Integrated Economic-Environmental Modeling (IEEM) for Evidence-Based Public Policy and Investment Design.

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May 2 to 5, 2023. Santiago, Chile.

RMGEO Consultants Inc.

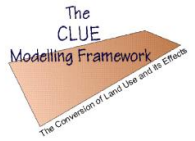
LAND USE LAND COVER CHANGE MODELING FOR IEEM

LULC MODELING FOR IEEM

- Basic requirements for IEEM integration:

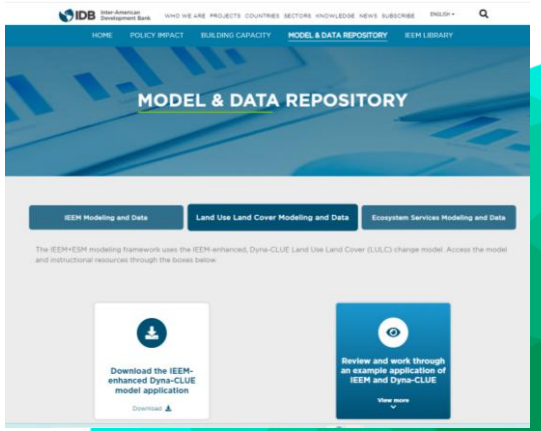
1. Can use demand for land as an input (this is derived from IEEM).
2. Outputs in the from of LULC raster maps.
3. Can handle multiple regions. **Why?**
4. Capacity to operate at 'adequate resolution' for ES modeling.
5. Straightforward to format data and run, good error detection.

- We use the Dynamic Conversion of Land Use and its Effects (Dyna-CLUE) model.
- Applied in 180+ studies in 28 countries globally at varying scales.
- Visit OPEN IEEM for Dyna-CLUE manual and **video tutorial series**.

