Conservation Banking & Landscape Equivalency Analysis

State of Science Workshop OSW
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Ecological Services & Markets

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Scaling biodiversity markets on a changing planet

- Landscape & habitat modeling
- Population Viability Analysis
- Credit & market design
- Software to mange trades & uncertainty

Webinar Series:

Conversations on Species Credits

YouTube

Conservation Banking

- Conservation & Private Equity cultures differ
- Advanced mitigation with performance standards to justify credits
- Financial assurances for long term performance
  - Conservation easements with long term endowments

In Lieu Fee Programs

- Administratively attractive
- Historically, not as successful as banks

Doyle, M. W. 2019. The Financial and Environmental Risks of In Lieu Fee Programs for Compensatory Mitigation. Nicholas Institute for Environmental Policy Duke University

Integration of ILFs & Banks

North Carolina Division of Mitigation Services

- Bank credits available, used first
- If not, ILF Enabling Instrument: USACE and NC DENR
  - RFP: state procurement process
    - Well known success criteria
    - Price & technical quality determines winner
  - CE conveyed to NC for long term management
  - 4 million feet of streams & 80,000 acres of natural areas
- **Integration** provides price stability & quality projects

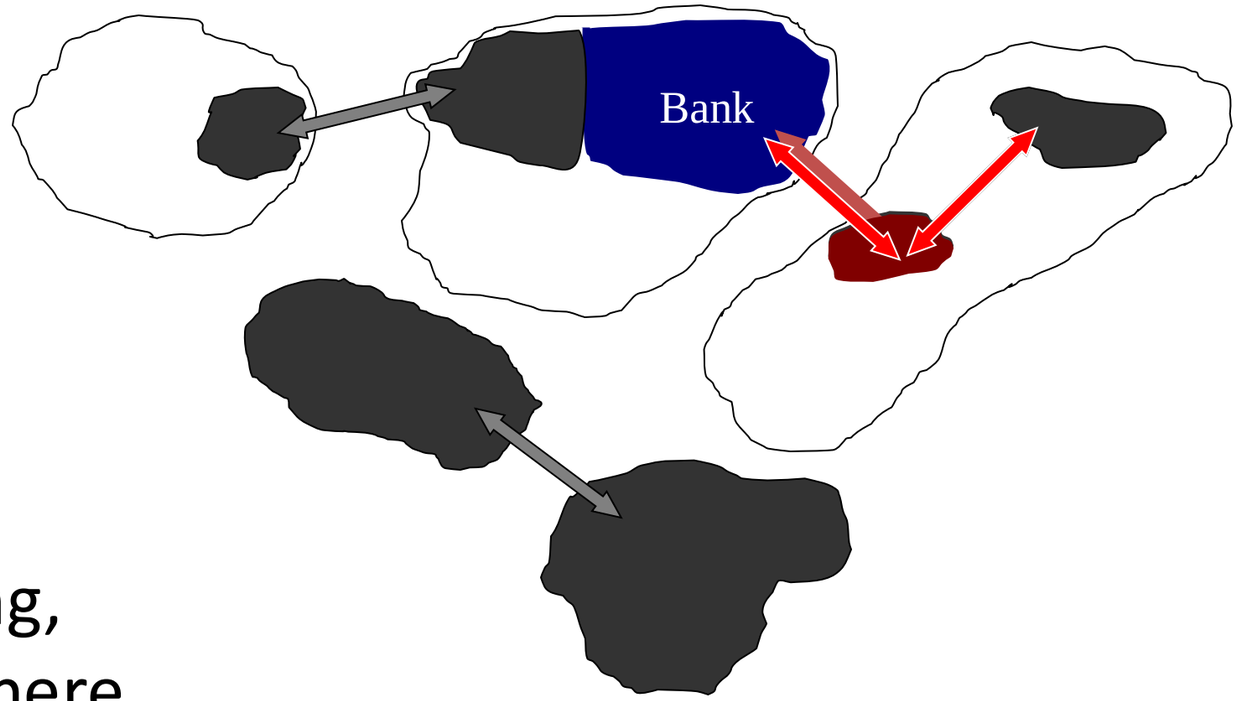
Landscape Considerations for Species

Environmental markets → Non-equilibrium landscapes

- Habitat area & connectivity change over time
- Rates of reproduction

↕

- Rates of dispersal



Trades affect rates of drift, inbreeding, and local extinction occurring elsewhere…

Network Externalities & Time Lag Effects (Bruggeman et al. 2005; 2009)

Resource-based Compensation

Habitat Equivalency Analysis

(Mazzotta et al. 1994; Jones & Pease 1997)

- Services from habitat (generic)
- Scale with acres
- “discounted Service Acre Years”

Resource Equivalency Analysis

(Zafonte & Hampton 2007)

- Service = counts of species
- Scale with acres
- “discounted Resource Acre Years”

