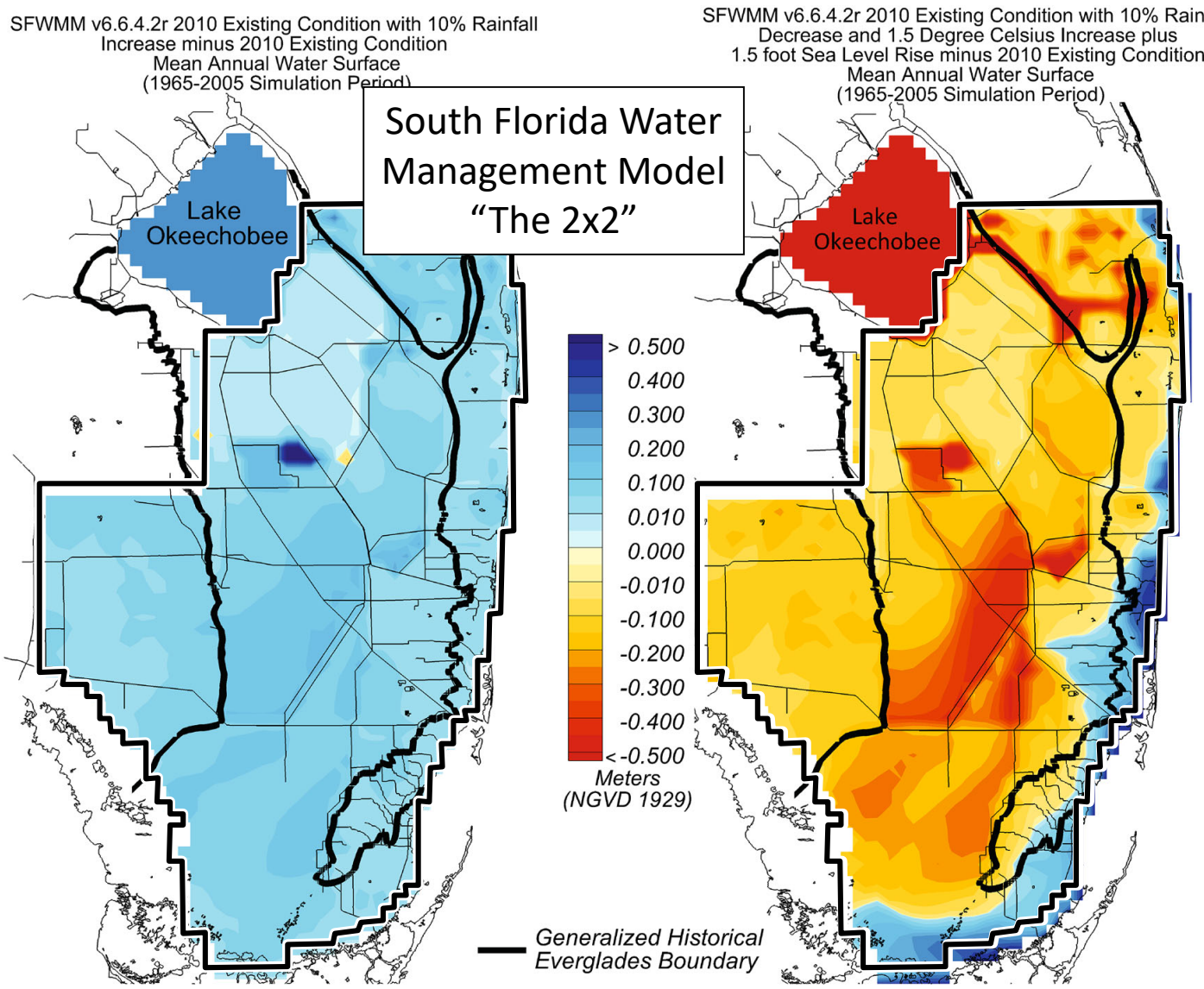
Shifting Ground:

Landscape-Scale Modeling Of Soil Biogeochemistry under Climate Change in the Florida Everglades

Hilary Flower
Mark Rains
Carl Fitz
Bill Orem
Sue Newman
Todd Osborne
Ramesh Reddy
Jayantha Obeysekera

GEER 2019

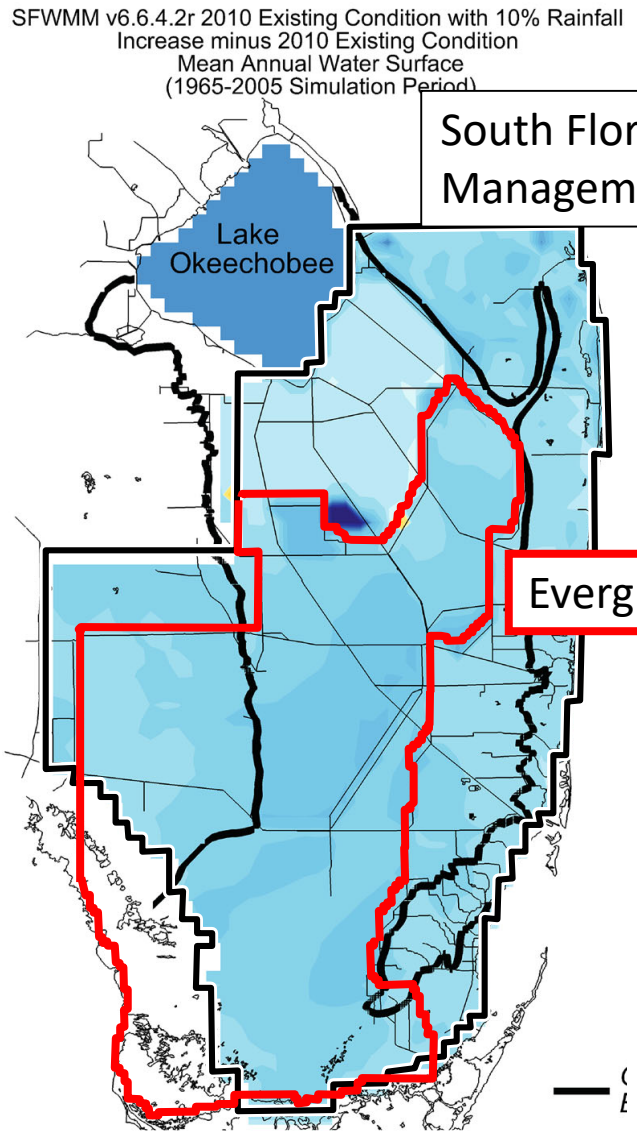

How do you plan restoration in the face of climate change?
Vulnerabilities and Resilience
Restoration: Risks and Benefits



Climate Sensitivity Runs and Regional Hydrologic Modeling for Predicting the Response of the Greater Florida Everglades Ecosystem to Climate Change

Jayantha Obeysekera · Jenifer Barnes · Martha Nungesser

[Obesekera et al., 2015]



South Florida Water Management Model

Water levels
Water flows through control structures

Everglades Landscape Model

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

Today's Talk
Three Climate Scenarios
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Results: Maps of Soil Phosphorus
Map of Methylmercury Production
Time Series of Muck Fire Risk
Implications for Restoration

