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:

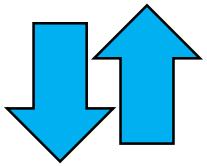
Vulnerabilities and Resilience
Risks and Benefits

Northern Everglades
Biogeochemical Processes

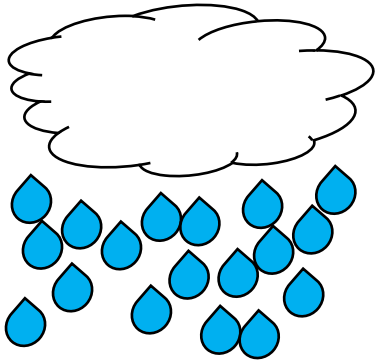
Today's Talk
Three Climate Scenarios
Everglades Landscape Model
Soil Phosphorus
Methylmercury Production
Muck Fire Risk
Implications for Restoration

2010 Baseline +
Two climate change scenarios:

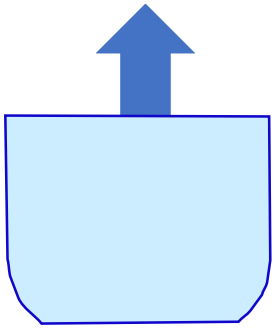
“CERP 0”



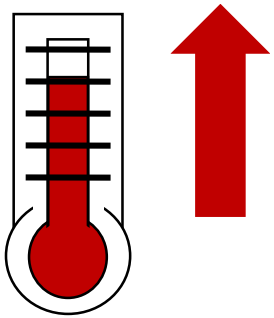
±10%



Sea Level Rise
+0.5 m



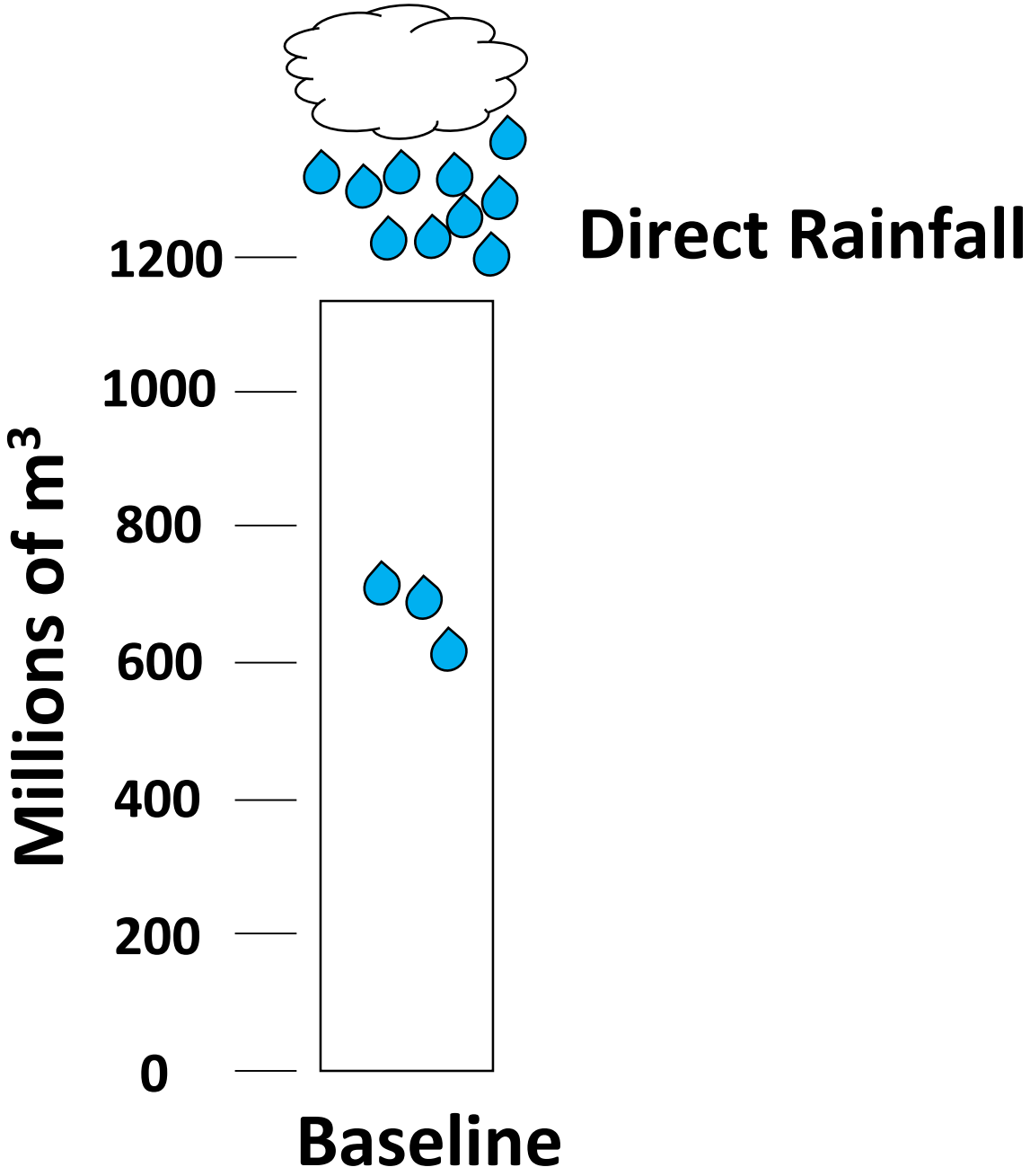
Temperature
+1.5 C

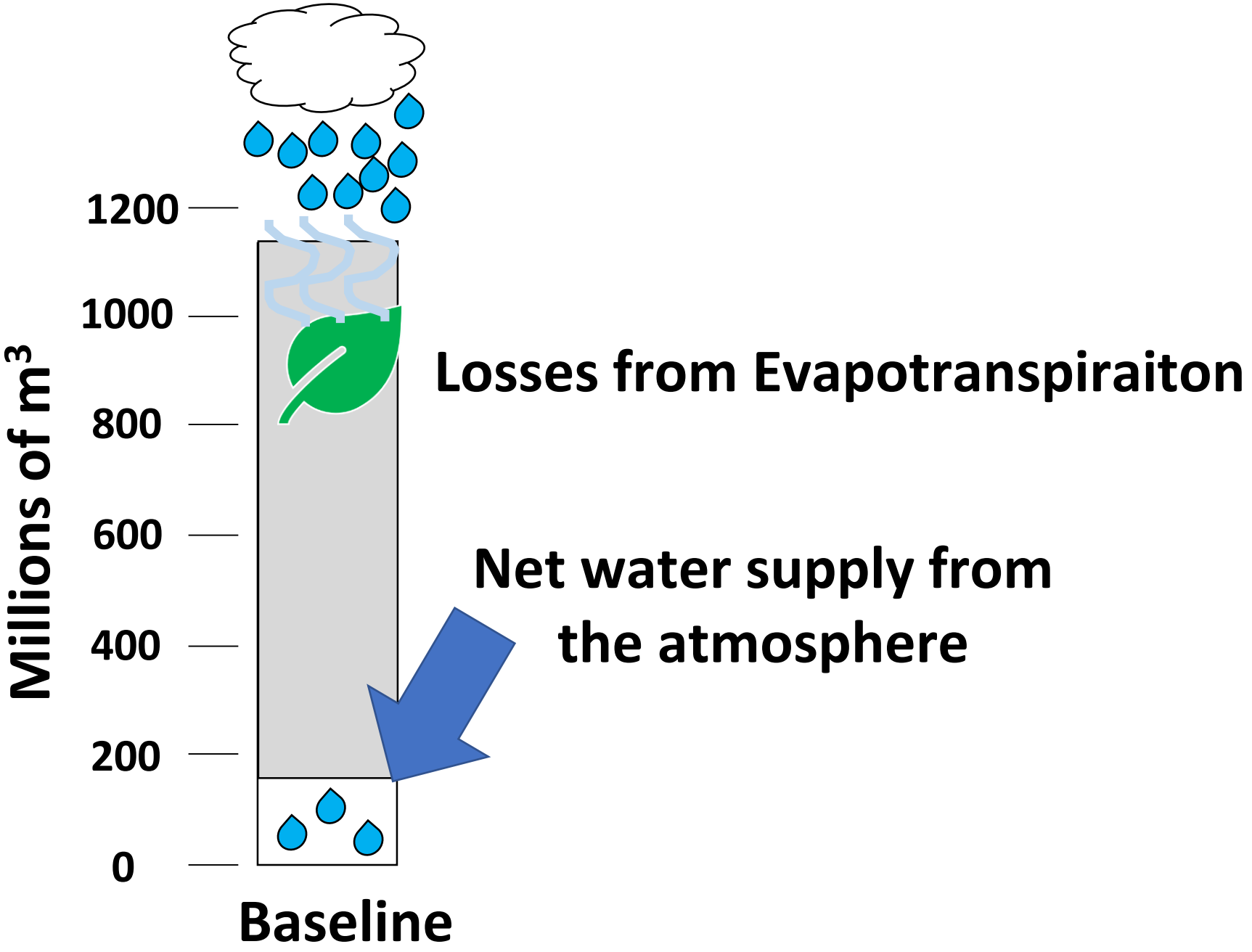


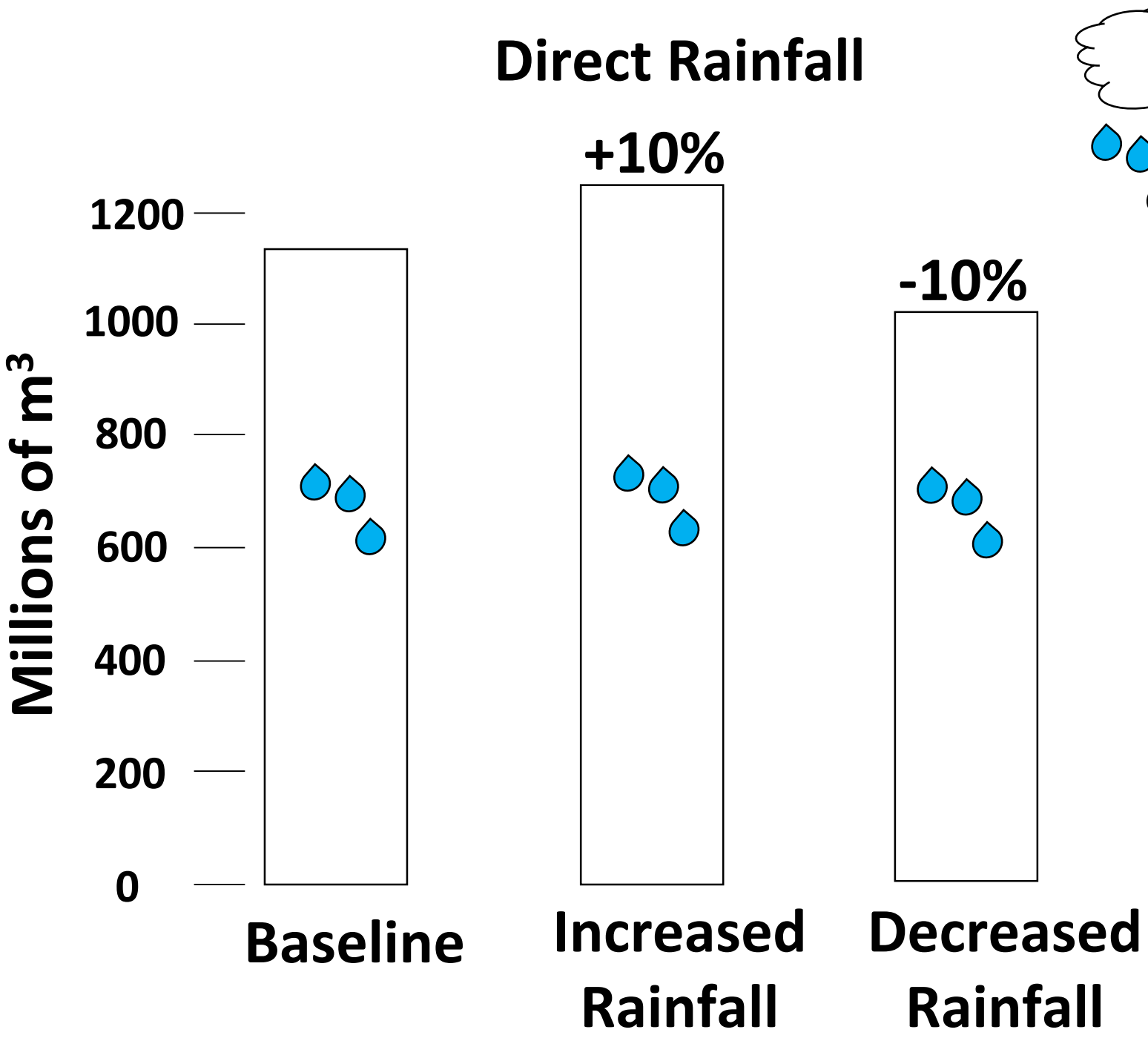
Evapotranspiration
+ 7%

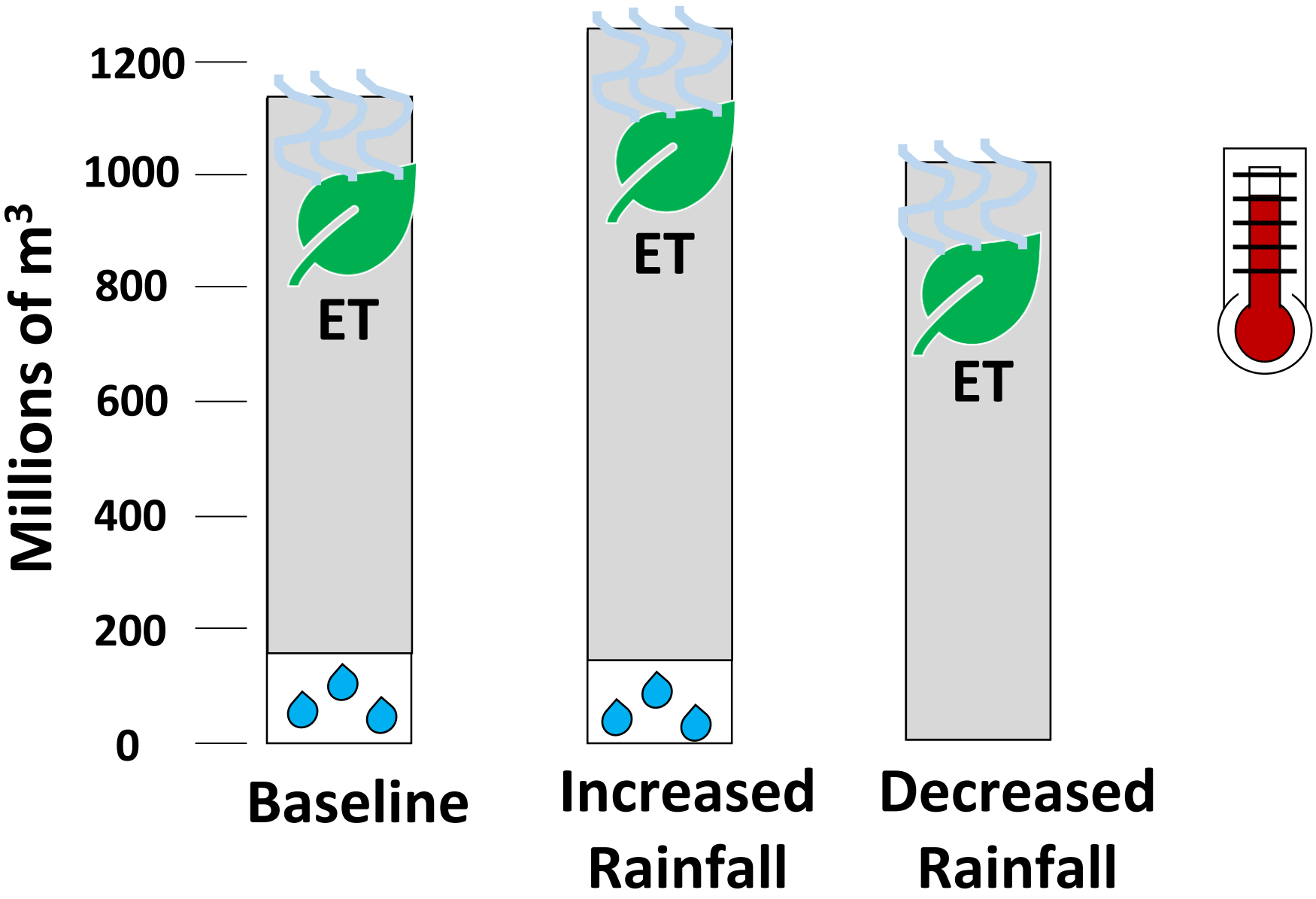
Obesekera et al., 2011
and 2015