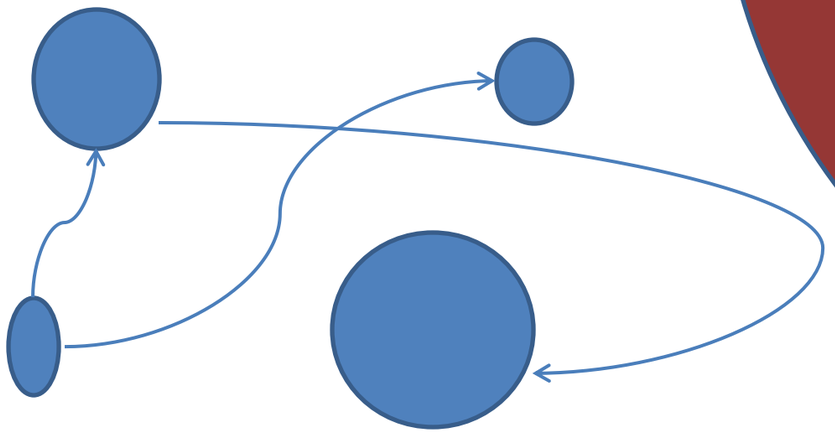
Landscape Equivalency Analysis

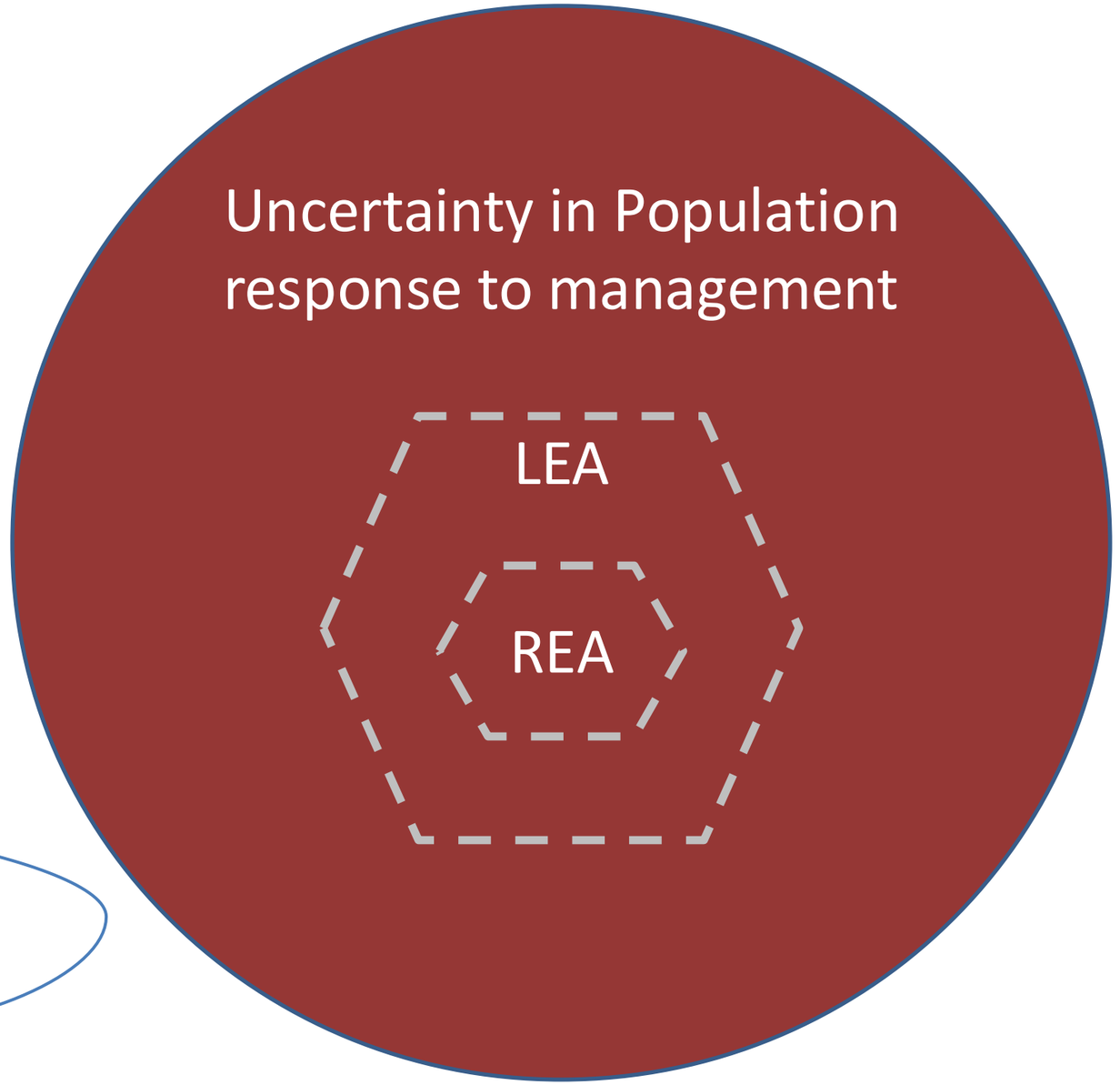
(Bruggeman et al. 2005)

