Modeling Landscape Scale Plant Community Response to Climate Change and Human Management

Scott M. Duke-Sylvester[1]
Jenneke Visser[1]
Eric White[2]

1. *University of Louisiana at Lafayette*
2. *The Water Institute of the Gulf*

Questions

How will Louisiana's wetland ecosystems change in response to ...

… sea level rise?

… future management?

marsh creation projects

water/sediment diversion

maintenance

Approach

Linked multi-model

- Hydrology
- Morphology
- Vegetation
- Barrier islands
- Fish, shrimp, clams
- Birds, mammals

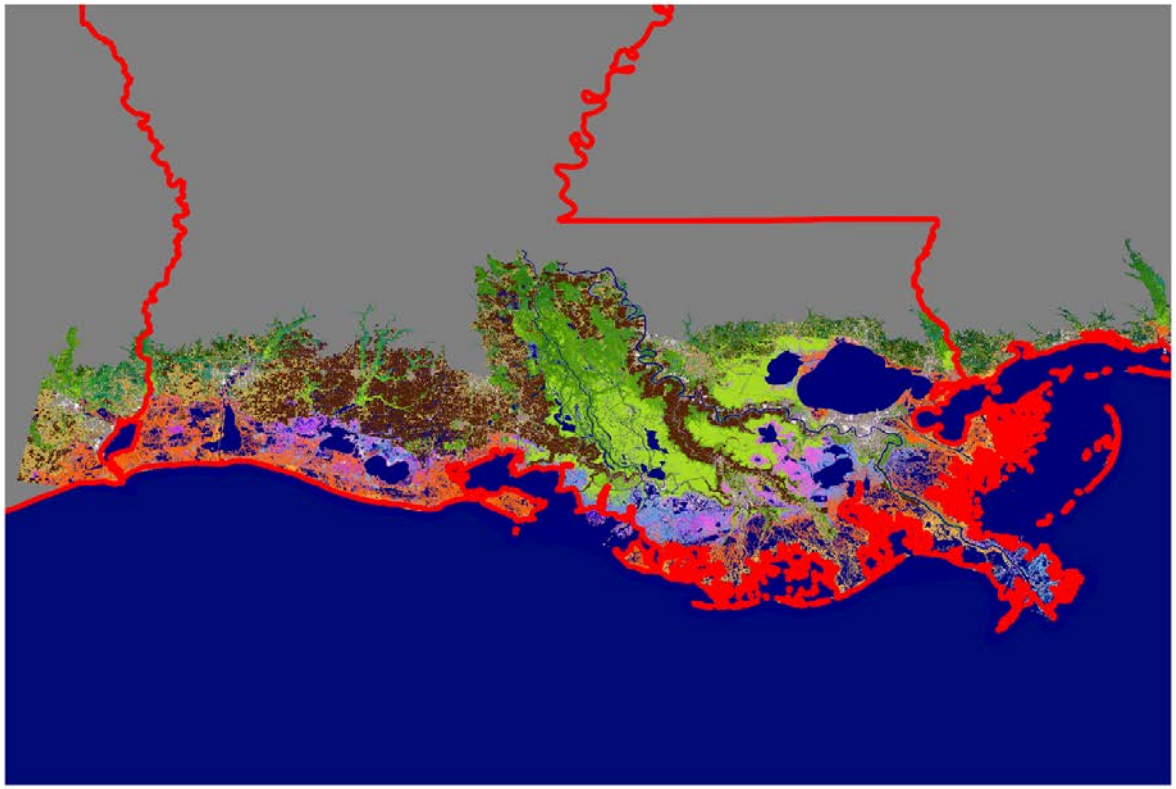
Domain

Entire coast

500x500 meters

178904 cells

50 year



Habitat and Species

Habitat	Species
Bottomland Hardwood Forest	**Quercus lyrata, Quercus texana, Quercus laurifolia, Ulmus americana, Quercus nigra, Quercus virginiana**
Swamp Forest	**Salix nigra, Taxodium distichum, Nyssa aquatica**
Fresh Floating Marsh	**Panicum hemitomon, Eleocharis baldwinii, Hydrocotyle umbellata**
Fresh Attached Marsh	Morella cerifera, Panicum hemitomon, Sagittaria latifolia, Zizaniopsis miliacea, Cladium mariscus, Typha domingensis
Intermediate Marsh	Sagittaria lancifolia, Phragmites australis, Schoenoplectus californicus, Iva frutescens, Baccharis halimifolia
Brackish Marsh	Spartina patens, Paspalum vaginatum
Saline Marsh	Juncus roemerianus, Distichlis spicata, Spartina alterniflora, Avicennia germinans
Dune	***Uniola paniculata*, *Panicum amarum*, *Sporobolus virginicus***
Swale	***Spartina patens*, *Distichlis spicata*, *Solidago sempervirens*, *Strophostyles helvola*, *Baccharis halimifolia***

