Restoration Scaling: Ecology and Economics

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Concepts of Scaling and Equivalence

- Scaling matches losses and gains to determine extent of compensation or restoration
- Ecological equivalence
  - Resource equivalency analysis (REA)
    - abundance equivalence (e.g., 1,000 individuals lost per year requires 1,000 individuals produced per year)
    - biomass equivalence (e.g., production foregone of the individuals lost requires equivalent production gained)
  - Habitat equivalency analysis (HEA)
    - type, quality, and extent of habitat lost requires equivalent habitat gained

Value Equivalence

- Value equivalence
  - economic estimate of total value of loss matched with habitat-based and/or non habitat-based actions that the public values equivalently

Restoration

- Habitat-based
  - e.g., tidal wetlands, intertidal mudflats, and sloughs
- Non-habitat based
  - e.g., purchase of commercial fishing capacity (fishing licenses)

Habitat Restoration Issues

- Uses of habitat restoration
  - Provides a supplement to technology implementation
  - Informs decision-making – costs of restoration compared to costs of preventive technologies

Use of restoration in either context raises key ecological and economic issues

Ecological Issues

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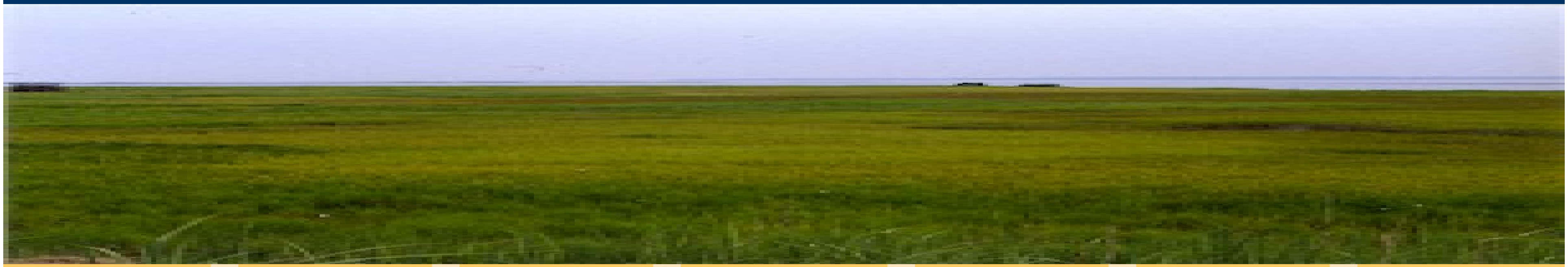
What restoration options are relevant?

- Are the species and life stages of interest habitat-limited?

- What habitat is limiting?

How much of the relevant restoration is needed to offset I&E losses?

- Scaling is an objective method for determining how much
- Scaling matches losses and gains to determine extent of restoration

