From Scenarios to Sections: A Parameter Framework for Sea Level Rise–Responsive Design

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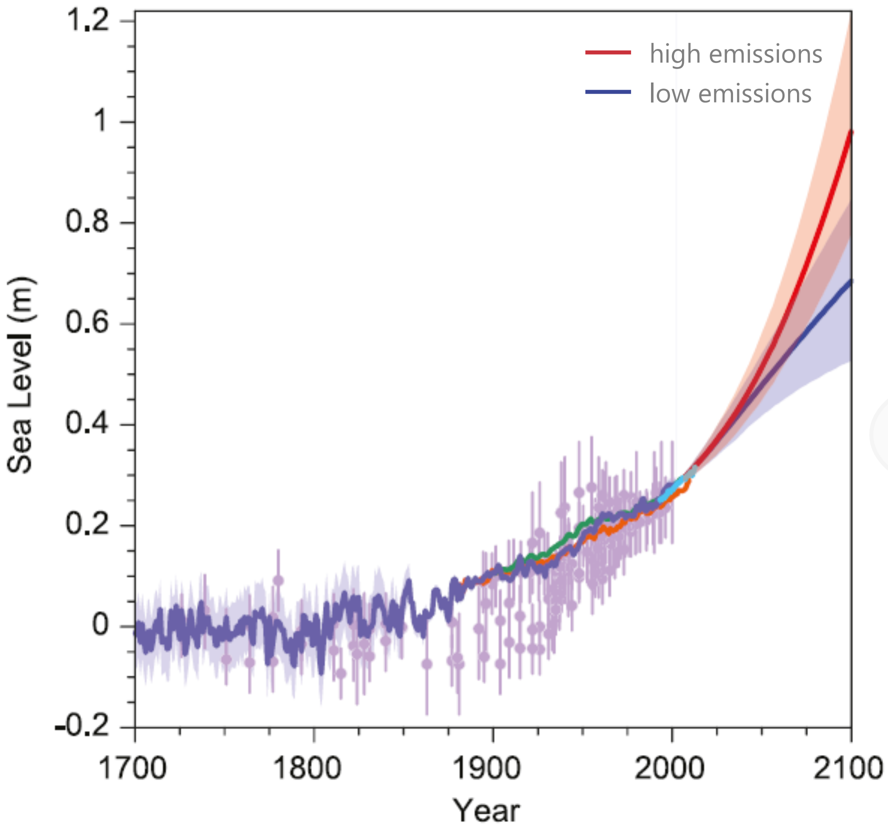
SCIENCE SIDE

Scenarios · uncertainty · time

SLR projections



Inputs scenarios

Outputs curves

Framing uncertainty

Fig. 1. Past and future sea-level rise. For the past, proxy data are shown in light purple and tide gauge data in blue.. Source: IPCC AR5 Fig. 13.27.

Translation gaps?

PRACTICE SIDE

missing translation

Design decision space

What should design do with this?

What elevation?

What slope?

What width?

What setback?

What species?

What tolerance range?

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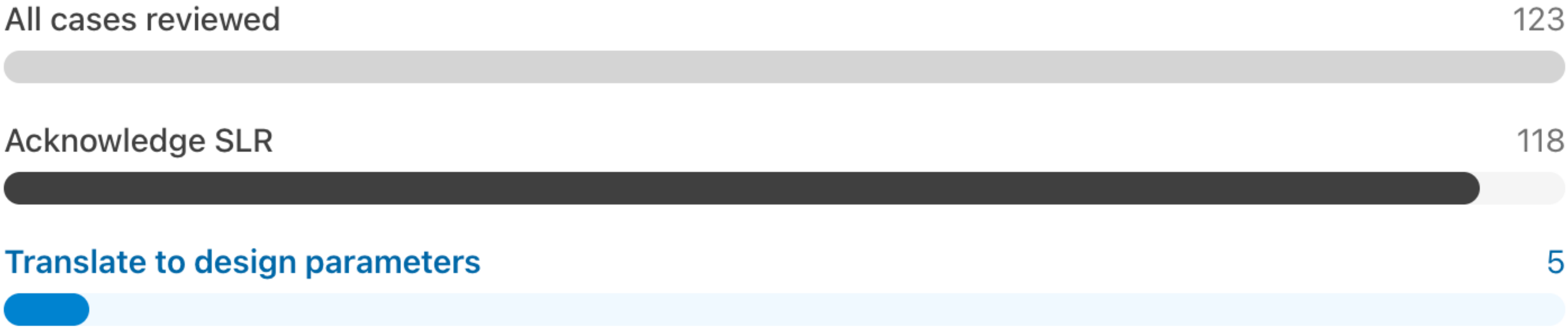
meta-analysis

