ValParCH: Integrating land use change, Ecosystem Service and Biodiversity modelling to simulate pathways towards a functioning Ecological Infrastructure for Switzerland

Other Conference Item

Author(s):
Black, Benjamin; Adde, Antoine; Külling, Nathan; Grêt-Regamey, Adrienne; Guisan, Antoine; Lehmann, Anthony

Publication date:
2022-07-07

Permanent link:
https://doi.org/10.3929/ethz-b-000593508

Originally published in:
https://doi.org/10.13140/RG.2.2.20111.66720

ValPar.CH:

Integrating land use change, Ecosystem Service and Biodiversity modelling to simulate pathways for a functioning Ecological Infrastructure for Switzerland.

Benjamin Black, Antoine Adde, Nathan Külling, Adrienne Grêt-Regamey, Antoine Guisan, Anthony Lehmann

ValPar.CH

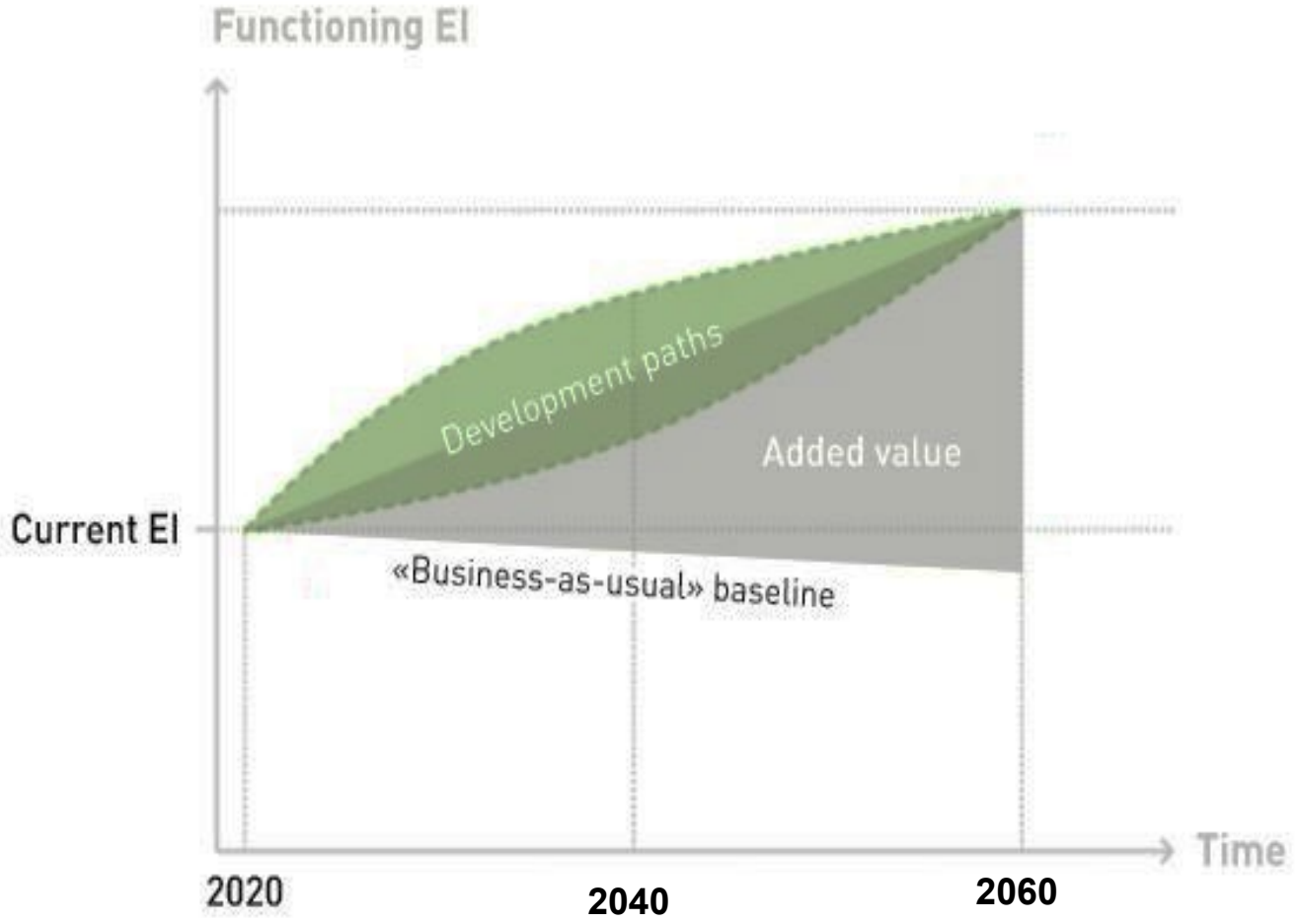
iEMSs 2022

ValPar.CH

Project goal: Assess the added value of a functioning Ecological Infrastructure for Switzerland.

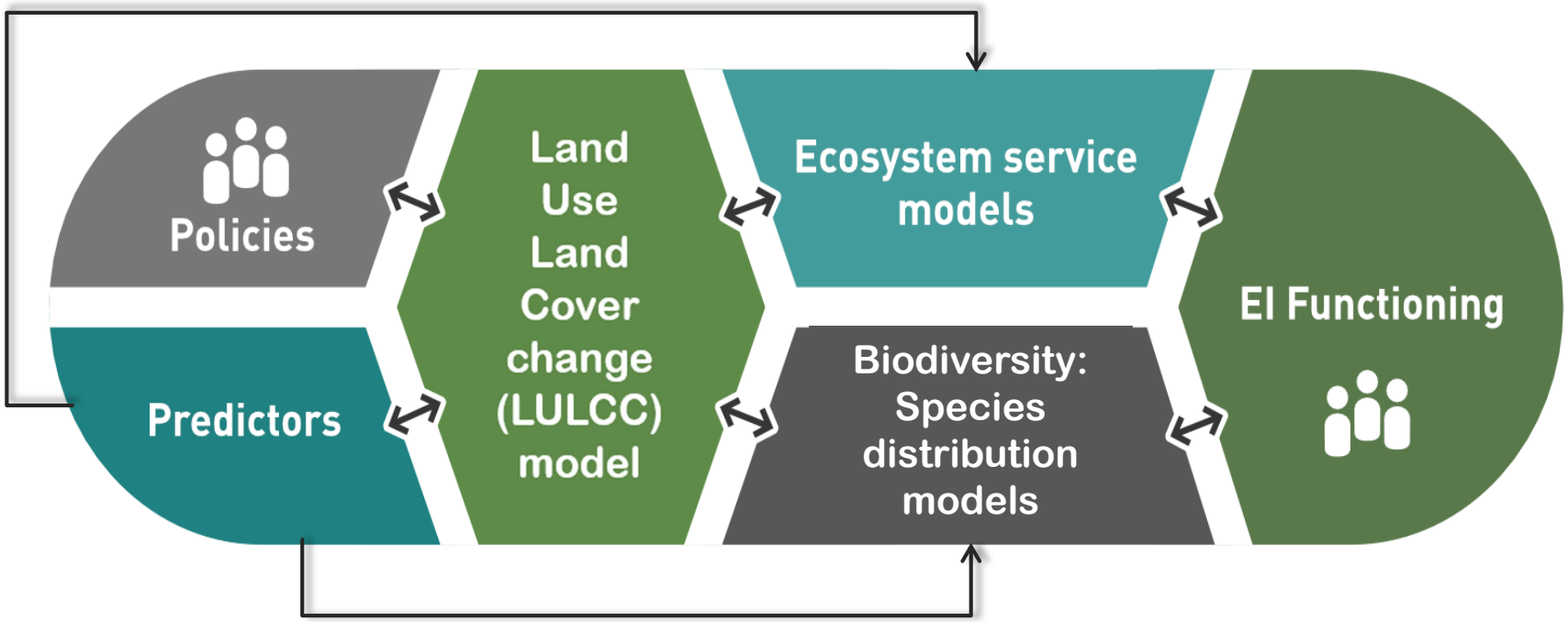
Definition: "Ecological Infrastructure (EI) refers to a network of high quality natural and semi-natural landscape elements planned and managed to provide ecosystem services (ES) and support biodiversity."

