Improving Linkages Between Earth Observations and Ecosystem Service Models with Essential Biodiversity Variables

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natural capital PROJECT

GEO BON

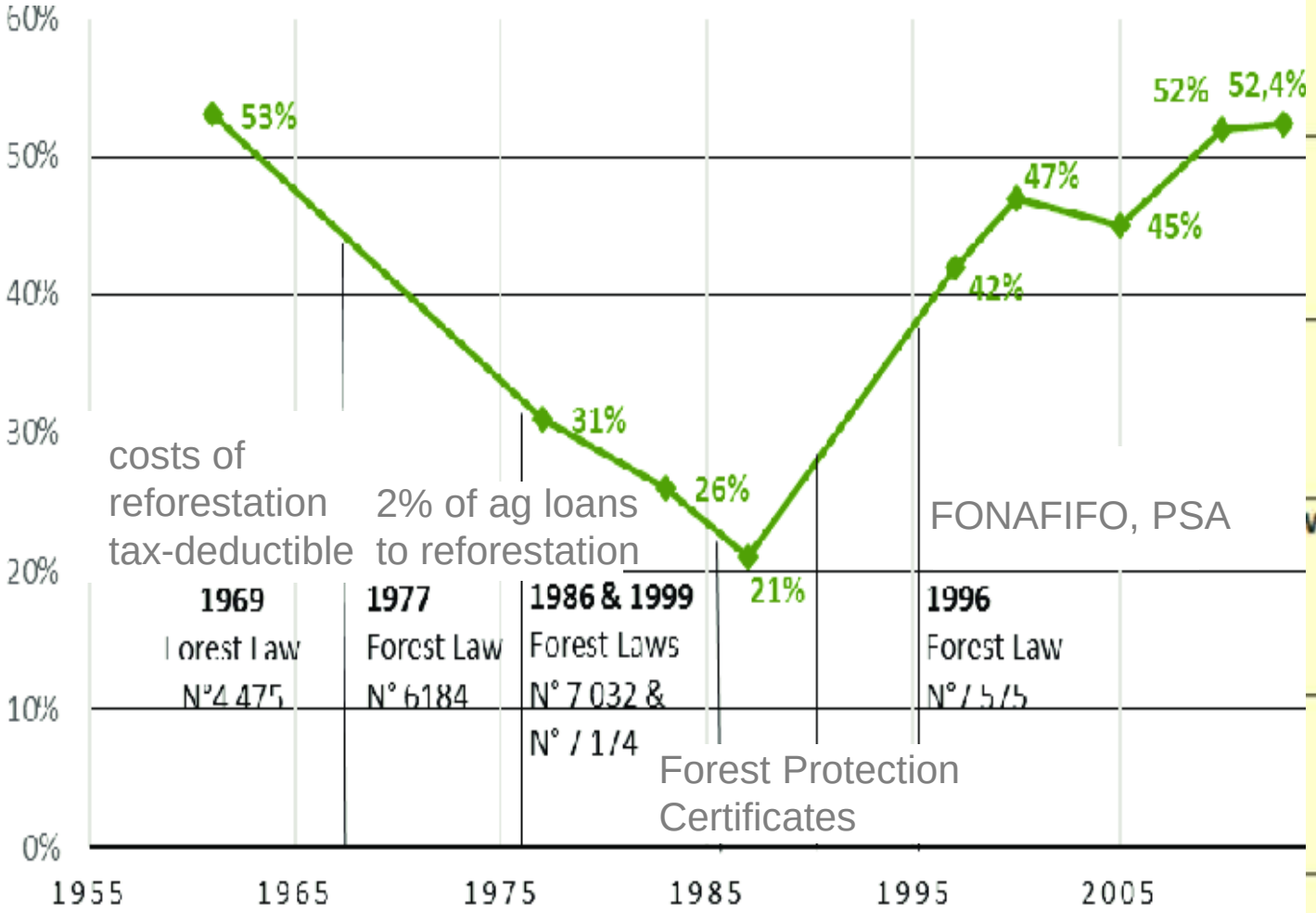
NASA

COSTA RICA GOBIERNO DEL BICENTENARIO

minae

BC CR BANCO CENTRAL DE COSTA RICA

Costa Rica's History



Source: Adam, 2017

Natural Regeneration	$205/ha distributed in five years $41/ha/year 2 ha min-300 ha max Contracts for 5 years
Reforestation	$980/ha distributed in five years 1-50%, 2-20%, 3-15%, 4-10%, 5-5% 1 ha min-300 ha max contracts for 15 years
Agroforestry Systems	$1,3/tree distributed in three years 1-65%, 2-20%, 3-15% 350 trees min-3500 trees max Contracts for 5 years
Forest Protection	$320/ha distributed in five years $64/ha/year 2 ha min-300 ha max Contracts for 5 years
Water Resource Protection Forest	$400/ha distributed in five years $80/ha/year 2 ha min-300 ha max Contracts for 5 years
Protection of Forest Conservation Gaps	$375/ha distributed in five years $75/ha/year 2 ha min-300 ha max Contracts for 5 years
Forest Management	$250/ha distributed in five years $50/ha/year 2 ha min-300 ha max Contracts for 5 years

Source: FONAFIFO, 2012.

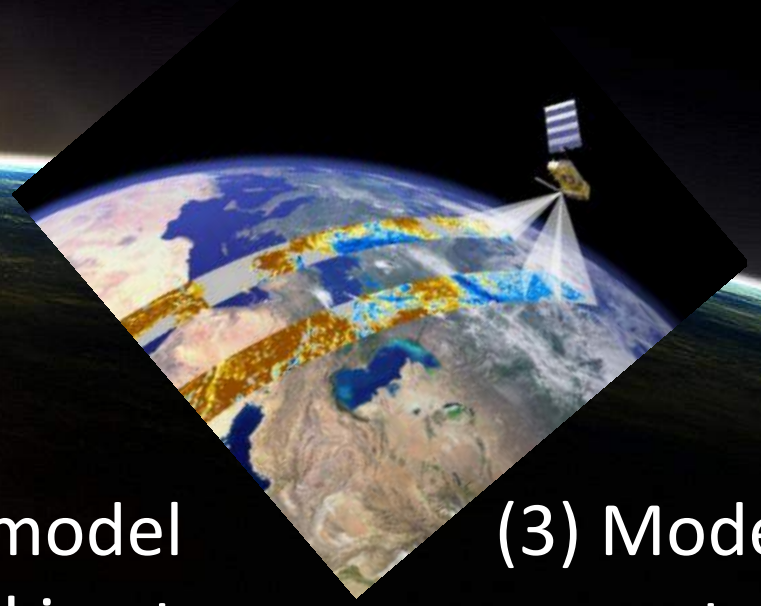
President Carlos Alvarado Quesada

Costa Rica's Future

- Carbon neutrality by 2050
- Piloting the first national accounts in ecosystem services using the UN SEEA framework
  - Carbon
  - Coffee (pollination)
  - Ecotourism
  - Water regulation
- Intention for policy use: "rebooting" national payments for ES, development planning, protected area management, decarbonization strategies

