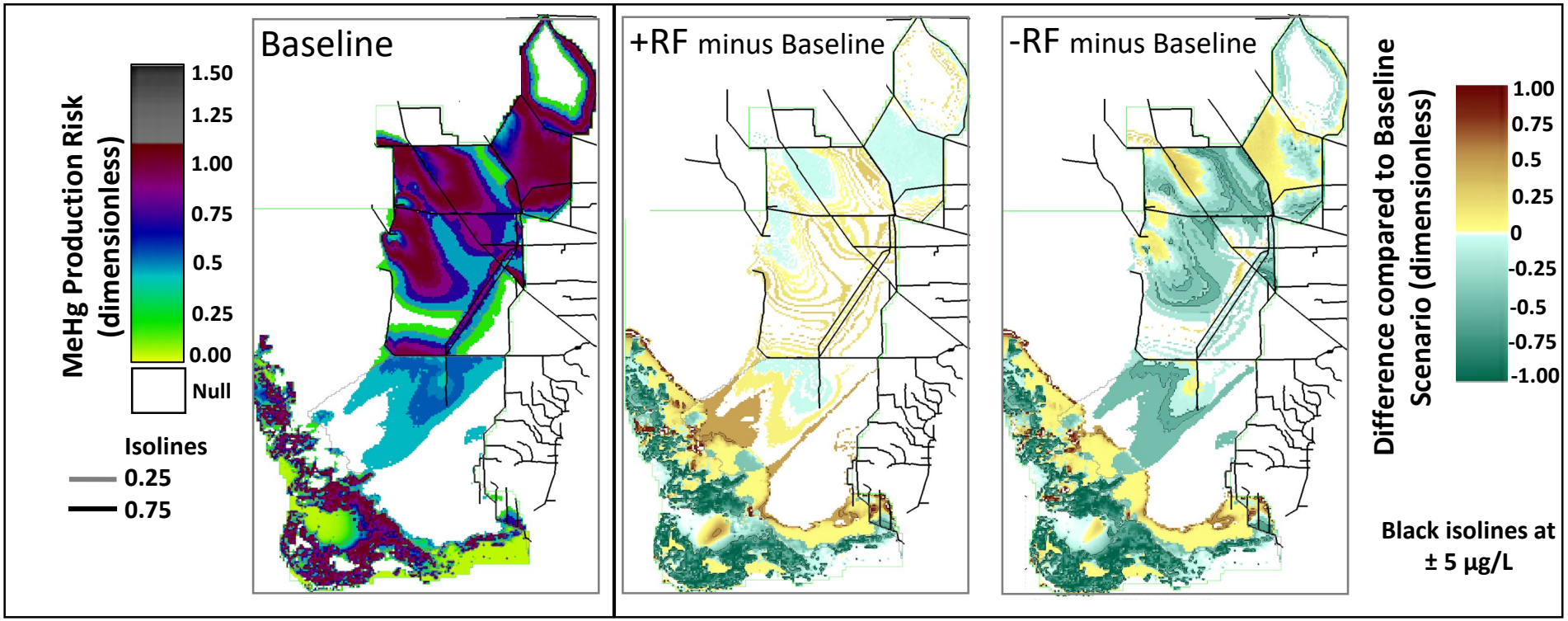
Methylmercury Production Risk





Graph: Langer et al., 2001

Methylmercury Production Risk



In a warming world, in the absence of restoration:

Increased rainfall

May require more inflow

Eutrophication risk

Methylmercury production risk

Trade-off

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Everglades Peat 1-3 mm/yr

Muck fire a creeping slow-burning fire
burns mainly under the surface of the soil

