Everglades Patterning: Altered Water, Altered Landscape*

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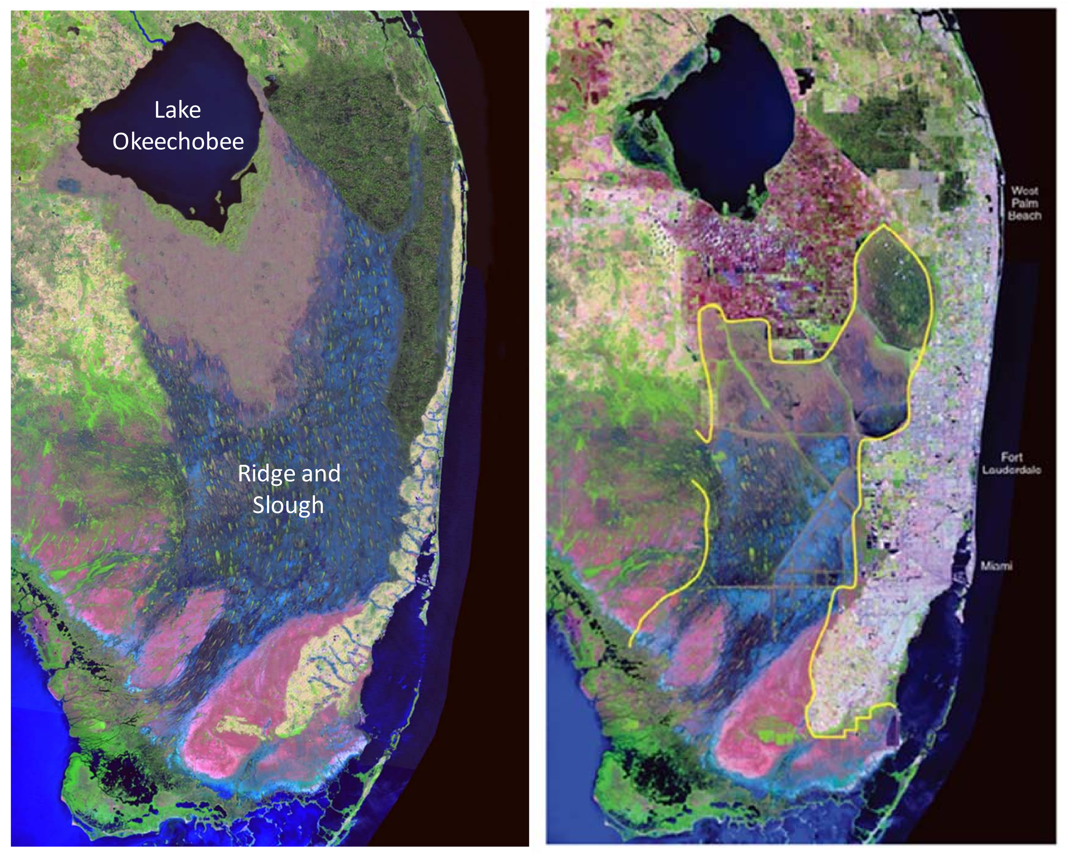
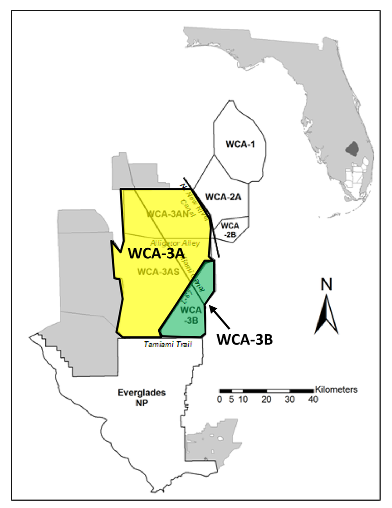


Simulated pre-drainage image (left) showing the pre-drainage system and current satellite image (right) of south Florida

The Everglades is a unique subtropical patterned peatland. The original natural patterns were elongated ridges and tree islands among interconnected sloughs, all highly directional and uniform across the peatland. Water management over 130 years has altered hydrology and patterns have changed in response. Restoration of this Ridge and Slough landscape is a major target of Everglades restoration.

