Modeling Restoration Outcomes for the Everglades Ridge-Slough Landscape

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Restoration Ecology
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RESEARCH ARTICLE

Predicting outcomes of restored Everglades high flow: a model system for scientifically managed floodplains

Jay Choi[1], Jud W. Harvey[1,2]

Factors Affecting Restoration Success

Hydrologic Conditions:
Maintain water depth and flow for vegetation communities and ecological processes

Functionalities of the Landscape:
Deep water slough (60%) between ridges supports production and diverse ecosystem

Degraded

Restored

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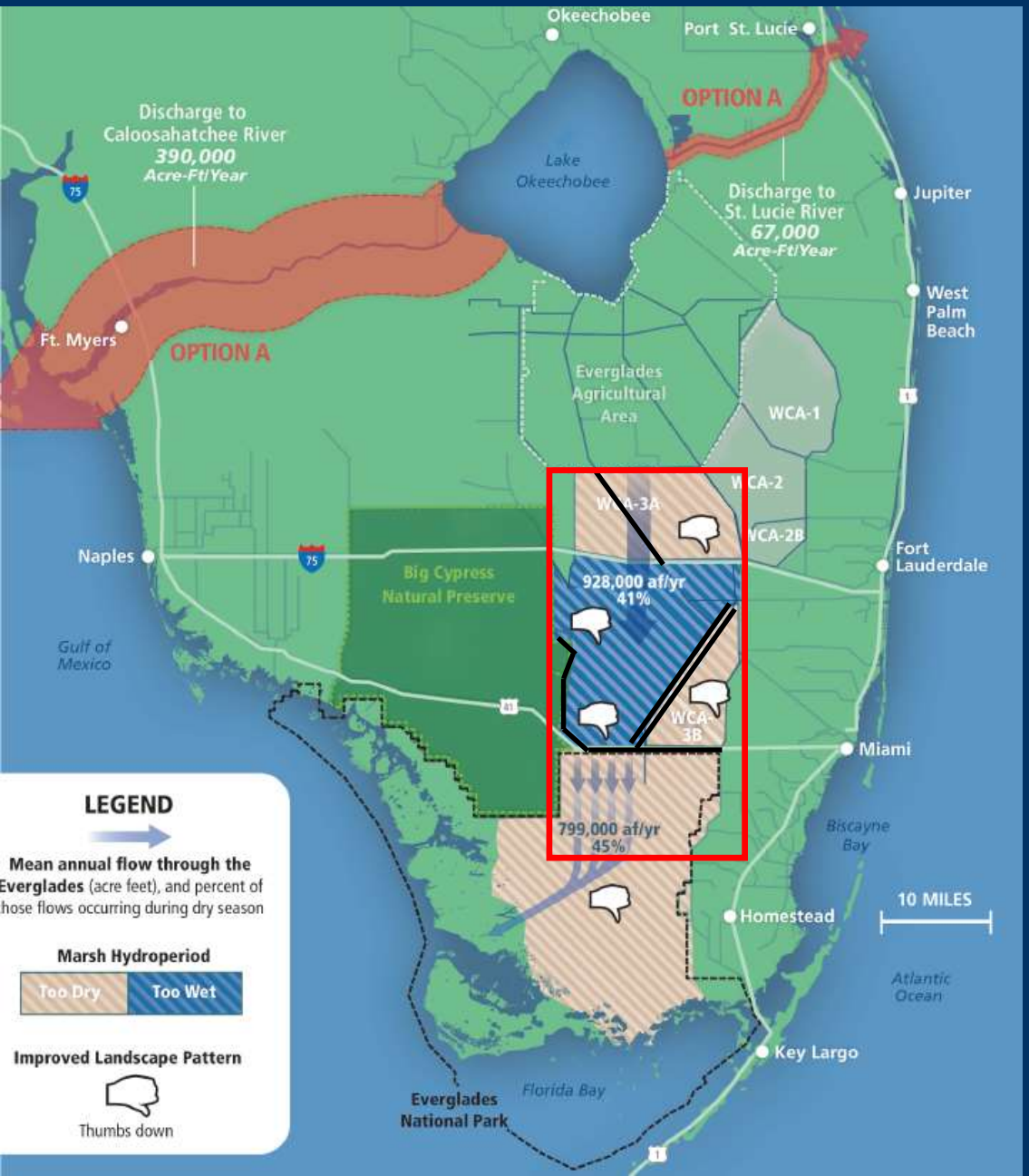
Everglades Restoration Options



Option A = No Action
Existing Conditions Baseline (ECB)

(SERES Report, 2015 Everglades Foundation)

Goal

Forecast outcomes of 4 restoration options in different sub-basins

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Everglades Restoration Options

		Options	Water Storage (acre-feet/yr)	% Predrainage flows	% Reduction of Internal Barriers to Sheet Flow
No Action	A	Existing Conditions Baseline (ECB)	0	52	125 miles of levees
Moderate	B	Comprehensive Everglades Restoration Plan (CERP)	3.0M	87	54
Moderate	C	Partial Restoration (PR) "CERP light"	1.2M	79	54
Aggressive	D	Expanded Storage and Decomp (ESD)	1.3M	91	69
Aggressive	E	Maximum Storage and Decomp (MSD)	2.7M	90	75