Submodels

Emergent marsh

Floating vegetation

Lowland forest

Upland forest

SAV

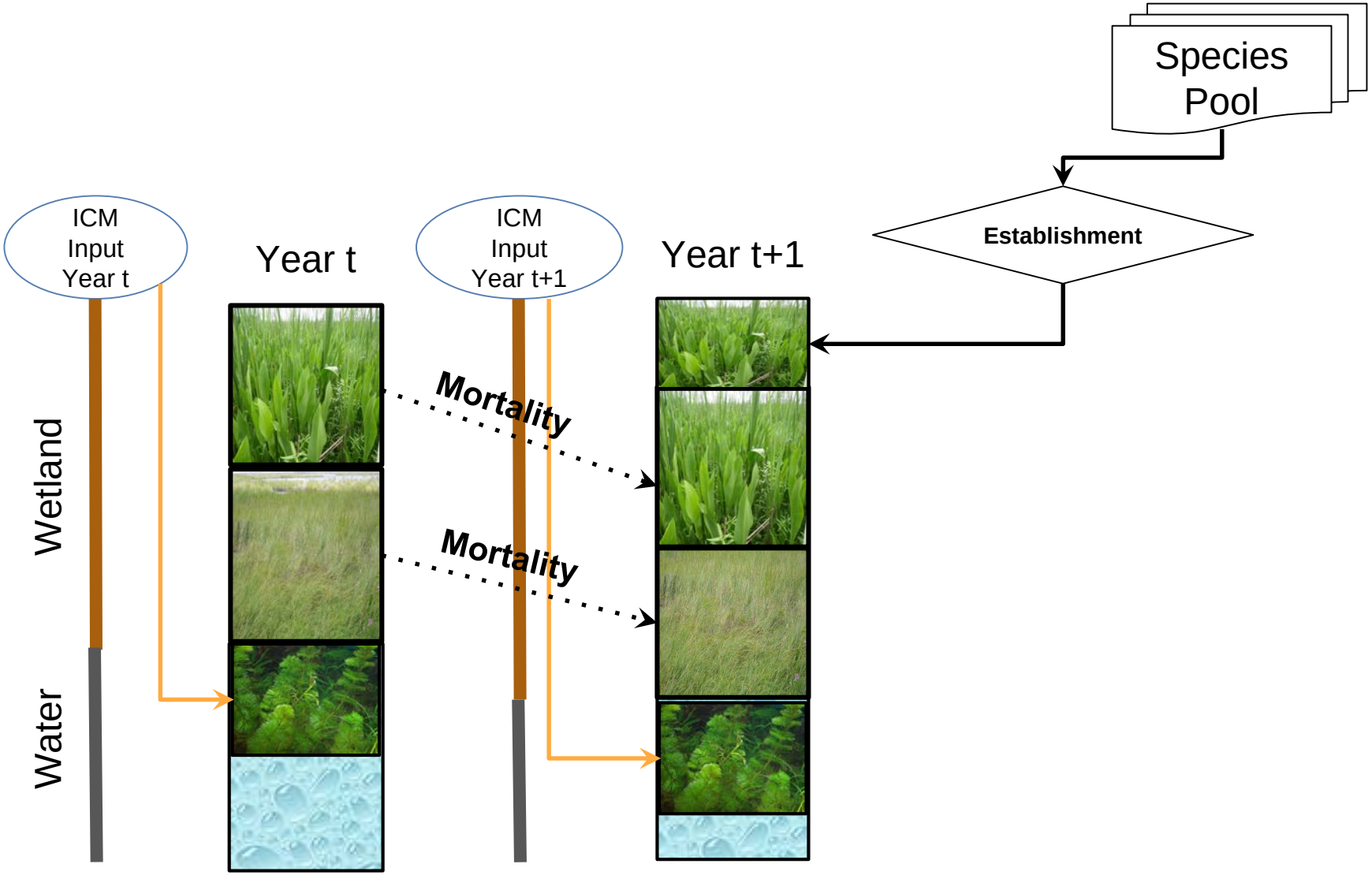
Ecological Processes

Species niche

- Salinity
- Hydrologic variation
- Inundation
- Water temperature

Dispersal

Conceptual Model



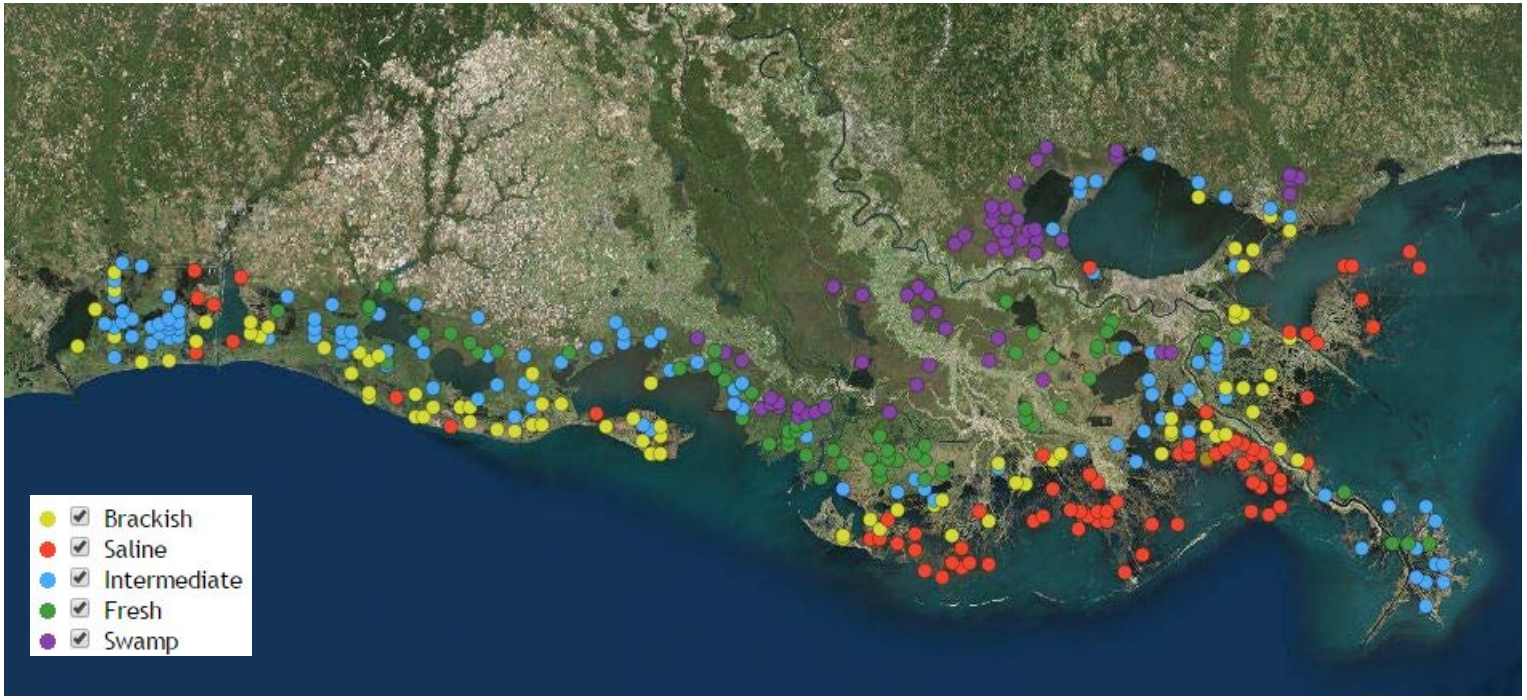
Emergent wetlands: *S. alterniflora*

Water Level Variability (standard deviation of water level, meters)

Salinity (annual median, ppt)	0.00	0.04	0.08	0.12	0.16	0.20	0.24	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	10.00
0.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
4.0	1.00	1.00	1.00	0.90	0.90	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5.0	1.00	1.00	1.00	0.75	0.75	0.75	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6.0	1.00	1.00	0.90	0.60	0.60	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7.0	1.00	1.00	0.75	0.45	0.45	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00
8.0	1.00	1.00	0.60	0.30	0.30	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.00
9.0	1.00	0.85	0.45	0.15	0.15	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90
10.0	1.00	0.70	0.30	0.00	0.00	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
12.0	1.00	0.70	0.30	0.00	0.00	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
14.0	1.00	0.70	0.30	0.00	0.00	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
16.0	1.00	0.70	0.30	0.00	0.00	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
18.0	1.00	0.70	0.30	0.00	0.00	0.00	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
20.0	1.00	0.90	0.50	0.20	0.20	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95
22.0	1.00	1.00	0.70	0.40	0.40	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00
24.0	1.00	1.00	1.00	0.60	0.60	0.60	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00
26.0	1.00	1.00	1.00	0.80	0.80	0.80	0.90	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
28.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
100.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Data for Calibration

- Coastwide Reference Monitoring System
  - 56 Swamp stations in 2012
  - 336 Marsh stations from 2007 through 2014



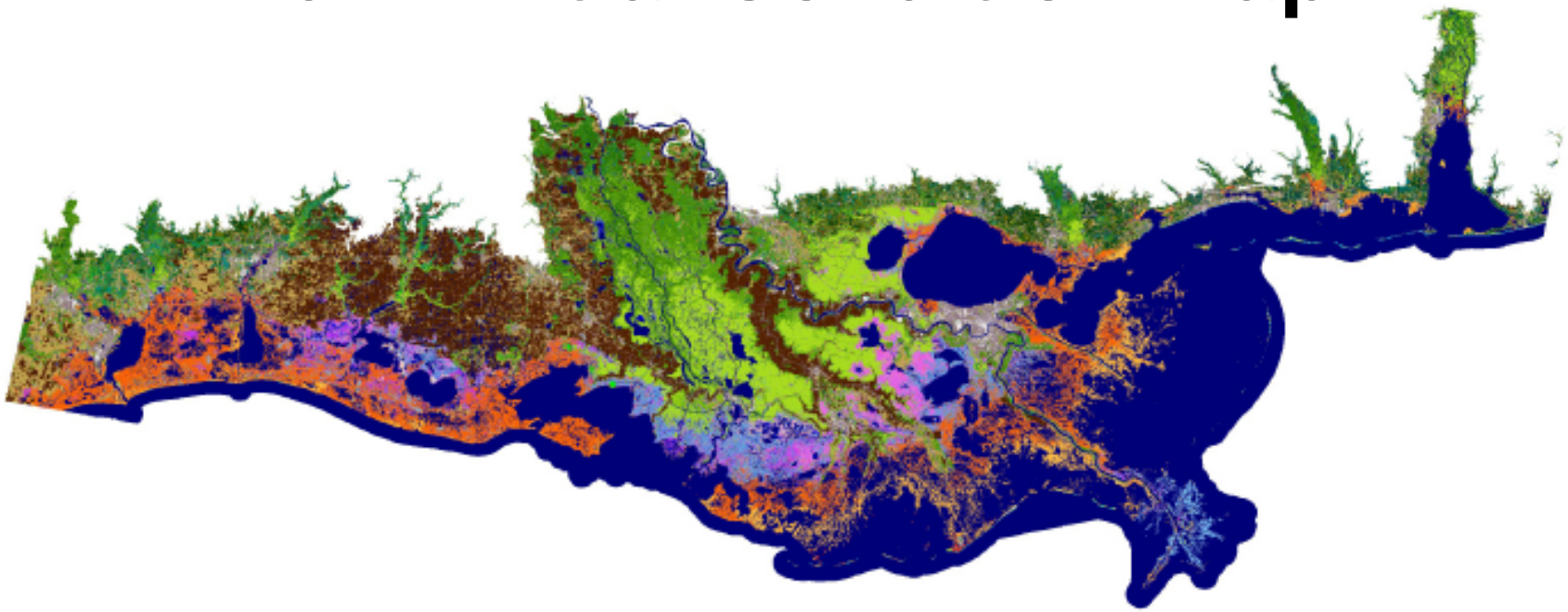
Submerged Aquatic Vegetation

- $Cover = 1.83 - 3.73 \times 10^{-2}\ T - 7.76 \times 10^{-2}\ S + 2.58\ D$
- T = water temp., ^{o}C
- S = salinity, ppt
- D = water depth, m

Upland forests

Elevation (m)	QULE	QUTE	QULA3	ULAM	QUNI	QUVI
-0.1525	0	0	0	0	0	0
0	0.1	0.1	0.1	0	0	0
0.1525	0.2	0.2	0.2	0	0	0
0.305	0.3	0.3	0.3	0.1	0.1	0
0.475	0.4	0.4	0.4	0.2	0.2	0
0.61	0.7	0.7	0.7	0.3	0.3	0
0.7625	0.8	0.8	0.8	0.4	0.4	0
0.915	1	1	1	0.6	0.6	0.2
1.0675	1	1	1	0.7	0.7	0.4
1.22	0.8	0.8	0.8	1	1	0.6
1.3725	0.7	0.7	0.7	1	1	0.8
1.525	0.4	0.4	0.4	0.6	0.6	1
1.6775	0.2	0.2	0.2	0.4	0.4	1
1.83	0	0	0	0.2	0.2	1
1.9825	0	0	0	0.1	0.1	1
2.135	0	0	0	0	0	1