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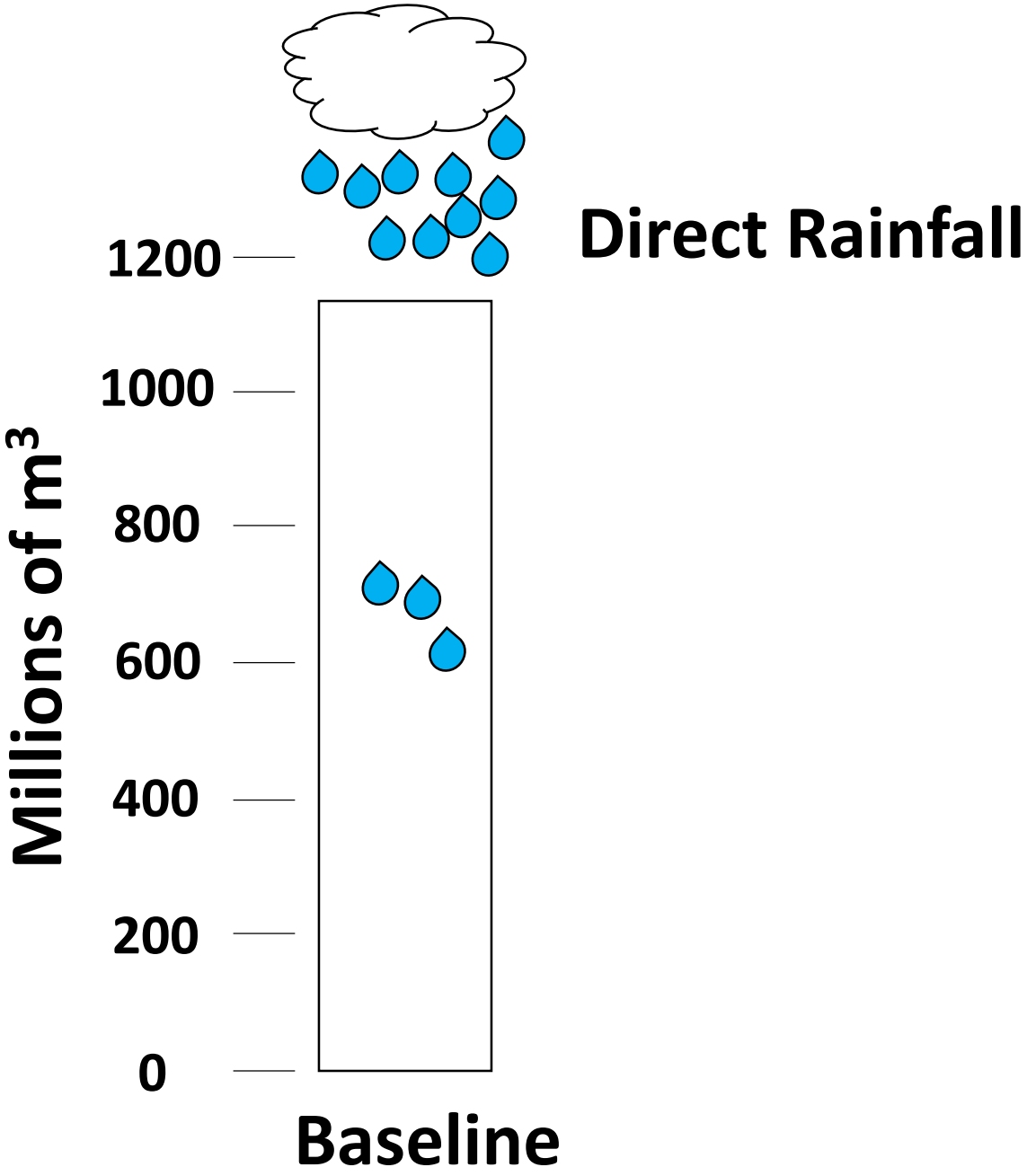
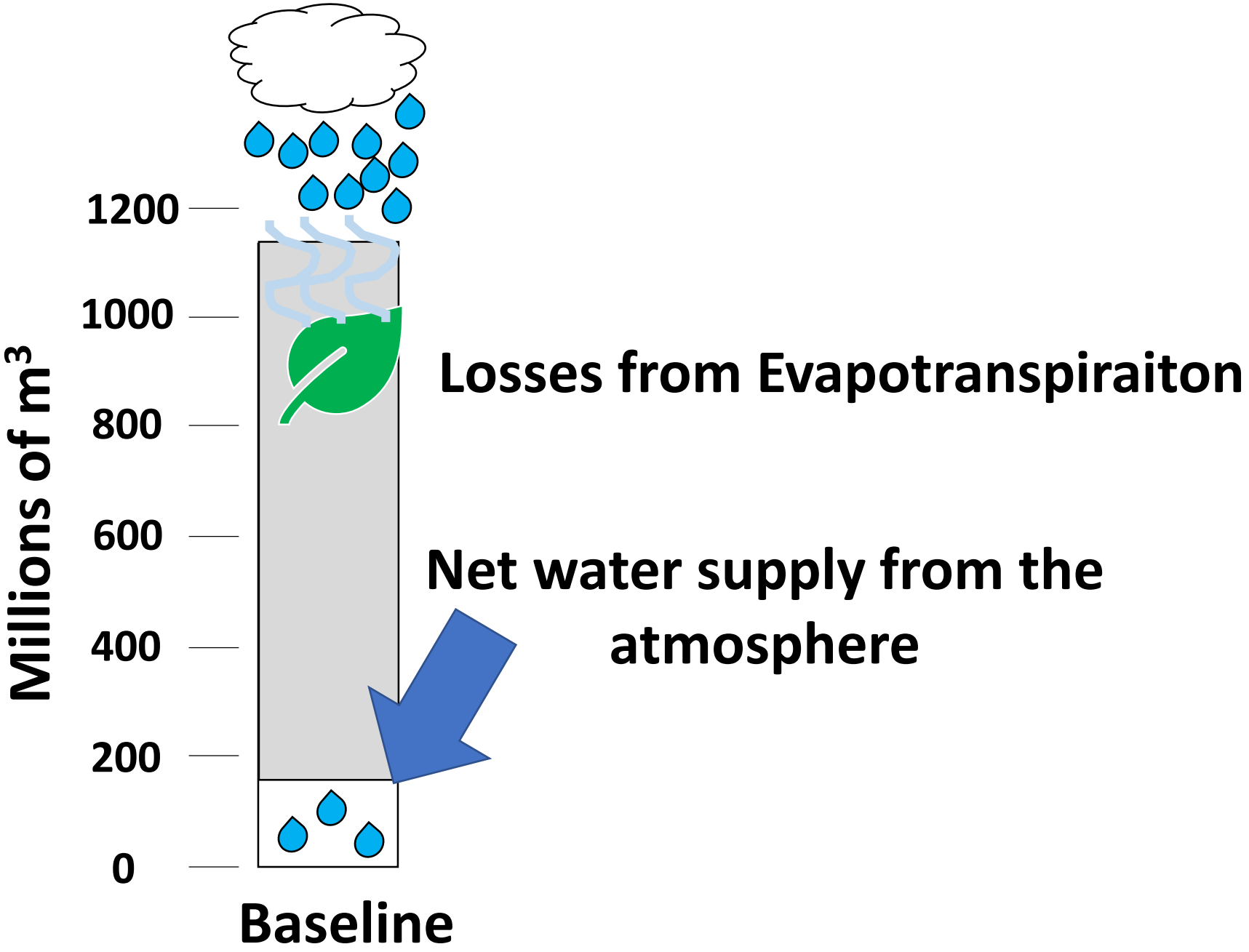
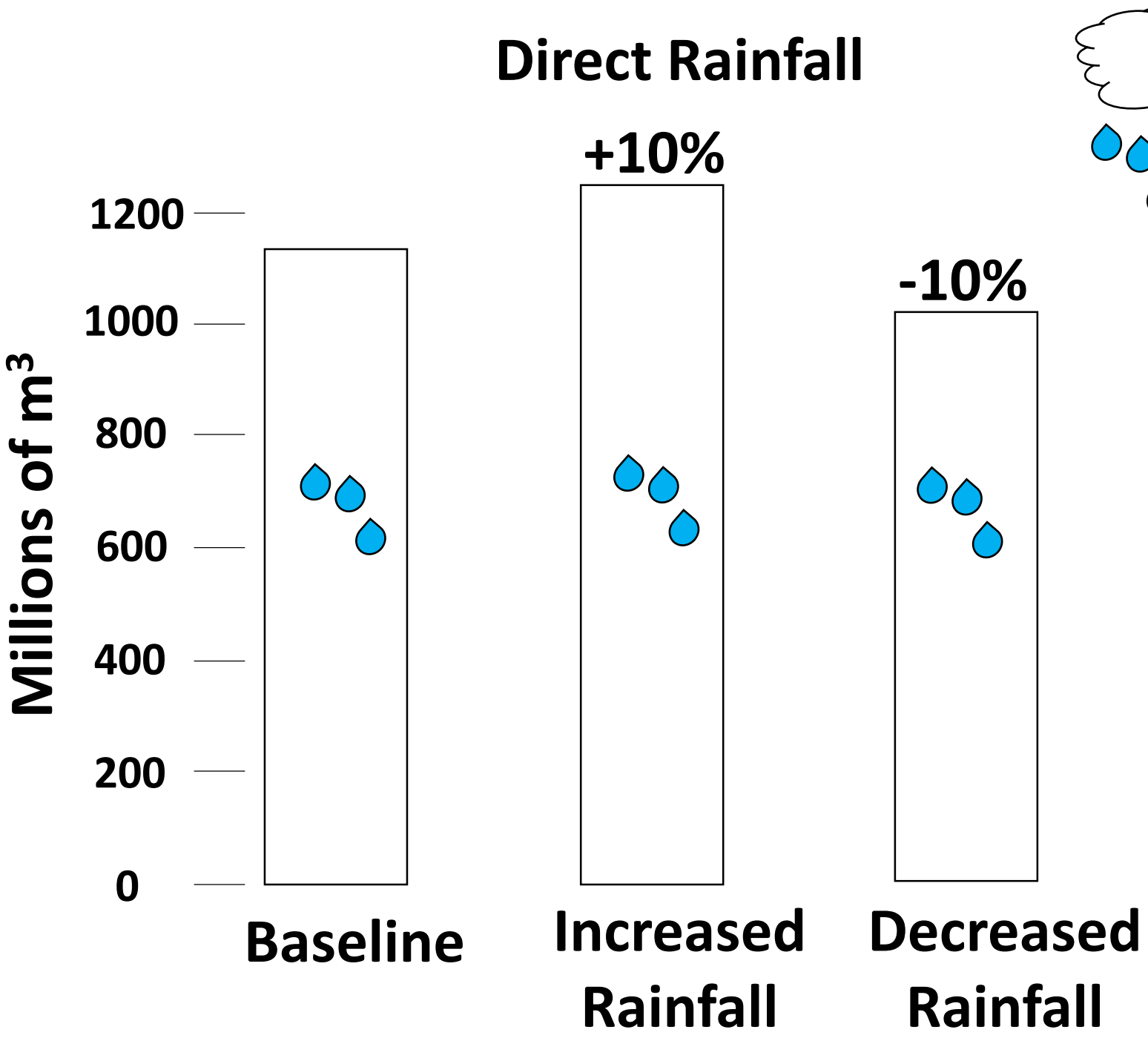
2010 Baseline +
Two climate change scenarios:

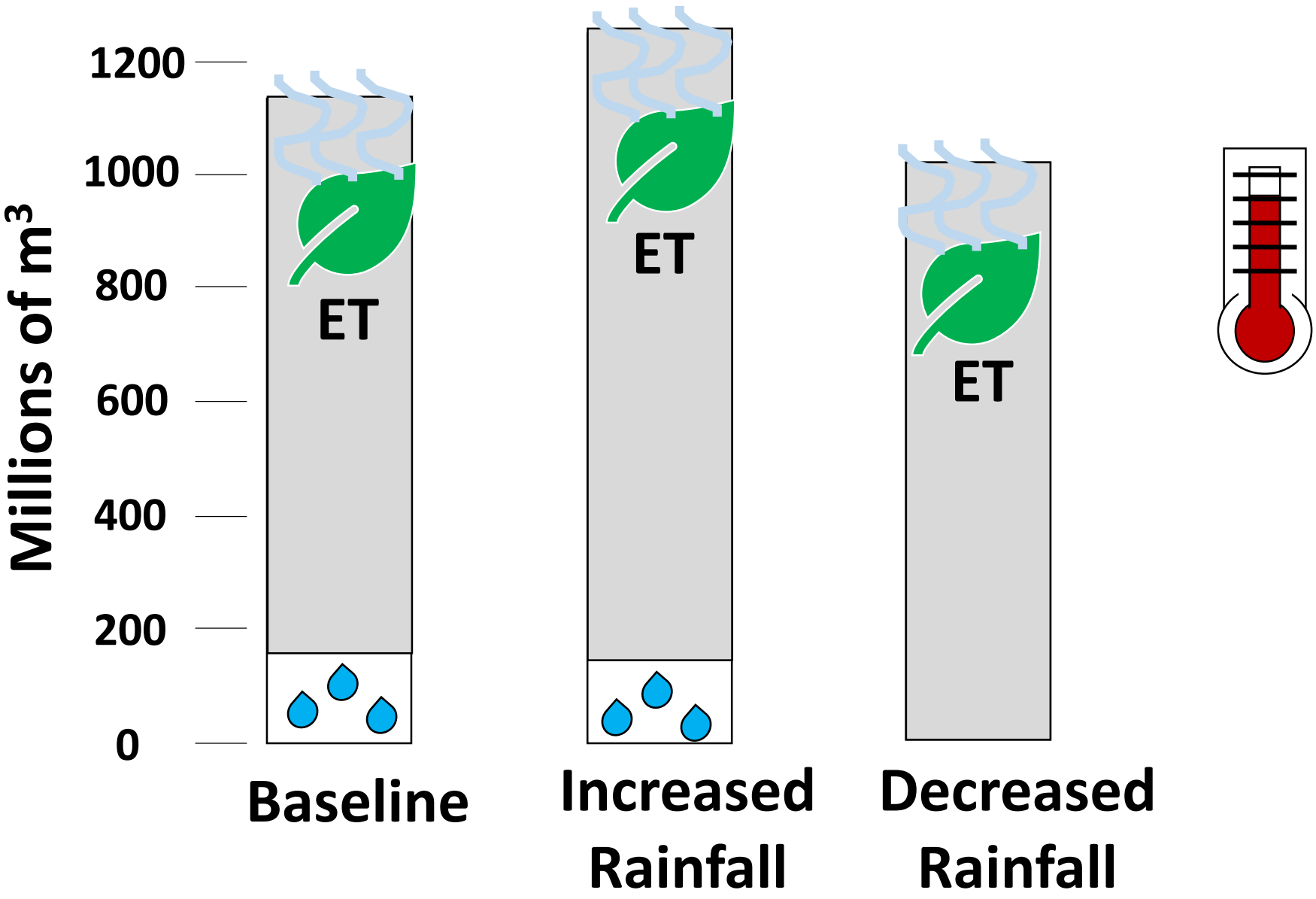
“CERP 0”