Irene Alvarado Quesada, BCCR

New frontiers in modeling ecosystem services for national accounts



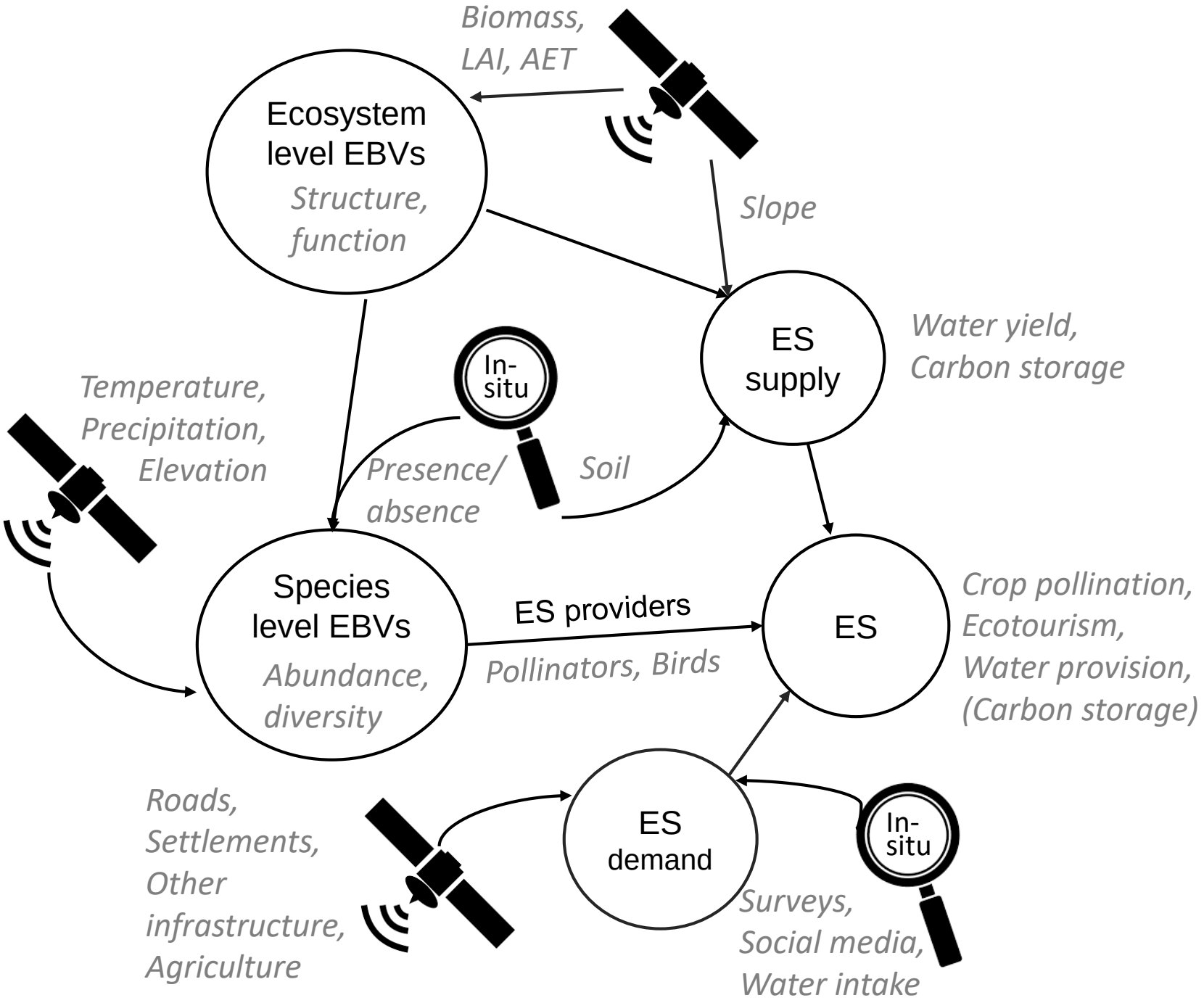
(1) Satellite data on *details* of vegetation:
diversity or condition to drive ecosystem service models

(2) Improving model accuracy by linking to ecosystem services providers

(3) Modeling ecosystem service demand or beneficiaries

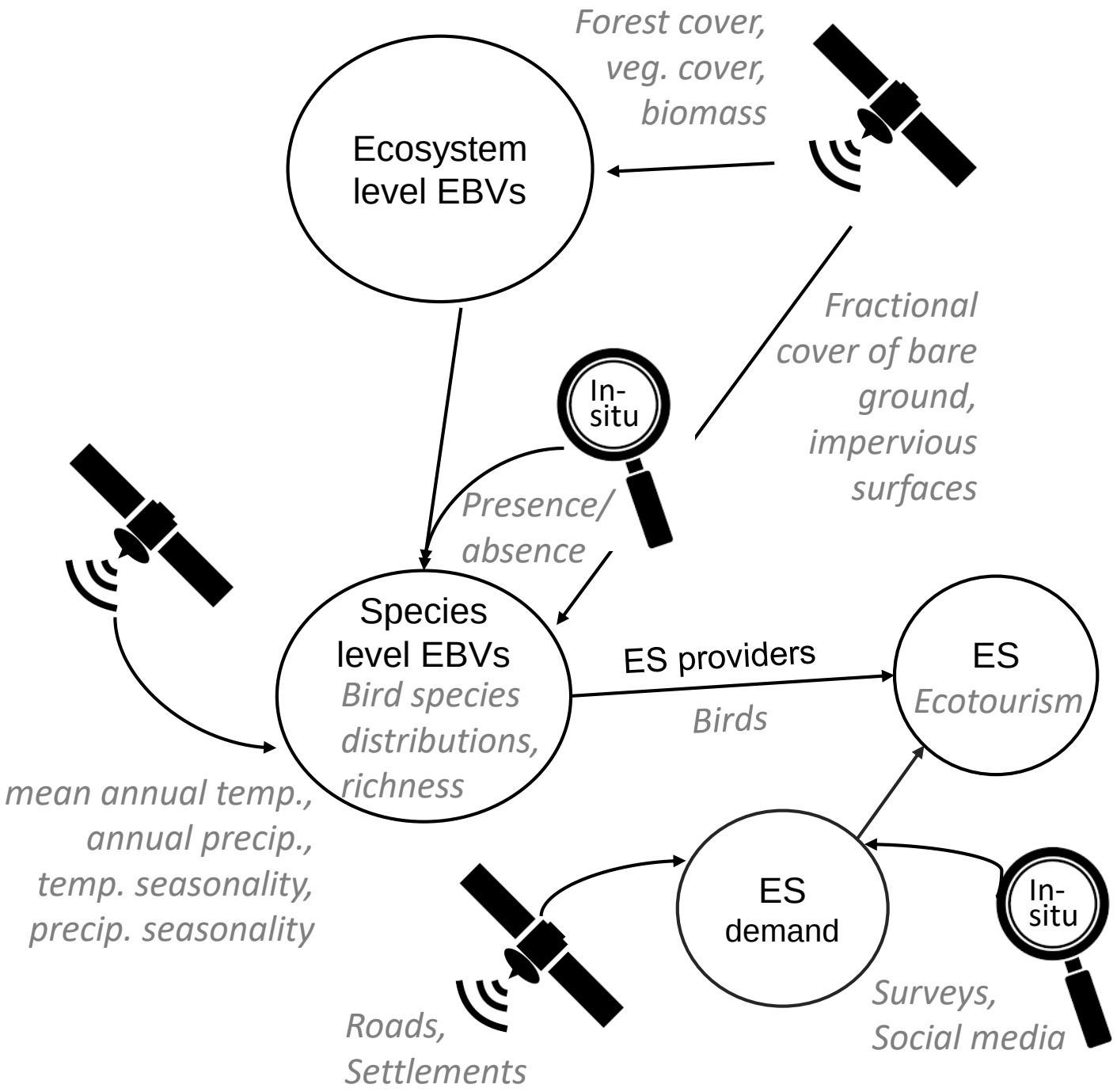
Essential Biodiversity Variables

Class	Examples
Genetic composition	Allelic diversity
Species populations	Distribution, abundance
Species traits	Body mass
Community composition	Taxonomic diversity
Ecosystem function	Net Primary Productivity
Ecosystem structure	Extent, vertical structure