Photo from Firescience.gov

Muck fire

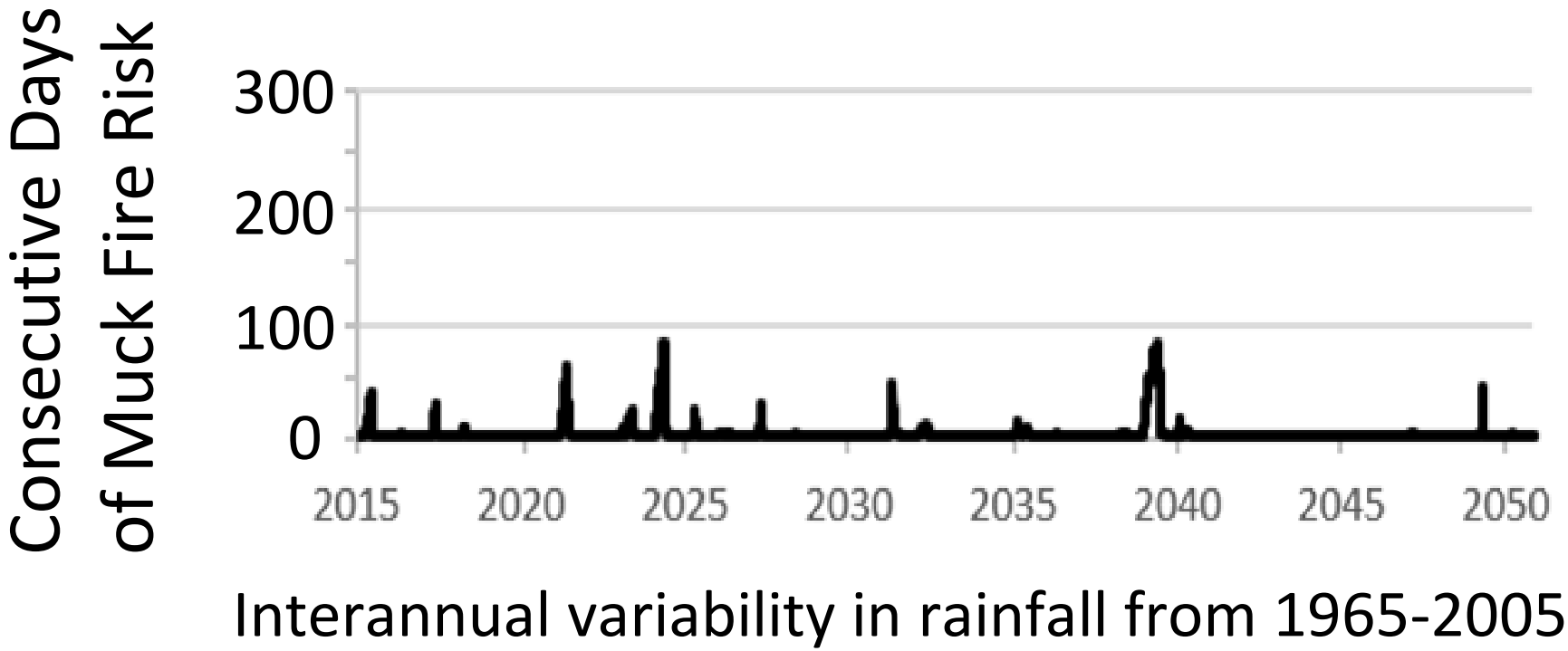
1944, Miami Herald

Large areas lost 8-20 cm of ground surface