(SERES Report, 2015, Everglades Foundation)

Our Approach:

1. Existing Hydrologic Simulations From 1965-2000 *(SFWMD, 2008)*

2. Functionality Metrics of the Landscape

→ Forecast System-Wide Restoration Outcomes

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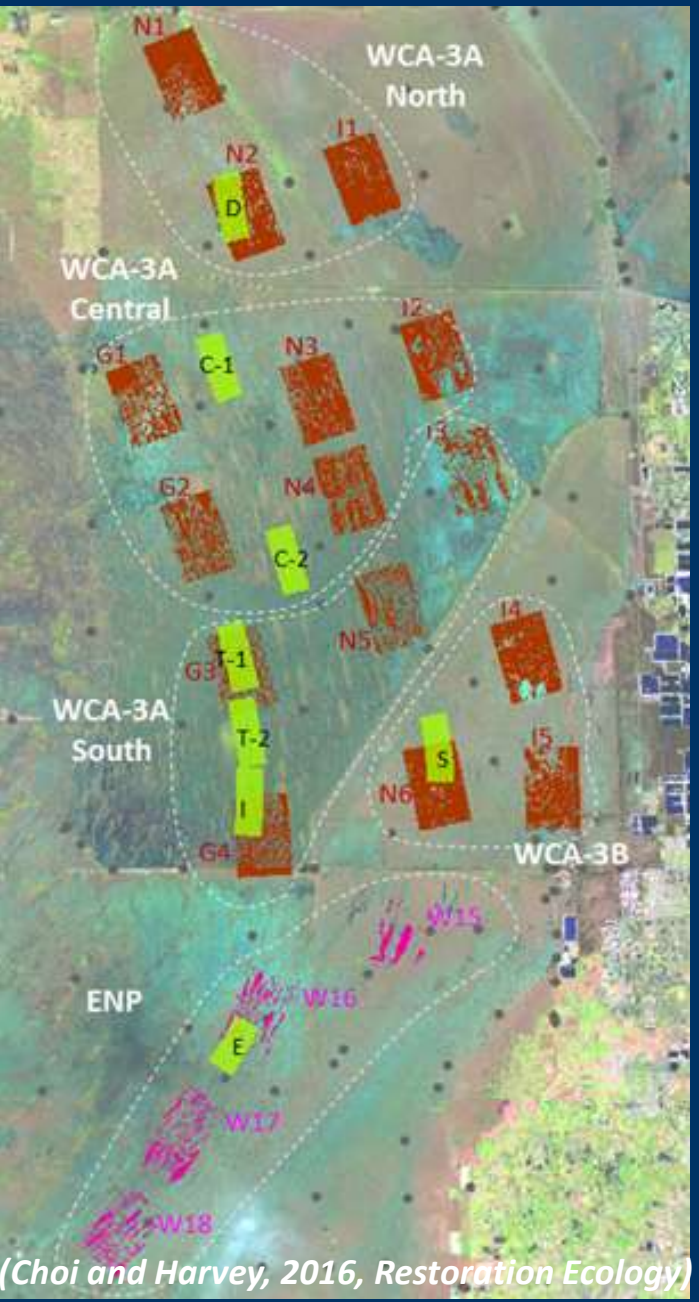
Metrics of Ridge-Slough Functionality



(Choi and Harvey, 2016, Restoration Ecology)

Wu et al., 2006
Ecological Complexity

Nungesser, 2011
Wetlands Ecology and Management

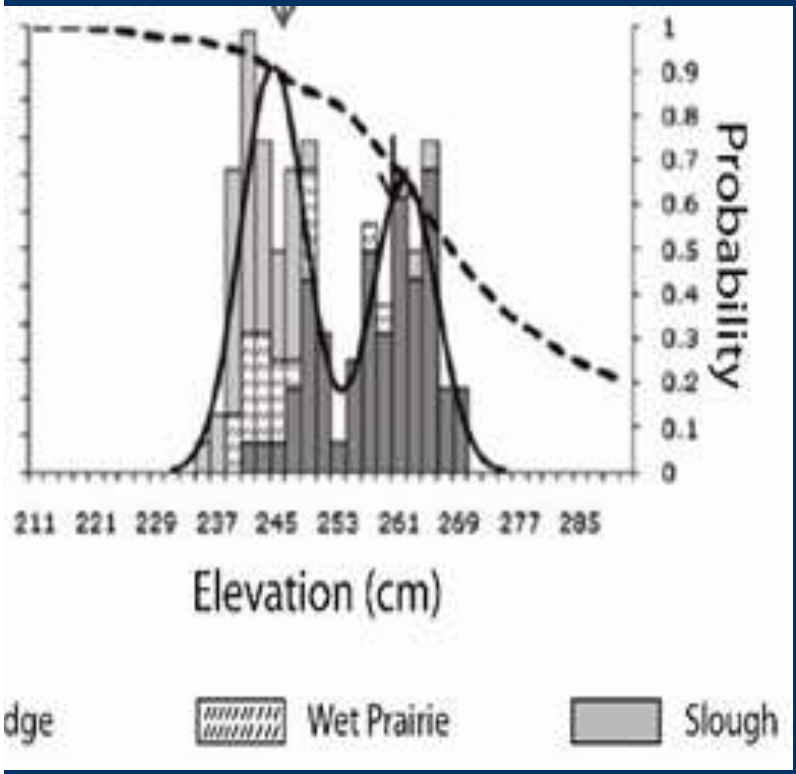
Watts et al., 2010
Ecosystems

e-slough microtopography

Good: >20 cm difference

At Risk: 10-20 cm difference

Poor: <10 cm difference



(Watts et al., 2010)