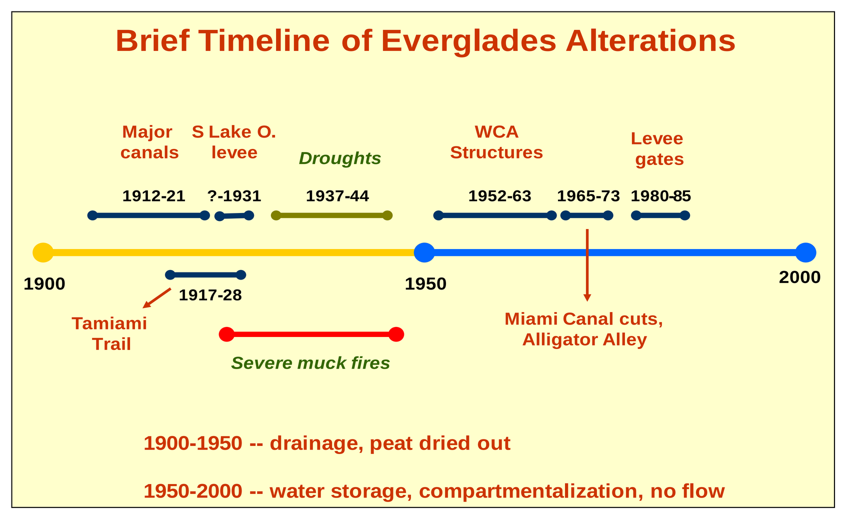
To understand how and when patterns altered, we mapped patterns at 15 study plots over time in Water Conservation Area 3 (WCA-3), where most of the remaining patterned areas are located, from a time series of aerial photographs (1940, 1953, 1972, 1984, and 2004). Metrics to quantify changes were developed, applied, and analyzed to determine declines and improvements in pattern quality for each of 15 study plots (Nungesser 2011). Trajectories tracing pattern quality for each plot show improvements, degradation, and stability of patterns. By understanding pattern change trajectories and hydrologic patterns at those sites, we can better understand how to restore the Ridge and Slough.

BACKGROUND

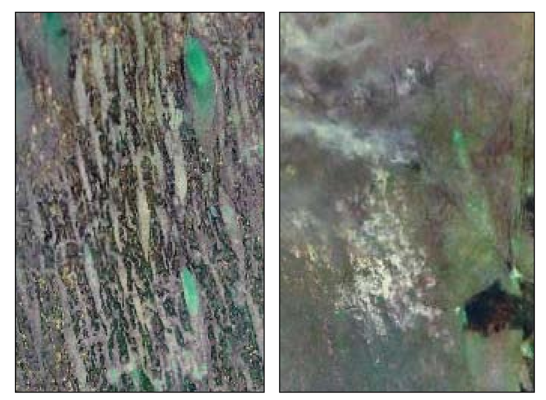


Water Conservation Area 3, consisting of compartments A, and B, is located in south Florida and is part of the Everglades restoration area

Drainage, drought, fire, compartmentalization, flooding, and lack of variation in water depths altered natural hydropatterns. Canals drained most of eastern and central WCA-3, then compartmentalization drained the north and flooded southern and eastern WCA-3A. Patterns reflect these changes in hydrologic conditions.



What do these patterns look like?
Strong patterns are long, linear, and regularly spaced.
Degraded patterns have disappeared, and open wet areas are sparse. Immediately below are aerial views and below these are their appearance from the ground and at low elevation.