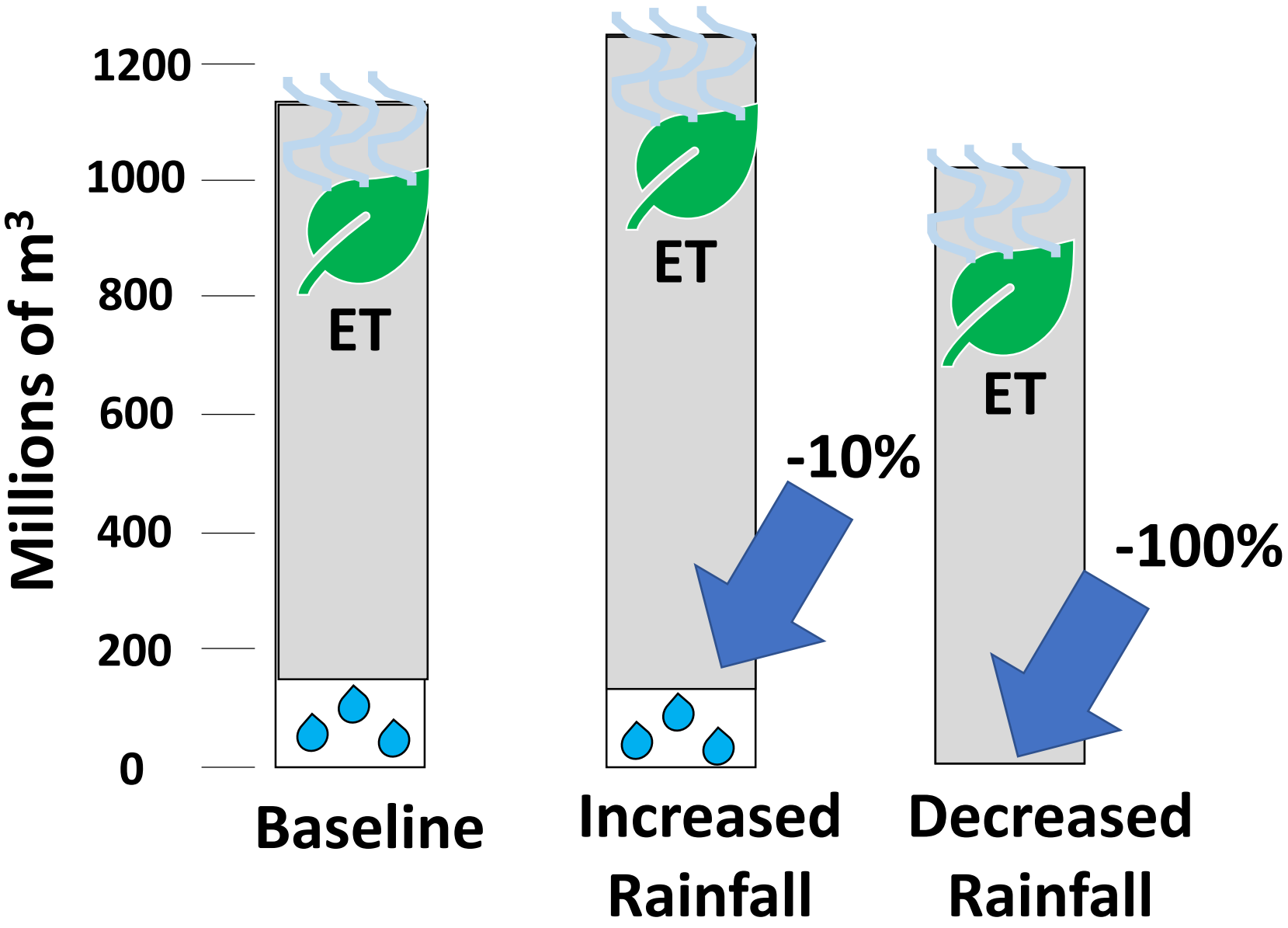
Obesekera et al., 2011

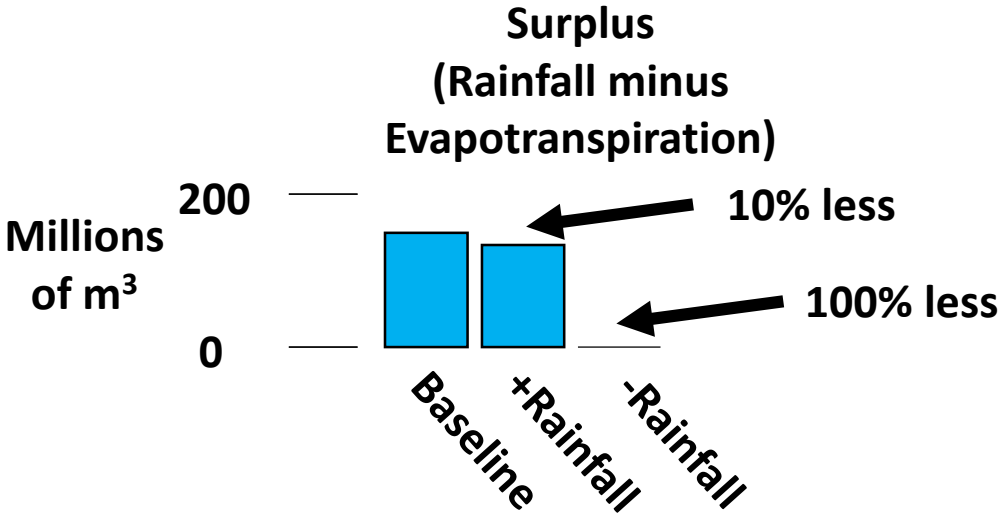

Direct Rainfall
1200
1000
800
600
400
200
0
Millions of m3
Baseline


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

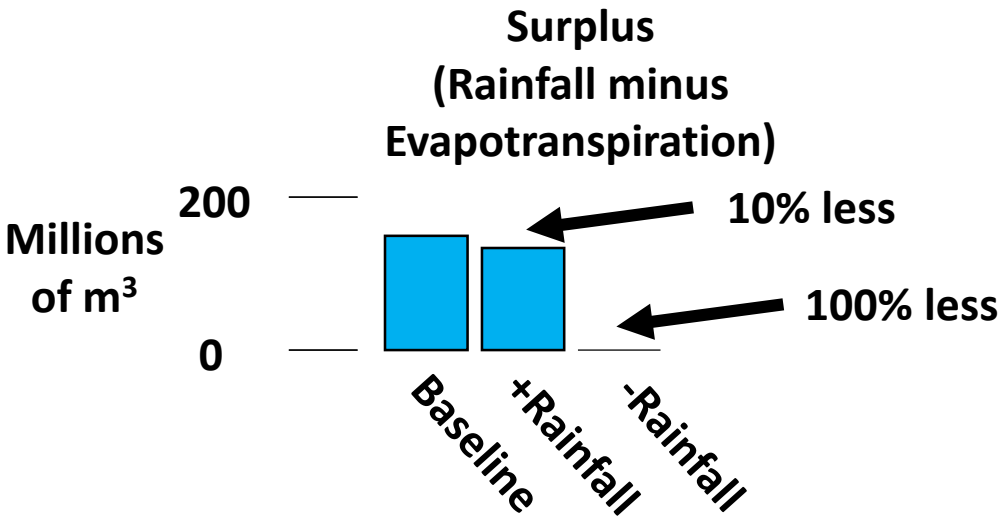

Direct Rainfall
+10%
-10%
1200
1000
800
600
400
200
0
Millions of m3
Baseline
Increased Rainfall
Decreased Rainfall

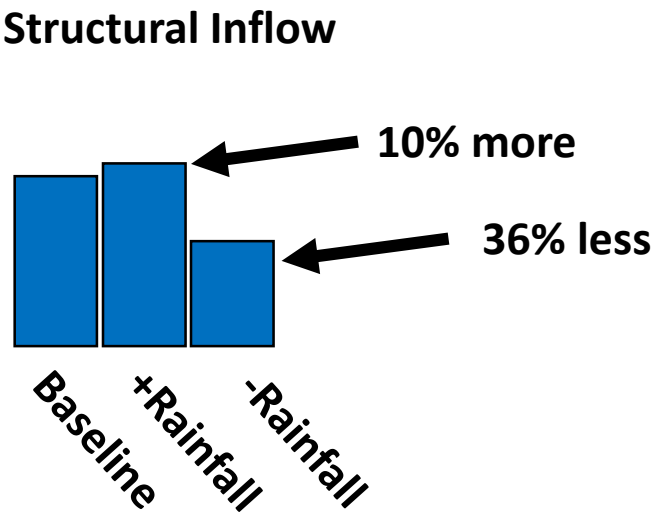

Millions of m3
1200
1000
800
600
400
200
0
ET
ET
ET
Baseline
Increased Rainfall
Decreased Rainfall