Most projects acknowledge SLR, but very few translate it into design parameters

95.9% acknowledge SLR → **4.1%** translate to design parameters



Pang, B., & Deal, B. (2025). Bridging Design and Climate Realities: A Meta-Synthesis of Coastal Landscape Interventions and Climate Integration. Land (2012), 14(9).

What translation logic can be extracted from the five exemplar projects?

Research question

How do the five exemplar projects translate SLR scenarios into actionable design parameters?

Can that logic be extracted, codified, and transferred beyond the original cases?

→

Approach

INPUT
Five exemplar projects

METHOD
Reverse-engineer each case to identify, extract, and code its translation logic.

OUTPUT
A transferable framework linking scenario, parameter, rule, and design specification.

WHY THIS MATTERS
Scenarios exist.
Design-ready translations do not.

WHAT IS BEING EXTRACTED
Parameters, thresholds, triggers, and decision rules from five exemplar projects.

WHAT FOLLOWS
Cross-case patterns, rule synthesis, and the SLR→DPF framework.

Left-to-right-workflow

From evidence extraction to translation framework

Step 1 — Case Documents
Project set · Figures · tables · Text
- 5 exemplar projects

→

Step 2 — Parameter Extraction
4 dimensions
- Vertical
- Horizontal
- Temporal
- Ecological

→

Step 3 — Provenance coding
evidence form
- D = designed
- M = modeled
- Mon = monitored

→

Step 4 — Gap Documentation
What is missing
- NR = not reported
- NA = not applicable
- ND = not determinable

→

Step 5 — Cross-Case Synthesis
Patterns across cases
- compare
- identify patterns
- synthesize

→

Step 6 — Framework + Rules
Translation output
- design logic
- IF – THEN rules
- operational use

EXTRACTION LOGIC

Evidence is extracted from text, figures, tables, and comparable parameter fields.

CODING LOGIC

Each parameter is coded by evidence basis and by whether it is reported, omitted, or not determinable for design use.

SYNTHESIS LOGIC

Cross-case comparison produces reusable framework components and IF–THEN translation rules.

Four dimensions of design translation

Literature-grounded organizational structure for parameter extraction

Vertical

How high? How strong?

Defines elevation and loading requirements.

- target elevation
- flood depth / freeboard
- SLR allowance

Horizontal

How wide? Where?

Defines extent, footprint, and configuration.

- marsh / buffer width
- intervention area
- spatial configuration

Temporal

When to act? When to change?

Defines sequencing and trigger logic over time.

- design horizon
- thresholds / tipping points
- adaptation phases

Ecological

What survives? What persists?

Defines living-system performance and persistence.

- Vegetation type
- Accretion rate
- Accommodation space

map+ compact summary table

Five exemplar projects across contexts

Project	Location	Type	Key Contribution
Taylor-Burns et al. (2024)	San Francisco Bay, USA	Marsh restoration + flood valuation	Platform elevation targeting; SLR-benefit scaling
Castagno et al. (2022)	US Atlantic (idealized)	Wave attenuation modeling	Width × coverage thresholds for wave reduction
Marijnissen et al. (2020)	Ems-Dollard, Netherlands	Wide Green Dike hybrid system	Dike-marsh integration; clay sourcing from foreshore
Raw et al. (2021)	Swartkops, South Africa	Tidal reconnection + C sequestration	Habitat migration under SLR; SLAMM modeling
Xu et al. (2021)	Xiamen, China	Urban flood exposure assessment	Reclamation–SLR interaction; exposure quantification

STEP 2 — FORENSIC EXTRACTION

How forensic extraction works

ID	Parameter	Dimension	Value	Rule	Provenance	Source
V1	Platform target elevation	Vertical	+1.0 m MSL (=2.0 m NAVD 88)	**IF** marsh elevation < +1.0 m MSL **THEN** apply sediment nourishment	Designed	“bring the sites to a mean elevation of 2 m NAVD88”

Each parameter is traced to a specific page, figure, or table.