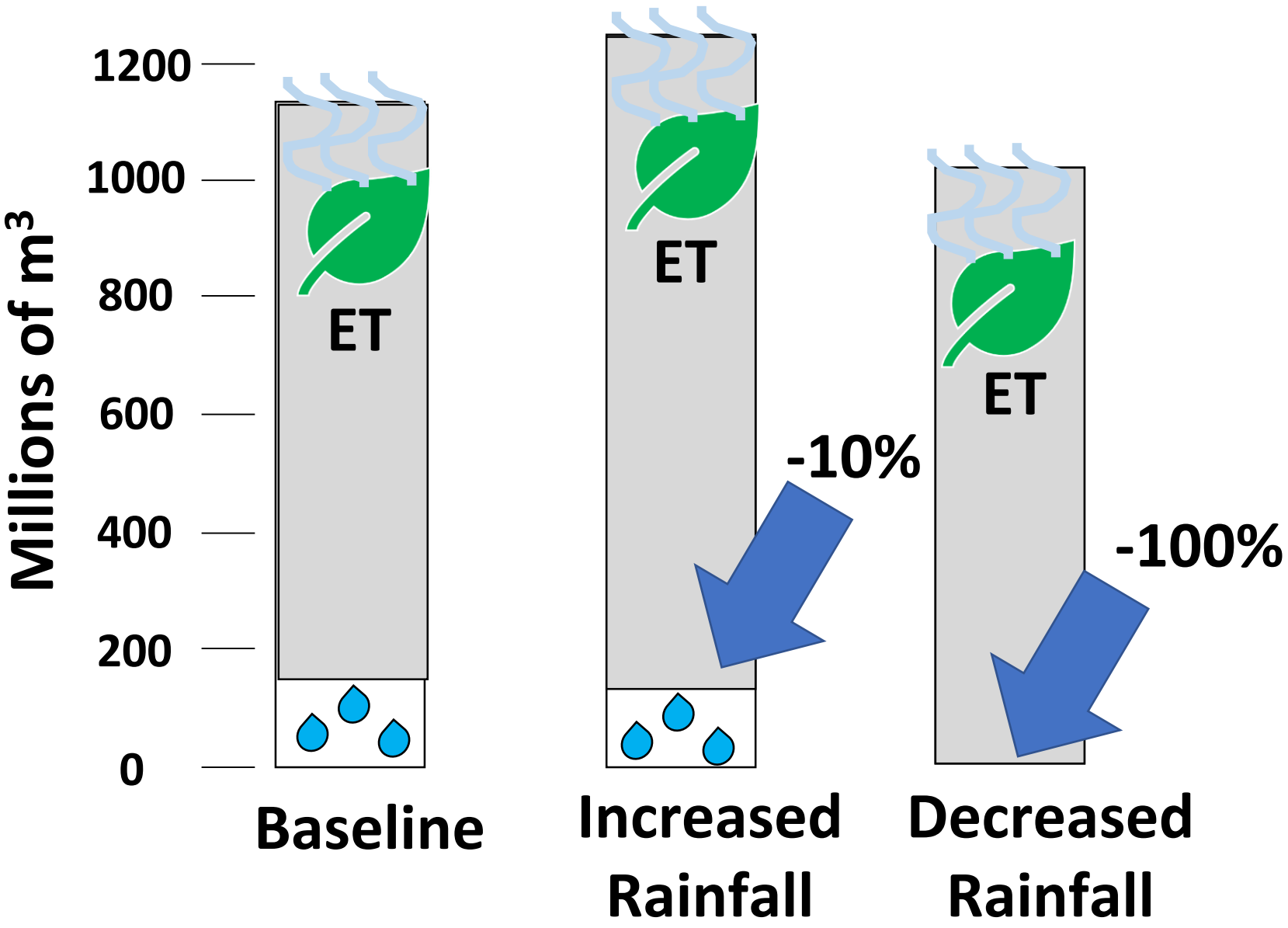
In a warming world,
in the absence of restoration,
what different trajectories
might the ecosystem take
depending on whether rainfall increases or decreases?


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

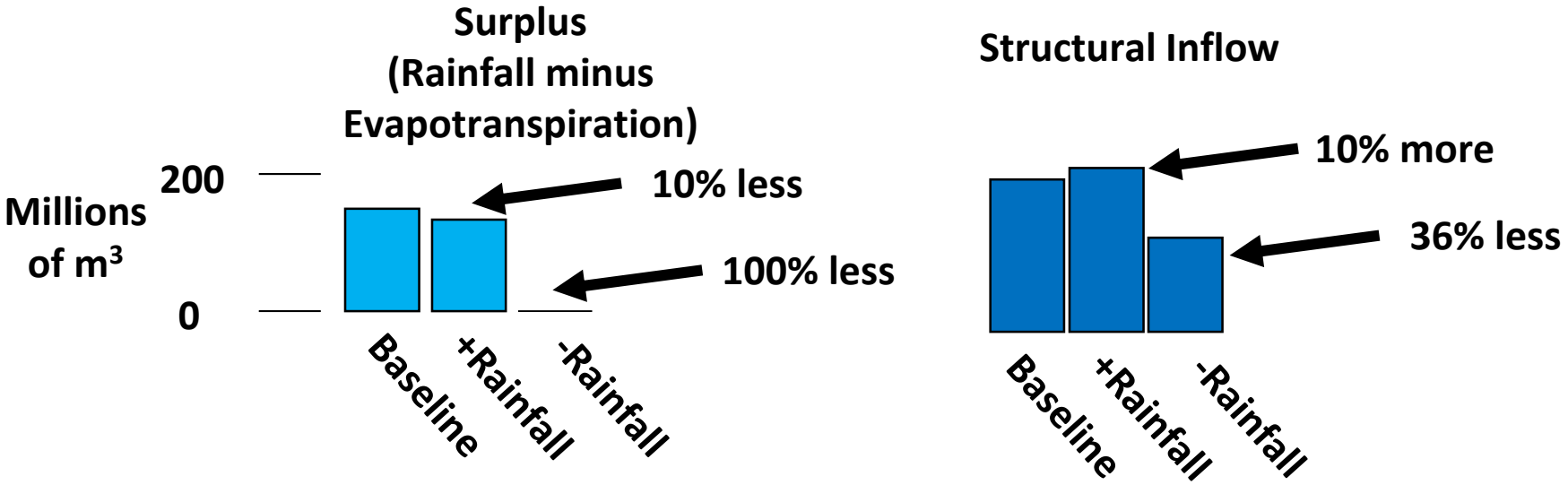

1200
1000
800
600
400
200
0
Millions of m3
Losses from Evapotranspiraiton
Net water supply from the atmosphere
Baseline