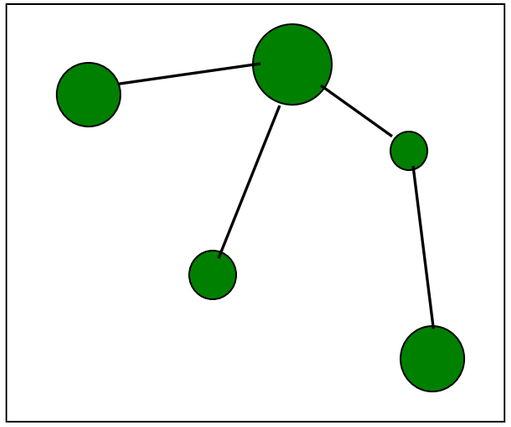
- Service = any valuable landscape function
- Services affected by multiple spatial dimensions
- Includes habitat fragmentation effects, or “network externalities”
- “discounted Landscape Service Years”

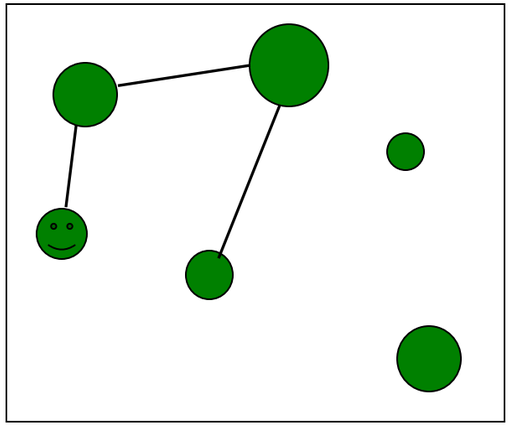
LEA: spatial variation across landscape in

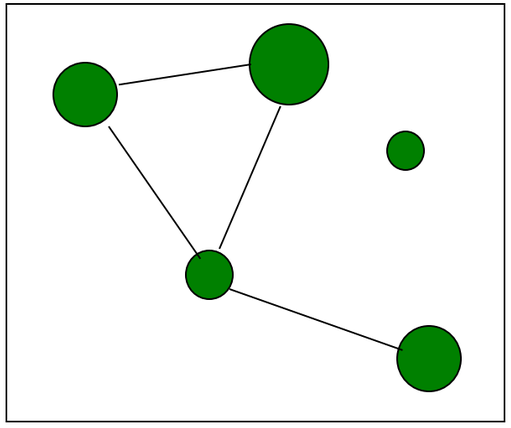
- Dispersal
- Reproduction
- Foraging











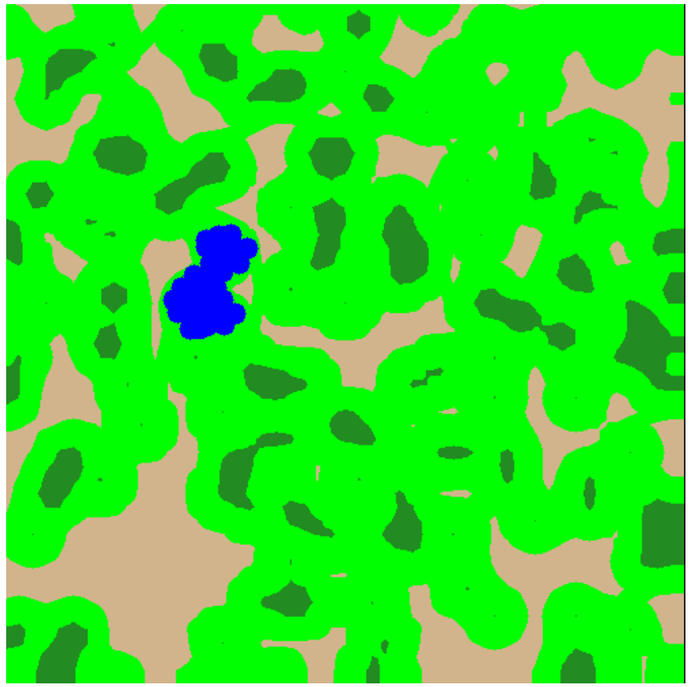
Landscape Equivalency Analysis

- Include network externality into credit/debit analyses
- Estimate the ability of alternative configurations of patches within the landscape to provide equivalent service flows.
- If two patches are traded and no net change in landscape service results – the patches are “landscape equivalent”.
  - Perfect equivalency rarely results – captured in left over credits
  - Smart credits – genetic theory used to reward defragmentation

(Bruggeman et al. 2005; 2009)