Gaps are coded explicitly as NR, NA, or ND.

Provenance coding distinguishes designed, measured, and modeled values.

IF–THEN rules capture the logic linking scenario evidence to specification.

Cross-Case Synthesis: Four patterns emerged across the five projects

Pattern 01

Discrete SLR Steps

Projects convert continuous SLR projections into discrete thresholds (0.3 / 0.5 / 1.0 m) that trigger design responses.

Pattern 02

Width × Coverage Logic

Wave attenuation depends on marsh width and vegetation cover; ≥100 m width with ≥50% cover repeatedly delivers strong reduction.

Pattern 03

Elevation Convergence

Platform targets converge around local tidal frames rather than arbitrary absolute elevations.

Pattern 04

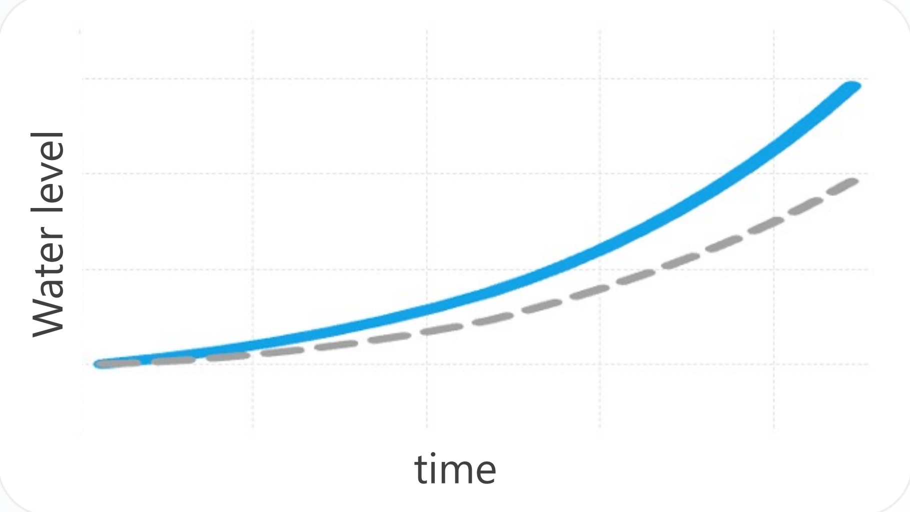
Accretion–SLR Balance

When accretion no longer keeps pace with SLR, intervention shifts to sediment addition or tidal reconnection.

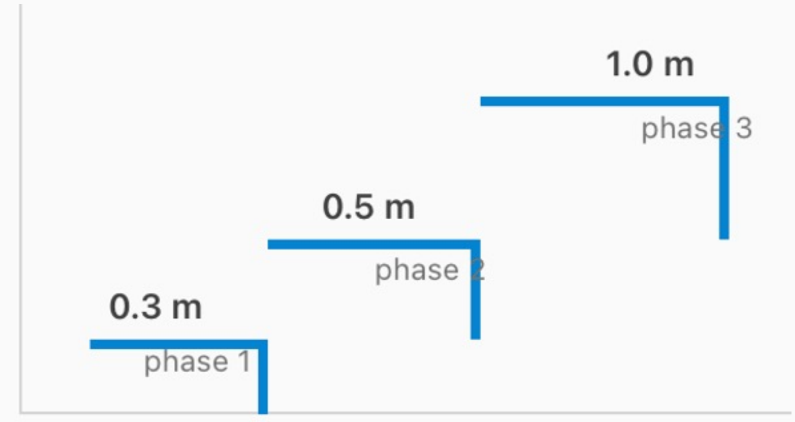
science curve → design increments

From continuous projection to discrete design steps

What scientists produce



What designers use



How each project operationalizes SLR steps

- **Common thresholds**
  0.3 m · 0.5 m · 1.0 m
- **Typical phase logic**
  protection → accommodation → migration
- **Operational rule**
  higher SLR thresholds → larger design responses

KEY INSIGHT

All five projects convert continuous SLR projections into discrete steps that trigger specific design responses.