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

Water management rules in the SFWM Model
Structural Inflow



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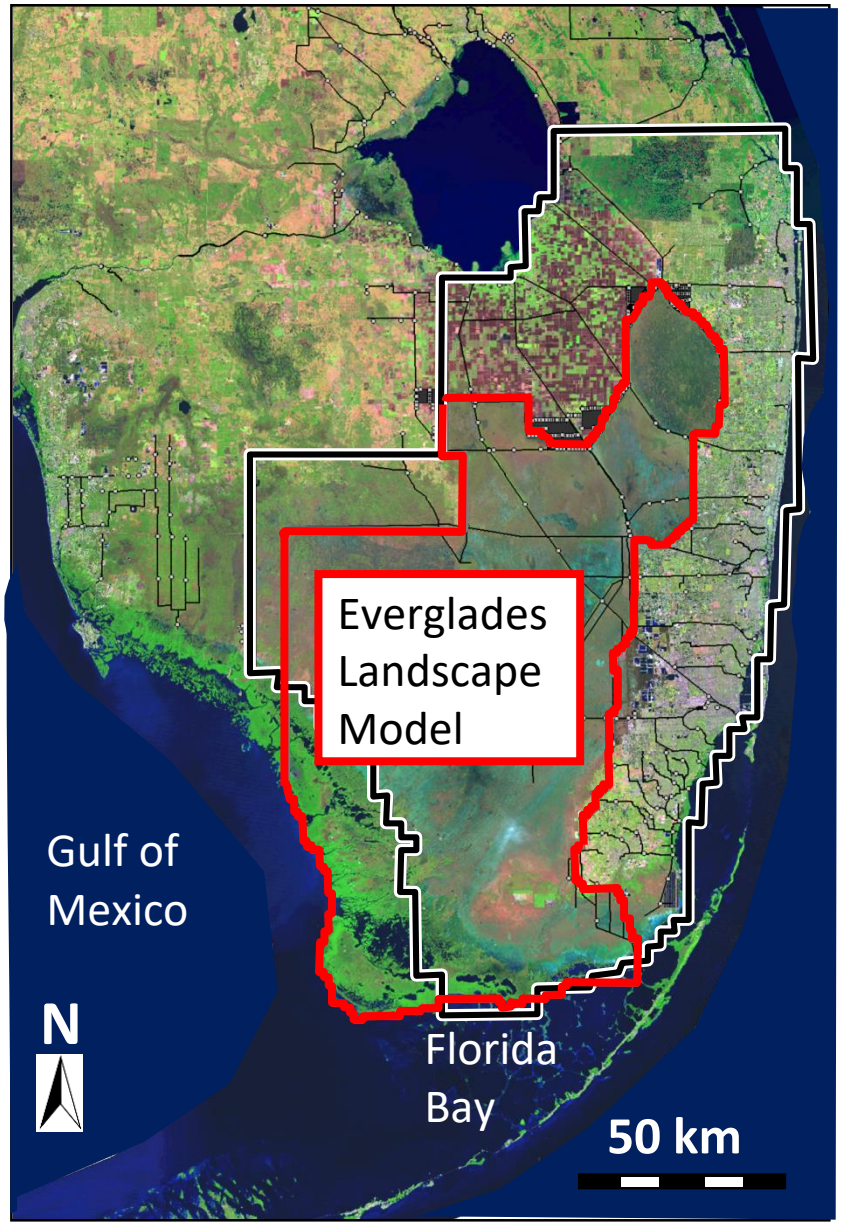
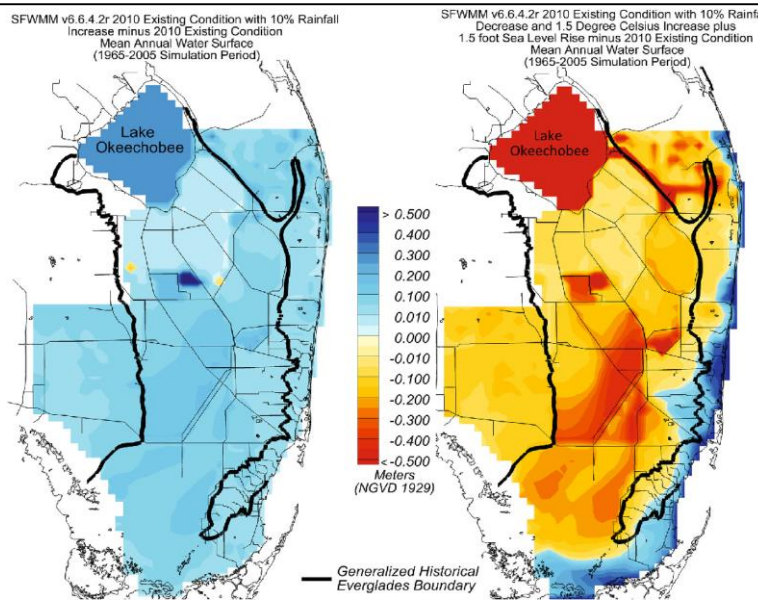
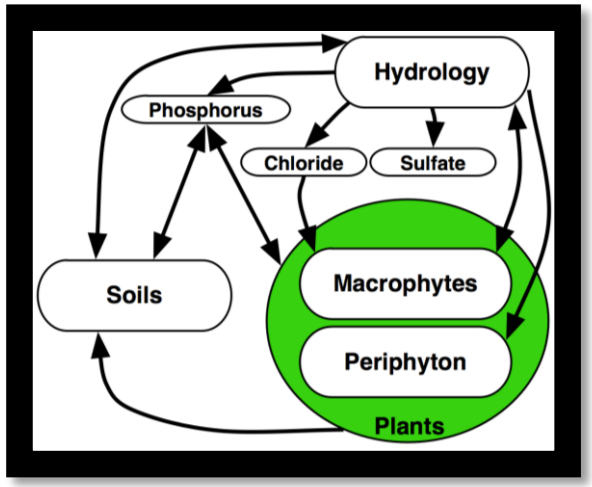
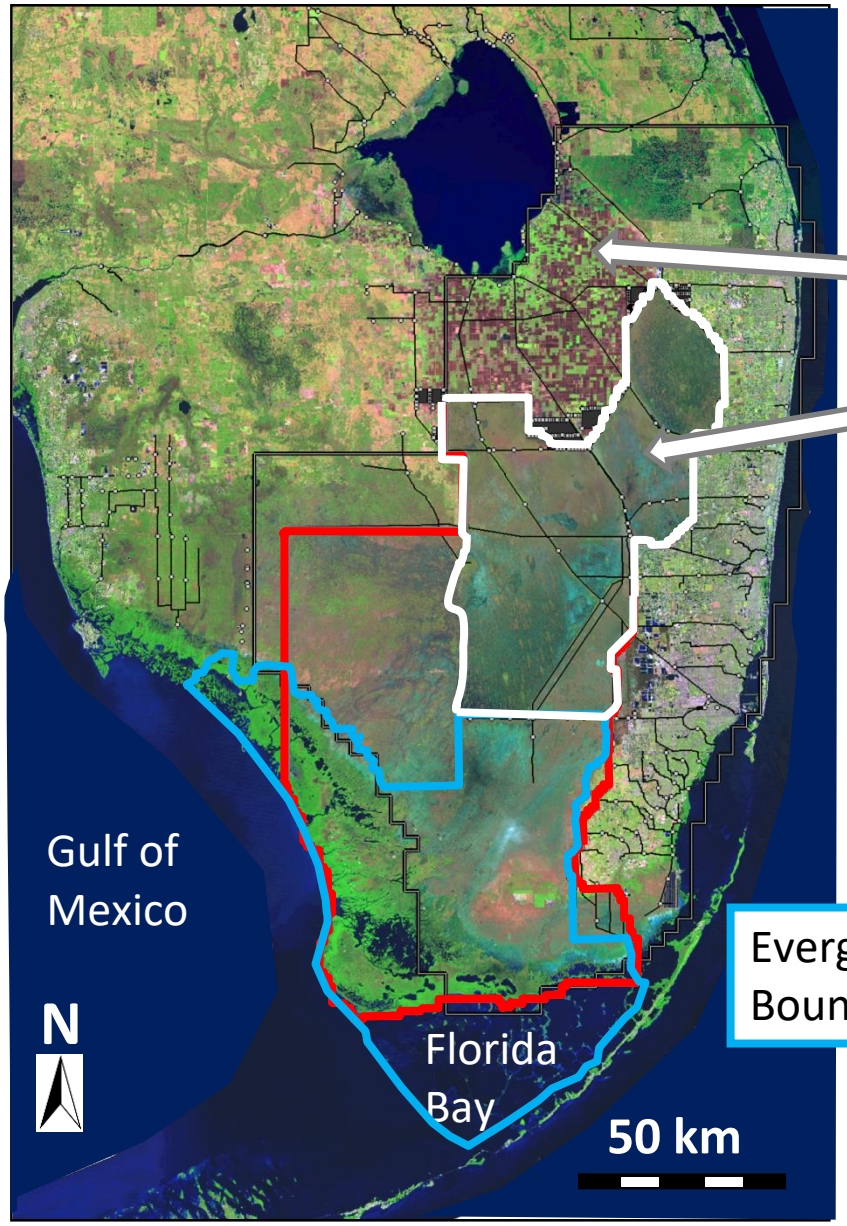


