A vision, framework, and customizeable decision support toolbox for conservation action

John Gallo, Ph.D.

Outline

- Introduction
  - Conservation Challenges
  - Vision: Engaged Conservation Planning and Management
- LandscapeDSS Framework
- LandscapeDST v 1.01
- Onward!
  - Online Community
  - Use and Support

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Acknowledgements
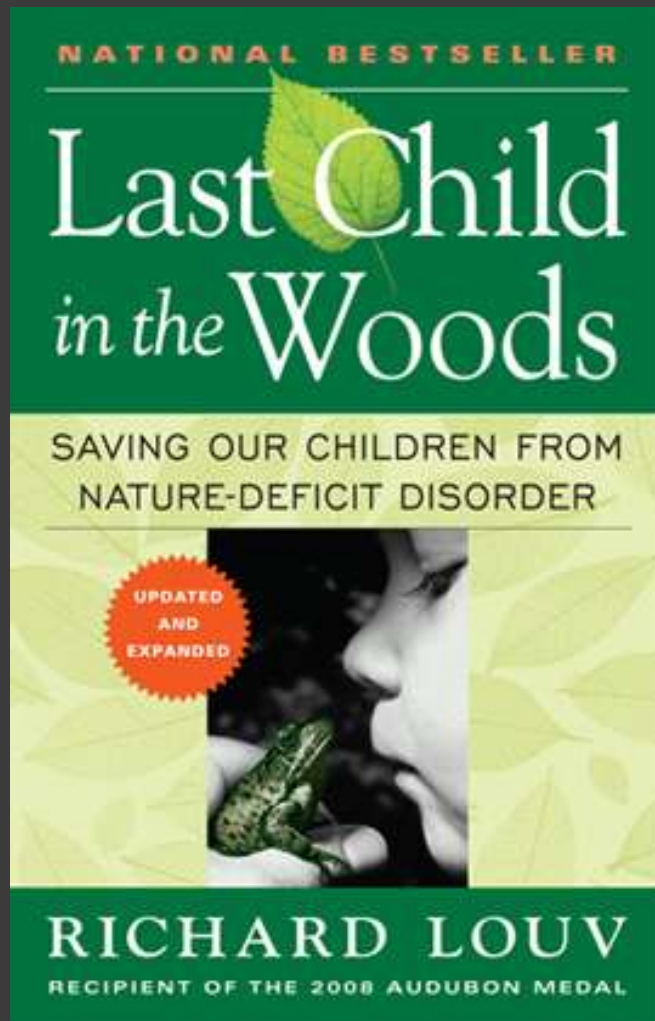
By: El Patojo; Flickr User

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Got Problems?

- Growing human population and consumption

- Habitat loss and fragmentation

- Climate Crisis

- Economic breakdowns

- Limited funds and passion for conservation

Corbis.com

© Chehalem Wine

National Pride

Duty

Spiritual Quest
Effort Toward Health

Time Stress

Concern for Appearance

Civic Engagement

Personal Expression

Survival

Xenophobia

Saving on Principle

Sensualism

Introspection & Empathy*
Introspection & Empathy*

Fulfillment

Sexism

Attraction for Crowds

Brand Apathy

Ecological Concern

Culture Sampling

Personal Control

Ecological Fatalism

Adaptability to Complexity

Rejection of Order

Skepticism of Advertising

Global Consciousness

Multiculturalism

Religion a la Carte

Acceptance of Violence

Penchant for Risk

Sexual Permissiveness

Flexible Families

Individuality

U.S. Socio-cultural trends 1992-2004 American Environics

2006

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By Oliver Pergams

"Plants and animals don't cause the problems, people do. ..The natural sciences alone are not enough, but must often be integrated with the social sciences to achieve any long-term conservation success."   -Oliver Pergams
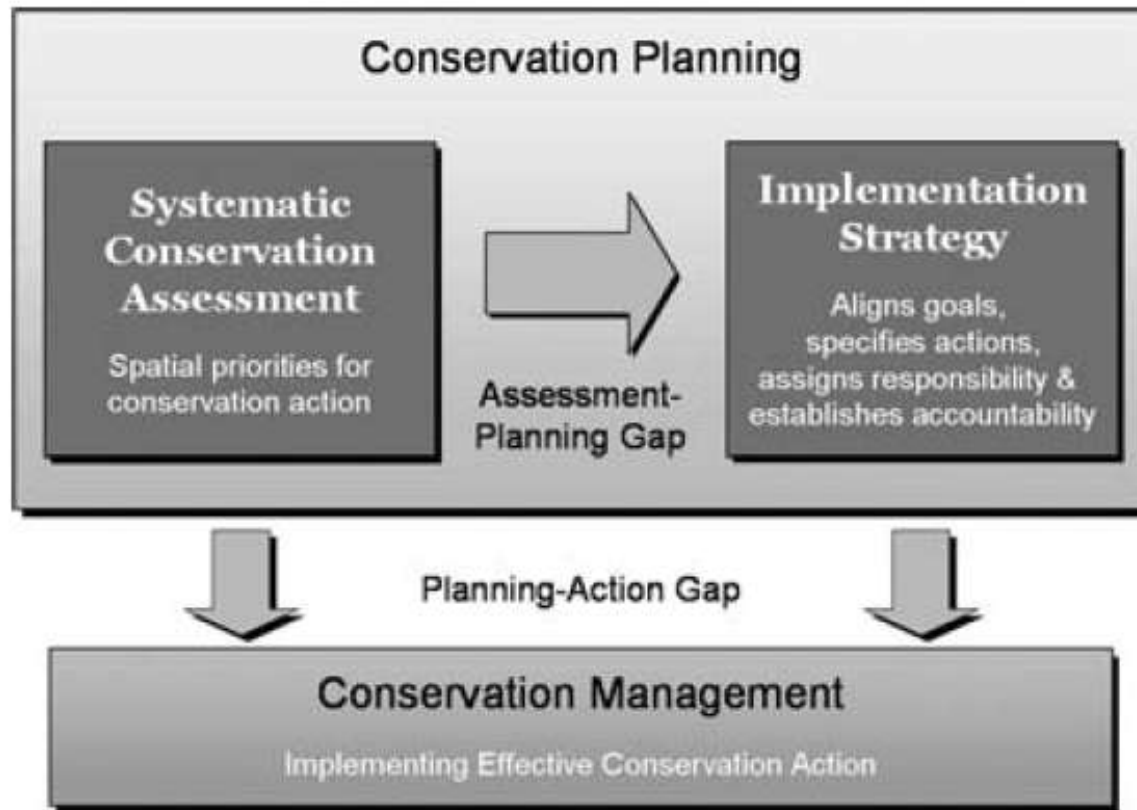
A Grand Challenge to Conservation Science

- "success [of the discipline] will be measured
  - by the degree to which we can integrate scientific understanding into our community life,
  - by the effectiveness of our approaches to sustaining the diversity of life and the health of ecosystems,
  - and by the respect for the living world we are able to foster within our varied cultures and within the human heart." (Meine, Soule and Noss 2006)
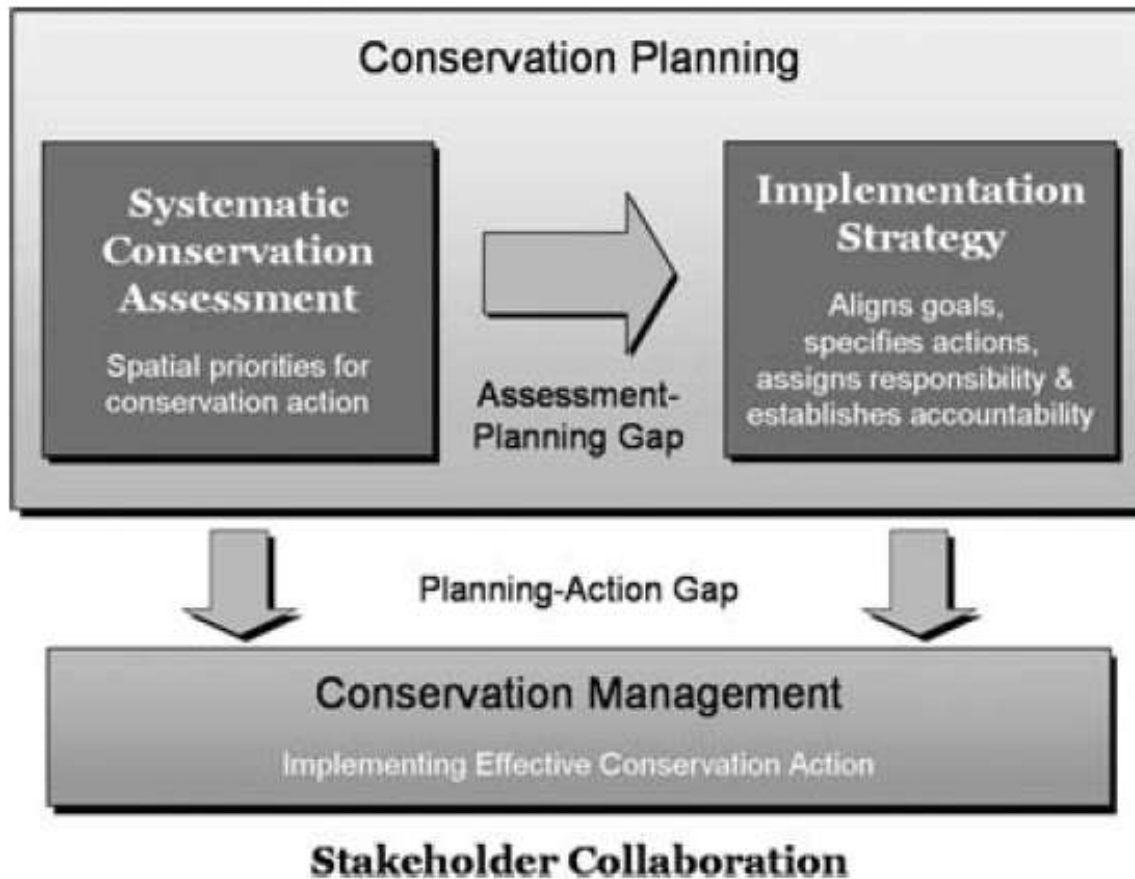
Meeting the Grand Challenge in designing a DSS for Conservation

- The DSS is applied and used.
- It uses the best-available science
  - Conservation Planning
  - Landscape Ecology
- Fosters respect for the living world
  - Experience
  - Awareness
  - Understanding

Overcoming barriers to conservation action

Conservation Planning

Systematic Conservation Assessment
Spatial priorities for conservation action

Assessment-Planning Gap

Implementation Strategy
Aligns goals, specifies actions, assigns responsibility & establishes accountability

Planning-Action Gap

Conservation Management
Implementing Effective Conservation Action

Adopted from Knight, Cowling, and Campbell 2006; Knight, Driver, et al. 2006   13

A key part of the solution

Knight, Cowling, and Campbell 2006; Knight, Driver, et al. 2006

A strategy for meeting the third aspect of the Grand Challenge

- Dramatically increase the number of people engaged in conservation planning and monitoring
  - "everyone is a stakeholder to some degree"
  - Several types of engagement
  - 1 order of magnitude now
 - 3 orders of magnitude in 10 years.
- Maintain scientific rigor

"Web 2.0"

- emerging web software AND <u>culture</u>
- driven by interaction that is:
  - asynchronous
  - distributed
  - two-way
  - real-time
  - stimulating and useful
  - does not require an intermediary
- Ex: Wikipidia, Craig's List, Facebook

(Robbins 2005)

PPGIS, the science of how to use GIS to:

- include local knowledge,
- contextualize complex spatial information,
- allow participants to
  - dynamically interact with input,
  - analyze alternatives
- empower individuals and groups
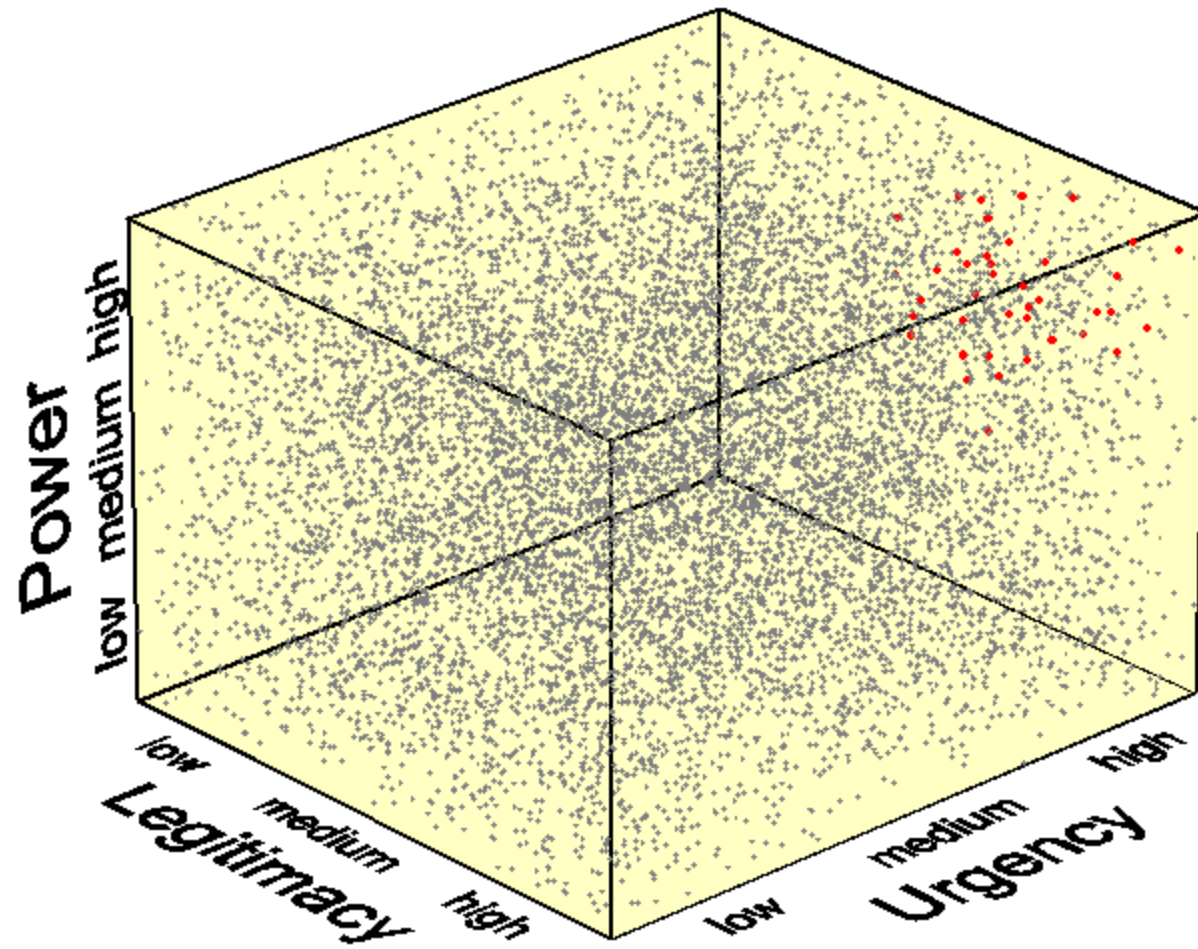
(Siebor 2006)