Objective: Simulate the future development of EI under multiple scenarios (pathways) intended to secure a functioning EI by 2060.

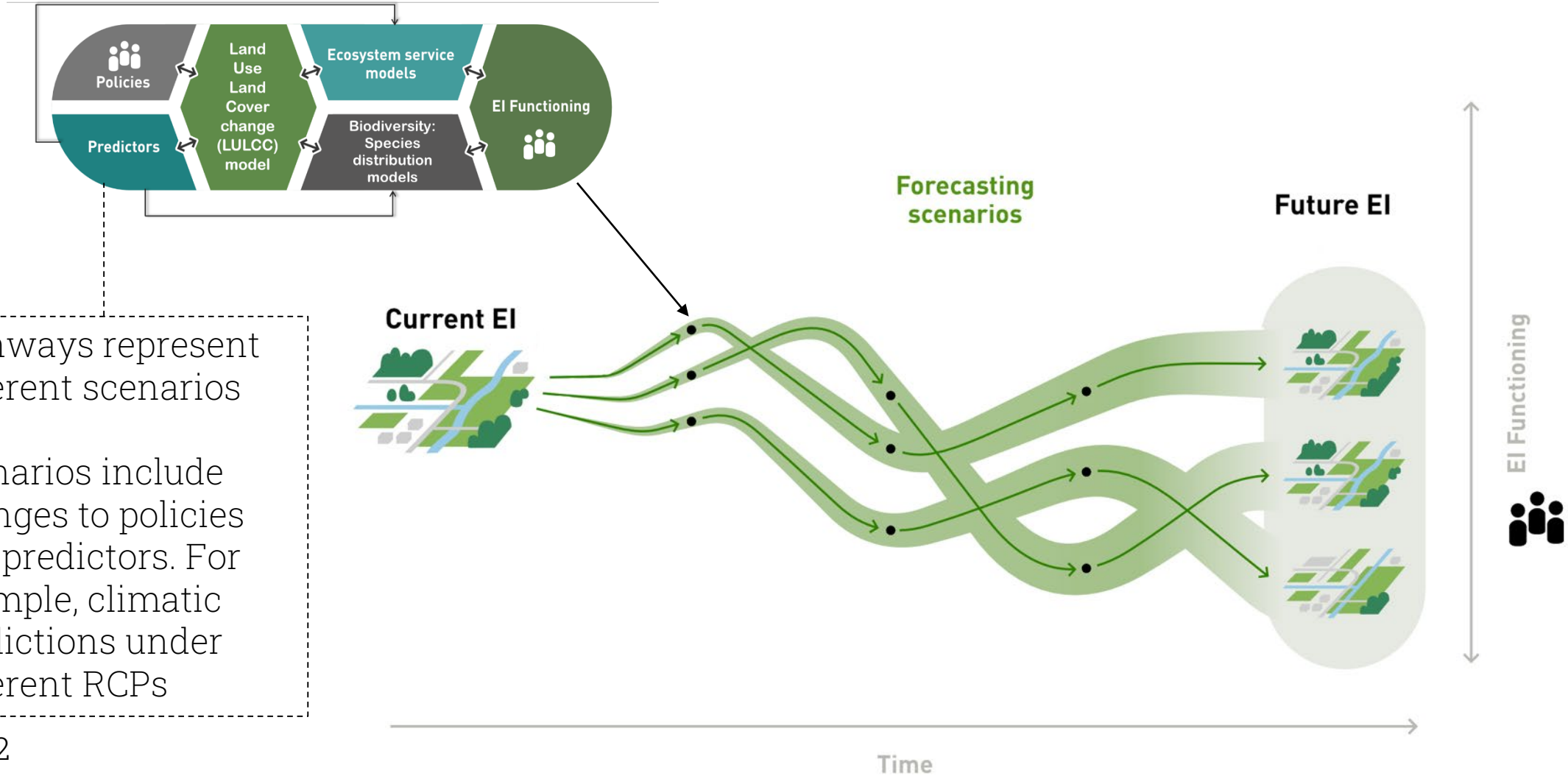


Operationalizing Ecological Infrastructure

"Ecological Infrastructure (EI) refers to a network of high quality **natural and semi-natural landscape elements** planned and managed to provide **ecosystem services (ES)** and support **biodiversity**."