Adaptive Phasing

IF an SLR threshold is crossed

THEN trigger the next design phase and preserve migration space

KEY PAYOFF

higher SLR thresholds trigger larger phased responses

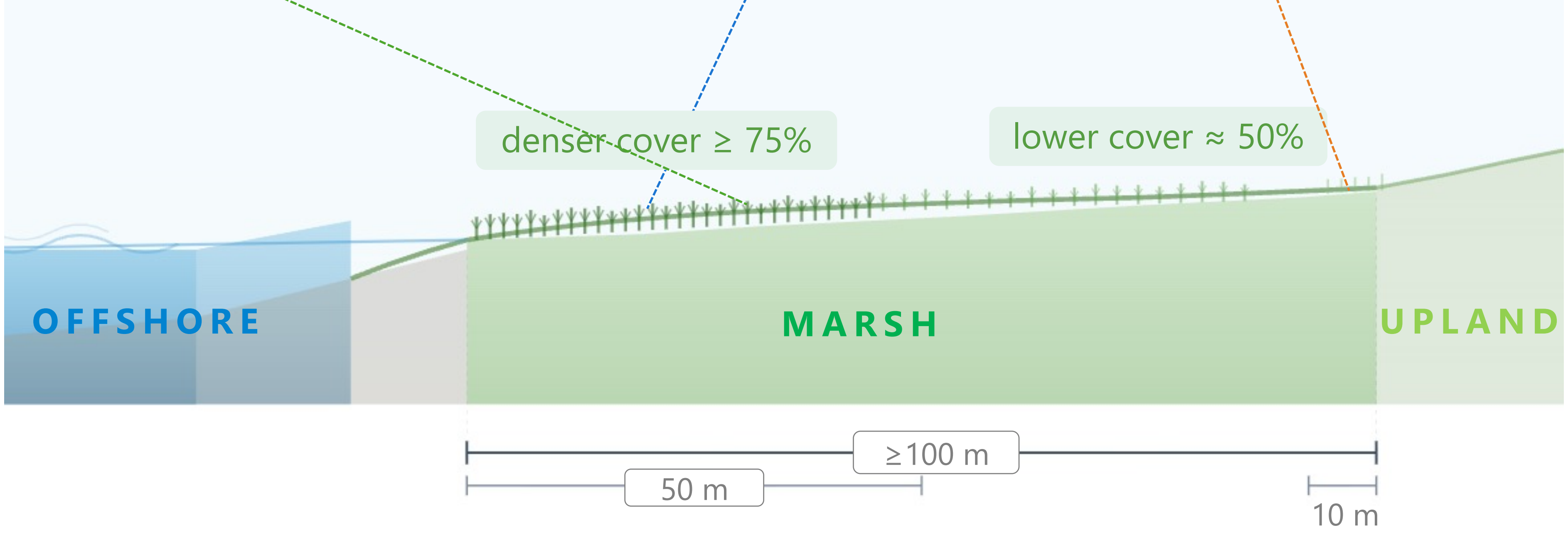
Cross-section logic

Marsh width and vegetation benchmark for wave reduction

100 M BENCHMARK
≥100 m width + ≥50% vegetation
→ ≈95% wave energy reduction

50 M BENCHMARK