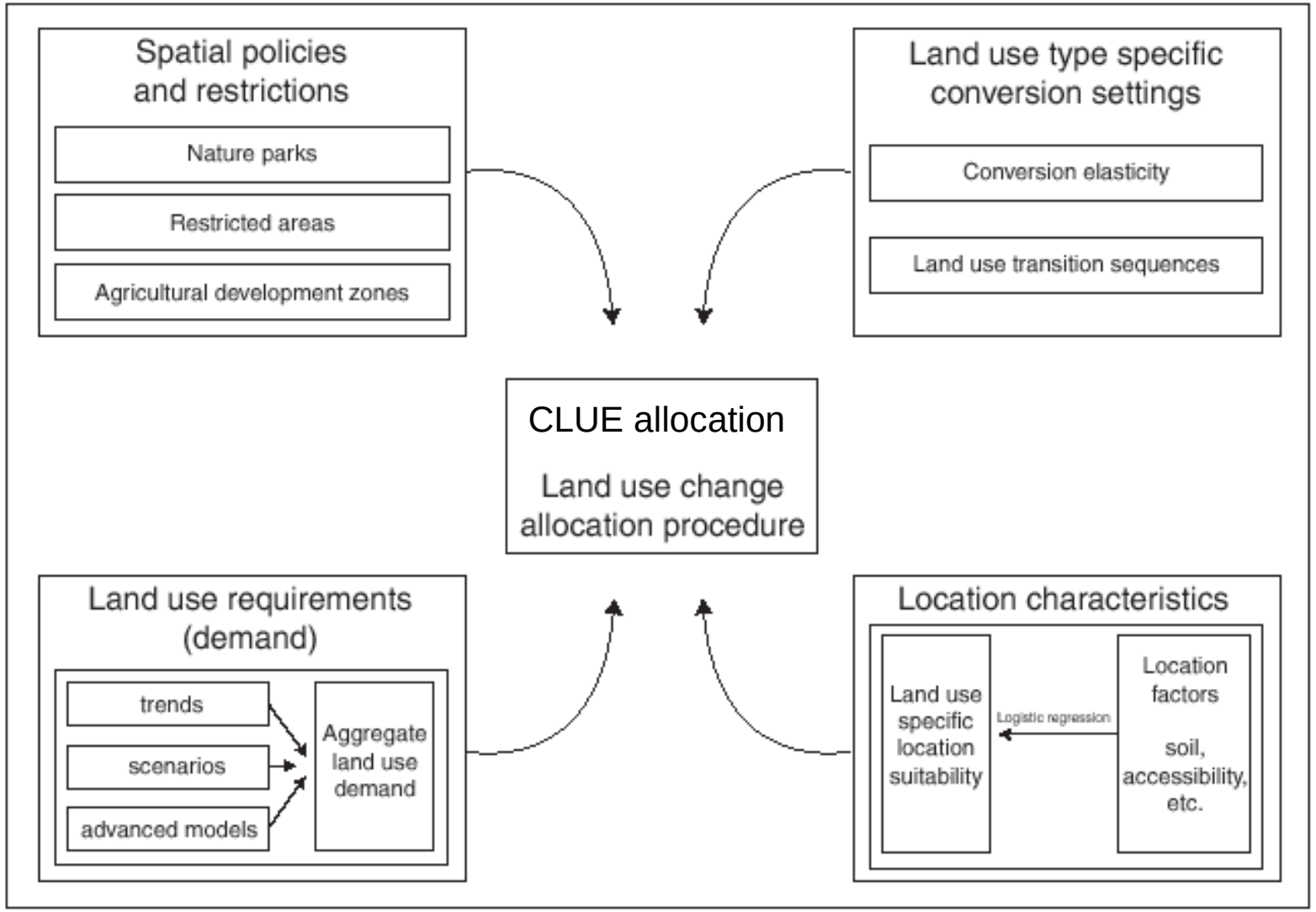


The CLUE model
Article
More info and model.

The CLUMondo land systems model
Article
More info and model.