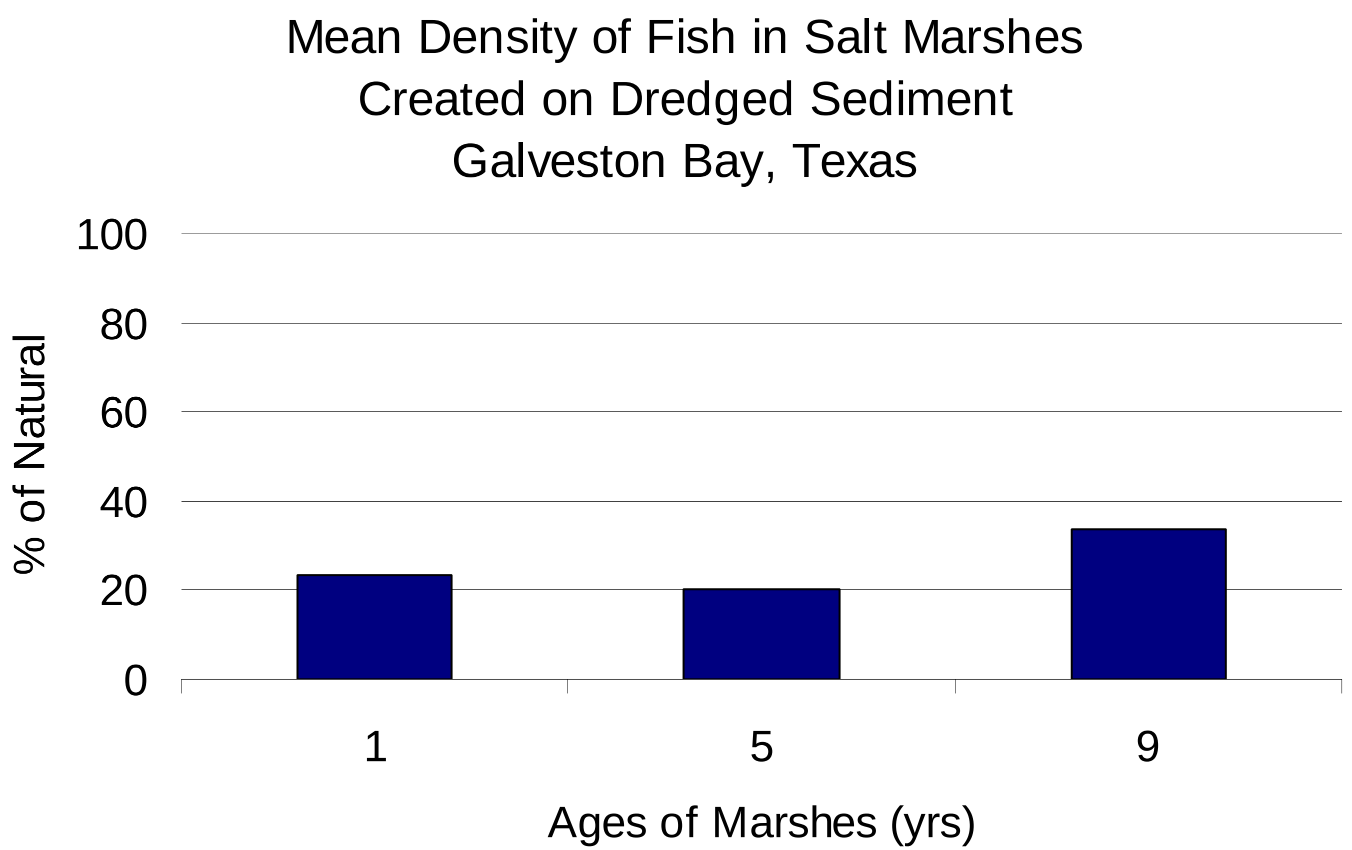


Calculating scale of implementation

- Need common metric for losses and gains
- Need to account for losses and gains through time
- Need to determine relationship between habitat and production of organisms
  - E.g., recruitment or production per year

Calculating scale of implementation (cont.)

- Need to account for restoration trajectory
  - Time lag from beginning of restoration action until benefits begin to accrue
  - Maximum life span of restoration benefits
  - Point of maximum benefits
- Trajectory will differ for different
  - Species
  - Habitat structures and functions



Sources: Minello 1997; Minello and Webb 1997.

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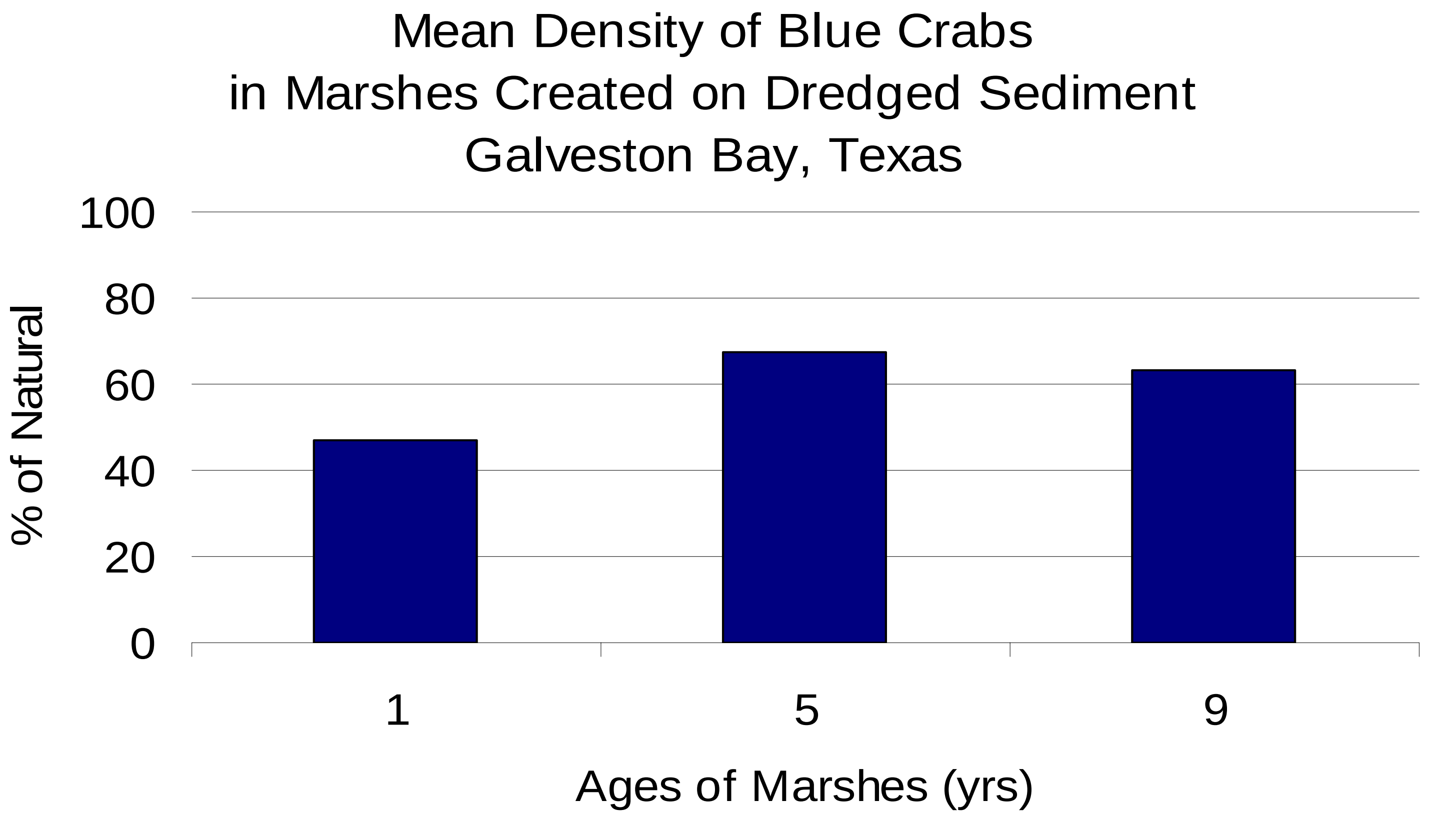