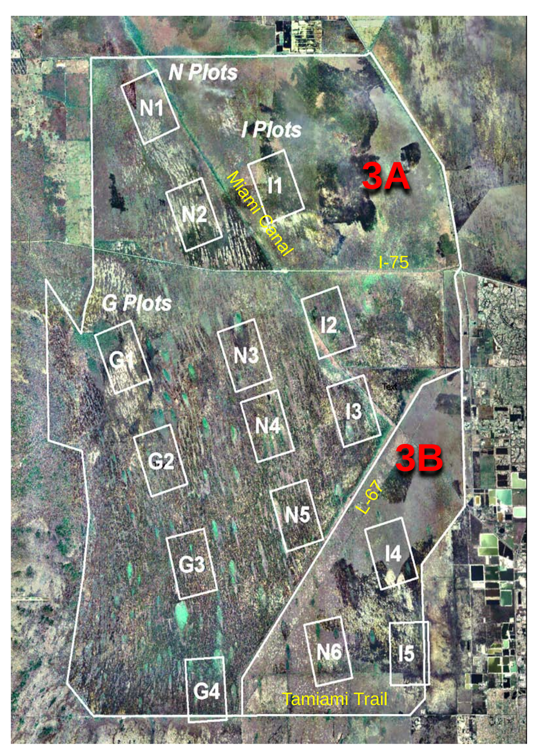


Strong patterns   Degraded patterns

Photos courtesy of C. McVoy

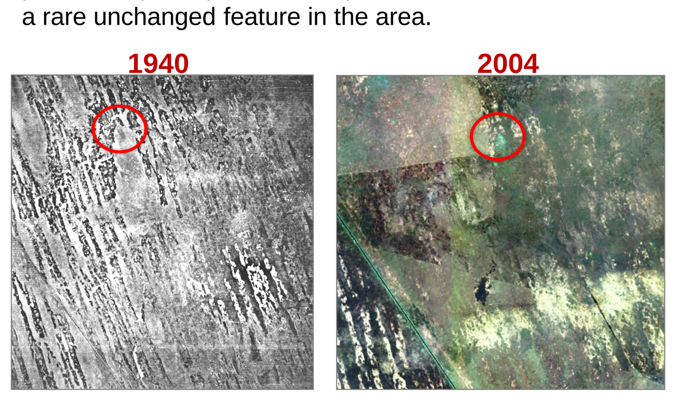
DATA AND MAPS

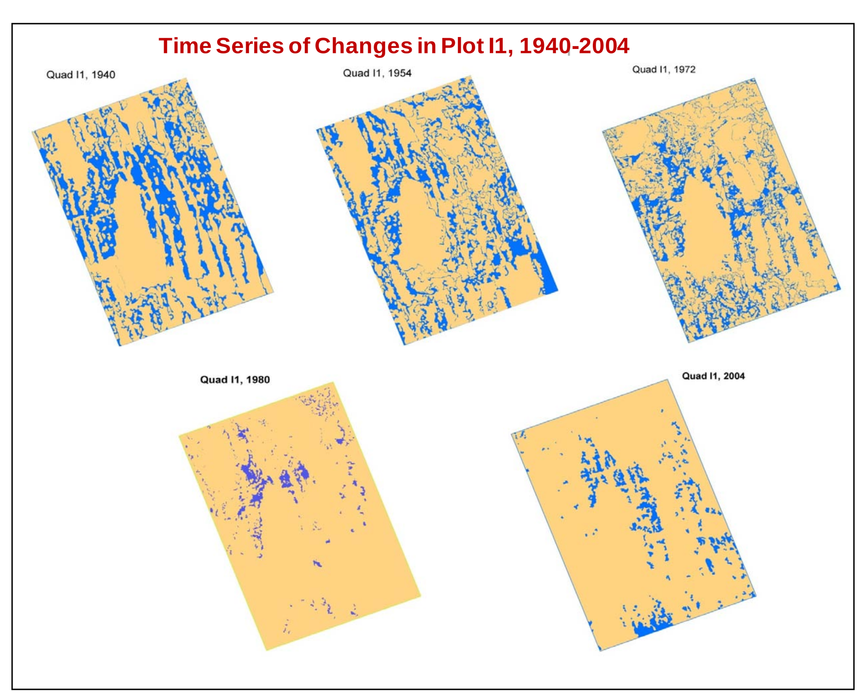
Water Conservation Area 3



Aerial photo showing locations of 15 study plots, 4 km x 6 km in size, along 3 transects - G, N, and I from west to east in WCA-3A and -3B.