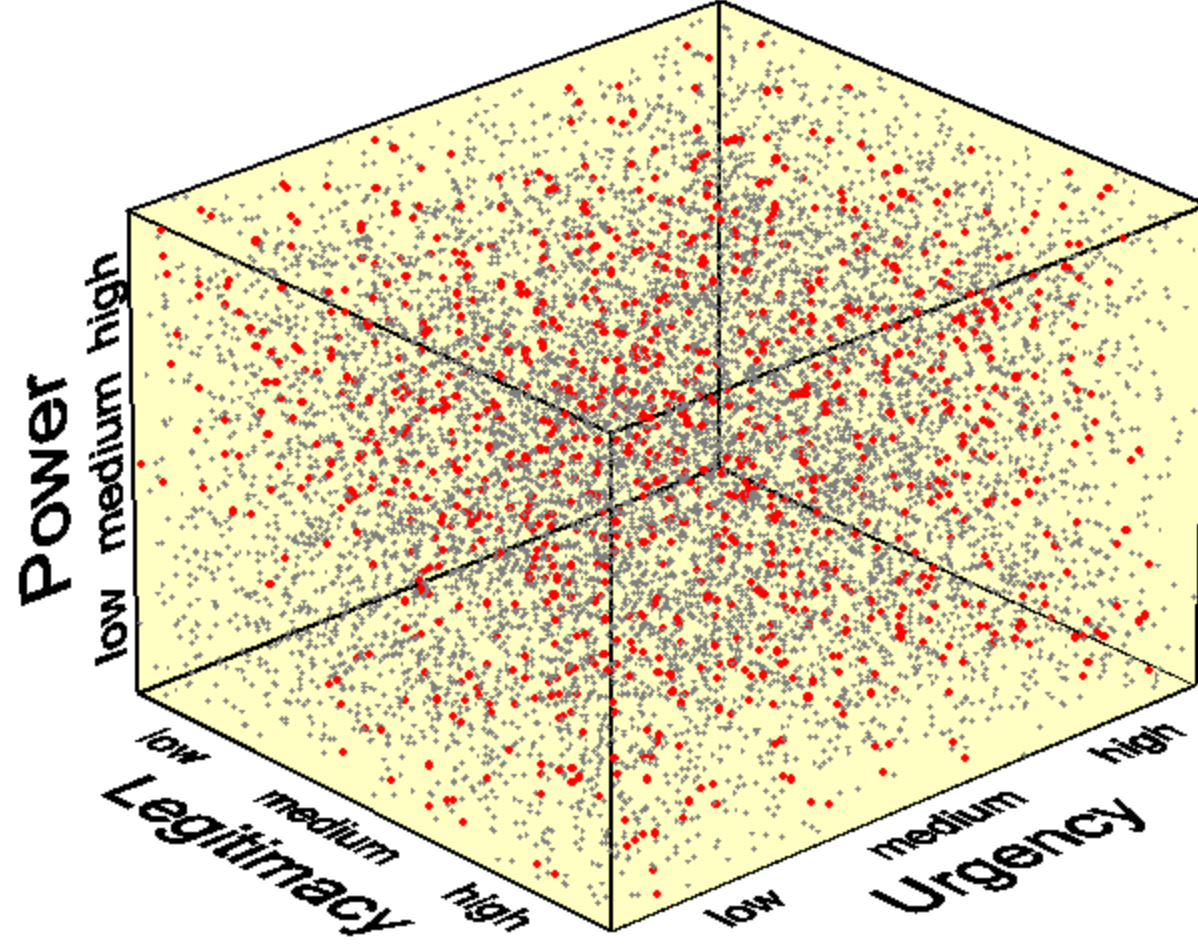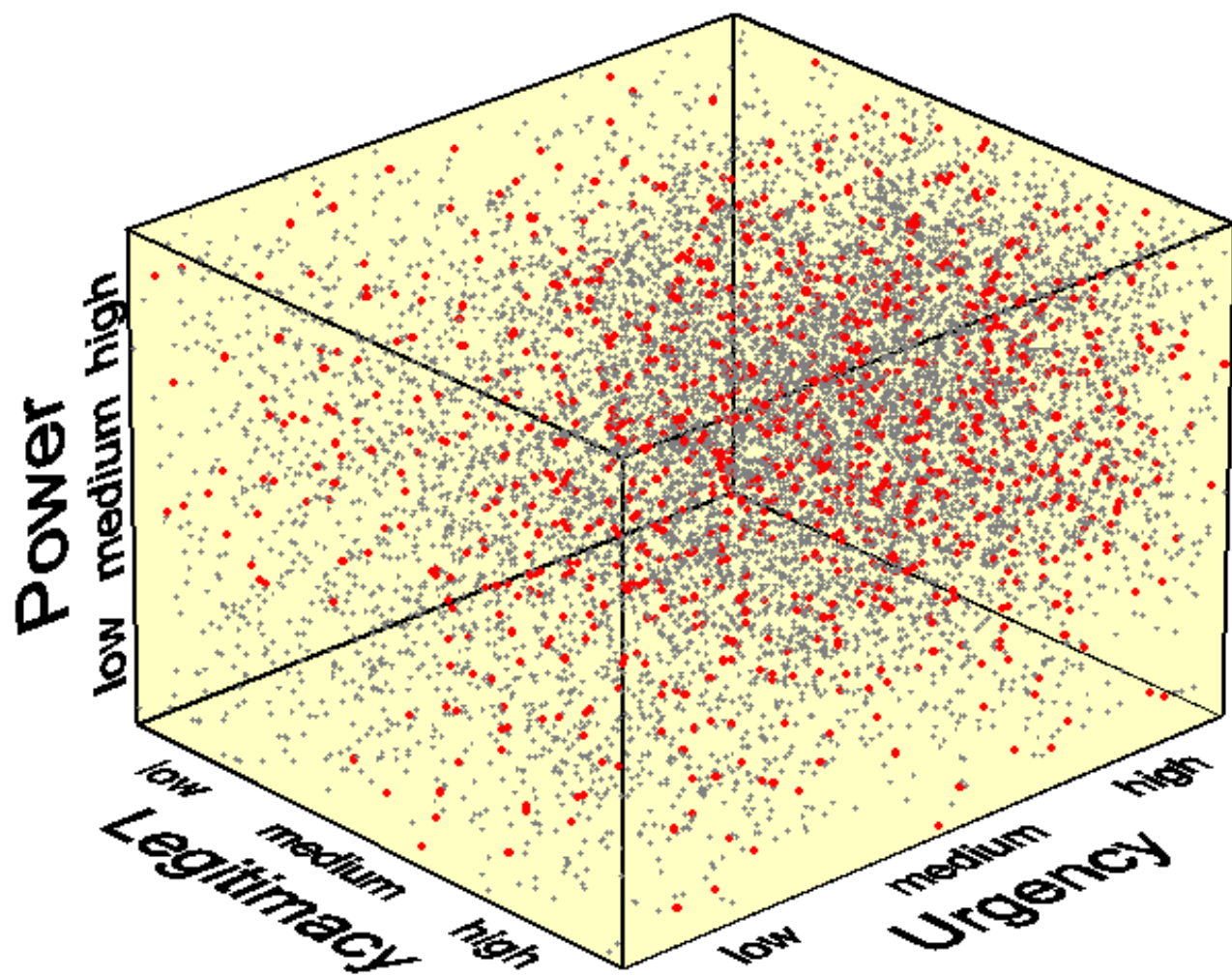# Engaged Conservation Planning and Management

Communications Framework:
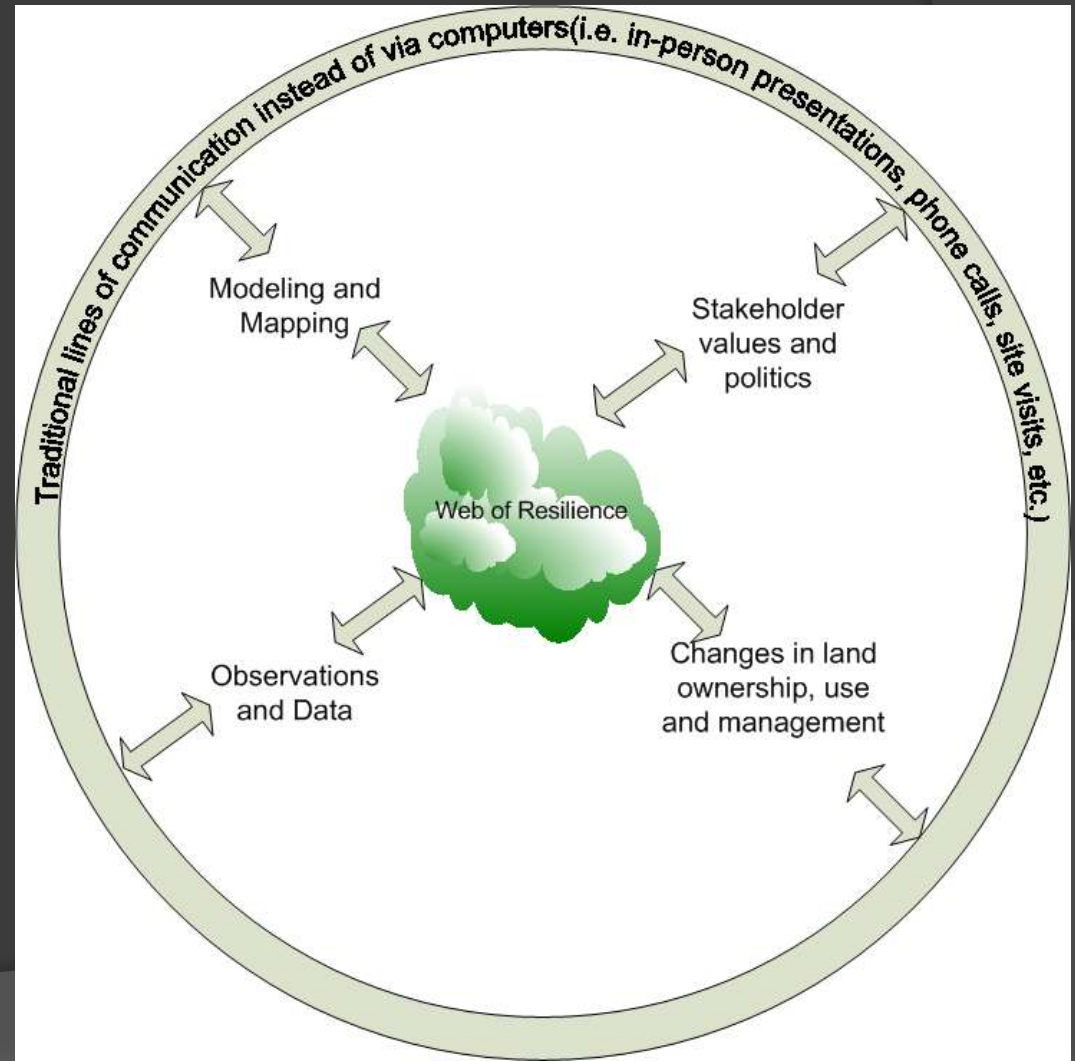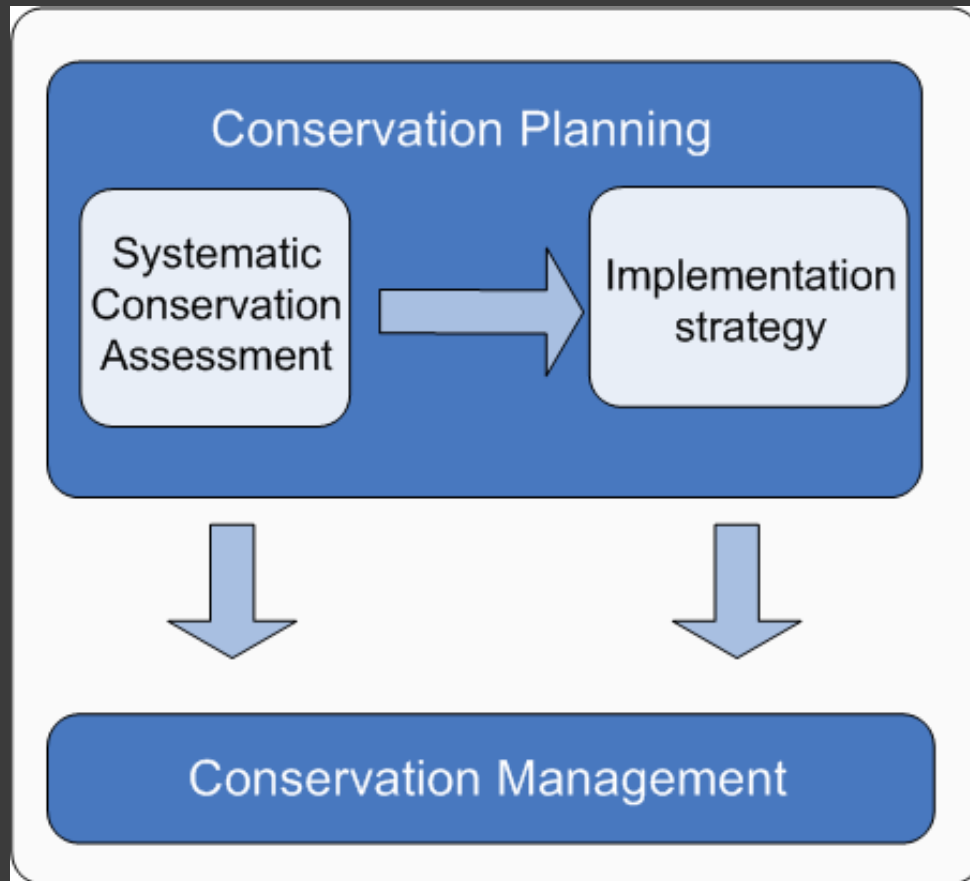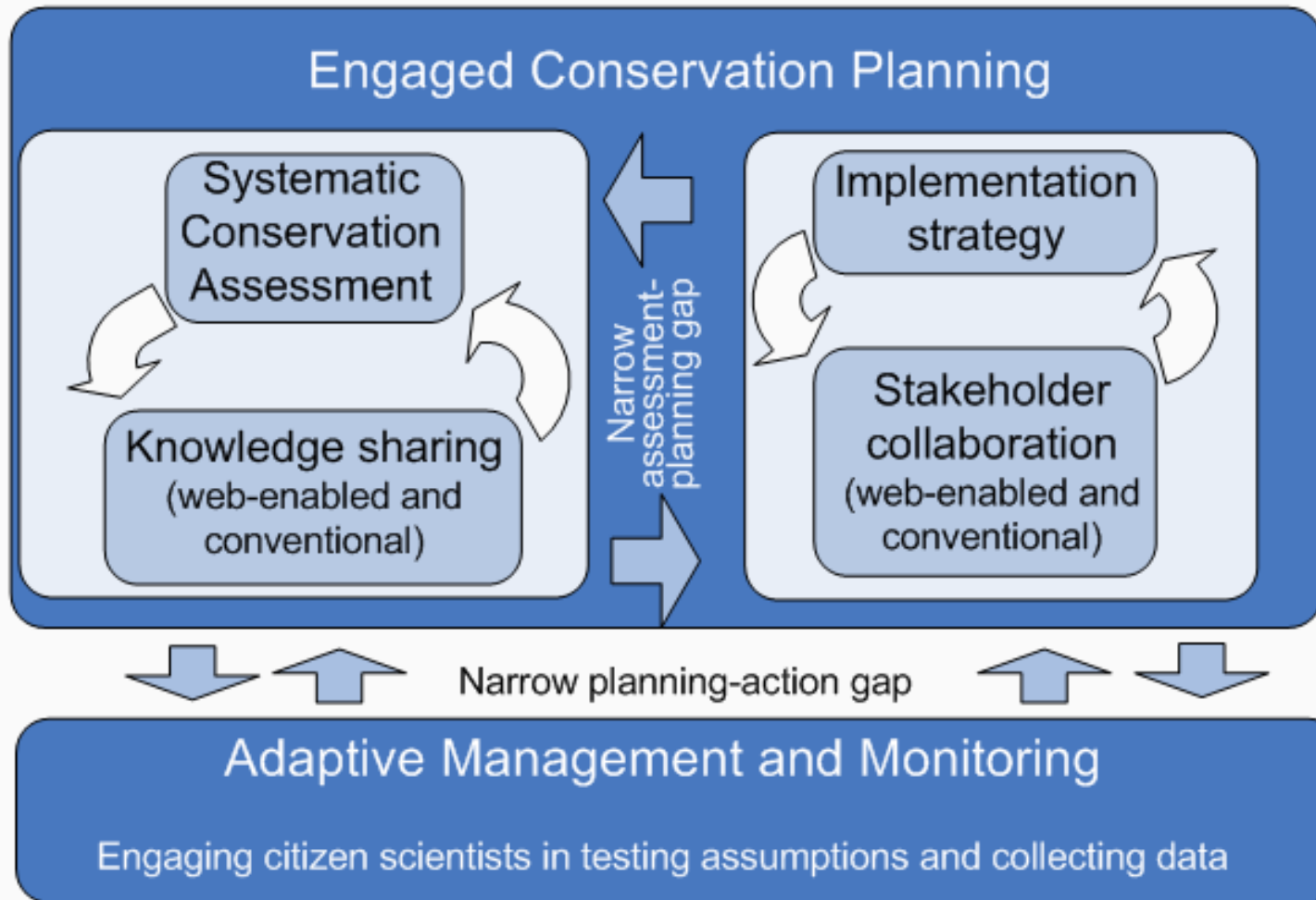
Some benefits of this engagement (1of 2)

- "buy in" to products by end-users
- Consensus building and reducing conflicts
- Builds trust among local experts, stakeholders, and scientists
- Social learning institutions
- More people to navigate the science through the socio-political maze

Some benefits of this engagement (2 of 2)

- Builds society's understanding of conservation science
- Fieldwork in nature
- Enables attitude change
- Provides opportunity for professionals to be out in nature
- Economies of scale: reduces cost of data collection
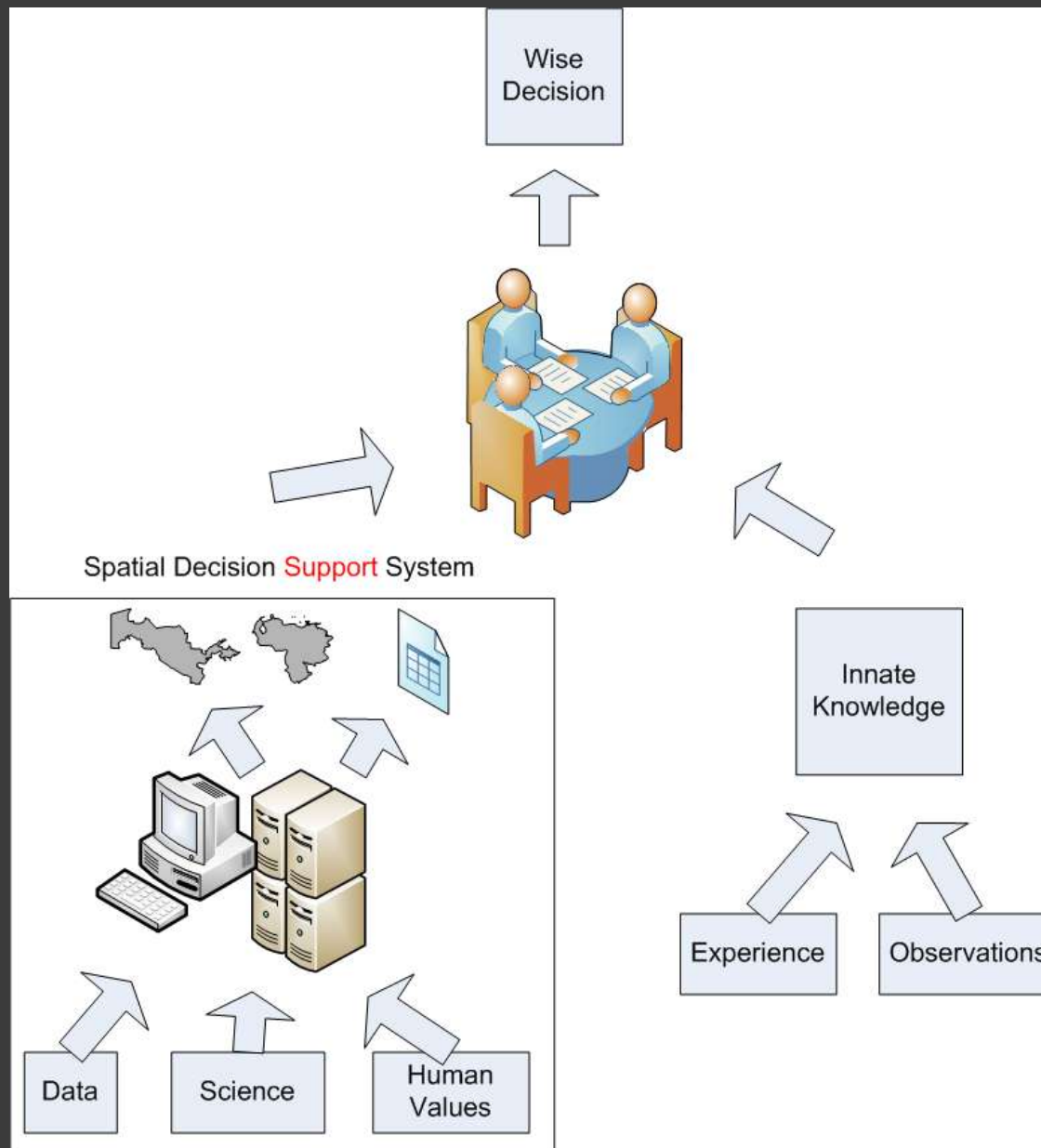- Increased usefulness to end-users

Challenges to an ECPM DSS

- The DSS needs to be understood by more people.
- Web 2.0 coordination needs front-end set-up.
- Contributed knowledge and data need filtering mechanisms
  - QA/QC
  - Sensitivity

Next:

- Introduction
- LandscapeDSS Framework
- LandscapeDST v 1.01
- Onward
  - Online Community
  - Support

Wise Decision

Spatial Decision Support System

Innate Knowledge

Experience

Observations

Data

Science

Human Values

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What are some example spatial prioritization topics?