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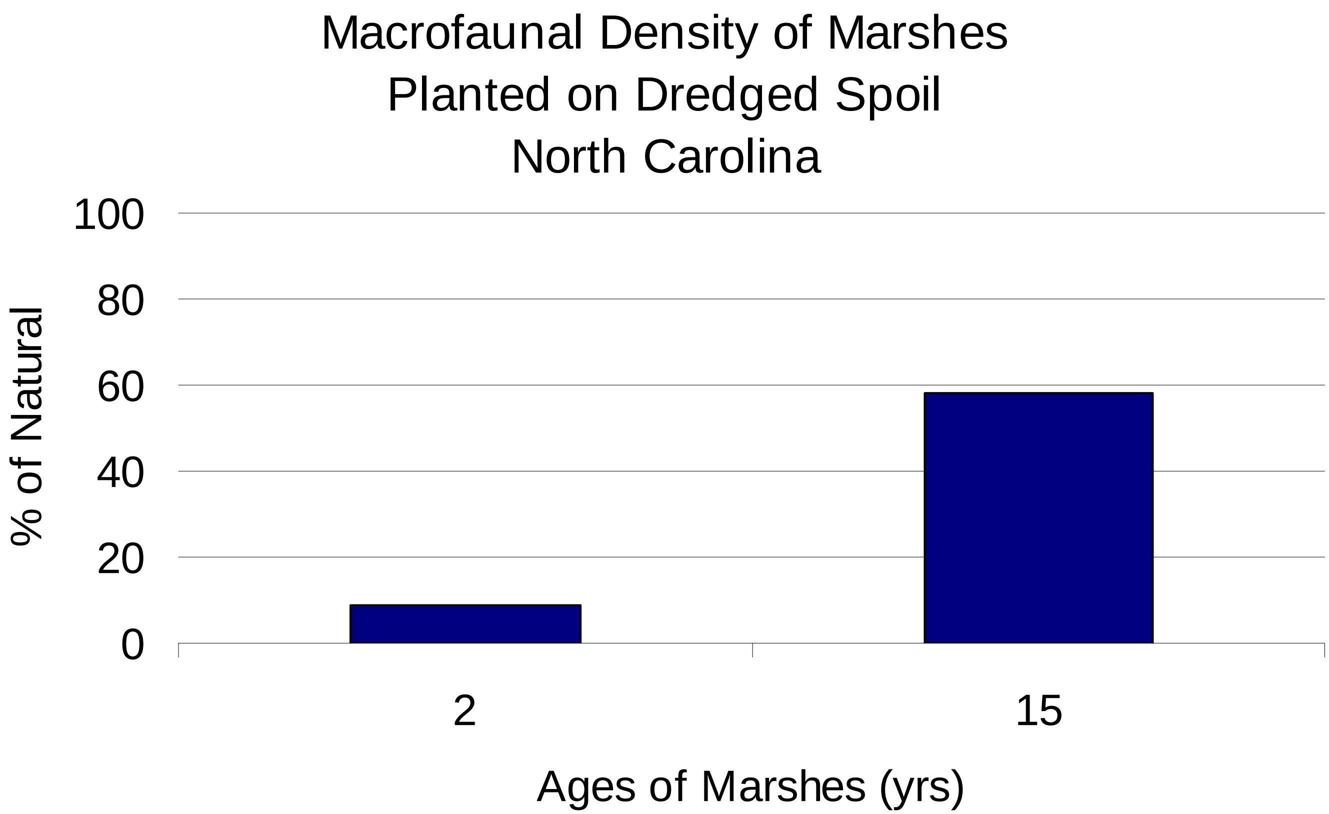

Sources: Cammen 1976; Sacco et al. 1994.