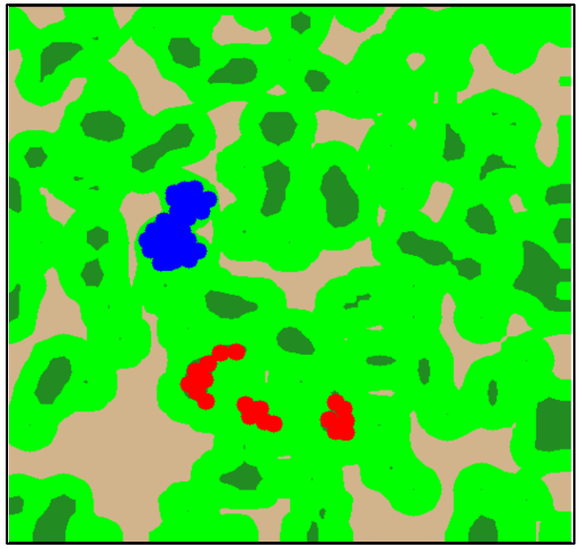
RCW: LEA Trades with Dispersal Uncertainty

3. **Year 25, add Bank to Baseline, m**
   - **25 territories added**



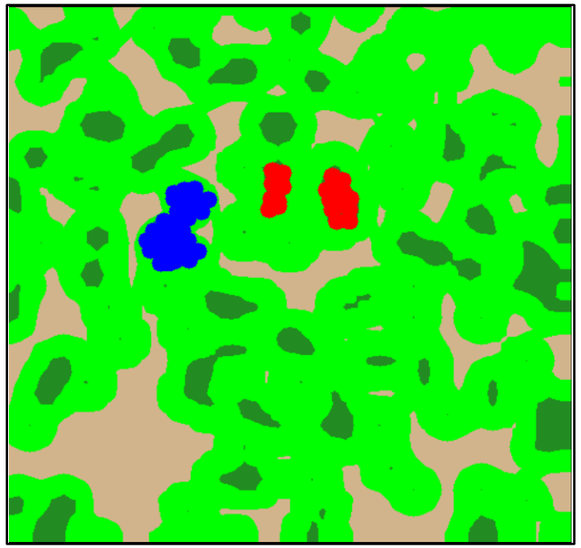
Year 40,

4. **take area “A”, w**
   - **14 territories lost**



Or,

5. **take area “B”, w**
   - **14 territories lost**



Expected Value of Perfect Information

(Bruggeman 2015, Plos One)

LSYs, credits remaining in bank after the trade
Using 5 best dispersal models from POM

	N	Hs	Dst
EV[A|5 Models]	2.46	1.36	3.54
EV[B|5 Models]	2.02	0.621	1.64
EVPI	0	0	0
EVPI - $	$0		

How valuable are 13 yrs of data? using Trade B

Credit (LSY N) = $7.2 million

Expected Value Of Updated Models 2.16 — Expected Value Of Old Model 1.17 = Value of updating Model with new data 0.989 $7.15 million

Closing Thoughts

- Adaptive Management
  - Landscape-scale program evaluation is possible
- Regulatory certainty can be provided while recognizing scientific uncertainty
  - Speed Transactions & Species Recovery
- Price discovery for mitigation critical process
  - ILF
  - Conservation Banks – private risk
- Competitive markets best for birds, energy providers & land owners

