A r b o r M e t r o p o l i s

Regional afforestation as a backbone for ecosystem-based adaptation in the metropolitan area of Monterrey, Mexico



21.06.2024

Urban Ecology
Isa van der Bijl

Contents

1. RESEARCH
Analysis
Project framing

2. METHODOLOGY
Problematisation
Research framework

3. DESIGN STRATEGY
Value map
Inventory
Forest catalogue
Vision map
Stakeholders

4. DESIGN INTERVENTIONS
[1] Valle Alto
[2] Ríveras del Río

5. SYSTEMIC DESIGN

1.
RESEARCH

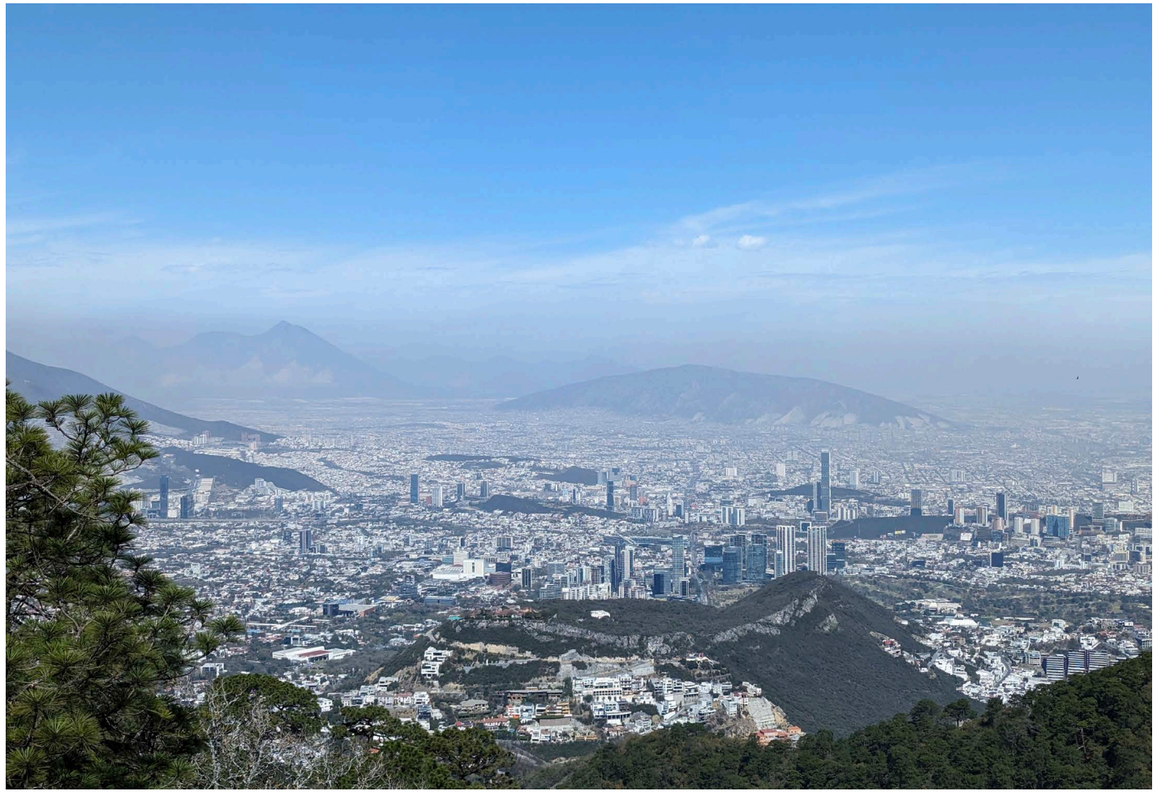
Site location

Monterrey Metropolitan Area



Huertas, et al. © 2020. This work is openly licensed via CC BY 4.0. *Detailed map on location of MMA.* ResearchGate. Retrieved April 26, 2024, adapted from https://www.researchgate.net/figure/Detailed-map-on-the-location-of-a-Monterreys-Metropolitan-Area-MMA-and-b-the_fig2_342634789

Industrialized region



Social context

NAFTA
North American Free Trade Agreement.
Rapid and intense development.

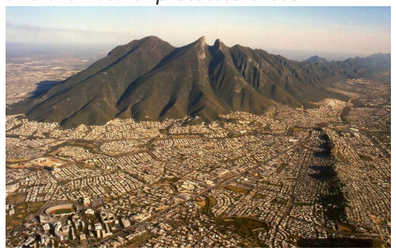
Industrial city
Agglomeration economies that benefit from colocation.

Population MMA
1990: 2.691.000
2023: 5.117.000

Boundaries of expansion
Mountains, natural protected areas, and municipalities.

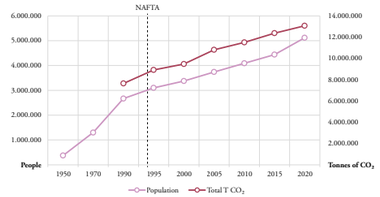
The demand of the region is growing.

The juxtaposition of the urban sprawl and the natural protected areas



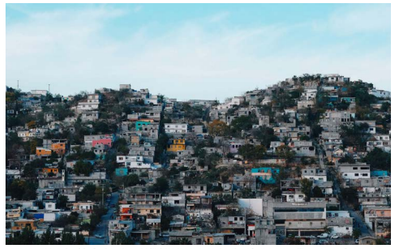
Heim, A. (2011, September 8). *Cerro de la Silla*. TNW. https://thenextweb.com/news/why-monterrey-mexico-needed-a-startup-weekend

Relation between population growth and Tons of CO_2



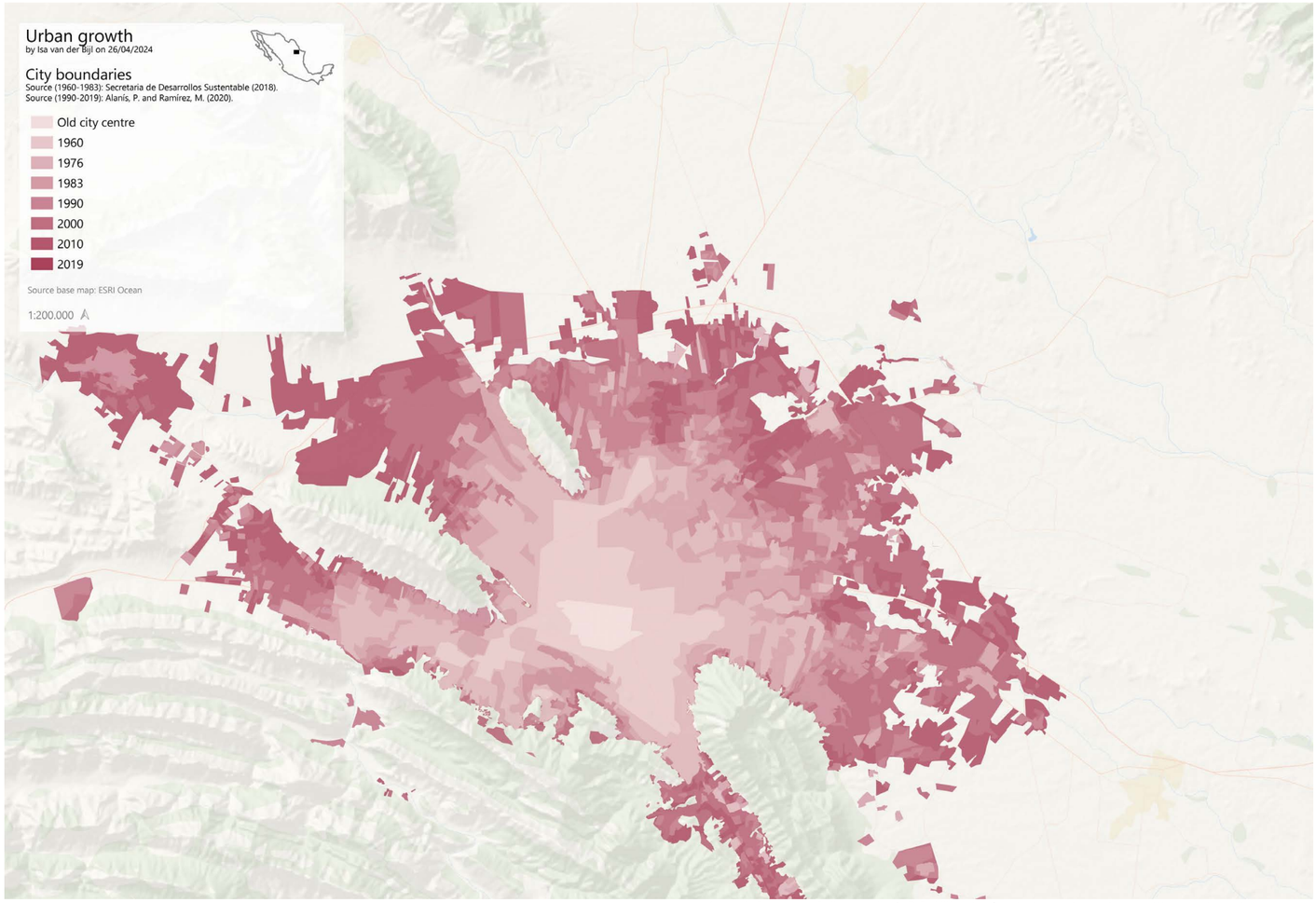
Carpio, A., Ponce-Lopez, R., & Lozano-García, D. F. (2021). Urban form, land use, and cover change and their impact on carbon emissions in the Monterrey Metropolitan area, Mexico. *Urban Climate*, *39*, 100947. https://doi.org/10.1016/j.uclim.2021.100947

Developed hillsides in Monterrey



Lozano Valdes, D. (2016). *Developed hillsides loom over the city of Monterrey*. The Nature Conservacy. https://www.nature.org/en-us/what-we-do/our-insights/perspectives/growing-greener-in-mexico-city-of-the-mountains/

Demographic growth



Carpio, A., Ponce-Lopez, R., & Lozano-García, D. F. (2021). Urban form, land use, and cover change and their impact on carbon emissions in the Monterrey Metropolitan area, Mexico. *Urban Climate*, *39*, 100947. https://doi.org/10.1016/j.uclim.2021.100947

Ecological zones

Cohabitation of three eco types.

[1] Subtropical desert



Wikiloc. (n.d.-a). *Aguja Superior, Carricitos, Mina, Nuevo León*. Wikiloc: Trails of the World. https://www.wikiloc.com/trails/hiking/mexico/nuevo-leon/carricitos

[2] Subtropical mountain system

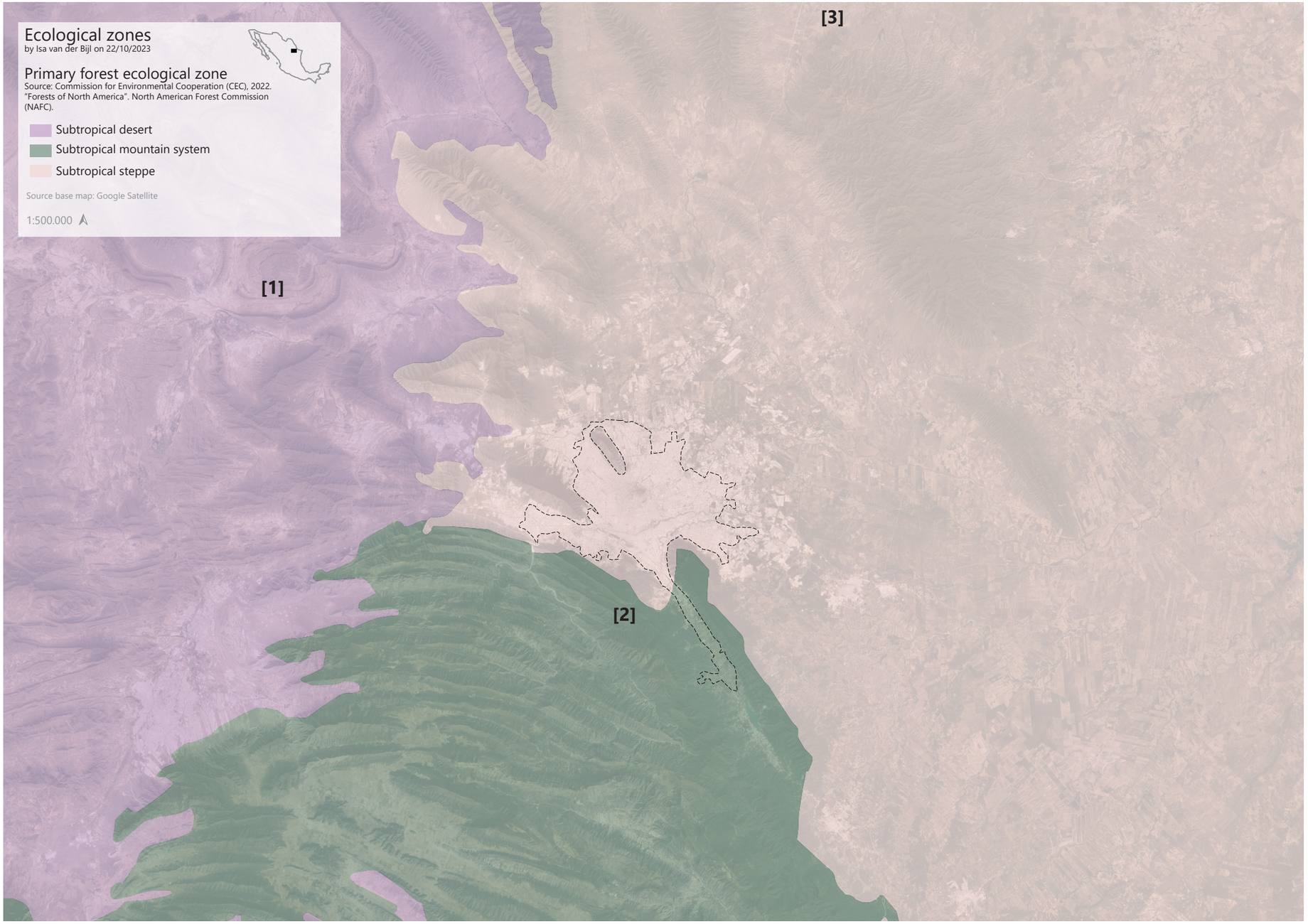


Serafini, G. (2008, April 20). *Hiking to El Pinal*. https://www.flickr.com/photos/gserafini/2427214184/

[3] Subtropical steppe

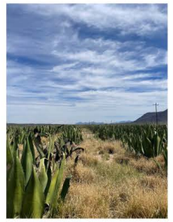


Wikiloc. (n.d.-c). *El cóleo bordo río*. Wikiloc: Trails of the World. https://www.wikiloc.com/hiking-trails/rio-salado-san-blas-120522533/photo-77227027



Site visit to Mexico

Subtropical desert


Villa de Patos

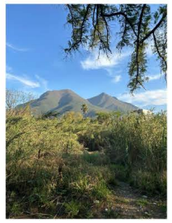

Yellow rapeseed


Prickly pear

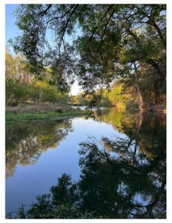

Maguey agave


Sheep farming

Subtropical steppe


Cerro de la Silla

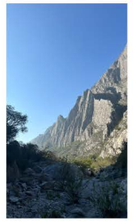

Río la Silla park


Río la Silla river

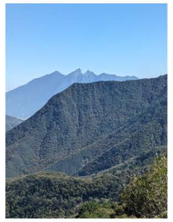

Río Santa Catarina

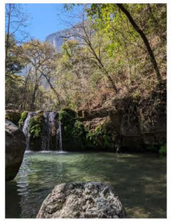

Planta Norte

Subtropical mountain system


La Huasteca

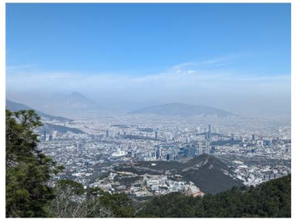

Rock formations

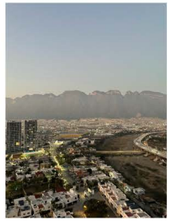

Chipinque park


La Estanzuela


El Salto

City centre

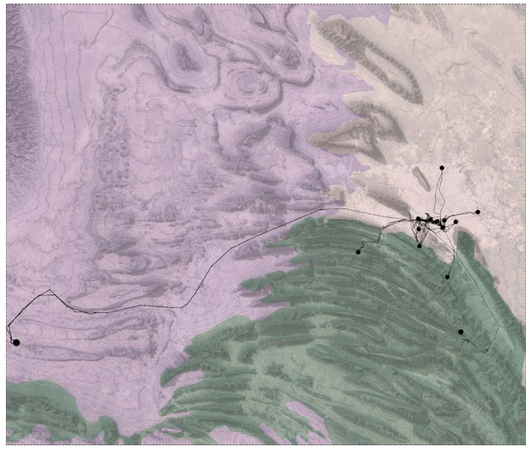

View from Chipinque


Dry riverbed


Polluted riverbed


Sunflowers in river

Route taken during site visit



Human influence on terrestrial ecosystems

Need for a regional strategy.

[1] Severe air quality issues



Copeland, C. (2019, November 30). *Air quality alert issued in Nuevo León for second time this week. Mexico News Daily*. Retrieved October 28, 2023, from https://mexiconewsdaily.com/news/air-quality-alert-in-nuevo-leon-for-second-time/

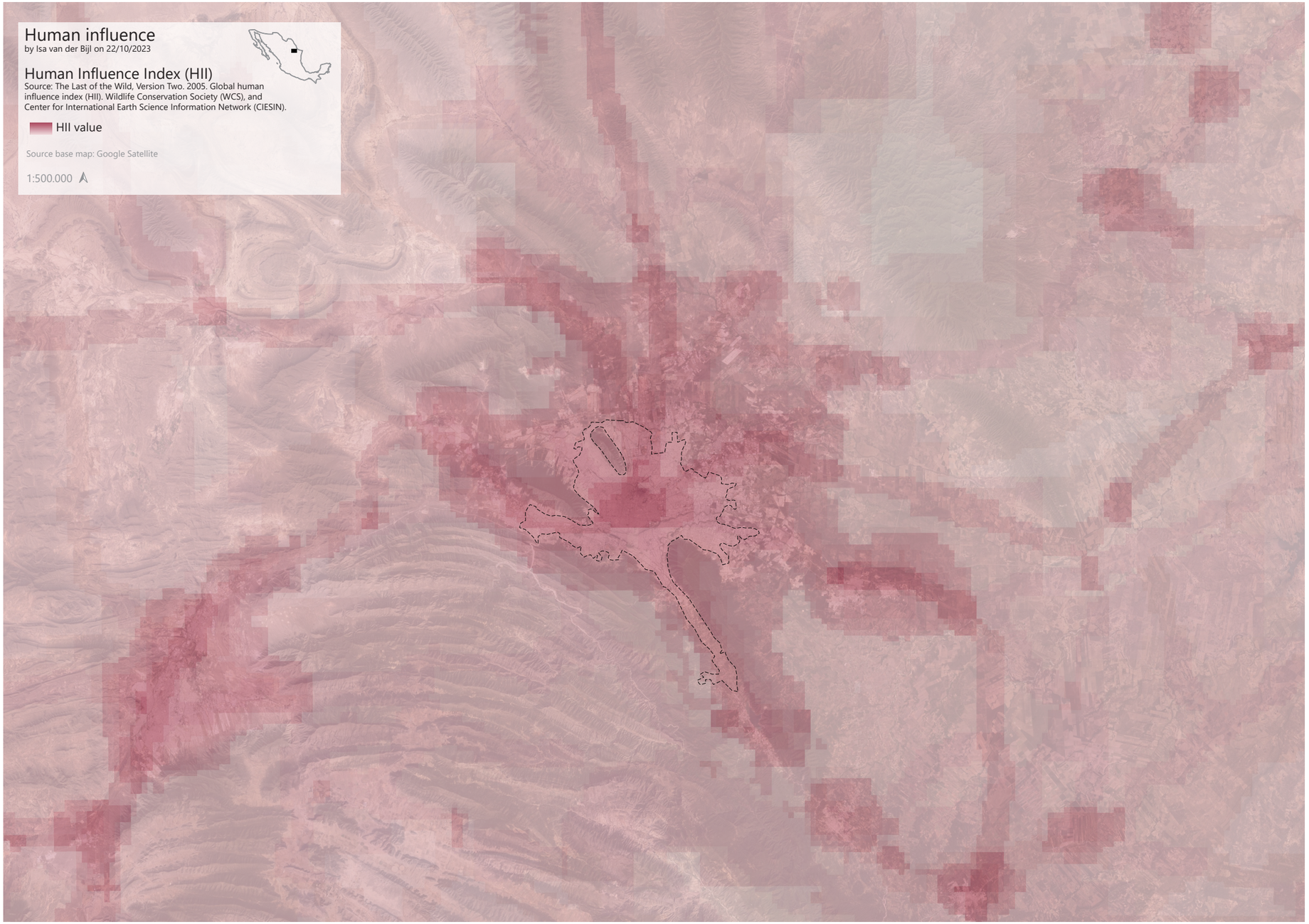
[2] Pollution



[3] Car dependency



Reddit. (2021). *Monterrey, NL, MX*. Image from Carlows93. Retrieved from https://www.reddit.com/r/UrbanHell/comments/mqxvyn/monterrey_nl_mx/