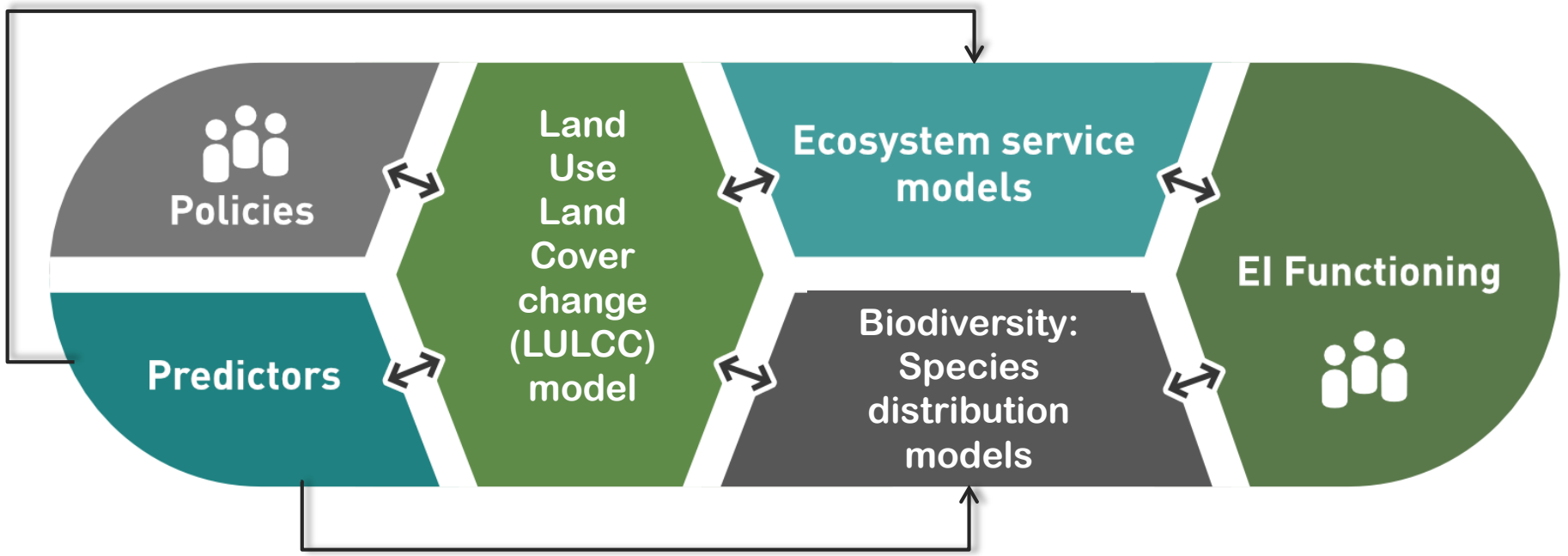


Simulating EI development pathways



- Pathways represent different scenarios
- Scenarios include changes to policies and predictors. For example, climatic predictions under different RCPs

Operationalizing Ecological Infrastructure



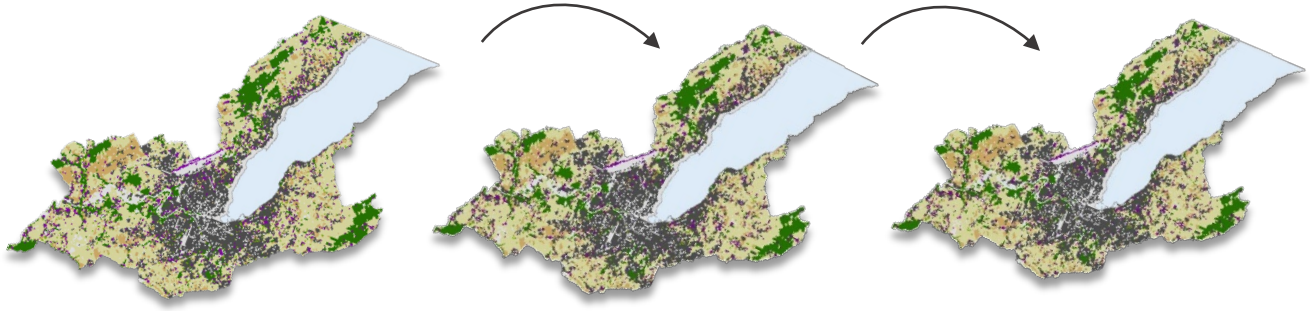
Challenges:

- Model Integration: harmonizing predictors and outputs
- Coherent result of EI functioning

Land Use Land Cover change (LULCC) model

Cellular Automata model to simulate **LULCC in space and time**

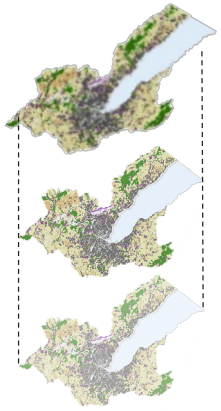
2020 → 2025 → Repeat until 2060



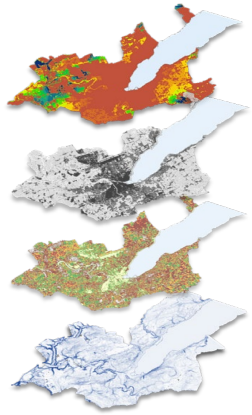
At each time step:

Calculate probabilities of land use changes per pixel

2009
1997
1985



Statistical models based upon historic LULC data and environmental/socioeconomic predictors



Allocate quantity of land use changes according to scenario

		2025									
	Class transistions	Settlement/ urban/ameni ties	Static	Open forest	Closed forest	Overgrown/sh rubland/unpro ductive vegetation	Intensive agriculture	Alpine pastures	Grassland/ meadows	Permanent crops	Glacier
2020	ttlement/urban/ameniti	183548	1355	59	85	64	282	58	1033	45	0
	Static	1071	723326	1048	1215	3727	895	501	1533	61	40
	Open forest	1008	1263	152621	27791	1013	135	2929	4384	76	0
	Closed forest	566	2406	41199	1043091	1706	14	869	800	36	0
	/shrubland/unproductiv	81	859	6096	9309	261005	9	382	157	18	0
	Intensive agriculture	7705	2629	130	42	92	398332	2	15904	2284	0
	Alpine pastures	312	1328	4562	1564	6482	8	480422	261	2	0
	Grassland/meadows	11466	2654	3306	719	541	4861	700	505075	1820	0
	Permanent crops	3195	243	174	38	37	2532	7	8599	46628	0
	Glacier	0	20348	0	0	29	0	5	0	0	114235