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

Results: Maps of Soil Phosphorus

Map of Methylmercury Production

Time Series of Muck Fire Risk

Implications for Restoration

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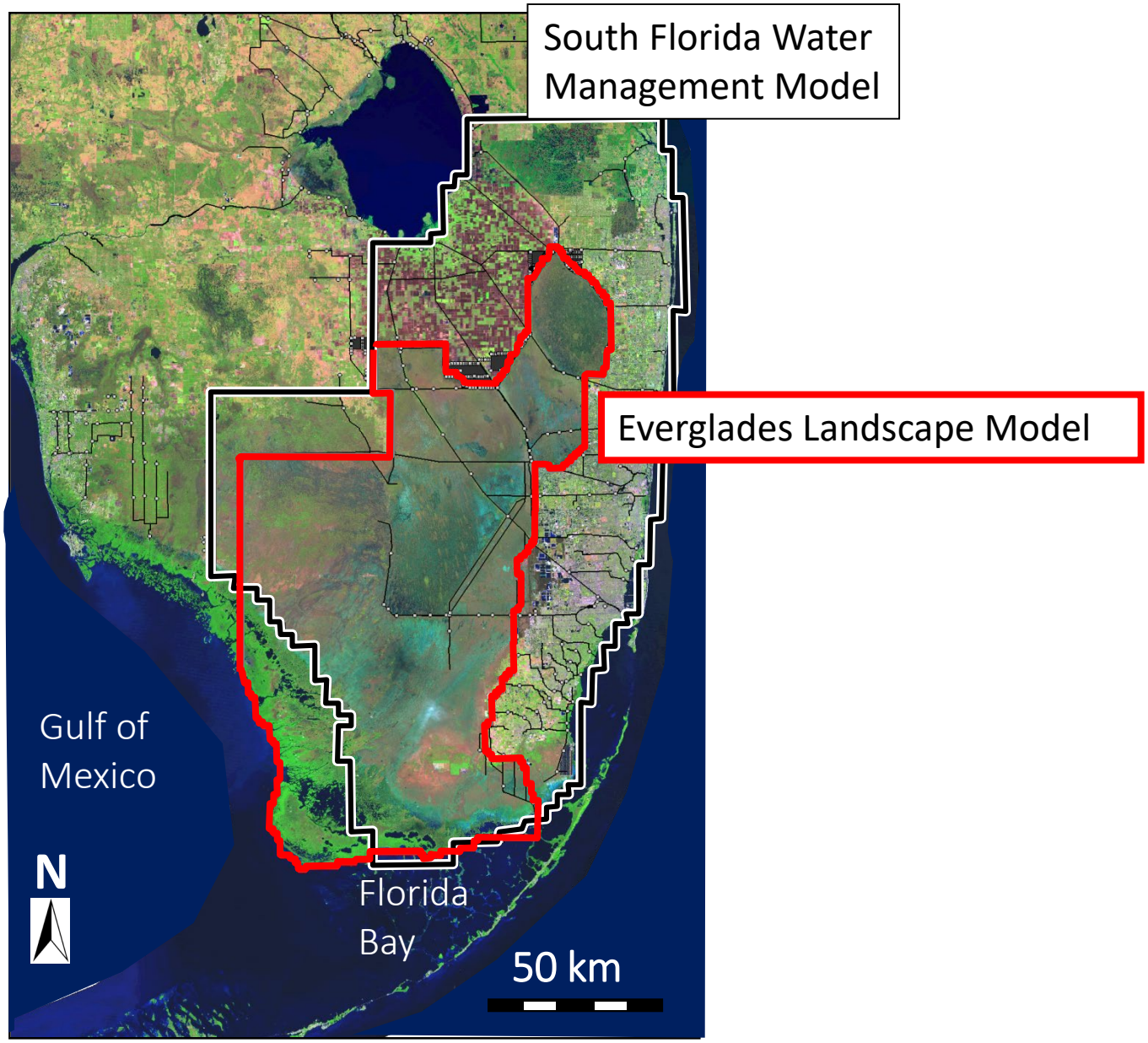
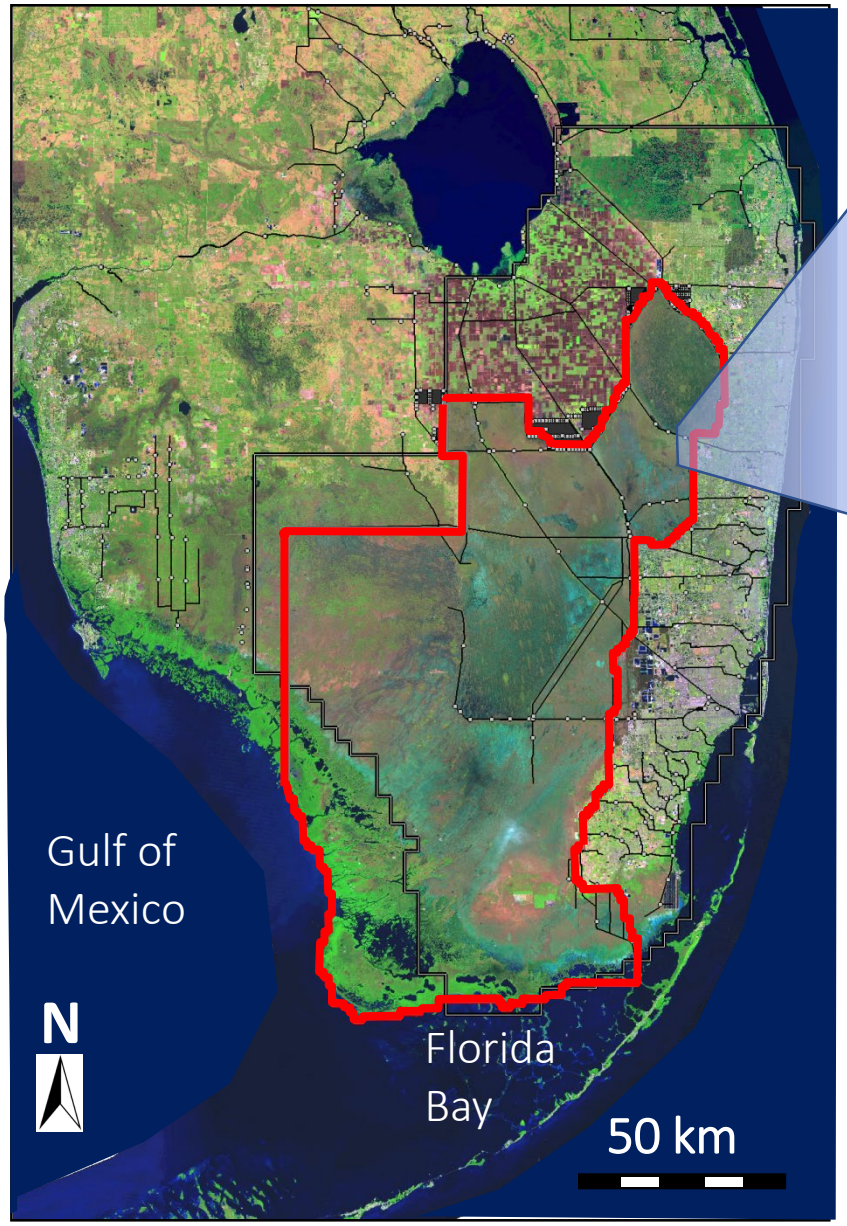
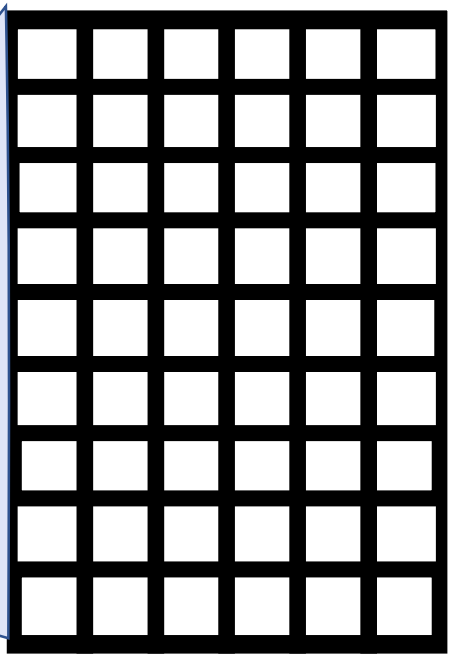
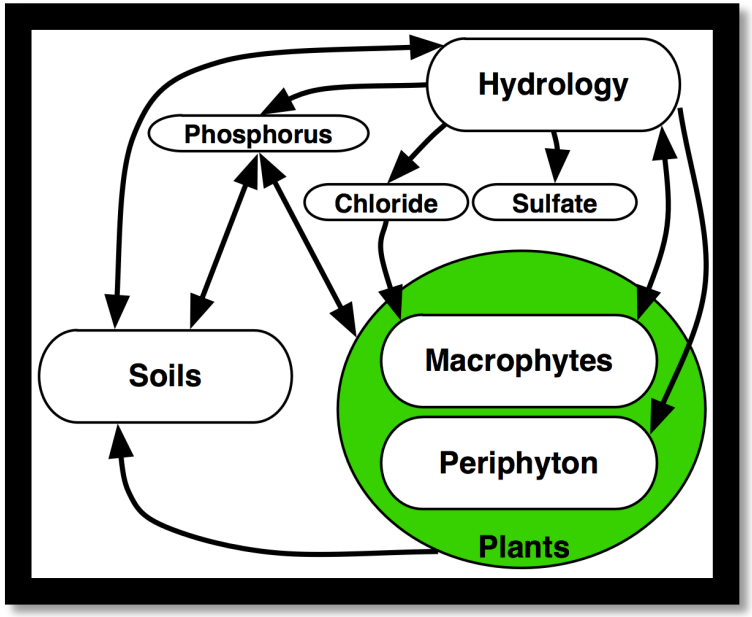

South Florida Water Management Model
Everglades Landscape Model
Gulf of Mexico
Florida Bay
N
50 km