- Fee-transfer candidates
- Conservation easement candidates
- Different types of easement within a property
- Wilderness area candidates
- Solar array siting
- Mitigation siting
- SDSS

Goals for an ECPM DSS

- Broadly participatory in use
  - Data contribution
  - Parameterization
  - Validation
- Broadly participatory in development
- And…

Traditional: Estimate the best conservation network

Goal #3: Conservation assessment not only identifies a network of sites to conserve, but also the conservation value and attributes **of every site in a study area.**
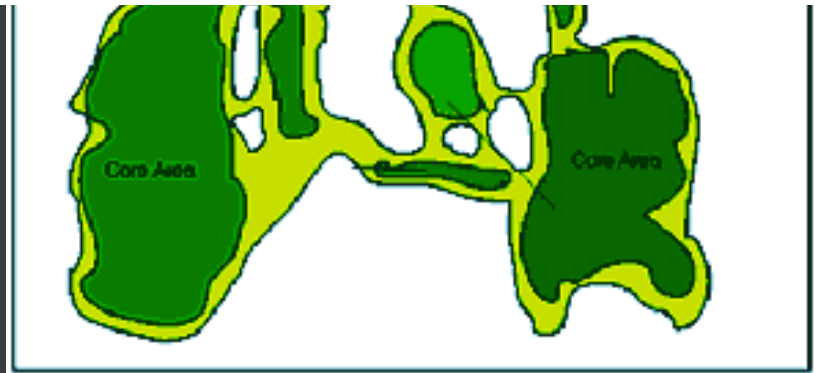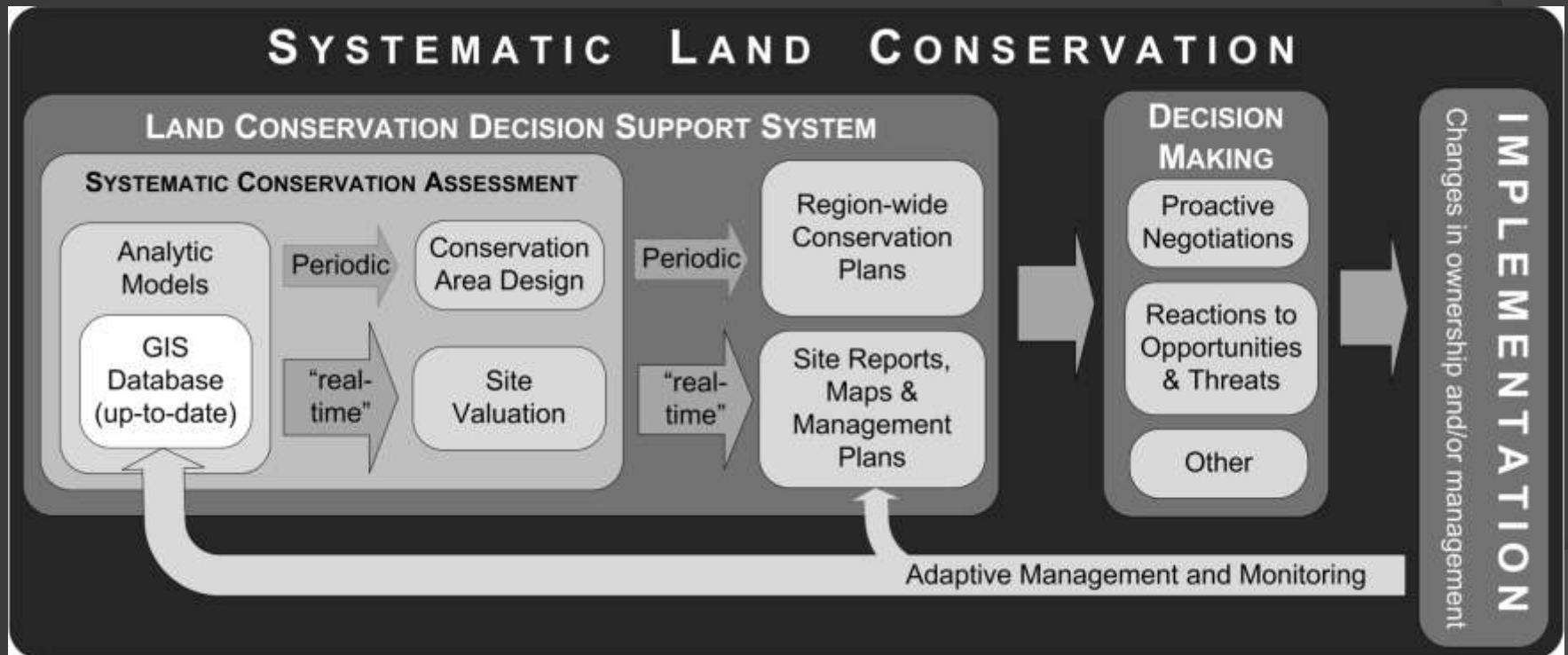
Uncertain and dynamic world

Goal #4: Move away from once-off conservation assessments towards **"living" decision support systems**

The Living SDSS

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Accounting for conservation diversity

Goal #5: the benefits of stewardship areas and the working landscape are accounted for in assessing biodiversity priorities, and are part of the solutions.

Summary of goals for DSS

- Broadly participatory in use
- Broadly participatory in development
- Solution sets AND site assessments
- Adaptive and living
- Conservation diversity

Software to facilitate this?

- One possibility:
  - MARXAN with Zones
    - LINKED WITH
  - NatureServe Vista
    - LINKED WITH
  - "Corridor Designer"
- But, could be problematic.

DSS development

- Currently, an ArcToolbox
  - ArcGIS 9.x
  - Spatial Analyst
  - Modelbuilder
  - Python
- Integrated, shareable, customizable system.
- Free
- "Open access" model for development.
- Return on Investment Framework

Modelbuilder description or demo

Some ROI Development History

- California Legacy Project 2000
  - NCEAS Working Group 2002
  - Davis et al. 2005, 2007
- Wilson, Possingham and others 2007
- Gallo Dissertation (2007)
  - Public product: Regional Conservation Guide
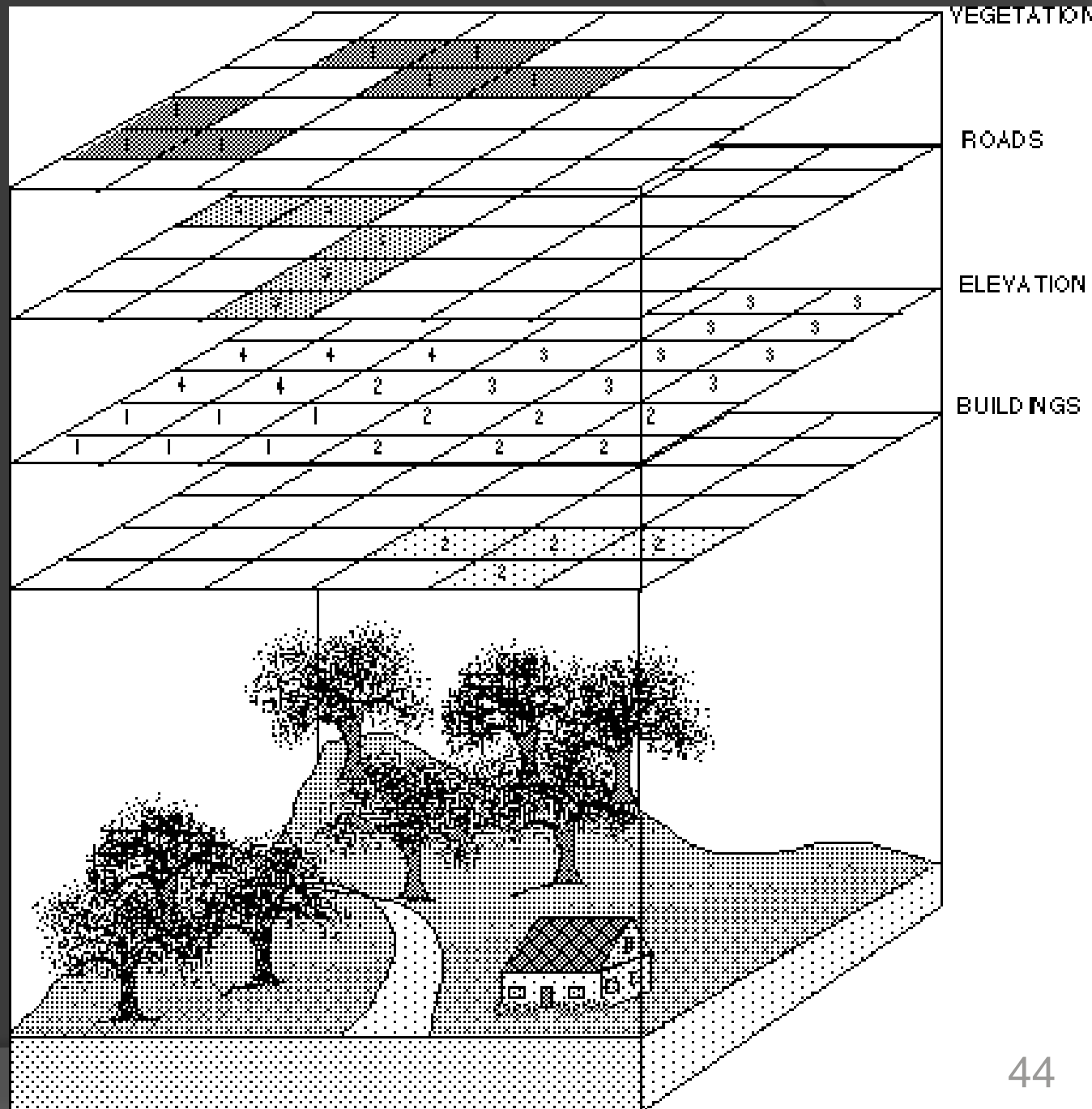- Gallo, Lombard, Cowling, and others, In Revision
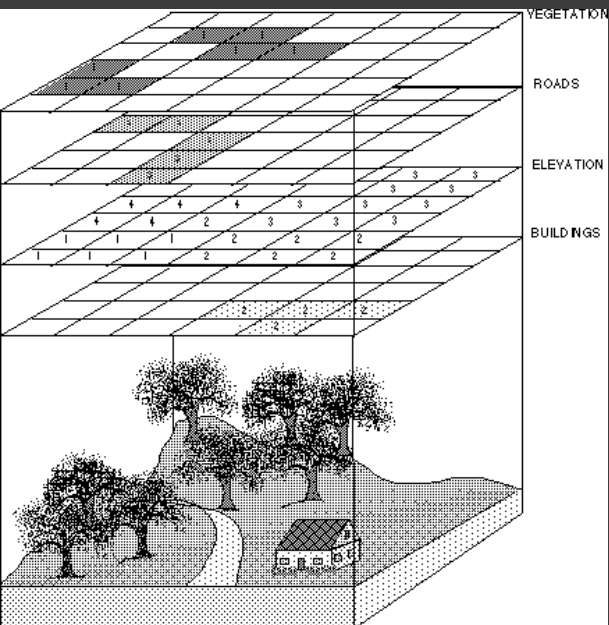
Applying the Return on Investment (ROI) Framework

- "Best Bang for your Buck"
  - Benefit and Cost
- Multi-criteria Hierarchy
- Continuous benefit functions
  - Continuous accounting of representation rather than discrete
  - Account for partial benefits to biodiversity
- Connectivity and Contiguity
- Solution sets and site assessment

Multi-Criteria Decision Analysis (MCDA)

- Builds consensus among multiple parties (Feick & Hall 1999; Redpath et al. 2004; Balasubramaniam & Voulvoulis 2005; Gallo et al. In Review);

- Parameterizing it is straightforward and intuitive (Malcezewski 2000; Balasubramaniam & Voulvoulis 2005; Malczewski 2006)

- Users can quickly view the effects of different weight values and implement sensitivity analyses (Malczewski 2006)

- Site specific prioritization and descriptions (Gallo et al. in revision)

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How does it work?

Map algebra-Sum:

Species Representation Layer

1.0	0.5
0	0.5

+

Habitat Representation Layer

1.0	1.0
0.5	0.0

=

Summed Layer

2.0	1.5
0.5	0.5

Weighted Sum:

Weight 1

Species

0.2 X

1.0	0.5
0	0.5

+

Weight 2

Habitat

0.8 X

1.0	1.0
0.5	0.0

=

Weighted Sum

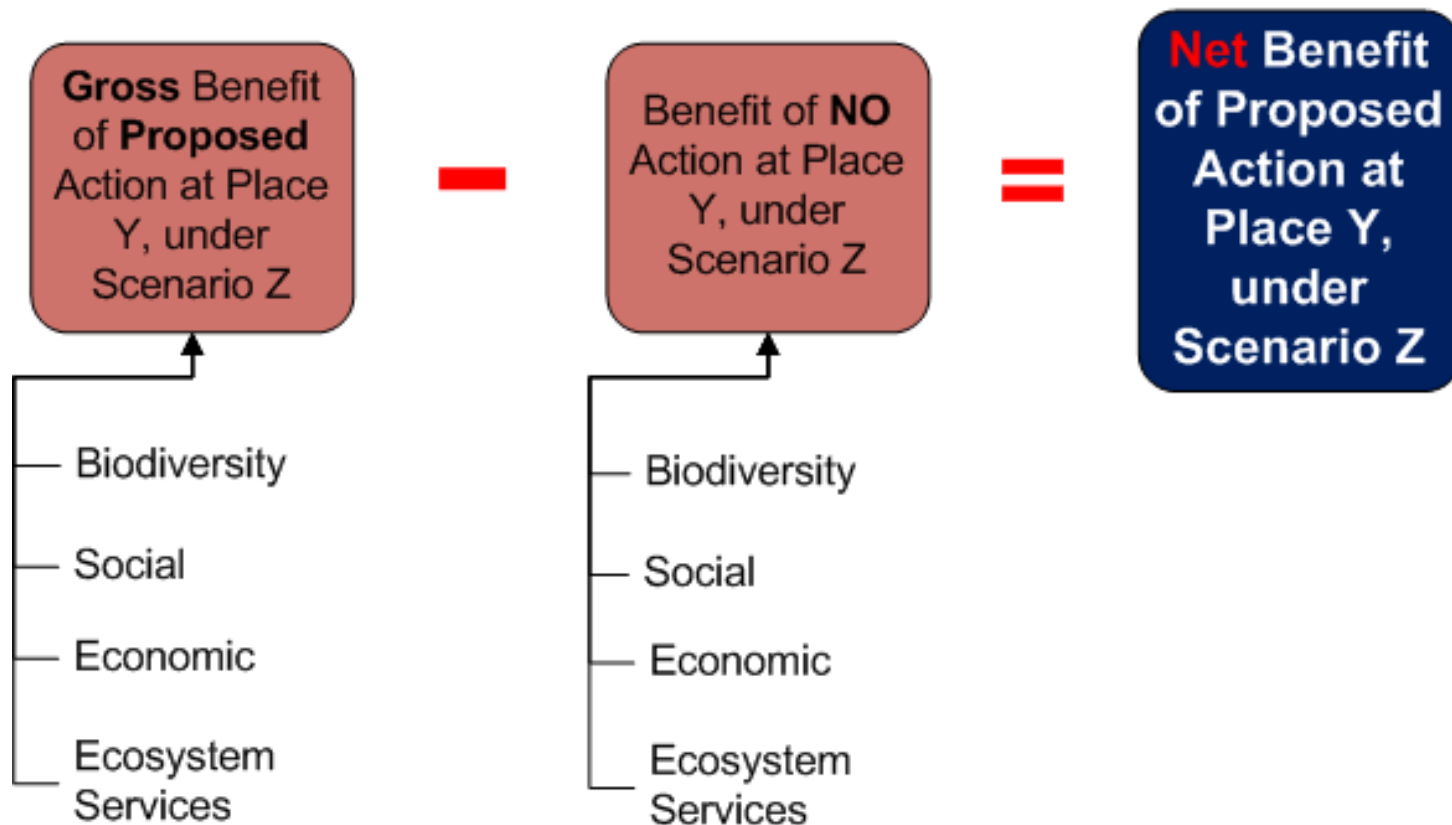| 1.0	0.9
0.4	0.1

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Choose your criteria and set your weights:

Combine with other objectives:

Incorporate threat:

Gross Benefit of **Proposed** Action at Place Y, under Scenario Z

— Biodiversity

— Social

— Economic

— Ecosystem Services

−

Benefit of **NO** Action at Place Y, under Scenario Z

— Biodiversity

— Social

— Economic

— Ecosystem Services

=

Net Benefit of Proposed Action at Place Y, under Scenario Z

Relative Conservation Priority of Performing Action X, at Place Y, Given Scenario Z