2014 Initial Condition Map



50 0 50 100 150 200 km

Legend

LAVegMod Initial Conditions

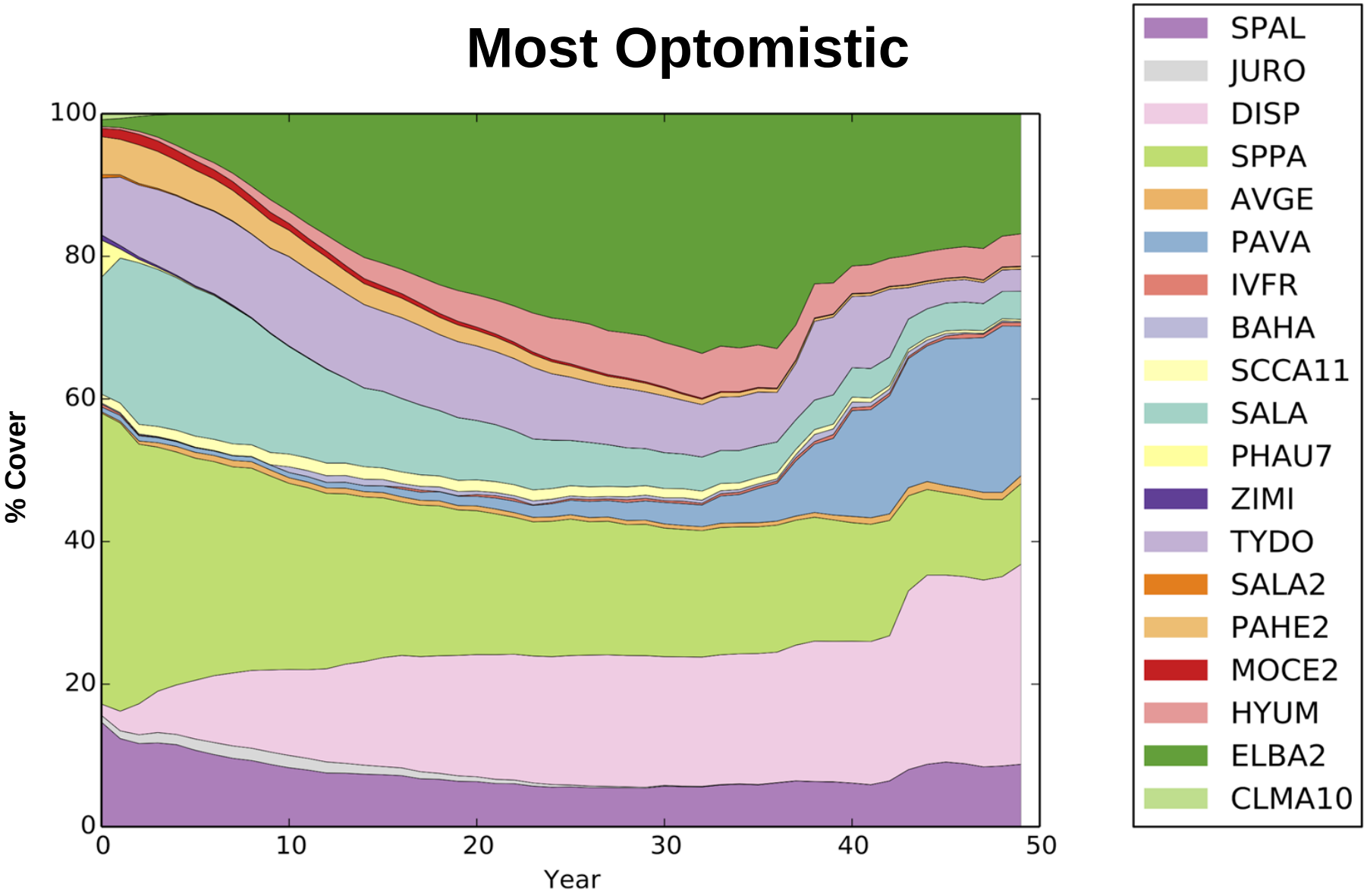
- QUTE
- QUVI
- QULA3
- ULAM
- QUVI
- QULE
- QUNI
- NYAQ2
- NYAQ2
- TADI2
- SANI
- NYAQ2
- TADI2
- CLMA10
- ELBA2
- ELBA2_Flt
- HYUM
- HYUM_Flt
- MOCE2
- PAHE2
- PAHE2_Flt
- SALA2
- TYDO
- ZIMI
- PHAU7
- SALA
- SCCA11
- BAHA
- IVFR
- PAVA
- AVGE
- SPPA
- DISP
- JURO
- SPAL
- STHE9
- SOSE
- DISPBI
- SPPABI
- SPVI3
- PAAM2
- UNPA
- BAHABI
- SAV
- NOTMOD
- BAREGRND
- BAREGRND
- Water

Model Results

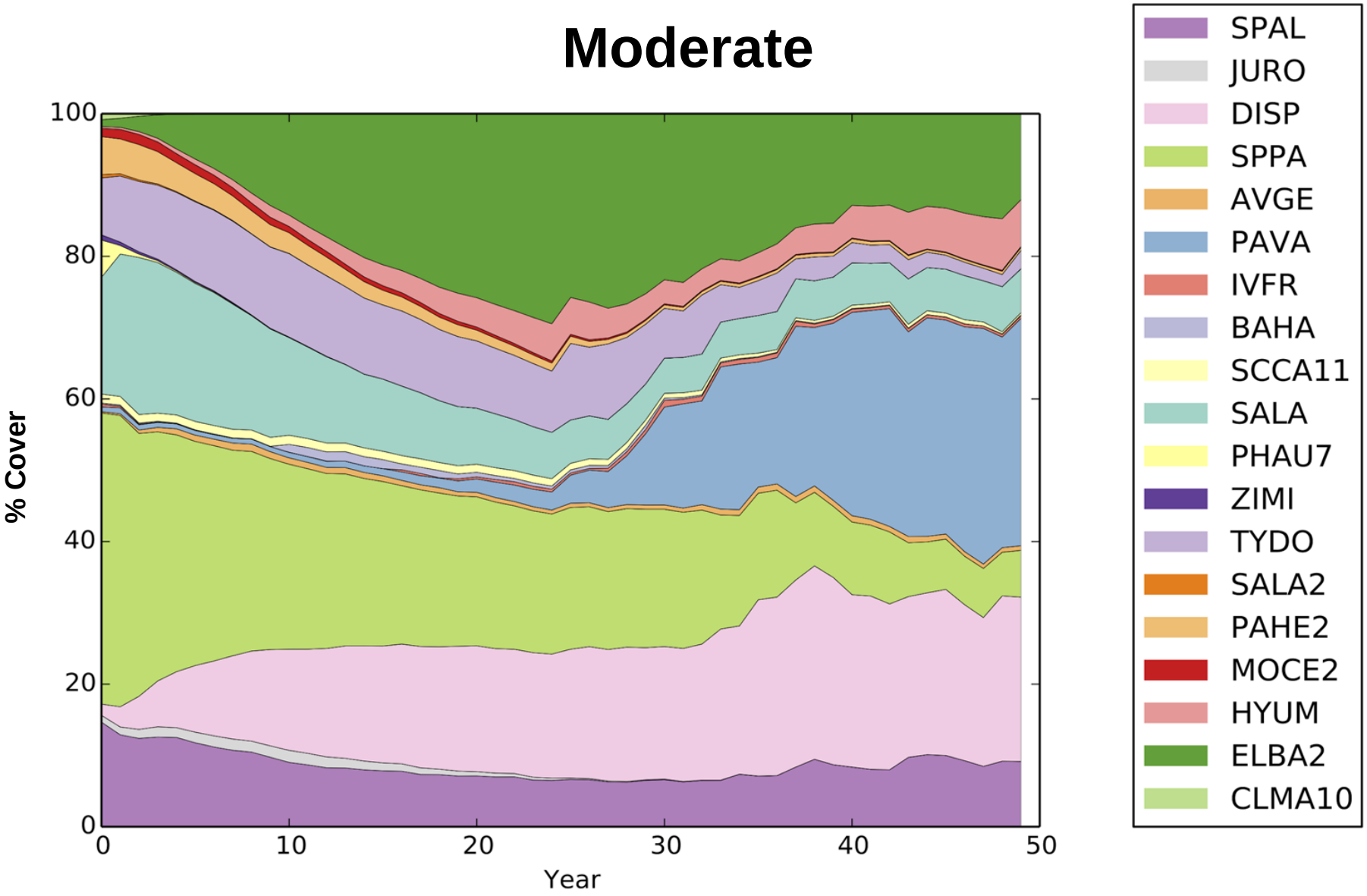
Scenario	ESLR (m/50 year)	Subsidence
Most optimistic	0.43	20%
Moderate	0.63	50%
Least optimistic	0.83	50%