Below is part of study plot I1, an area of original strong patterning that degraded over time. All of the pre-drainage Ridge and Slough landscape was strongly patterned (McVoy et al. 2011). The red circle encloses a rare unchanged feature in the area.





Sample of digitized maps and pattern degradation from 1940 (upper left) to 2004 (lower right) in study plot I1. The tan represents emergent vegetation (ridges and tree islands) and blue shows open water.

Each study plot was located on georeferenced aerial photographs from the years 1940, 1953, 1972, 1984, and 2004, producing a time series of 5 maps for each location (75 maps).

Metrics of ridges/tree islands included length/width ratio, perimeter/area ratio, total number, maximum length, and two indices: LewN and PAN (defined at right, above). Hierarchical clusters of all 75 plots of these values identified 5 major groupings ranging from strong patterns to degraded patterns. NMDS (non-metric multidimensional scaling) confirmed validity of these clusters, and correlations indicated that the number of long, thin ridges dominated pattern strength. Trajectories of these 5 categories were plotted to see changes in quality over 64 years.

References:

McVoy, C.W., W.A. Park, J. Obeysekera, J.A. VanArman, and T.W. Dreschel. 2011. Landscapes and Hydrology of the Pre-drainage Everglades. University Press of Florida, Gainesville.
* Nungesser, Martha K. 2011. Reading the landscape: Temporal and spatial changes in a patterned peatland. Wetlands Ecology and Management (19:6): 475-493.

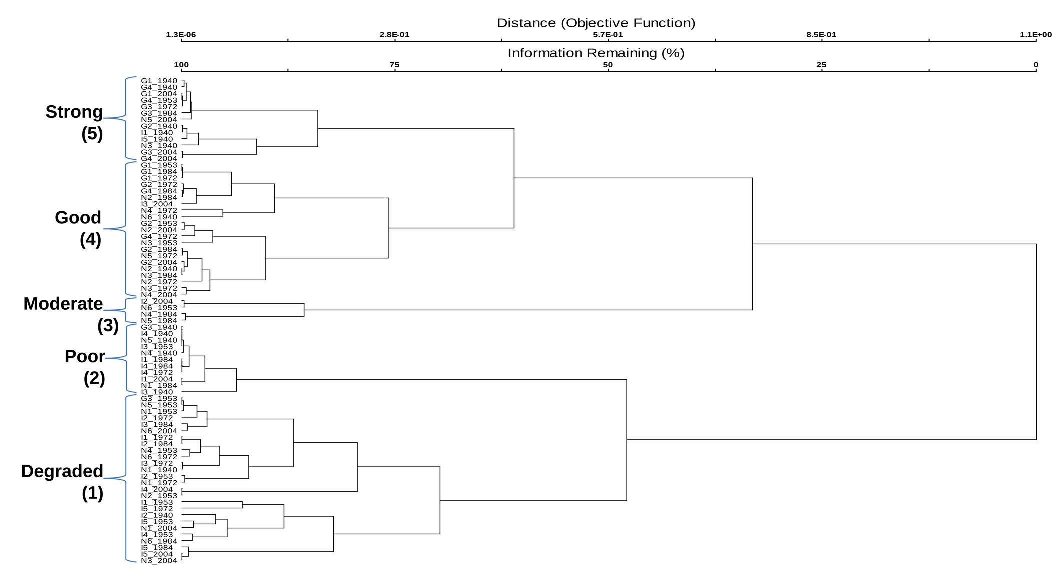
ANALYSIS AND RESULTS

Ridge and Slough metrics used in this analysis:
L=length, W=width, P=perimeter, A=area, *n*=number of ridges >300 m long.