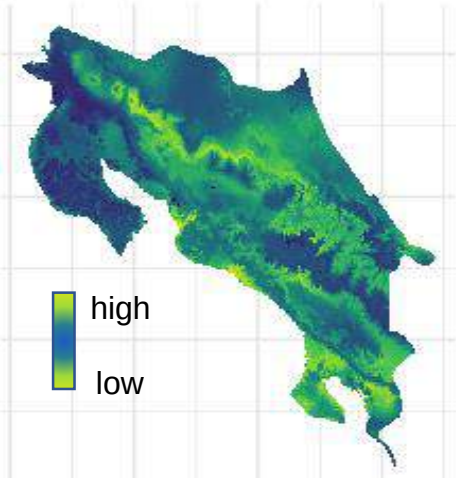

Biomass,
LAI, AET
Ecosystem
level EBVs
Structure,
function
Slope
ES
supply
Water yield,
Carbon storage
In-
situ
Temperature,
Precipitation,
Elevation
Presence/
absence
Soil
Species
level EBVs
Abundance,
diversity
ES providers
Pollinators, Birds
ES
Crop pollination,
Ecotourism,
Water provision,
(Carbon storage)
Roads,
Settlements,
Other
infrastructure,
Agriculture
ES
demand
In-
situ
Surveys,
Social media,
Water intake

Ecotourism

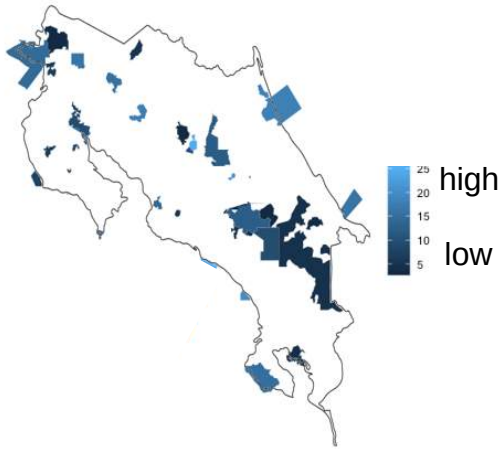
How much of a difference does biodiversity make to visitation patterns?



Bird species richness



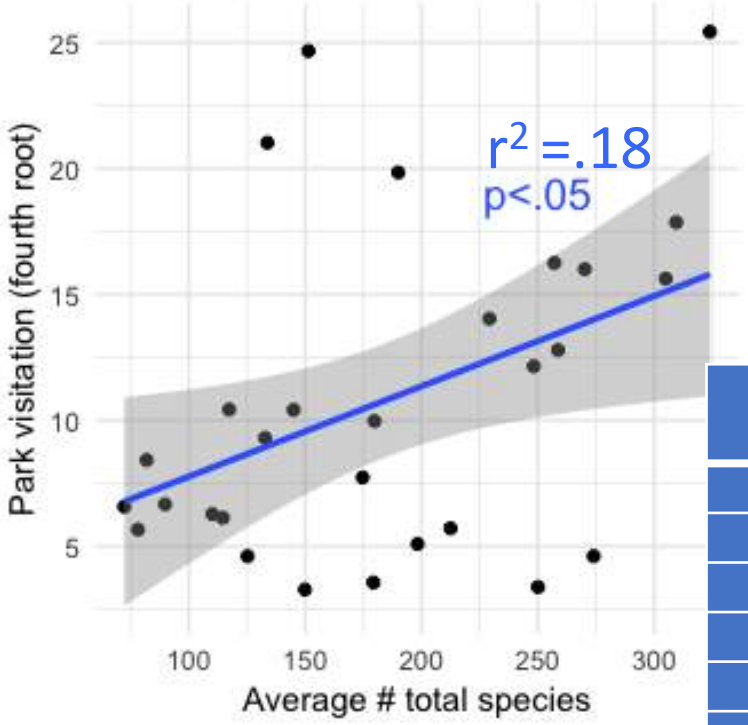
National park visitation (survey)

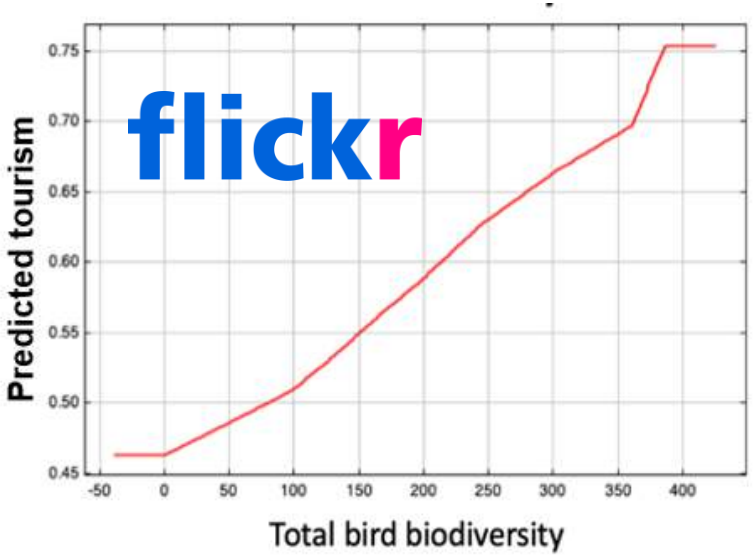


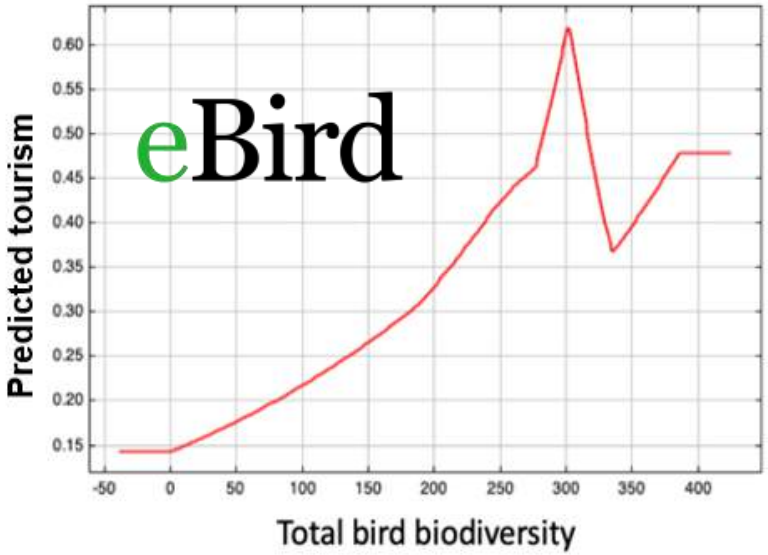
Georeferenced social media points ~ visitation

Biodiversity predicts visitation

Protected area visitation







Variable	Percent Contribution	Permutation Importance
Annual mean temperature	0.5	1.3
Annual precipitation	3.3	3.1
Protected area distance	14.4	11.3
Road distance	18.4	24
Water distance	2.8	3
Tree cover	2	0.2
Diversity – total species	36.4	43.4
Diversity – regional endemics	17.7	9.4
Diversity – expert rangemap	4.6	4.1

Variable	Percent Contribution	Permutation Importance
Annual mean temperature	4.8	7.7
Annual precipitation	2	5.5
Protected area distance	27.3	18.6
Road distance	8.6	10.4
Water distance	6.2	0.9
Tree cover	3	1.5
Diversity – total species	20	22
Diversity – regional endemics	16.1	12.6
Diversity – expert rangemap	12	20.9