ESLR = Eustatic Sea Level Rise

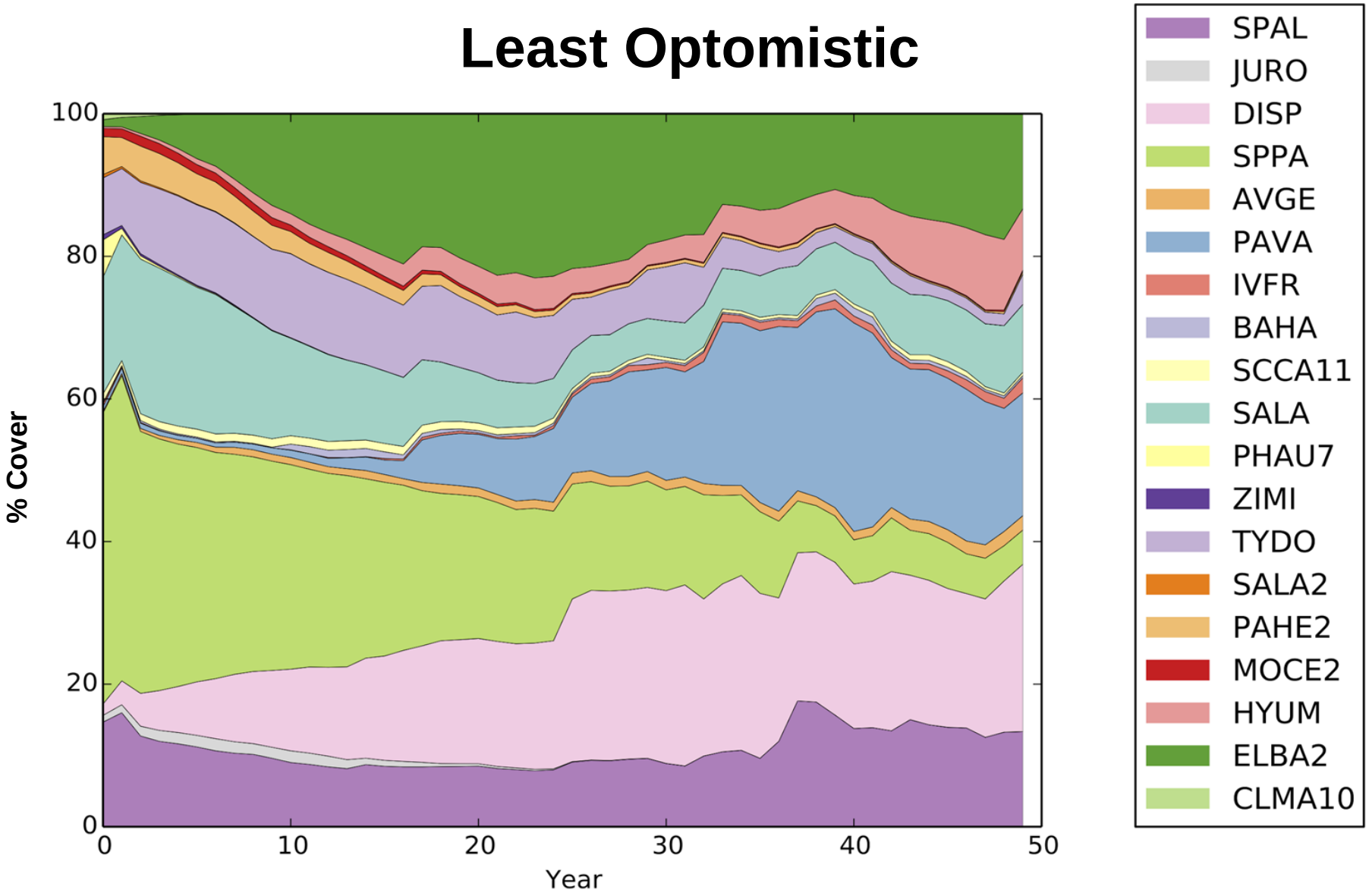
Most Optomistic



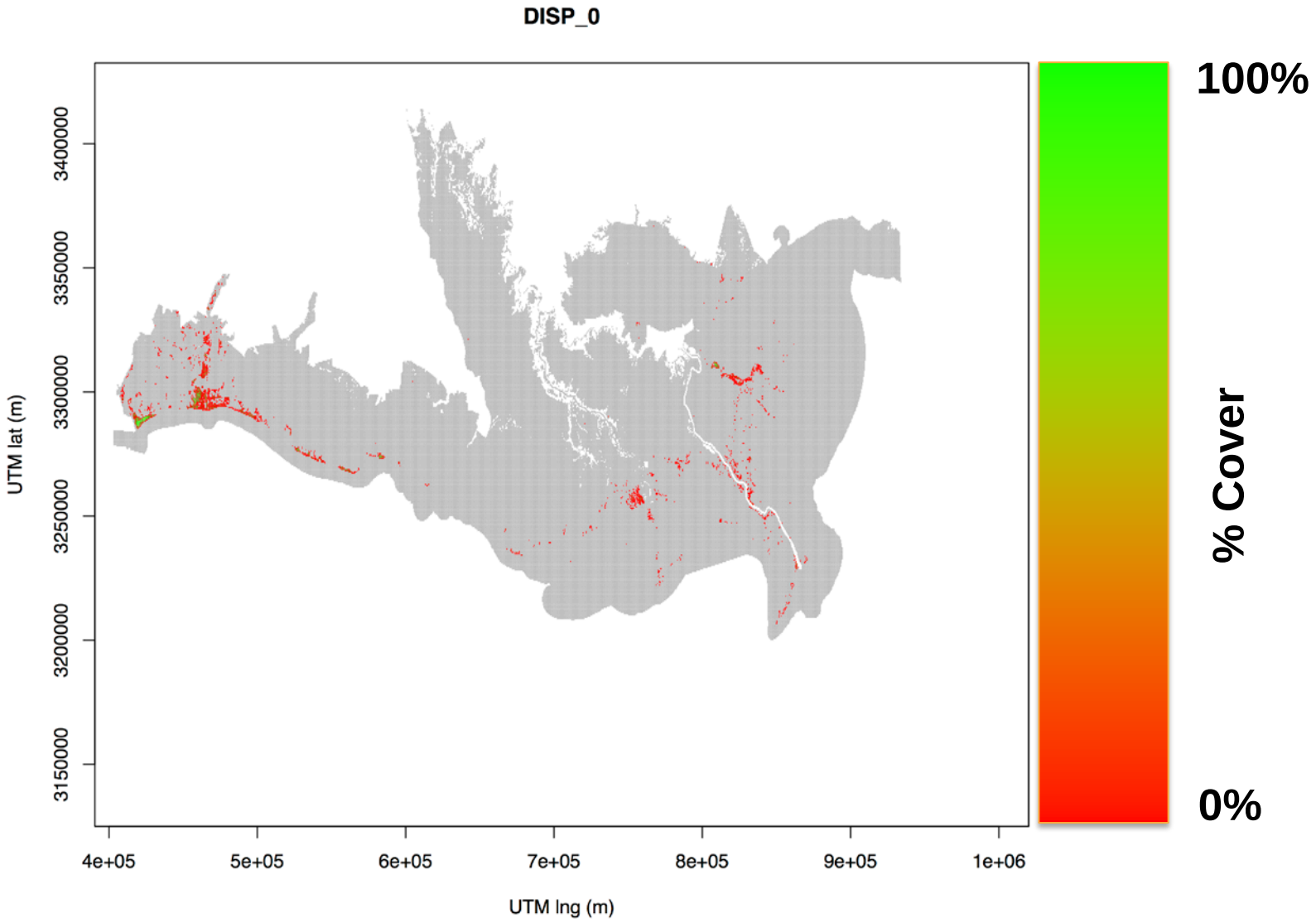
Moderate


% Cover
100
80
60
40
20
0
0
10
20
30
40
50
Year
SPAL
JURO
DISP
SPPA
AVGE
PAVA
IVFR
BAHA
SCCA11
SALA
PHAU7
ZIMI
TYDO
SALA2
PAHE2
MOCE2
HYUM
ELBA2
CLMA10