Ecosystem service models

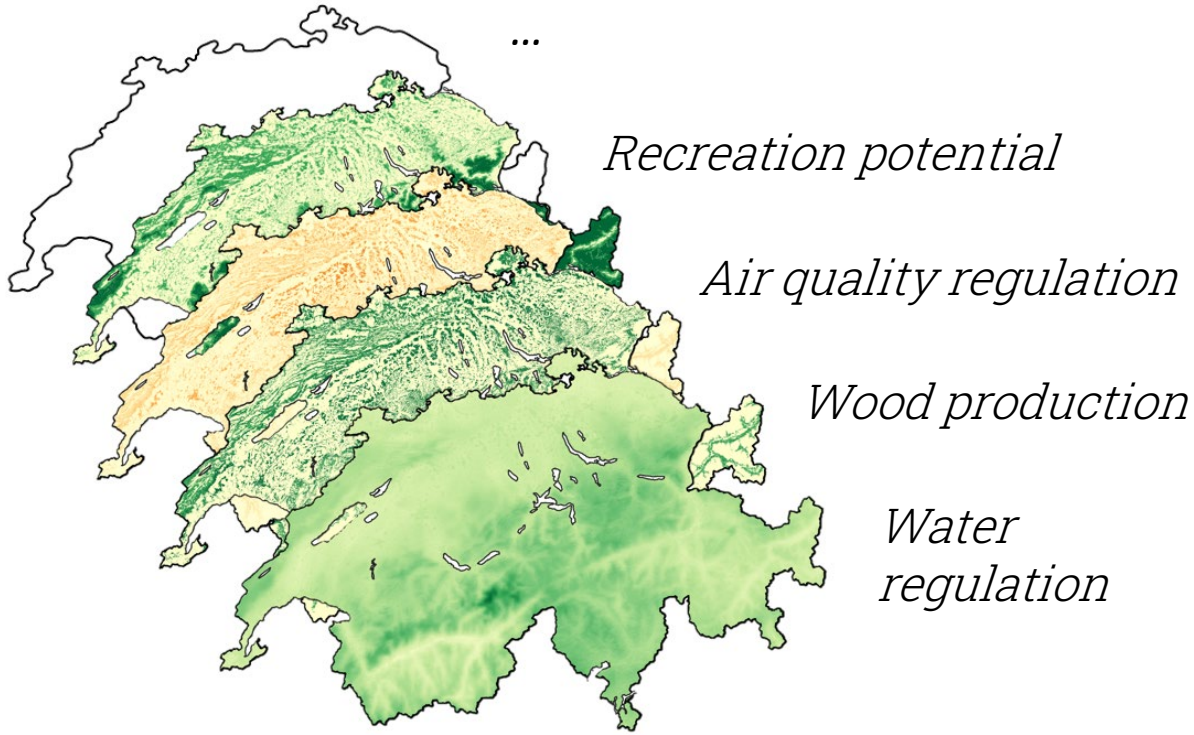
For each ES (17 total):

1. Selection of ES indicator

2. Data acquisition and processing

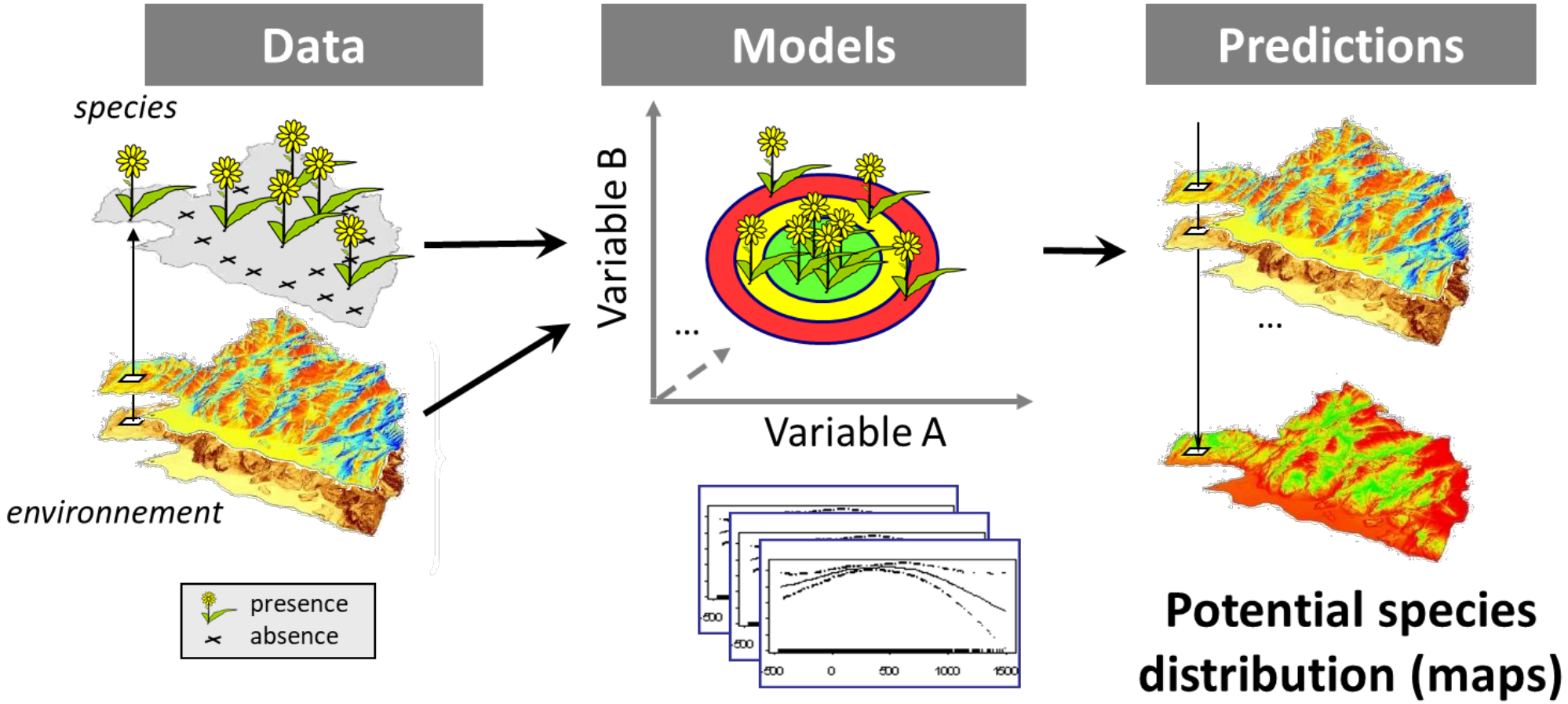
3. Method selection

- Data extrapolation
- Process Modeling
- Experts consultation
- Lookup tables



Biodiversity: Species distribution models (SDMs)

SDMs: Generalizing species distributions in space (and time)

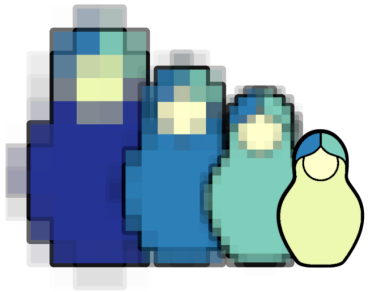


Guisan & Zimmermann (2000); Ecol. Mod., Guisan & Thuiller (2005); Ecol. Lett., Guisan et al. (2017)