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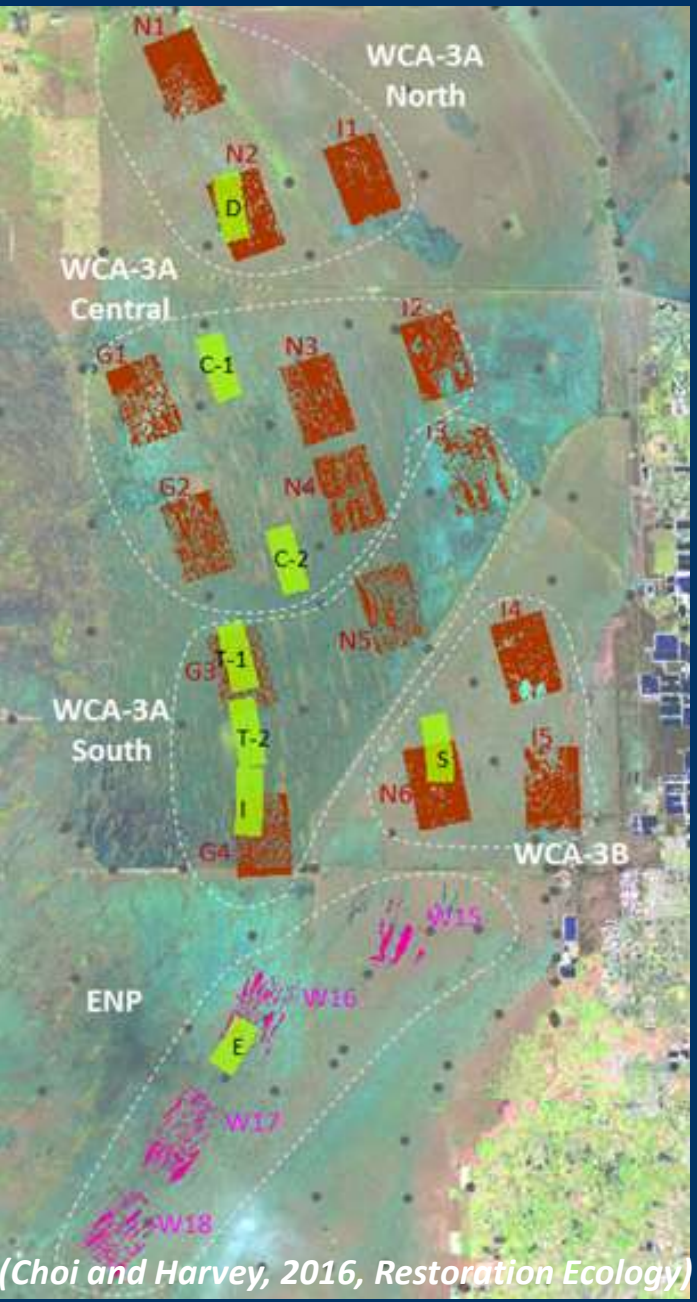
Metrics of Ridge-Slough Functionality



(Choi and Harvey, 2016, Restoration Ecology)