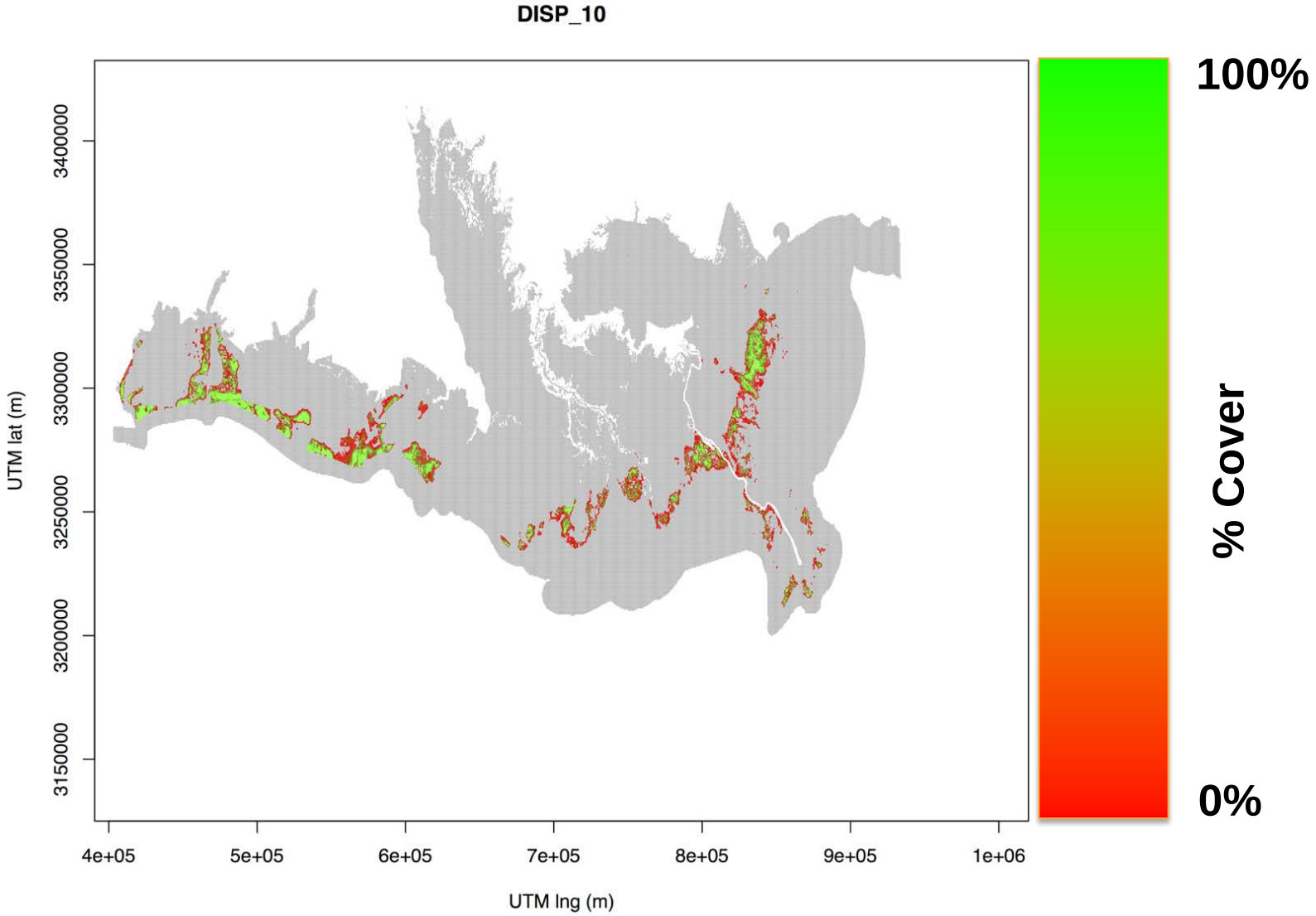
Least Optomistic



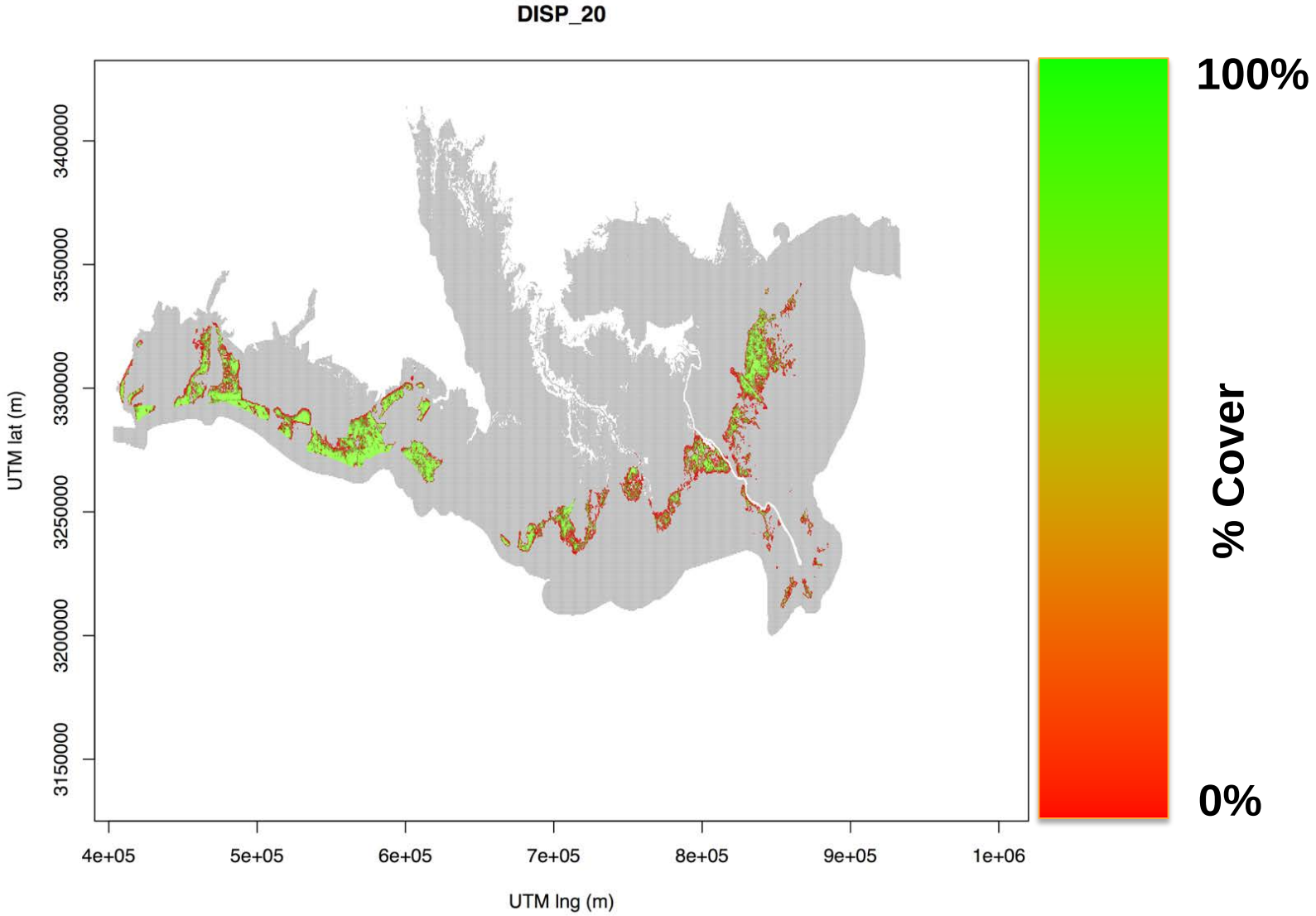
Most Optomistic
Distichlis spicata: Year 00



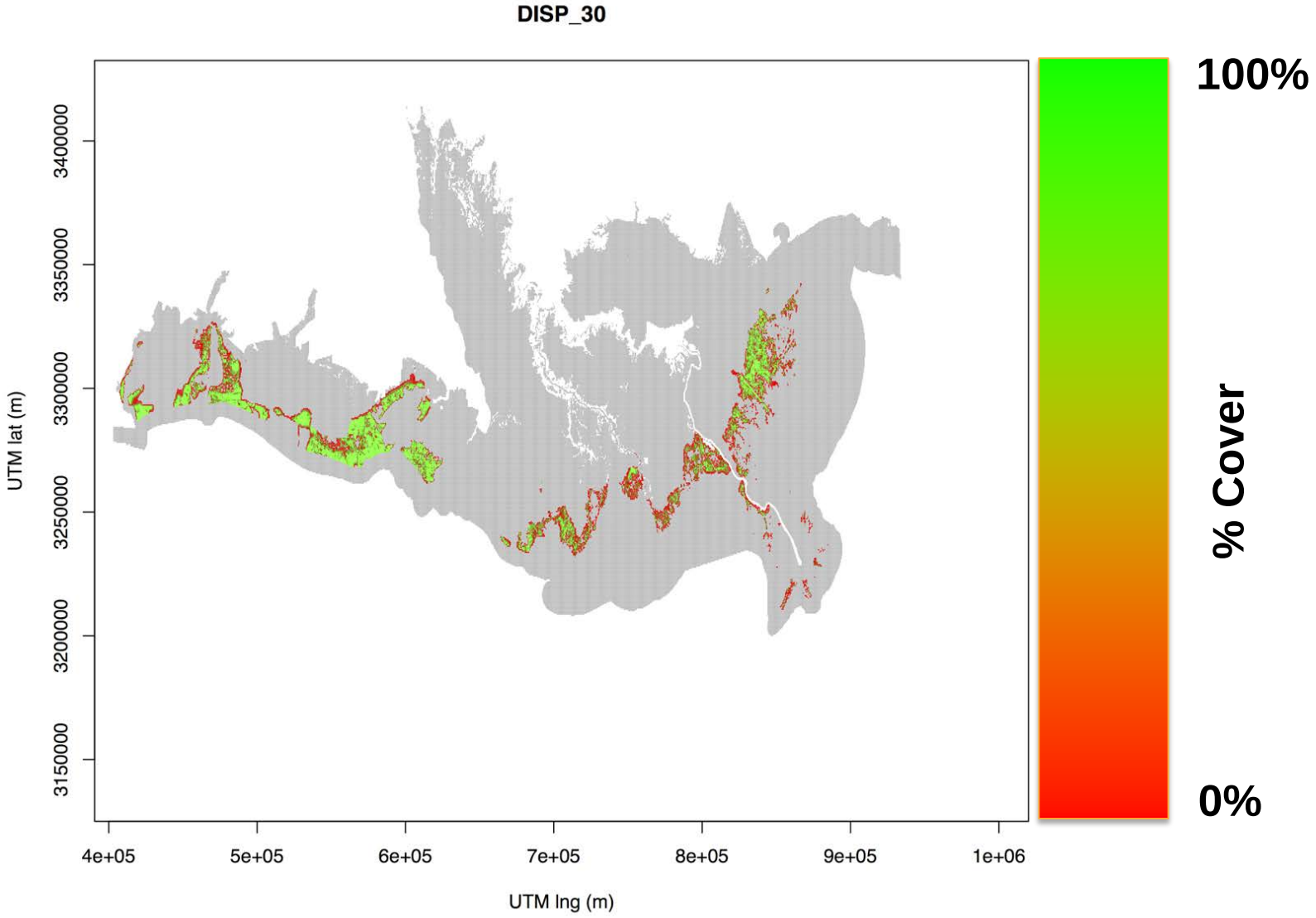
Most Optomistic
Distichlis spicata: Year 10



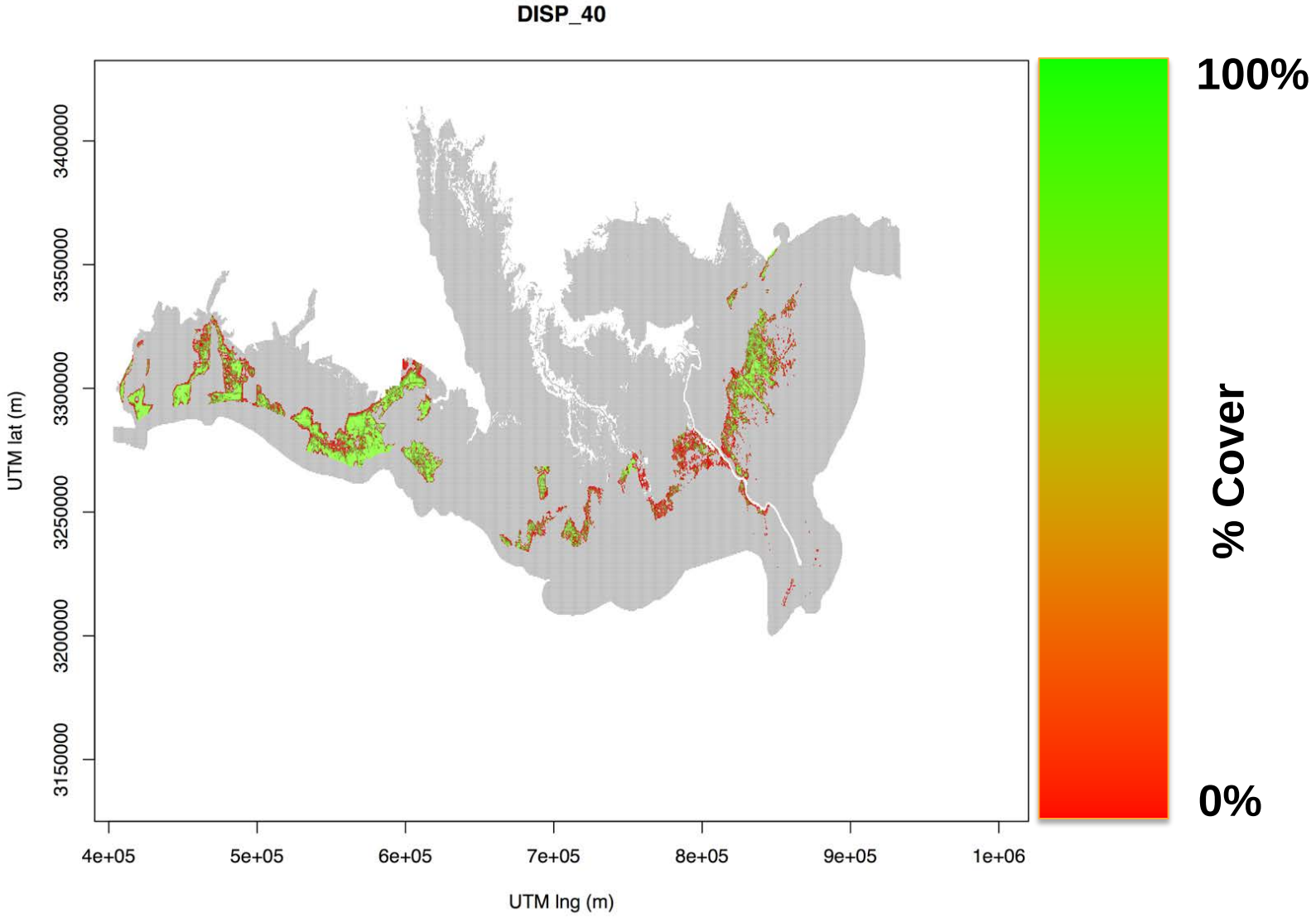
Most Optomistic
Distichlis spicata: Year 20