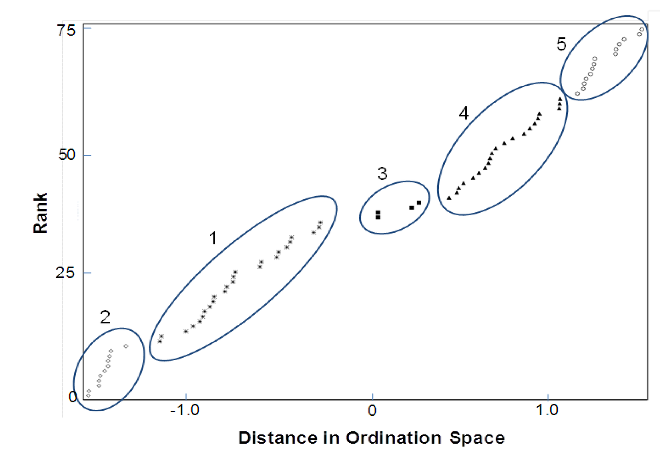
Indices: $\text{LeWN} = \sum_{i=1}^{n} L/W$; $\text{PAN} = \sum_{i=1}^{n} P/A$

Pattern ranks: 5: Strong, 4: Good, 3: Moderate, 2: Poor, 1: Degraded

Data from all 75 maps were classified using agglomerative hierarchical clustering. Clusters identified categories of strong, good, moderate, poor, and degraded patterns (top to bottom, 5 to 1 respectively).



Nonmetric multidimensional scaling (ordination) produced excellent agreement with the clusters, showing clear distinctions between the groups.



Means comparisons of variables defining pattern quality. Letters in parentheses indicate the group memberships; those that are the same indicate no significant differences for that variable in the category

Category	n plots	ridges/plot	PA	LW	LeWN	PAN
5	14	77.8 (a)	0.0606 (a)	6.48 (a)	487.85 (a)	4.5427 (a)
4	21	32.4 (b)	0.0376 (a,b)	6.66 (a)	203.38 (b)	1.2198 (b)
3	4	13.3 (c)	0.0453 (a,b)	5.34 (a,b)	70.54 (c)	0.5946 (a,b)
2	25	3.2 (c)	0.0271 (a,b)	4.98 (b)	15.96 (c)	0.0941 (b)
1	11	1.0 (c)	0.0158 (b)	2.77 (c)	2.77 (c)	0.0158 (b)

Correlations indicate that the clusters are most strongly defined by the LeWN index and the number of ridges/tree islands (correlation with Axis 1, the x axis).