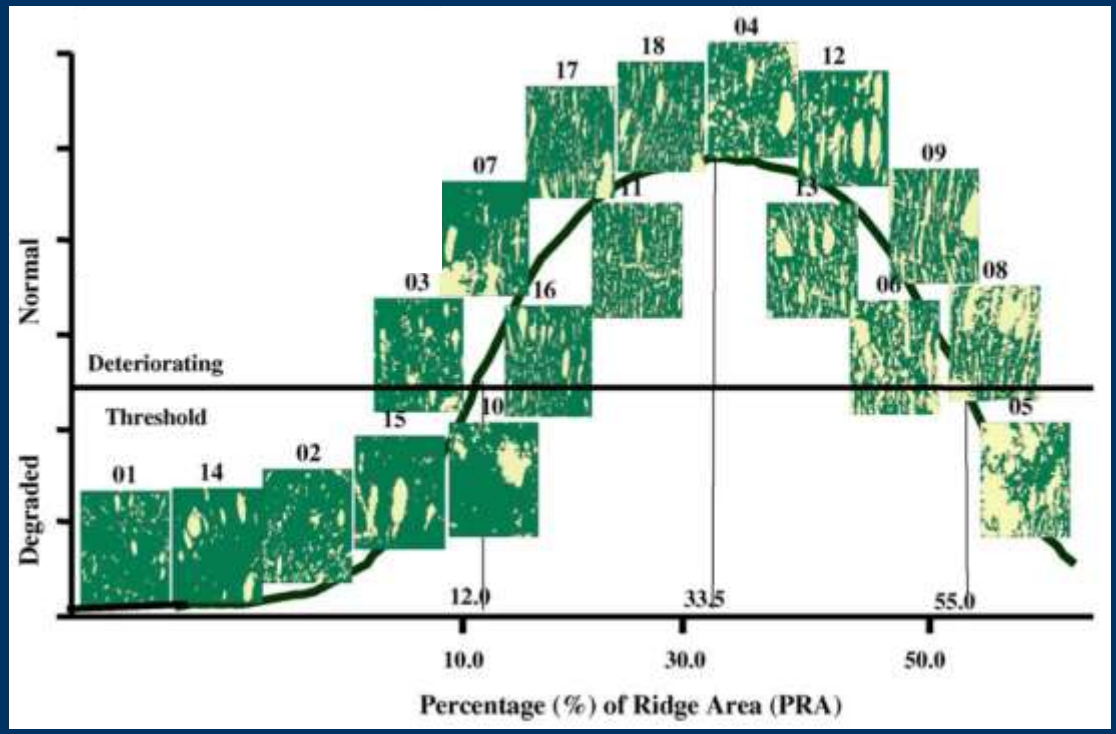
1. Ridge-slough microtopography

2. Vegetation (ridge) coverage

Good: <50 %

At Risk: 50-65 %

Poor: >65 %



(Wu et al., 2006)

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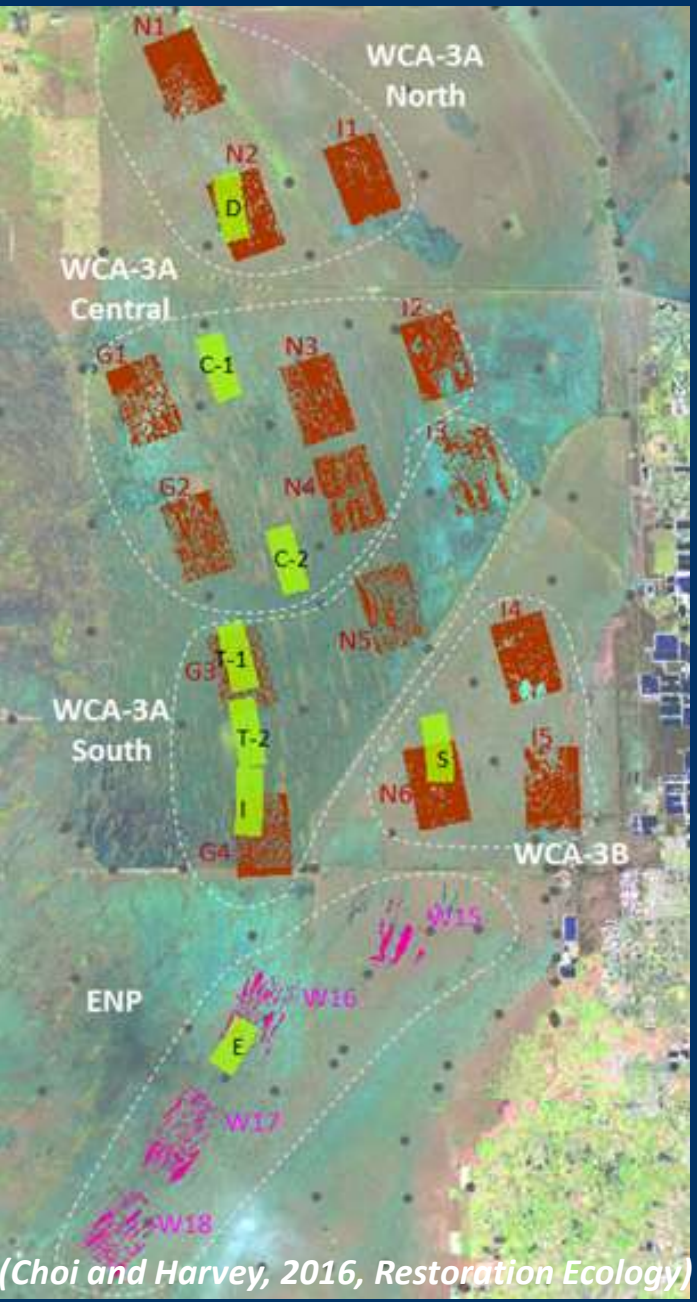
Metrics of Ridge-Slough Functionality



(Choi and Harvey, 2016, Restoration Ecology)

1. Ridge-slough microtopography

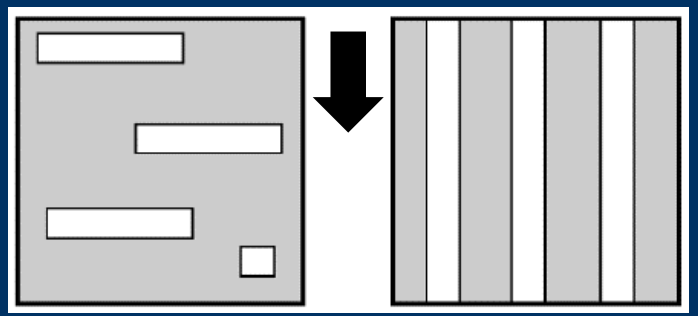
2. Vegetation (ridge) coverage

3. Directional Connectivity Index (DCI)

Good: >0.6

At Risk: 0.4-0.6

Poor: <0.4



DCI = 0 DCI = 1

(Larsen et al., 2012)