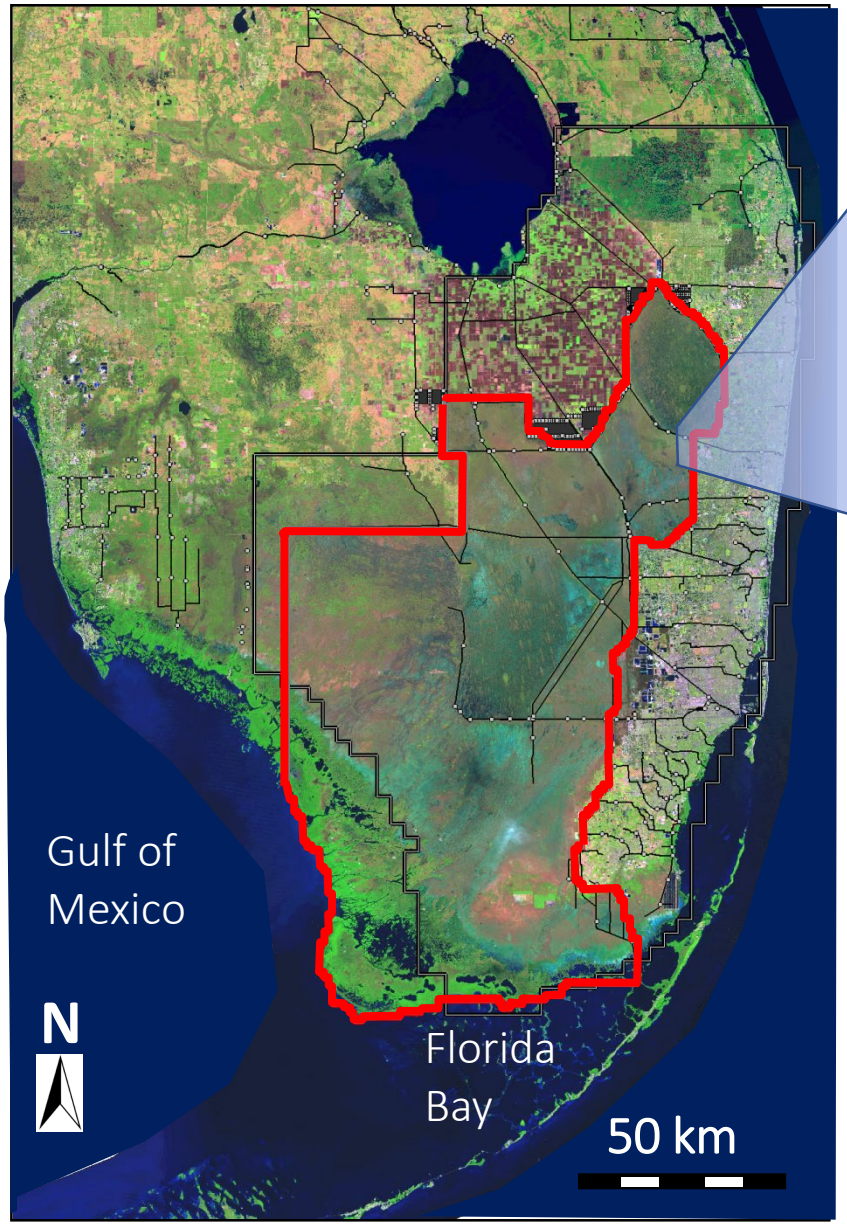
Everglades Landscape Model

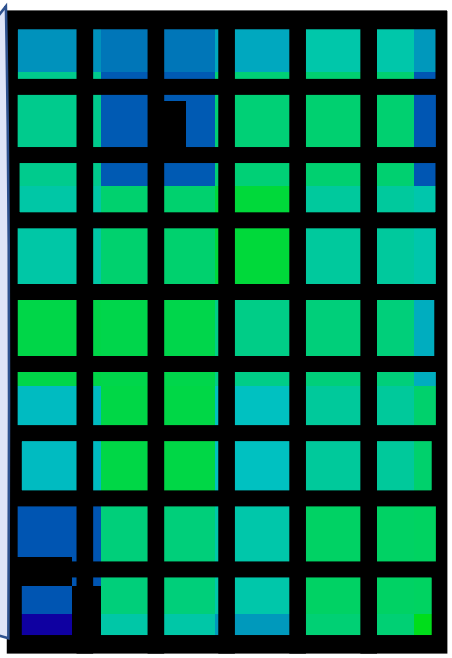






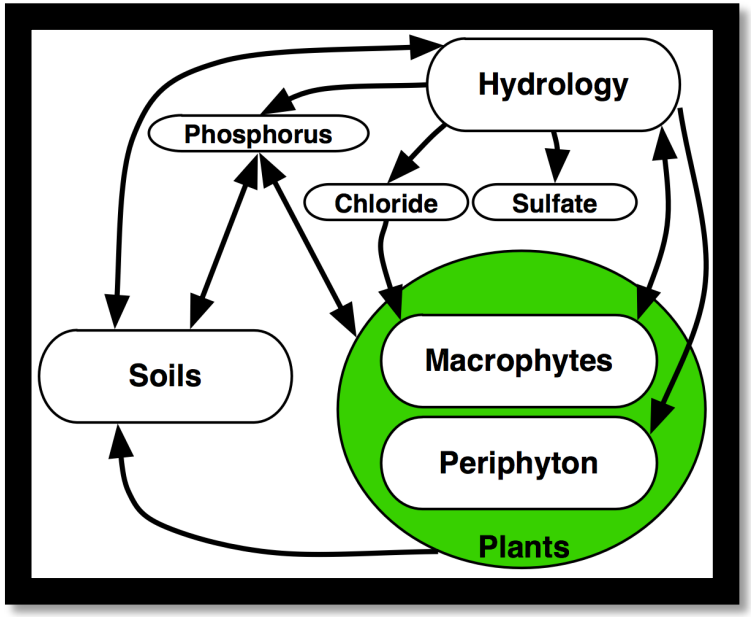
Everglades Landscape Model



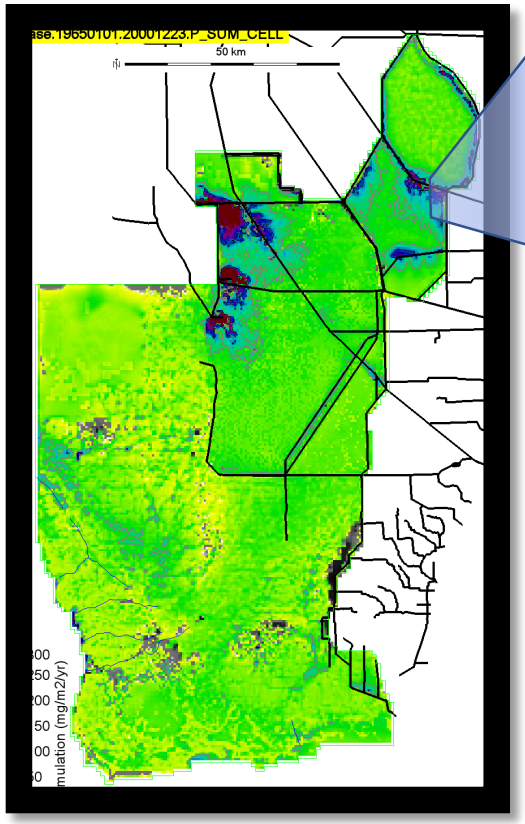


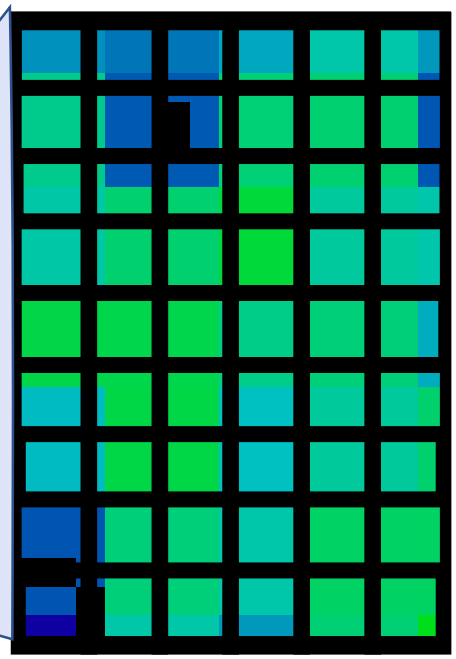
Phosphorus Accumulation Rate mg/m²/yr

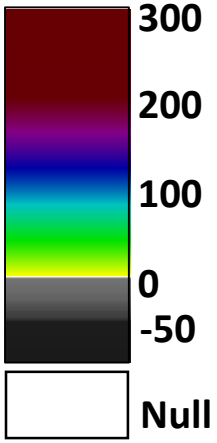
300
200
100
0
-50
Null



Everglades Landscape Model







Phosphorus Accumulation Rate in Peat Soil

$mg/m^2/yr$

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Phosphorus accumulation rate in peat soil