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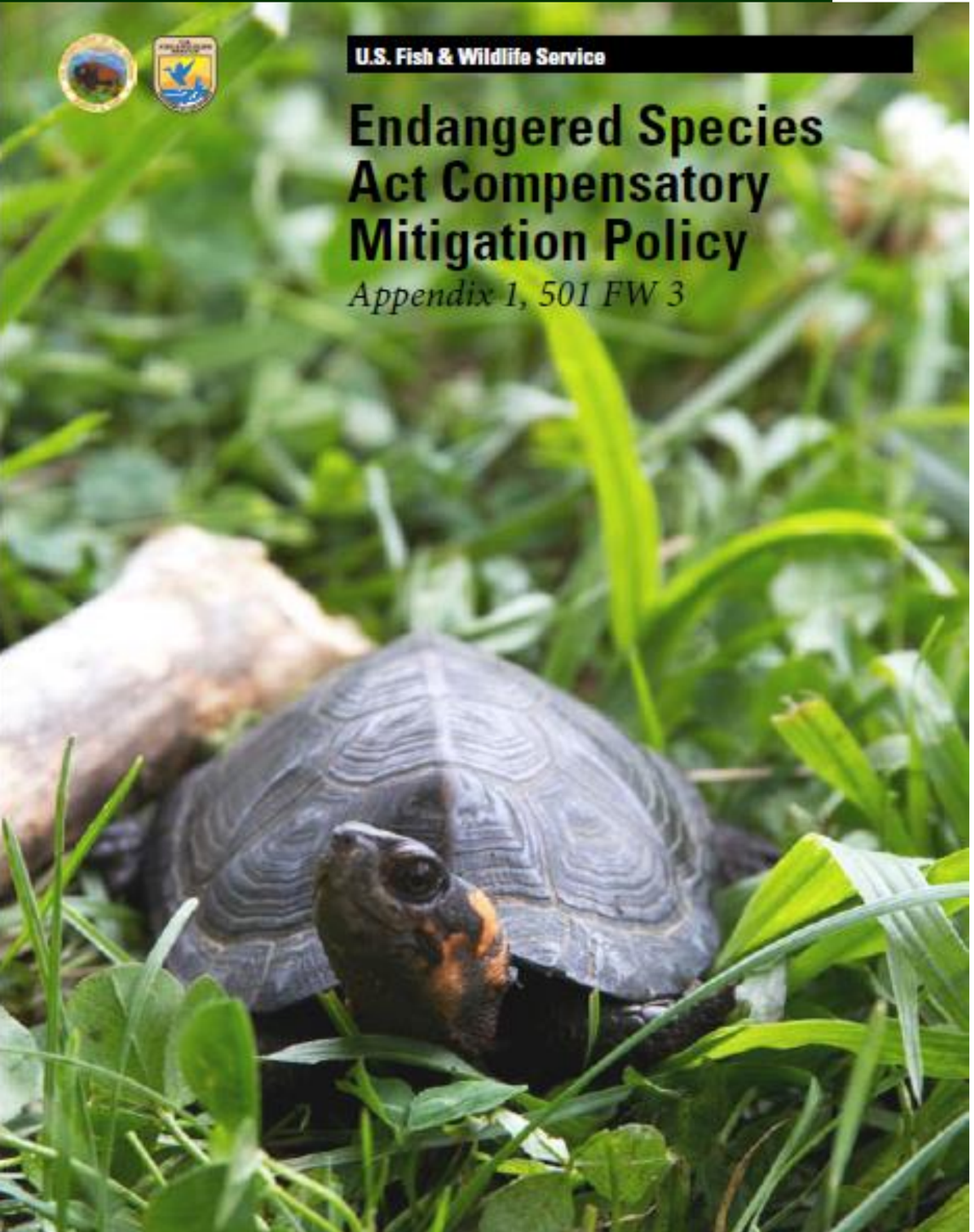
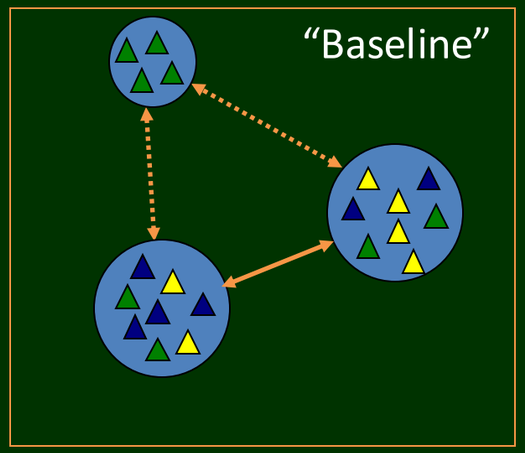
Back up slides

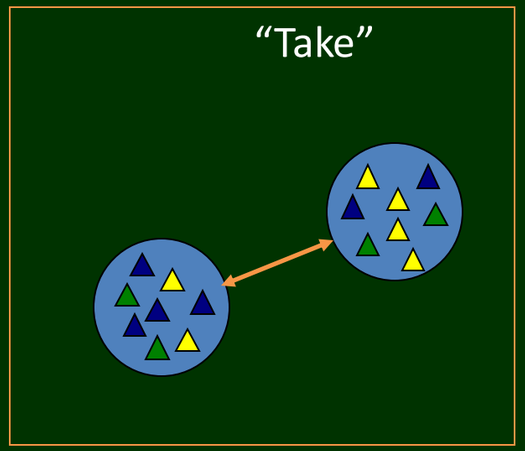


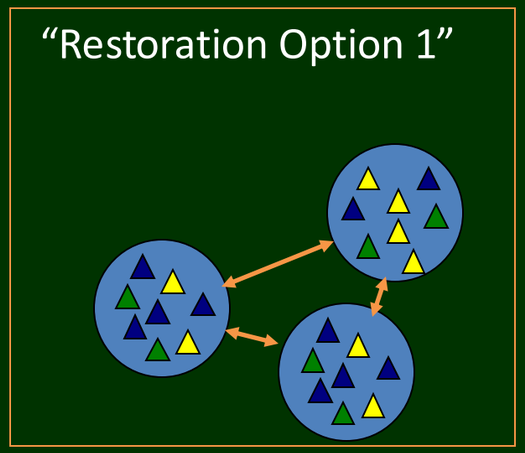
- Landscape-scale conservation required to offset impact of take (no net loss)
- Effects from climate change should be included
- Metrics based on Best Available Science
- Uncertainty noted & Adaptive Management applied