Next steps: machine learning for content

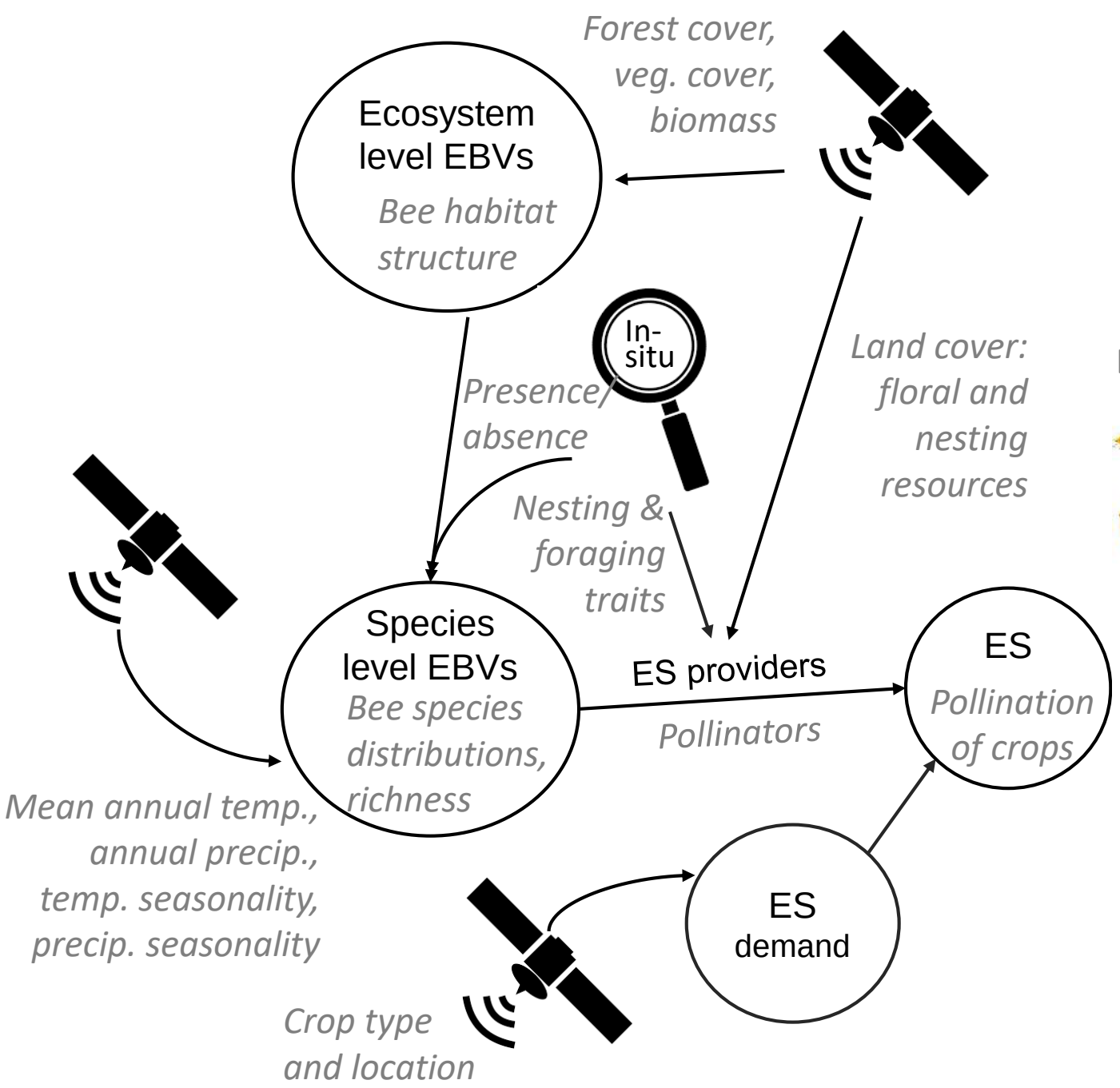
"The quetzal is maybe the most beautiful bird in the world. The best opportunity to see one is now in March, in Monteverde in Costa Rica.""

"My best bird of the year so far, this striped owl, near Jaco in Costa Rica"

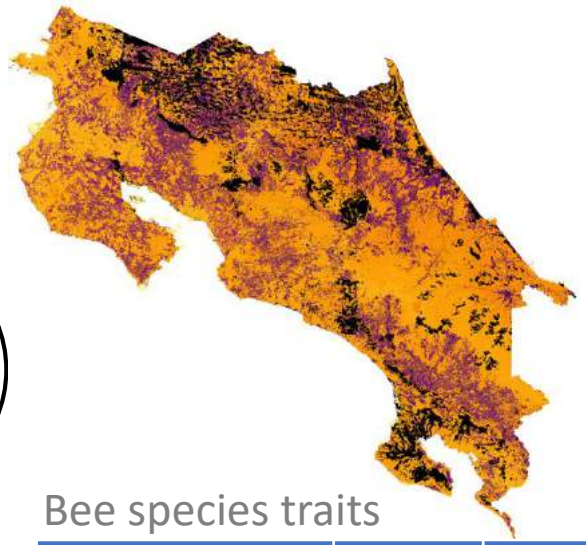
"Another gorgeous bird from our Central American trip – this time a bare-throated tiger heron at Tortuguera, Costa Rica"

Pollination

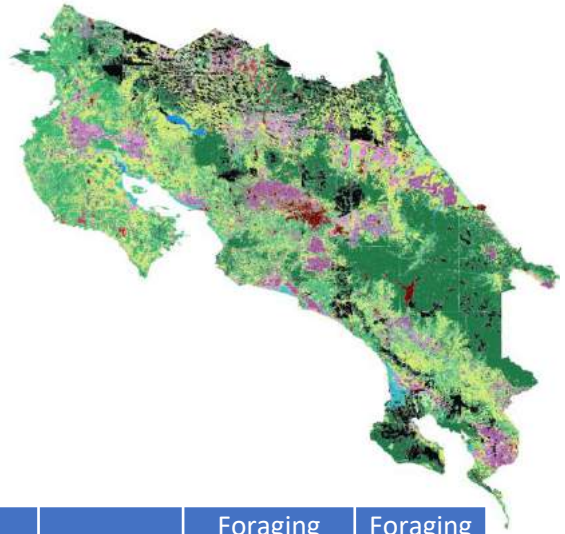
How much of a difference does biodiversity make to pollinator availability?