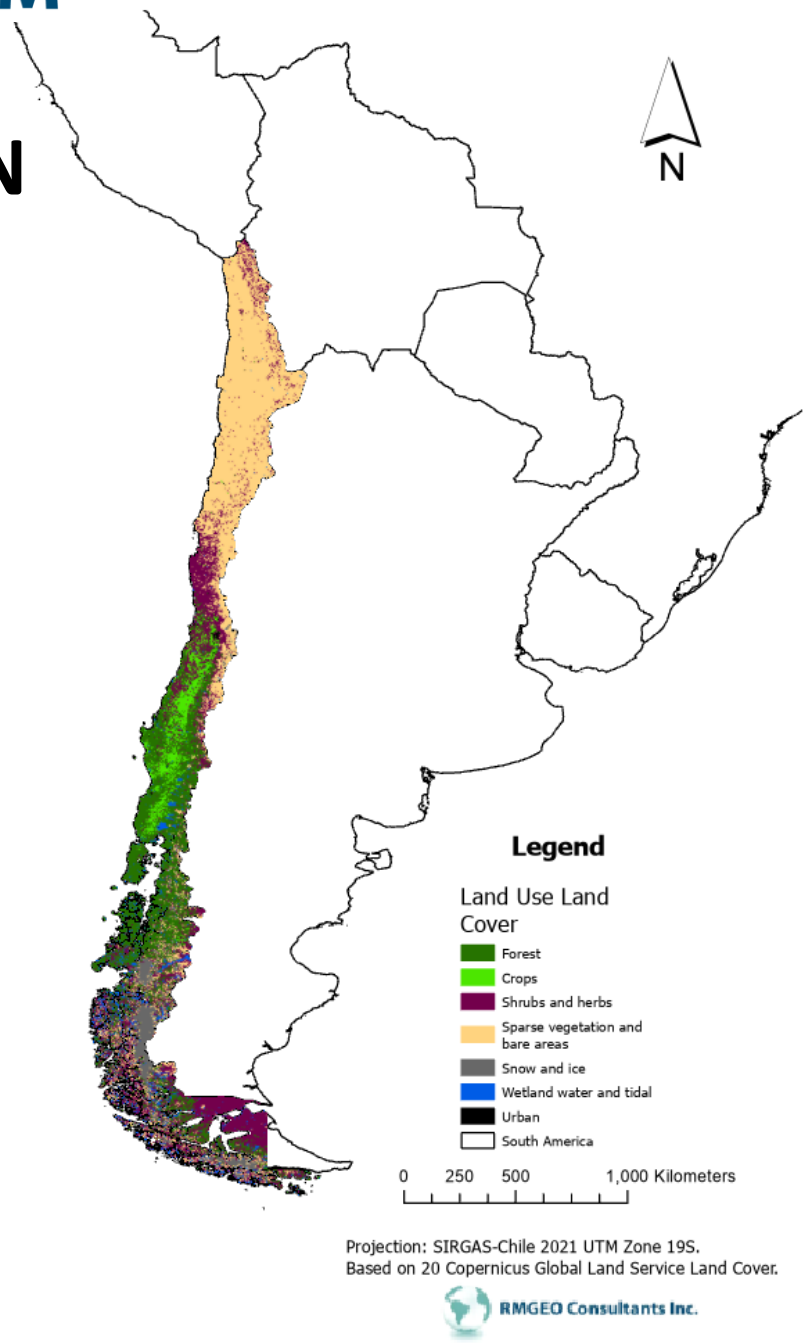


DYNA-CLUE OVERVIEW



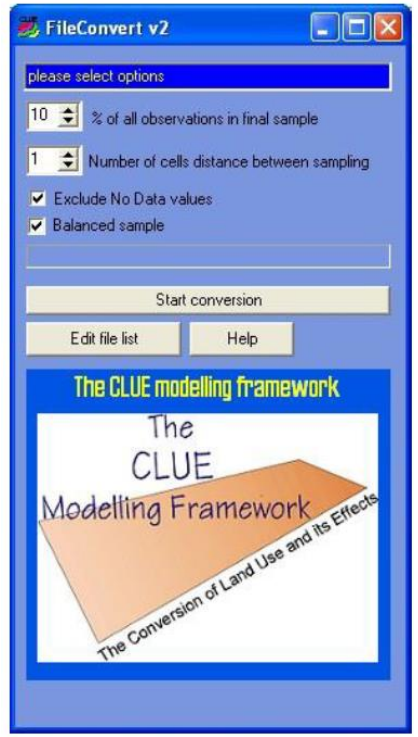
DYNA-CLUE DATA PREPARATION

- LULC map (national or globally sourced). 7 to 10 classes, some static.
- Regions: Amazon tipping point: 26; Habitat Banking/Colombia: 30.
- Base Map: Copernicus 2019 Global Land Service, 100m; 23 classes reclassified to 7.
- Level of disaggregation depends on policy question.
- IEEM baseline will use LULC map initial areas (cross check census data); includes forest, crops (different disaggregations) and grassland.



DYNA-CLUE FILE PREPARATION

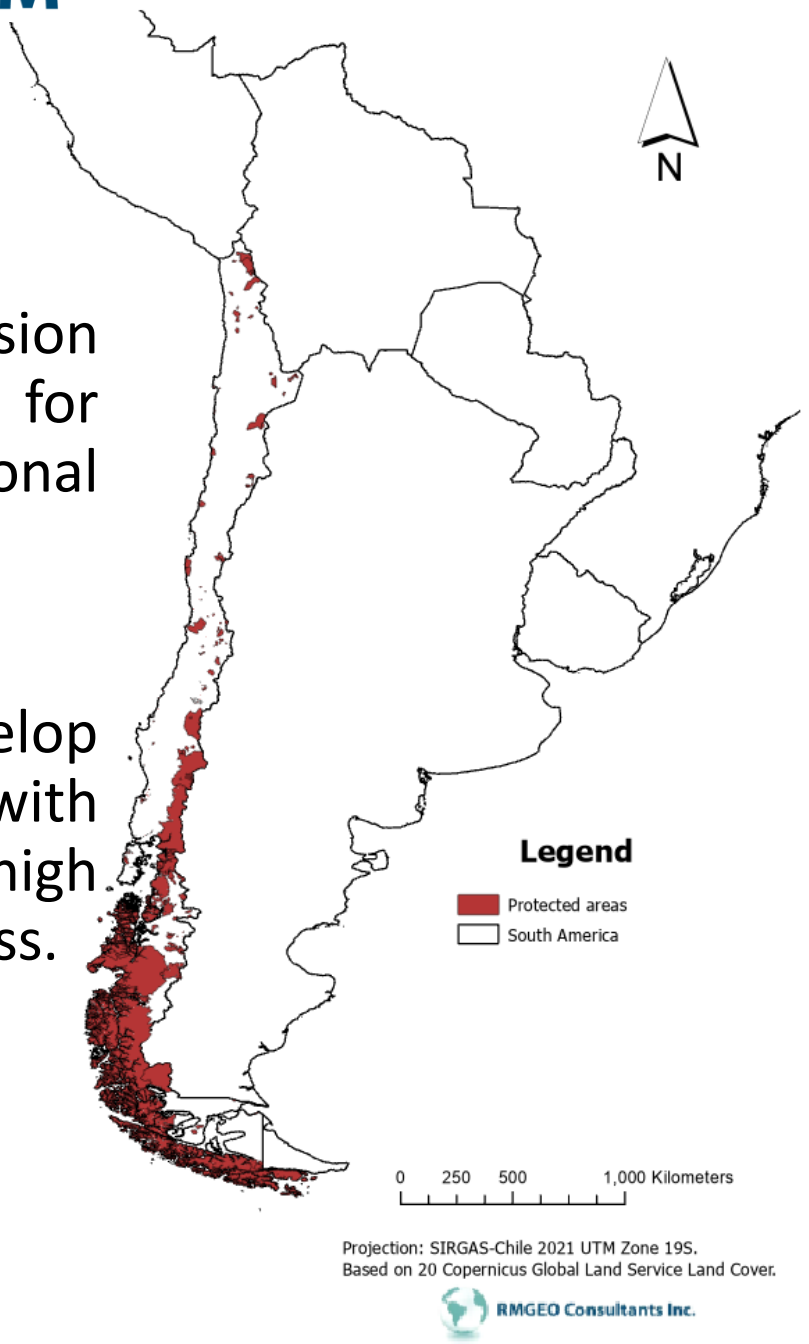
- Create mask of area of interest: region file with exclusion areas. Apply regional mask to all ascii spatial inputs to ensure same dimensions.
- Create binary presence/absence LULC class maps.
- Extract driving factors.
- Use conversion tool to translate spatial data into a tabular format for import in statistical packages. One table for each binary LULC map and all drivers.
- Run stepwise regression in statistical package (Stata, R, SPSS, by hand).