Acres of Restoration Required

Service	Recovery Curve Shape		
	Linear	Convex	Concave
Soil Stabilization (5 years)	332	325	339
Soil Chemistry (25 years)	445	402	500

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Calculating scale of implementation

- Not necessarily 1:1
  - If assume 1:1 and ratio is 2:1, will underestimate habitat needed
  - If assume 1:1 and ratio is 0.5:1, will overestimate habitat needed
- A scientific question
- Use of expert panels to address data needs and achieve scientific consensus

Uncertainty

- Develop upper and lower bound estimates of losses and gains
- If sufficient data are available, develop confidence intervals
- Alternatively, use multiple methods to obtain high and low estimates

Economic Issues

Cost-benefit analysis

- Concept of value
  - Value is based on human preferences
  - Individual value: How much an individual is willing to give up or exchange for the loss of a good or service?

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Value is composed of use and nonuse values

- Use values
  - Direct uses – consumptive and nonconsumptive, e.g., fish harvesting
  - Indirect uses – support or protect direct uses, e.g., forage fish

Value is composed of use and nonuse values (cont.)

- Nonuse values
  - Existence value – knowledge that resource is available and protected
  - Bequest value – availability for future use

Valuation

- Use values are easier to measure than nonuse values – but cannot omit nonuse values
- Use and nonuse values are independent and additive

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Nonuse values

- Nonuse values seldom considered in 316(b) studies
  - Methods are available to quantify and monetize nonuse values
  - Methods are controversial and can be expensive
  - But valuation studies are incomplete without inclusion of nonuse values

Nonuse values (cont.)

- Most I&E organisms lack direct use value
  - Use value can only be estimated indirectly, e.g., contribution of forage fish to yield of fish with market value
  - Valuation is incomplete without consideration of nonuse values; can lead to significant underestimate of total value

Nonuse values (cont.)

- EPA 316(b) focus groups indicated nonuse values may be significant
  - Both users and nonusers hold values for reducing I&E
  - Main motives for reducing I&E are existence and bequest (nonuse) values
  - All fish species (including forage fish) play an important role in affected ecosystems and therefore have significant values

(Report available at: http://www.epa.gov/waterscience/316b/)

Cost and value

- Cost indicates value only under very limited conditions
  - When cost is voluntarily incurred, value is at least as much as cost

Cost-cost analysis

- Cost of restoration compared to cost of technology
- Can inform decision-making without knowing values
- Requires full accounting of restoration benefits

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Evaluating technology costs – Brayton Point

- Are the costs of technology "wholly disproportionate to the benefits?"
- Congress and the courts have recognized that even unquantifiable natural resource values may be significant to the public and should be considered
- If values are ignored or perceived to be too low, environmental resources may be depleted

Evaluating Technology Costs – Brayton Point

- EPA R1 used habitat-based replacement cost (HRC) analysis to place technology costs in perspective
- HRC combines HEA and REA –
  - habitat need to produce organisms lost (based on maximum)
- Restoration costs can be estimated more easily and reliably than resource values
- HRC estimates the cost to restore habitat to a condition sufficient to naturally produce the organisms lost in an effective, ecologically sound manner

Restoration costs

- Land acquisition or conservation easement
- Physical intervention to conduct restoration
- Planning, coordinating, and communicating
- Management of restoration actions
- Maintenance
- Monitoring of effectiveness
- Adaptive management

Evaluating Technology Costs – Brayton Point

- EPA R1 considered the cost of restoring organisms lost compared to cost of technology to avoid losses

- Restoration costs - $28M per year,
  Closed Cycle Cooling – $41M, with
  cost to ratepayer of $0.03 to $0.13 per month

- CC cooling was permit requirement

Conclusions

- Scaling is an objective way to quantify restoration needed to offset losses

- Objective advantages of scaling depend on addressing underlying ecological and economic issues associated with both the implementation of scaling and the application of scaling results

Conclusions (cont.)

- Use of expert panels help address data needs and achieve scientific consensus
- Use of multiple methods help account for uncertainty
- Goal is to develop an estimate of the scale of restoration that is
  - Ecologically meaningful
  - Scientifically sound
  - Consensus-building