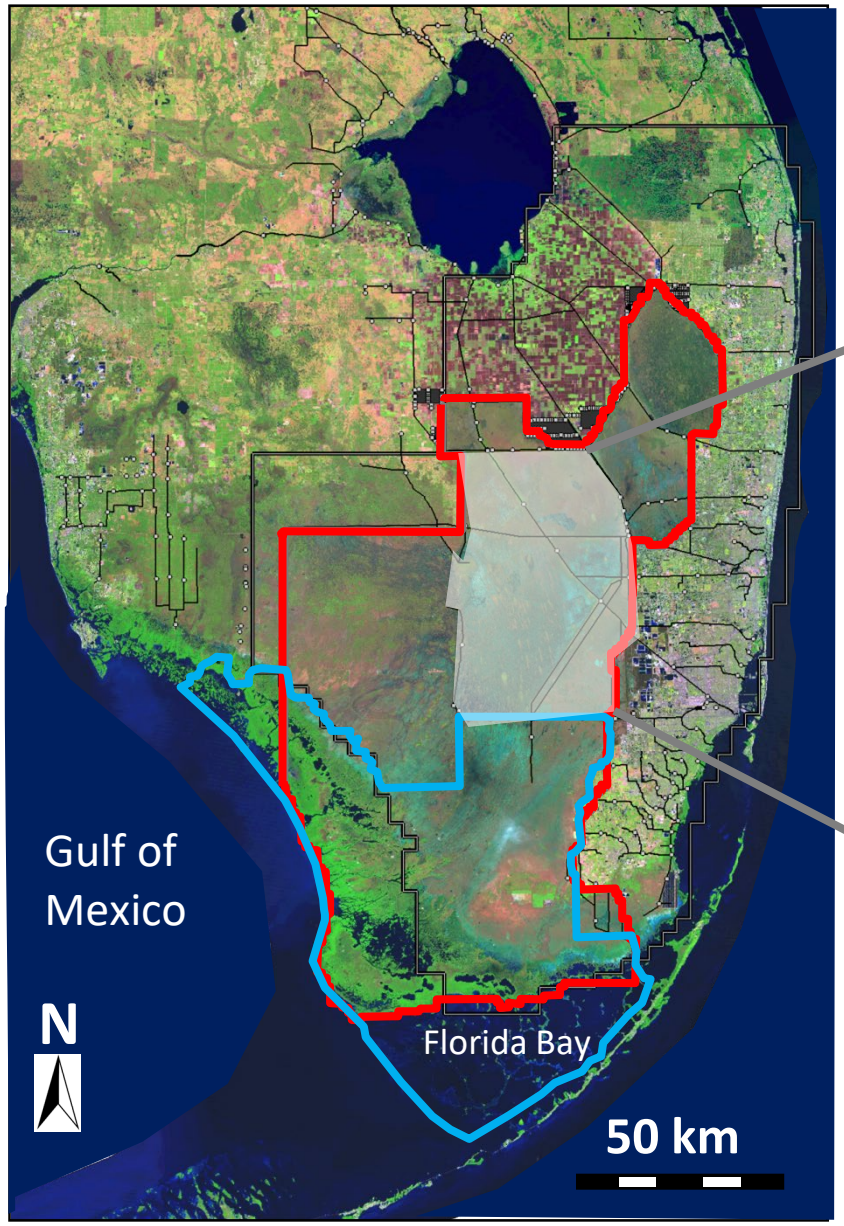
Muck fire risk index in ELM

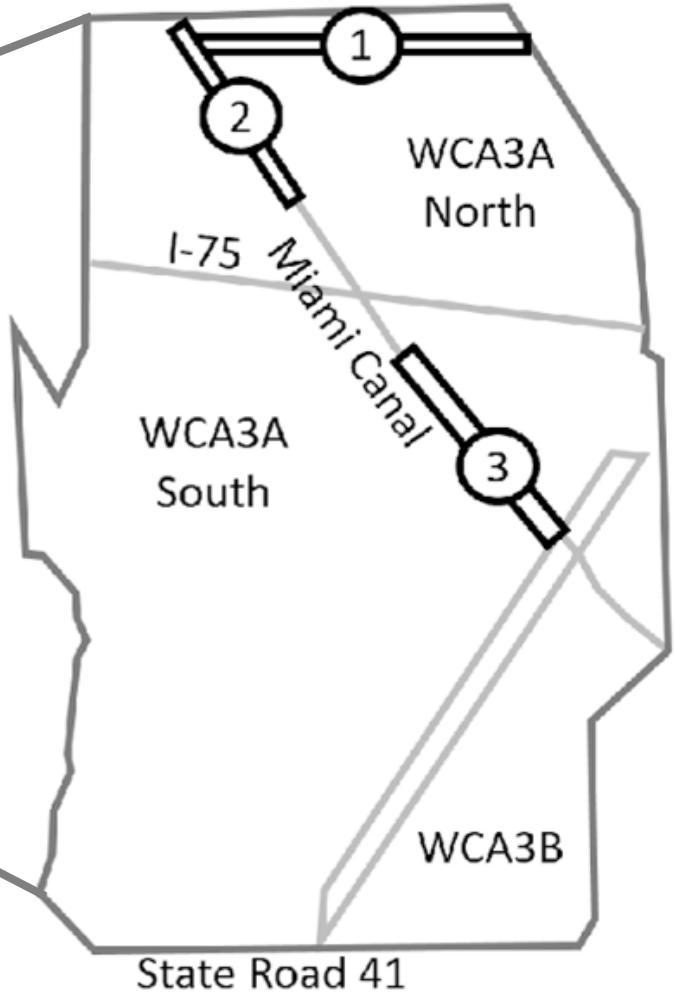
The cumulative number of consecutive days that the Unsaturated zone is