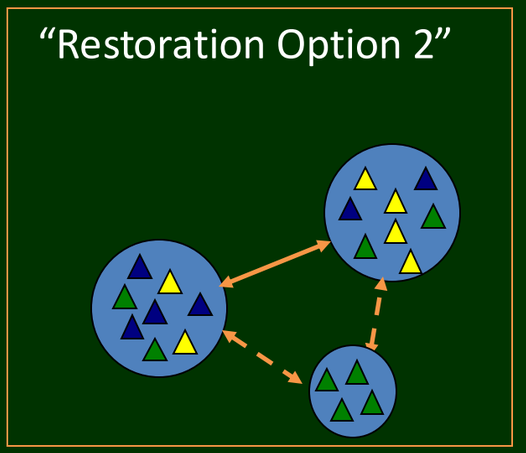
One Migrant Per Generation: 20% of genetic diversity partitioned among breeding groups

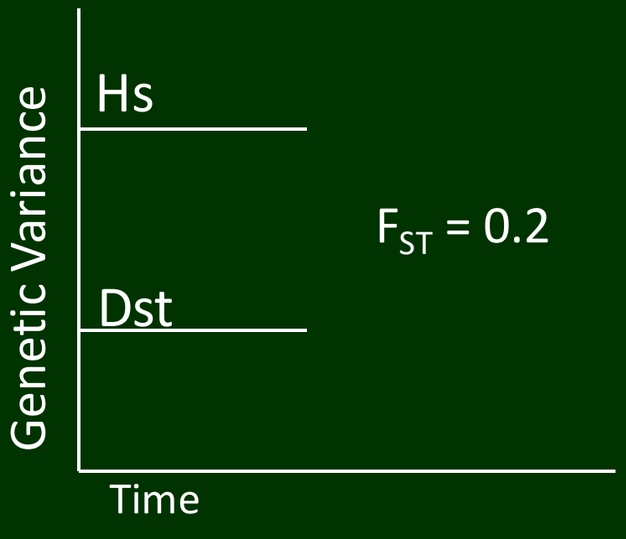
- Too little connectivity leads to genetic drift and inbreeding depression
- Too much connectivity prevents opportunities for local adaptations & group selection