Natural protected areas

[1] Area Natural Protegida Sierra de las Mitras



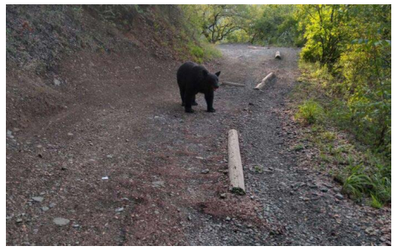
Materia prima, Loana, E., & Sisniega. (n.d.). *Las Mitros*. Atlas Materia Prima. https://atlasmateriaprima.net/Las-Mitras

[2] Monumento Natural Cerro de la Silla

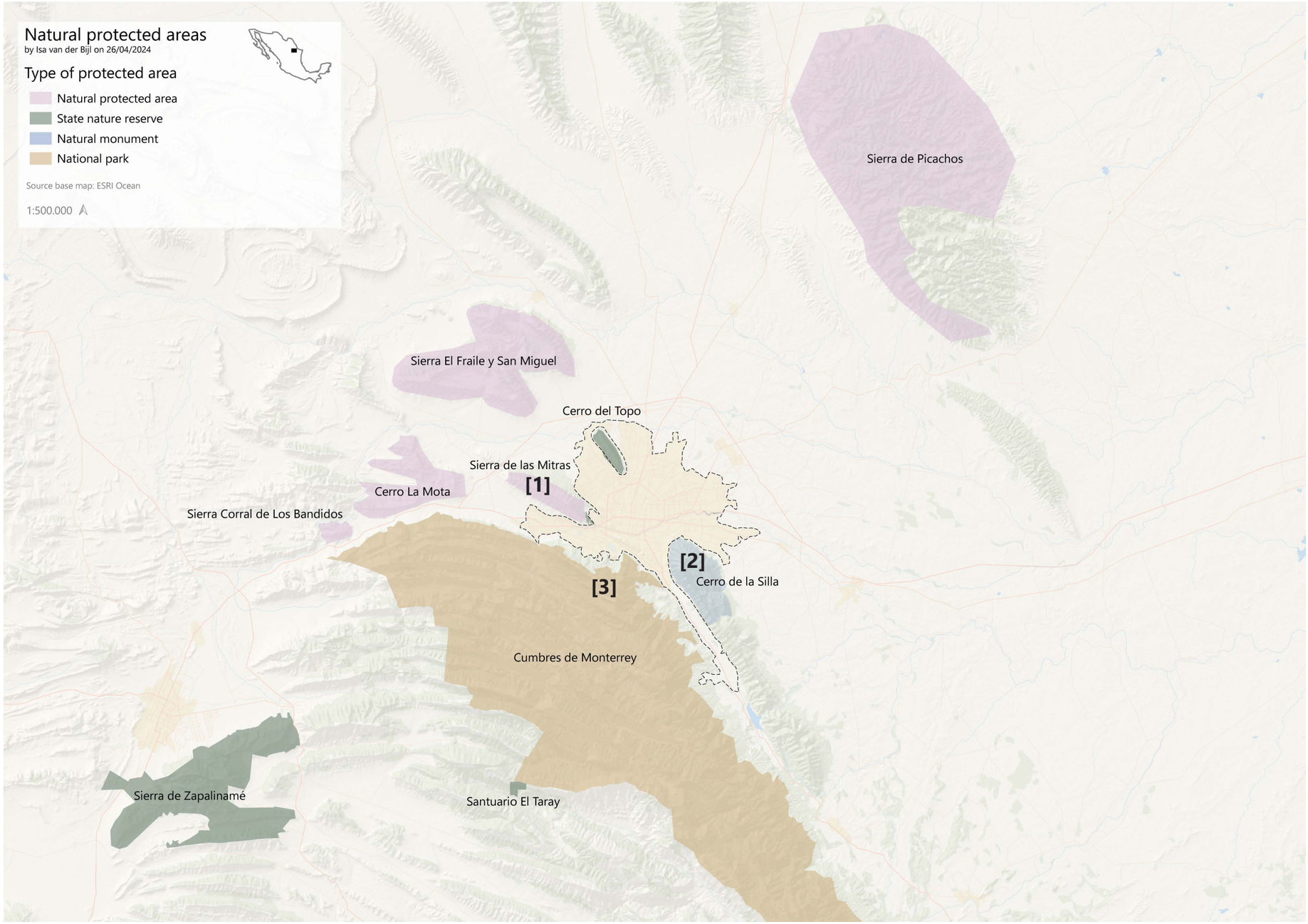


Trejo, Y. & Special. (2022, August 1). *Cerro de la Silla*. Diario AS. https://mexico.as.com/actualidad/cerro-de-la-silla-por-que-se-llama-asi-donde-se-localiza-y-curiosidades-n/

[3] Parque National Cumbres de Monterrey



Escapadas por México Desconocido. (2022, December 12). *Parque Ecológico Chipinque*. Escapadas. https://escapadas.mexicodesconocido.com.mx/atractivos/parque-ecologico-chipinque-el-bosque-sobre-la-ciudad/



Dominant drivers of forest cover loss

The system is weakening.

[1] Wildfires burning in Nuevo León on March 27, 2021



NASA. (2021. March 27). *Fires and Thermal Anomalies*. NASA Worldview. https://worldview.earthdata.nasa.gov/

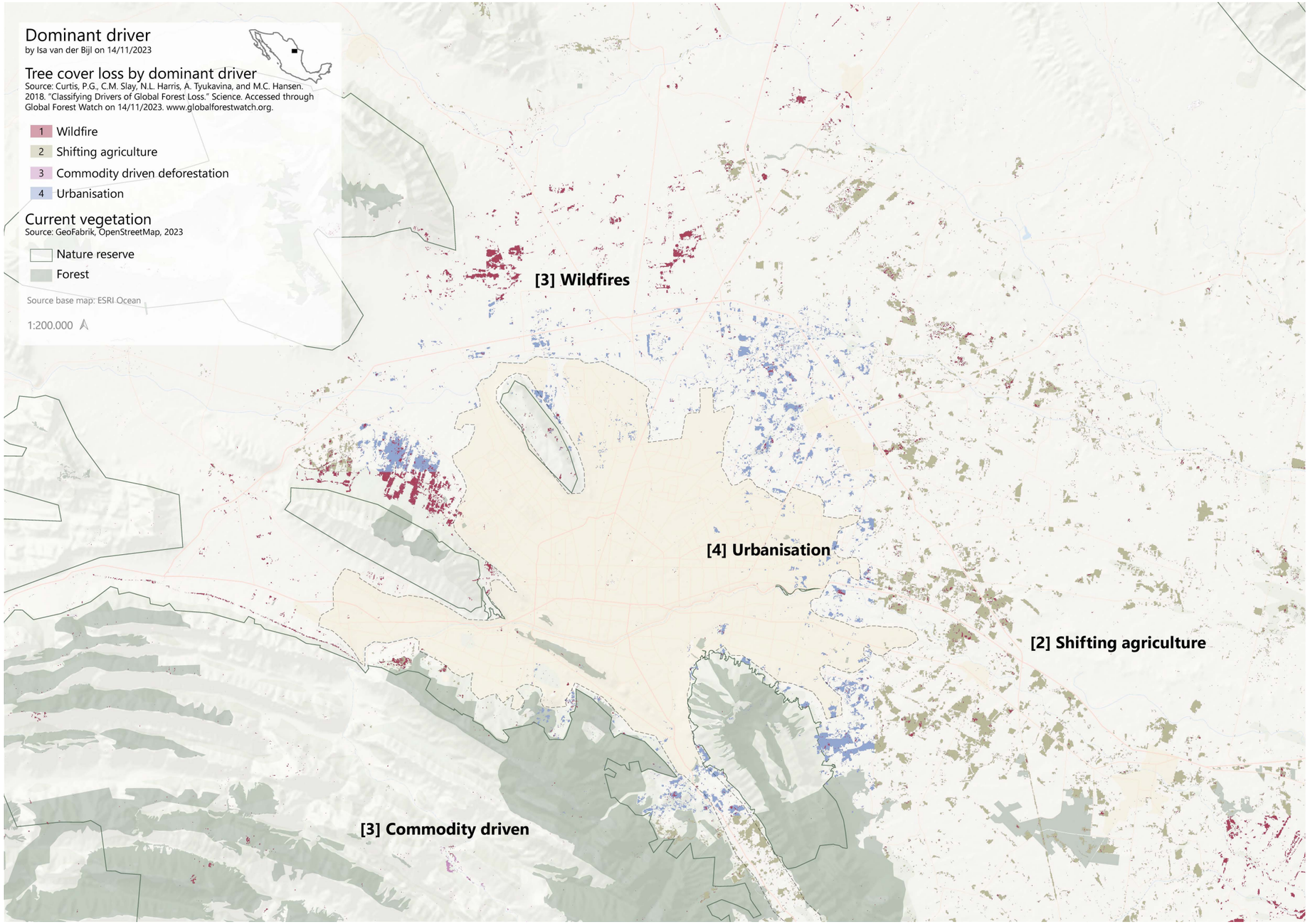
[2] Wildfires in Sierra de Santiago



Protección Civil Nuevo León. (2022). *El incendio en la Sierra de Santiago*. Infobae. https://www.infobae.com/en/2022/04/19/nuevo-leon-forest-fire-in-the-sierra-de-santiago-was-100-controlled/

[3] Result of wildfires close to La Ciénega de González





Fragmented landscape
Potential to intervene

The higher the level of land occupation, the lower the degree of possible transformation of the land.

Challenge in Monterrey's fragmented landscape.

Need for a regional strategy from urban to rural areas.



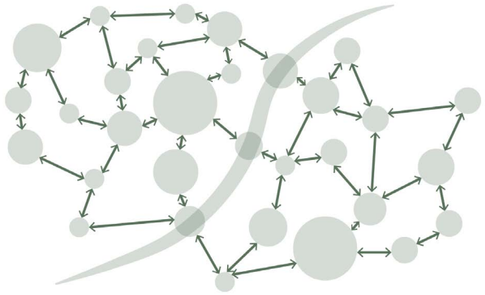
Adapted from Recubenis Sanchis, I. (2020). *Restoring Systemic Proximities: Towards the re-territorialization of the Dutch Rivierenland*. TU Delft. Retrieved from http://resolver.tudelft.nl/uuid:2d79ab24-9ac8-4b1f-8bca-ed4eeb999e71

Project framing

URBAN FORESTRY AND REGIONAL AFFORESTATION



Enhance ecosystem services



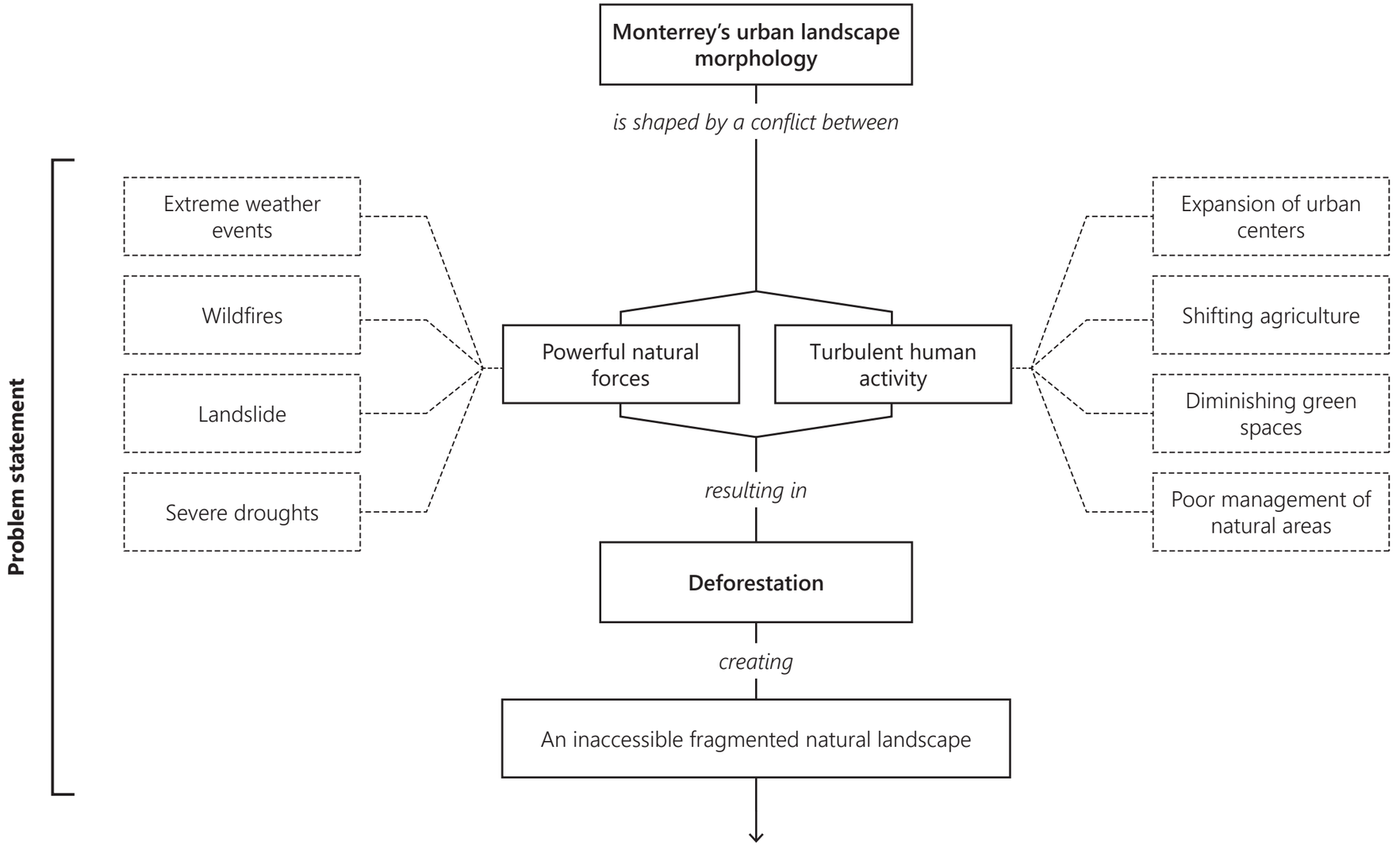
Defragment the natural landscape



Harmonize human-nature relationships

2.
METHODOLOGY

Problematisation



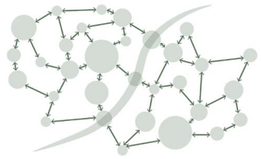
Research questions

Research question

"To what extent can **urban forestry** be upscaled in Monterrey, Mexico to enhance ecosystem services, defragment the natural landscape, and harmonize the relationship between people and nature, aiming for **ecological restoration** using ecosystem-based solutions, within an integrated **system of care**, and a **long-term plan** for green-blue infrastructures?"



Enhance ecosystem services



Defragment the natural landscape



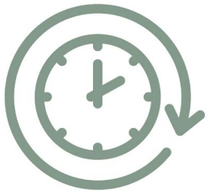
Harmonize human-nature relationships



Ecological restoration

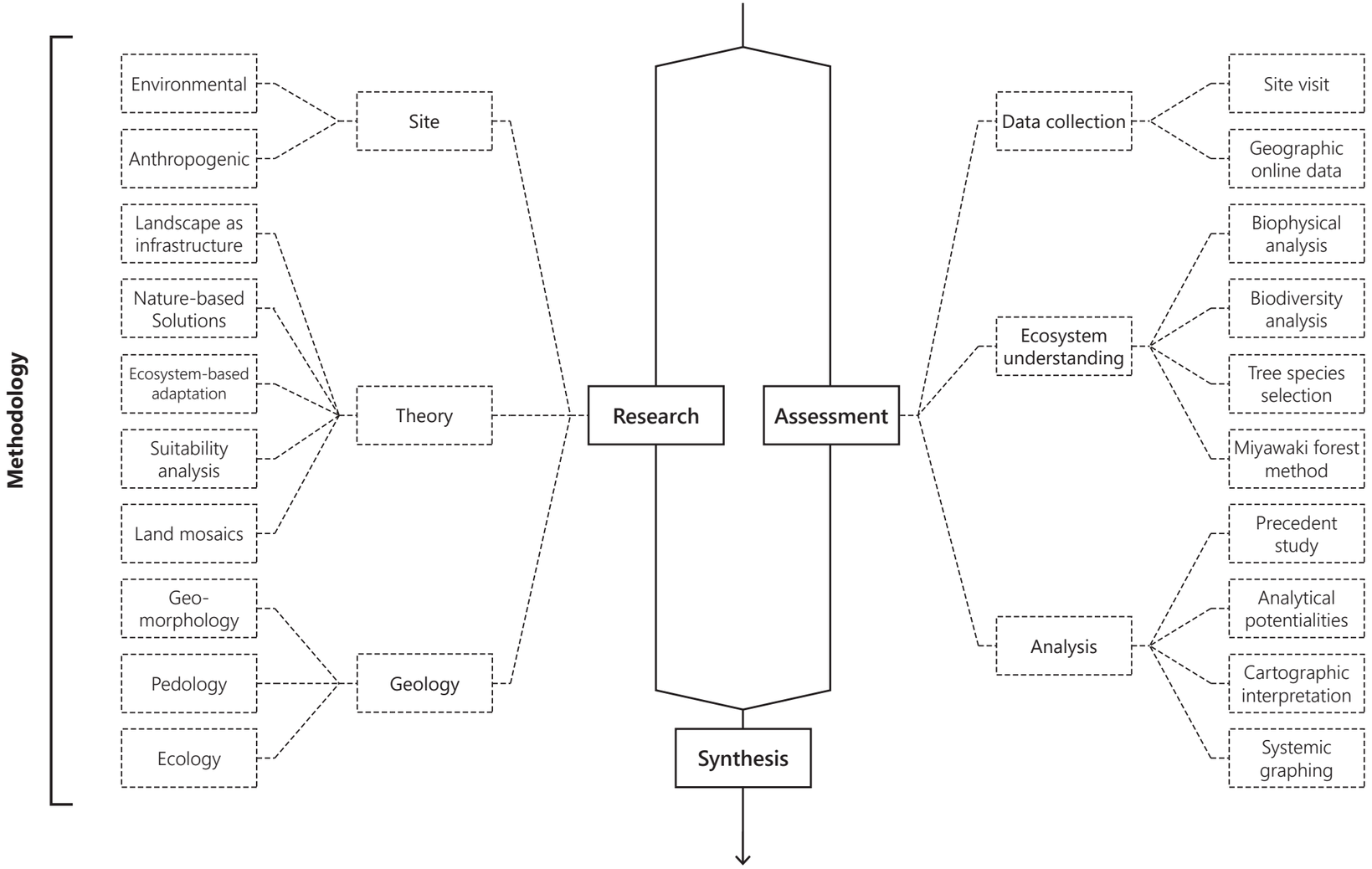


System of care

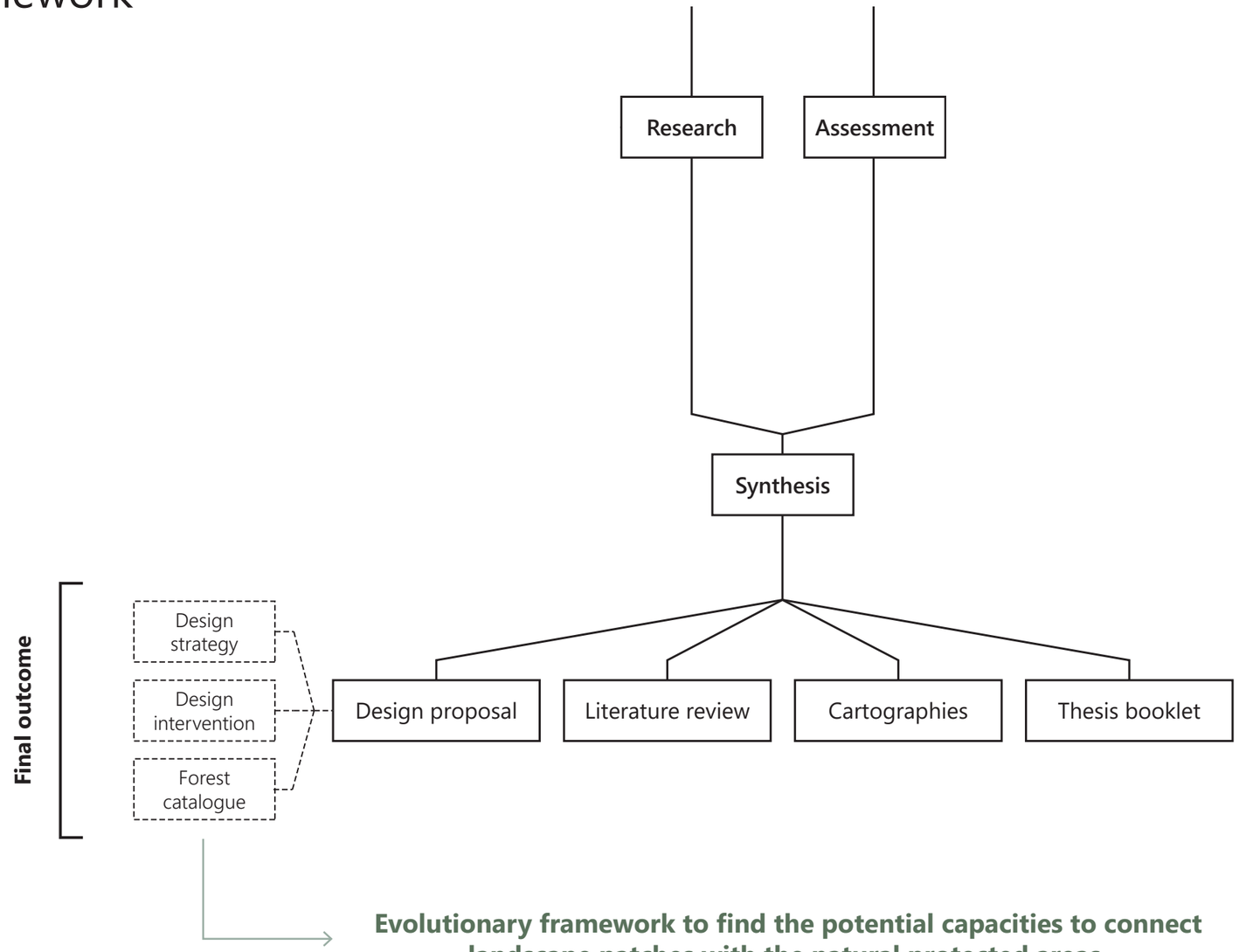


Long-term plan

Research framework



Research framework



Evolutionary framework to find the potential capacities to connect landscape patches with the natural protected areas.