50 m width + ≥75% vegetation
→ 80–90% wave reduction

10 M EDGE CASE
10 m vegetated edge
→ >50% (low), >80% (high)



Wave Attenuation

IF wave exposure increases and a higher protection level is required

THEN increase marsh width and vegetation cover

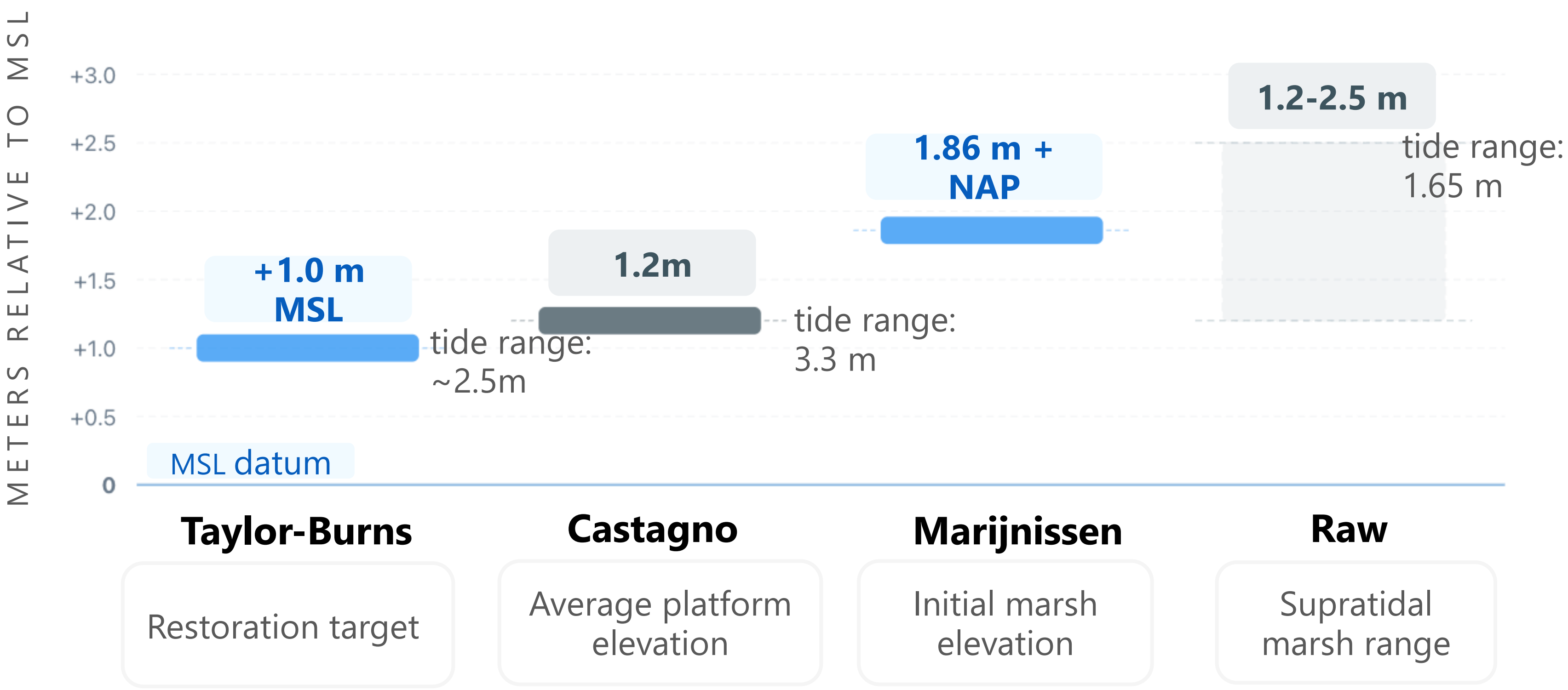
KEY INSIGHT

Wave attenuation is repeatedly operationalized through width and vegetation together.