Net Benefit of Proposed Action — 0.50

Feasibility of Proposed Action — 0.50

Gross Benefit of Proposed Action — minus — Benefit of NO Action

Biodiversity, Social, Economic, Ecosystem Services

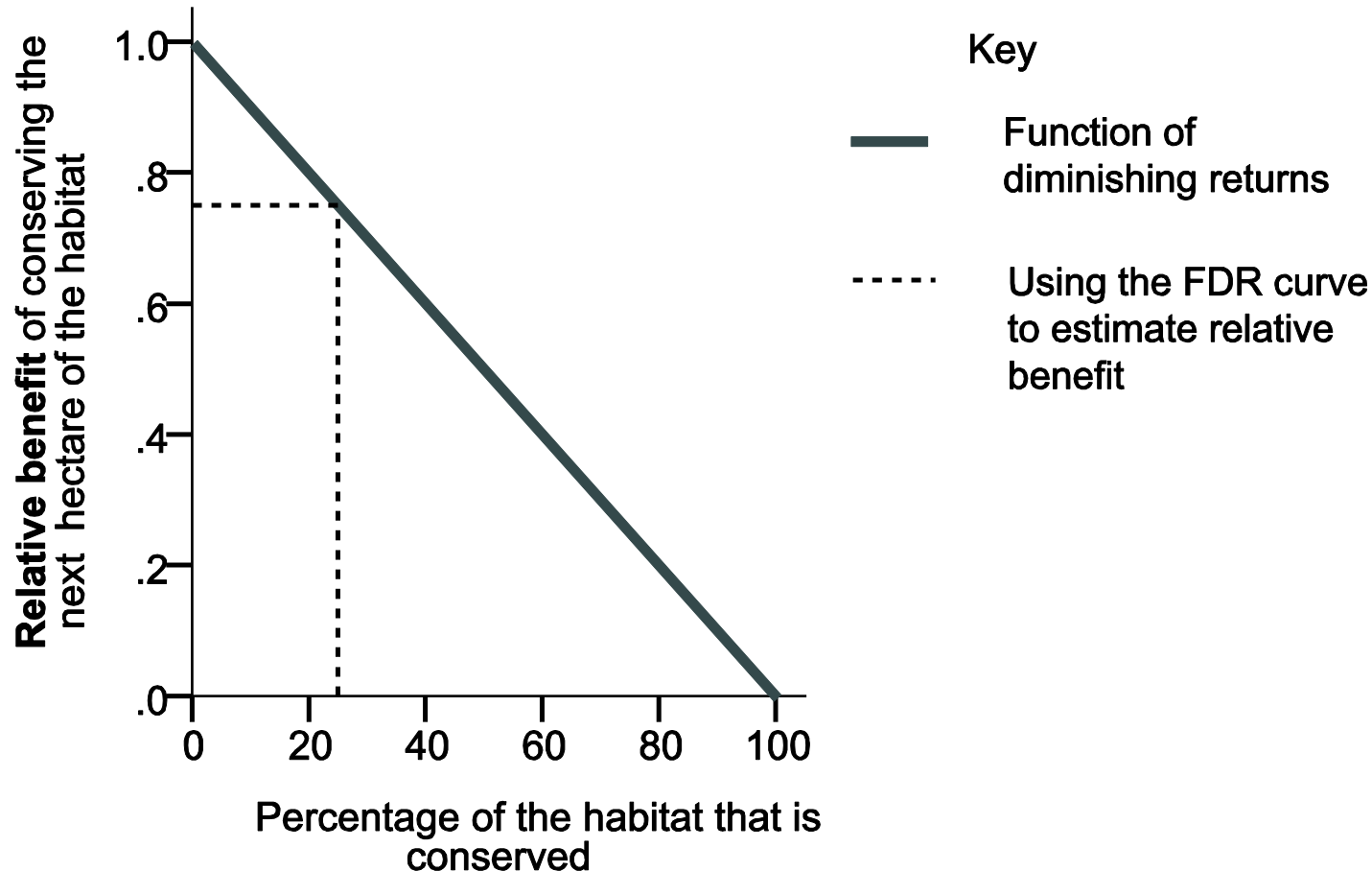Political Ecology, Initial Financial Investment, Ongoing Management Costs, Etcetera

Different Actions

Continuous benefit functions

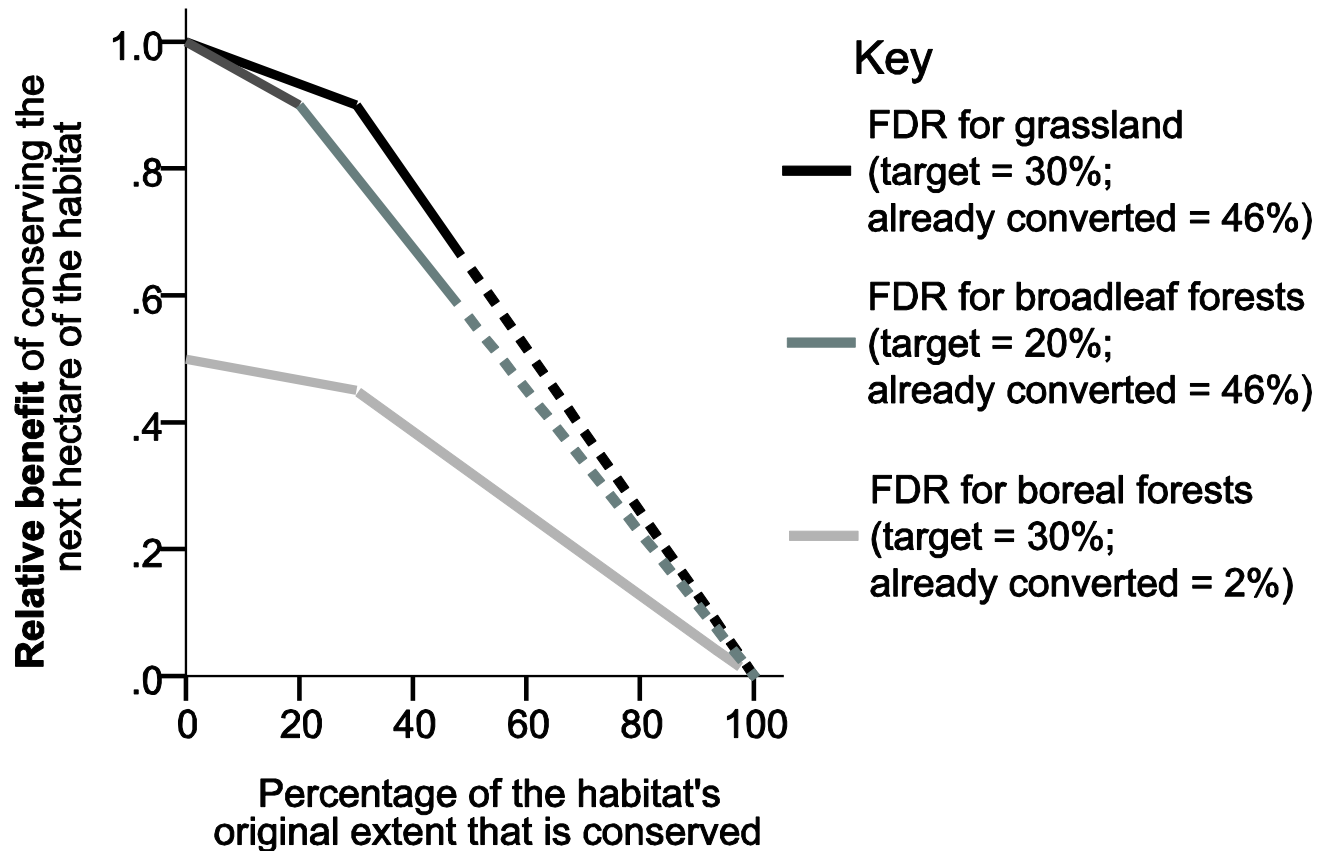Note: "Functions of diminishing returns" = "Continuous benefit functions"

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Target-based value of Habitat X

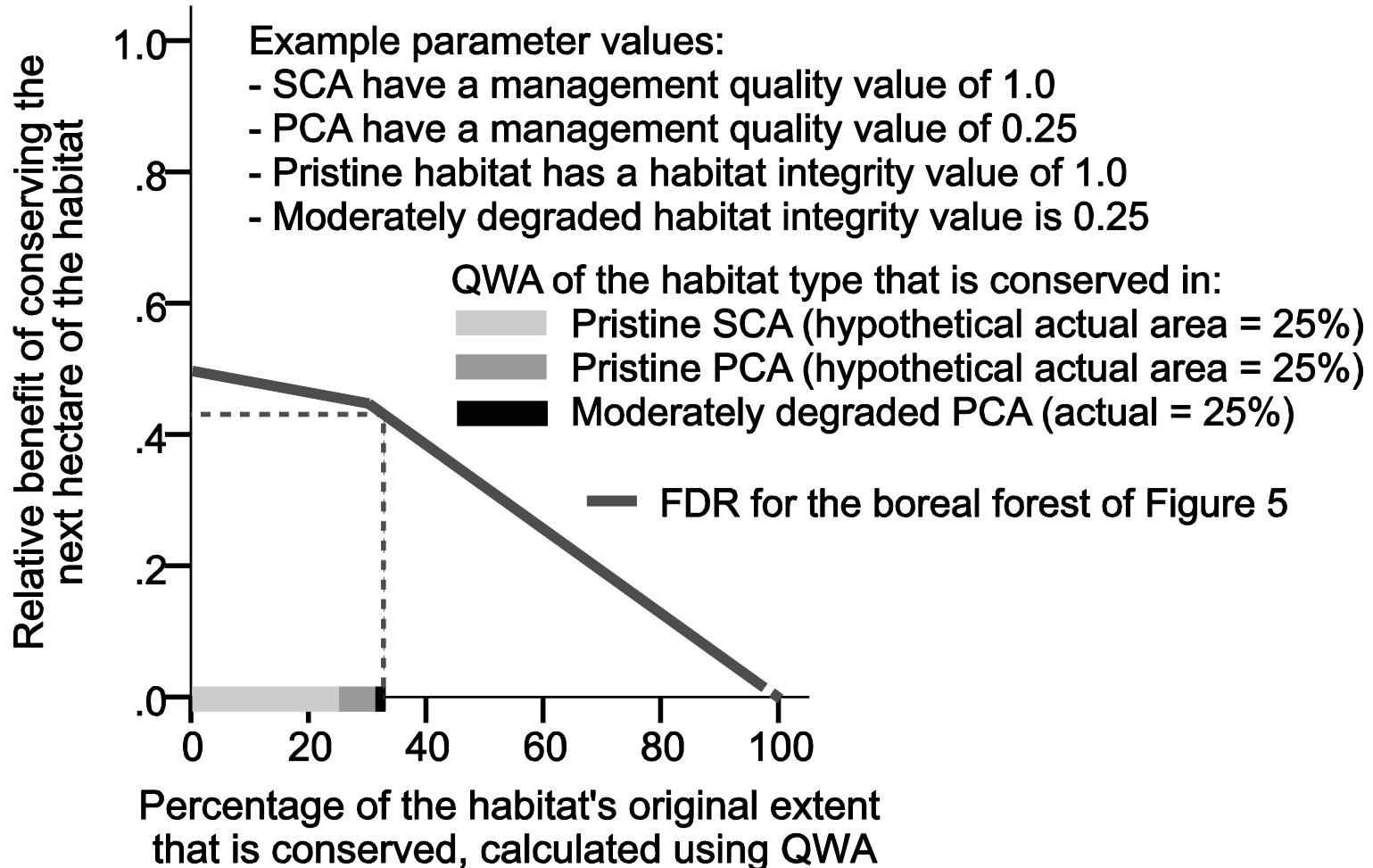
KEY:

T = Target

Relative value of conserving the next HA of the element

Percentage of element (e.g. habitat X) that is **protected**

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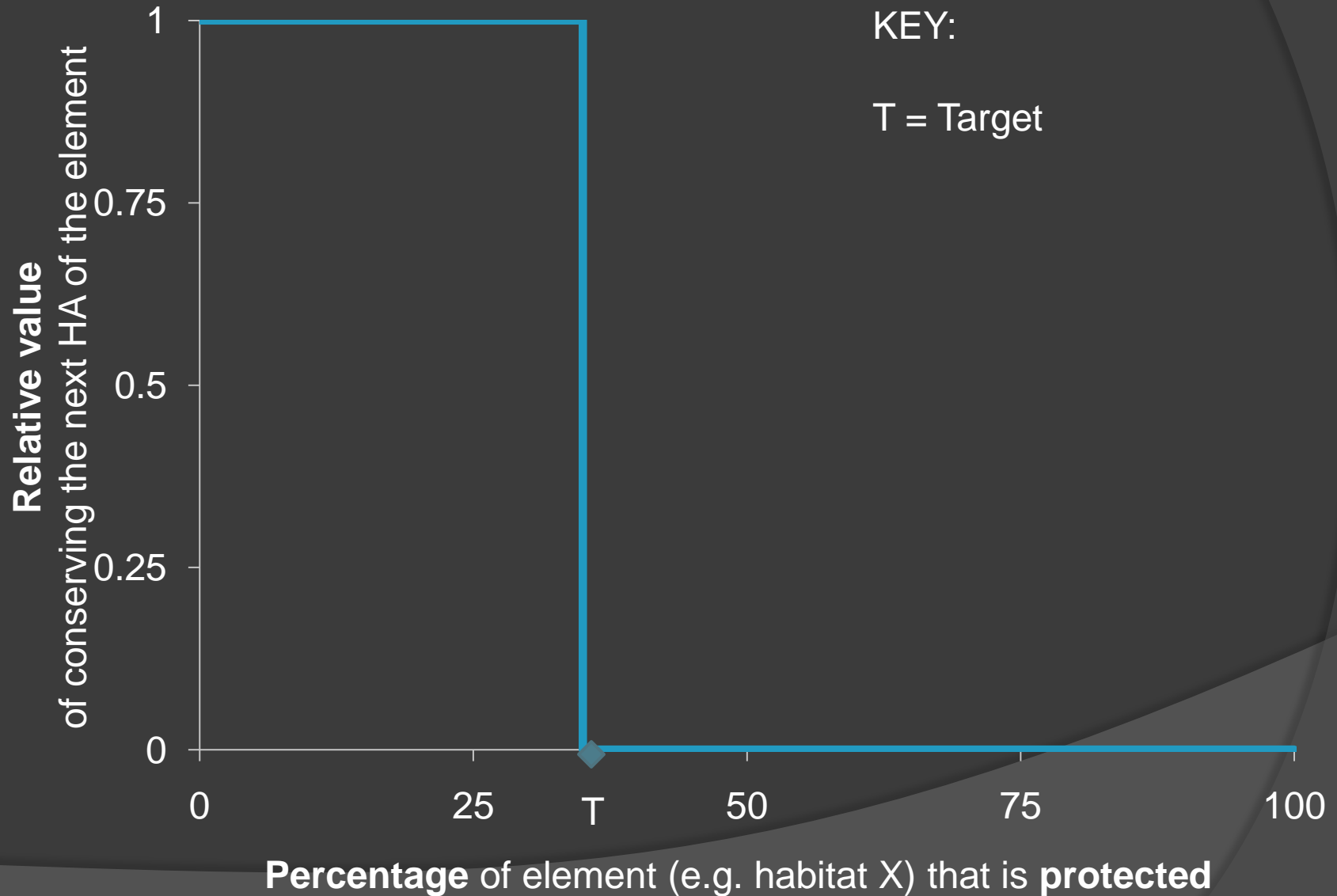
Each habitat has its own curve
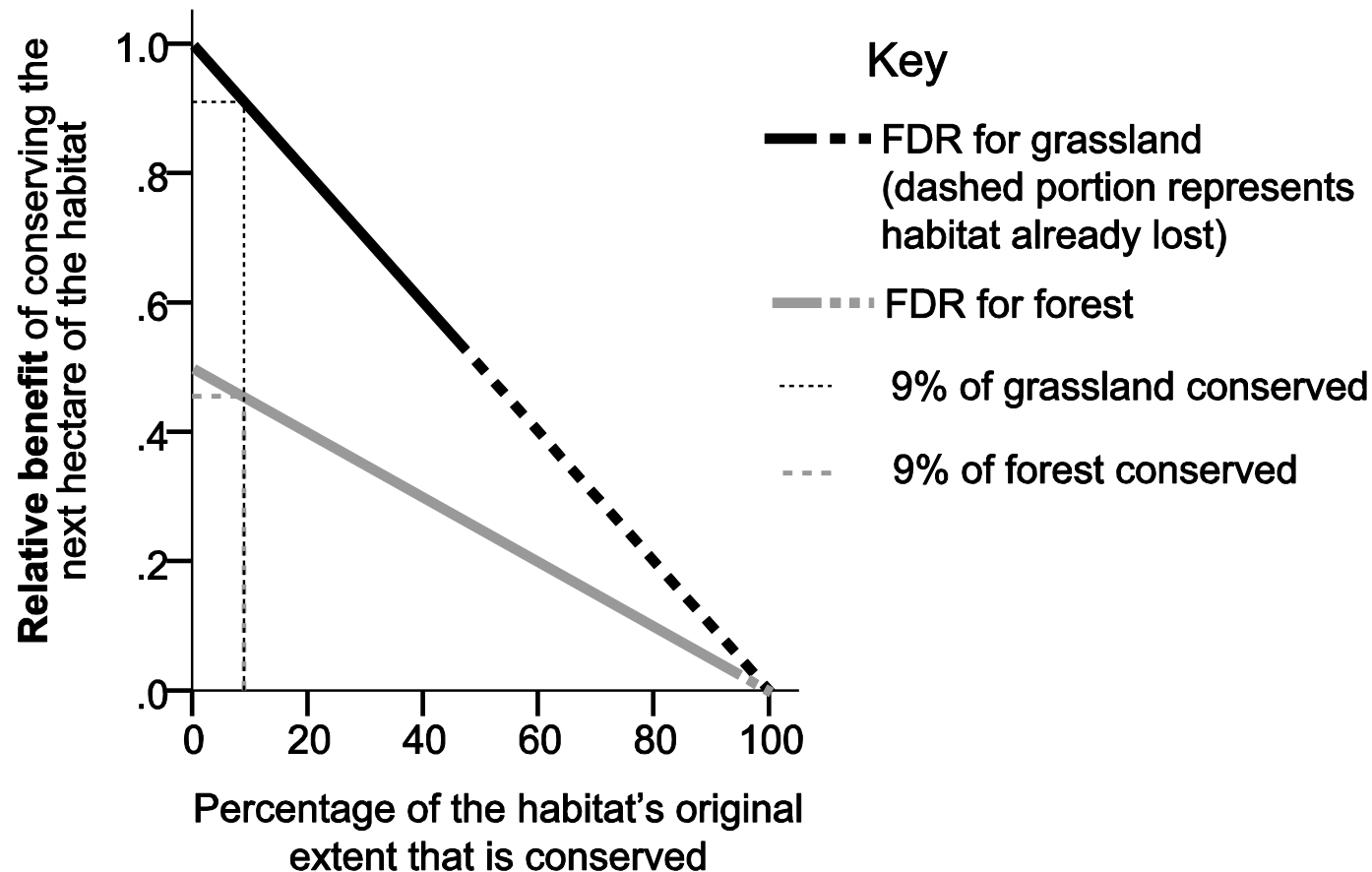
Curves automatically defined