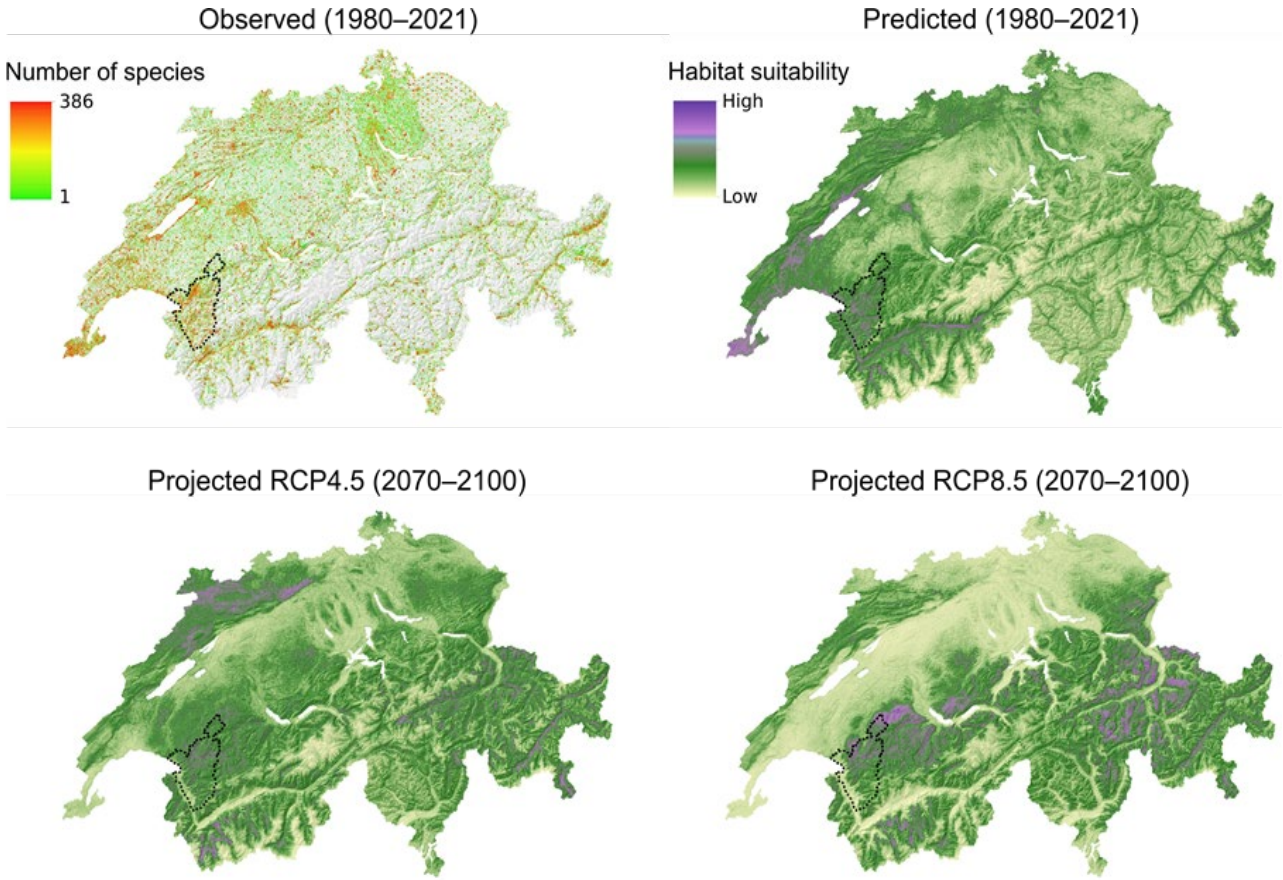
Biodiversity: Species distribution models

N-SDM

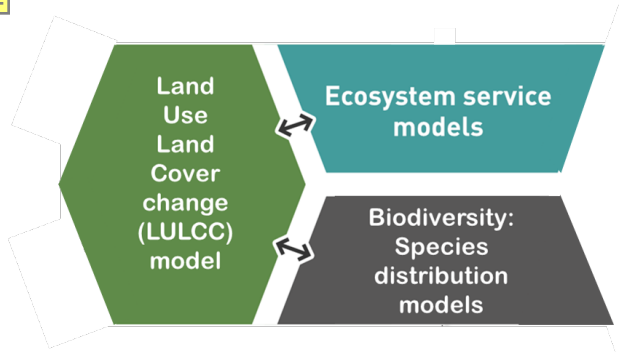
Nested Species Distribution Modelling



- High-performance computing SDM pipeline developed within ValPar.ch
- Allows:
  - combining multi-level species data (nested)
  - uniting leading-edge SDM techniques
  - modelling thousands of species simultaneously within a competitive time frame

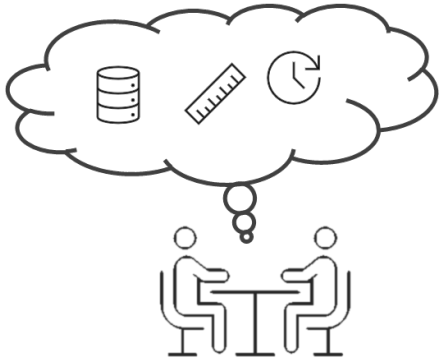


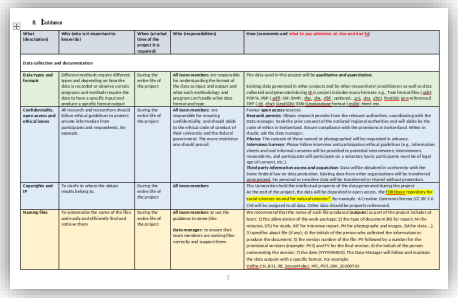
Adde et al. (in prep) "N-SDM: a high-performance computing pipeline for Nested Species Distribution Modelling"



Model integration: Data

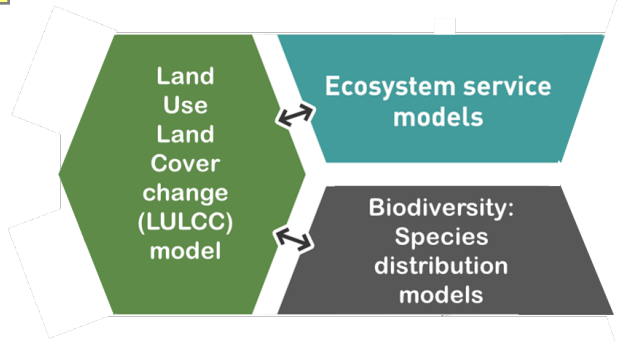
- Common spatial resolution, extent and CRS
- Aggregation of land use classes
- Predictor selection to maximise commonality between models <-> selection of ES models.
- Minimise predictors that cannot be projected in time.
- Data prepared by one group to minimize inconsistencies and duplication of efforts.
- Cloud-based data sharing, plan for Data management plan dissemination of results