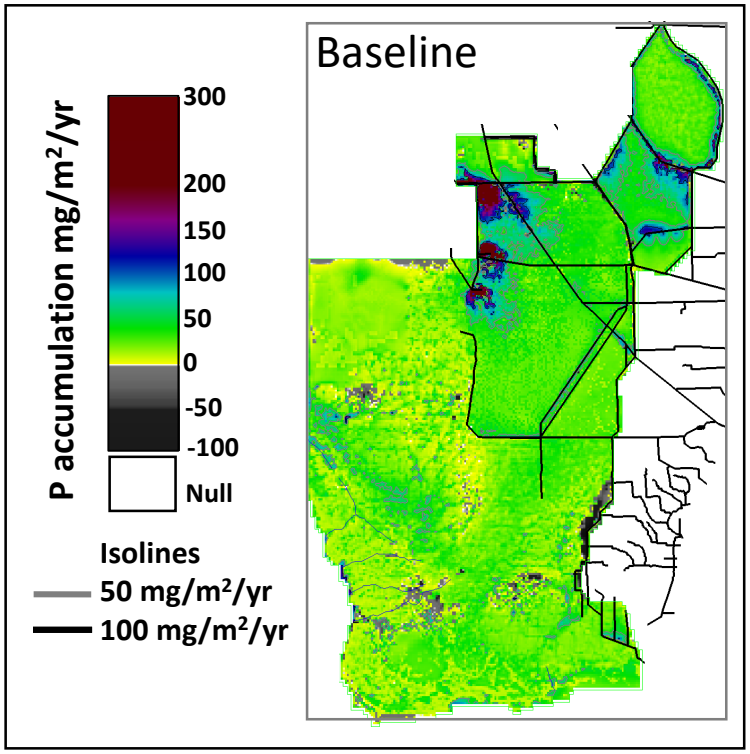
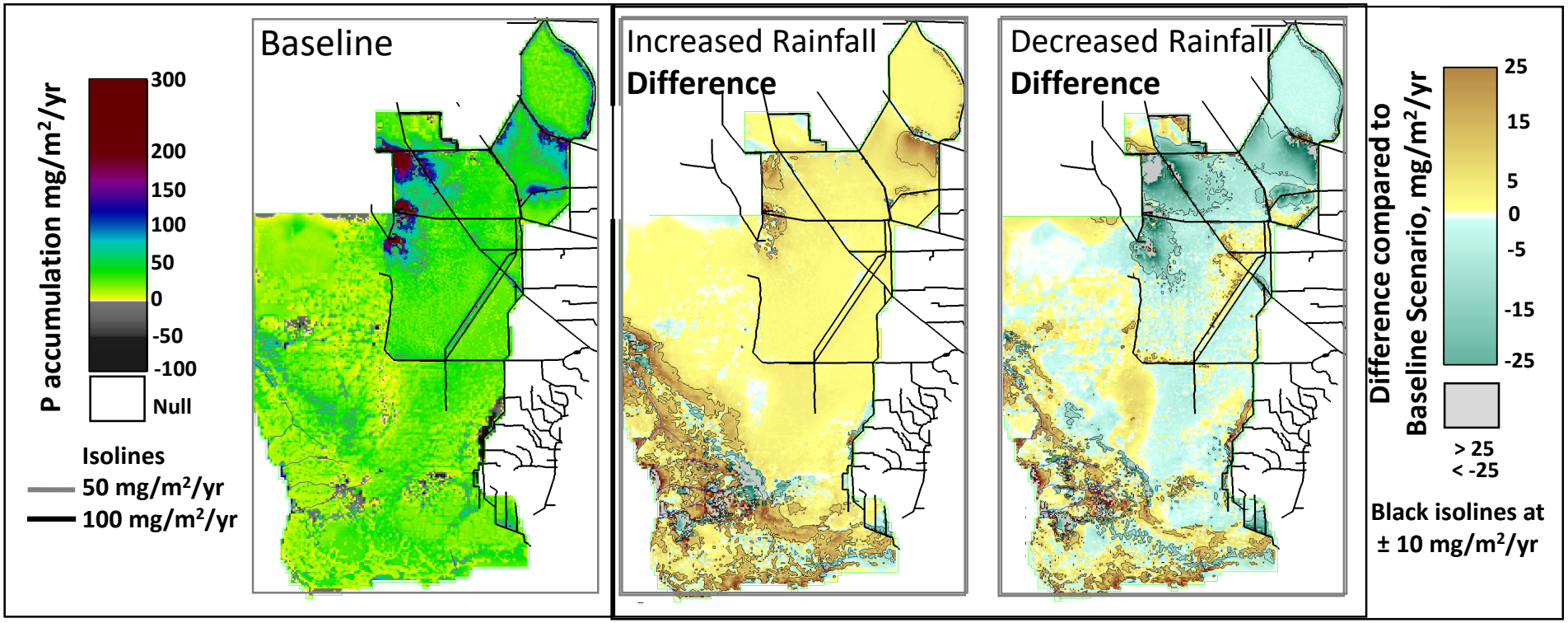
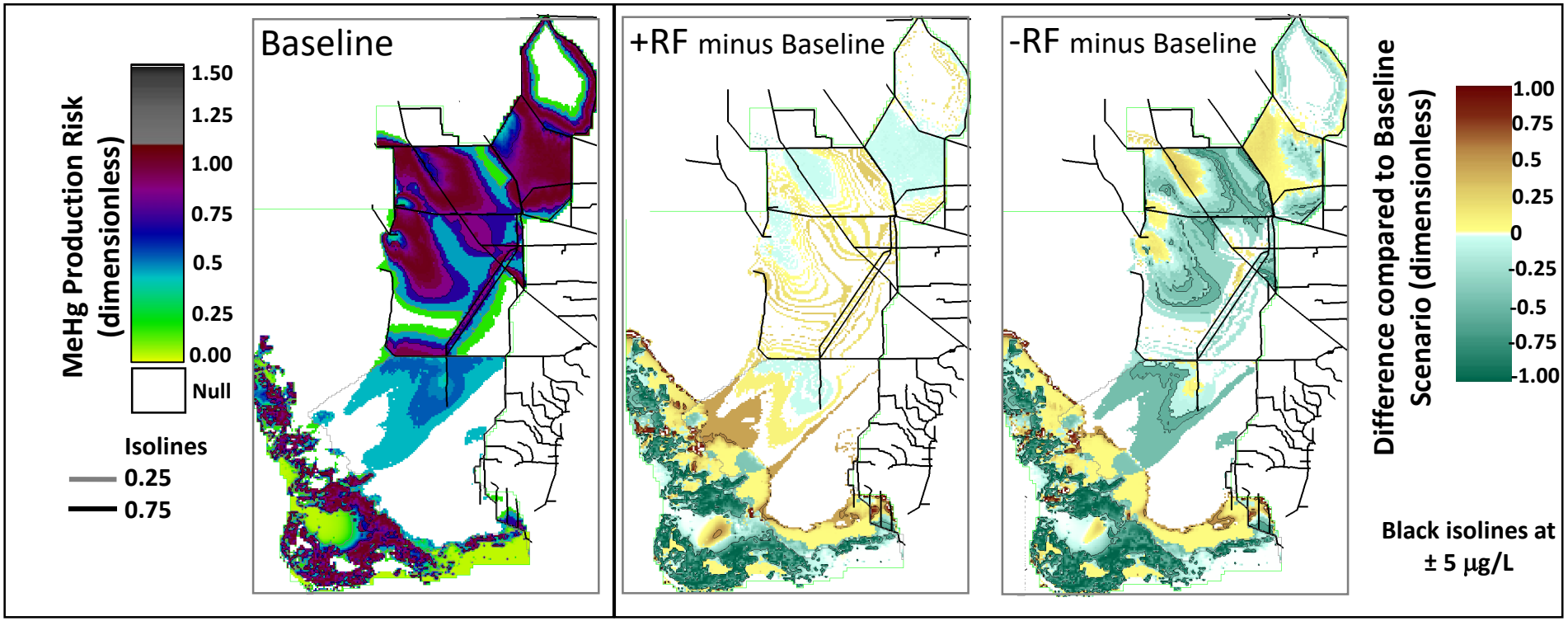