Bee species distributions



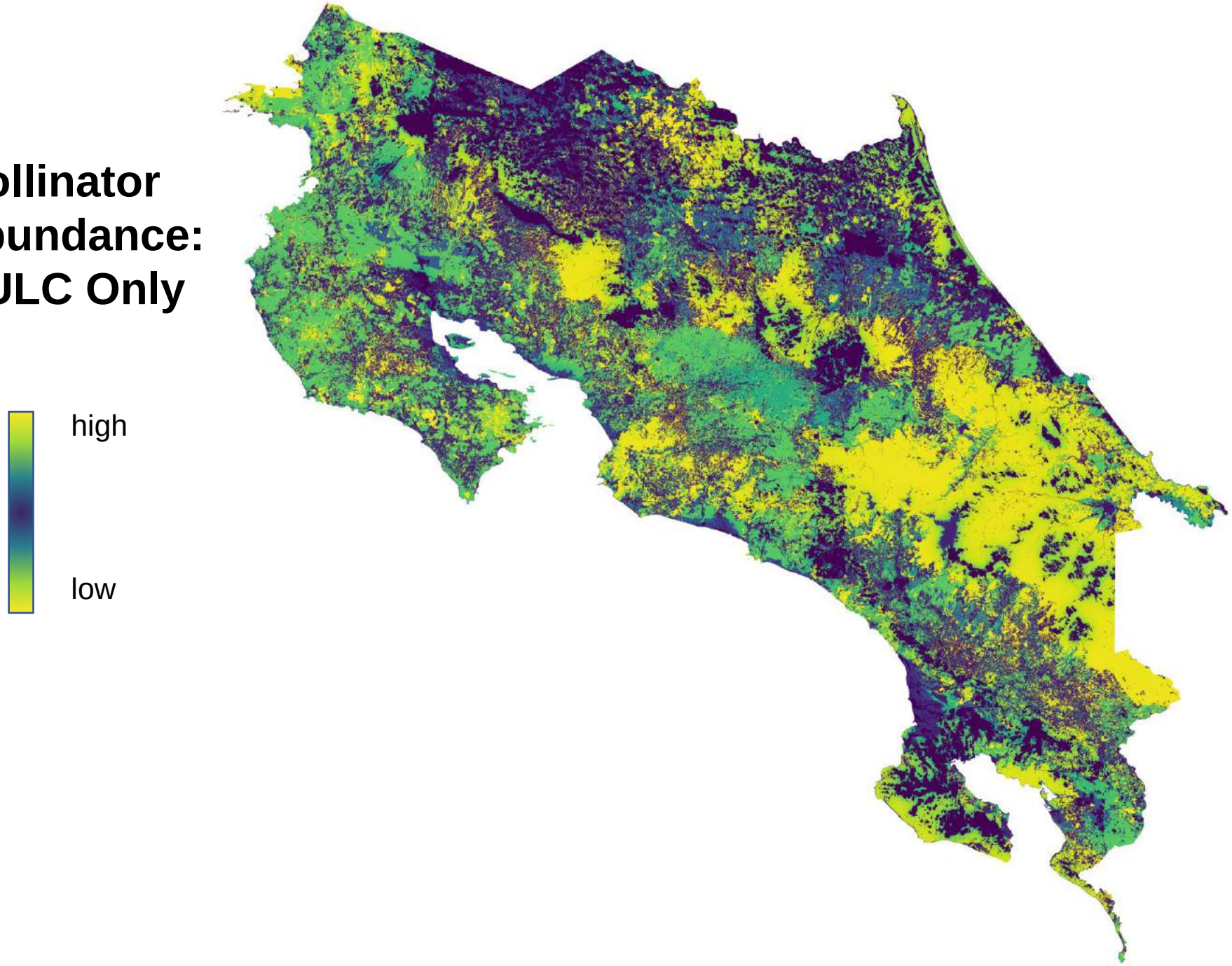
LULC: nesting & floral



Bee species traits

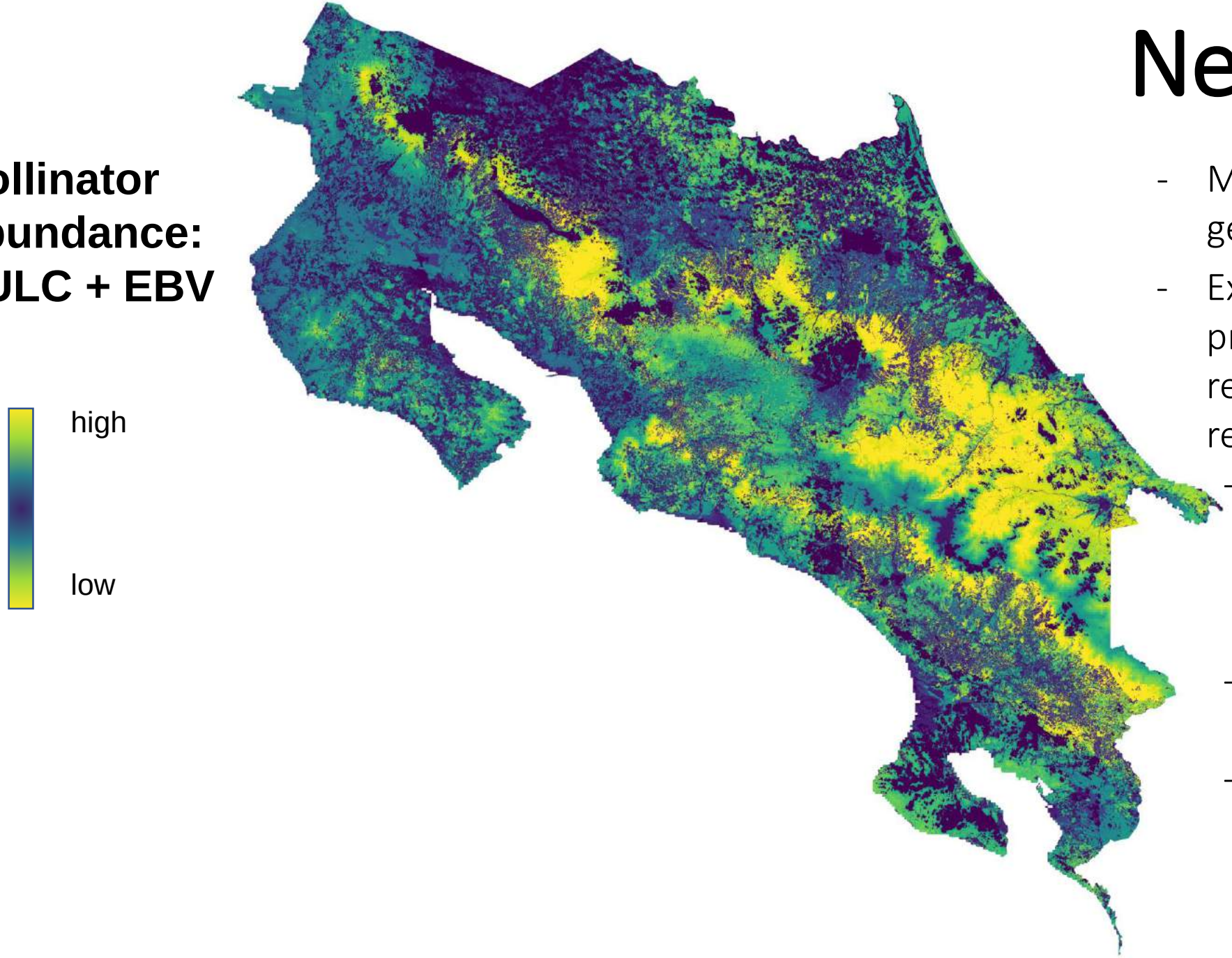
species	foraging range (m)	Cavity nester	Ground nester	Foraging activity: spring	Foraging activity: summer
Tetragonisca angustula	600	1	0	1	1
Partamona combinatea	800	1	1	1	1
Partamona cupira	800	1	1	1	1
Melipona beecheii	5000	1	0	1	1
Melipona bicolor	2200	1	0	1	1
Melipona compressipes	2470	1	0	1	1
.....					