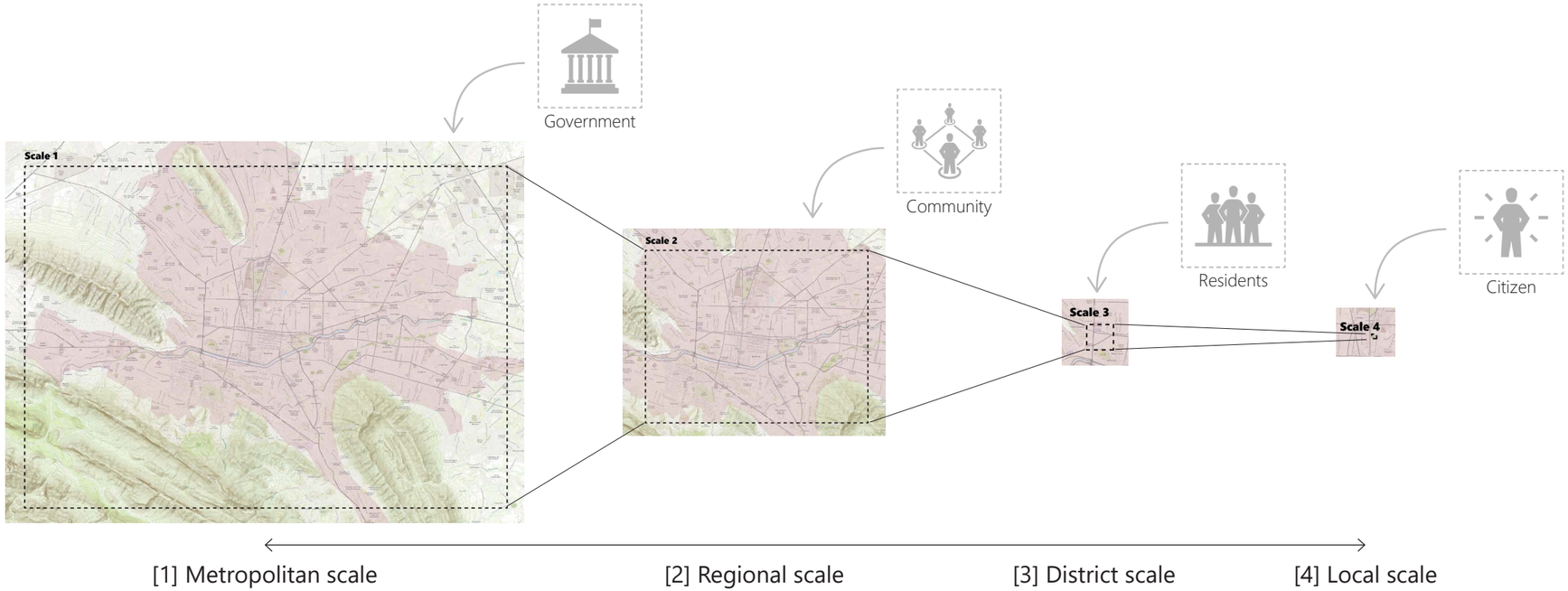
Trans-scalar project

Design aims

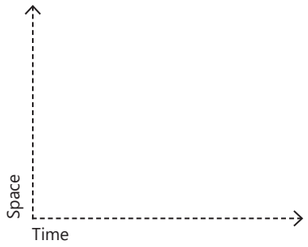
→ Upscaling afforestation
→ Address sensitive areas
→ Defragmentation
→ Mitigating climate extremes
→ Potentialities

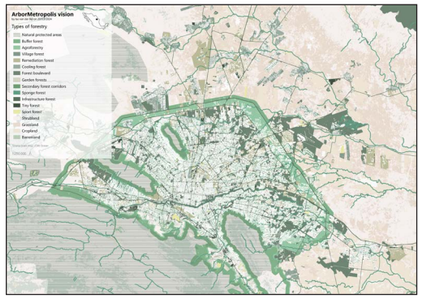
\+

Evolutionary framework



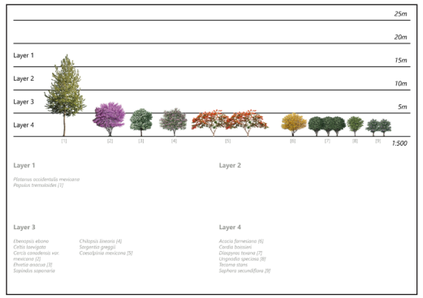
Explorative design to find the potential capacaties to connect landscape patches with the natural protected areas.




Connecting protected areas


Creating an ecological continuum


Introducing new forest typologies


Selecting species mix

3.

DESIGN STRATEGY

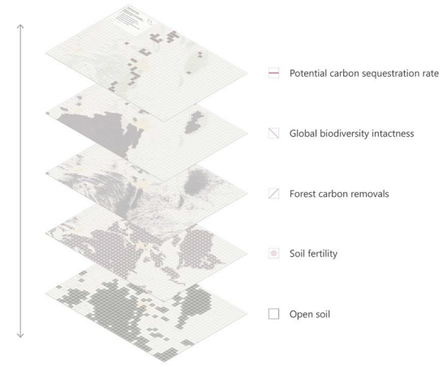
Value map

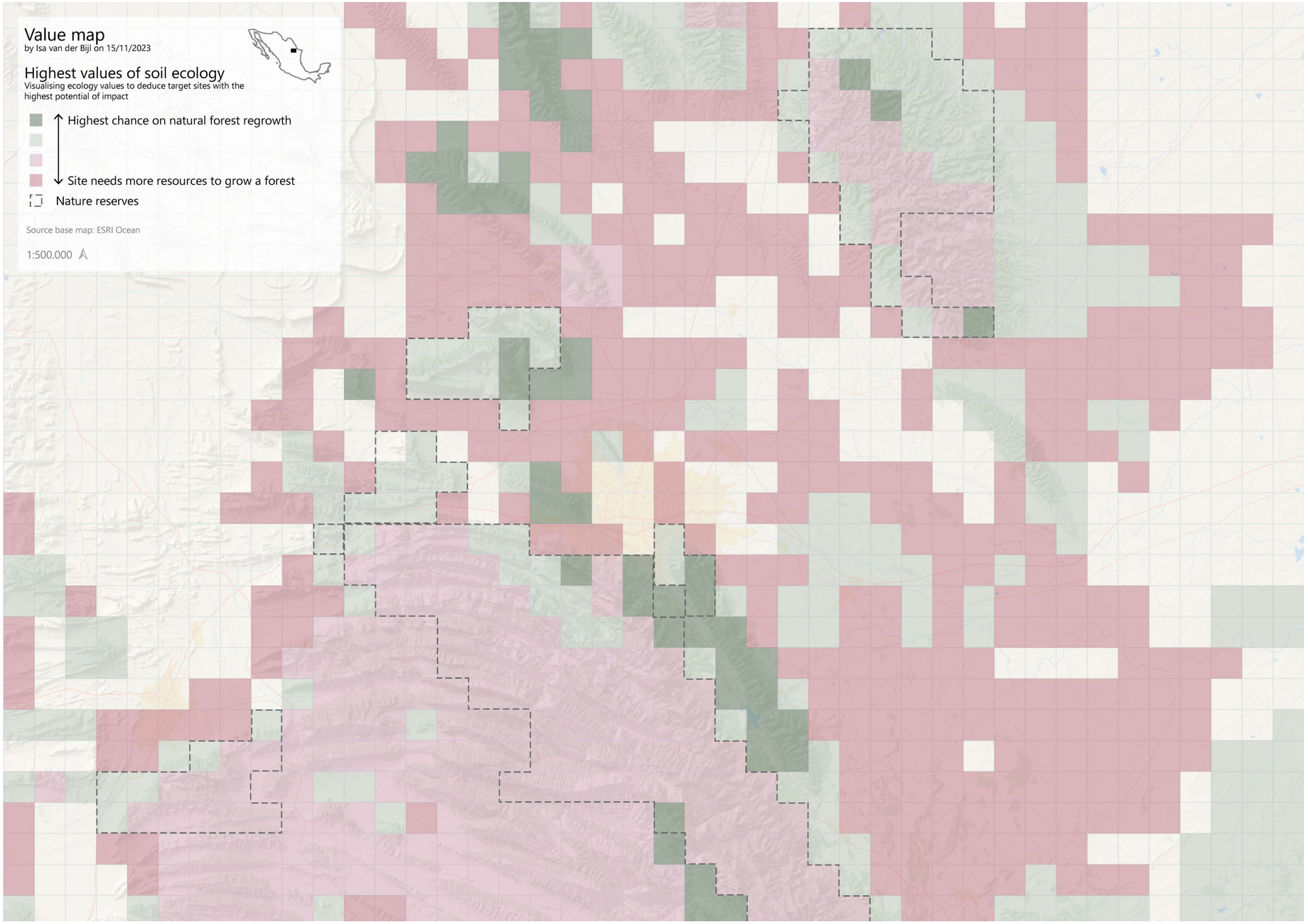
Highest chance on natural forest regrowth

Site needs more resources to grow a forest

Nature reserves

Soil ecology layers





Strategy
Inventory

STAKEHOLDER

- Citizen
- Residents
- Companies
- Community
- Municipality
- Government

URBAN

- [1] Formal community
- [2] Informal community
- [3] Gated community
- [4] Infrastructure
- [5] City centre
- [6] Small isolated villages
- [7] Public services and industry

LANDSCAPE

- [A] Forest
- [B] Shrubland
- [C] Grassland
- [D] Cropland
- [E] Barren land
- [F] Water system
- [G] Urban vegetation
- [H] Natural protected area

FORESTRY

- Production forest
  - Agroforestry
  - Village forest
- Climate forest
  - Buffer forest
  - Sponge forest
  - Cooling forest
- Biodiversity forest
  - Tiny forest
  - Garden forest
- Health forest
  - Infrastructure forest
  - Remediation forest
- Recreation forest
  - Forest boulevard
  - Forest corridors
  - Sport forest

Adapted from Flux. (2023, April 25). *Bossenboek - ontwerpend onderzoek naar nieuwe bostypes in Nederland*. Issuu. https://issuu.com/fluxlandscapearchitecture/docs/hlb_bossenboek_281122_spreads

Urban inventory

URBAN

[1] Formal community

[2] Informal community

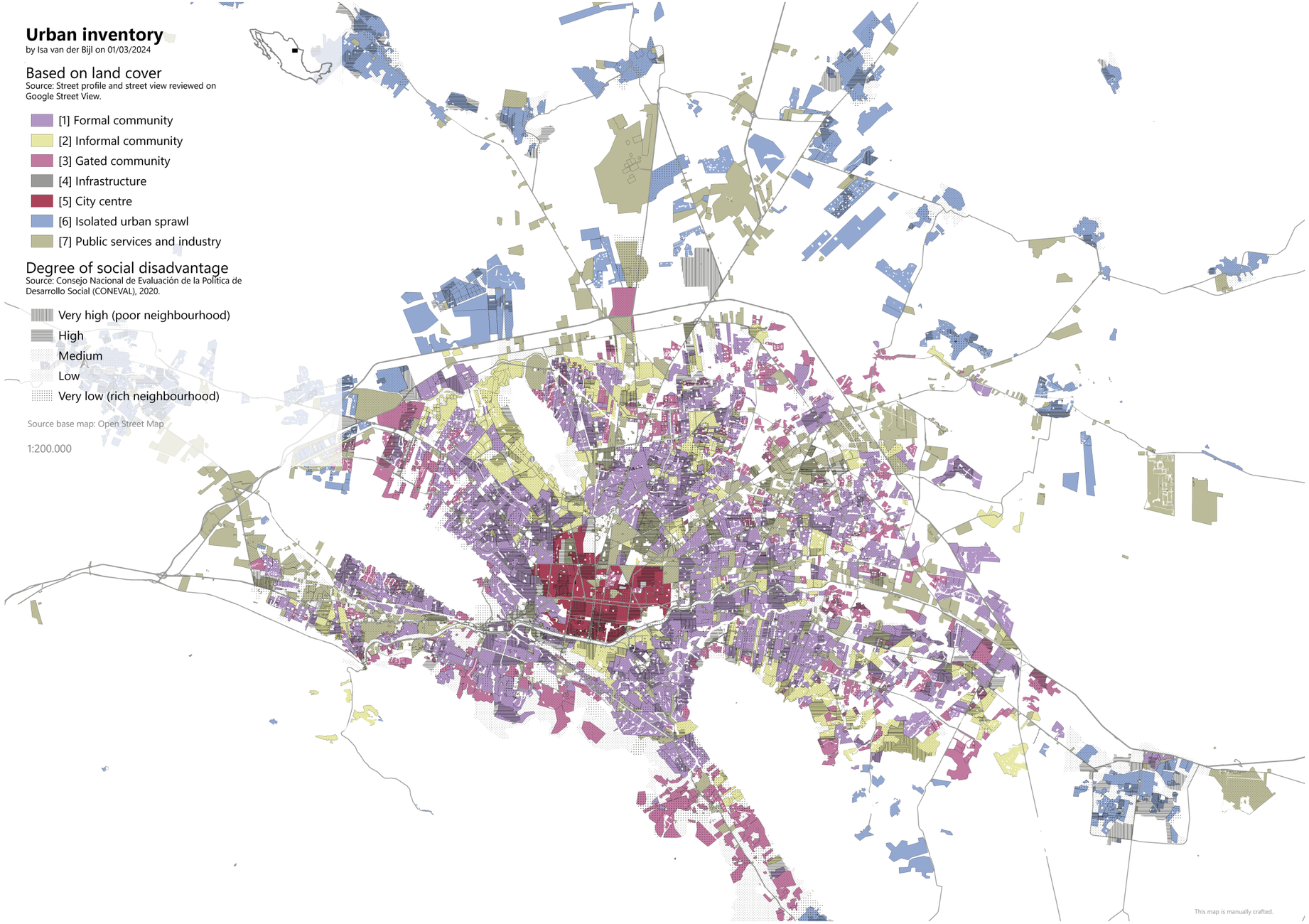
[3] Gated community

[4] Infrastructure

[5] City centre

[6] Small isolated villages

[7] Public services and industry



Landscape inventory

LANDSCAPE

[A] Forest

[B] Shrubland

[C] Grassland

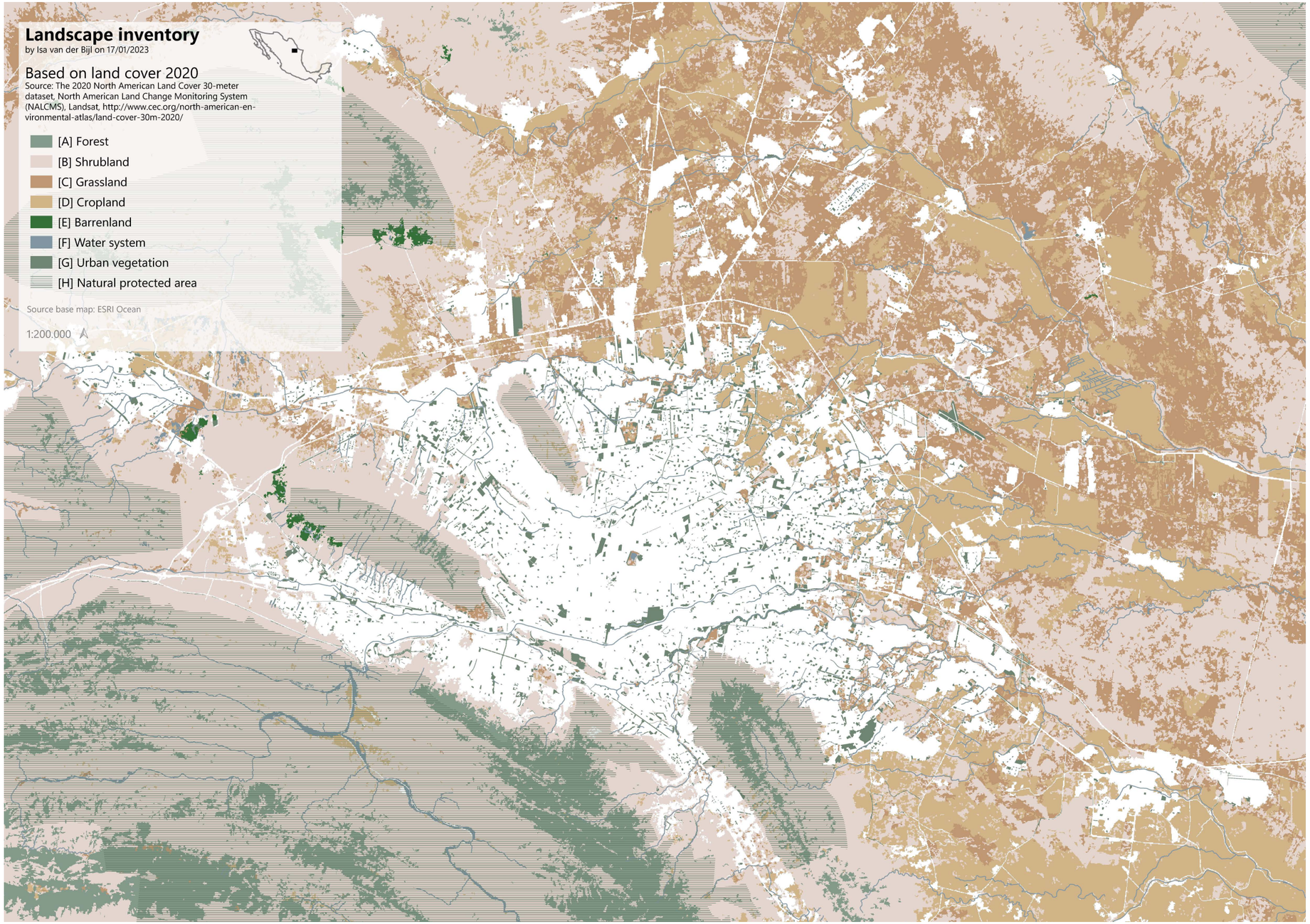
[D] Cropland

[E] Barren land

[F] Water system

[G] Urban vegetation

[H] Natural protected area



Forest catalogue

FORESTRY

Production forest
- Agroforestry
- Village forest

Climate forest
- Buffer forest
- Sponge forest
- Cooling forest

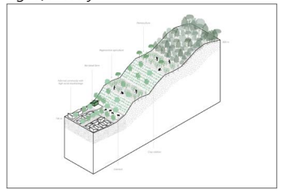
Biodiversity forest
- Tiny forest
- Garden forest

Health forest
- Infrastructure forest
- Remediation forest

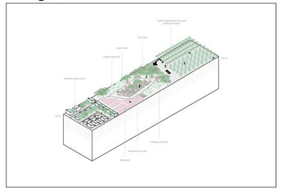
Recreation forest
- Forest boulevard
- Forest corridors
- Sport forest