Relative benefit of conserving the next hectare of the habitat (y-axis: .0, .2, .4, .6, .8, 1.0)

Percentage of the habitat's original extent that is conserved (x-axis: 0, 20, 40, 60, 80, 100)

Key

FDR for grassland
(target = 30%;
already converted = 46%)

FDR for broadleaf forests
(target = 20%;
already converted = 46%)

FDR for boreal forests
(target = 30%;
already converted = 2%)

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Quality-weighted area

Example parameter values:
- SCA have a management quality value of 1.0
- PCA have a management quality value of 0.25
- Pristine habitat has a habitat integrity value of 1.0
- Moderately degraded habitat integrity value is 0.25

QWA of the habitat type that is conserved in:
Pristine SCA (hypothetical actual area = 25%)
Pristine PCA (hypothetical actual area = 25%)
Moderately degraded PCA (actual = 25%)

FDR for the boreal forest of Figure 5

y-axis: Relative benefit of conserving the next hectare of the habitat

x-axis: Percentage of the habitat's original extent that is conserved, calculated using QWA

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User defines the importance of reaching targeted thresholds

FDR that results if the parameters are set for:

Relative benefit of conserving the next hectare of the habitat

Percentage of the habitat's original extent that is conserved

no emphasis on target achievement

low emphasis on target achievement

medium emphasis on target achievement

highest emphasis on target achievement
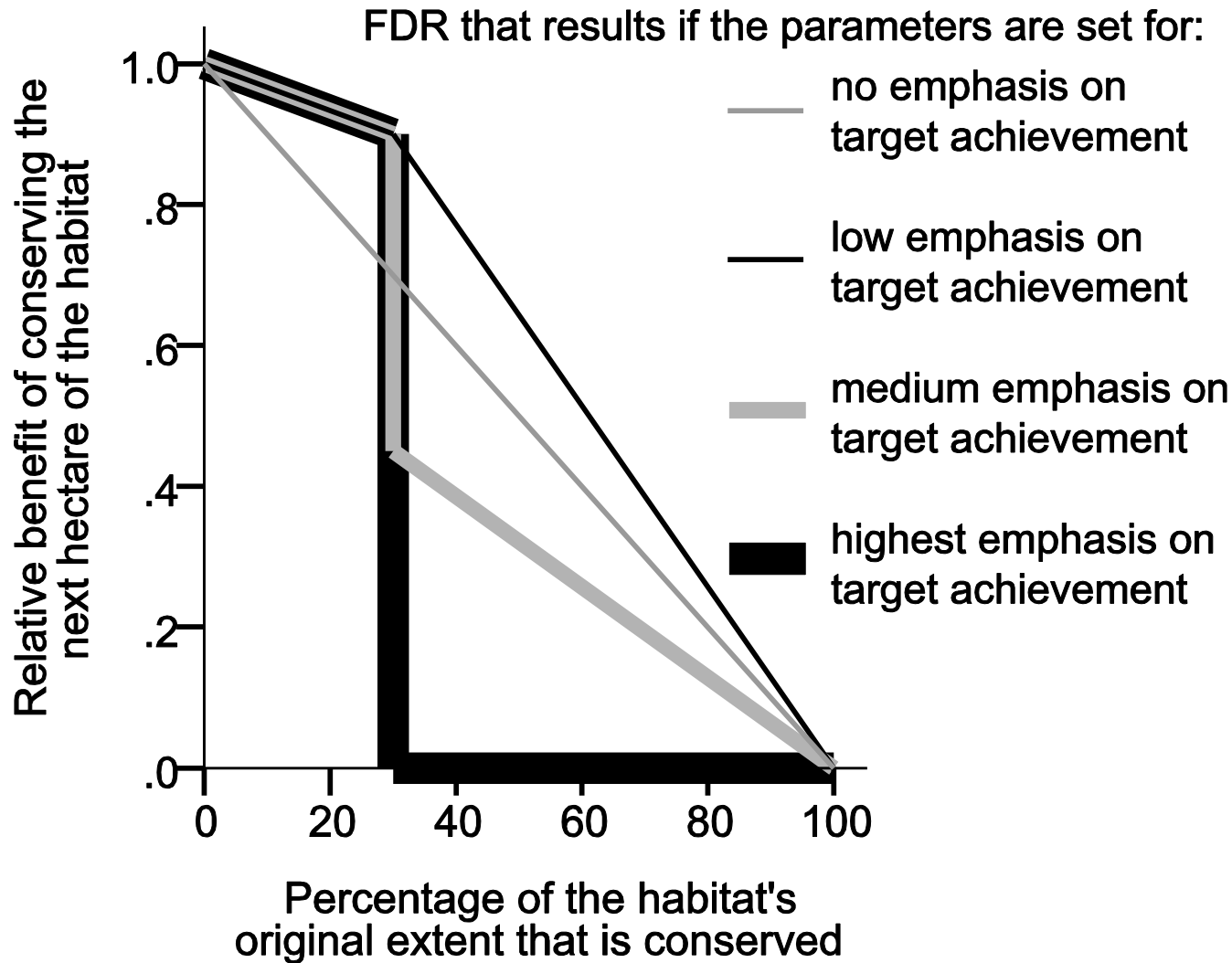
- Key data requirement:
  - Estimated total area of the historical extent of each habitat type.
- Go to Continuous Benefit Function parameter tester (Excel spreadsheet)

Same principle applies to

- Species representation
- Can be used to define threat over time

Estimating optimal solution sets

(Recalculation of the
continuous benefit functions)
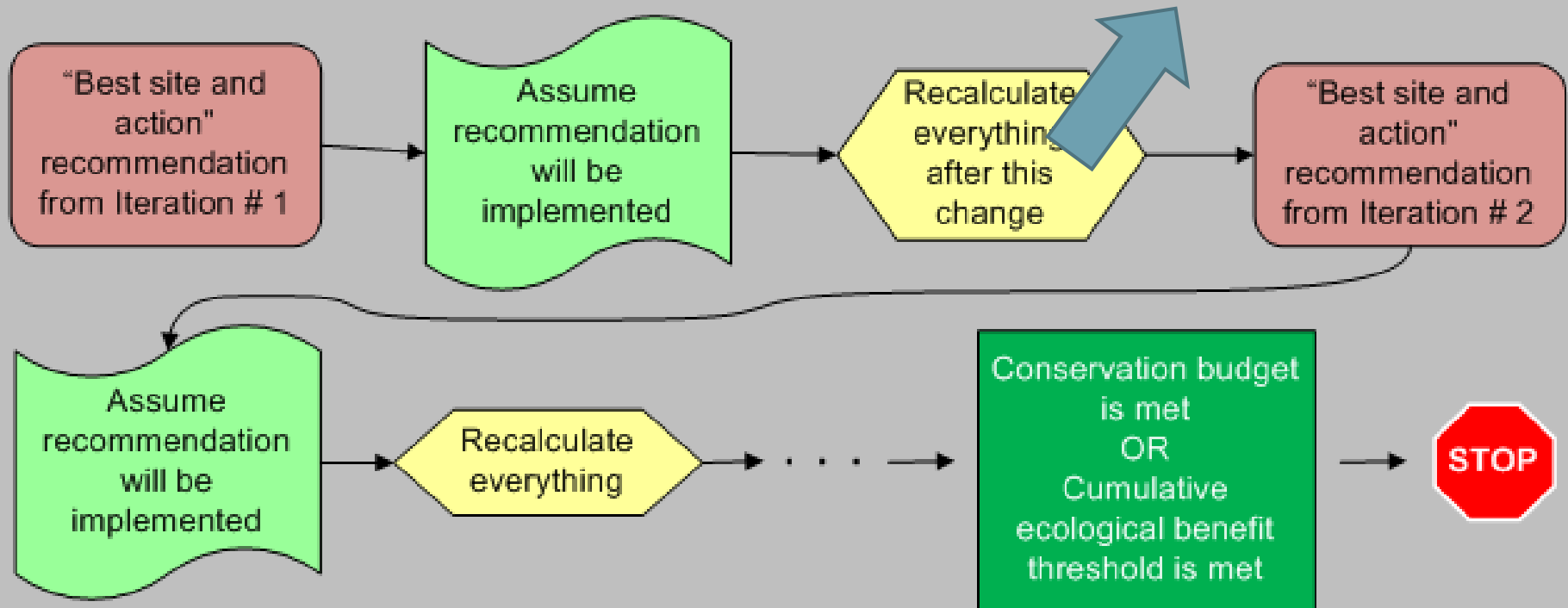
LandscapeDS Framework Summarized

- Hierarchical multi-criteria system
- Continuous benefit functions
- Conservation diversity
- Site assessment AND solution sets
- Compares action to no action alternative

Next:

- Introduction
- LandscapeDSS Framework
- LandscapeDST v 1.01
  - Connectivity and Contiguity
  - Threat
- Onward
  - Online Community
  - Support

LandscapeDST Community

LandscapeDST Sign-up Sheet
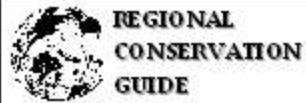
Name	e-mail (write big please)	Send me a Password	Tell me more about the Coordinator Position	What are the Volunteer opportunities?	**Optiona** (such as area of organization's your phone
		☐	☐	☐	

CALIFORNIA ESSENTIAL HABITAT CONNECTIVITY PROJECT

FIGURE ES.1.
ESSENTIAL HABITAT
CONNECTIVITY NETWORK

Essential Connectivity Areas*

Less Cost

More Cost

Natural Landscape Blocks

Potential Riparian Connections

Interstate Connections

Ecoregions

*Cumulative cost to ecological flows

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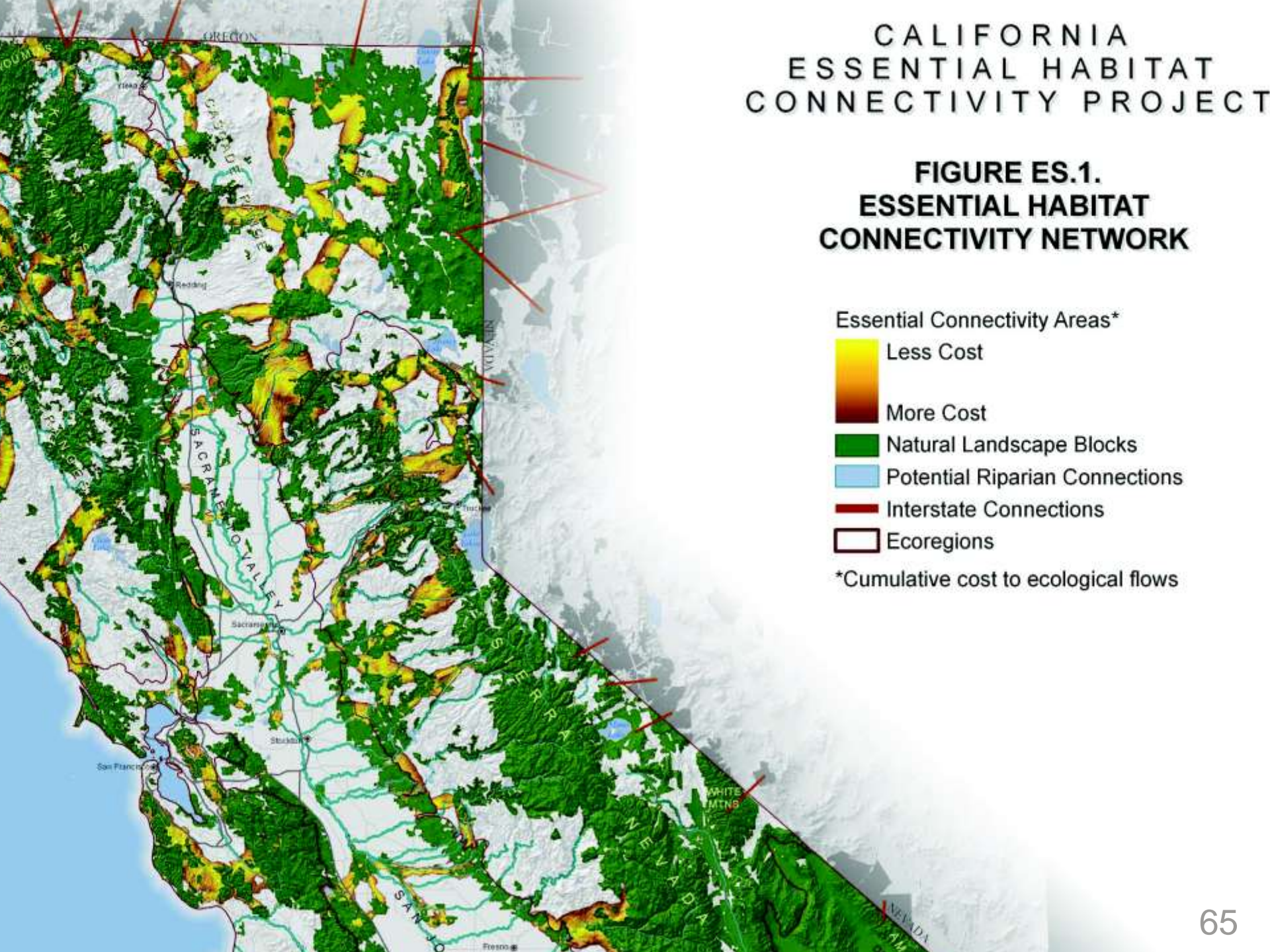
No Relative Permeability Score:

Relative Permeability:

Map titled "M Lion Gated LCP; All Corridors, Not Standardized" from REGIONAL CONSERVATION GUIDE. Legend shows Permeability: Low (1/630), High (1/48), Wild Lands. Map marked DRAFT.
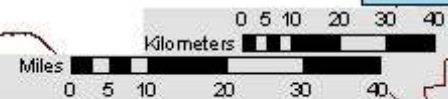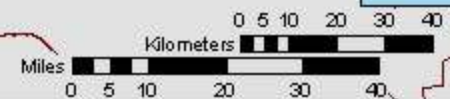
No Permeability:

M Lion Gated LCP; All Corridors, Standardized

Blend between the two considerations:

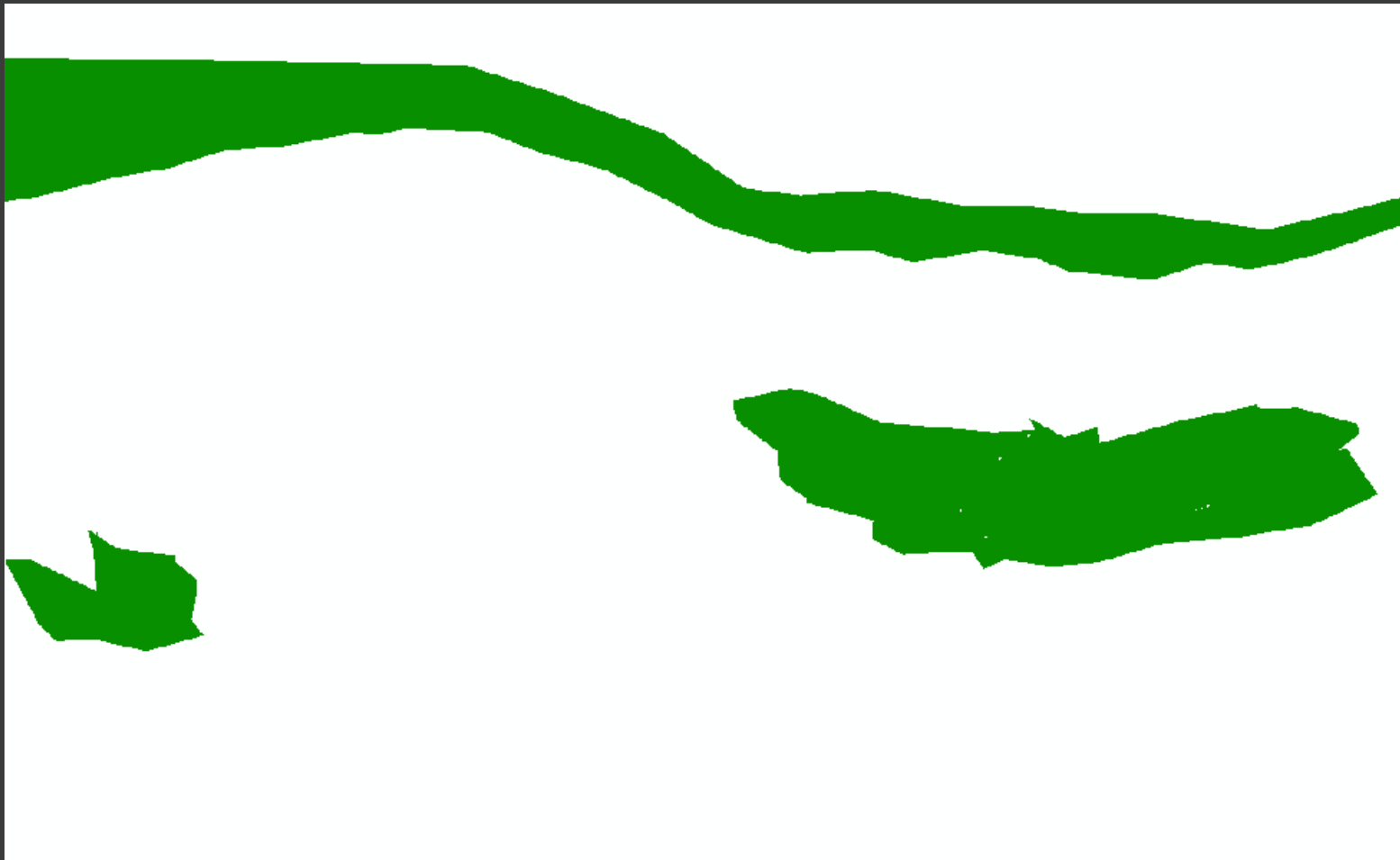Figure 14: Large Wildlife Linkages within the Conception Coast Region
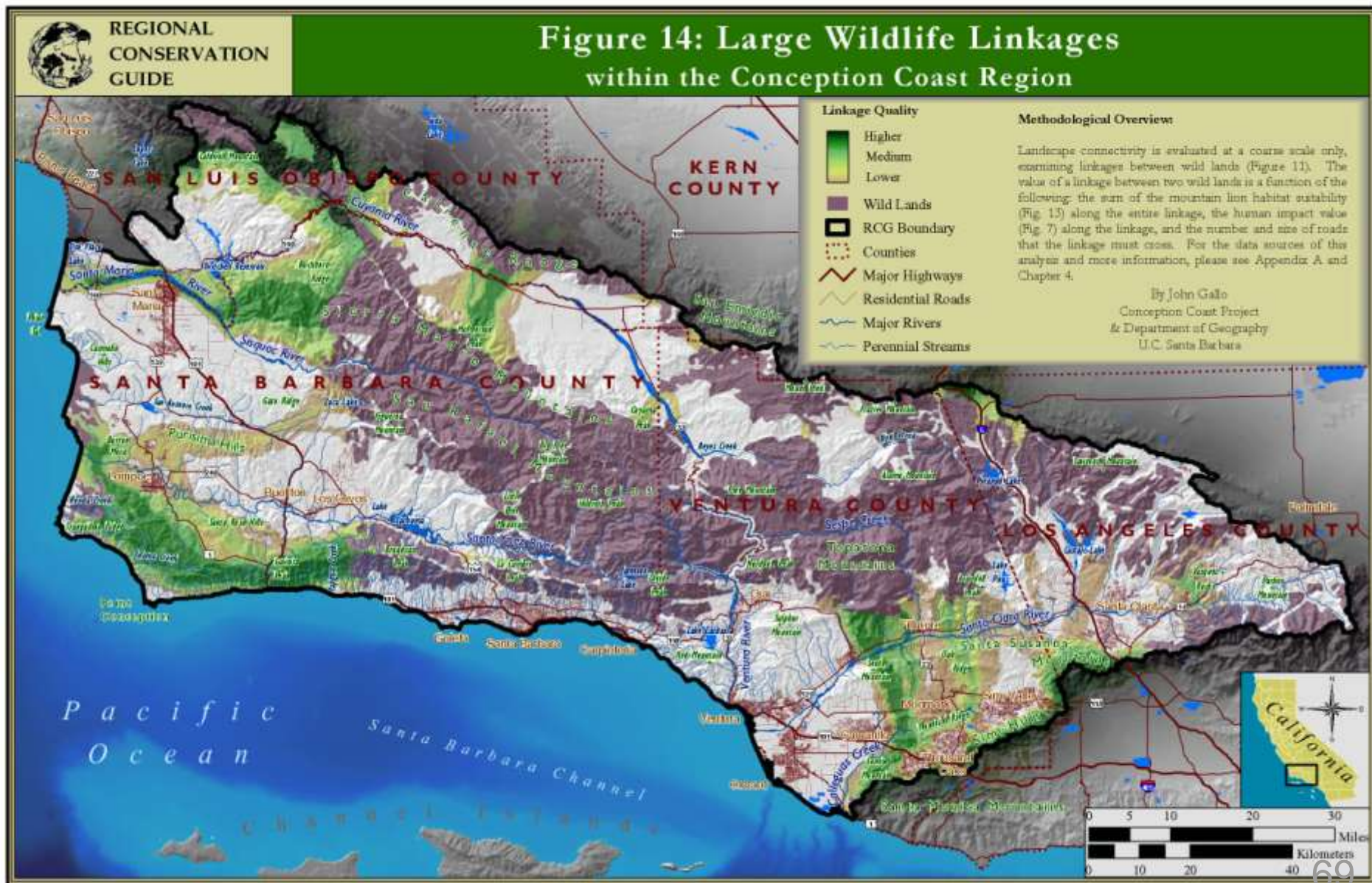
Fig 1: v1.01 biodiv value
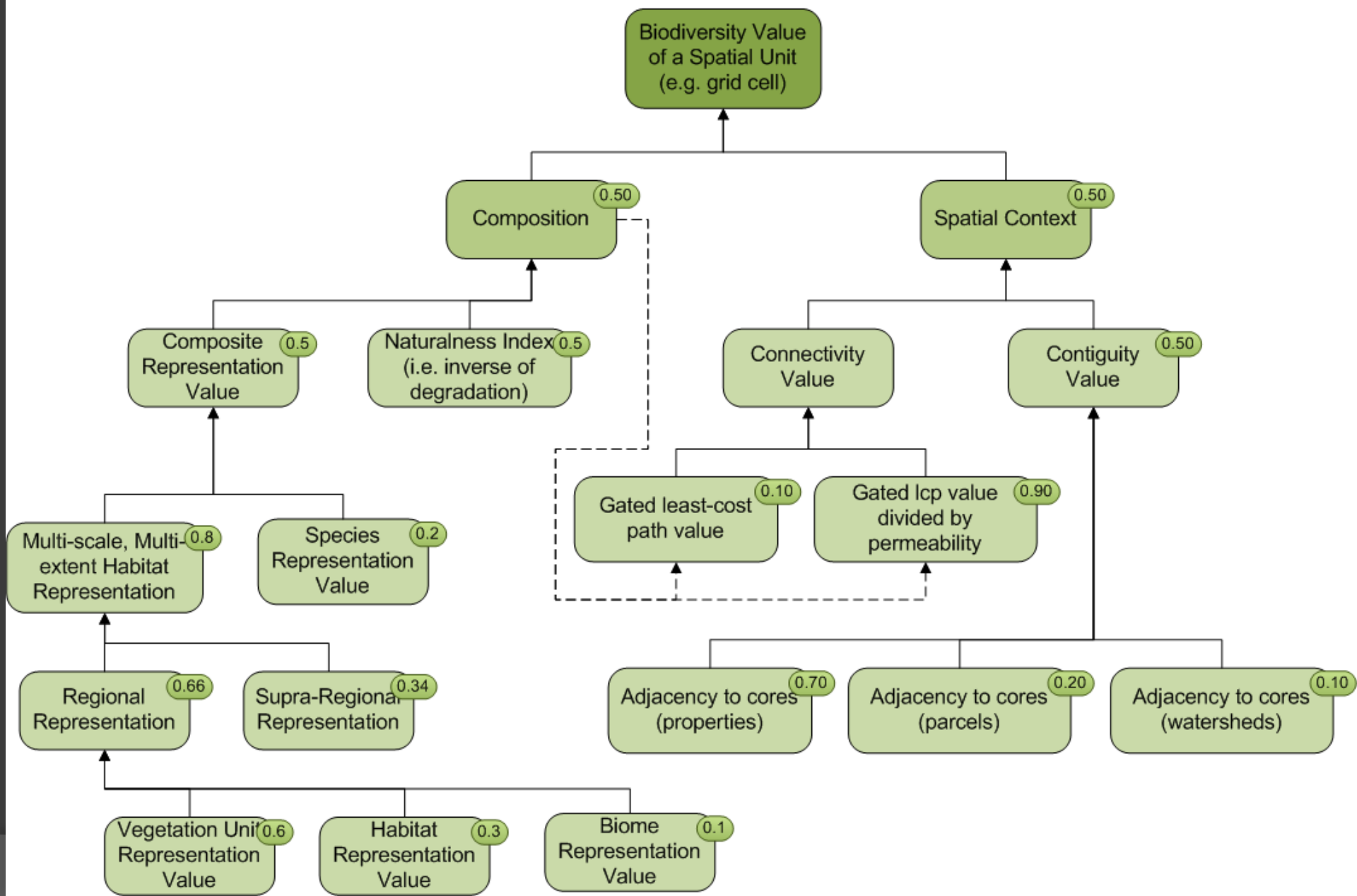
Programmed:
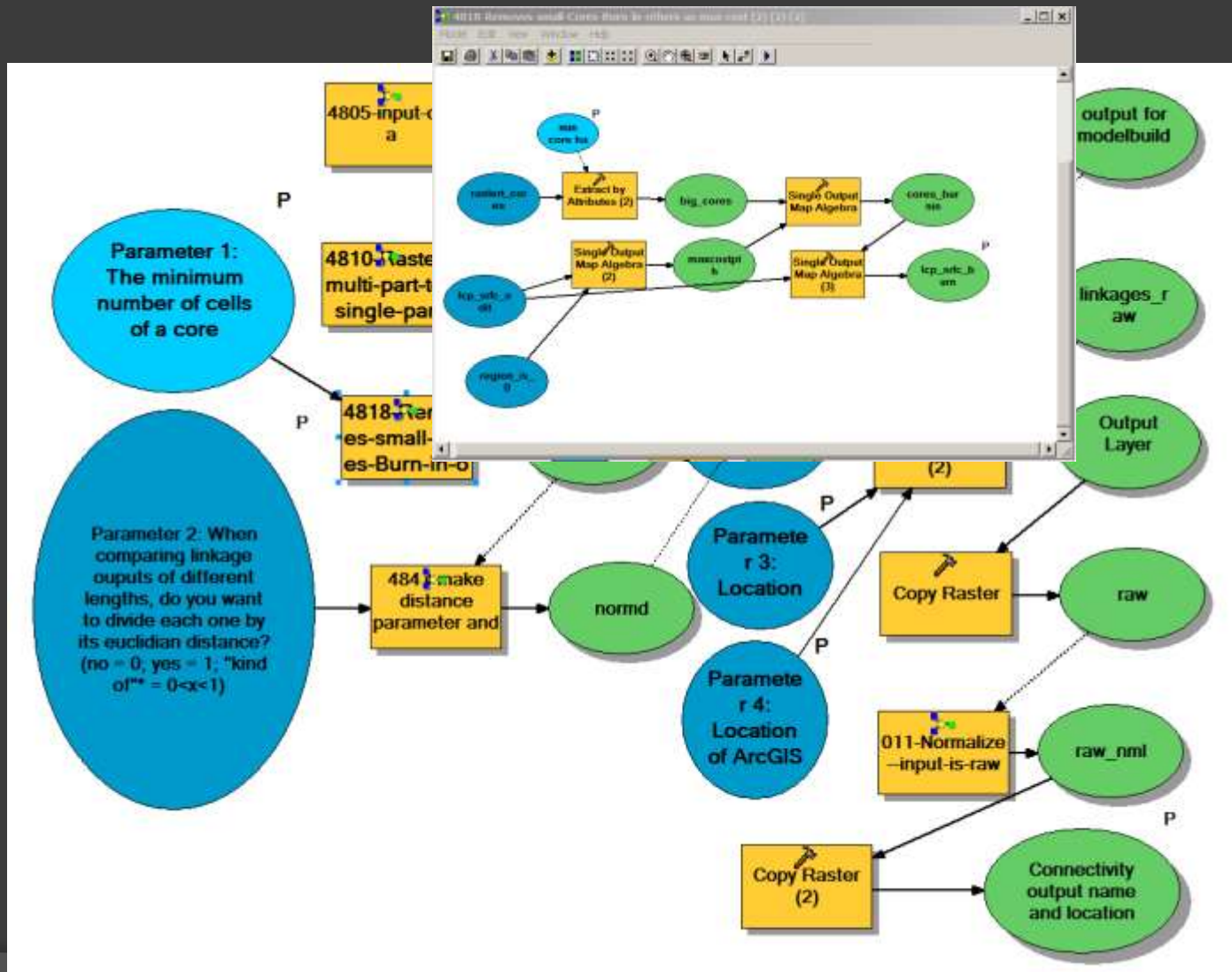
Contiguity