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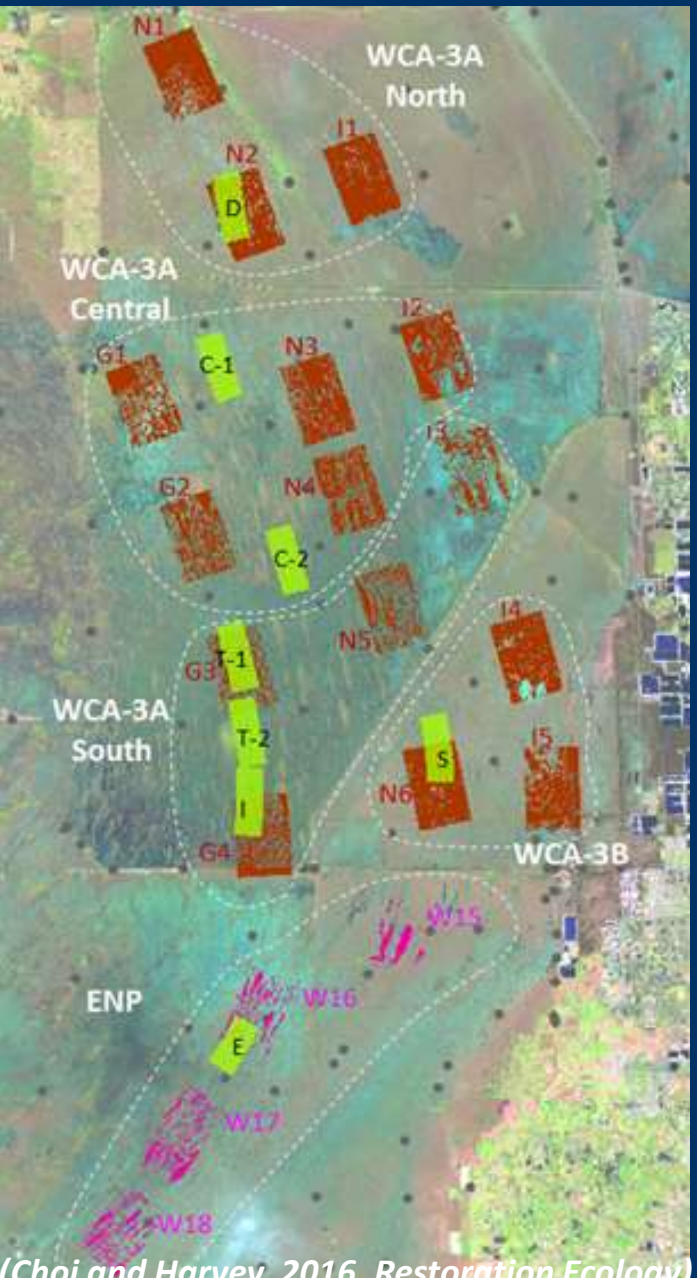
Metrics of Ridge-Slough Functionality



(Choi and Harvey, 2016, Restoration Ecology)

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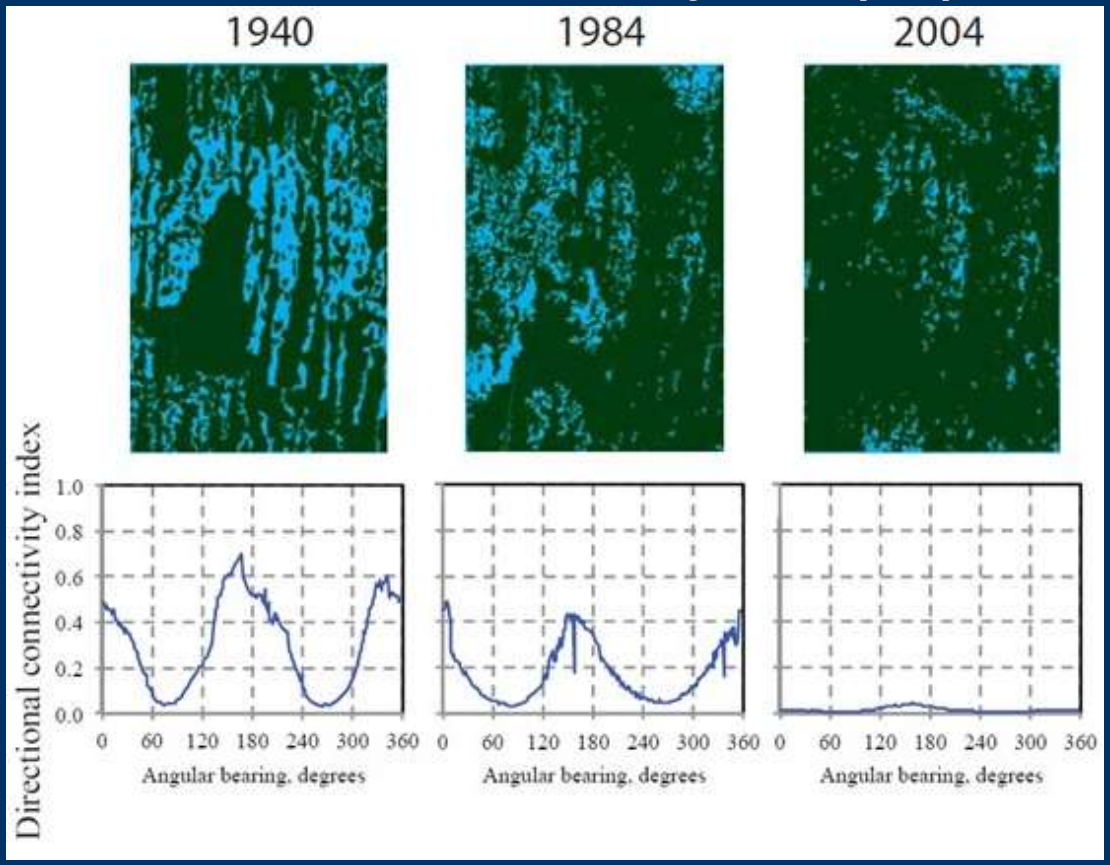