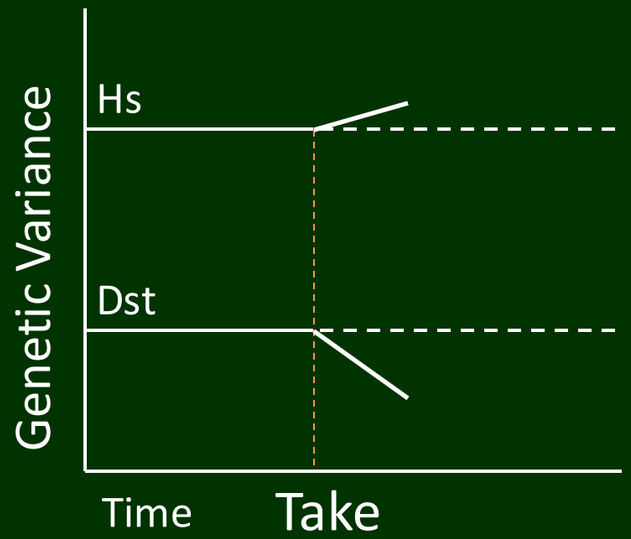


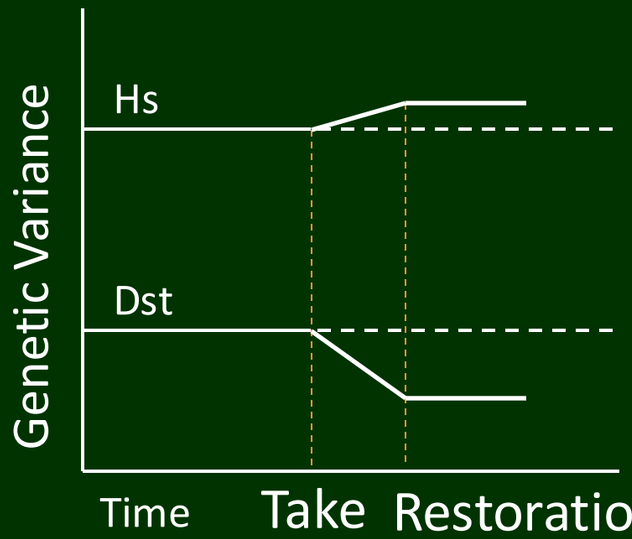


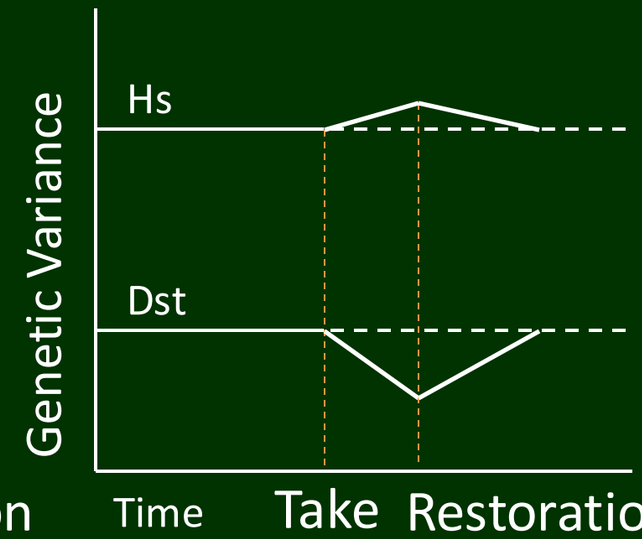








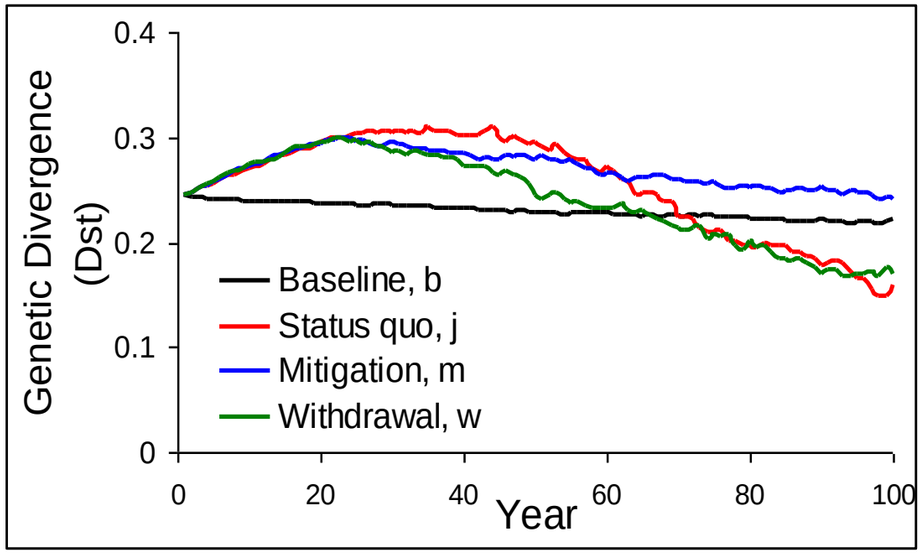




Landscape Equivalency Analysis:

Credits & Debits

Goal: approximate baseline (pre-settlement) levels. Greater genetic variance within or among units not necessarily better for sustainability



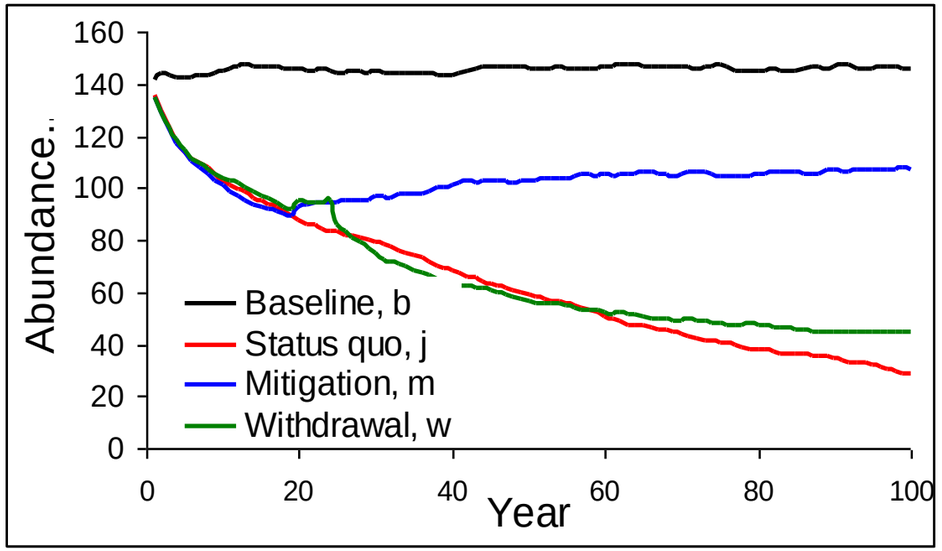
$$E\left[LSY_C{}^G\right] = \sum_{t=W}^{100}\left(\frac{\left|b_t{}^G - j_t{}^G\right|}{b_t{}^G}\right) - \sum_{t=W}^{\infty}\left(\frac{\left|b_t{}^G - m_t{}^G\right|}{b_t{}^G}\right)$$

$$E\left[LSY_D{}^G\right] = \sum_{t=W}^{100}\left(\frac{\left|b_t{}^G - w_t{}^G\right|}{b_t{}^G}\right) - \sum_{t=W}^{\infty}\left(\frac{\left|b_t{}^G - m_t{}^G\right|}{b_t{}^G}\right)$$