Pollinator abundance: LULC Only



Next steps

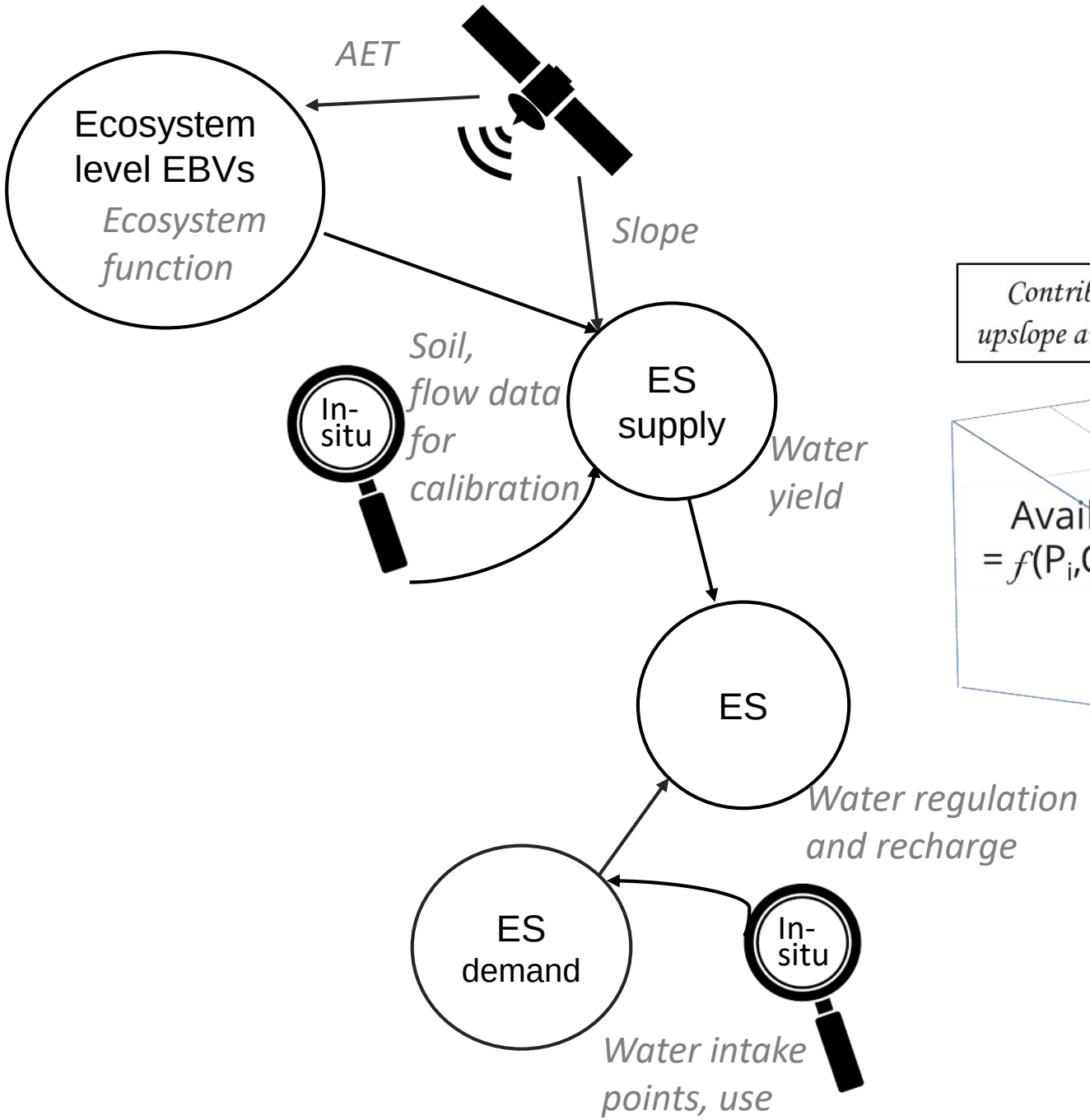
Pollinator abundance: LULC + EBV

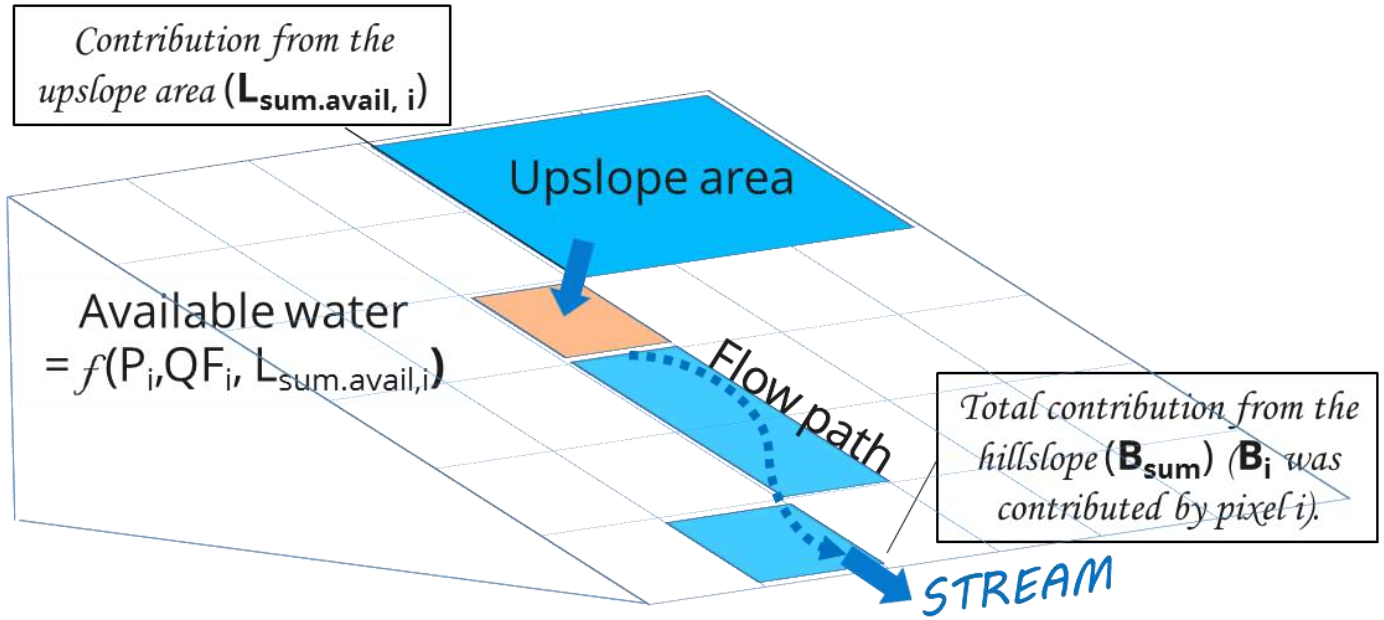


- Modeling pollination; get coffee maps
- Explore other EO products for representing floral resources and nesting:
  - LAI variance for agriculture (correlated w/ intensity)
  - NDVI for pasture productivity
  - LiDAR for forest understory