PRODUCTION FORESTRY

Agroforestry

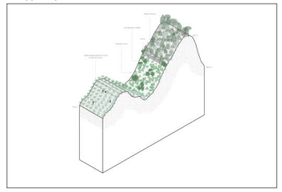


Village forest

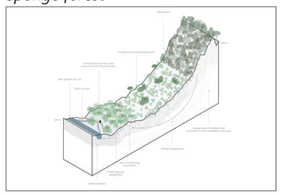


CLIMATE FORESTRY

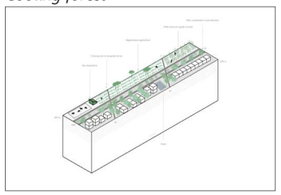
Buffer forest



Sponge forest

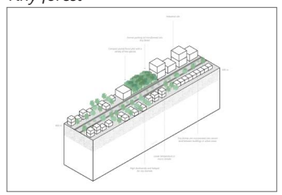


Cooling forest

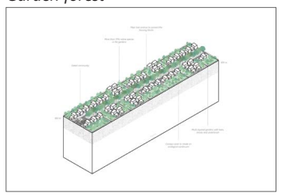


BIODIVERSITY FORESTRY

Tiny forest

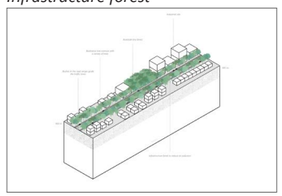


Garden forest

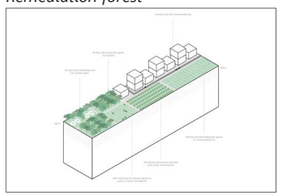


HEALTH FORESTRY

Infrastructure forest

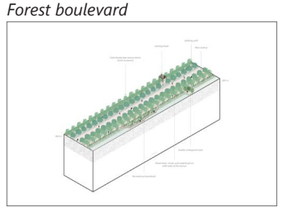


Remediation forest

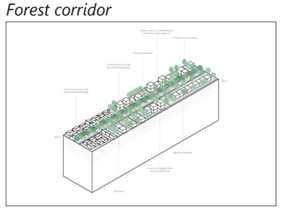


RECREATION FORESTRY

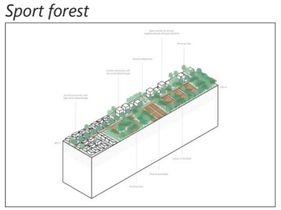
Forest boulevard



Forest corridor



Sport forest

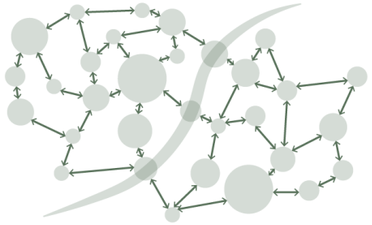


Forest catalogue

Backbone

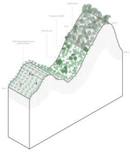
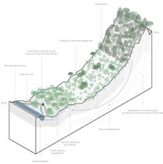
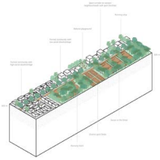
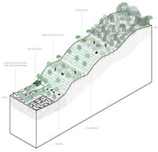
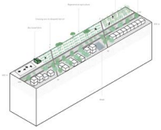
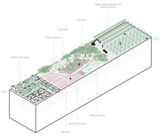
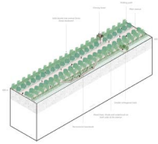
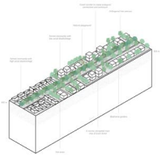
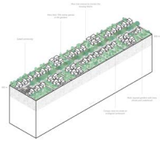
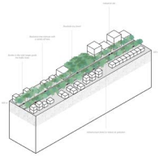
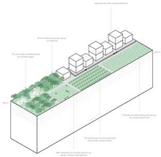
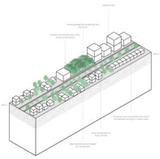


Continuum

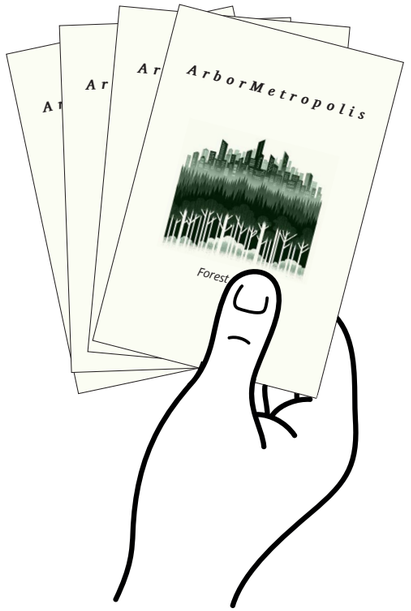


Patch



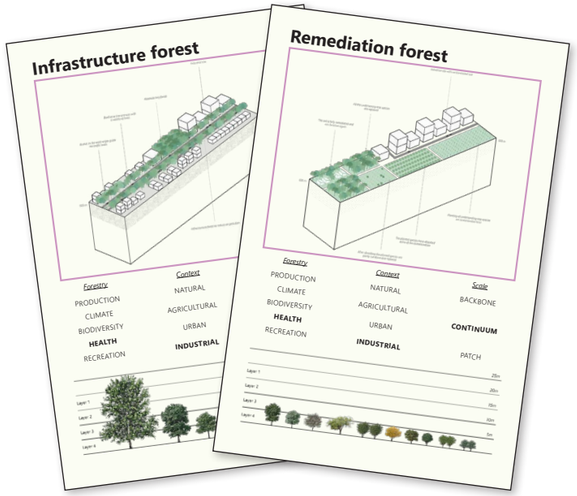
	BACKBONE	CONTINUUM	PATCH
NATURAL	 *Buffer forest*	 *Sponge forest*	 *Sport forest*
AGRICULTURAL	 *Agroforestry*	 *Cooling forest*	 *Village forest*
URBAN	 *Forest boulevard*	 *Forest corridor*	 *Garden forest*
INDUSTRIAL	 *Infrastructure forest*	 *Remediation forest*	 *Tiny forest*

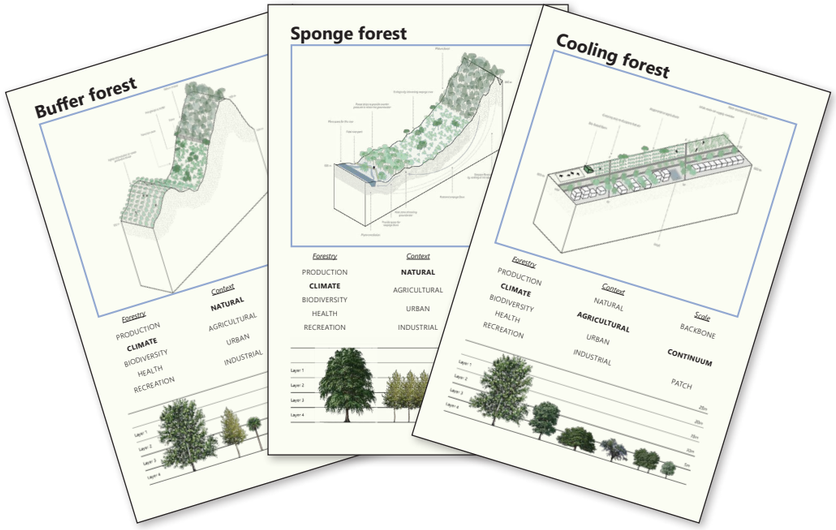
Forest catalogue cards

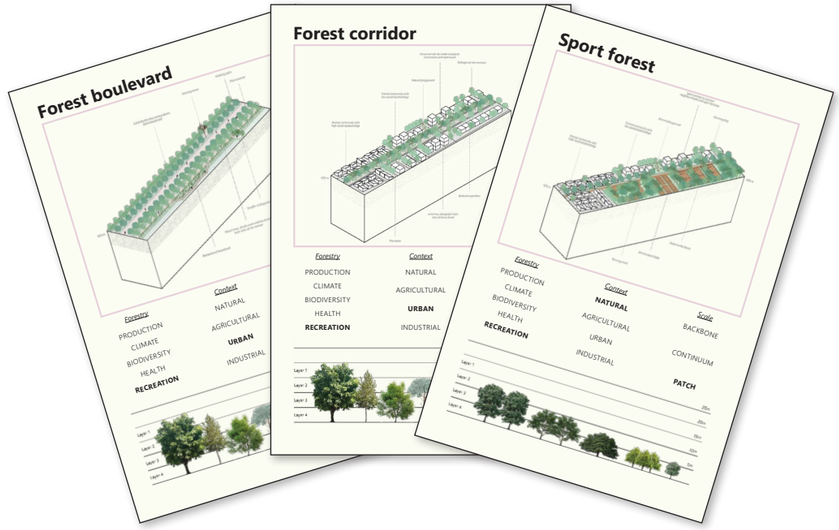












ArborMetropolis vision

FORESTRY

Forestry types


Agroforestry


Village forest


Cooling forest


Tiny forest


Remediation forest


Forest boulevard

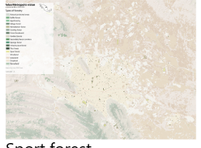

Buffer forest

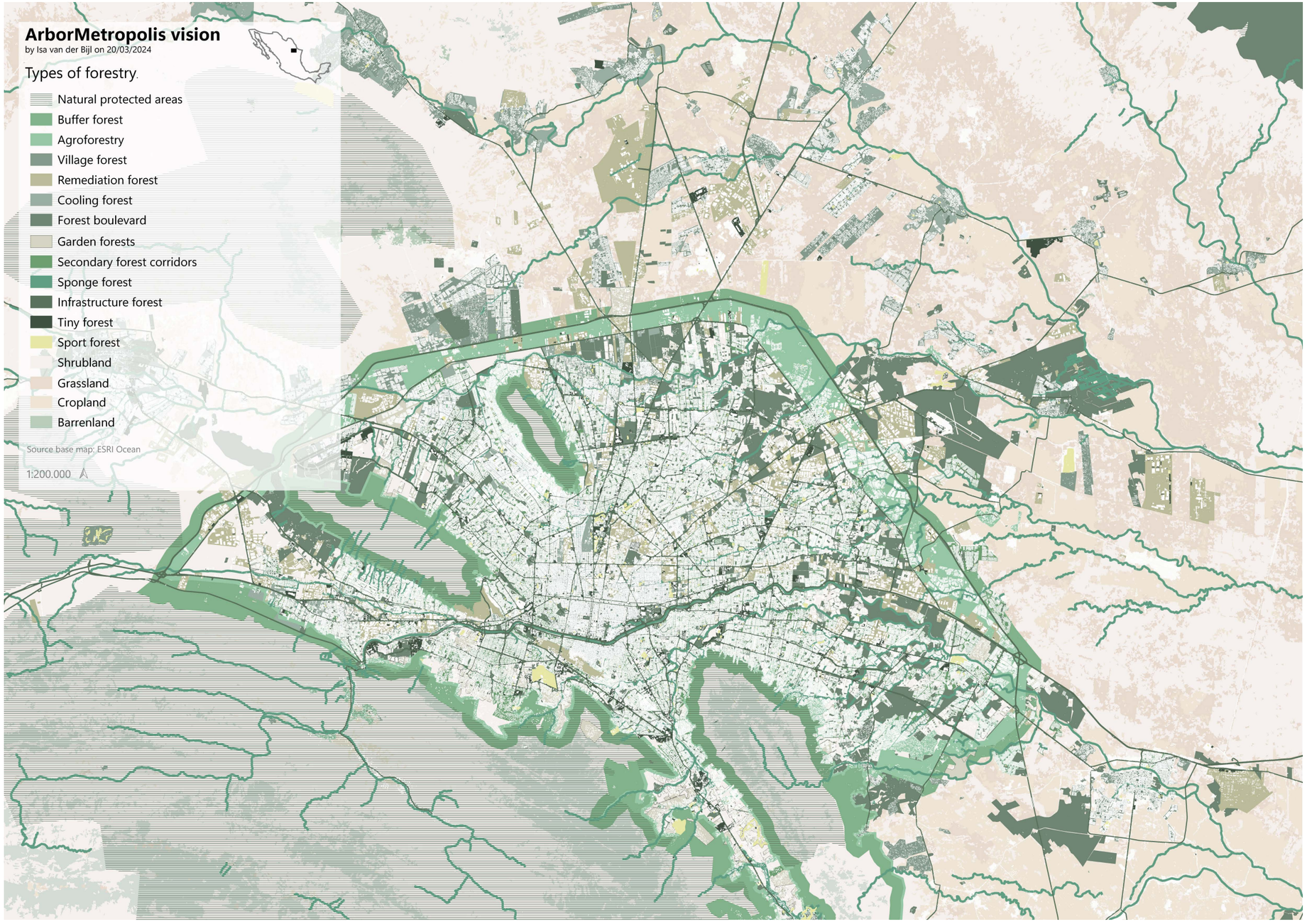

Sponge forest


Garden forest


Infrastructure forest


Forest corridors


Sport forest



Ecosystem services



Provisioning services

Food production
Wood production
Forest products
Food security

Regulating services

Water flow and quality regulation
Erosion control
Landslide protection
Water storage and retention
Flood protection
Micro climate control
Urban heat island mitigation
Air quality improvement
Soil remediation
Noise reduction

Cultural services

Recreation
Creation of jobs
Sense of place
Education
Community engagement
Ecotourism
Physical health benefits
Mental health benefits

Supporting services

Soil formation
Nutrient cycling
Soil stability
Waste decomposition
Detoxification of pollutants
Habitat provision
Species movement

Stakeholder framework

Private



Private companies



Private landowners



FAMM

Primary actors
- *Private companies*
- *Private landowners*
- *FAMM: Monterrey Metropolitan Environmental Fund*

Secondary actors
- *Communal land holders*
- *ITESM: Monterrey Institute of Technology and Higher Education*

Wider environment
- *SMEs: Local small and medium enterprises*
- *FEMSA: Fomento Económico Mexicano (a Mexican multinational beverage and retail company)*

Public



Municipal entities



INECC



PNCM

Primary actors
- *Municipalities of Monterrey Metropolitan Area*
- *INECC: National Institute of Ecology and Climate Change*
- *PNCM: National Park Cumbres de Monterrey*

Secondary actors
- *State of Nuevo León*
- *CONABIO: National Commission for the Knowledge and Use of Biodiversity*
- *CONAFOR: National Forestry Commission*
- *CONANP: National Commission of Natural Protected Areas*

Wider environment
- *CONAGUA: National Water Commission*
- *SEMARNAT: Secretariat of Environment and Natural Resources*
- *SEDATU: Secretariat of Agrarian, Land, and Urban Development*
- *SECTUR: Secretariat of Tourism*

Civic



RE



Local residents



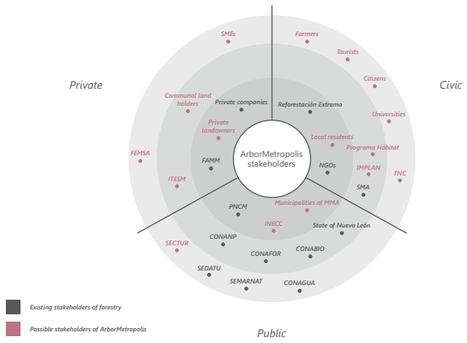
NGOs

Primary actors
- *RE: Reforestación Extrema*
- *Local residents*
- *NGOs: Non-Governmental Organizations*

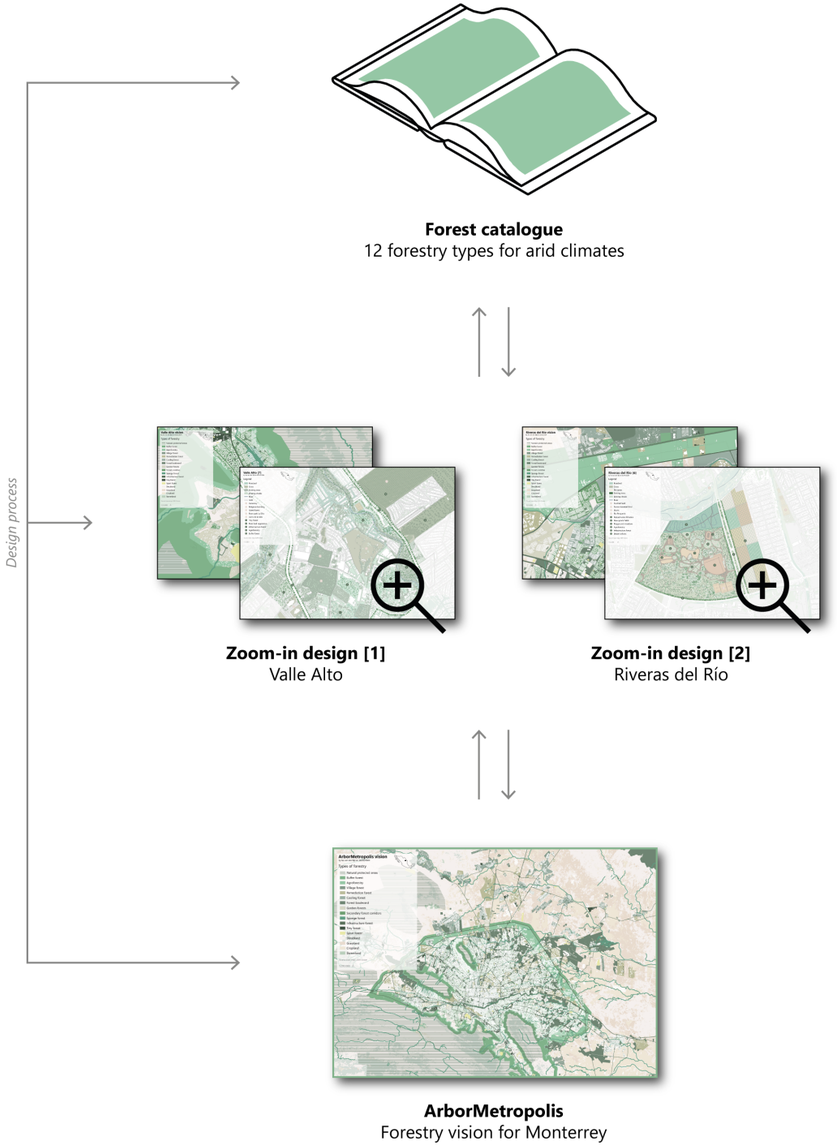
Secondary actors
- *Progama Hábitat*
- *SMA: Secretariat of the Environment*
- *IMPLAN: Municipal Institute of Urban Planning and Coexistence of Monterrey*

Wider environment
- *Farmers*
- *Tourists*
- *Citizens*
- *Universities*
- *TNC: The Nature Conservancy*

Stakeholder diagram



Design framework



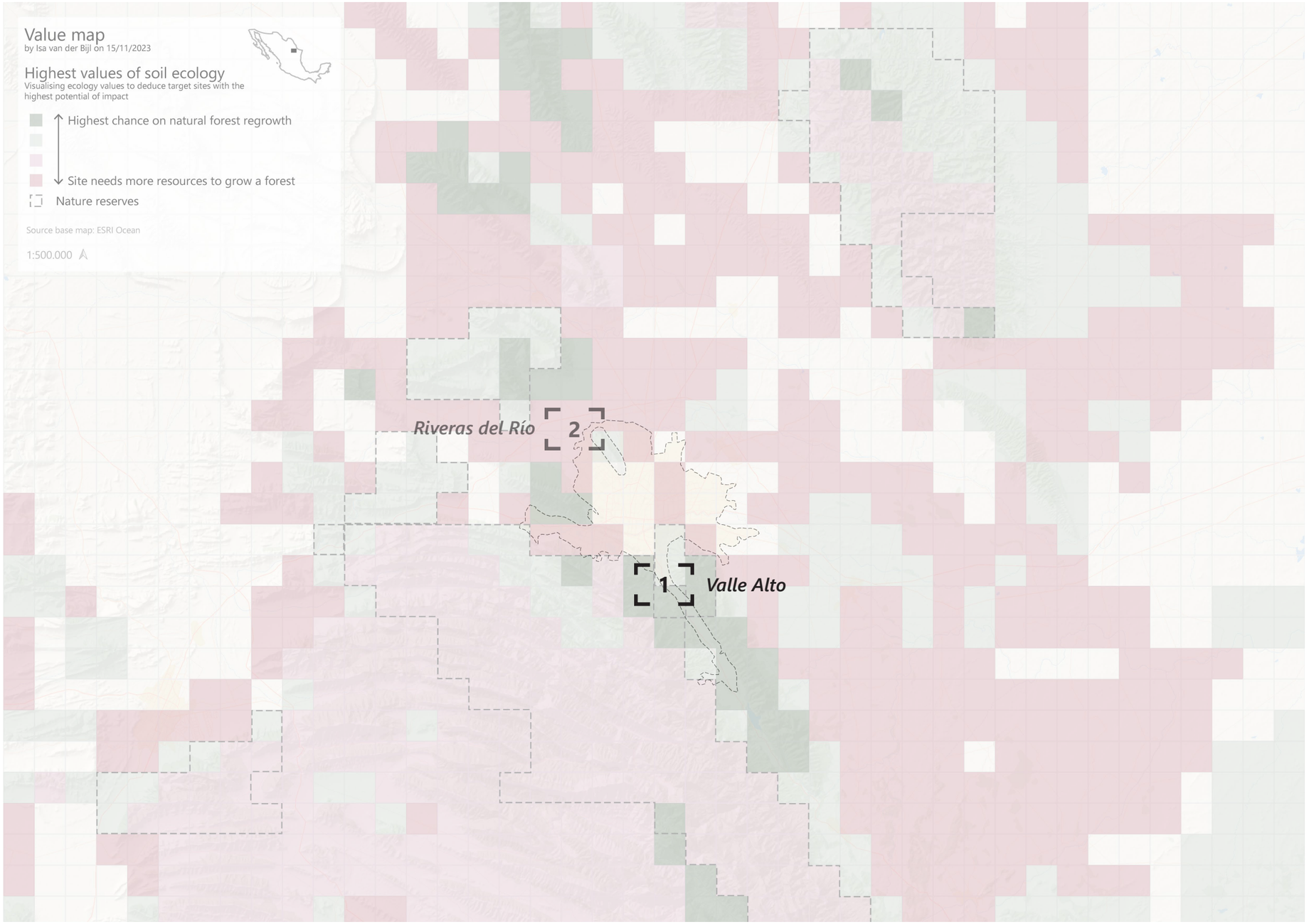
4.
DESIGN INTERVENTIONS

Zoom-in locations

Most impactful to intervene

Most critical to intervene

Nature reserves

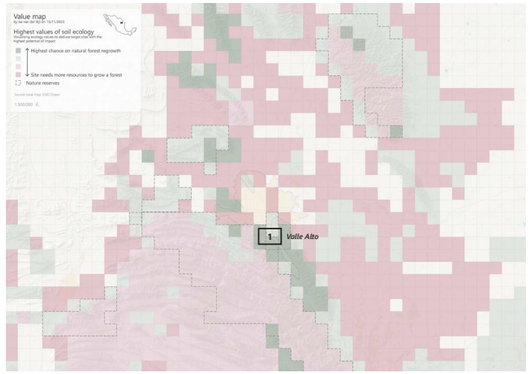


Valle Alto
Zoom-in location [1]

Neighbourhood built between two nature reserves.