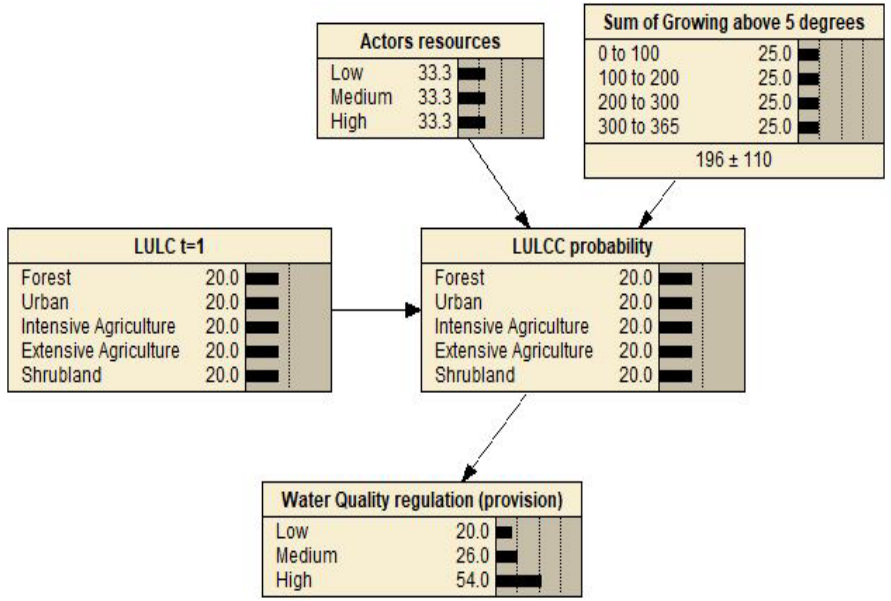
GeoServer

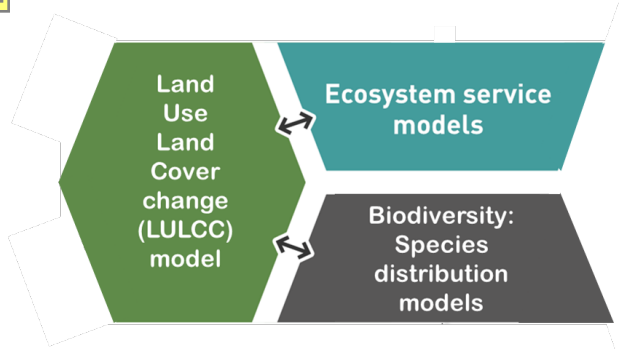
ArcGIS StoryMaps



Model integration: Model choice

- Proposal specified: **spatialized dynamic Bayesian Networks**.
- Developed for ~1 year but collaboration made it clear that it wasn't viable.
- Switch to: Dinamica EGO: non-commercial, better integration, natively spatial.
- Lesson: Sometimes integrative projects require reconsideration of approach despite 'sunk costs'