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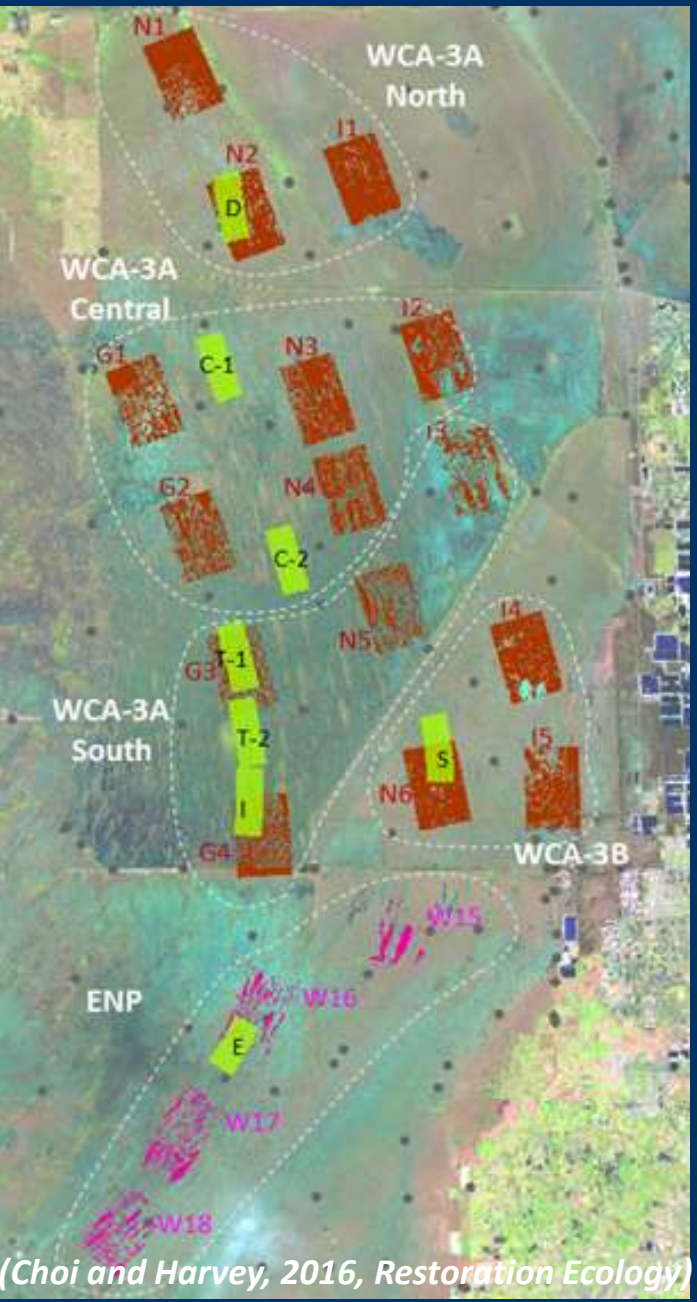
Target Hydrologic Conditions



(Choi and Harvey, 2016, Restoration Ecology)

1. Water Depth in Sloughs (cm)

	Dry Season	Wet Season
Good:	15-35	55-75
At Risk:	5-15	35-55 or 75-85
Poor:	<5	<35 or >85

2. Hydroperiod (# days sloughs are flowing)

Good:	>350
At Risk:	340-350
Poor:	<340

3. Flow velocity (cm/s)

Good:	>1.0
At Risk:	0.4-1.0
Poor:	<0.4

4. Angle between flow and slough orientation (degree)

Good:	<20
At Risk:	20-35
Poor:	>35

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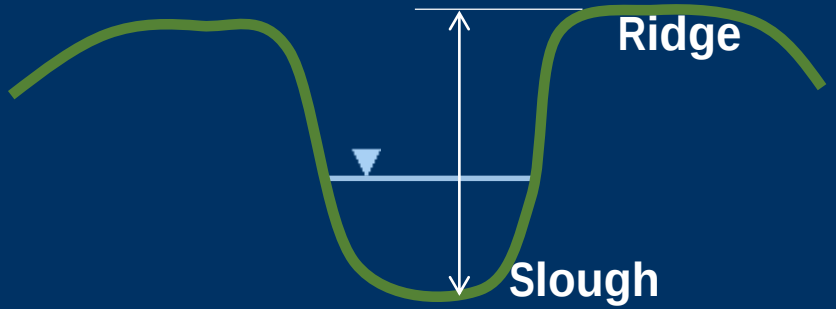
Flattening of Ridge-Slough Microtopography (Present-Day)