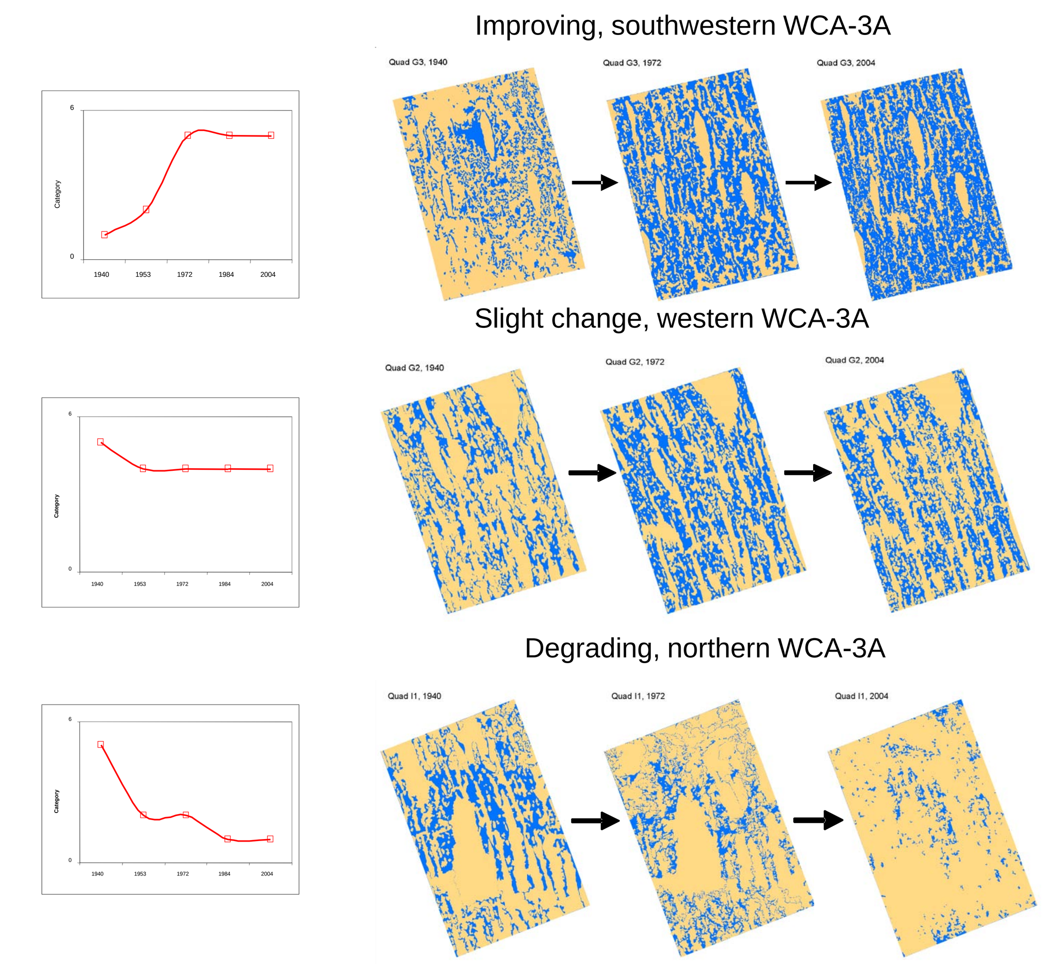
	n	PA	LW	LeWN	PAN	Axis 1
n	1.0000					
PA	0.2891	1.0000				
LW	0.3265	0.2283	1.0000			
LeWN	0.9502	0.3511	0.4880	1.0000		
PAN	0.5025	0.9461	0.2317	0.4558	1.0000	
Axis 1	0.8544	0.3362	0.6508	0.8739	0.4438	1.0000

- Clusters of pattern metrics corresponded to pattern quality
- Patterns were dynamic - improving, degrading, or stable
- Pattern trajectories varied by location rather than uniformly across the landscape
- Patterns degraded where conditions were dry and survived or improved where wet
- Patterns show multi-decadal resilience