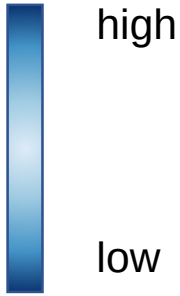
Water regulation

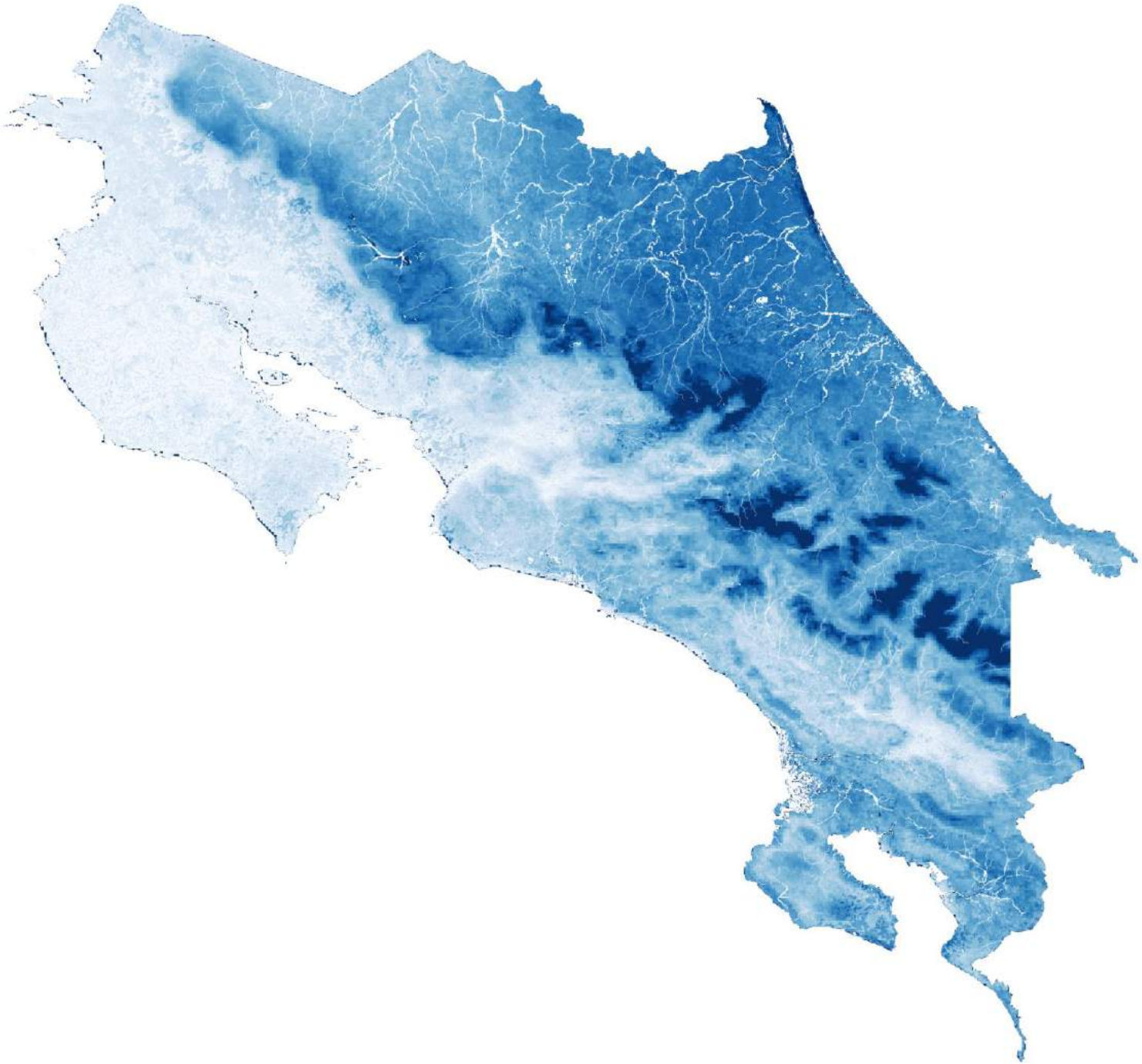
How much of a difference does biodiversity make to water recharge & dry season flow?


AET
Ecosystem level EBVs
Ecosystem function
Slope
Soil, flow data for calibration
In-situ
ES supply
Water yield
ES
Water regulation and recharge
ES demand
In-situ
Water intake points, use

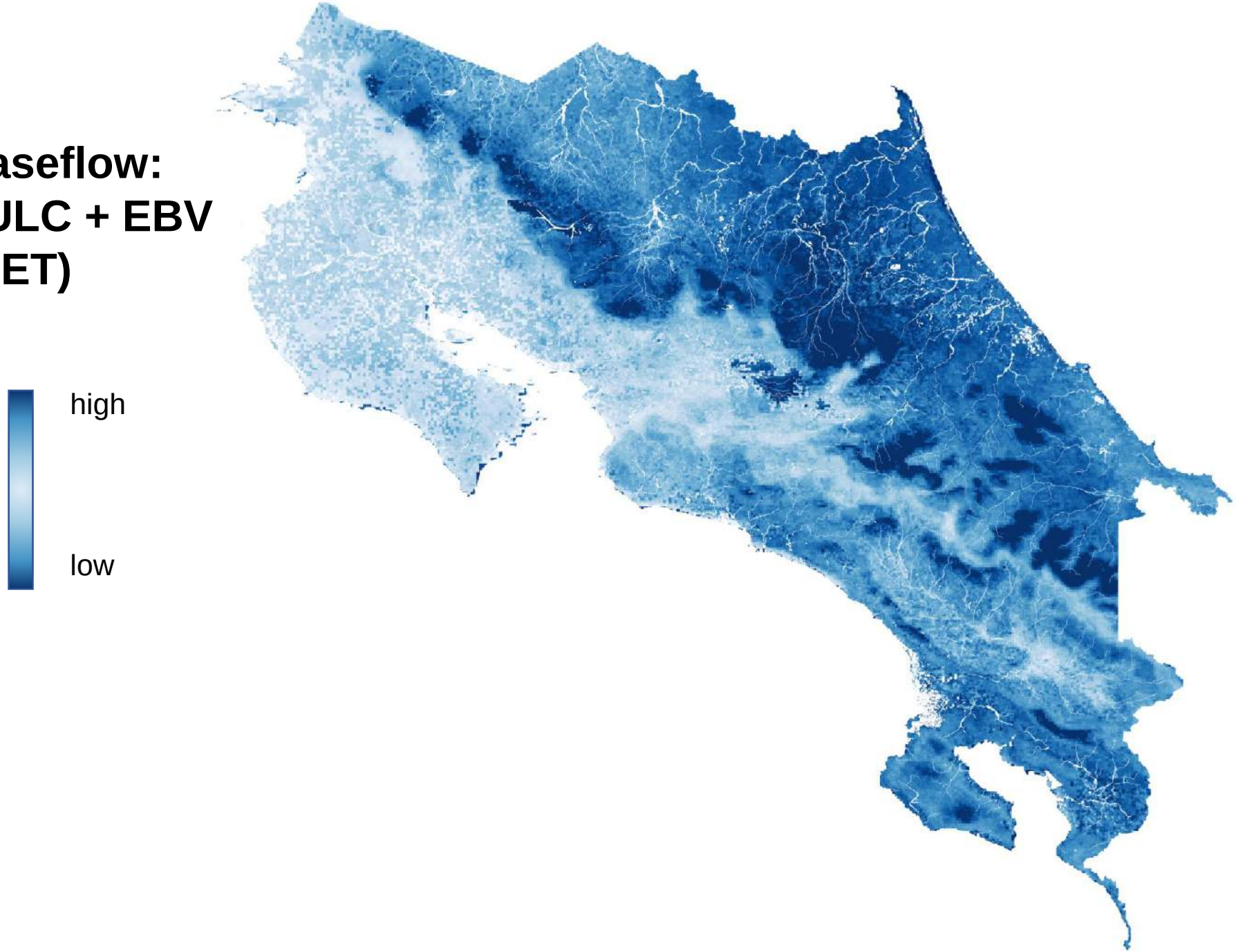

Contribution from the upslope area ($L_{sum.avail,\ i}$)
Upslope area
Available water
$= f(P_i, QF_i, L_{sum.avail,i})$
Flow path
Total contribution from the hillslope (B_{sum}) (B_i was contributed by pixel i).
STREAM

Baseflow: LULC only (crop coefficient)