Parcels

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Properties
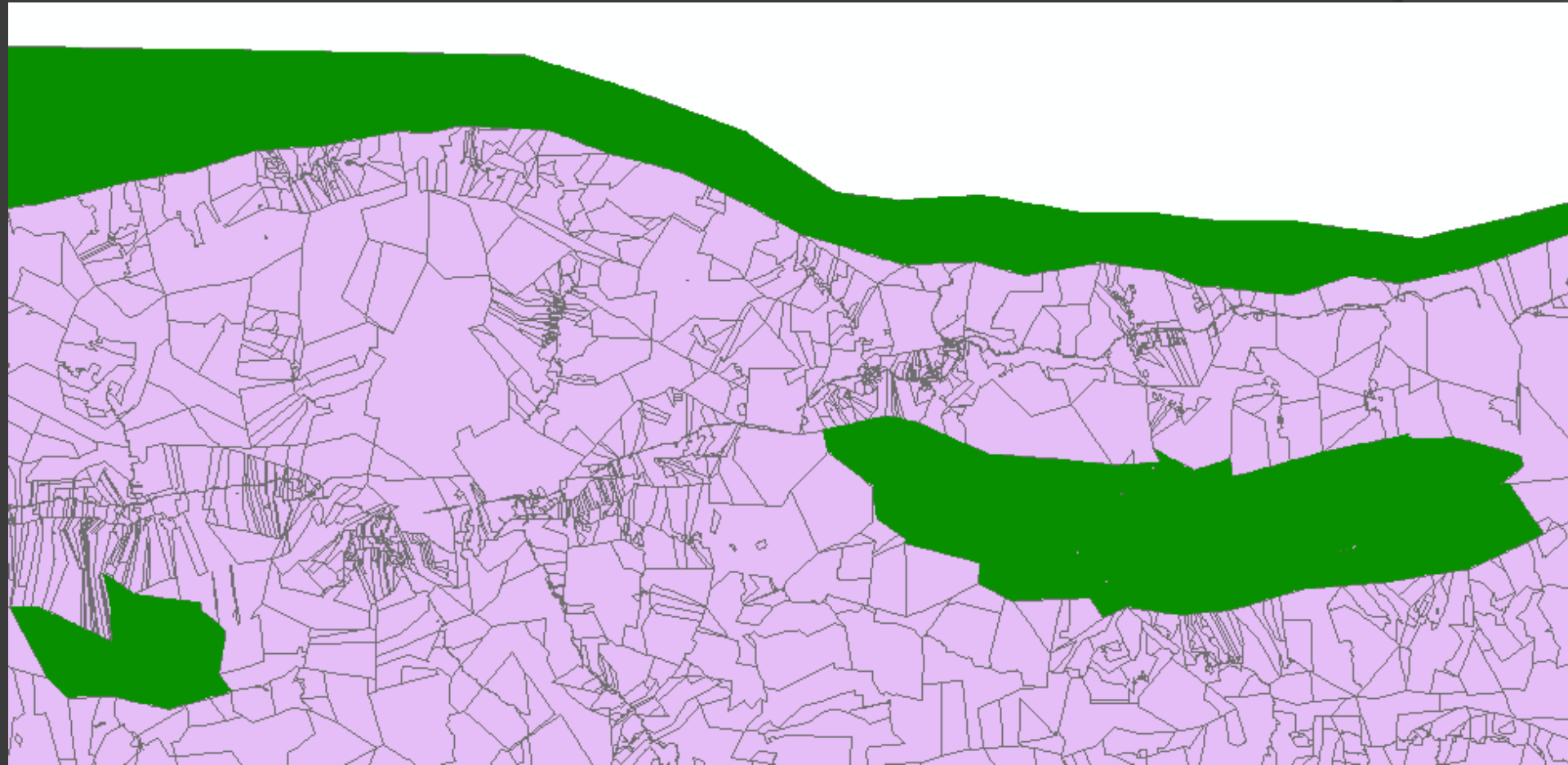
Watersheds
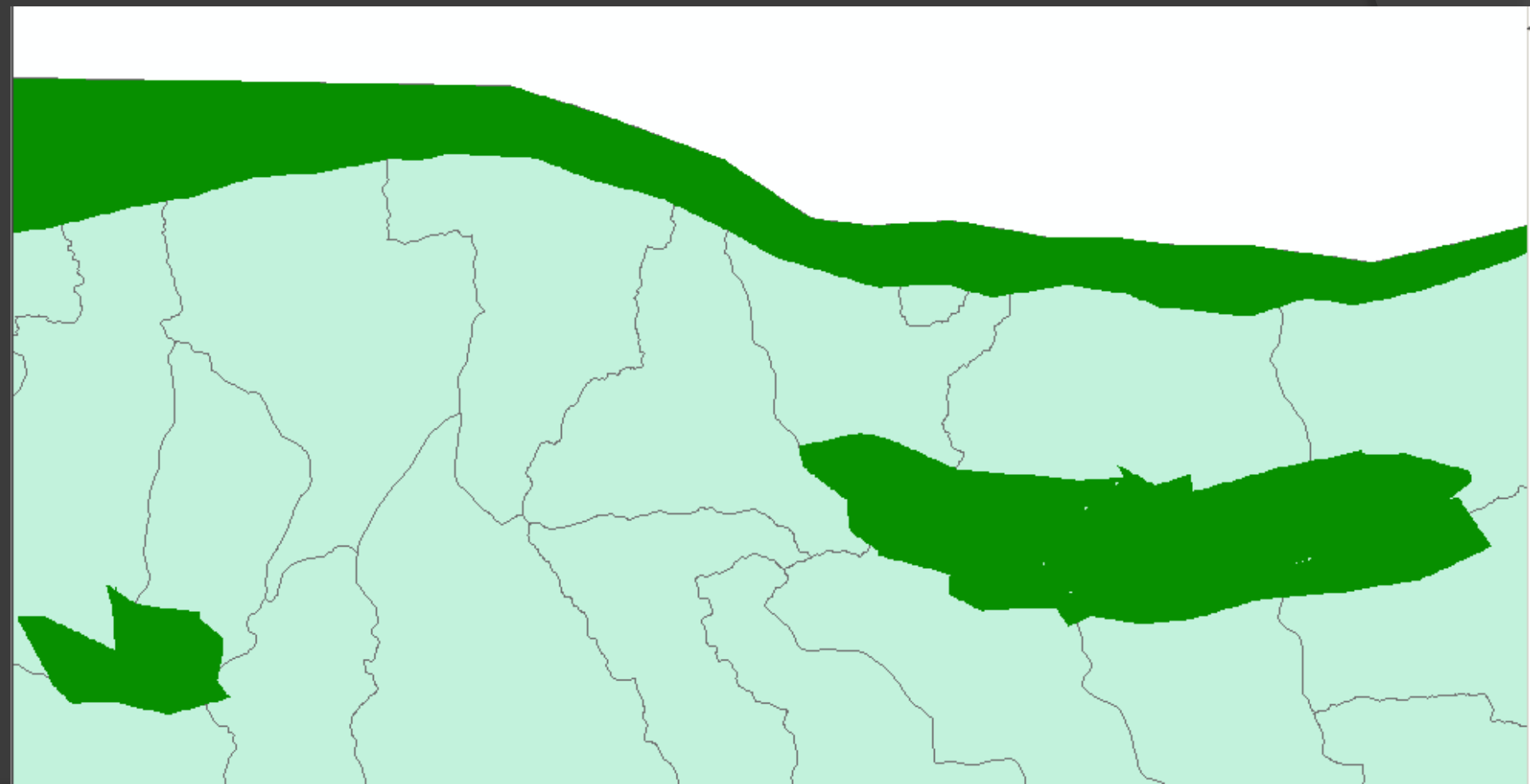
Fig 1: v1.01 biodiv value
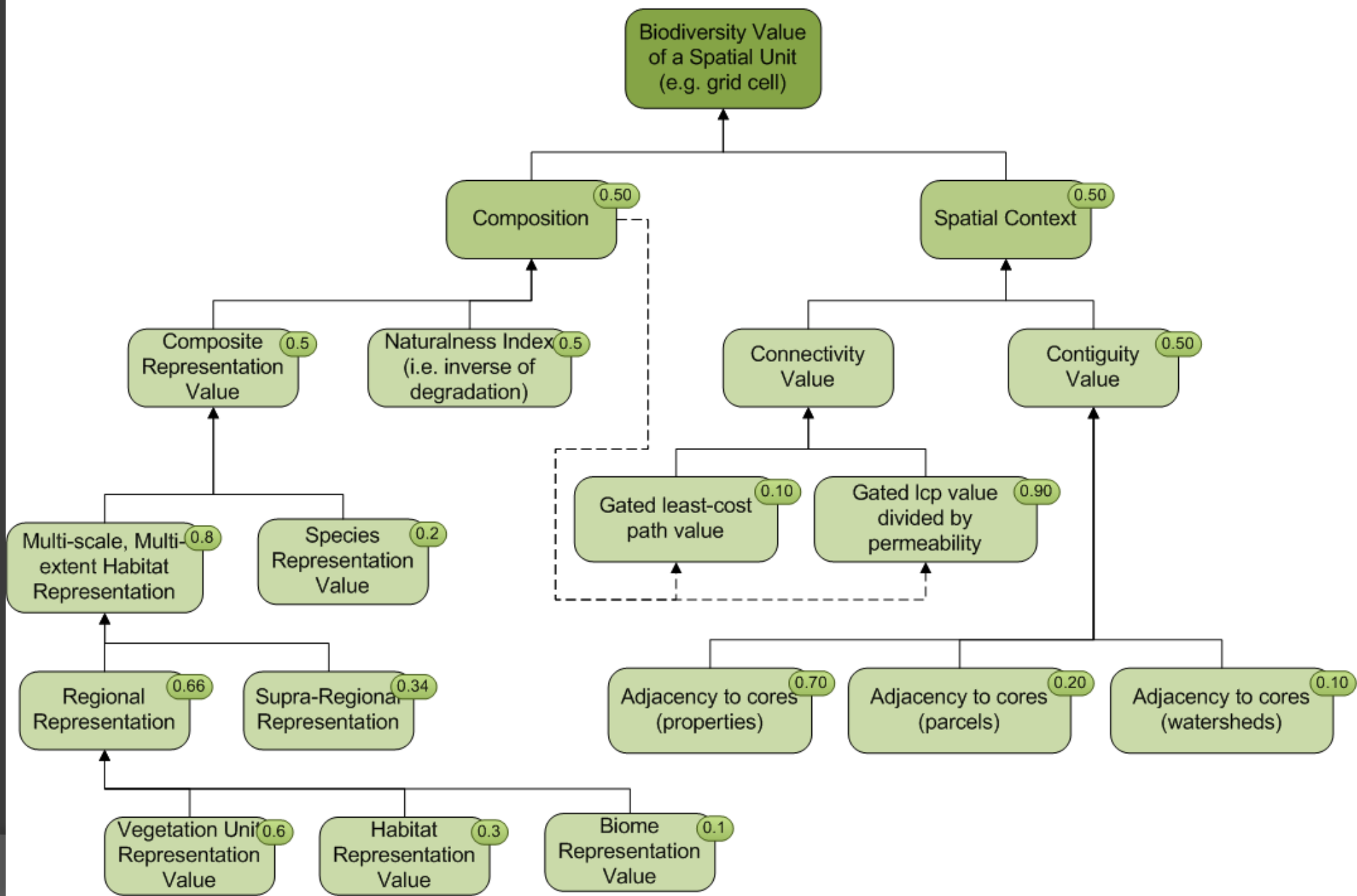
Fig 3: v1.01 cons priority

Relative Conservation Priority
of Performing Action X, at Place Y, Given Scenario Z

Weighted Division

Marginal Benefit of Proposed Action — 0.50

Feasibility of Proposed Action — 0.50

Cost of Initial Financial Investment

Ongoing Management Costs
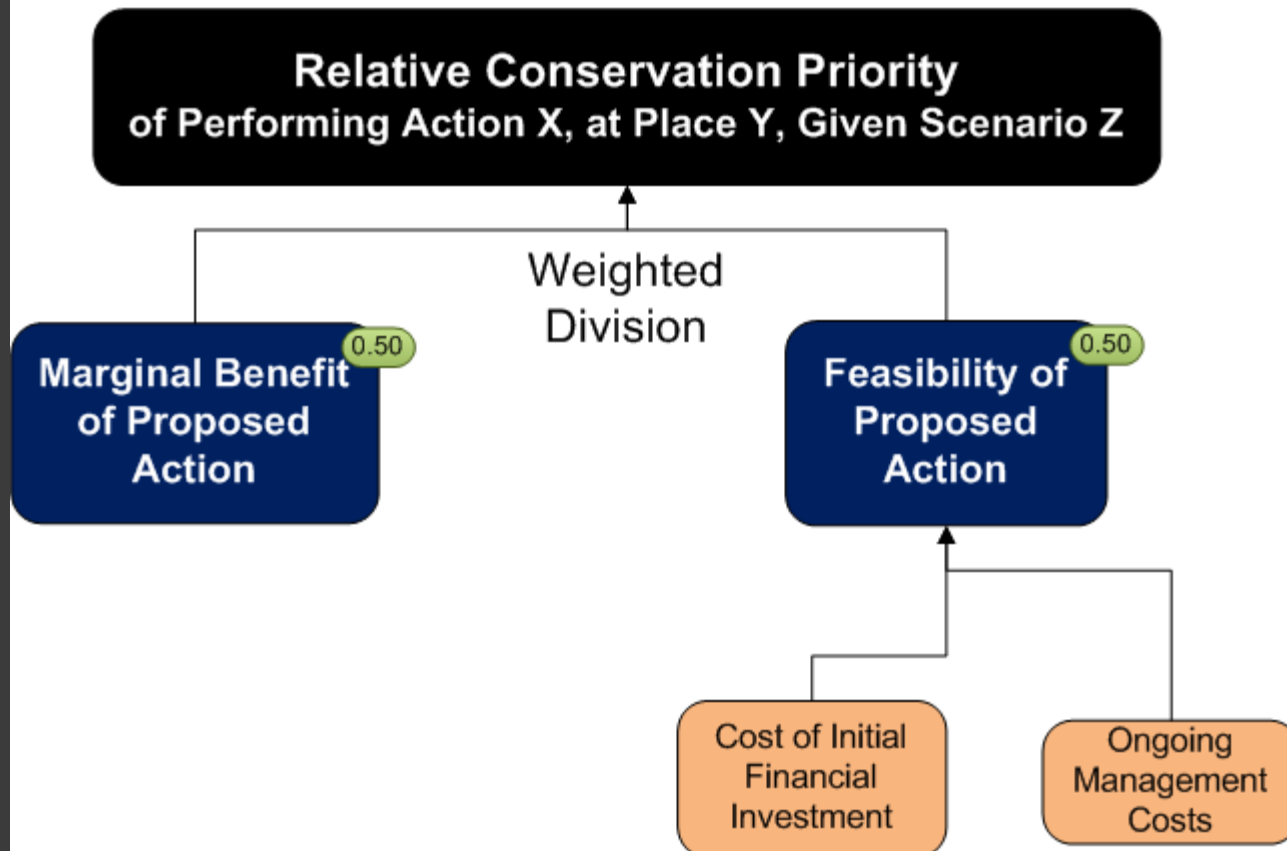
Pilot Projects

- 1) Little Karoo, South Africa
  - Started in 2008
  - All input data available with LandscapeDST v 1.01
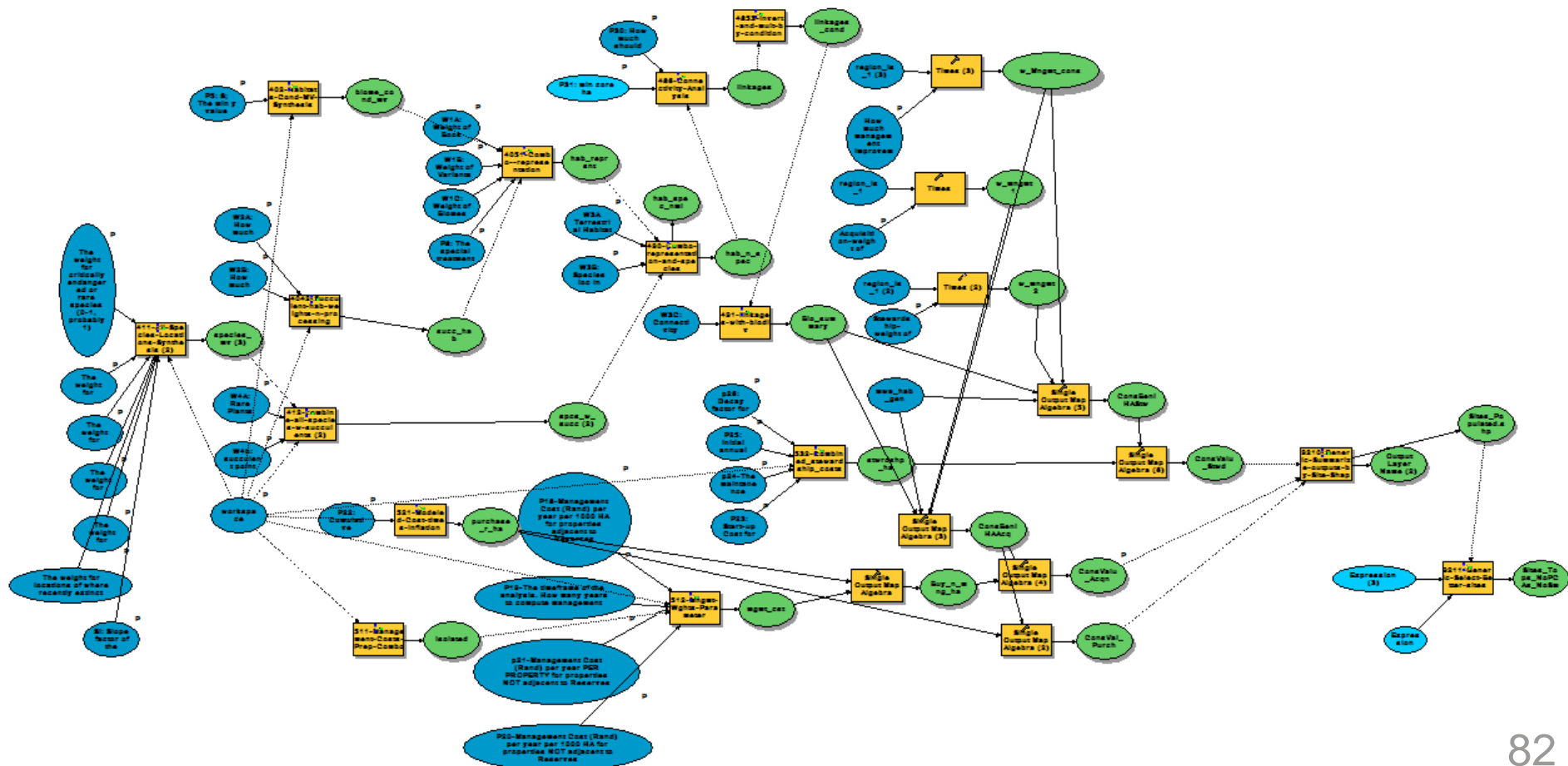
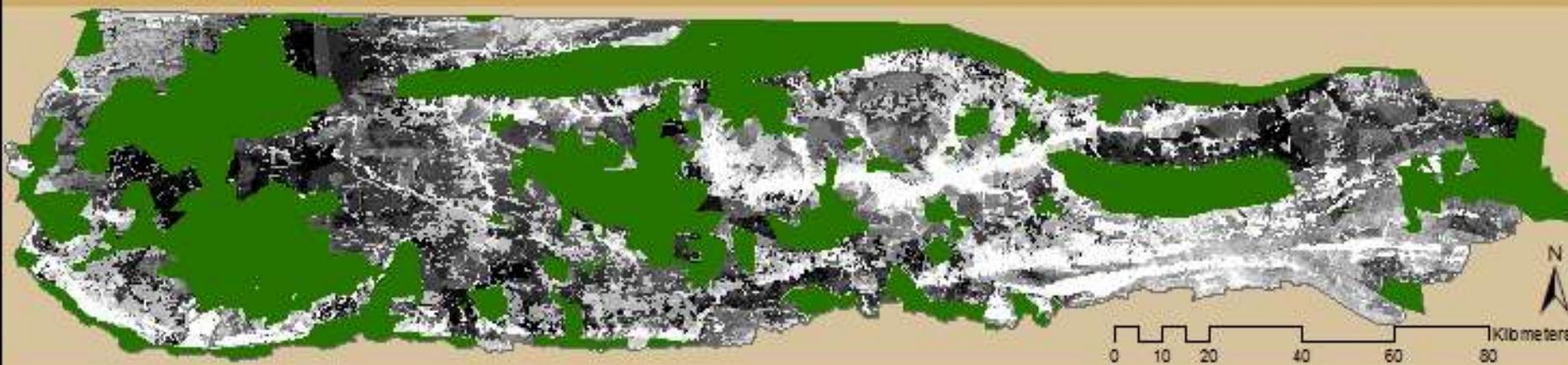# Estimated Acquisition Value of all hectares outside of reserves

Acquisition Value
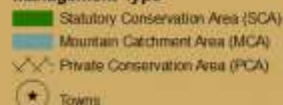Value
High
Low

Kilometers
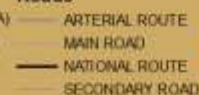0   10   20   40   60   80

Good Sites for Acquisition

All the good sites are displayed (those greater than the mean plus standard deviation of conservation value for all sites, and that are greater than 100 HA). Conservation value is measured in expected "Biodiversity Benefits" per Rand spent, so the higher the better.