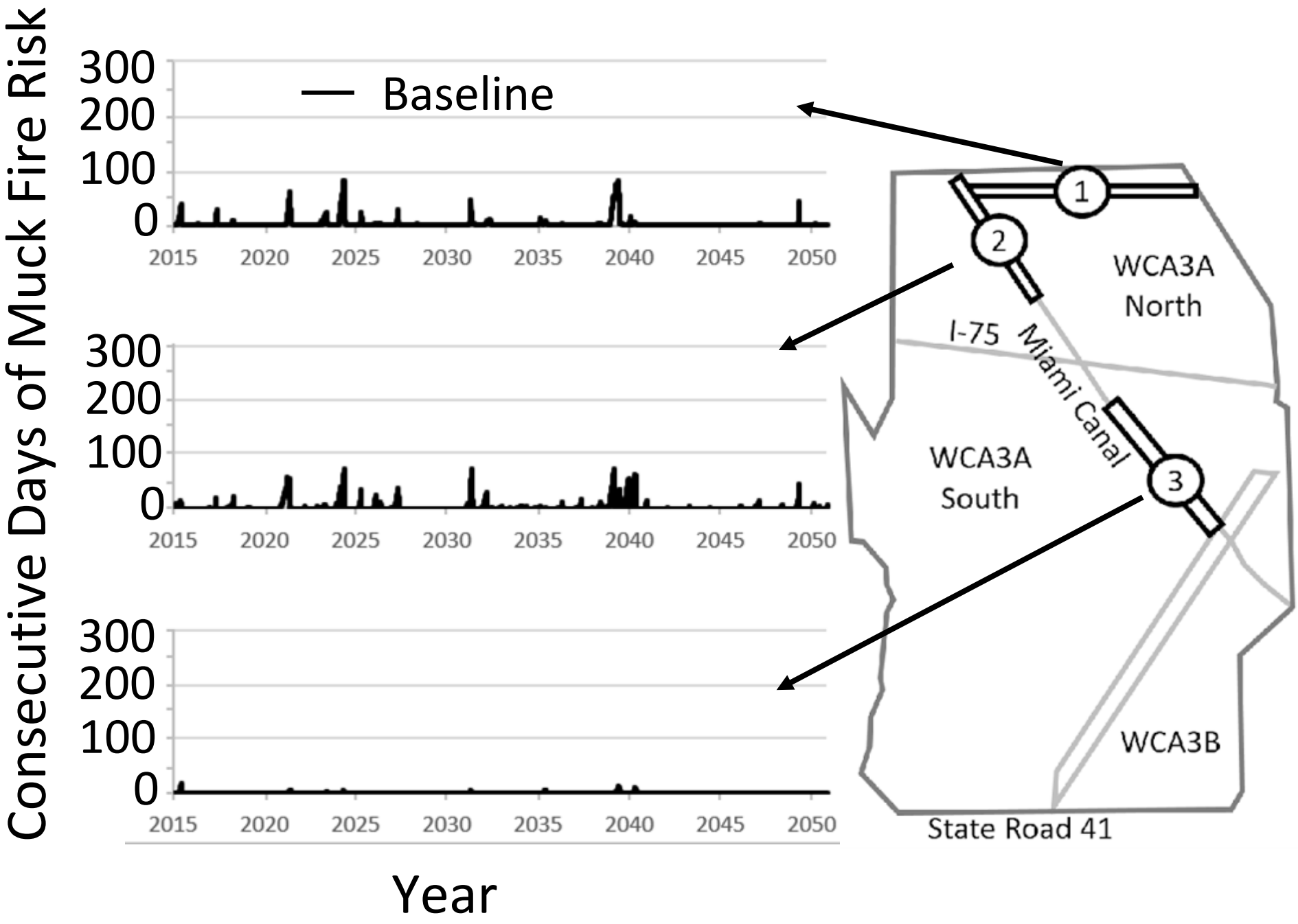
- Deeper than 15 cm below the land surface
- Moisture of <50%