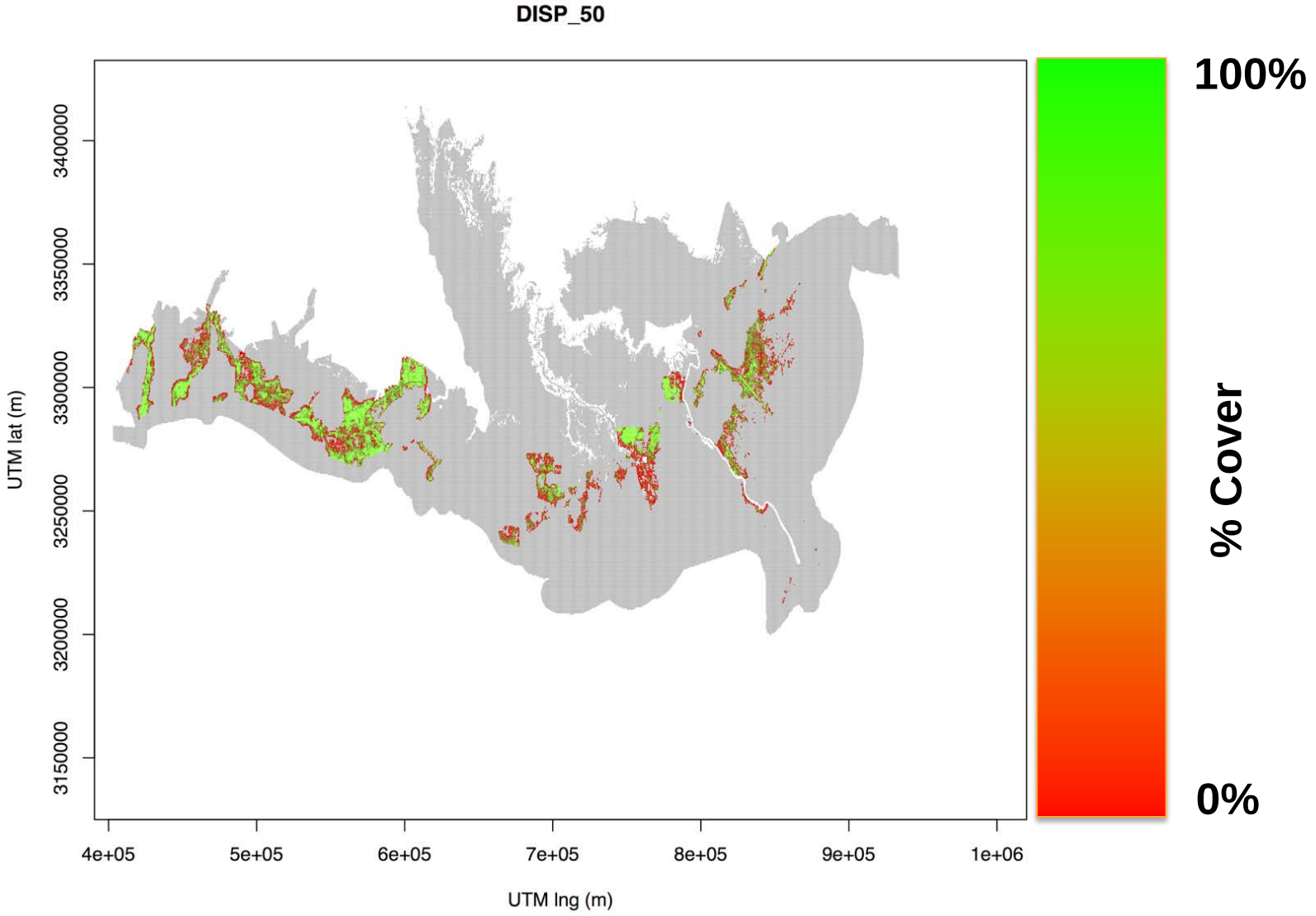
Most Optomistic
Distichlis spicata: Year 30