EXCLUSION AREAS

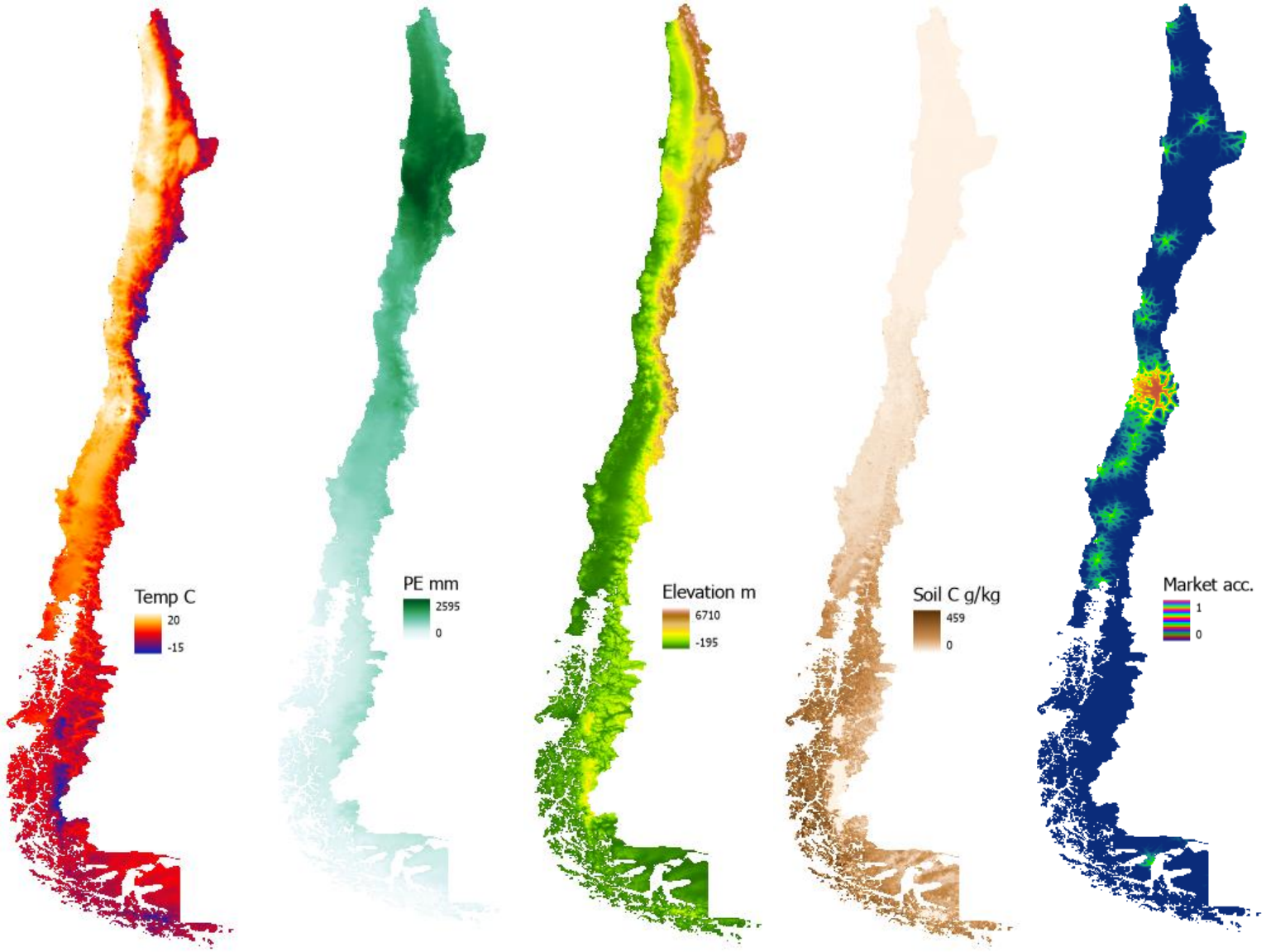
- Protected areas and other areas. Exclusion renders these areas ineligible for conversion. Protected areas from national source or ‘Protected Planet’ database.

- Using ES model outputs to develop exclusion layers, for example, areas with high pollinator abundance or high susceptibility for nutrient or sediment loss.