Model integration: Software

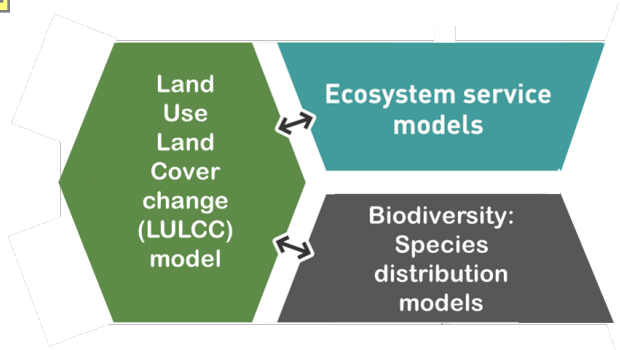
ES modelling

Data preparation

LULCC modelling

Dinamica EGO

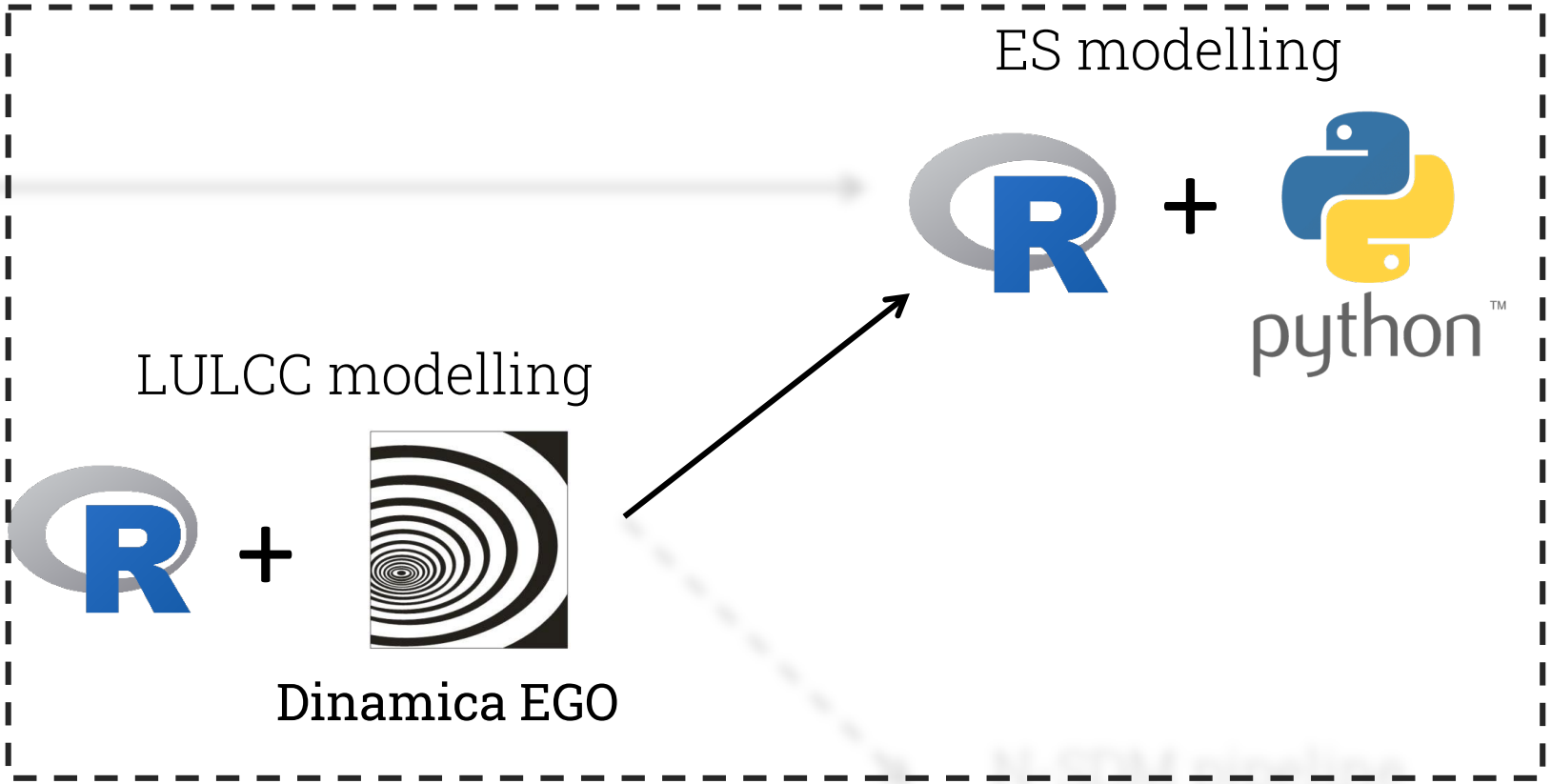
N-SDM pipeline

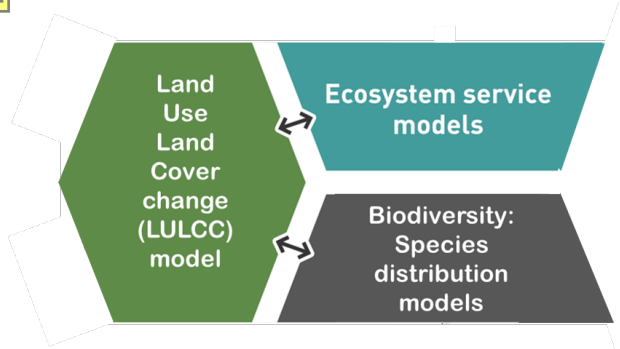


Model integration: Challenges

Direct integration possible through incorporation of R and Python scripts within Dinamica EGO

We hope to share to formalise the scripts used to do this as custom Dinamica 'functors' for others to utilise





Model integration: Challenges

Direct integration not possible due to the N-SDM pipeline utilising HPC cluster

Simulated LULC layers transferred manually

LULCC modelling

Dinamica EGO

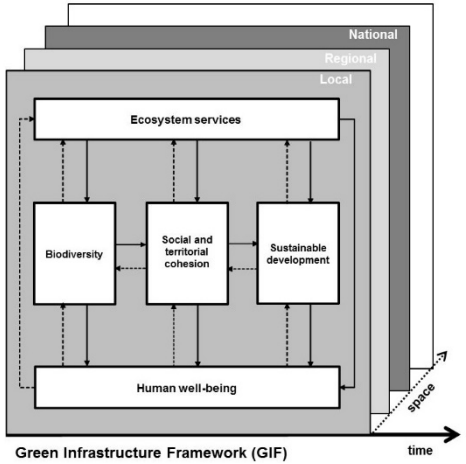
N-SDM pipeline

EI Functioning

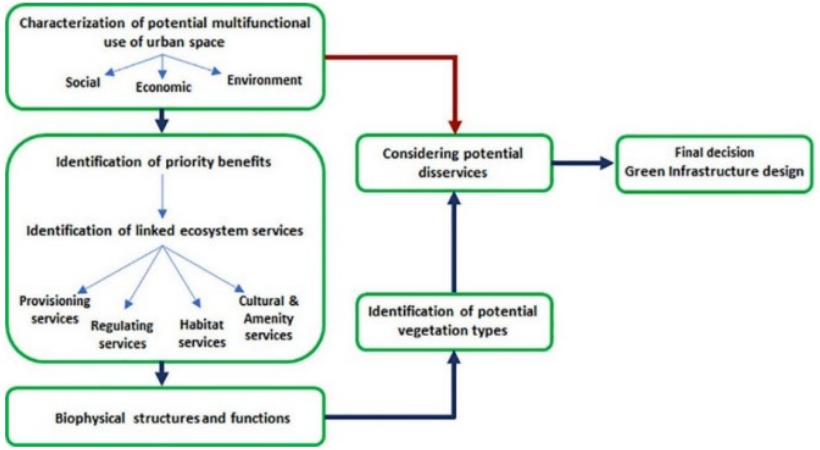
EI output: Challenges

- Definition of 'functioning' EI is problematic:
  - Subjective/Anthropocentric
  - Implies antonymous state ('non-functioning') and threshold

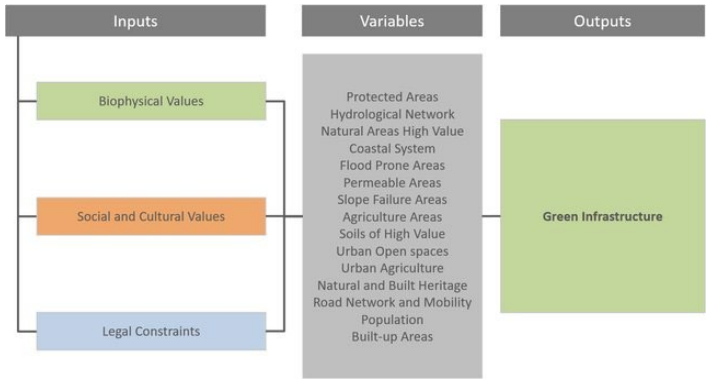
- Numerous conceptual frameworks, limited attempts to operationalise