Gated communities are still claiming land.

Highway as ecological barrier.





Typologies



[1]
Formal community



[2]
Informal community



[3]
Gated community



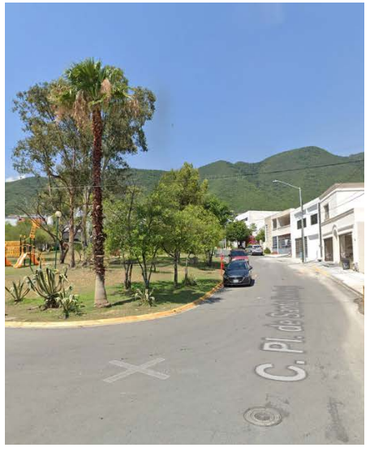
[7]
Public services and industry



[F]
Water system



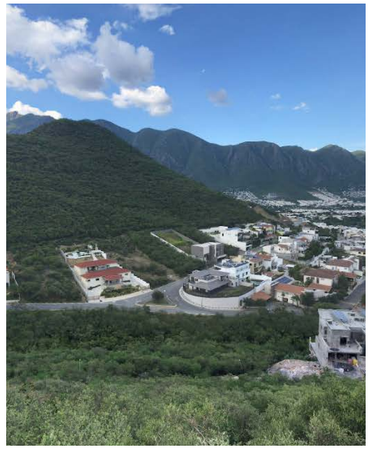
[G]
Urban vegetation



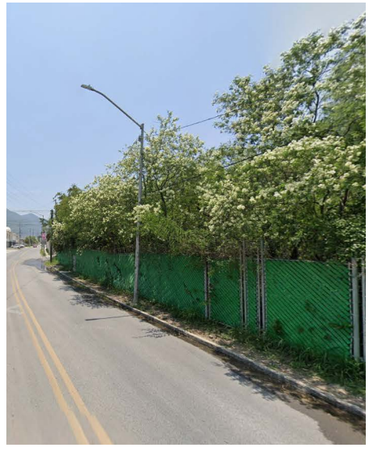
Plaza de Santo Domingo



Santa Anita street



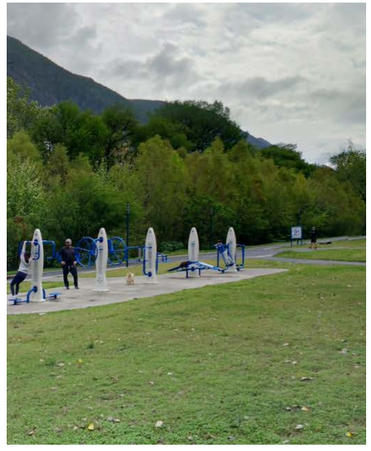
Community Rincon de las Aves around a hill



Gated forest



River that leads to Chipinque



Río la Silla natural park

Google Maps. (2023, June). *22 C. Pl. de Santo Domingo* [Street view]. Retrieved January, 30, 2024. Google Maps.

Google Maps (2022, December). *1515 Sta. Anita* [Street view]. Retrieved January, 30, 2024. Google Maps.

Villa Roa, L. (2019, July). *Rincon de las Aves* [Street view]. Retrieved January, 30, 2024. Google Maps.

Google Maps. (2021, June). *5517 Loma de Los Pinos* [Street view]. Retrieved April, 3, 2024. Google Maps.

De Loss, S. (2021, April). *Cañada del Pinal*. Wikiloc: Trails of the World. https://www.wikiloc.com/hiking-trails/canada-del-pinal-70378625/photo-46333612

Dávila, A. (2017, March). *Río la Silla natural park* [Street view]. Retrieved January, 30, 2024. Google Maps.

Opportunities

Valle Alto

[1] Formal community



[2] Informal community



[3] Gated community



[7] Public services and industry



[F] Water systen



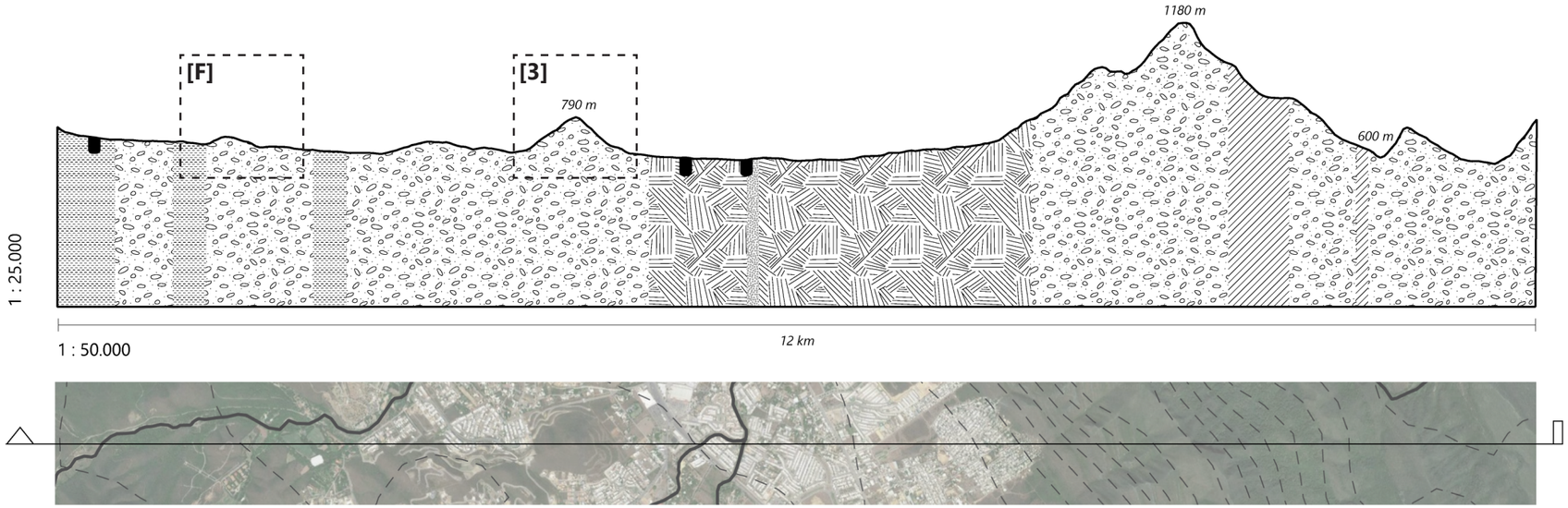
[G] Urban vegetation





Soil types

Both type of soils are able to grow trees and plants, but different species.



Transverse

Legend

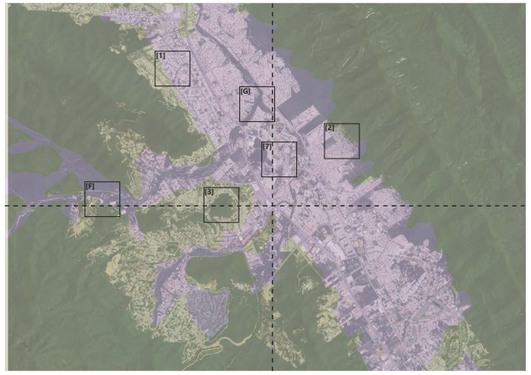
- Softer soil types
- Rocky soil types

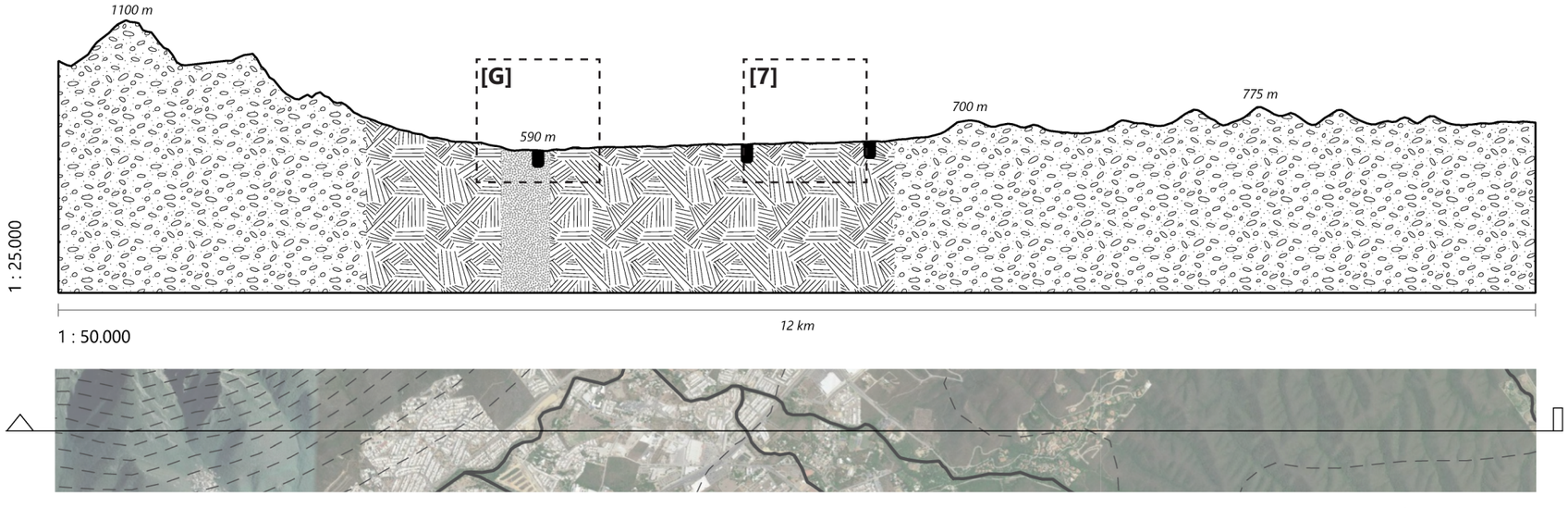
Soils with limitations to root growth
Leptosol *(thin or with many coarse fragments)*

Pronounced accumulation of organic matter in the mineral topsoil
Phaeozem *(dark topsoil, no secondary carbonates (unless very deep), high base status)*

Soils with clay-enriched subsoil
Luvisol *(high-activity clays, exchangeable base cations)*

Soils with little or no profile differentiation
Fluvisol *(stratified fluviatile, marine or lacustrine sediments)*
Regosol *(no significant profile development)*

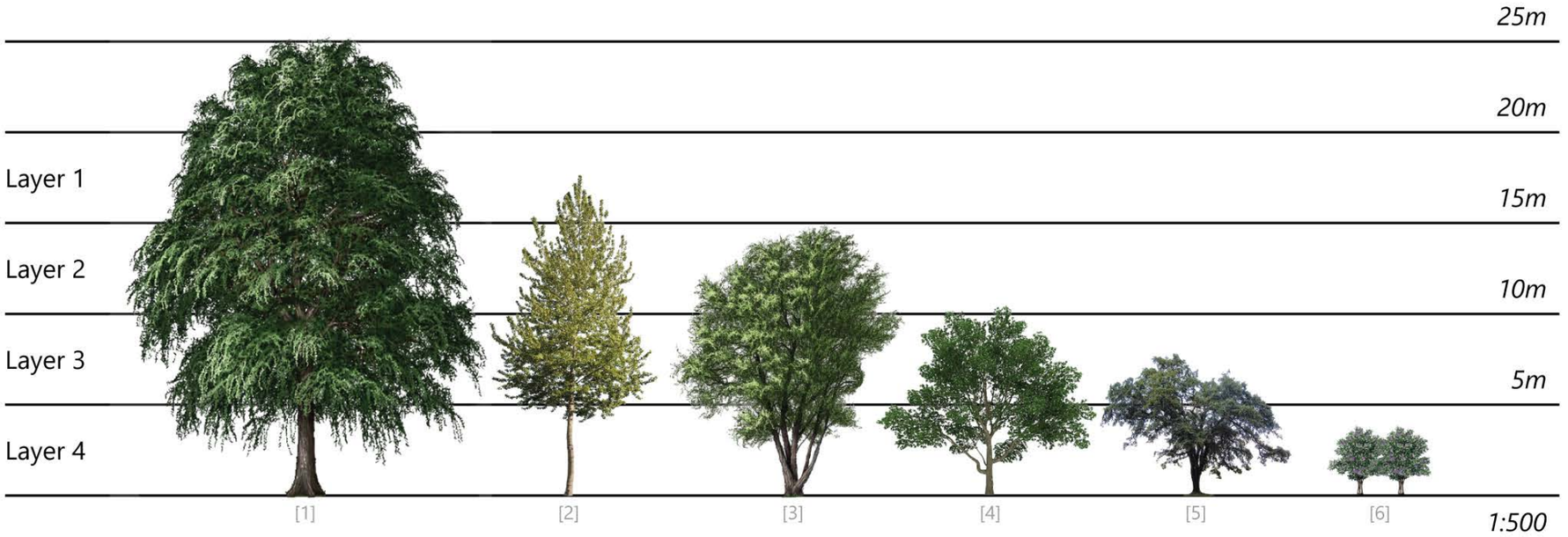




Longitudinal

Tree species selection

Valle Alto



Layer 1

Taxodium mucronatum [1]
Platanus occidentalis mexicana
Populus tremuloides [2]

Layer 2

Junglas mollis
Salix nigra [3]
Quercus polymorpha

Layer 3

Quercus virginiana [4]
Quercus canbyi
Quercus laceyi
Quercus graciliformis
Quercus fusiformis
Ulmus crassifolia [5]
Ehretia anacua
Sapindus saponaria
Sargentia greggii

Layer 4

Cordia boissieri
Diospyros texana
Ungnadia speciosa
Sophora secundiflora [7]