South Florida Water Management Model





Everglades Landscape Model



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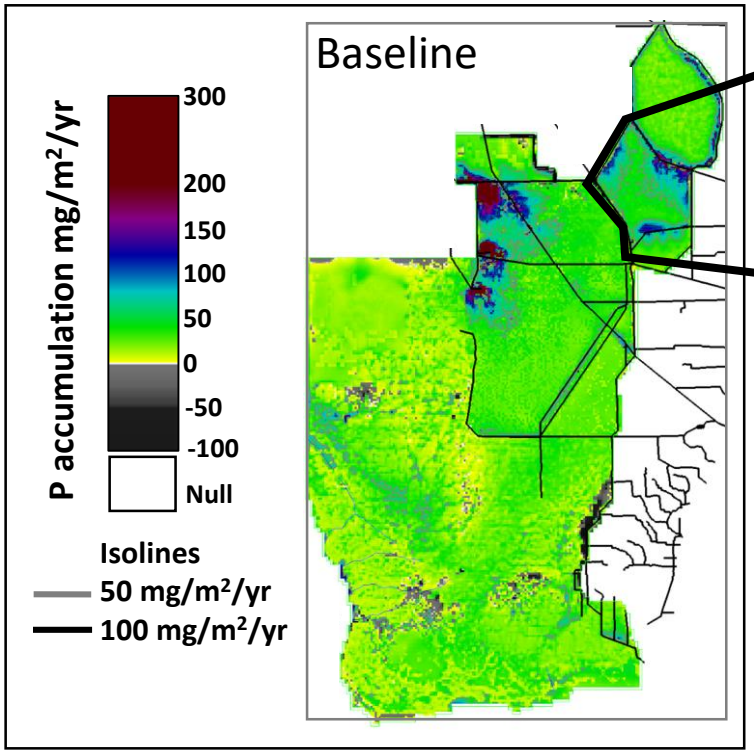
Phosphorus accumulation in soil



Cattail occurrence (Lagerwall et al. 2012)

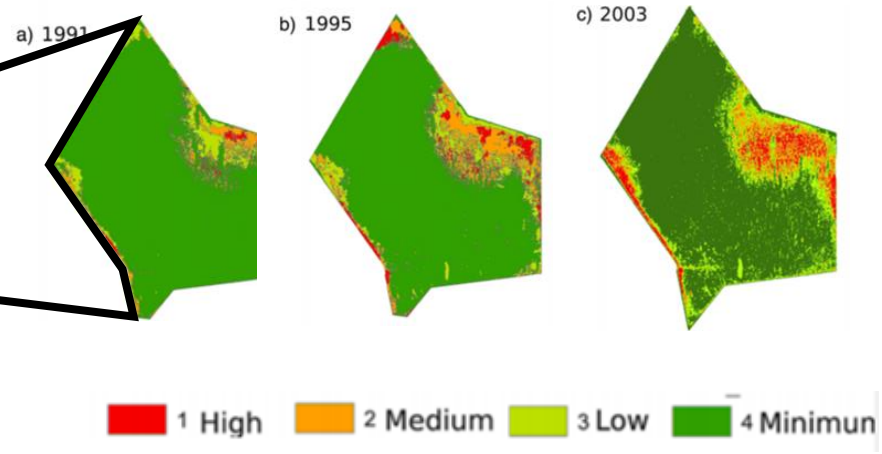
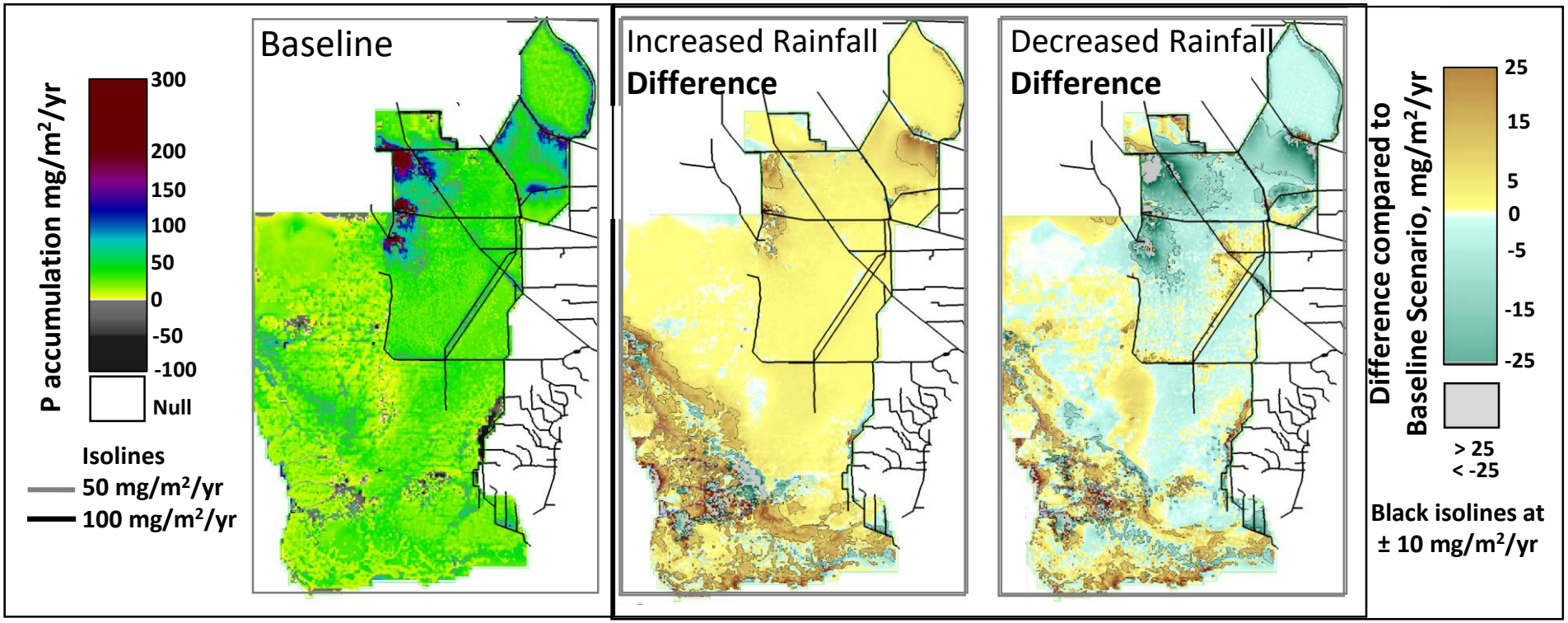