Most Optomistic
Distichlis spicata: Year 40

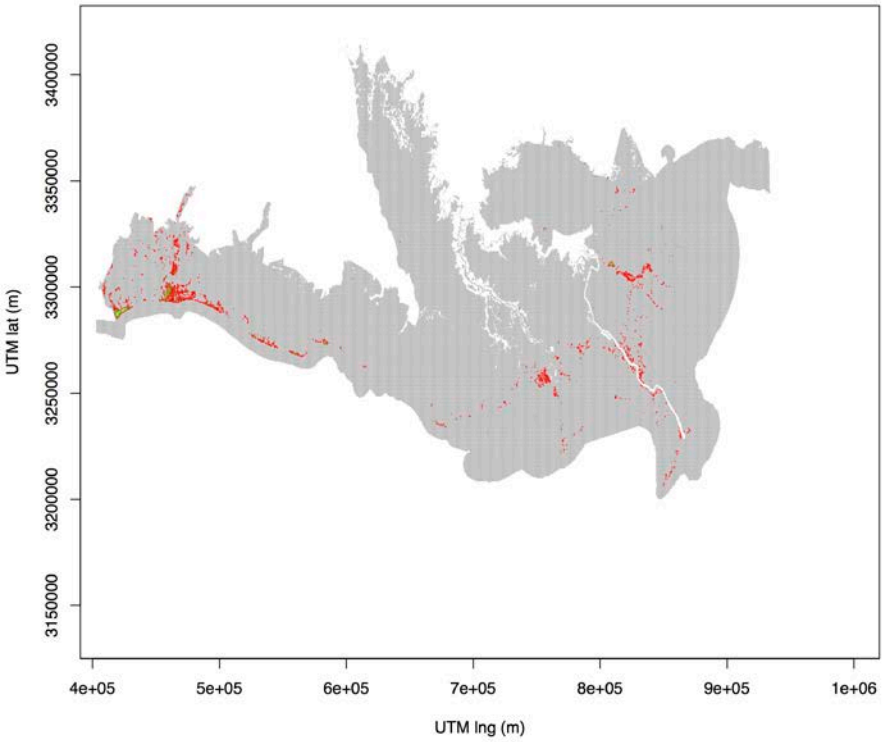


Most Optomistic
Distichlis spicata: Year 50

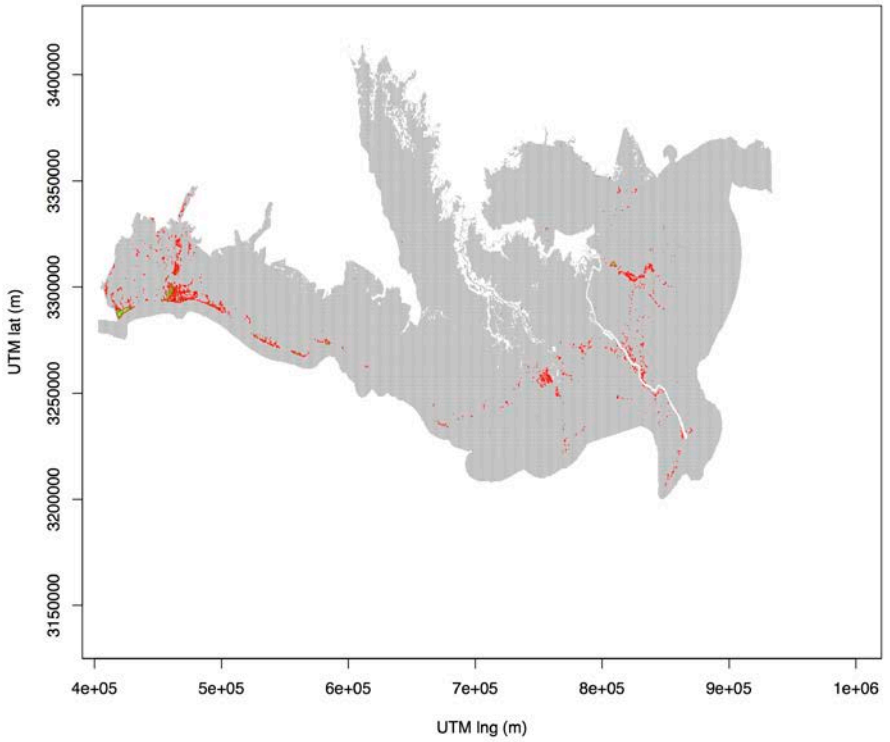


Most vs Least
Distichlis spicata: Year 00

Most



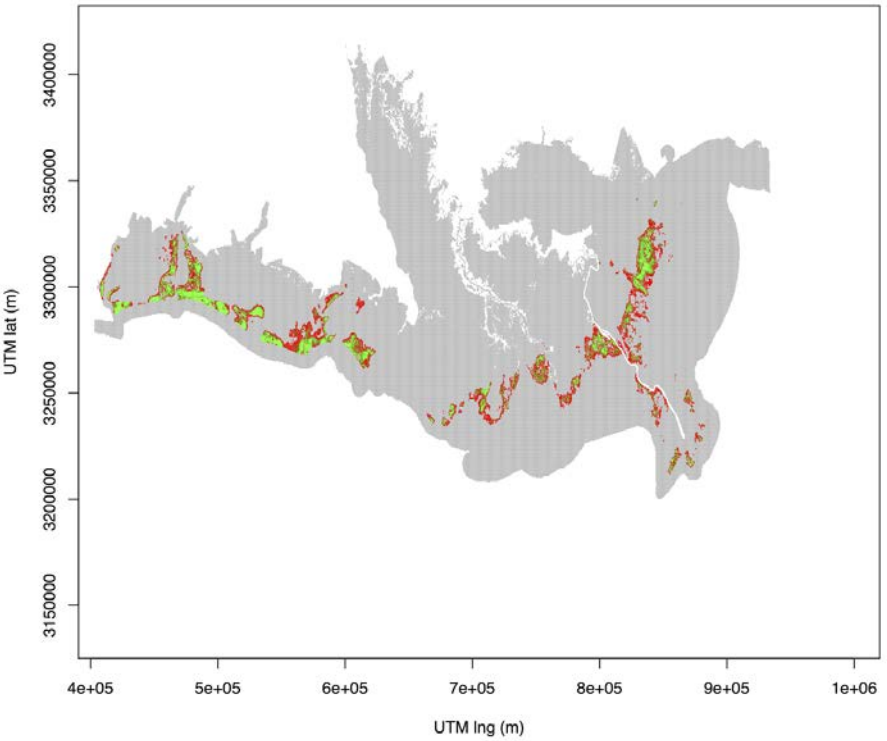
Least



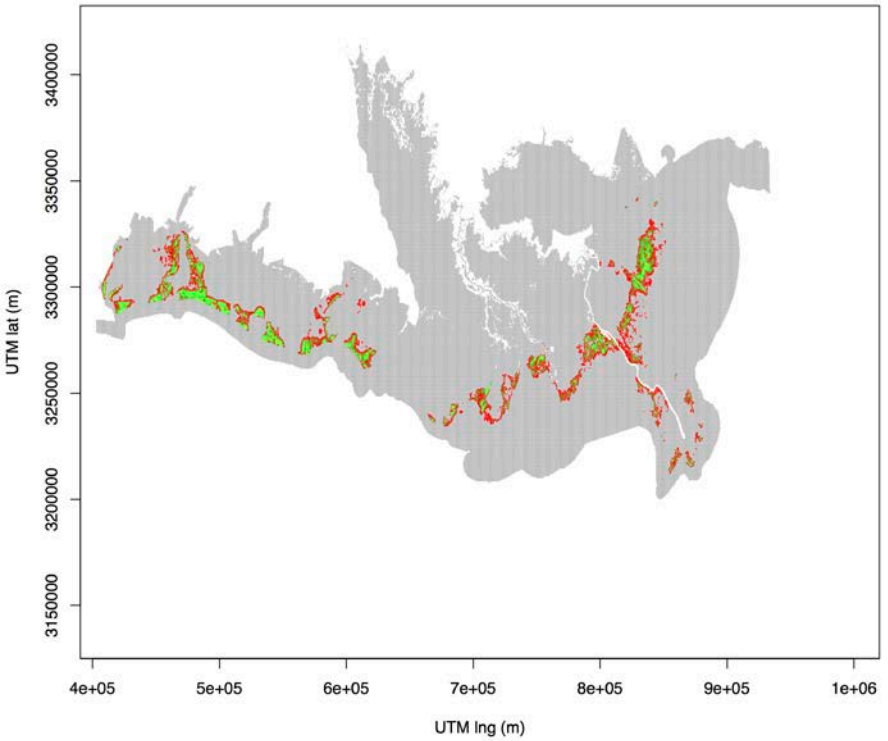
0% % Cover 100%

Most vs Least
Distichlis spicata: Year 10

Most



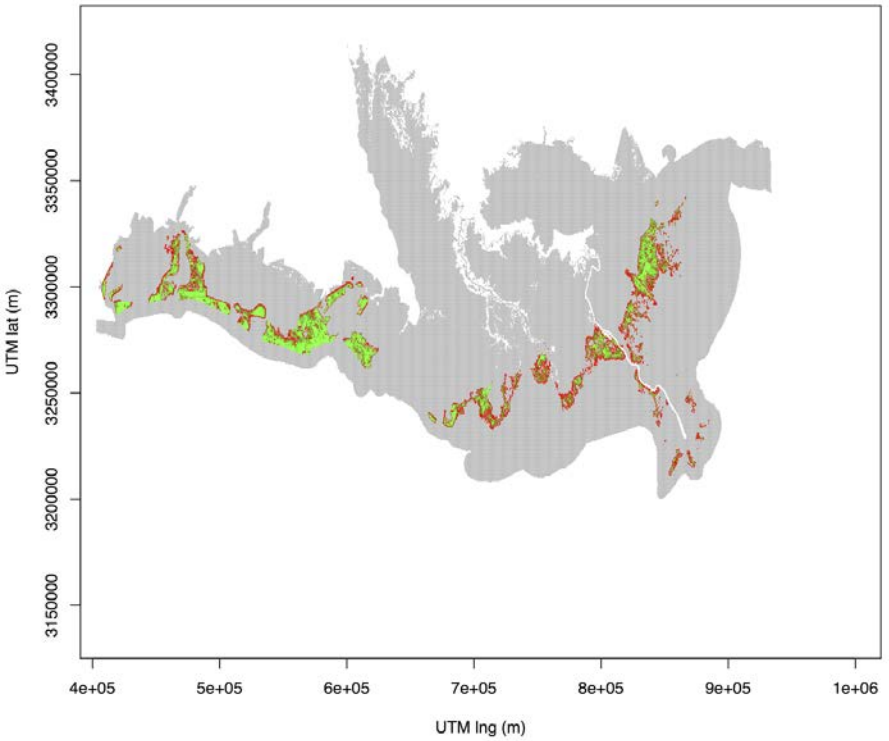
Least



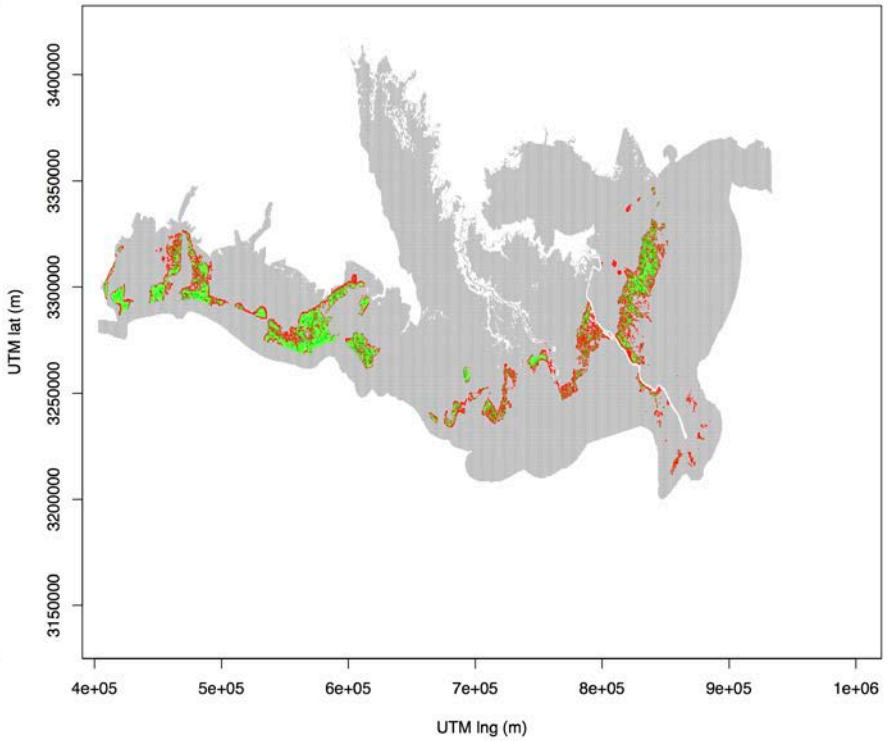
0% % Cover 100%

Most vs Least
Distichlis spicata: Year 20

Most



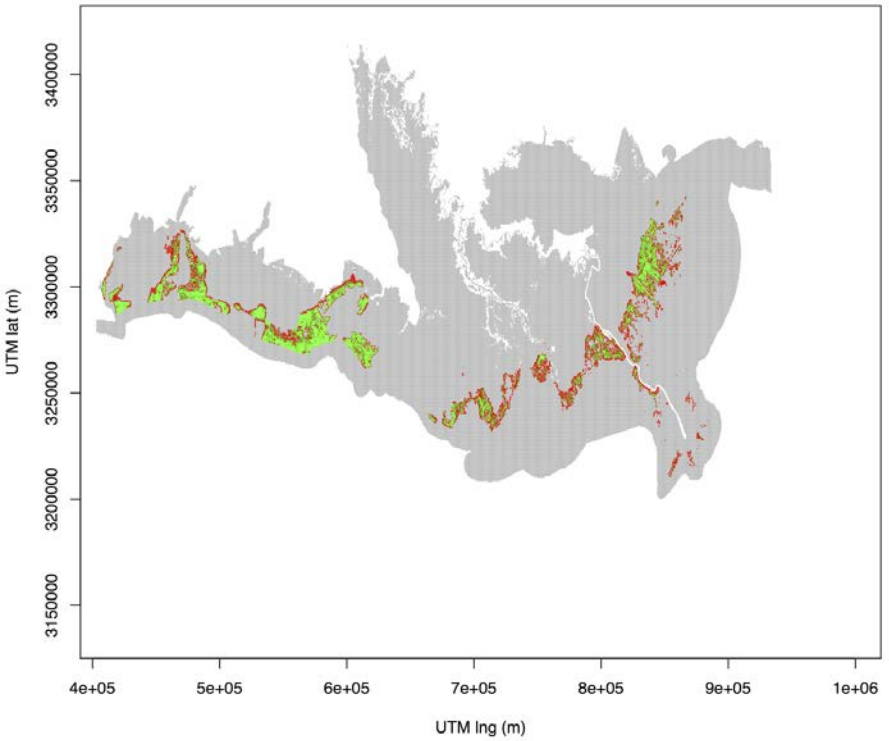
Least



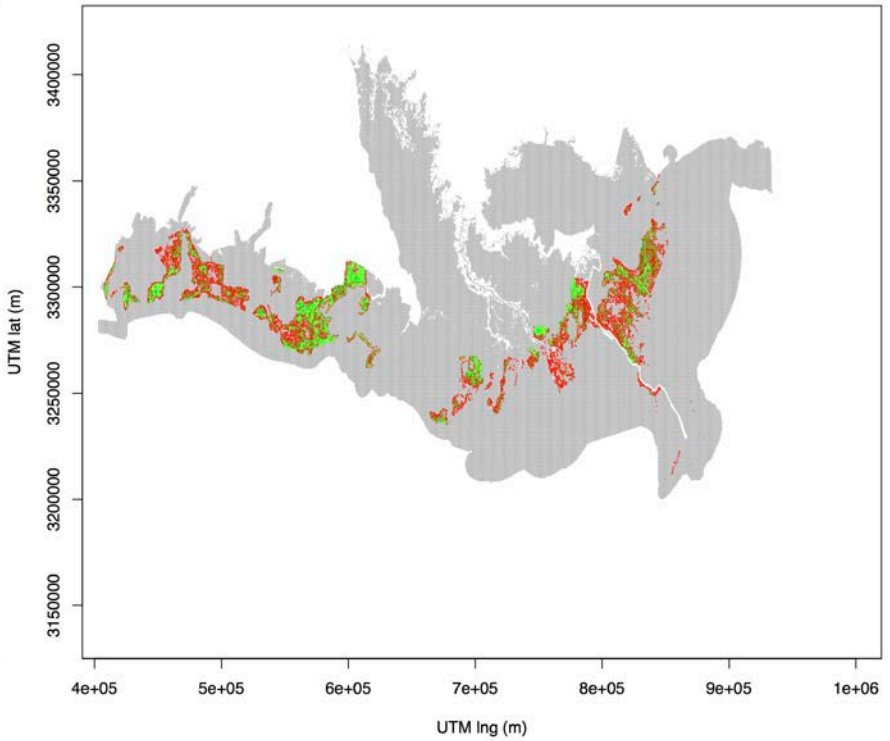
0% % Cover 100%

Most vs Least