Management Type
- Statutory Conservation Area (SCA)
- Mountain Catchment Area (MCA)
- Private Conservation Area (PCA)
- Towns

Roads
- ARTERIAL ROUTE
- MAIN ROAD
- NATIONAL ROUTE
- SECONDARY ROAD

Conservation Value for Acquisition
- 0.49 - 0.57
- 0.58 - 0.67
- 0.68 - 0.79
- 0.80 - 0.95
- 0.96 - 1.20

LADISMITH
CALITZDORP
DE RUST
OUDTSHOORN
UNIONDALE
VAN WYKSDORP
MONTAGU
HEROLD
BARRYDALE

Kilometers
0   10   20   40   60   80
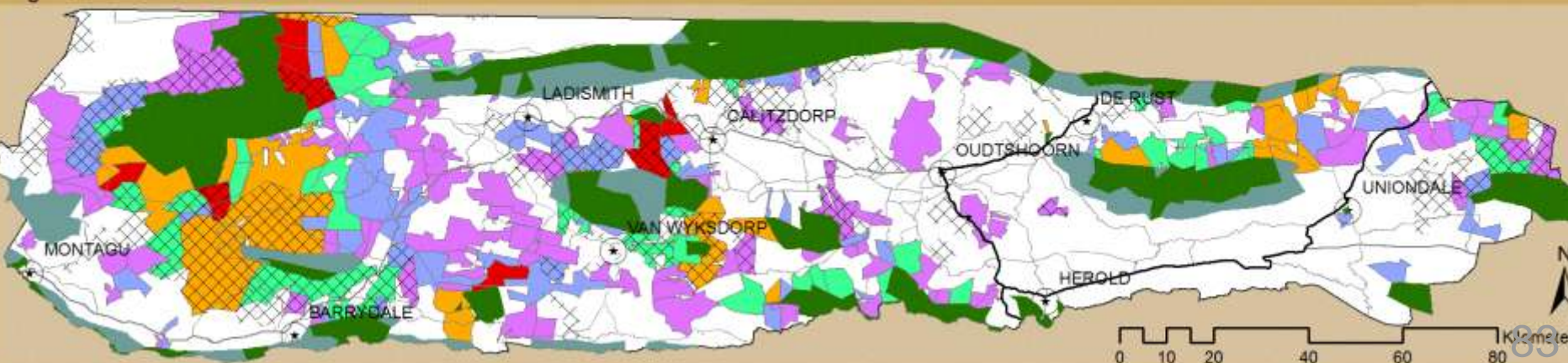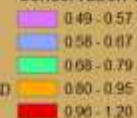
| Variable:	Triangle	Aardvark	Naauwkloof	Oudewagensdrift	BuffeljagsFontein1	Buffeljagsfontein2	DieFontein
Owner	FOURIE LOUIS	FOURIE	ASSEGAAY	BRITZ	REENEN	REENEN	JORDAAN
Site_ID	1125	3911	3502	3883	2455	2456	1552
Conservation Value for Acquisition based on Actual List Prices and Site-Level Calculations:	0.71	0.92	0.58	0.54	0.47	0.04	0.70
Conservation Value for acquisition based on modeled prices and hectare level calculations	0.64	0.98	0.62	0.81	0.45	0.05	0.61
ConsBeniAq	2499	2971	2641	2579	2002	1055	2378
ConVal_Pur	0.84	1.40	1.45	1.13	0.57	0.28	0.80
Bio_Beni	0.25	0.30	0.26	0.26	0.20	0.11	0.24
Acqtn_Cost	4644	3232	4372	3330	4480	24442	4009
Modeled List Price	3346	2166	1822	2346	3580	3750	3102
Actual List Price	2232	2058	2000	3808	3333	3333	2500
Actual List Price of the Site (Millions)	2.50	7.00	5.40	9.40	0.50	0.50	2.00
Purch_Site	4.00	8.02	5.04	9.99	0.42	0.48	2.91
Mgmt_Cost	1298	1066	2550	984	900	20692	907
Designated a PCA?	no	no	no	yes	no	no	no
Site_HA	1198	3685	2769	4263	121	128	947
Linkage	0.22	0.18	0.27	0.10	0.27	0.26	0.16
Representn	0.24	0.25	0.21	0.18	0.17	0.09	0.16
Species	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Biome_Rep	0.33	0.45	0.47	0.44	0.31	0.14	0.42
B_Hab_Rep	0.31	0.42	0.40	0.39	0.25	0.12	0.39
Varnt_Rep	0.30	0.32	0.28	0.26	0.24	0.12	0.28
Succ_Hab	0.57	0.56	0.52	0.46	0.50	0.53	0.36
Succ_Richn	0.80	0.80	0.84	0.74	0.76	0.77	0.63
Succ_Endem	0.51	0.50	0.44	0.38	0.44	0.47	0.29
Rare_Spec	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Succ_Spec	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Habitat Condition	0.47	0.67	0.70	0.63	0.48	0.20	0.66

84
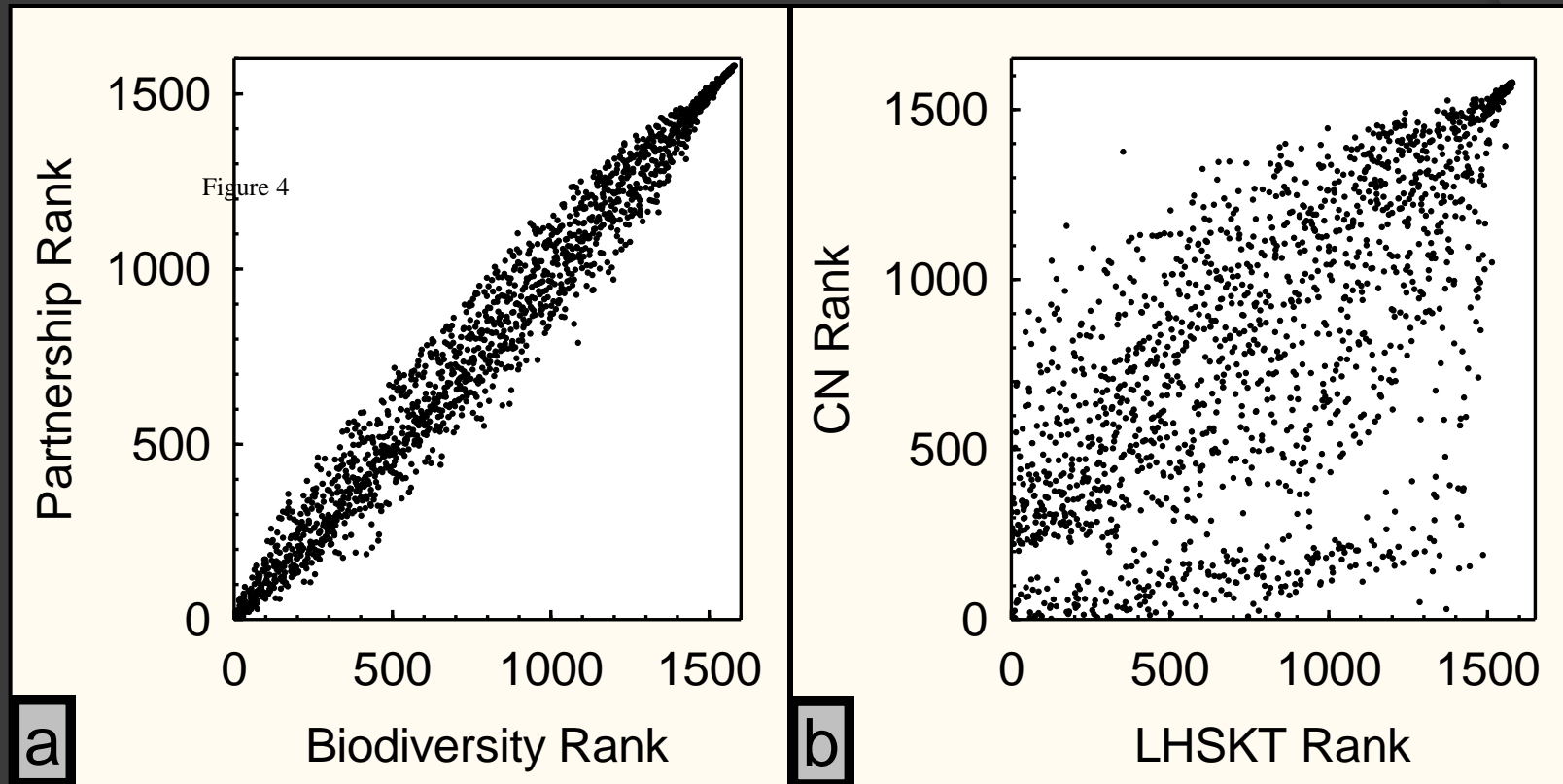
Figure 4: Depiction of how the conservation priority rank of all sites compared between (a) the partnership and biodiversity outputs ($r_s = 0.98$); and (b) CapeNature and Leslie Hill Succulent Karoo Trust outputs ($r_s = 0.66$). Each dot represents a site.

Pilot Projects

- Little Karoo, South Africa
  - Started in 2008
- Sonoma County, CA USA
  - Tom Robinson
  - Open-space District
  - Starting in 2010
- Potential:
  - Forest Restoration Priorities
    - NW California

Next:

- Introduction
- LandscapeDSS Framework
- LandscapeDST v 1.01
- Onward!
  - Online Community
  - Use and Support

Atlassian video

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LandscapeDST Development ▾

John Gallo ▾   History ▾

Issues   Wiki   Source   Reviews

Dashboards ▾   Issues ▾   Agile ▾   Administer project

➕ Create new issue

LandscapeDST Development / LDSTD-1

Greedy hueristic site selection algorithm

✎ Edit   Assign   Assign To Me   Comment   More Actions ▾   Resolve Issue   Close Issue   Workflow ▾   👁 View ▾

Details

Type:	🟢 New Feature	Status:	🔵 Open	
Priority:	⬆ Major	Resolution:	Unresolved	
Affects Version/s:	None	Fix Version/s:	None	
Component/s:	None			

Description:

▾ We need to add the greedy heuristic algorithm. This was created for an earlier version of the DST, and just needs to be updated and integrated. This is the heuristic that 1) identifies the site on the landscape that would give the most "bang for your buck" 2) selects that site and assumes it gets conserved with the action under consideration, 3) recalculates all the other sites given this assumption, 4) selects the next site and recalculates, 5) continues until a certain budget is met, or a certain number of sites have been selected.

Note, the pieces from the previous iteration have been copied and pasted in to the "LDST Factory" Toolbox, which is in the Toolboxes folder.

Environment:

for ArcGIS 9.3, to add to LandscapeDST version 1.01

People

Assignee:	Unassigned
Reporter:	John Gallo
Votes:	0 ✓
Watchers:	0 👁

Dates

Due:	20/Aug/10
Created:	Yesterday 11:57 AM
Updated:	Today 11:52 AM

Attachments

⬇ 👁 ➕

Estimating optimal solution

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- Click on the "LandscapeDST" toolbox version that you want
- Click Add
- Also add the Toolbox named "Favorites_1"

- You should now see a Toolbox called "LandscapeDST" with the version number.
  - It should now be included on the long list of Favorite GIS Toolboxes that you are

  ArcToolbox
  ⊕ 1_Favorites
  ⊕ Analysis Tools
    Cartography Tools
  ⊕ Conversion Tools
  ⊕ Data Management Tools
  ⊕ Geocoding Tools
  ⊕ LandscapeDST v1.01
  ⊕ LDST Factory

  familiar with, such as "Cartography Tools".

- In Tools/Options/Geoprocessing click the box for "Overwrite the outputs of geoprocessing operations" such that there is a checkmark when you are done.

  General
  ☑ Overwrite the outputs of geoprocessing operations
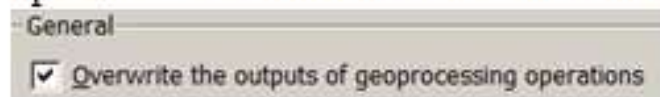
- Set your workspace and scratchworkspace
  - In your .mxd go to to Tools/Options/Geoprocessing/Environment/General and set them

Name ▲	Date modified	Type
Calibrating the Continuous Benefit Functions...	7/8/2010 5:28 PM	Microsoft
LandscapeDST v1_0 Start-up Guide.doc	7/5/2010 6:57 PM	Microsof
LandscapeDST v1_0 Start-up Guide.pdf	7/5/2010 6:57 PM	Adobe A
LandscapeDST v1_0 Tables.xls	7/8/2010 4:42 PM	Microsof
LandscapeDST-GNU GENERAL PUBLIC LICE...	6/11/2010 3:44 PM	Microsof
Multi-Criteria Hierarchy.pdf	7/5/2010 6:25 PM	Adobe A
Multi-Criteria Hierarchy.vsd	7/5/2010 6:25 PM	Microsof
potential_improvements.xls	6/11/2010 12:32 PM	Microsof
~$$Multi-Criteria Hierarchy.~vsd	7/8/2010 5:49 PM	~VSD Fil

Home Insert Page Layout Formulas Data Review View Add-Ins Acrobat

L53

	I (folder name)	J GIS_Layer	K Name on Multi-criteria Diagram	L Description
47	outputs	connectivity	Connectivity Value	
48	outputs	cons_value1	Relative Conservation Priority of Performing Action 1, at Place Y, Given Scenario Z	The Conservation Marginal Benefit divided by the Total Costs. Units are expre... Conservaiton Benefits per Rand. The GIS Field sdesignates the action under co... = Acquisition and St = Stewardship
49	outputs	cons_value2	Relative Conservation Priority of Performing Action 2, at Place Y, Given Scenario Z	The Conservation Marginal Benefit divided by the Total Costs. Units are expre... Conservaiton Benefits per Rand. The GIS Field sdesignates the action under co... = Acquisition and St = Stewardship
50	outputs	cons_value3		Irrelevant output for sample data of version 1.01; no conservation action type...
51	outputs	cons_value4		Irrelevant output for sample data of version 1.01; no conservation action type...
52	outputs	consbenihaacq		
53	outputs	consvalu_acqn		
54	outputs	core_adjacncy	Contiguity Value	
55	outputs	hab_reprsnt		
56	outputs	hab_value	Multi-scale, Multi-extent Habitat Representation	
57	outputs	natl_hab_rep	Supra-Regional Representation	

Conservation Actions | Data Dictionary | Parameters | Weights | old glossary-needs updating

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Organization "Space" on Online Community

- 501(c)3 status
- Open Recruitment
  - Advisory Board
  - Project Coordinator
  - Volunteers

Sample organization tasks

- Choosing our name?
  - Initial goals and mission
- Choosing our server
- Fleshing out the wiki
  - Update procedures and Versioning
  - User suggestions
  - Drafting our webpage

Potential path of Pilot Study "Spaces"

- Citizen science
- Knowledge Sharing
- Auto data upload into Regional Databases

Potential Path of Development "Space"

- Toolbox improvement and plug-ins
- ESRI – Atlassian Integration on the Cloud
- Online ArcServer scripting and workflow

Another potential path

- Our effort becomes a place for sketches and idea development $\rightarrow$ Adjusted and imported into existing frameworks, i.e.:
  - NatureServe
  - CommunityViz
  - Zonae Gogito?

By Woodleywonderworks, Flickr User

6:00 PM Dinner
7:00 PM Lobby
8:00 AM Breakfast
9:00 AM Lobby

Photo: Ethan Inlander and John Gallo

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Contact information:

John Gallo
gallo.ja@gmail.com
831-427-3854
707-813-7581

Gamkaberg Kloof, Little Karoo,
South Africa

Other discussion points
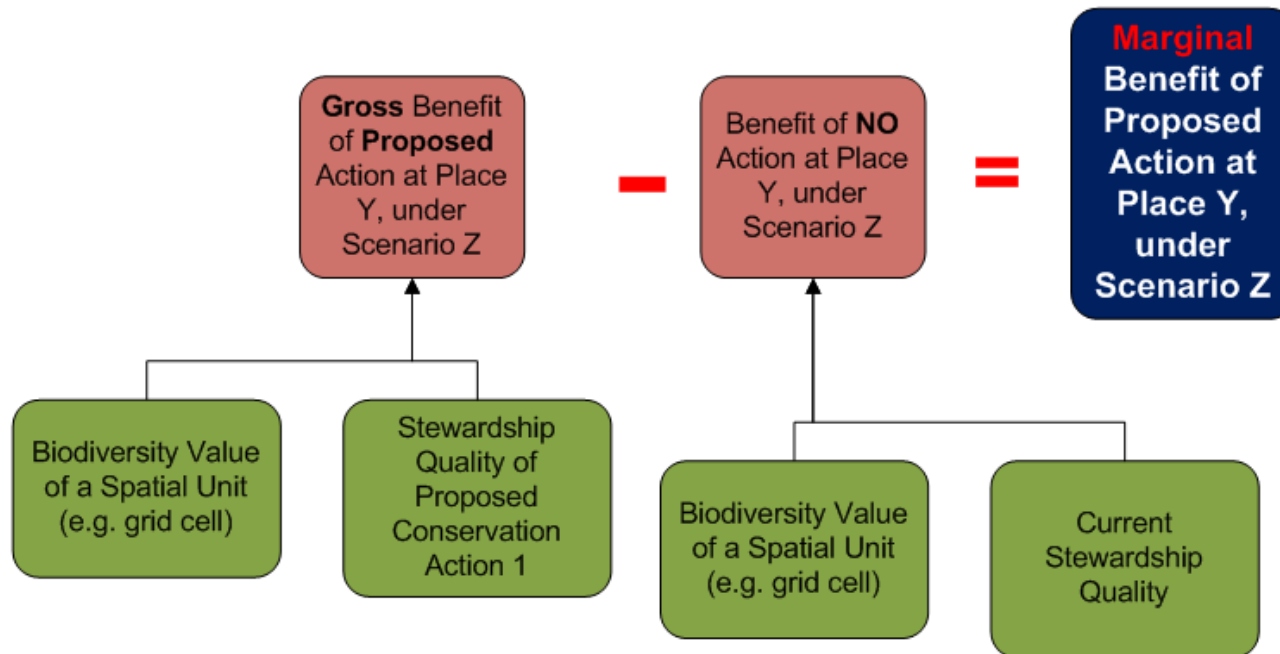
- "Naturalness" layer
- "Stewardship Quality" layer

Fig 2: v1.01 marg benefit

Gross Benefit of **Proposed** Action at Place Y, under Scenario Z

–

Benefit of **NO** Action at Place Y, under Scenario Z

=

Marginal **Benefit of Proposed Action at Place Y, under Scenario Z**

Biodiversity Value of a Spatial Unit (e.g. grid cell)

Stewardship Quality of Proposed Conservation Action 1

Biodiversity Value of a Spatial Unit (e.g. grid cell)

Current Stewardship Quality

These are weighted sums, with the default value of 0.5 strongly suggested. It may be that this should be a weighted multiplication in the future.

...tewardship quality value was considered a function of the quality of management (for biodiversity goals), as well as the ...kelihood that the land would have the same or better level of management at some future time, T. This likelihood was in turn ...function of the legal agreements pertaining to the property in question as well as the external factors and forces that would be ...ressuring the landowner to weaken management quality. Urban outgrowth modeling is an example input to such a ...onsideration. Stewardship value can be assigned on a property-by-property basis or based on the ownership-management ...ategory of the property.