Photo: Ben Wilson

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 rate in soil



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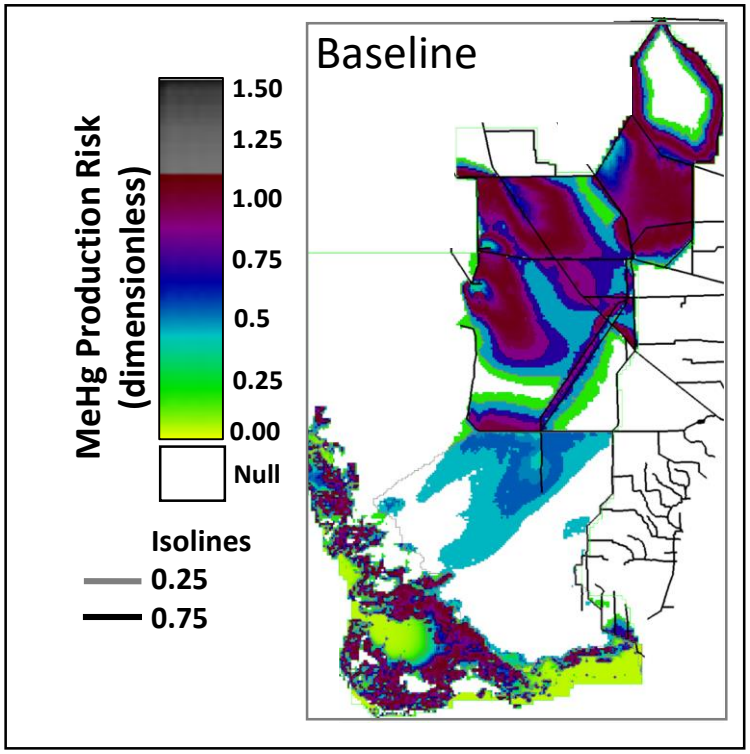
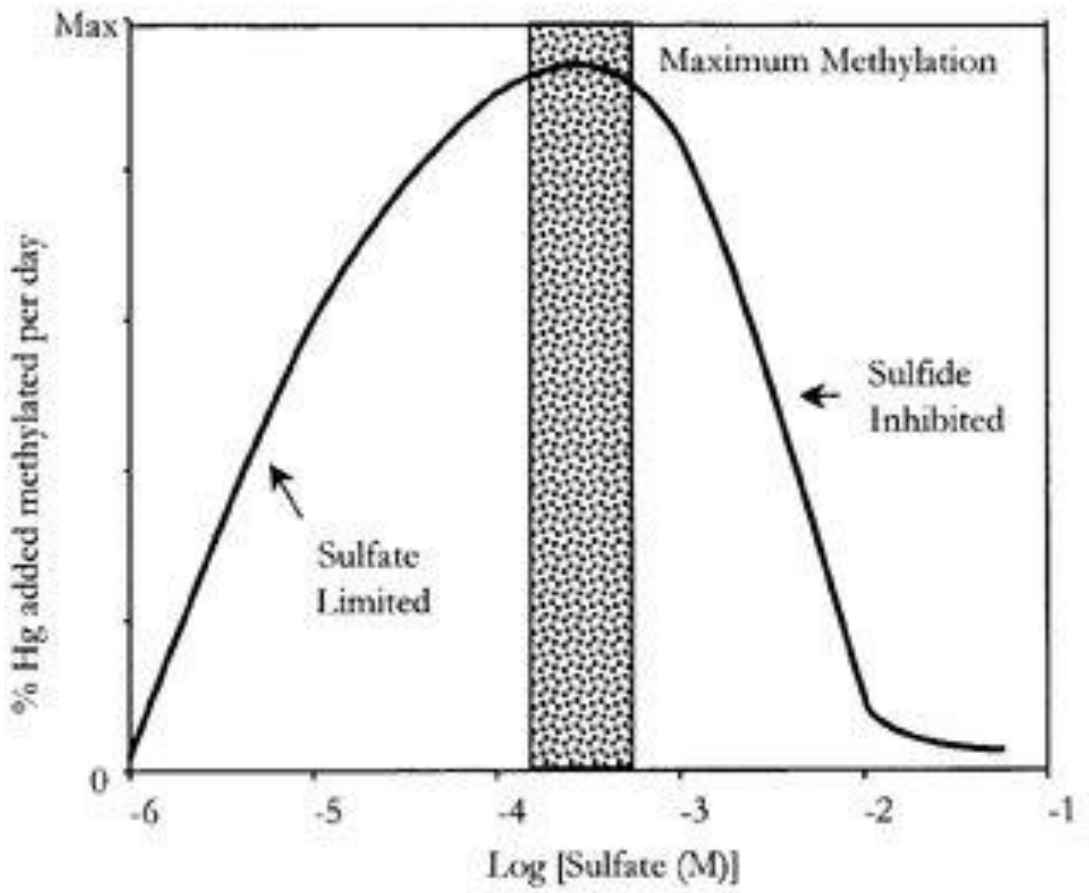
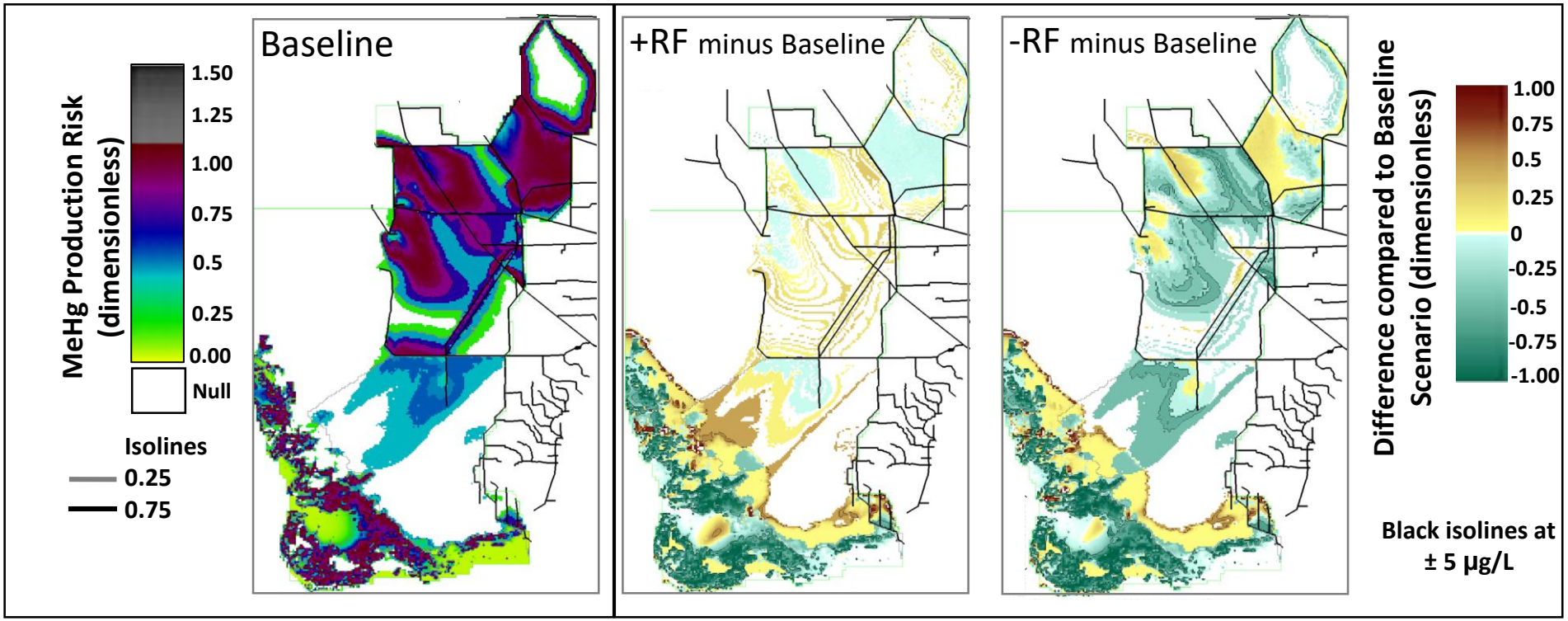
Methylmercury Production Risk





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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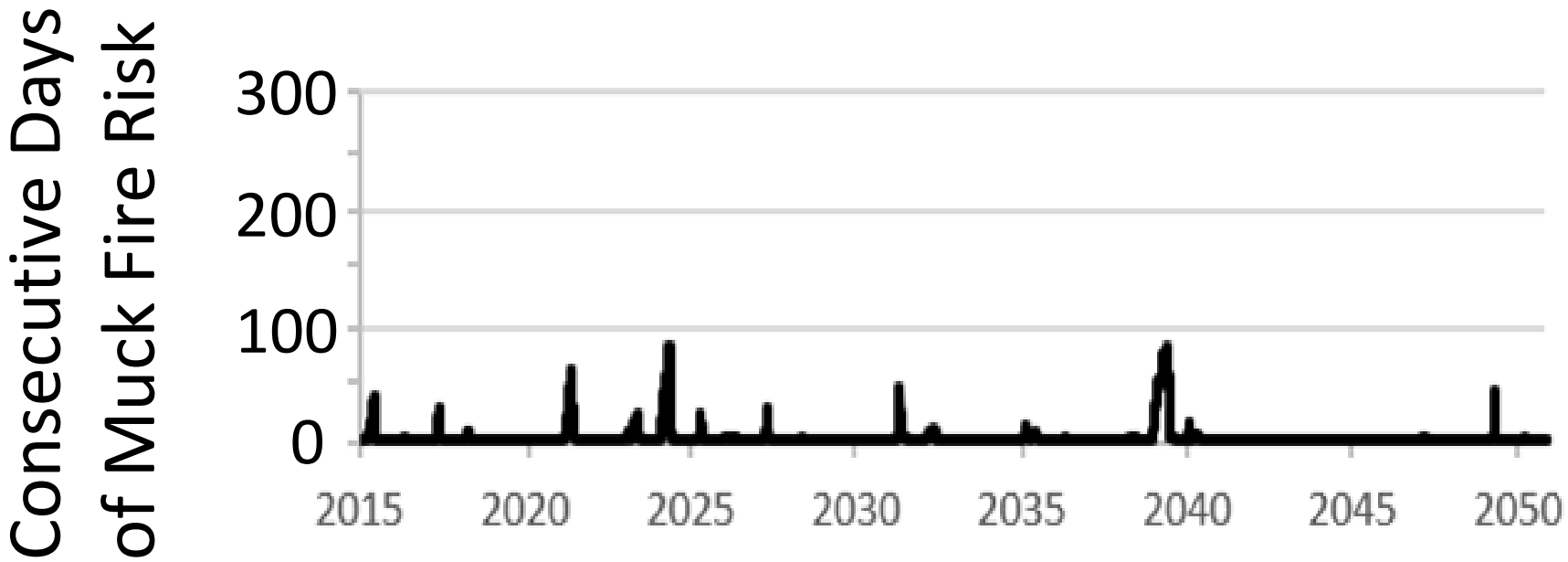
Muck fire risk index in ELM