Landscape Equivalency Analysis:

Credits & Debits

Landscape Service Years (LSYs) - time integrated estimate of the change in ecological service caused by change in landscape pattern

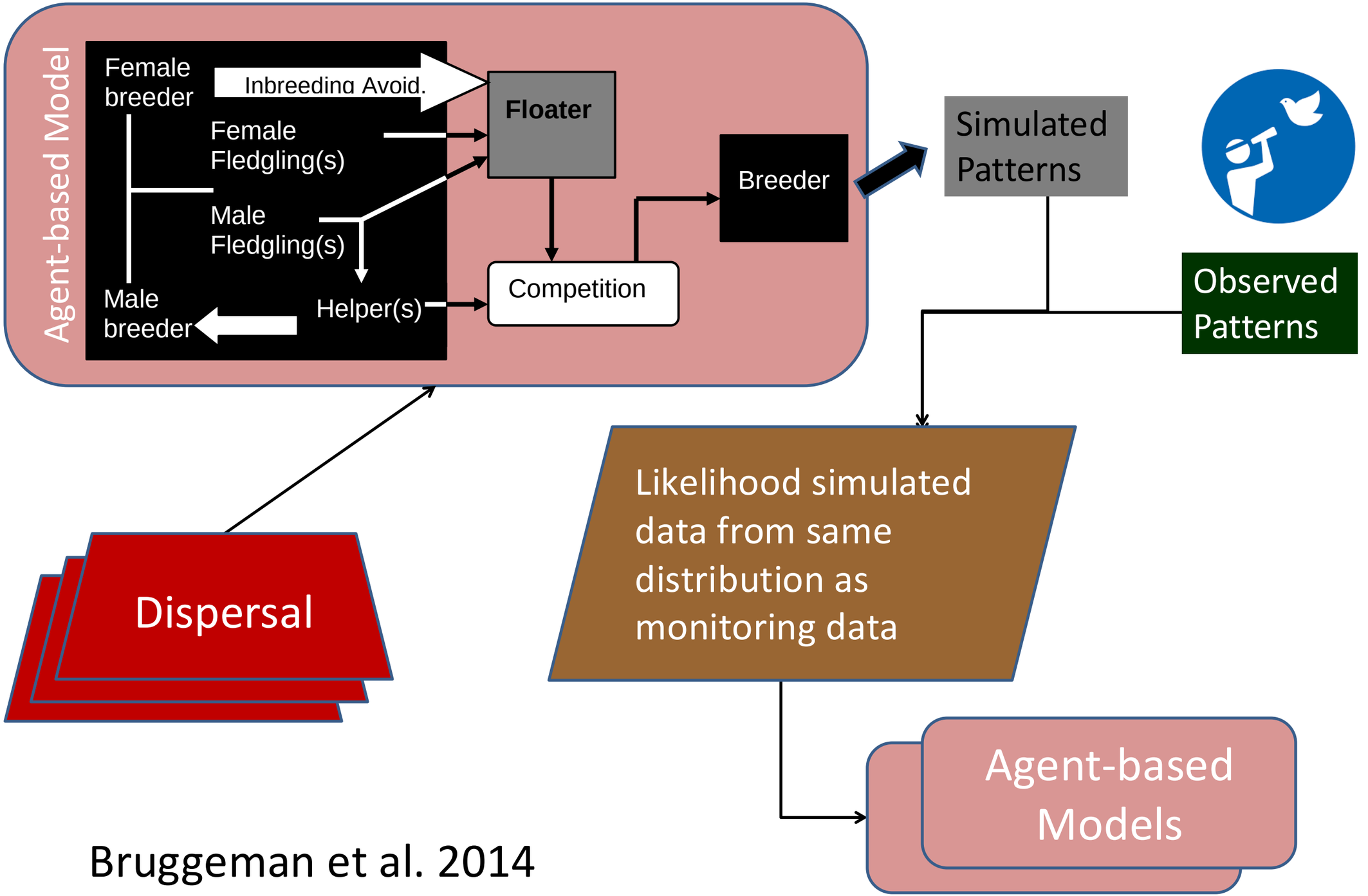


$$E\left[LSY_C{}^N\right] = \sum_{t=W}^{100}\left(\frac{m_t{}^N - j_t{}^N}{b_t^N}\right)$$

$$E\left[LSY_D{}^N\right] = \sum_{t=W}^{100}\left(\frac{m_t{}^N - w_t{}^N}{b_t^N}\right)$$

Discounting can be added

Machine Learning
Pattern Oriented Modeling



Bruggeman et al. 2014

Mitigation **Information** Hierarchy:

Update as monitoring data become available

Decision Analysis with Machine Learning

Cost-effective?

Cost-effective?

Cost-effective?

1. Habitat based (habitat-acres)
2. REA
3. LEA: Group-based models (e.g., matrix metapopulation models)
4. LEA: Agent-based models