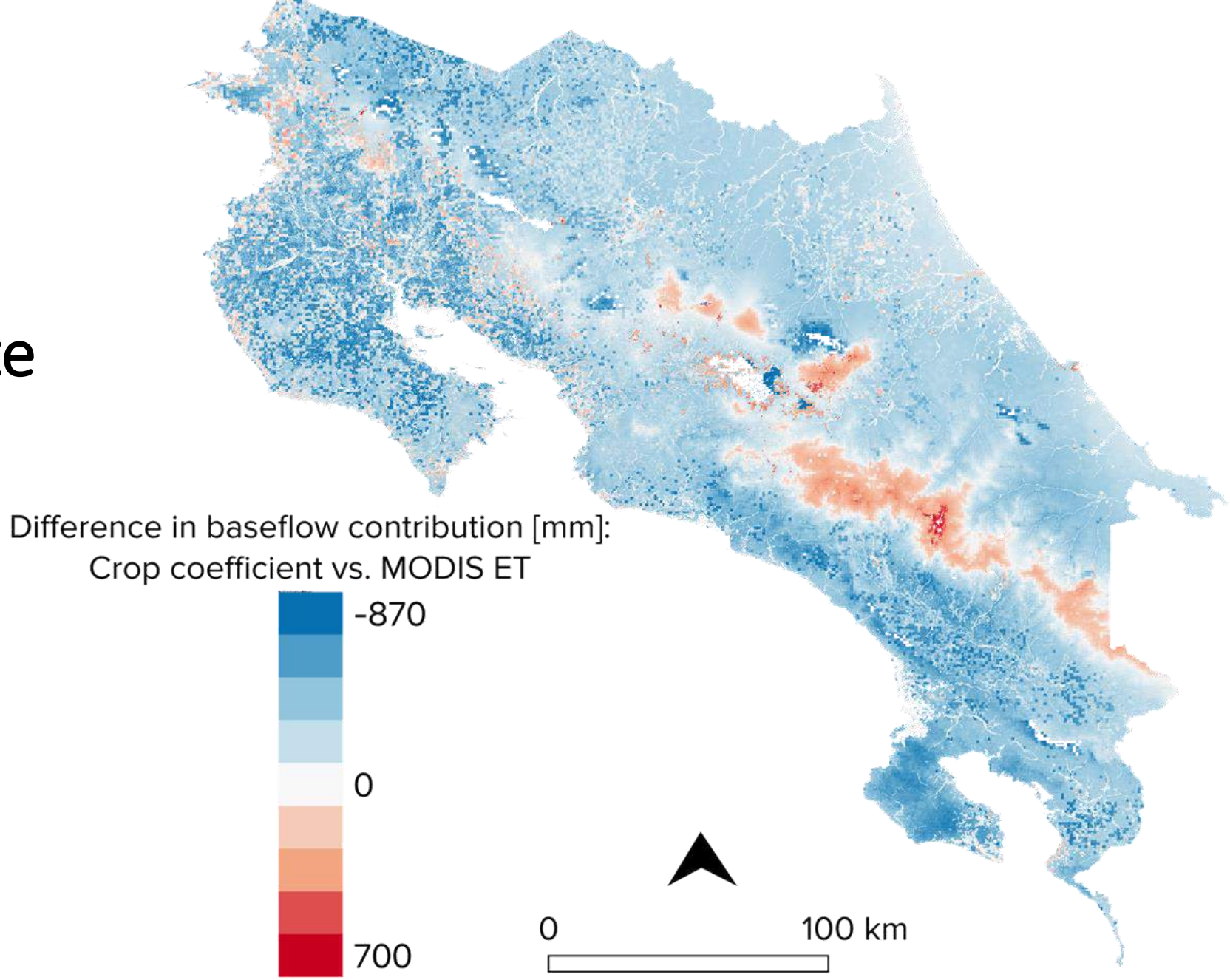




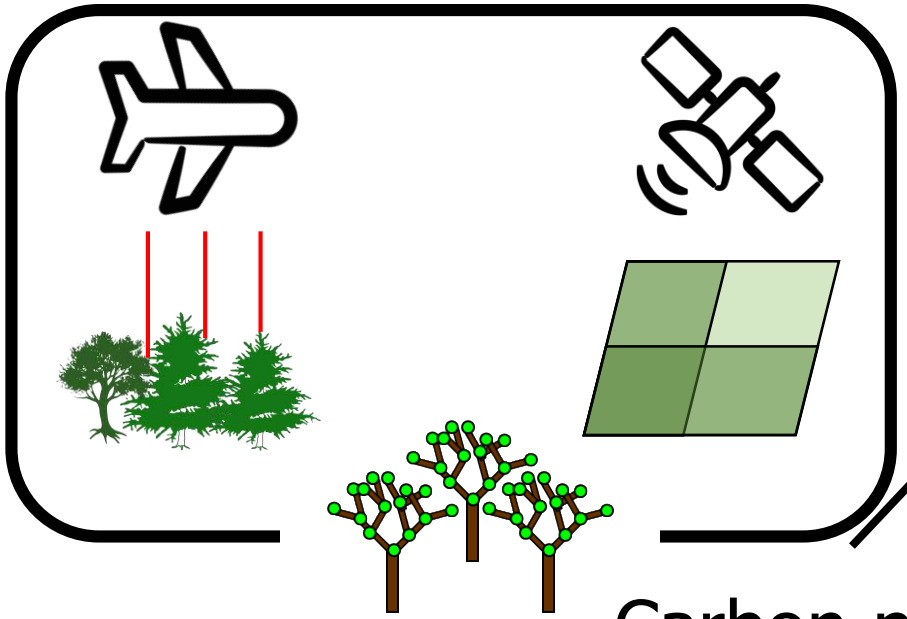
Baseflow: LULC + EBV (AET)

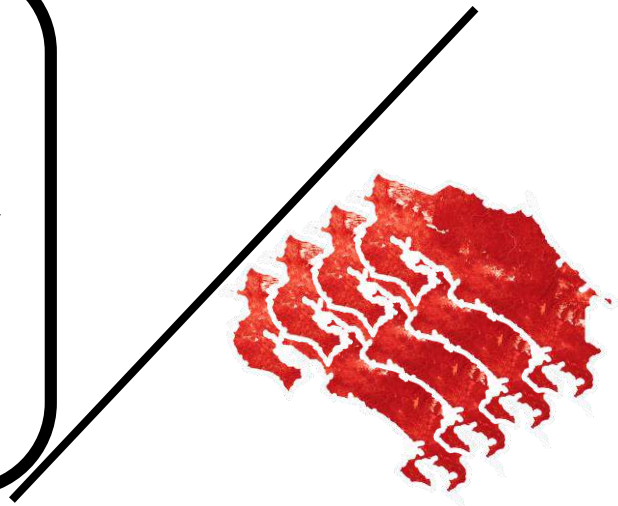


Using MODIS evapotranspiration suggests current models overestimate topographic effect on baseflow



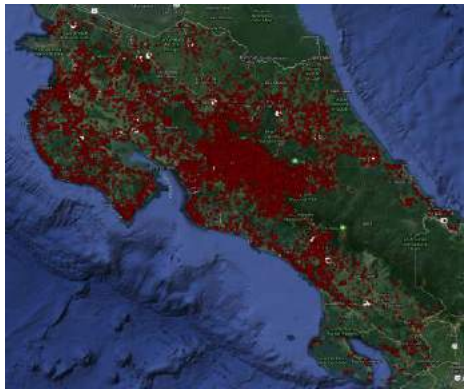
Next steps





Carbon / Drop

Carbon per drop to consider vegetation water use against water's local value for other uses



Local supply and demand for water determine where carbon is best stored

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