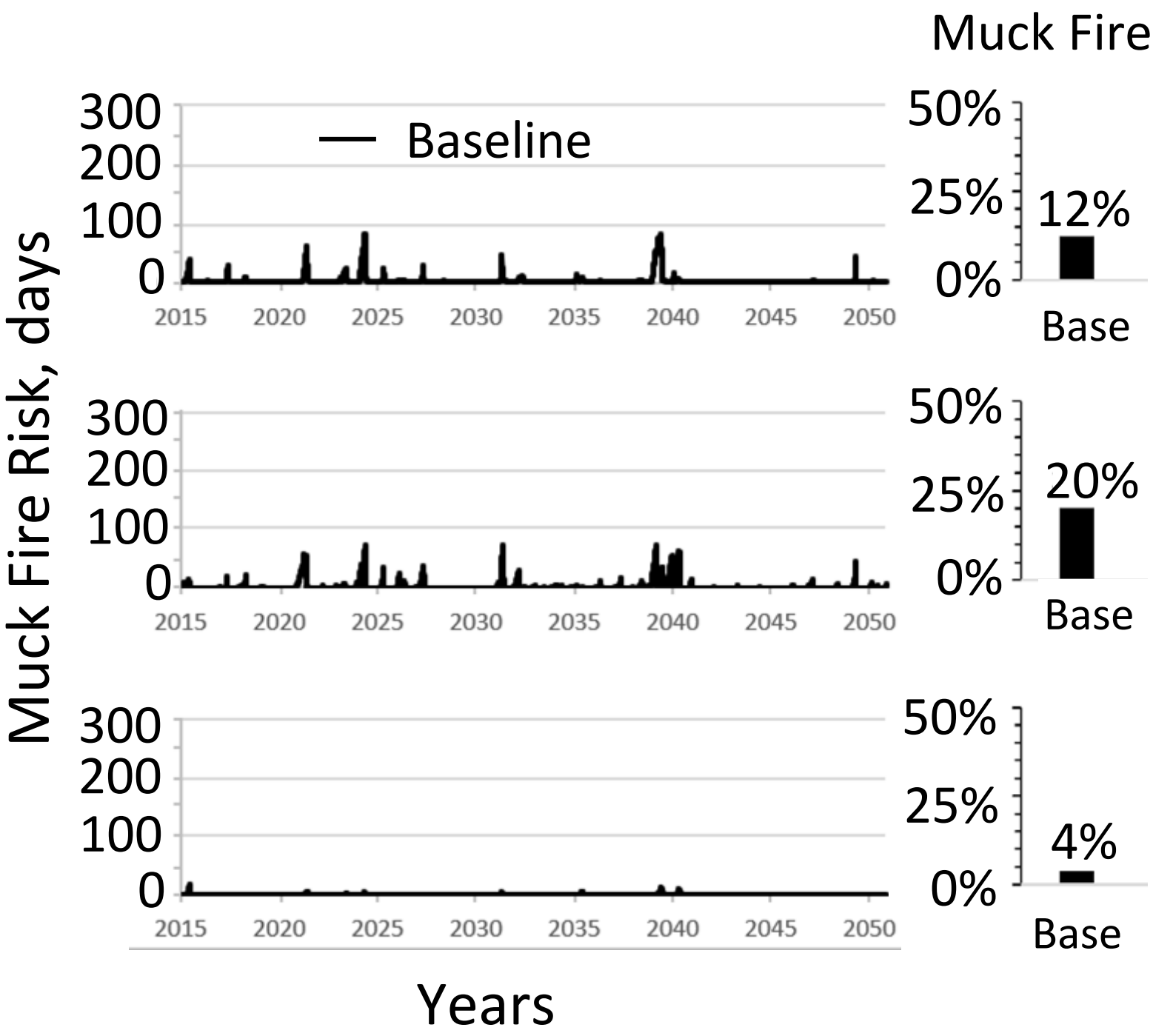


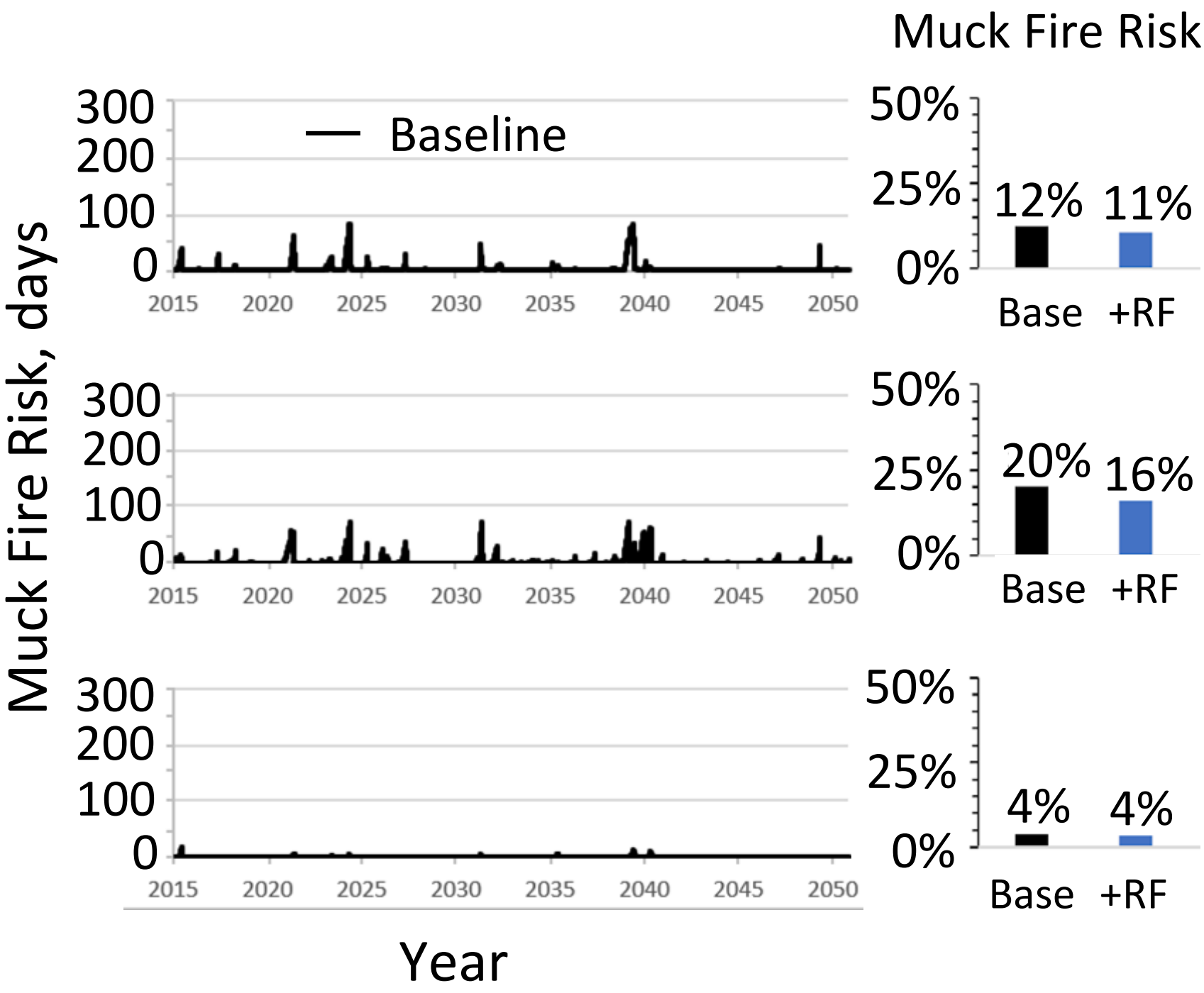
Time series of muck fire risk

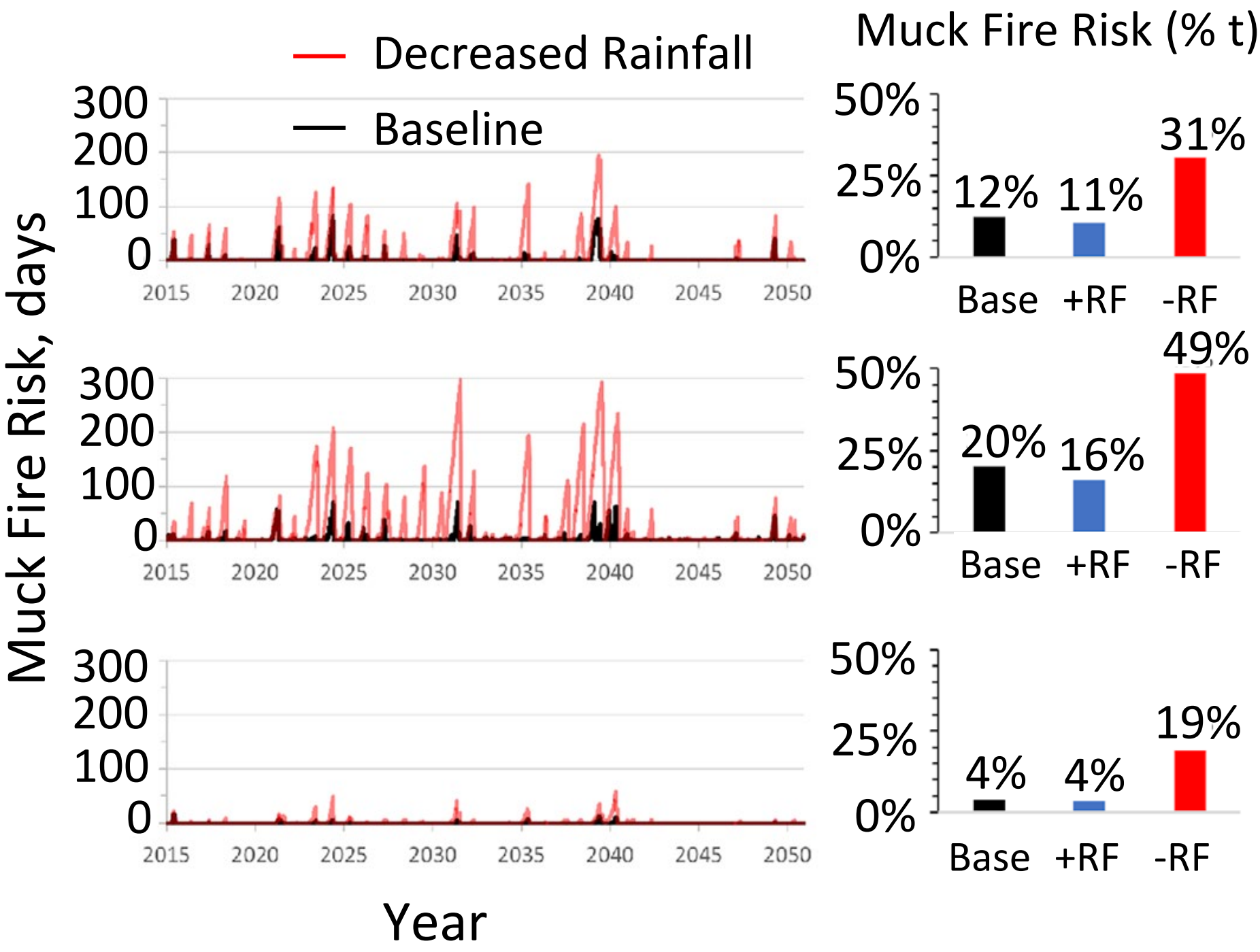





Consecutive Days of Muck Fire Risk
Baseline
300
200
100
0
2015
2020
2025
2030
2035
2040
2045
2050
Year
1
2
3
WCA3A
North
I-75
Miami Canal
WCA3A
South
WCA3B
State Road 41


Muck Fire Risk (% t)
Muck Fire Risk, days
Baseline
300
200
100
0
2015
2020
2025
2030
2035
2040
2045
2050
50%
25%
0%
12%
Base
20%
4%
Years