comparative section diagram

Platform elevations converge relative to local tidal frame

Successful platform targets are calibrated to local tidal reference frames



1 Taylor-Burns: Restoration target = +1.0 m MSL (= 2.0m NAVD 88) across San Francisco Bay sites.

2 Marijnissen: Initial marsh elevation μ =1.86 m + NAP (≈1.86 m above approximate MSL).

3 Castagno: Average marsh platform elevation = 1.2 m in the idealized model.

4 Raw: Supratidal marsh elevation range = 1.2 – 2.5 m above chart datum.

KEY INSIGHT

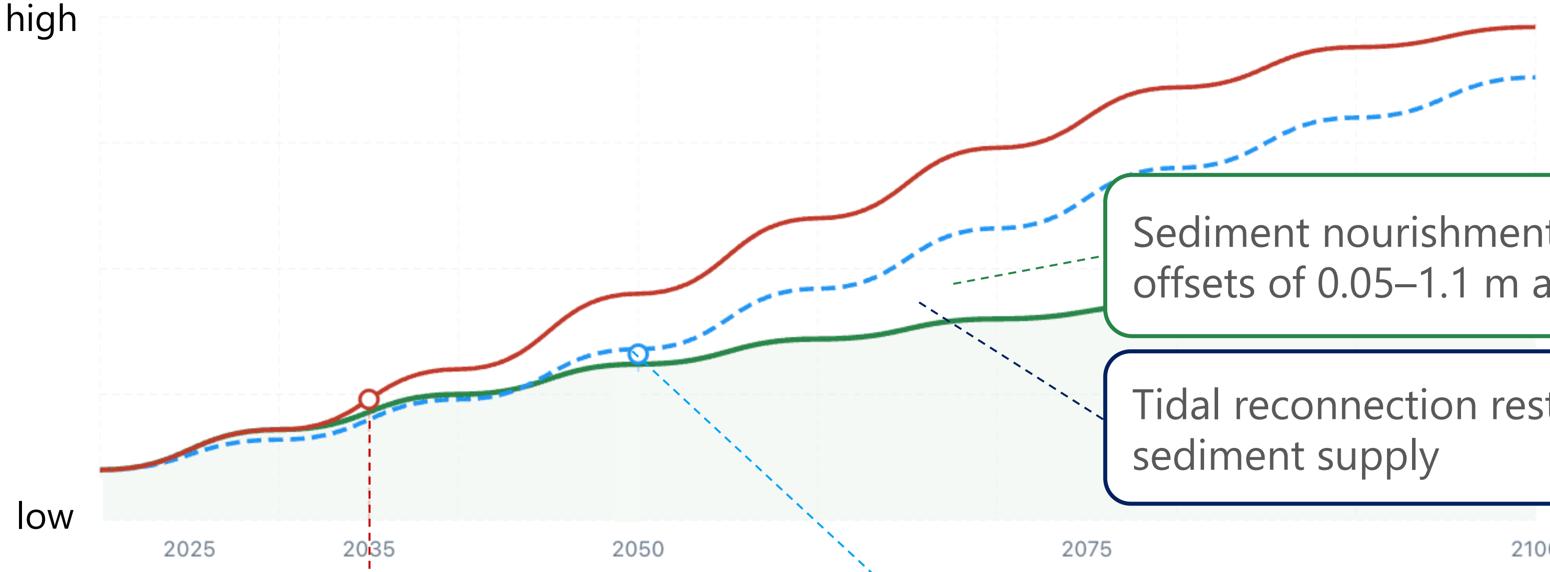
Across cases, marsh platform targets are set relative to local tidal frames, not arbitrary absolute elevations. This provides a transferable starting logic for section elevation design.

NAP = Amsterdam Ordnance Datum
NAVD 88 = North American Vertical Datum of 1988
MSL = Mean Sea Level

STEP 3 — CROSS-CASE SYNTHESIS

The accretion-SLR race and intervention timing

Marsh survival depends on whether accretion keeps pace with relative SLR



Sediment nourishment offsets of 0.05–1.1 m applied

Tidal reconnection restores sediment supply

SURVIVAL CONDITION
Accretion keeps pace → marsh persists

HIGH SCENARIO OUTPACED
Accretion lags SLR by **~2035**
(Marijnissen et al., 2020)

MEDIUM SCENARIO OUTPACED
Accretion lags SLR by **~2050**
(Marijnissen et al., 2020)

Sediment Balance

IF relative SLR exceeds accretion capacity

THEN evaluate sediment supplementation or hydrologic reconnection.

KEY INSIGHT

The issue is not whether marshes accrete, but when accretion no longer keeps pace.

What exemplar projects report — and what they still omit

WHAT EXEMPLARS DO REPORT

Strengths

- Discrete SLR steps
- Platform / restoration target elevations
- Model parameters and vegetation zonation

What exemplars report inconsistently or omit

Persistent gaps

- Flood design elevations (BFE, DFE, freeboard)
- Section geometry (slopes, sizing, planting densities)
- Monitoring protocols and adaptation triggers

KEY INSIGHT

Projects often report analysis-stage parameters, but omit the design-stage specifications needed for implementation.

S T E P 5 — F R A M E W O R K O U T P U T

horizontal logic · left to right

SLR to Design Parameter Framework

SLR Scenario →
- scenario step (0.3 / 0.5 / 1.0 m)
- projection year

Site Conditions →
- Wave exposure
- tidal frame
- accretion capacity
- migration space

Dimensional Parameters →
- Vertical,
- Horizontal,
- Temporal,
- Ecological.

IF-THEN Rules →
- Width x Coverage
- Accretion–SLR rule
- Phase-trigger logic

Design Specification
- Section drawing
- Elevation targets
- Phase triggers

K E Y I N S I G H T

From scenario to specification: select SLR condition → characterize site → apply dimensional parameters and IF-THEN rules → generate design targets.

Coastal design parameter reporting checklist

design literacy
interdisciplinary coordination
engineering sign-off

Vertical

What height must perform?