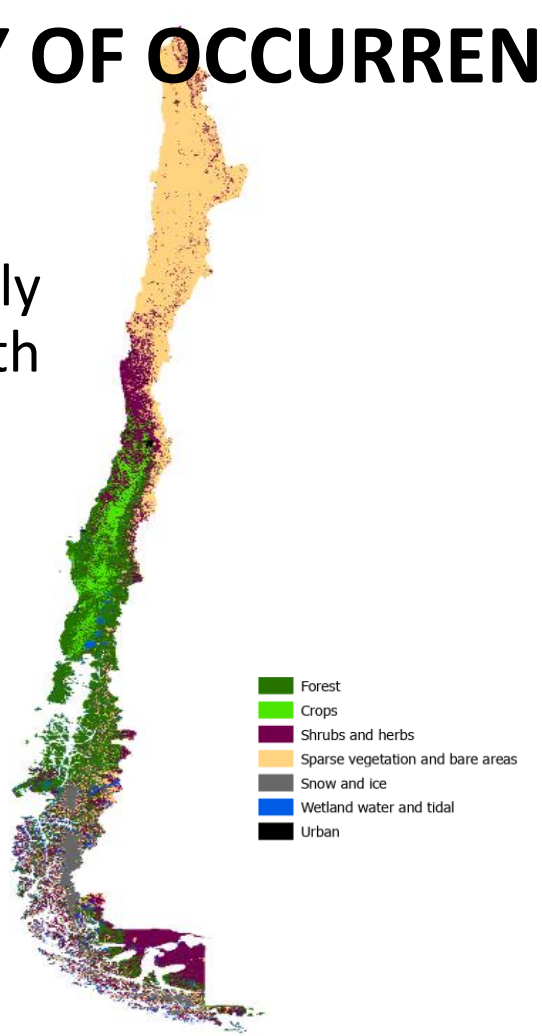
LULC DRIVING FACTORS

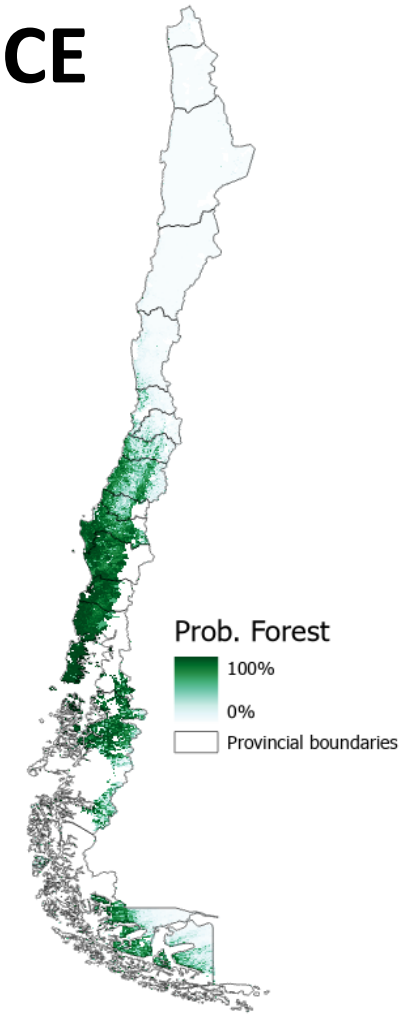
- 15 driving factors (climate, topography, soils, socioeconomic factors).
- Apply mask to (global) databases.
- LULC Datapacket; contains all spatial layers and example application; reuse.