Photo: Ben Wilson

Phosphorus accumulation rate in soil



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

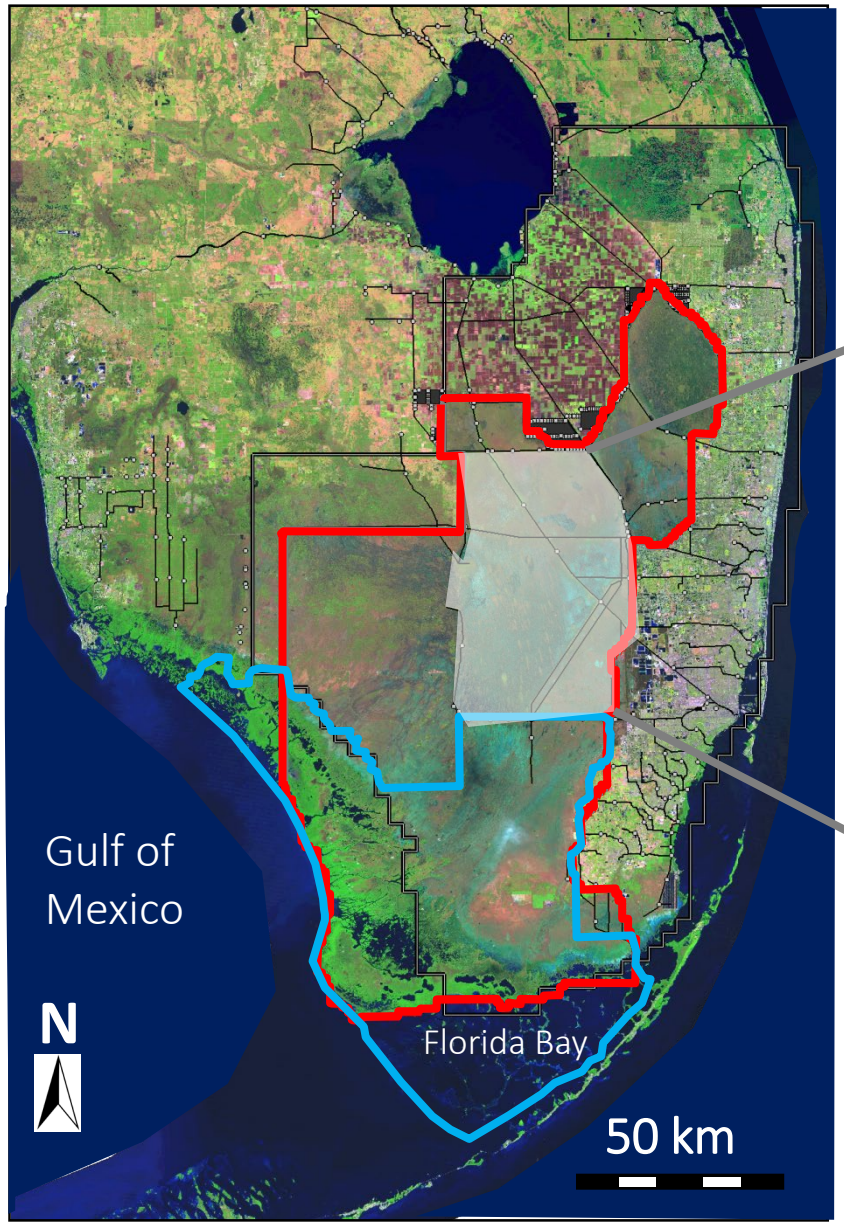
Photo from Firescience.gov

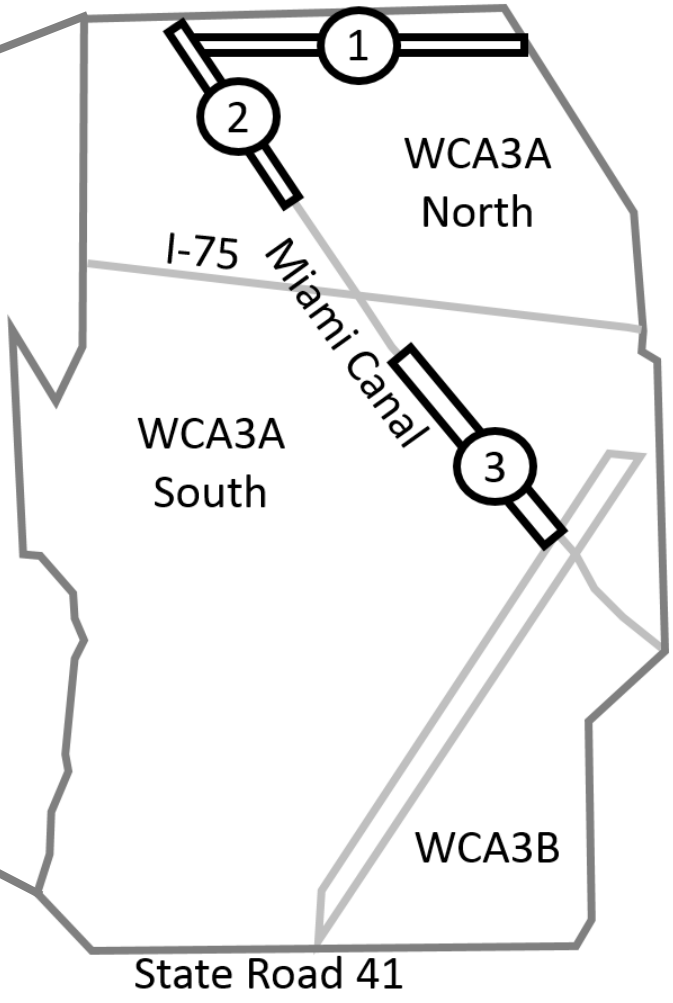
Muck fire

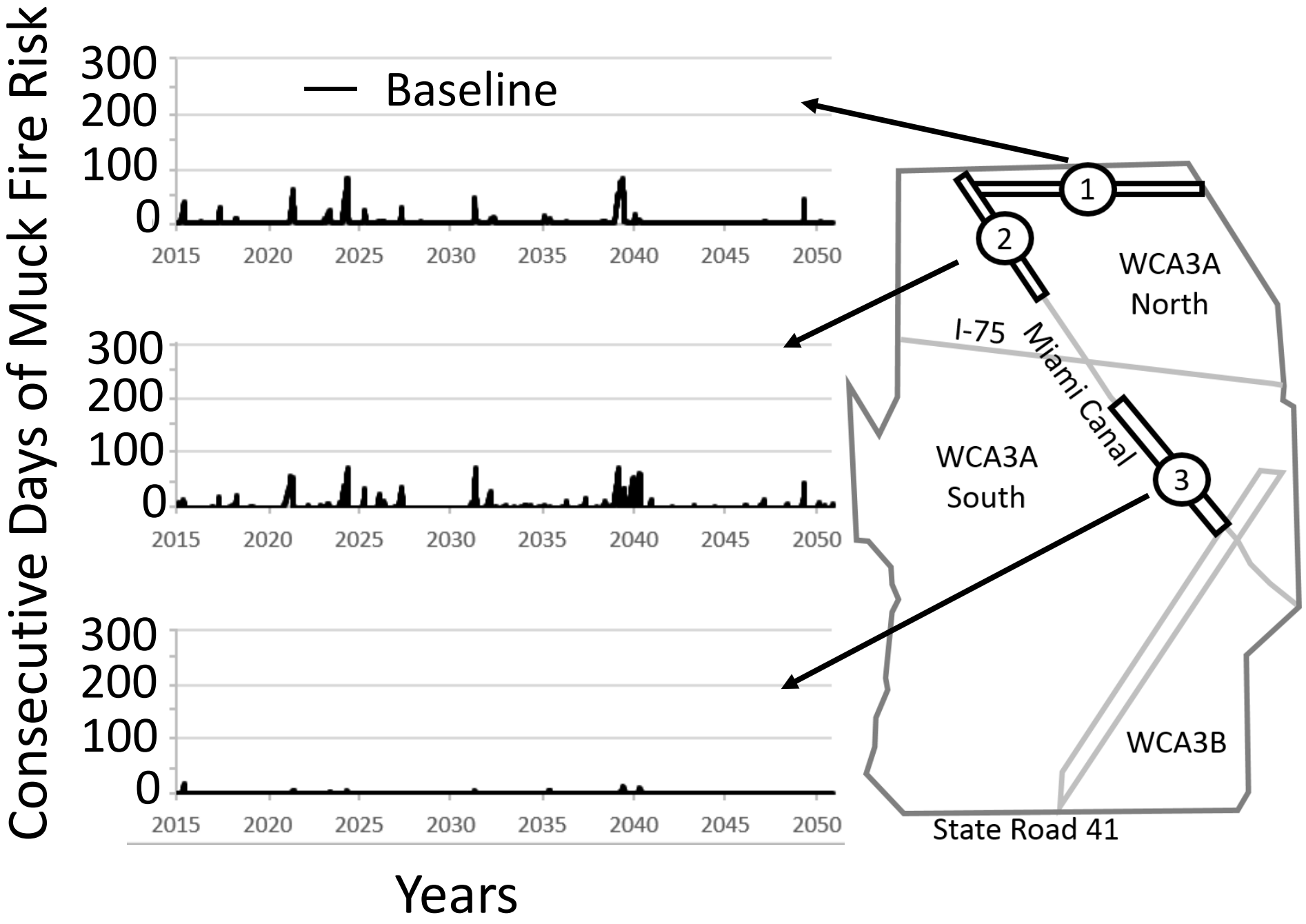
1944, Miami Herald

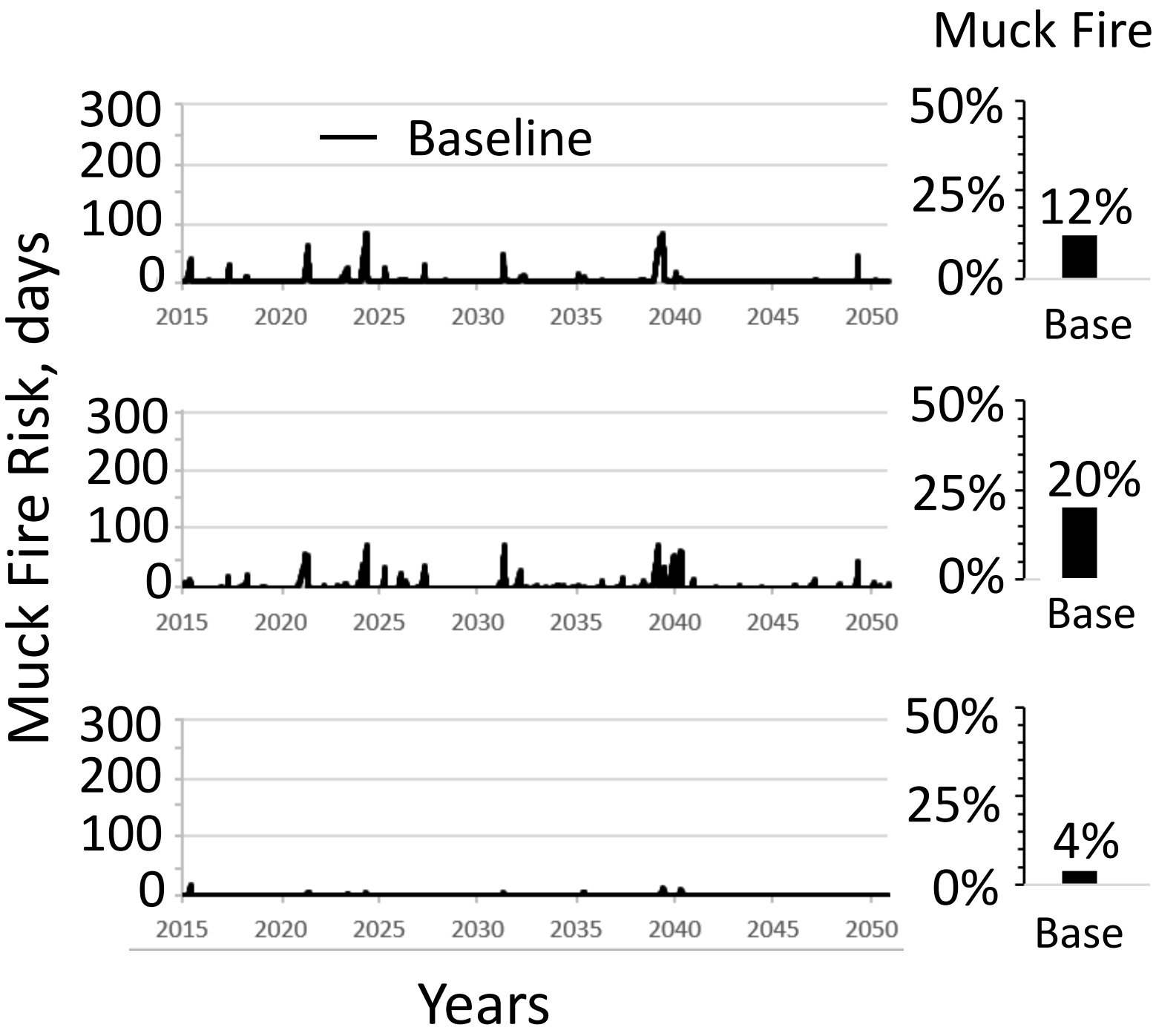
Large areas lost 8-20 cm of ground surface