Horizontal

How much space is required?

Temporal

When does the design change?

Ecological

What living system assumptions matter?

36 parameters across 4 dimensions. Full checklist (53 items, 8 sections) in the paper.

PURPOSE

Minimum reporting standard from analysis to specification.

USE CASE

Documentation checklist, extraction protocol, or review standard.

LOGIC

Dimensional organization makes omissions visible

STEP 5 — FRAMEWORK OUTPUT

What a parameter-informed coastal section can look like

Composite illustration — values drawn from five exemplar projects, classified by provenance

Translation demonstration

- Designed (D) — Specification values
- Modeled (M) — Analytical inputs
- Monitored (Mon) — Observed performance
- Temporal — Trigger / phase logic

HORIZONTAL · M

WAVE INPUT

Height = 1–5 m · T = 6–12 s

→ Sets forcing condition for section

HORIZONTAL · M

WIDTH × COVERAGE

≥100 m · ≥50% vegetation

→ 95% wave energy reduction

→ Becomes marsh width dimension

VERTICAL · D

PLATFORM ELEVATION

+1.0 m MSL target

(= 2.0 m NAVD88 in SF Bay)

→ Becomes platform grading elevation

TEMPORAL · D

TRIGGER LOGIC (illustrative)

IF accretion < SLR rate

→ add sediment to maintain platform

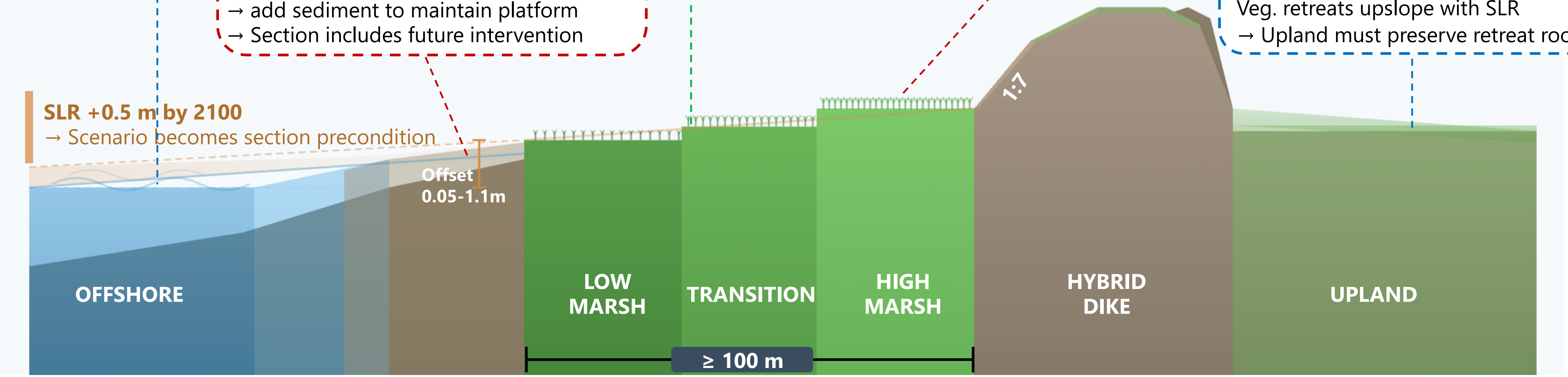
→ Section includes future intervention

ECOLOGICAL + TEMPORAL

MIGRATION SPACE

Veg. retreats upslope with SLR

→ Upland must preserve retreat room



pedagogy · practice · peer review

Three audiences, three forms of payoff

For the studio

- The SLR→DPF workflow structures coastal studios from site analysis to construction documents.
- IF–THEN rules give students a repeatable method alongside design intuition.
- The four dimensions organize critique: vertical, horizontal, temporal, and ecological.

For Practice

- Practitioners gain evidence-based benchmarks for permits and stakeholder communication.
- The framework connects climate scenarios to usable design specifications.
- Width and coverage benchmarks provide a grounded starting point for living shoreline sizing.

For Peer Review

- A proposed documentation standard for evaluating coastal adaptation publications.
- Reviewers check for parameters, provenance, and explicit gap reporting.
- A supplementary reporting checklist for coastal adaptation studies.

Thank you

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Ph.D. candidate | Open to lecturer and visiting assistant professor opportunities

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