Lafortezza *et al.* 2013



Semeraro *et al.* 2021

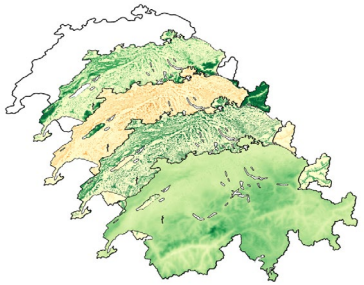


Amado *et al.* 2020

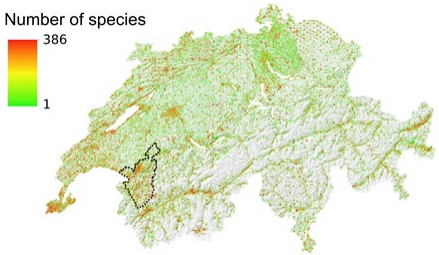
EI Functioning

EI output: ValPar.CH approach

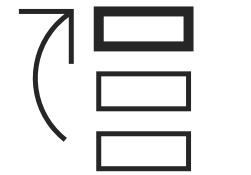
ES supply maps

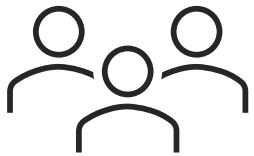


Biodiversity metric map

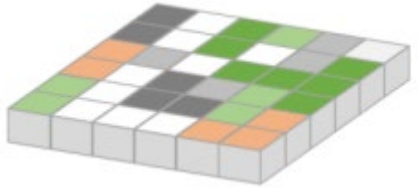


Participatory weighting of EI factors





Spatial prioritization of EI quality

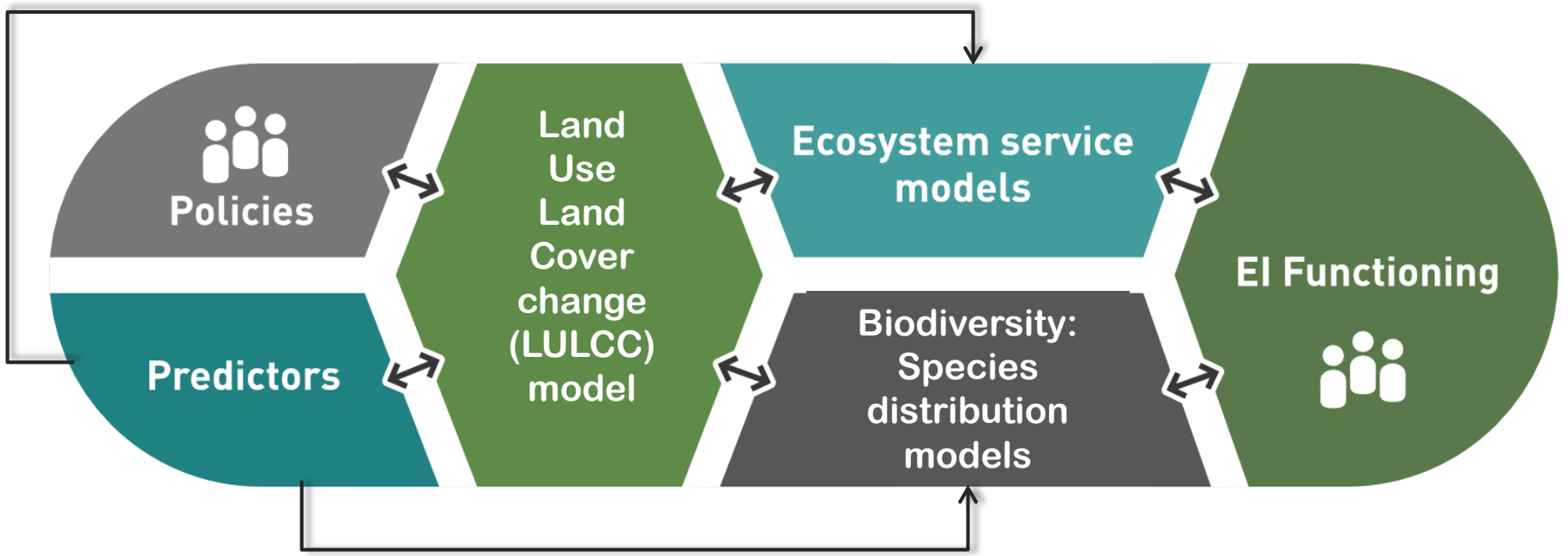


ZONATION
Conservation planning software

Comparison

Visions / normative goals for EI functioning

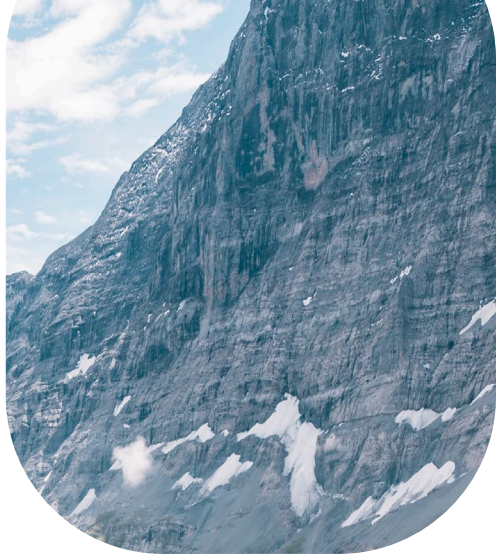
Summary

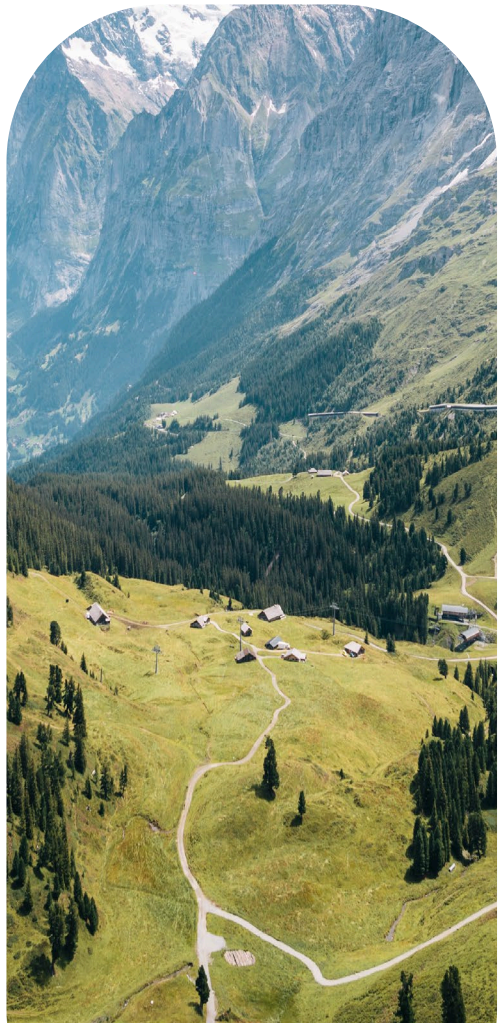


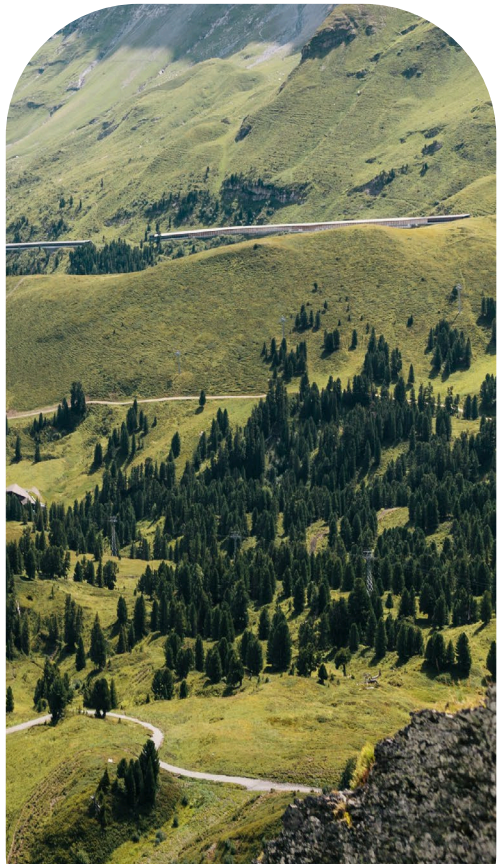
Lessons learned:

- Integration has to be intentional
- Collaboration is key: minimizes duplicated efforts, guards against incompatibility
- Flexibility

Valpar.CH website







Thank you for listening

I will now take any questions.