Distichlis spicata: Year 30

Most



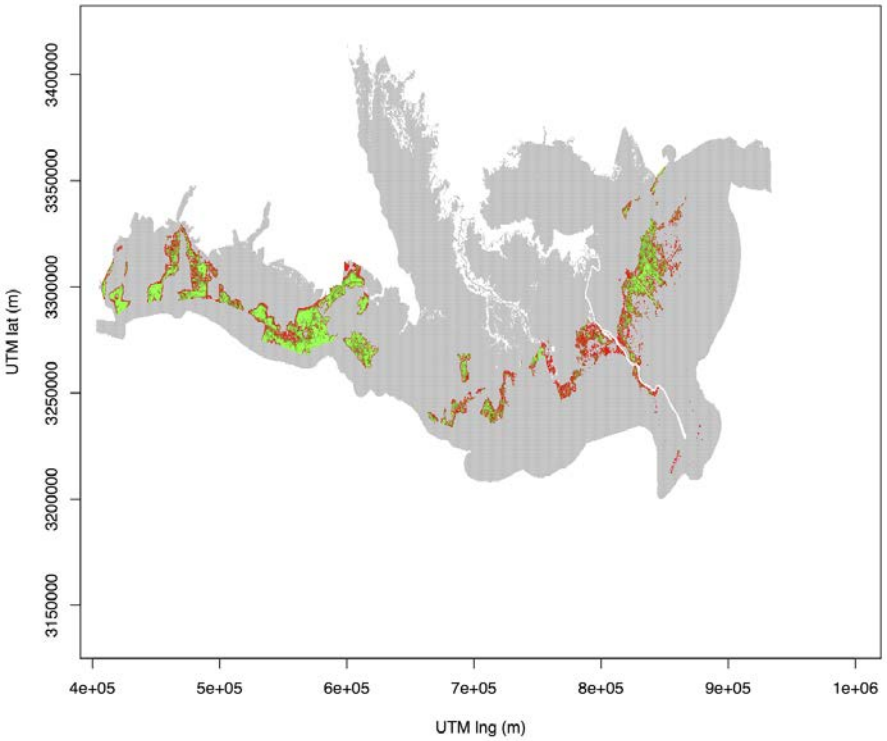
Least



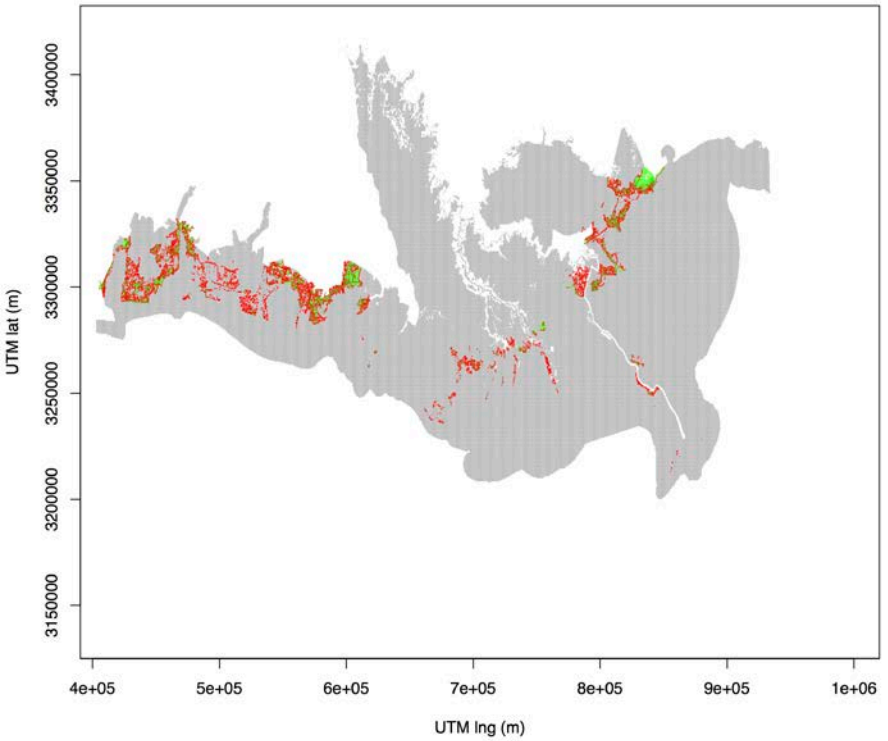
0% % Cover 100%

Most vs Least
Distichlis spicata: Year 40

Most



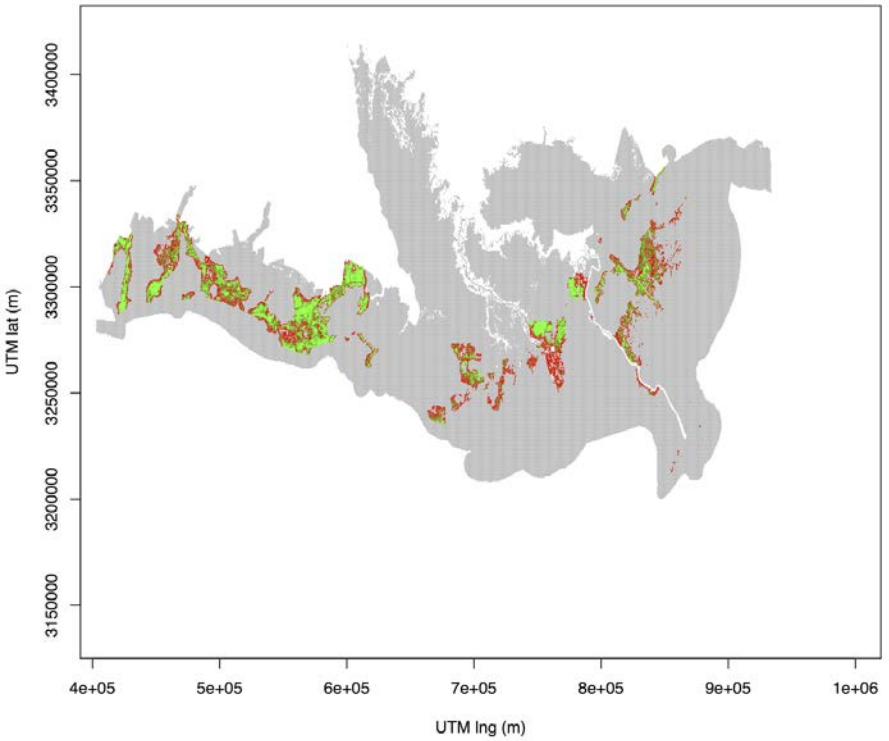
Least



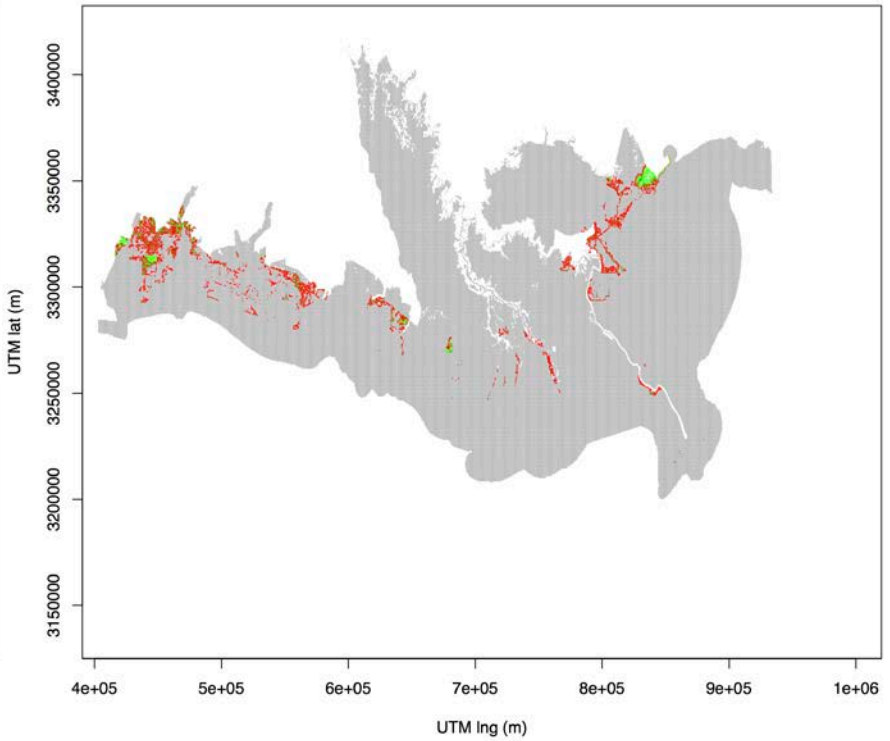
0% % Cover 100%

Most vs Least
Distichlis spicata: Year 50

Most



Least



0% % Cover 100%

Applications

Evaluate alterivative management options

Vegetation

Higher trophic level habitat

Acknowledgements

Jenneke Visser, *UL Lafayette*

Jacoby Carter, *USGS National Wetland Research Center*

Eric White, *The Water Institute of the Gulf*

Ehab Meshleh, *The Water Institute of the Gulf*