Design vision

Valle Alto

[1] Forest corridor



[2] Agroforestry



[3] Garden forest



[7] Tiny forest

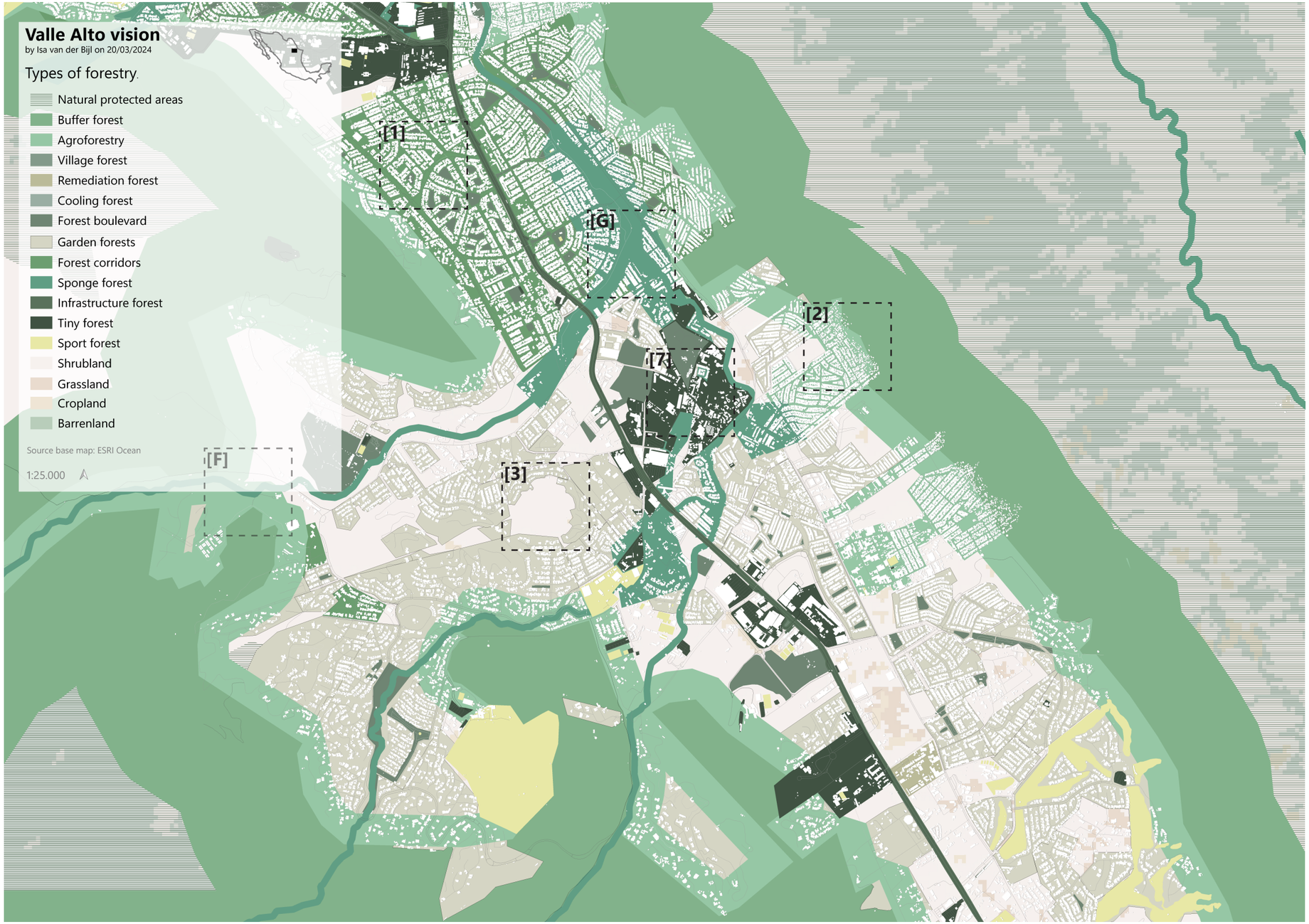


[F] Sponge forest

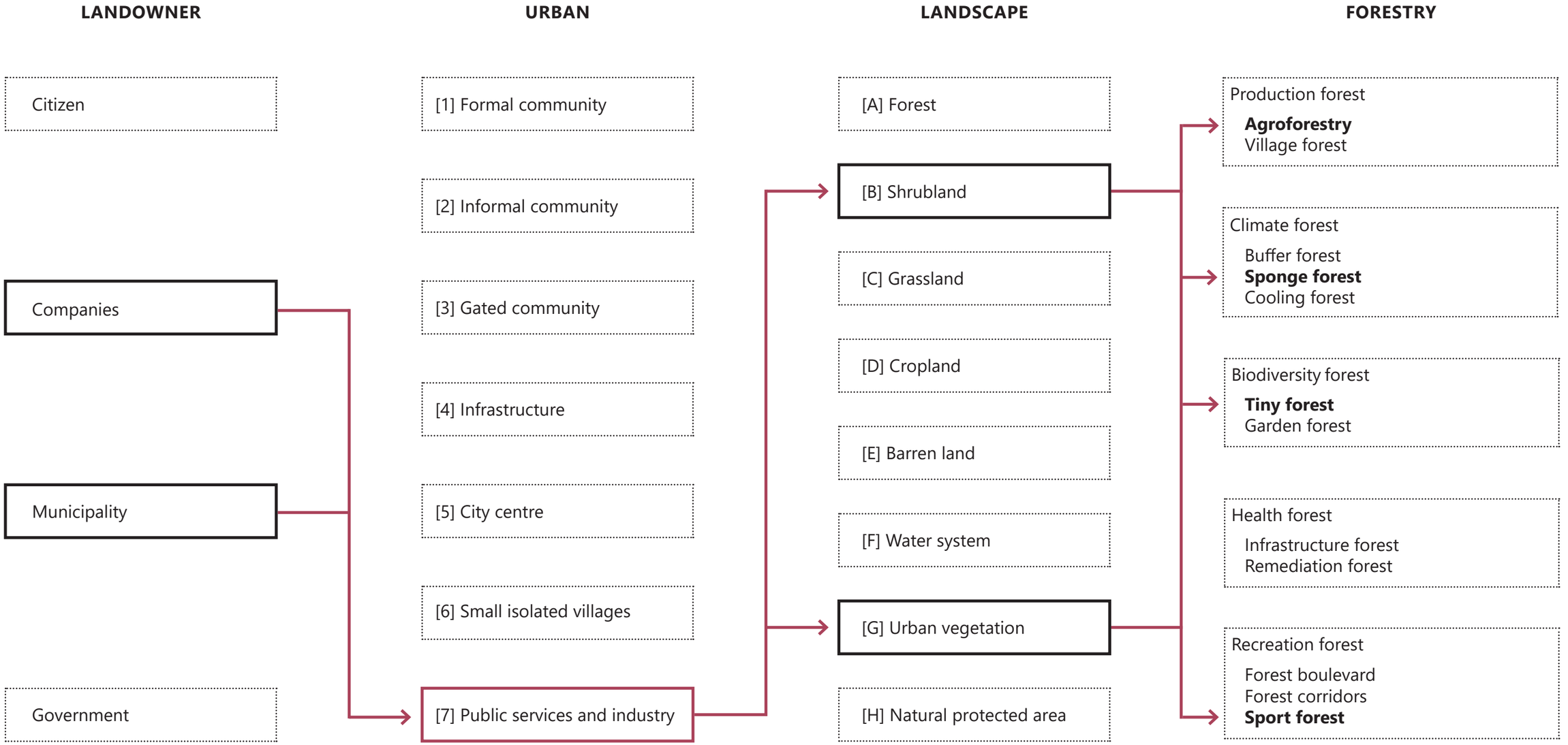


[G] Sponge forest





Strategy
Inventory



Existing situation

[7] Valle Alto



Gated forest



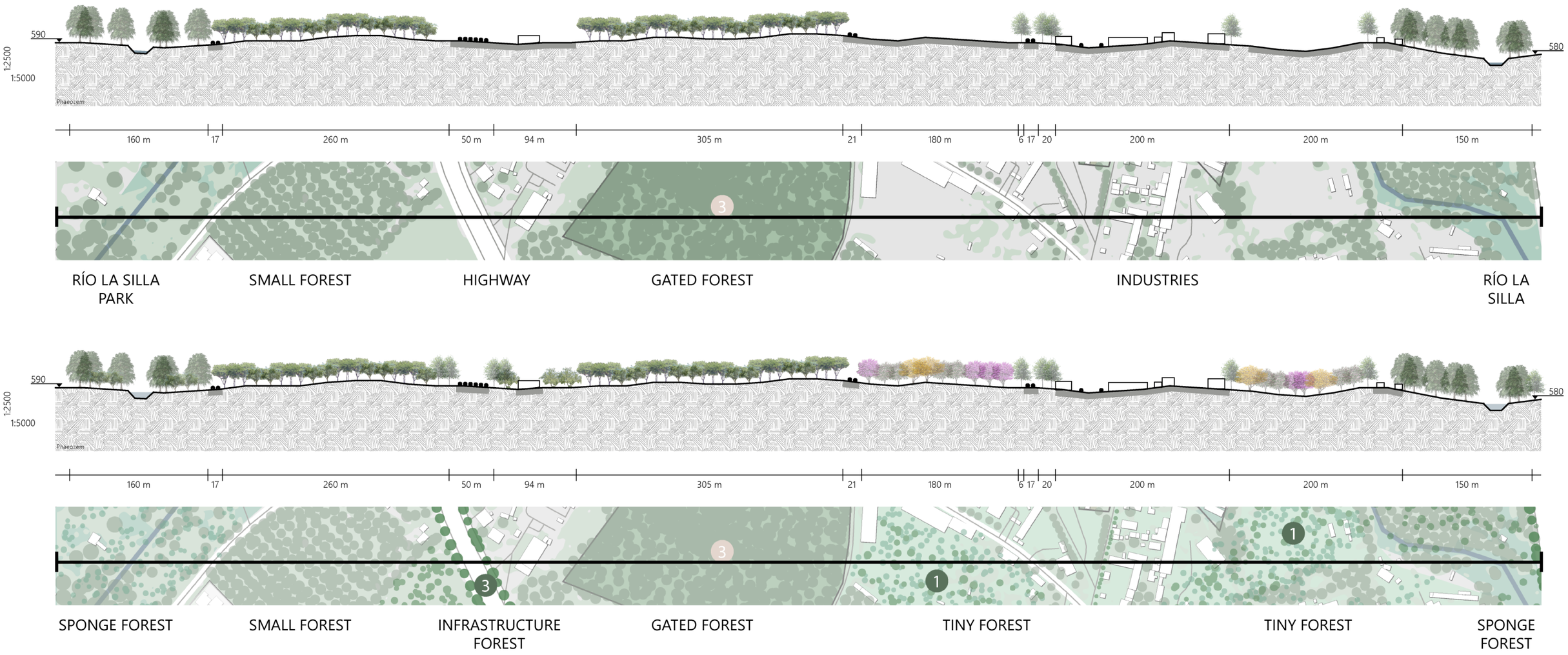
Tiny forest vision

[7] Valle Alto



Tiny forest vision

[7] Valle Alto



Sport forest

[7] Valle Alto



Dávila, A. (2017, March). *Río la Silla natural park* [Street view]. Google Maps. https://maps.app.goo.gl/wErpp9CLRjPR9TpCA



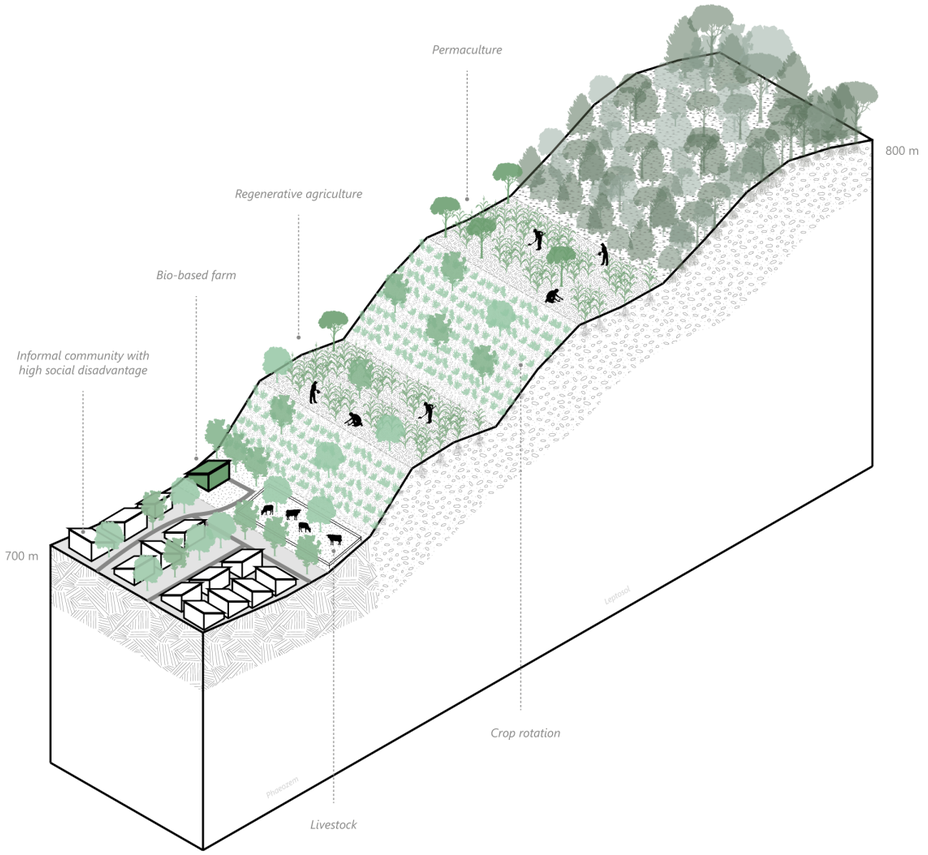




Agroforestry

Production forestry

Agricultural backbone



Ecosystem services

Food production	Wood production	Forest products	Food security	Erosion control	Landslide protection	Creation of jobs	Community engagement	Soil formation	Nutrient cycling	Soil stability



Layer 1

Layer 2

Junglas mollis [1]
Sabal mexicana [2]

Layer 3

Quercus virginiana [3]
Quercus fusiformis
Ebenopsis ebano [4]
Celtis laevigata
Ehretia anacua
Sapindus saponaria
Prosopis glandulosa
Chilopsis linearis
Parkinsonia aculeata [5]
Sargentia greggii
Sideroxylon celastrinum
Caesalpinia mexicana
Parkinsonia texana

Layer 4

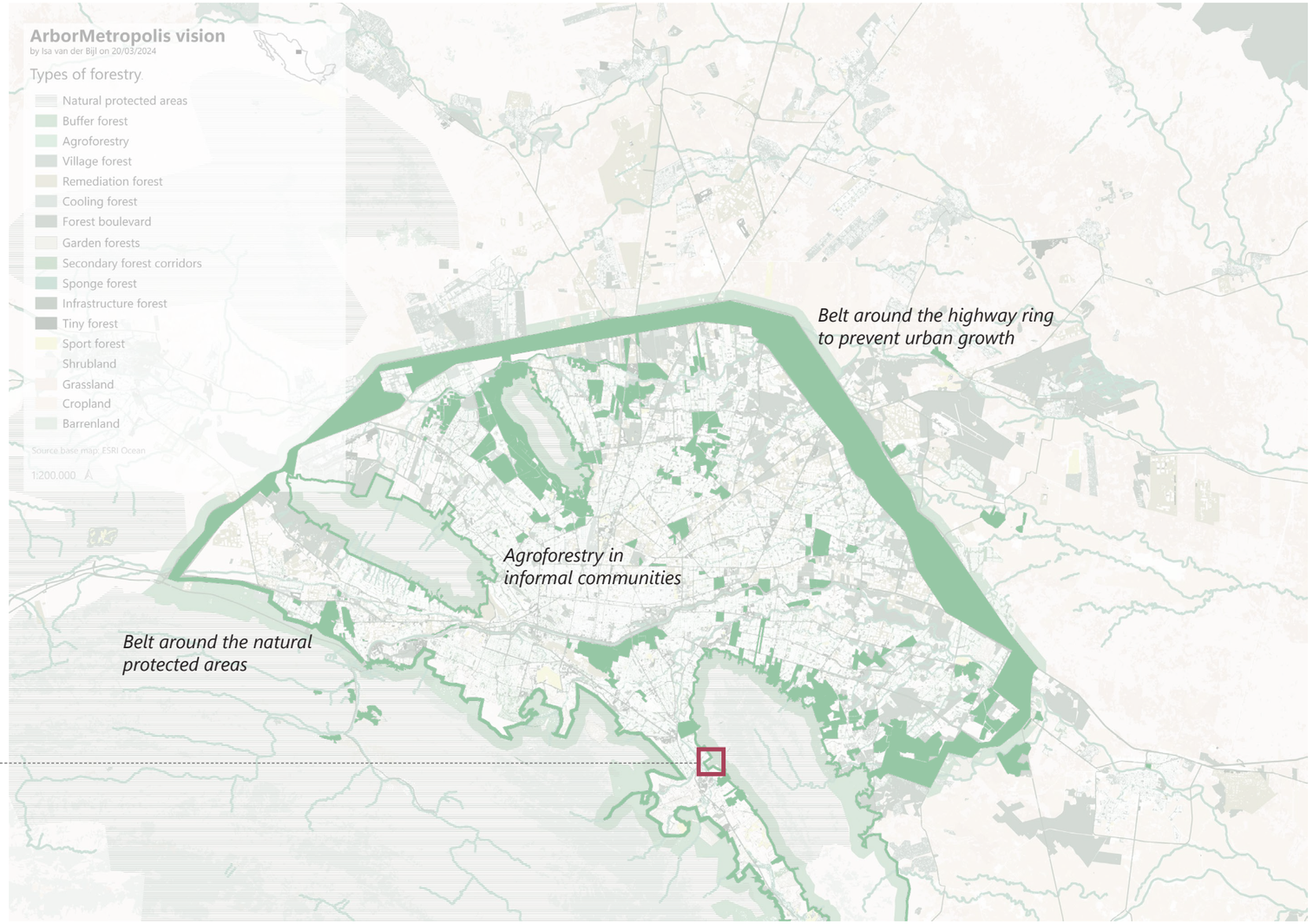
Acacia farnesiana [6]
Cordia boissieri
Diospyros texana
Yucca filifera
Acacia rigidula
Sophora secundiflora
Acacia berlandieri
Dodonaea viscosa
Celtis ehrenbergiana
Leucophyllum frutescens [7]
Larrea tridentata [8]
Agave americana [9]

Agroforestry

[7] Valle Alto

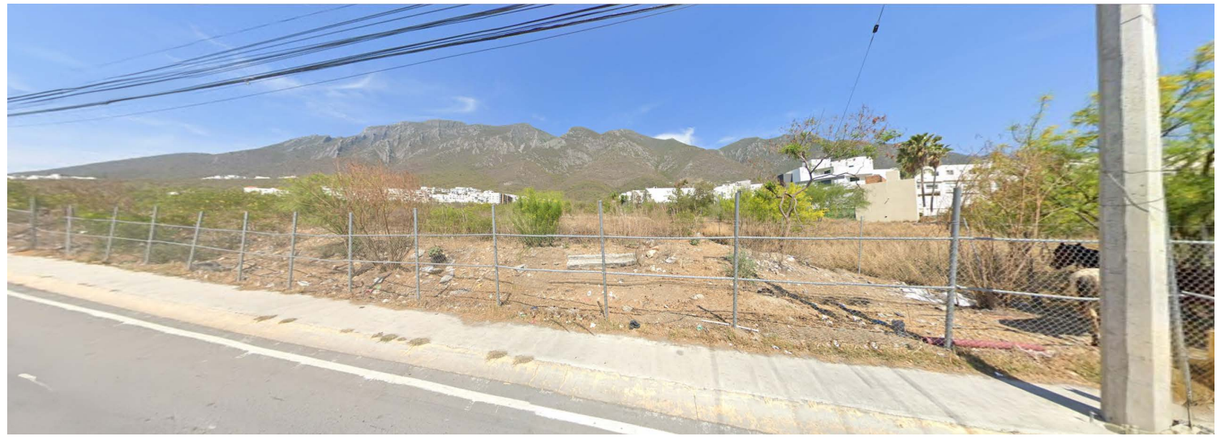






Agroforestry

[7] Valle Alto



Google Maps. (2023, March). *Eje Metropolitano 31* [Street view]. Google Maps. https://maps.app.goo.gl/c3A3VQRRQMhtNxjq7

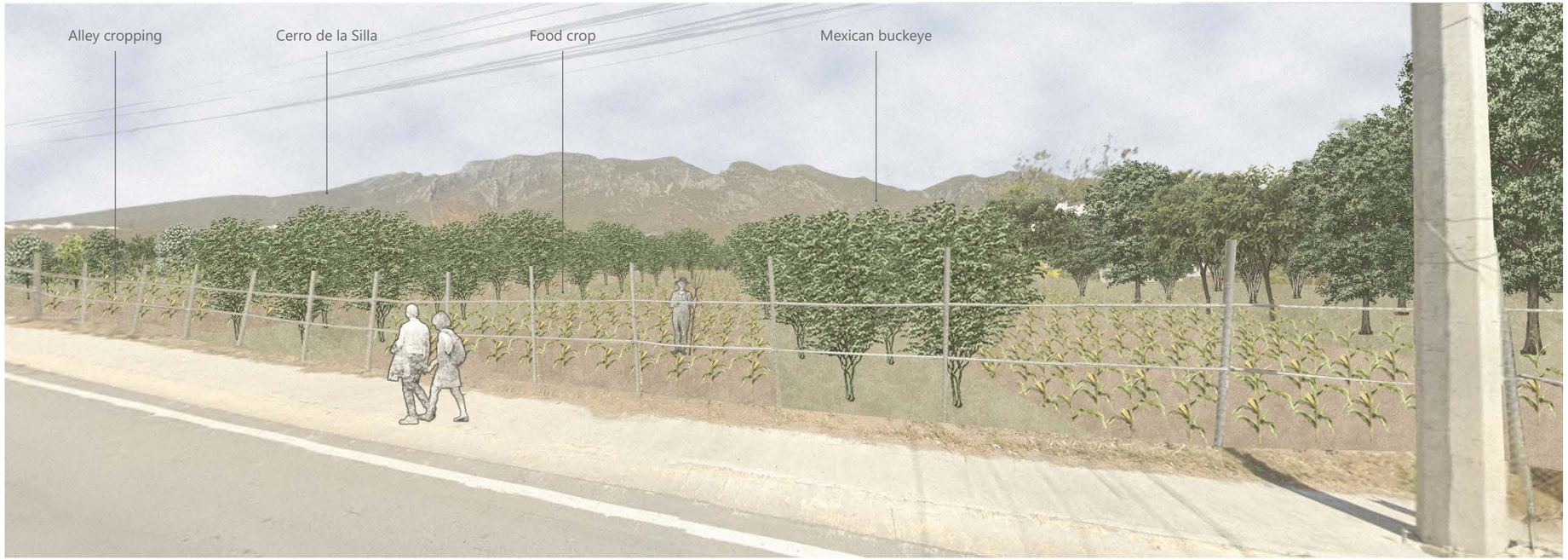


Enhance ecosystem services

Defragment the natural landscape

Harmonize human-nature relationships





Tiny forest

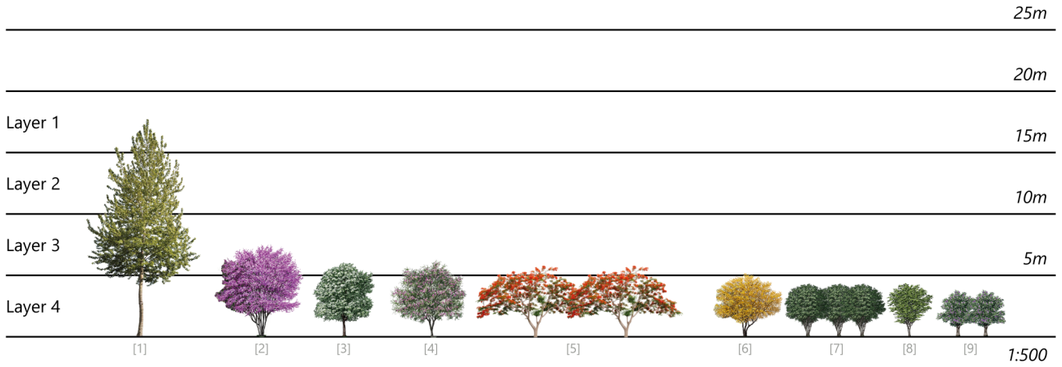
Biodiversity forestry

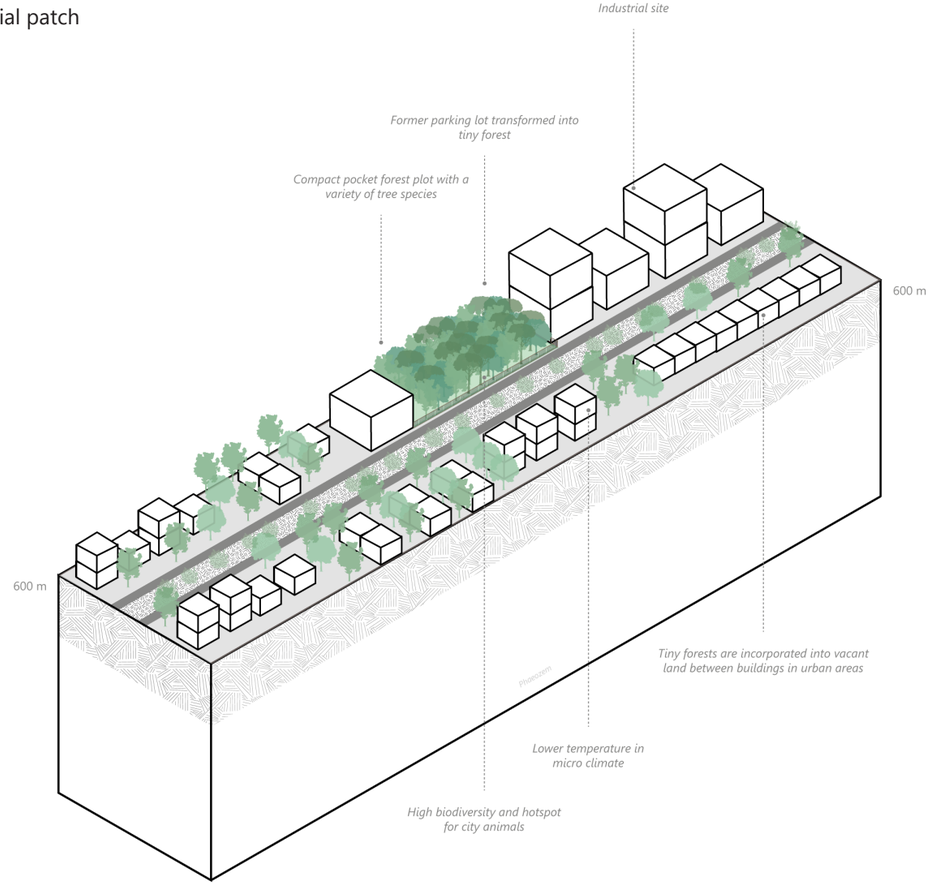


Industrial patch

Ecosystem services

Micro climate control	Urban heat island mitigation	Air quality improvement	Noise reduction	Sense of place	Education	Habitat provision





Adapted from Flux (2023).