Variation between ridge and slough landscape



Key

Good: >20 cm
At Risk: 10-20 cm
Poor: <10 cm

	Sub-basin				
Metric	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
Microtopographic difference (cm)	4.0	18.5	21.3	5.2	12.5

(Choi and Harvey, 2016, Restoration Ecology)

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Proliferation of Vegetation (Present-Day Sawgrass)

Key

Good: <50%
At Risk: 50-65%
Poor: >65%

	Sub-basin				
Metric	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
Vegetation Coverage (%)	74	61	42	86	54

(Choi and Harvey, 2016, Restoration Ecology)

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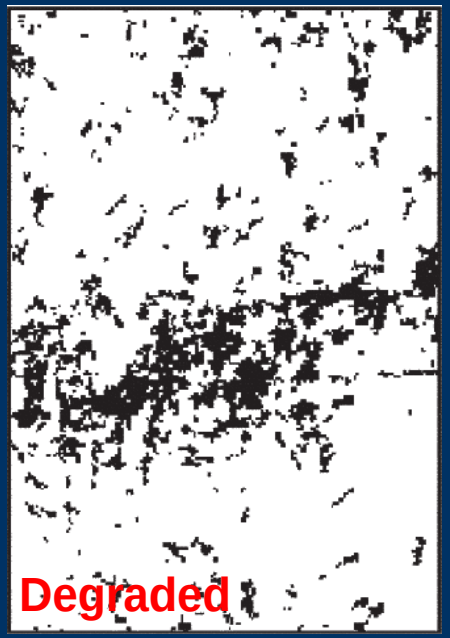
Lost Directional Connectivity of Landscape (Present-Day)



(Larsen et al., 2012)

Key

Good: >0.6
At Risk: 0.4-0.6
Poor: <0.4

Metric	Sub-basin				
	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
DCI	0.28	0.57	0.84	0.07	0.85

(Choi and Harvey, 2016, Restoration Ecology)

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Summary of Present-Day Landscape Functionality

Metric	Sub-basin				
	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
Microtopographic difference (cm)	4.0	18.5	21.3	5.2	12.5
Vegetation Coverage (%)	74	61	42	86	54
DCI	0.28	0.57	0.84	0.07	0.85

- Lost ridge and slough landscape functionality at WCA-3A North and WCA-3B

(Choi and Harvey, 2016, Restoration Ecology)

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Predicted Water Depth During Dry Season

Water depth in sloughs (cm)

	Options	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
No action	ECB	-5.3	12.1	24.4	18.4	20.6
Moderate	PR	-0.7	18.3	18.4	21.5	29.3
	CERP	-0.1	18.7	18.6	25.2	33.3
Aggressive	ESD	-1.3	18.2	16.6	18.6	30.3
	MSD	-7.2	13.9	14.6	23.2	32.6

- Restoration actions cannot improve the water depth at WCA-3A North during the dry season

Key

Good: 15-35 cm
At Risk: 5-15 cm
Poor: <5 cm

(Choi and Harvey, 2016, Restoration Ecology)

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Predicted Water Depth During Wet Season

Water depth in sloughs (cm)

	Options	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
No action	ECB	31.1	58.0	86.8	51.7	63.4
Moderate	PR	23.7	45.2	54.3	68.7	70.2
	CERP	23.5	43.8	52.9	70.9	71.9
Aggressive	ESD	25.1	40.6	46.2	81.3	73.4
	MSD	39.2	50.5	51.0	81.0	73.5

- Improvement at WCA-3A North, but only for most aggressive option
- Aggressive action may put WCA-3B at risk

Key

Good: 55-75 cm
At Risk: 35-55 or 75-85 cm
Poor: <35 or >85 cm

(Choi and Harvey, 2016, Restoration Ecology)

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Predicted Hydroperiod

days sloughs are flowing

	Options	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
No action	ECB	310	347	358	354	340
Moderate	PR	307	358	354	351	354
	CERP	307	358	354	358	362
Aggressive	ESD	300	354	351	347	354
	MSD	278	352	347	354	362

- **Restoration actions cannot improve the hydroperiod at WCA-3A North**

Key

Good: >350 d
At Risk: 340-350 d
Poor: <340 d

(Choi and Harvey, 2016, Restoration Ecology)