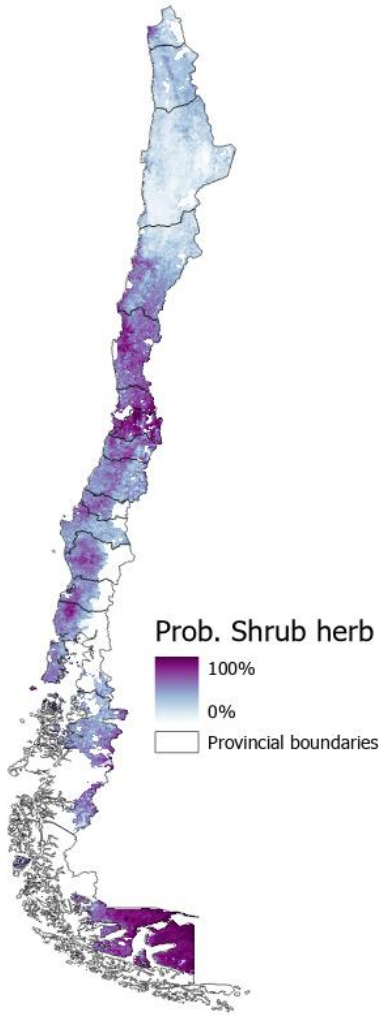


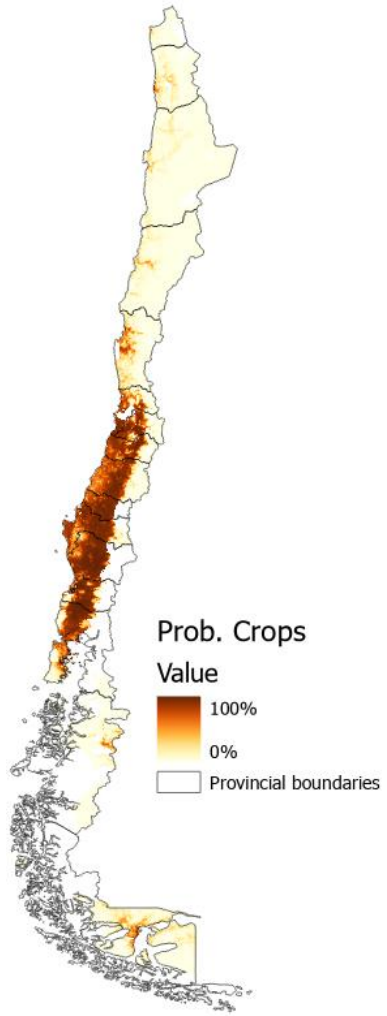
PROBABILITY OF OCCURRENCE

- Probability usually mostly aligned with current LULC.









DYNA-CLUE FILE PREPARATION

- Allow matrix.
- Allocation file (regression results).
- Main parameters file includes:

-dimensions of project (~3,000 rows or columns max), number of LULC classes, driving factors; conversion resistance; error terms

	FUTURE							
		Forest	Crops	Shrubs herb	Sparse veg	Snow and ice	Wetland, wate	Urban
PRESENT		0	1	2	3	4	5	6
Forest	0	1	1	0	0	0	0	0
Crops	1	0	1	0	0	0	0	0
Shrubs herb	2	1	0	1	0	0	0	0
Sparse veg	3	0	0	0	1	0	0	0
Snow and ice	4	0	0	0	0	1	0	0
Wetland, water	5	0	0	0	0	0	1	0
Urban	6	0	0	0	0	0	0	1