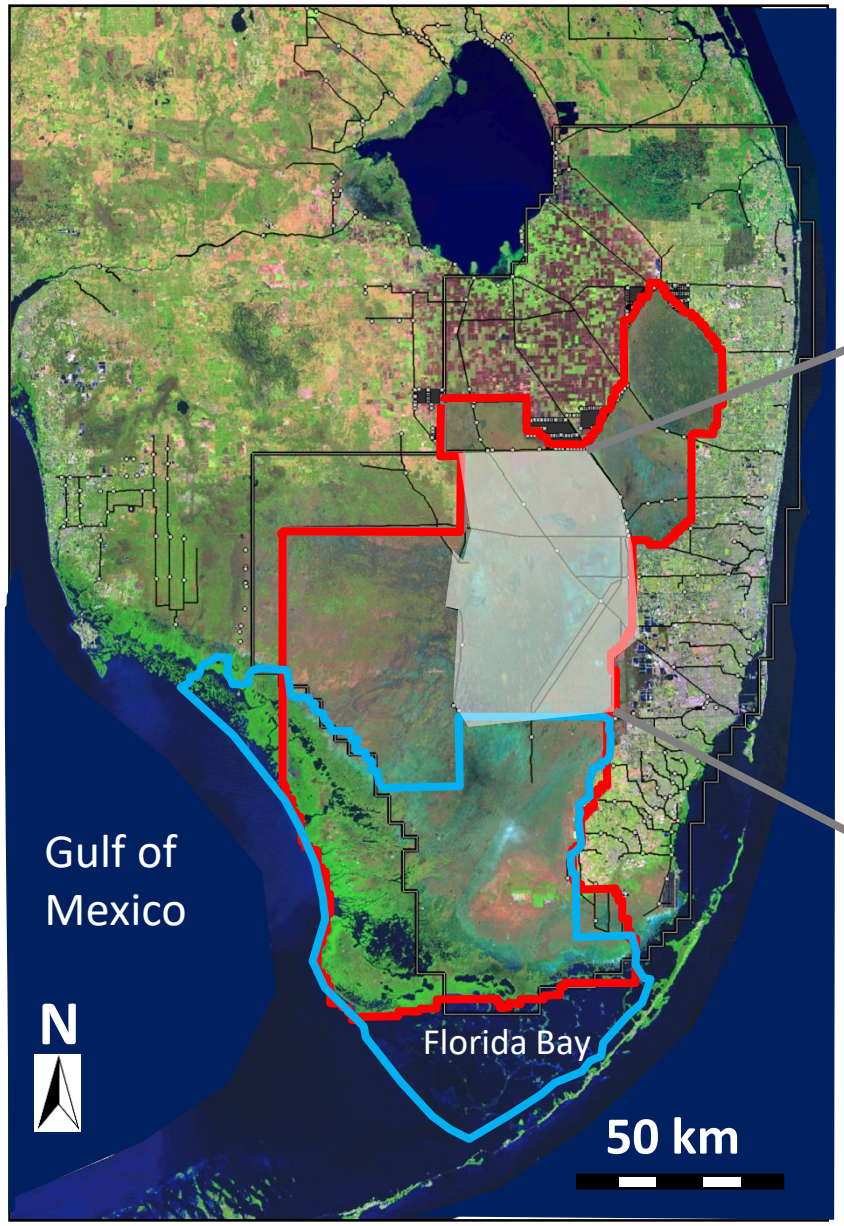
The cumulative number of consecutive days that the Unsaturated zone is

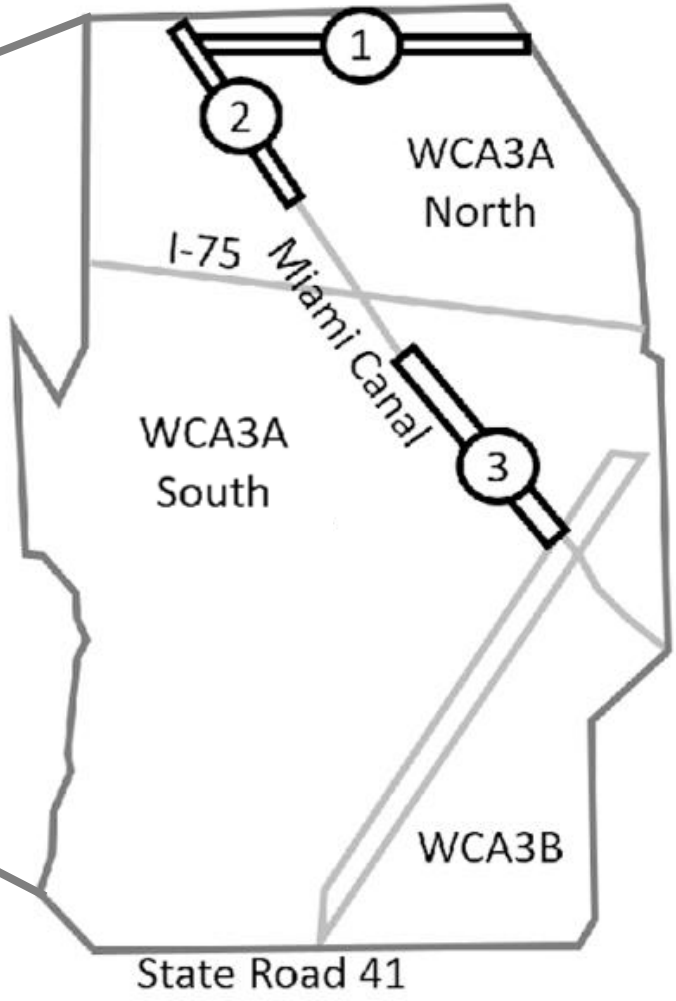
- Deeper than 15 cm below the land surface
- Moisture of <50%