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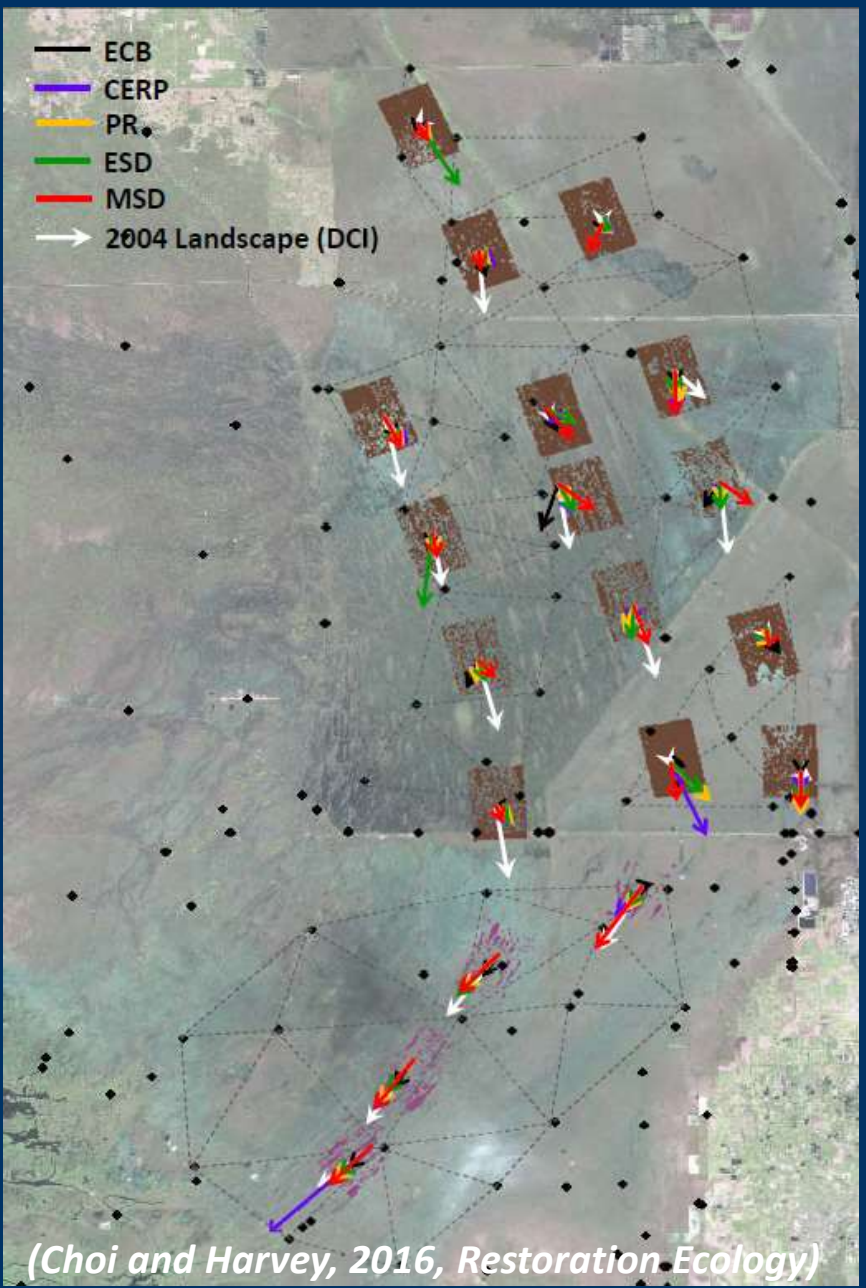
Predicted Flow Speed and Direction



(Choi and Harvey, 2016, Restoration Ecology)

Flow Speed (cm/s)

Options	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
ECB	0.2	0.4	0.2	0.1	0.7
PR	0.4	0.5	0.5	0.2	0.9
CERP	0.4	0.5	0.4	0.2	0.9
ESD	0.4	0.6	0.5	0.3	0.9
MSD	0.6	0.7	0.6	0.3	0.9

Good: >1.0 At Risk: 0.4-1.0 Poor: <0.4

Angle between flow direction and slough orientation (degree)

Options	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
ECB	21	20	46	36	37
PR	53	23	21	36	3
CERP	60	20	14	20	5
ESD	51	25	12	26	3
MSD	33	22	21	34	4

Good: <20 At Risk: 20-35 Poor: >35

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Forecasted (36 y) Restoration Outcome

	Options	WCA-3A North	WCA-3A Central	WCA-3A South	WCA-3B	ENP
No action	ECB	Poor	At Risk	Poor	Poor	At Risk
Moderate	PR	Poor	At Risk	Good	Poor	Good
	CERP	Poor	At Risk	Good	Poor	Good
Aggressive	ESD	Poor	At Risk	Good	Poor	Good
	MSD	Poor	At Risk	Good	Poor	Good

Failed to achieve target hydrologic conditions at WCA-3A North and WCA-3B

(Choi and Harvey, 2016, Restoration Ecology)

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Conclusions

- Not all sub-basins benefit equally from restoration.
- None of the restoration options are likely to improve ***WCA-3A North*** and ***WCA-3B*** functionality.
- All restoration options are likely to improve the hydrologic conditions at ***WCA-3A Central, WCA-3A South, and ENP***.
- For most cases, moderate and aggressive restoration options predicted very similar outcomes for landscape conditions.
- Present-day extent of ridge-slough microtopographic difference appears to be the best single predictor of restoration success.