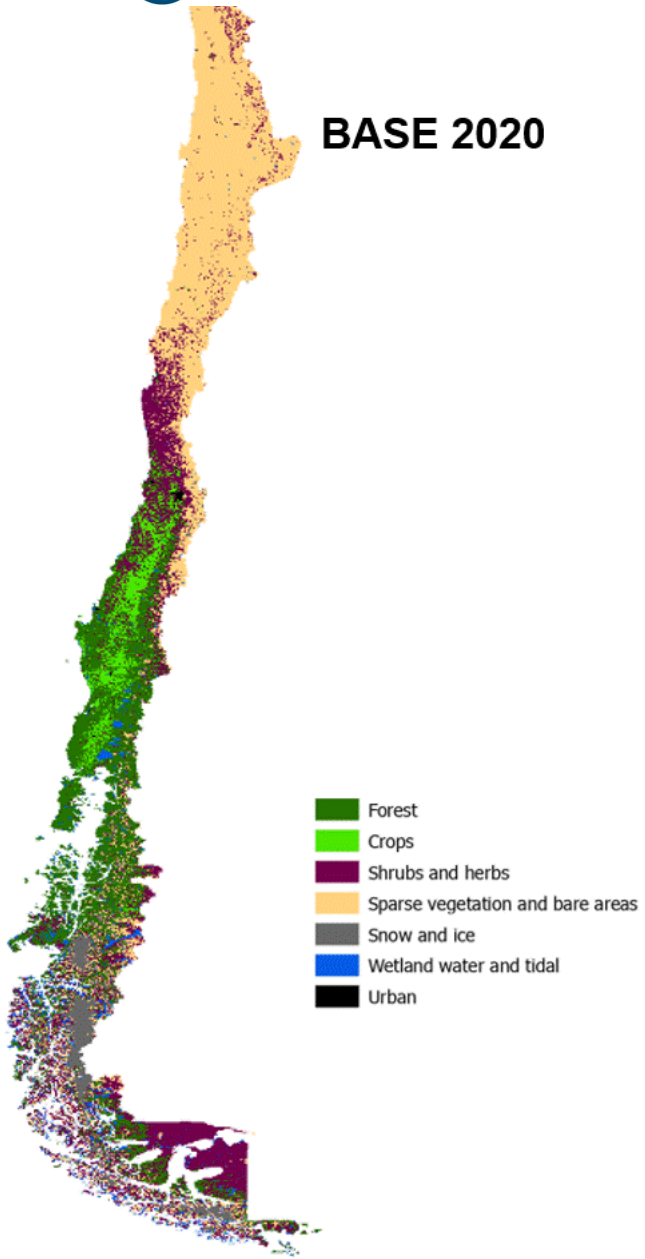
DYNA-CLUE FILE PREPARATION

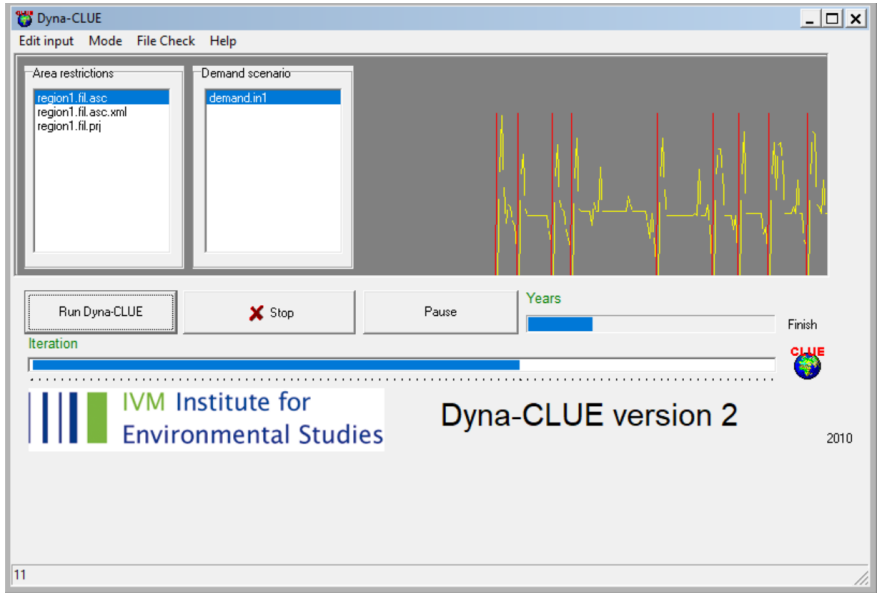
- Demand file for BASE (baseline) and each scenario derived from IEEM.
- Exogenous vs. endogenous land use? Time steps.
- Once application is working, scenarios can be implemented readily (LULC datapackets).

BASE	Forest	Crops	Shrubs	Sparse veg	Snow/ice	Wet/water	Urban
	0	1	2	3	4	5	6
Years of simulation	31						
2020 Year 0	17,728,281	4,213,750	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2021 Year 1	17,609,241	4,332,791	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2022 Year 2	17,490,999	4,451,032	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2023 Year 3	17,373,552	4,568,479	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2024 Year 4	17,256,894	4,685,138	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2025 Year 5	17,141,018	4,801,013	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2026 Year 6	17,025,921	4,916,110	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2027 Year 7	16,911,597	5,030,435	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2028 Year 8	16,798,040	5,143,991	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2029 Year 9	16,685,246	5,256,786	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2030 Year 10	16,573,209	5,368,822	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2031 Year 11	16,461,924	5,480,107	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2032 Year 12	16,351,387	5,590,644	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2033 Year 13	16,241,592	5,700,439	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2034 Year 14	16,132,534	5,809,497	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2035 Year 15	16,024,209	5,917,823	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2036 Year 16	15,916,610	6,025,421	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2037 Year 17	15,809,735	6,132,296	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2038 Year 18	15,703,577	6,238,454	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2039 Year 19	15,598,132	6,343,900	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2040 Year 20	15,493,394	6,448,637	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2041 Year 21	15,389,361	6,552,671	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2042 Year 22	15,286,025	6,656,006	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2043 Year 23	15,183,384	6,758,648	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2044 Year 24	15,081,431	6,860,600	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2045 Year 25	14,980,164	6,961,867	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2046 Year 26	14,879,576	7,062,455	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2047 Year 27	14,779,664	7,162,367	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2048 Year 28	14,680,422	7,261,609	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2049 Year 29	14,581,847	7,360,184	16,201,563	31,173,906	2,937,031	2,923,750	251,875
2050 Year 30	14,483,934	7,458,097	16,201,563	31,173,906	2,937,031	2,923,750	251,875
MODEL RUI	14490781.2	7454375	16198437.5	31173906.2	2937031.2	2923750	251875
DEVIATION BETWEEN DEMAND AND RESULT							
	0.05%	-0.05%	-0.02%	0.00%	0.00%	0.00%	0.00%

RUN DYNA-CLUE

- Baseline projection (deforestation, agricultural land expansion).
- Run scenarios.
- Convert outputs to .tif with projection for use in InVEST.