Layer 1

Platanus occidentalis mexicana
Populus tremuloides [1]

Layer 2

Layer 3

Ebenopsis ebano
Celtis laevigata
Cercis canadensis var. mexicana [2]
Ehretia anacua [3]
Sapindus saponaria
Chilopsis linearis [4]
Sargentia greggii
Caesalpinia mexicana [5]

Layer 4

Acacia farnesiana [6]
Cordia boissieri
Diospyros texana [7]
Ungnadia speciosa [8]
Tecoma stans
Sophora secundiflora [9]

Tiny forest

[7] Valle Alto



Private companies



NGOs



Local residents





Tiny forest

[7] Valle Alto



Google Maps. (2017, August). *Monterrey, Nuevo Leon* [Street view]. Google Maps. https://maps.app.goo.gl/esaCGL98YgbcXZRg6

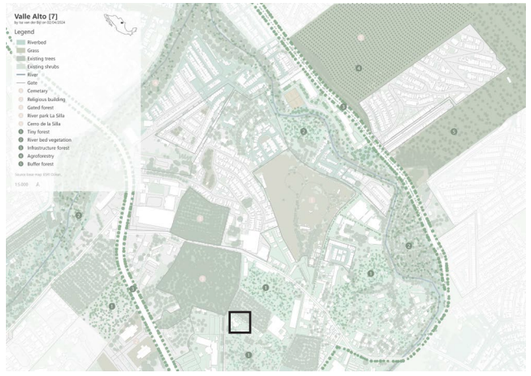
Enhance ecosystem services

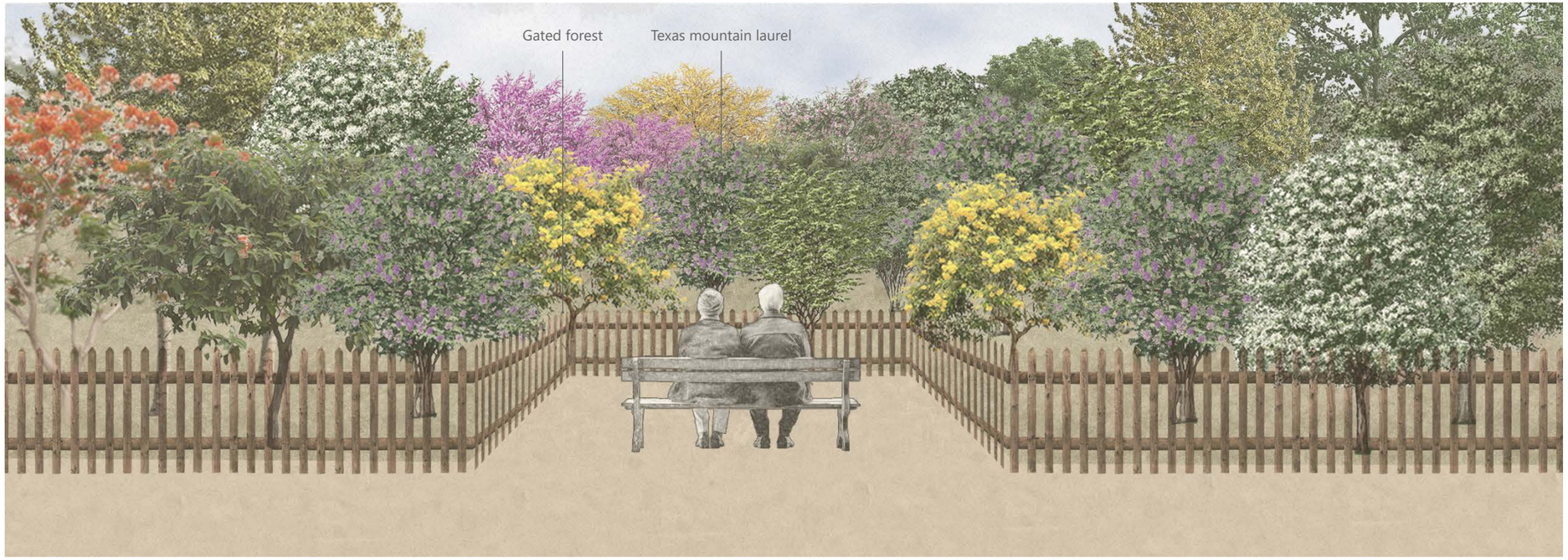


Defragment the natural landscape



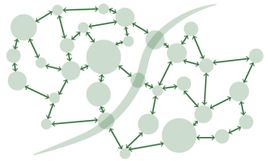
Harmonize human-nature relationships





Sponge forest

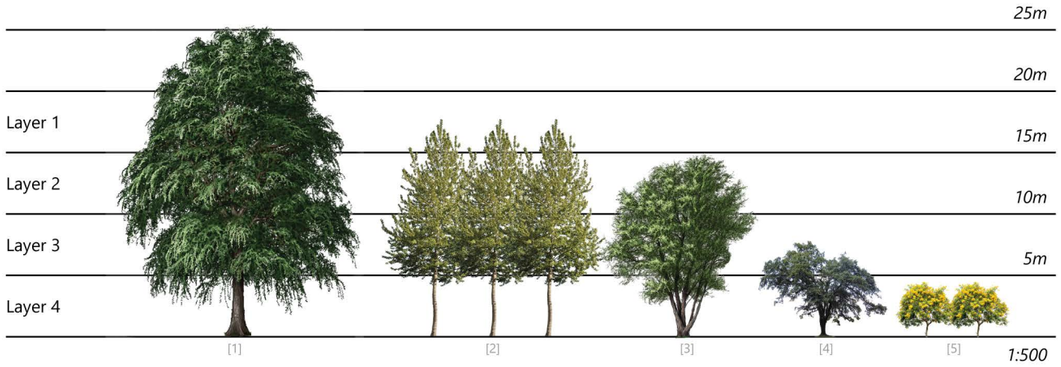
Climate forestry



Natural continuum

Ecosystem services

Water flow and quality regulation	Landslide protection	Water storage and retention	Flood protection	Soil remediation	Recreation	Ecotourism	Soil stability	Waste de-composition	Detoxification of pollutants	Species movement



Layer 1

Taxodium mucronatum [1]
Platanus occidentalis mexicana
Populus tremuloides [2]

Layer 2

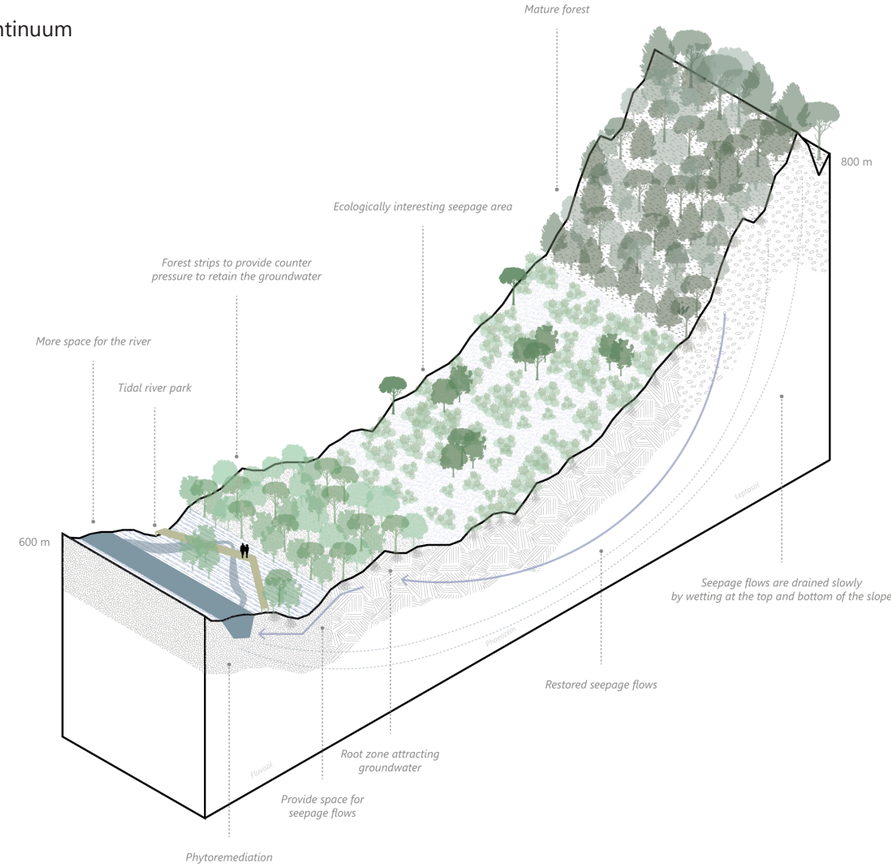
Junglas mollis
Salix nigra [3]

Layer 3

Quercus virginiana
Ulmus crassifolia [4]
Sapindus saponaria
Sargentia greggii

Layer 4

Tecoma stans [5]

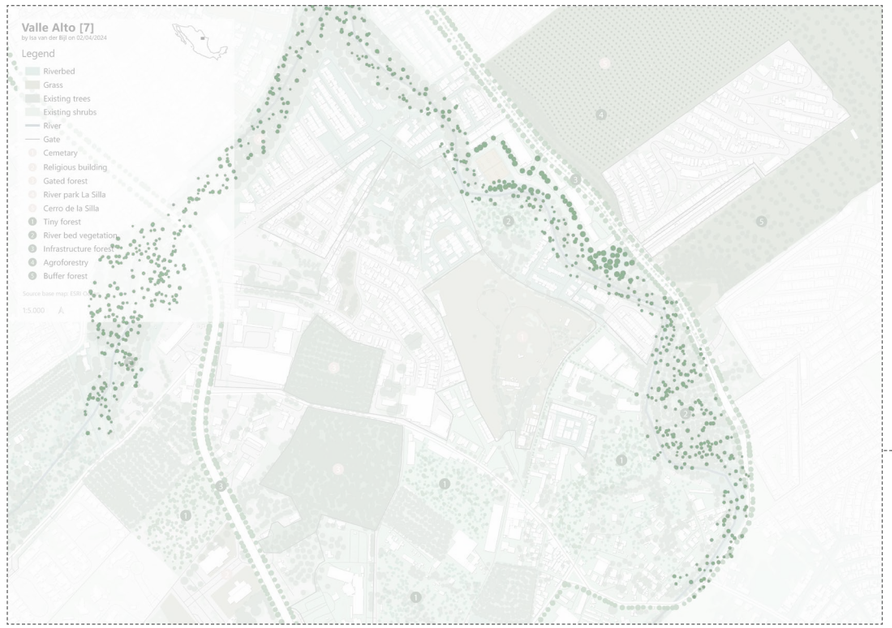


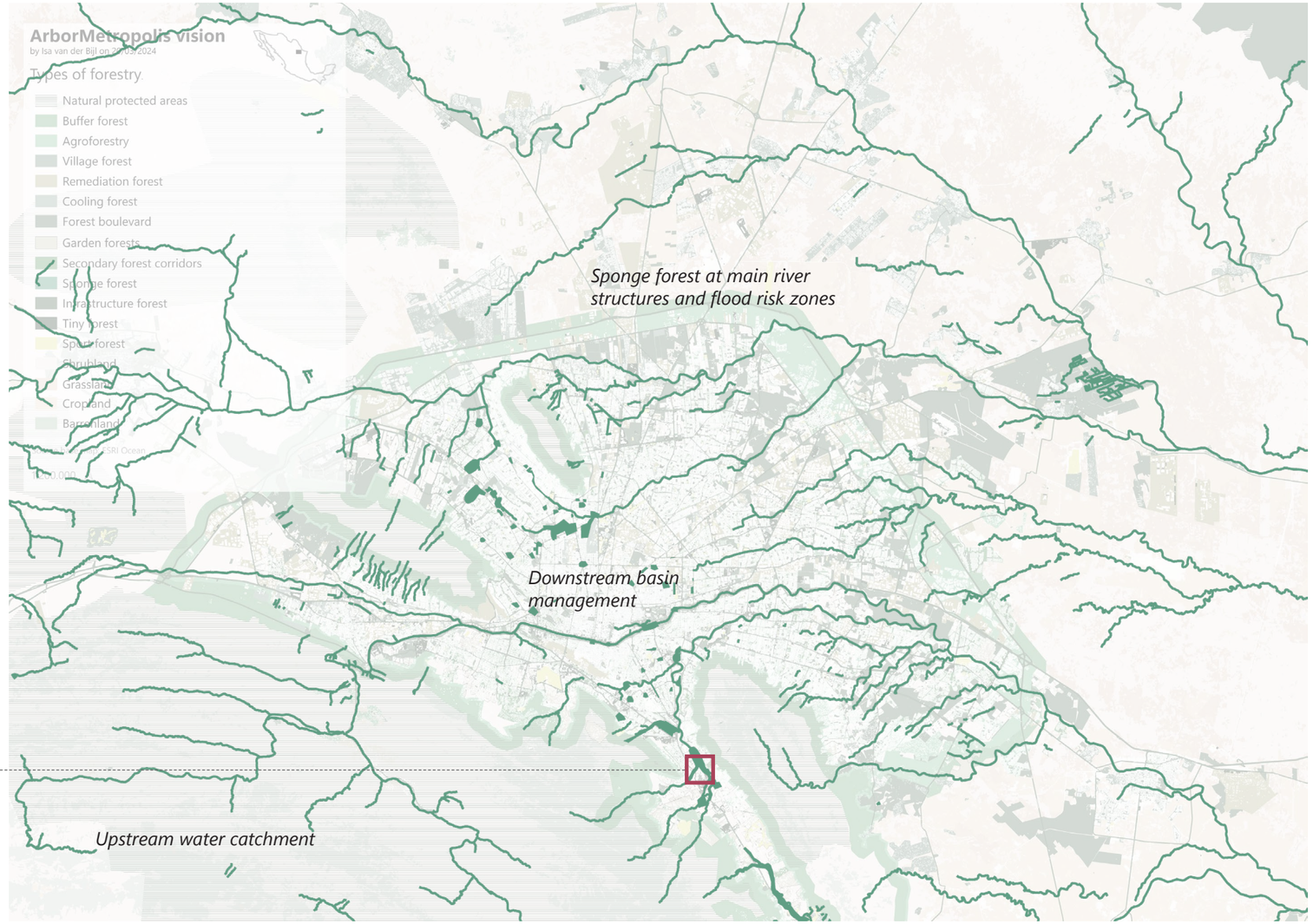
Adapted from Flux (2023).

Sponge forest

[7] Valle Alto







Sponge forest

[7] Valle Alto



Google Maps. (2023, June). *Eje Metropolitano 31* [Street view]. Google Maps. https://maps.app.goo.gl/7fzTHahihe38YGRs7

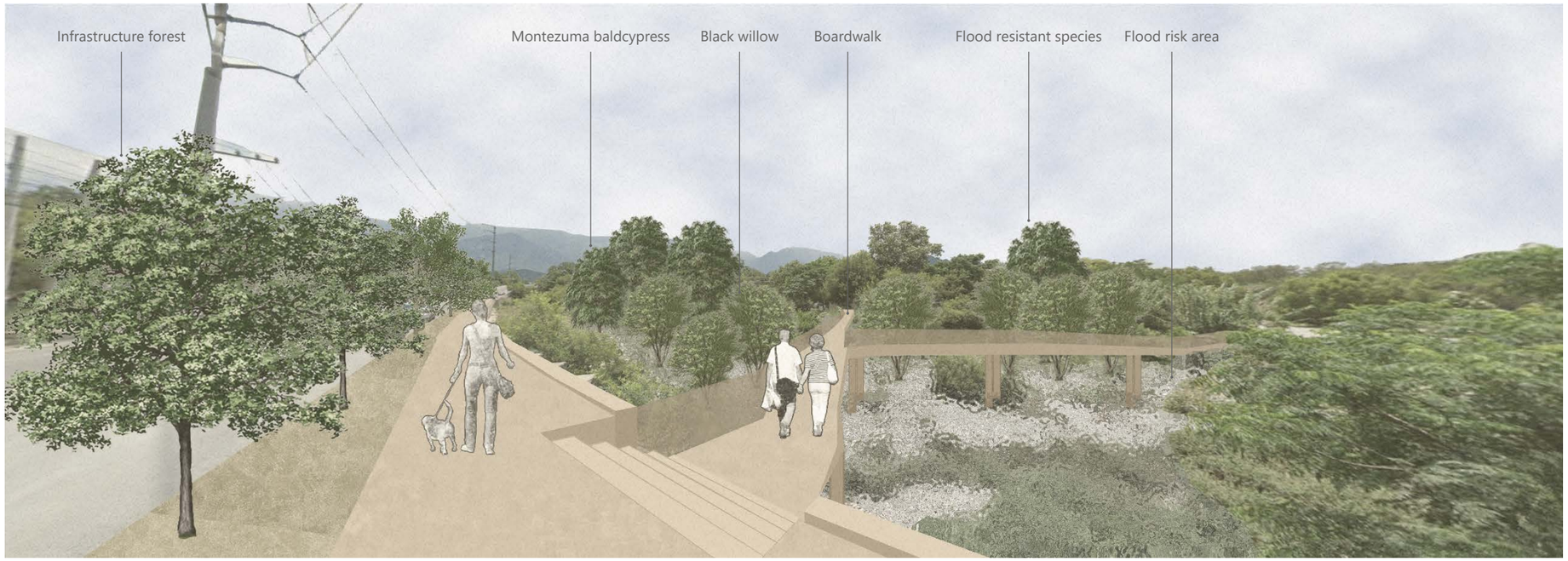


Enhance ecosystem services

Defragment the natural landscape

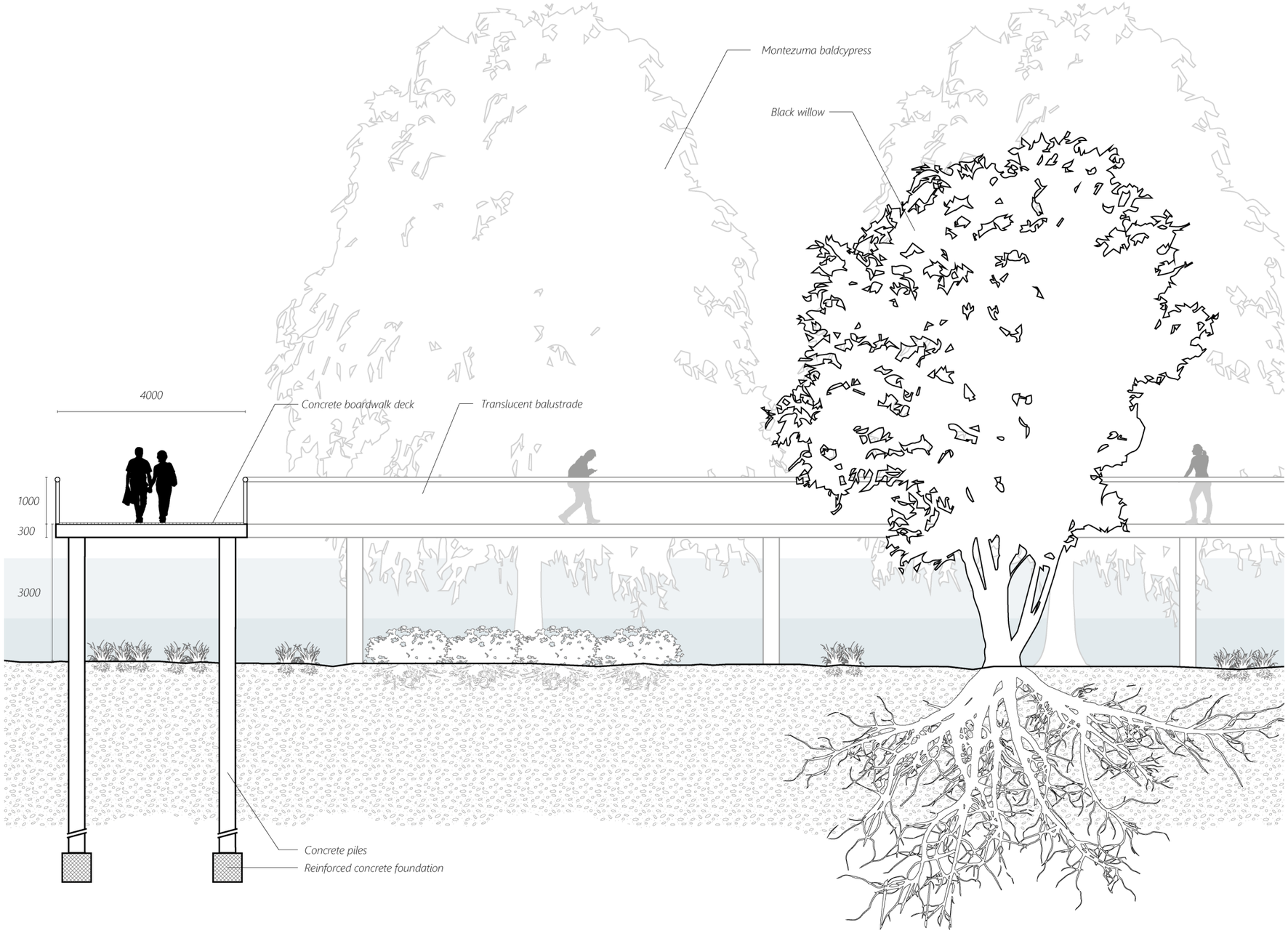
Harmonize human-nature relationships





Sponge forest

[7] Valle Alto

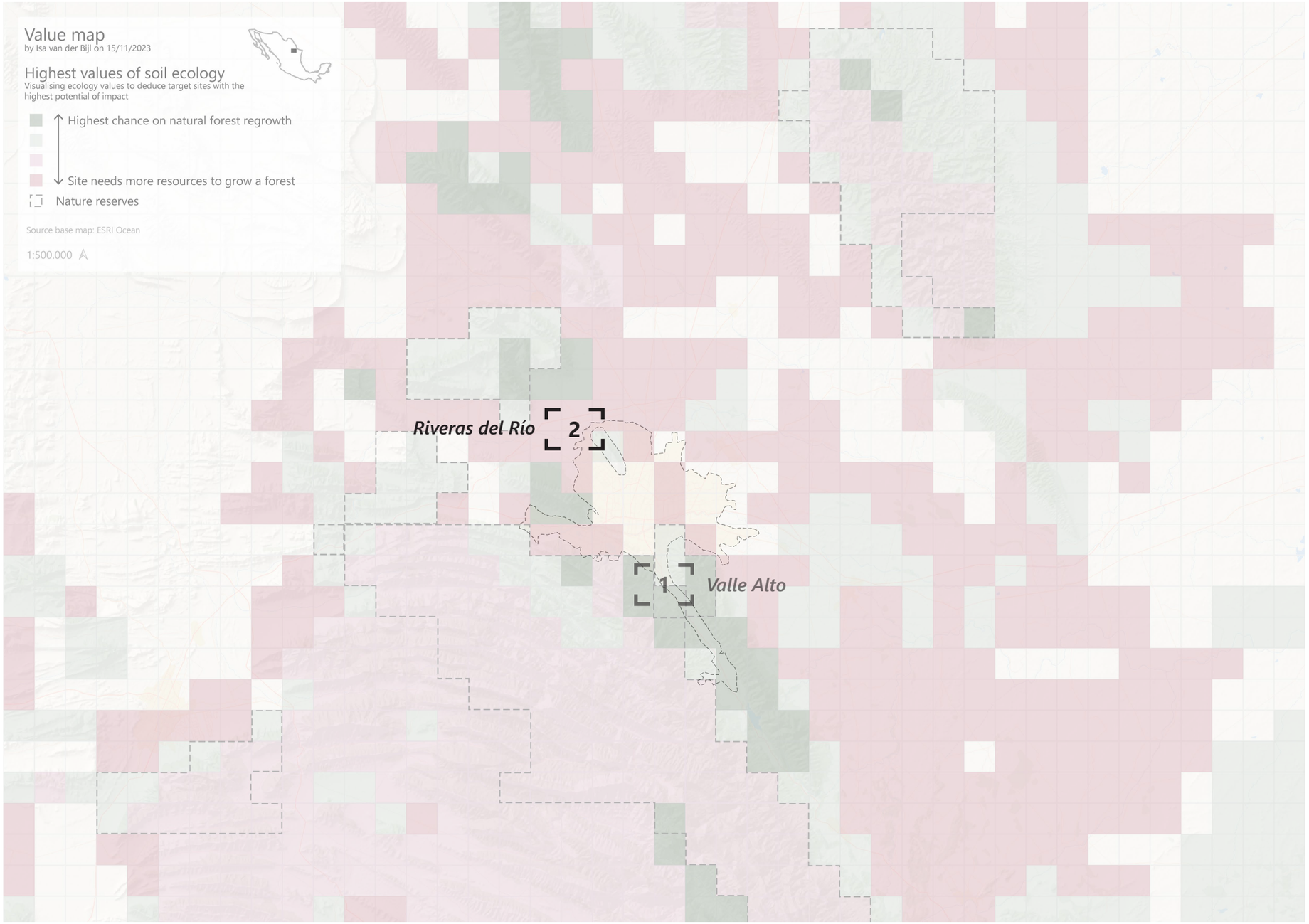


Zoom-in locations

Most impactful to intervene

Most critical to intervene

Nature reserves

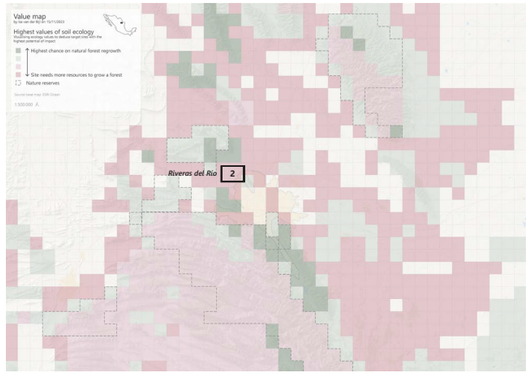


Riveras del Río
Zoom-in location [2]

Neighbourhood built next to a nature reserve and around a river.