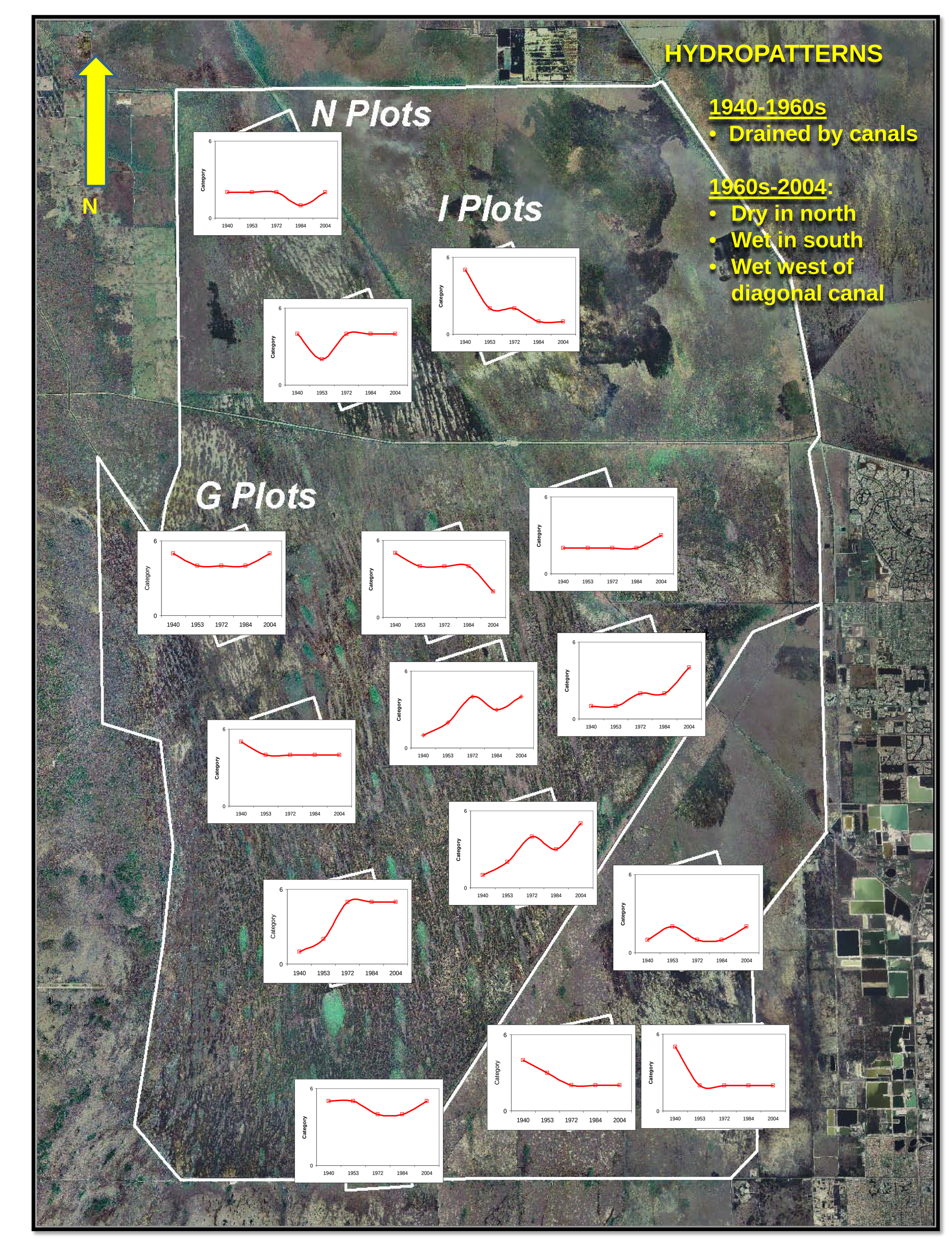
Rule of Thumb:
Pattern strength is dominated by LeWN and by the number of ridges longer than 300 m

Good to Strong:	20+ long ridges LeWN > 100
Moderate:	10-20 long ridges 100 > LeWN > 50
Poor or degraded:	< 10 long ridges LeWN < 50

TRAJECTORIES OF PATTERN QUALITY
(Highest is Strong, lowest is Degraded) Examples:



TRAJECTORIES OF PATTERN QUALITY IN STUDY PLOTS



CONCLUSIONS

- Patterns reflect the effects of hydrological drivers on the ecosystem
- Local, rather than regional, hydrologic conditions now dominate patterning
- Metrics provide quantifiable restoration targets
- Metrics are easily measured and calculated, cost-effective
- Patterns seem to respond to local hydrology in a few years
- It is essential to keep the Ridge and Slough landscape well hydrated to retain the patterns

Provides a landscape report card on the state of the ecosystem:

- ✓ **Cost-effective, timely, and simple to measure**
- ✓ **Landscape conditions and changes readily tracked**
- ✓ **Ideal for adaptive management**

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