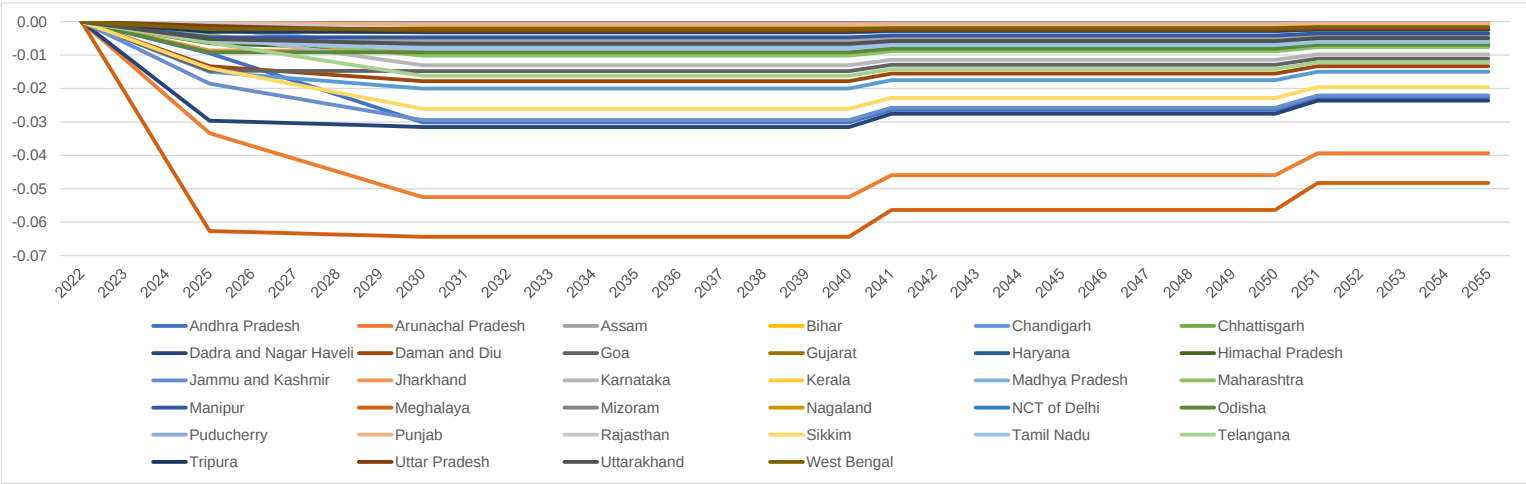




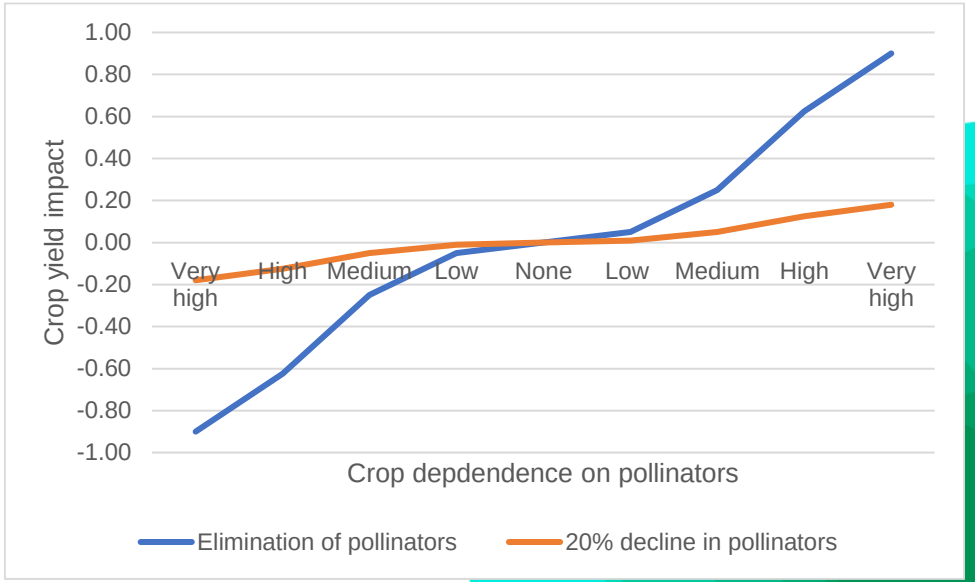
USING LULC MODELING RESULTS

- With Sediment Delivery Ratio and crop pollination models, calculate shocks to implement in IEEM. Single region vs. multiple regions.
- Exogenous vs. endogenous land use; **Brazil CCDR**.

Erosion shock



Crop pollination shock



CONCLUDING REMARKS

- Dyna-CLUE has worked relatively well, long history of applications across the globe.
- Intense data preparation requirements outside of model. Time consuming. Need tools to simplify data preparation/processing. No intuitive error detection.
- Dimensional limit which makes regional modeling at appropriate resolution challenging. Options include aggregation along agroecological zones; independent application by country (country demands for land); lower resolution.
- Funded by the IDB Inter-American Development Bank IEEM+ESM LULC change model beta version developed. More memory. facilitates integration with IEEM. Enhanced error detection. Coming soon!
- **See an application?**

Developing IEEM Modeling Infrastructure and Capacity Around the World.

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