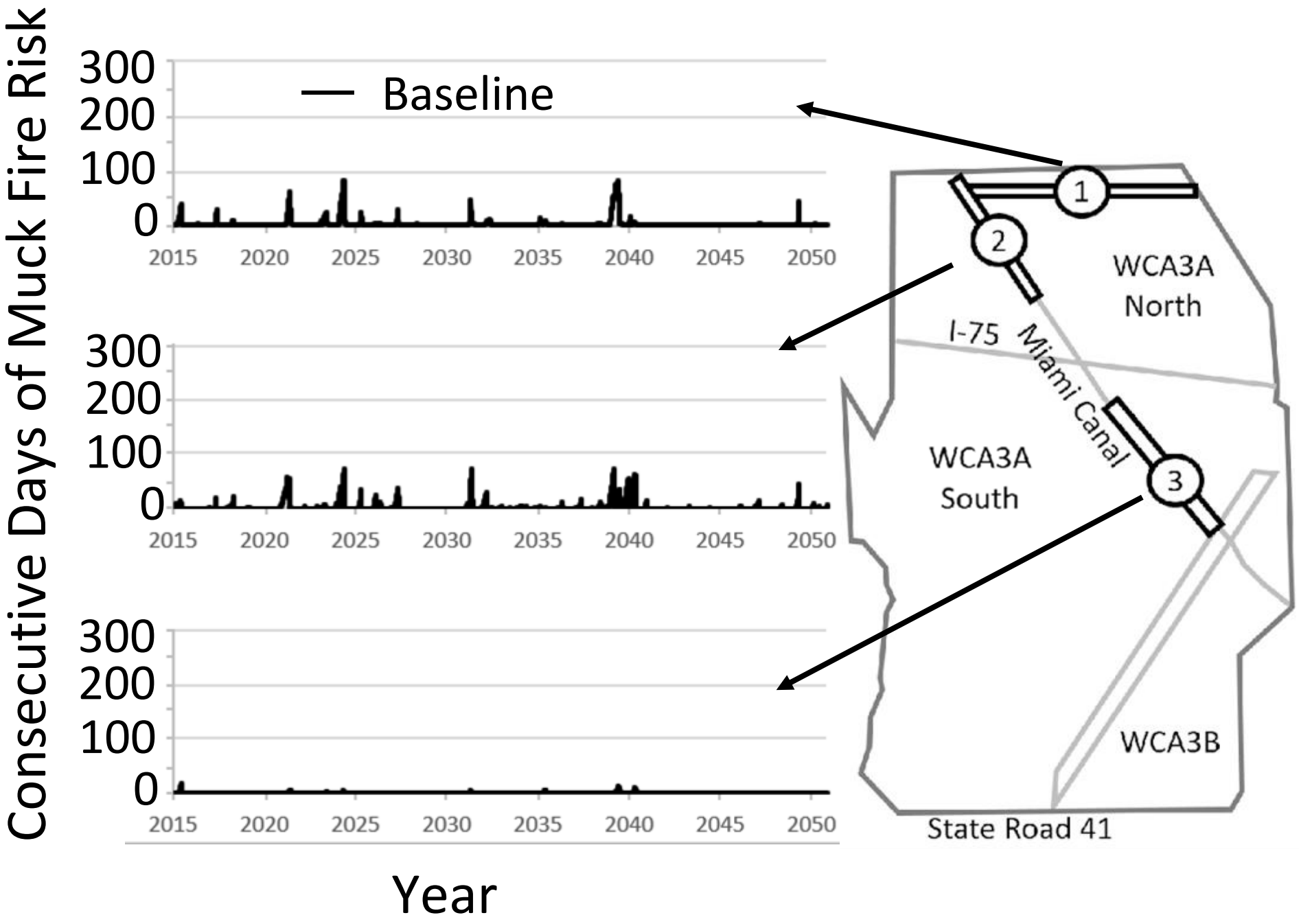


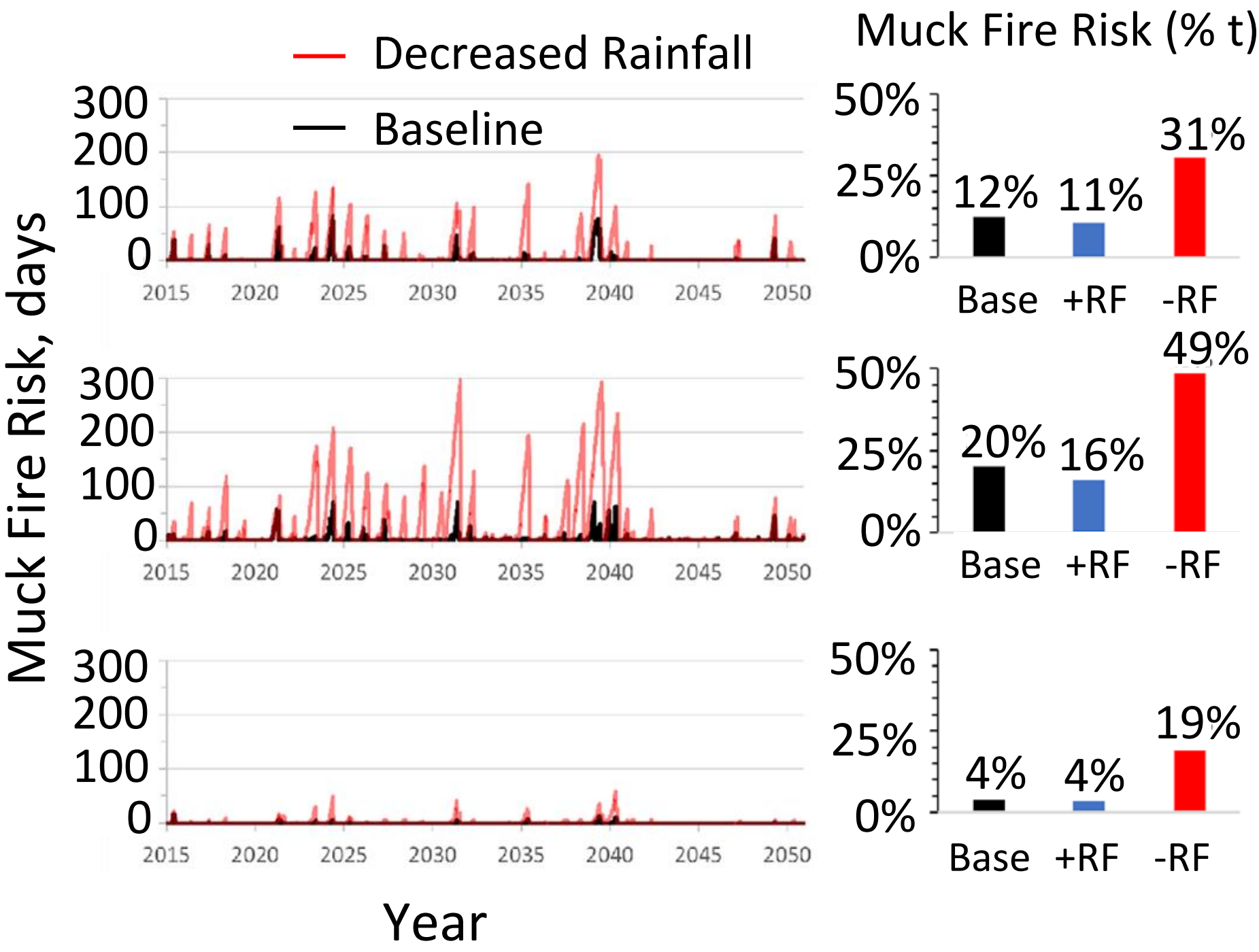
Interannual variability in rainfall from 1965-2005

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


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

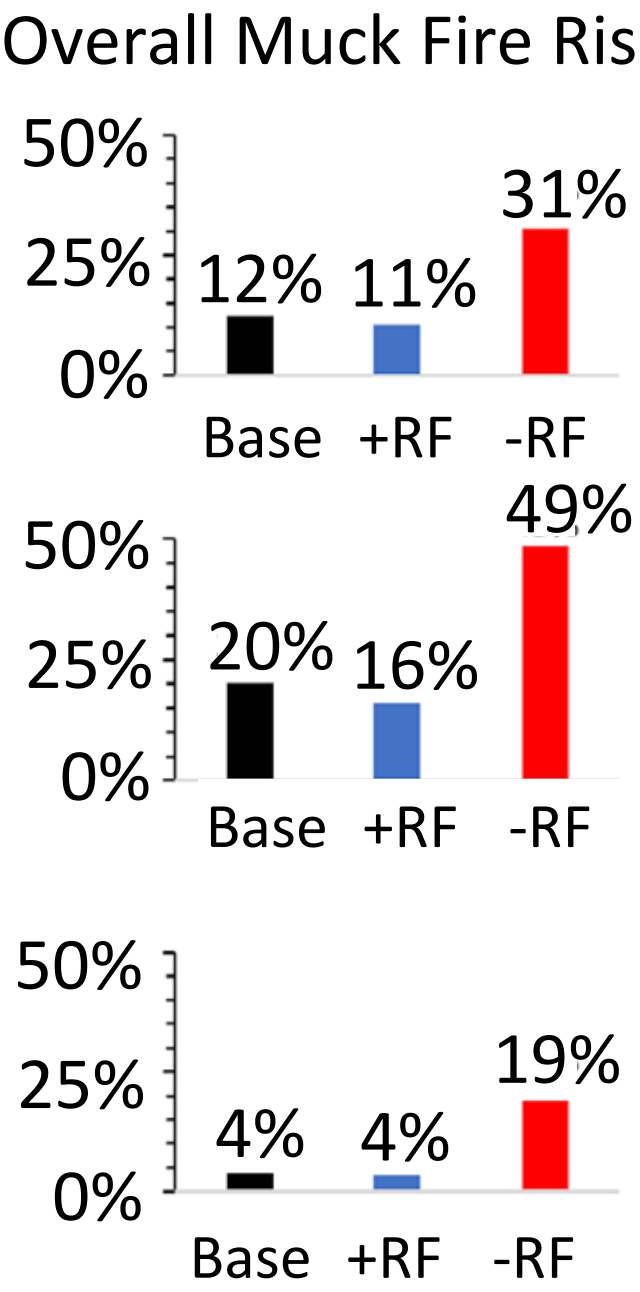
Slightly lower muck fire risk

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:

Shifting Ground: Landscape-Scale Modeling of Soil Biogeochemical Processes under Climate Change in the Florida Everglades