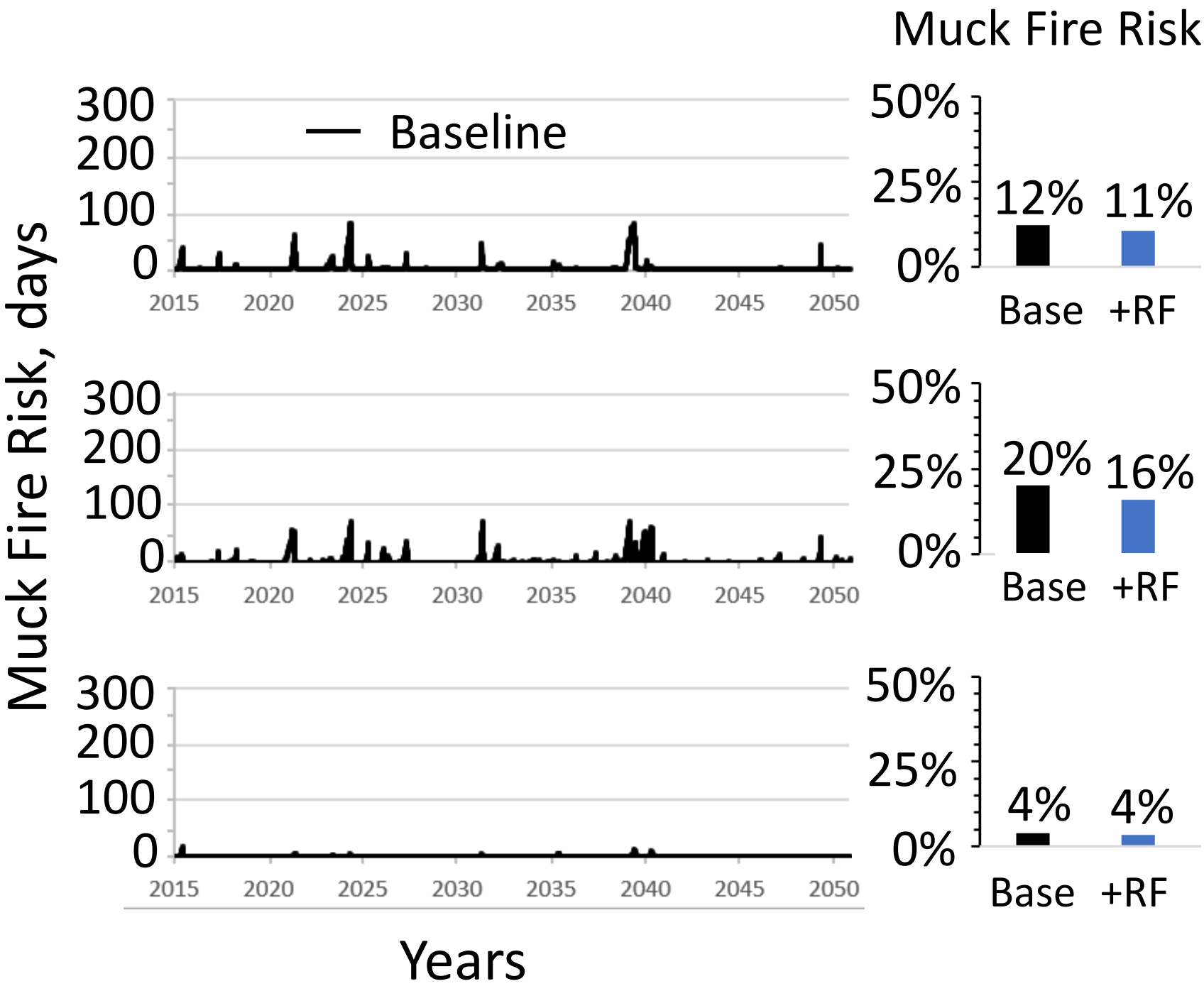
Time series of muck fire risk

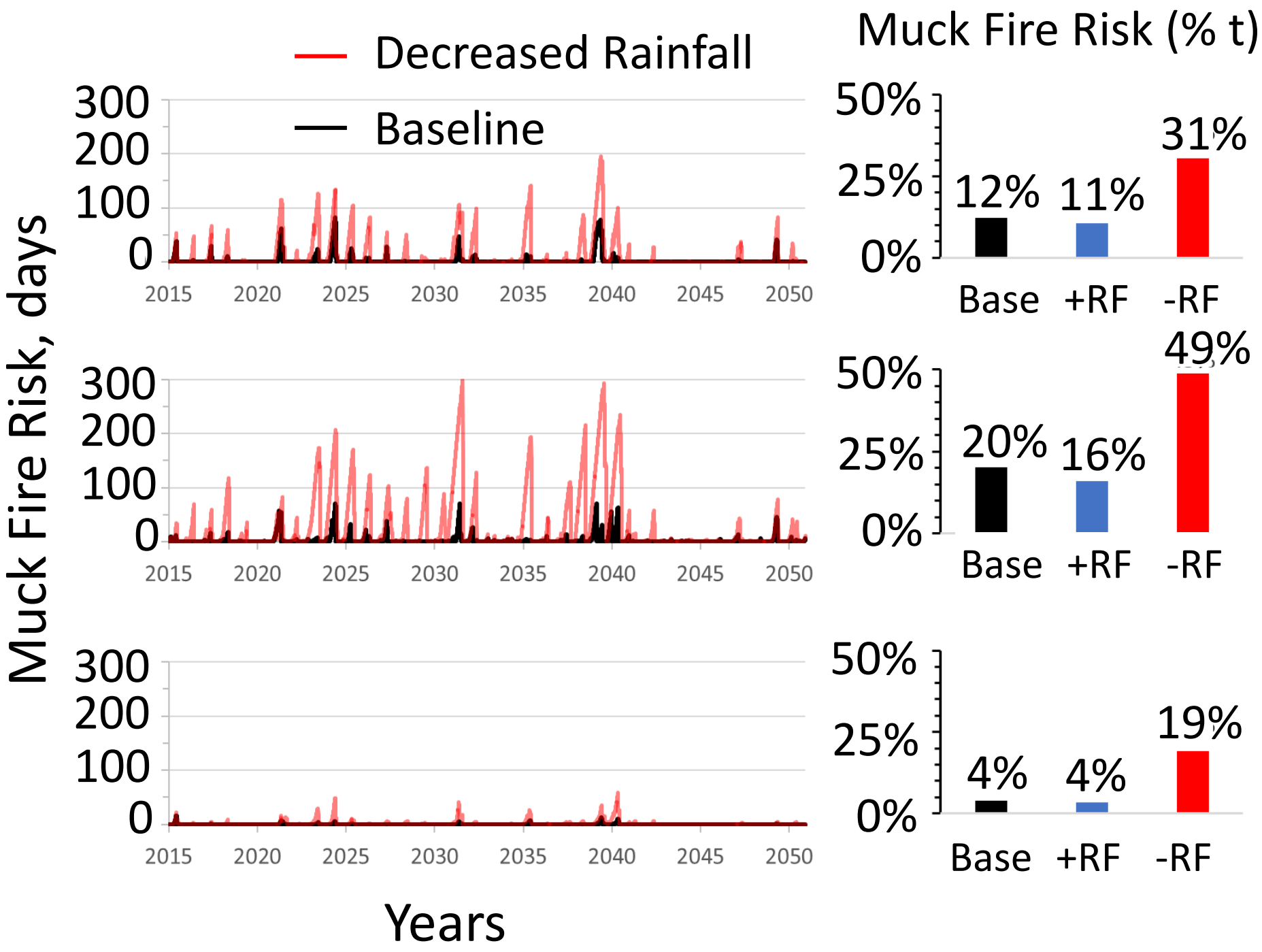





Consecutive Days of Muck Fire Risk
Baseline
300
200
100
0
2015
2020
2025
2030
2035
2040
2045
2050
Years
1
2
3
WCA3A
North
I-75
Miami Canal
WCA3A
South
WCA3B
State Road 41


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%
Years


Decreased Rainfall
Baseline
Muck Fire Risk, days
300
200
100
0
2015
2020
2025
2030
2035
2040
2045
2050
Years
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

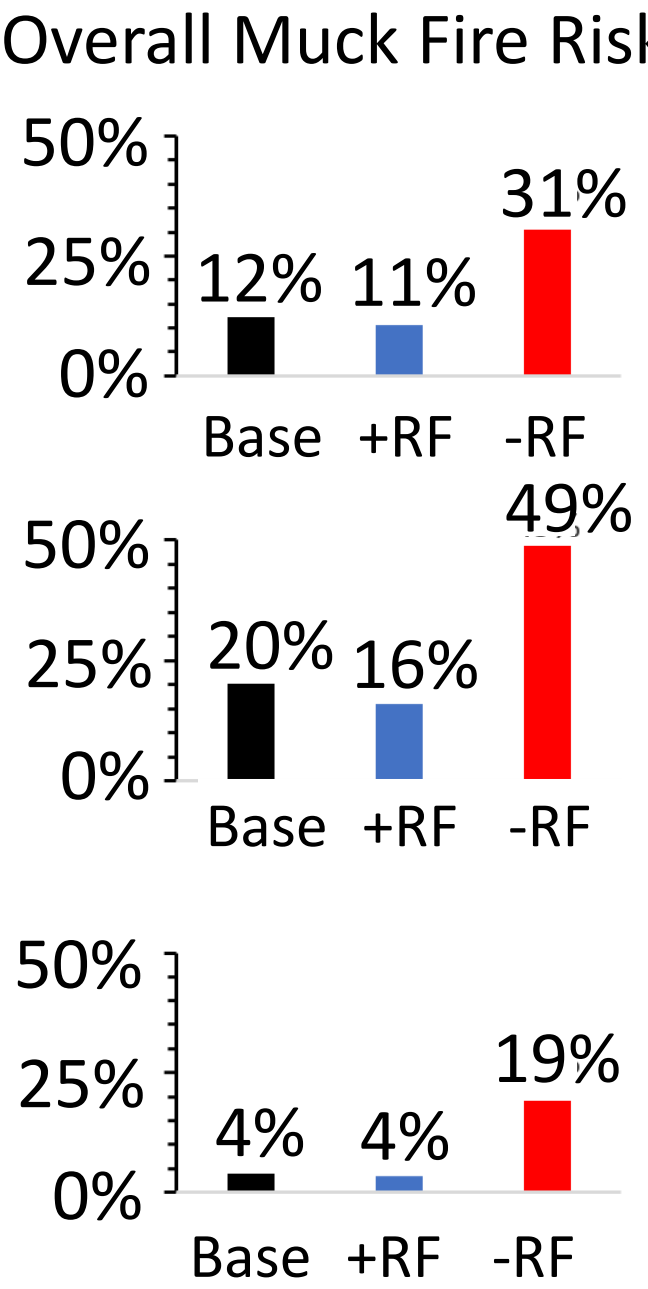
Slightly lower muck fire risk

More protection is needed

Decreased rainfall

High muck fire risk

Soil loss likely



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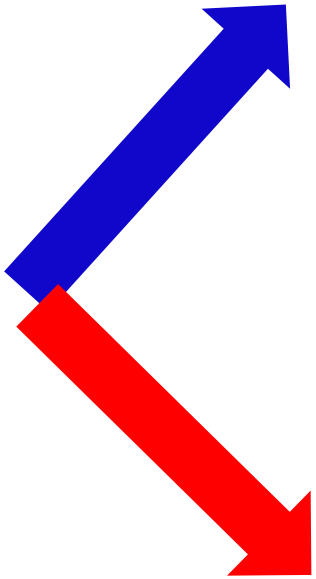

Increased Rainfall scenario:

- Slightly lower muck fire risk

  Need more water

- Exacerbates Eutrophication

  & Methylmercury production

  Need cleaner water

Decreased Rainfall scenario:

- Frequent Muck Fires

  Substantial soil loss likely

  Need more water

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Restoration is more urgent with climate change.

We gratefully acknowledge funding from:

- **NSF** as part of the Florida Coastal Everglades Long Term Ecological Research Project (FCE LTER)

- **USGS** Greater Everglades Priority Ecosystems Studies Program (Nick Aumen Program Manager).

Based on a 2019 Paper in Review:

Hilary Flower, Mark Rains, Carl Fitz, William Orem, Susan Newman, Todd Osborne, Ramesh Reddy, and Jayantha Obeysekera:

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

Related work:

Flower H, Rains M, Fitz HC (2017) Visioning the Future: Scenarios Modeling of the Florida Coastal Everglades Environmental Management 60:989–1009

Obeysekera J, Barnes J, Nungesser M. Climate sensitivity runs and regional hydrologic modeling for predicting the response of the greater Florida Everglades ecosystem to climate change. Environmental management. 2015 Apr 1;55(4):749-62.

Orem W, Newman S, Osborne TZ, Reddy KR. Projecting changes in Everglades soil biogeochemistry for carbon and other key elements, to possible 2060 climate and hydrologic scenarios. Environmental management. 2015 Apr 1;55(4):776-98.