Muck Fire Risk (% t)
Muck Fire Risk, days
Baseline
300
200
100
0
2015
2020
2025
2030
2035
2040
2045
2050
50%
25%
0%
12%
11%
Base
+RF
20%
16%
4%
4%
Year


Decreased Rainfall
Baseline
Muck Fire Risk, days
300
200
100
0
2015
2020
2025
2030
2035
2040
2045
2050
Year
Muck Fire Risk (% t)
50%
25%
0%
12%
11%
31%
Base
+RF
-RF
20%
16%
49%
4%
4%
19%

In a warming world, in the absence of restoration:

Increased rainfall

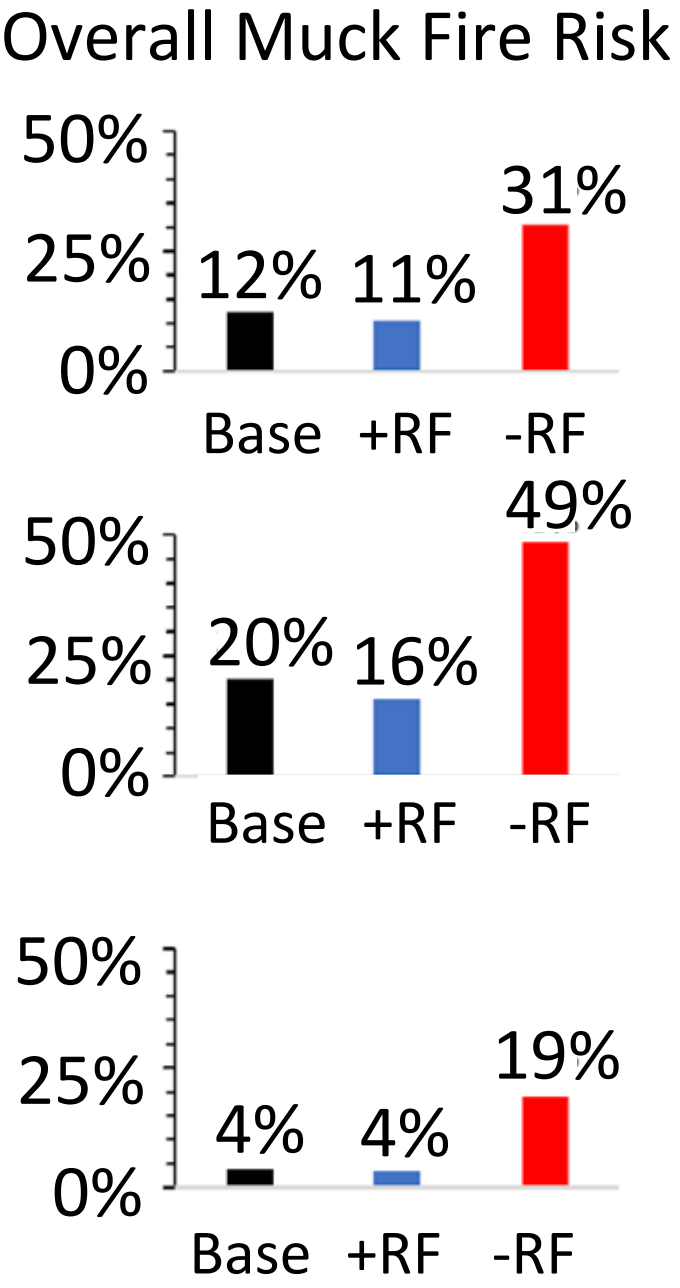
Slightly lower muck fire risk

More protection is needed

Decreased rainfall

High muck fire risk

Soil loss likely



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Muck Fire Risk

Increased Rainfall -slightly lower risk

Decreased Rainfall –frequent muck fires, soil loss likely

--Need more water

Eutrophication & Methylmercury production

Increased Rainfall –worse due to greater inflow

--Cleaner water

Restoration is more urgent

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Based on a 2019 Paper, Environmental Management 64(4) 416-435:
Hilary Flower, Mark Rains, Carl Fitz,
William Orem, Susan Newman, Todd Osborne,
Ramesh Reddy, and Jayantha Obeysekera:

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