High poverty level.

Highly polluted river.





Typologies

Riveras del Río



[1]
Formal community



[2]
Informal community



[4]
Infrastructure



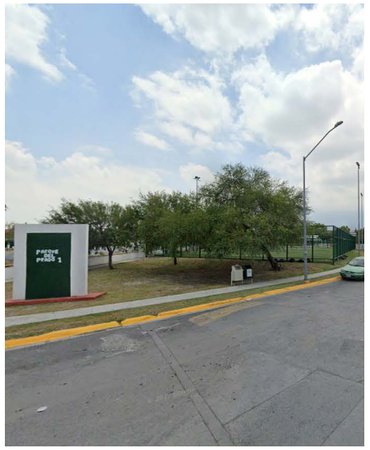
[6]
Isolated urban sprawl



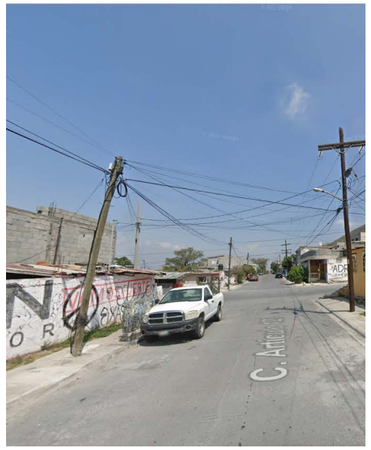
[G]
Urban vegetation



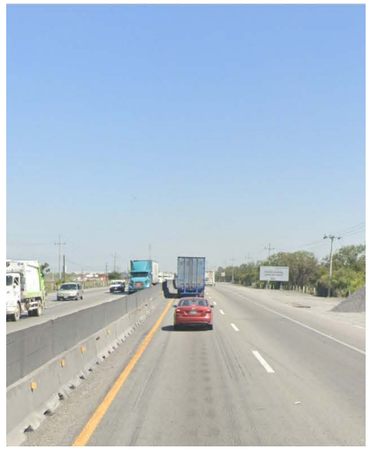
[H]
Natural protected area



Parque del Prado 1



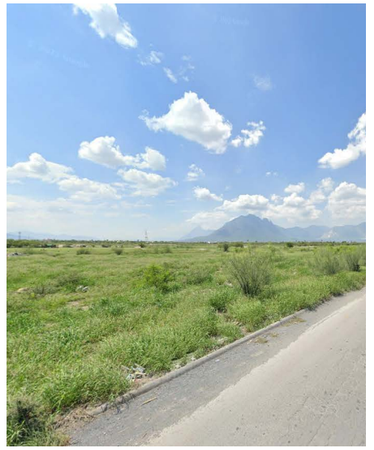
Colonia Croc



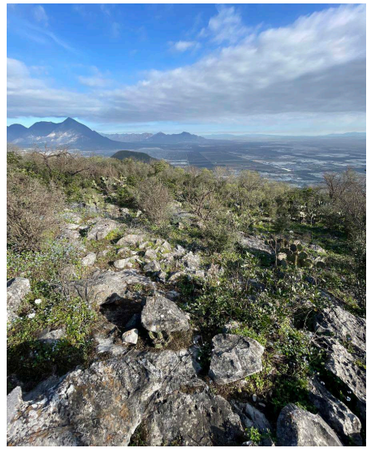
México 40 highway



Agropecuaria del Norte Lázaro Cárdenas



Plain field



Topo Chico

Google Maps. (2022, August). *314 Llanura Blanca* [Street view]. Retrieved April, 3, 2024. Google Maps.

Google Maps (2022, August). *1069 C. Artículo 123* [Street view]. Retrieved April, 3, 2024. Google Maps.

Google Maps (2022, October). *México 40* [Street view]. Retrieved April, 3, 2024. Google Maps.

Google Maps. (2019, July). *Chinameca* [Street view]. Retrieved April, 3, 2024. Google Maps.

Google Maps. (2022, September). *Av. Luis Donaldo Colosio Murrieta 2765* [Street view]. Retrieved April, 3, 2024. Google Maps.

Cheke 58. (2024, February). *Topochico subiendo por segundo cañon croc*. Wikiloc Trails of the World. https://www.wikiloc.com/hiking-trails/topochico-subiendo-por-segundo-canon-croc-162179133/photo-101573459

Opportunities

Riveras del Río

[1] Formal community



[2] Informal community



[4] Infrastructure



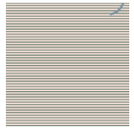
[6] Isolated urban sprawl

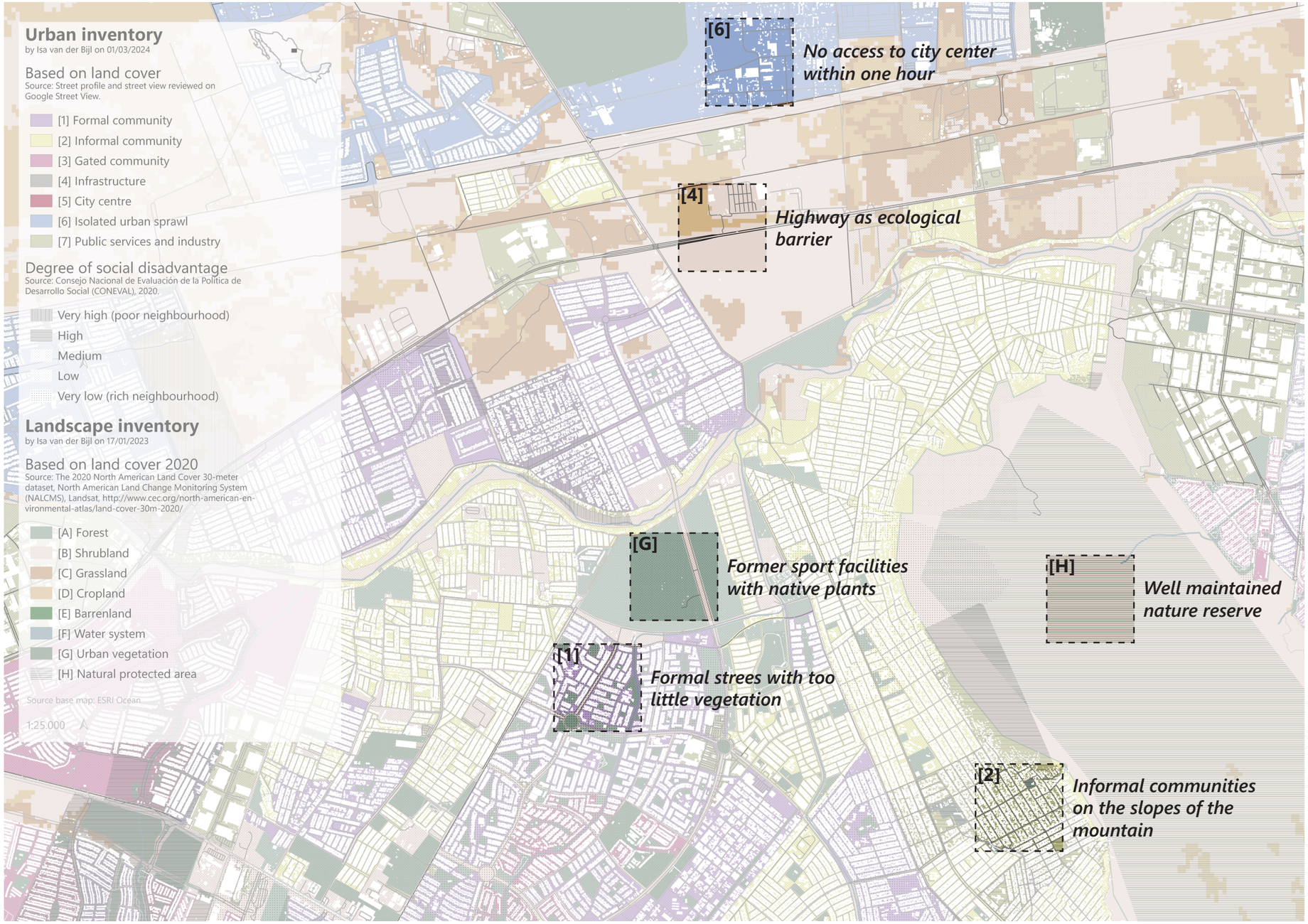


[G] Urban vegetation



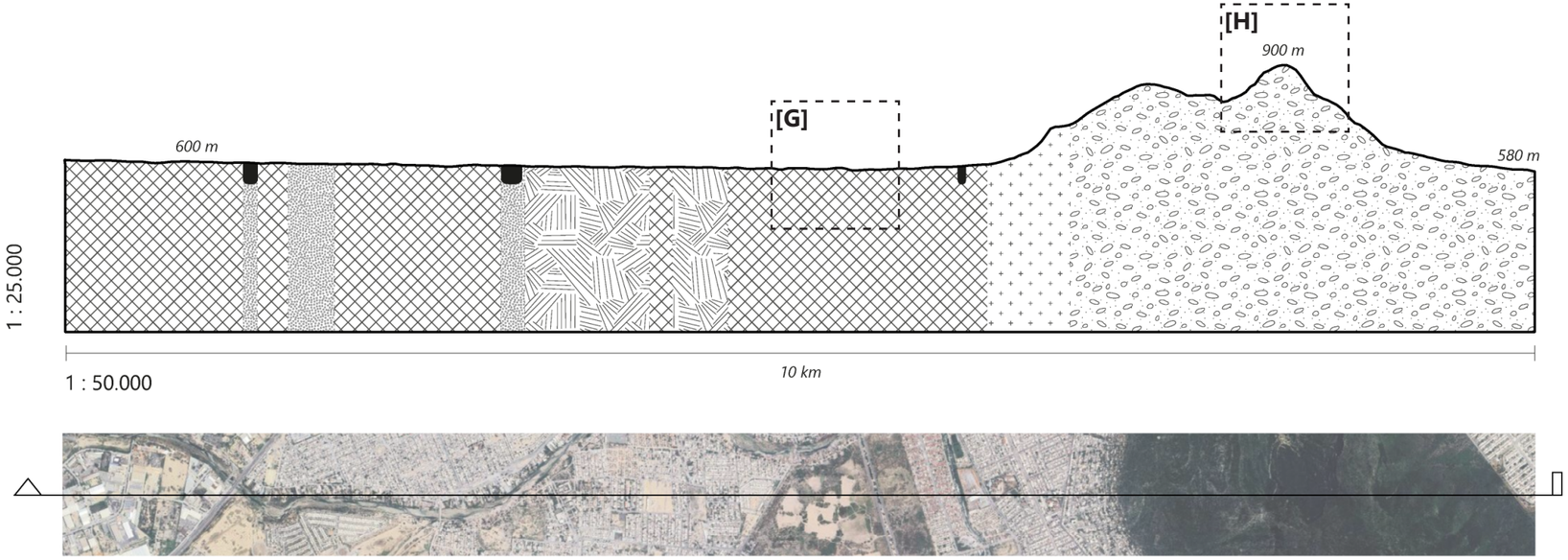
[H] Natural protected area



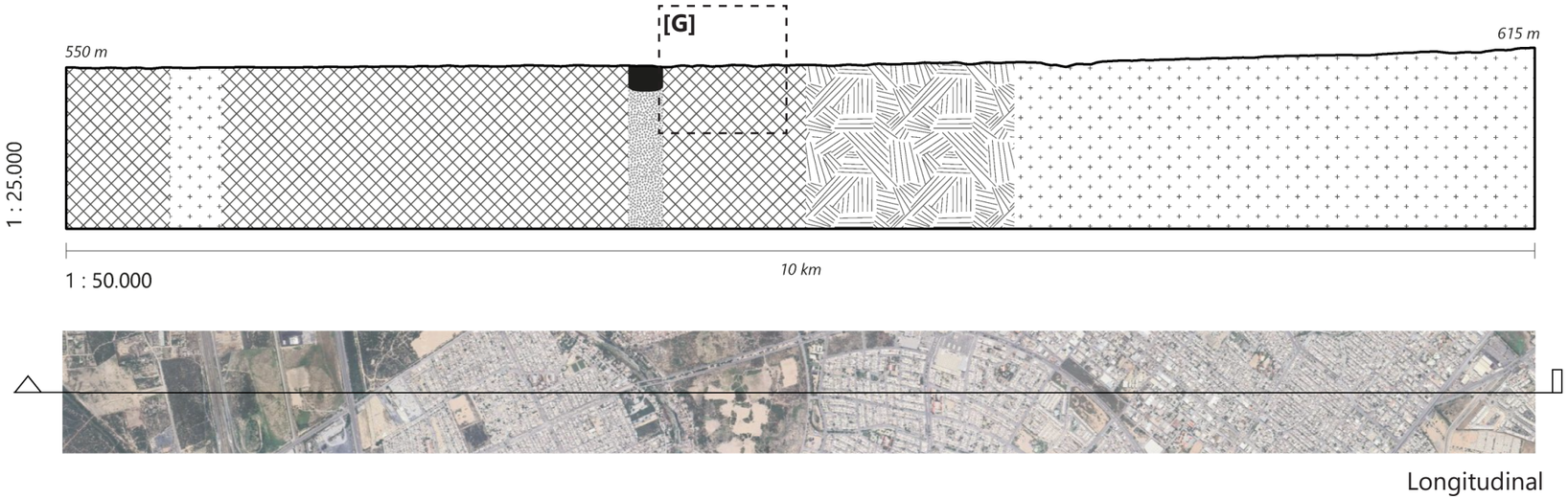


Soil types

Both type of soils are able to grow trees and plants, but different species.



Transverse



Longitudinal

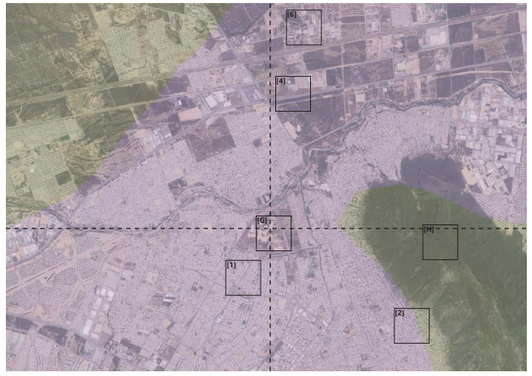
Legend

- Softer soil types
- Rocky soil types

Soils with limitations to root growth
Leptosol *(thin or with many coarse fragments)*

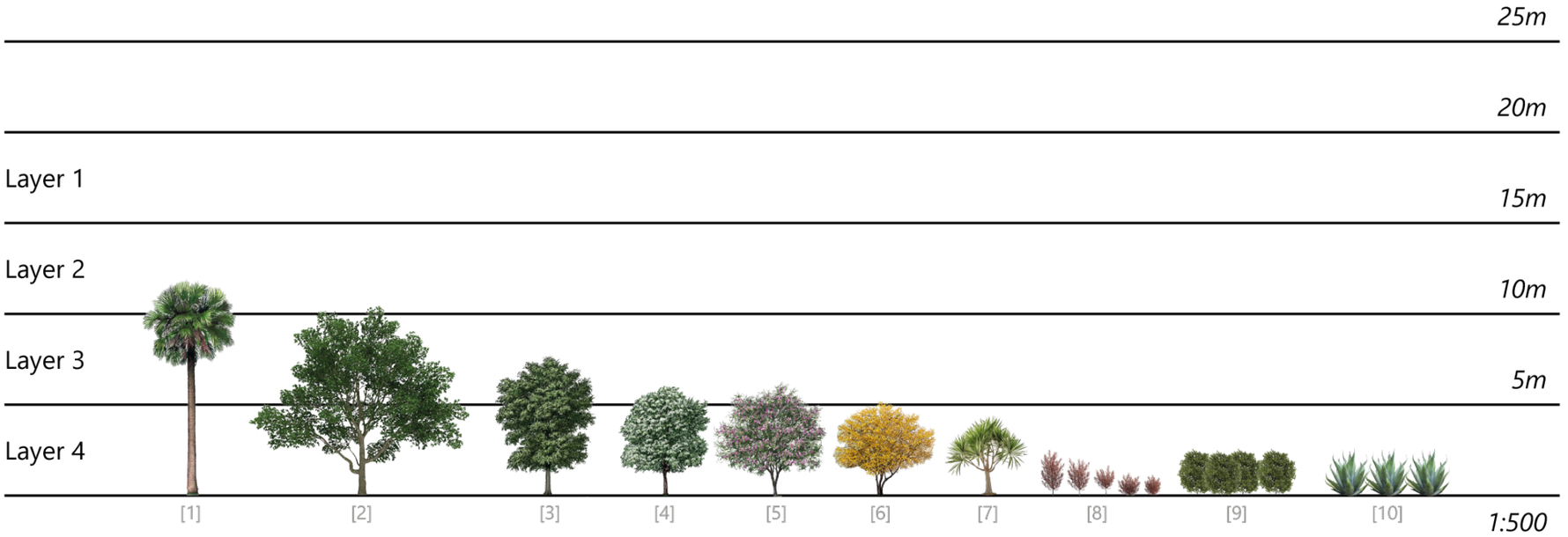
Pronounced accumulation of organic matter in the mineral topsoil
Phaeozem *(dark topsoil, no secondary carbonates (unless very deep), high base status)*
Kastanozem *(dark topsoil, no secondary carbonates)*

Soils with little or no profile differentiation
Fluvisol *(stratified fluviatile, marine or lacustrine sediments)*
Rendzina *(moderately developed) due to its moderately developed profile)*



Tree species selection

Riveras del Río



Layer 1

Layer 2

Junglas mollis
Quercus polymorpha
Sabal mexicana [1]

Layer 3

Quercus virginiana [2]
Quercus fusiformis
Ebenopsis ebano
Celtis laevigata [3]
Ehretia anacua [4]
Sapindus saponaria
Prosopis glandulosa
Chilopsis linearis [5]
Parkinsonia aculeata
Sargentia greggii
Caesalpinia mexicana

Layer 4

Acacia farnesiana [6]
Cordia boissieri
Diospyros texana
Yucca filifera [7]
Sophora secundiflora
Acacia berlandieri
Dodonaea viscosa [8]
Celtis ehrenbergiana [9]
Leucophyllum frutescens
Larrea tridentata
Agave americana [10]

Forestry vision

Riveras del Río

[1] Forest corridor



[2] Agroforestry



[4] Infrastructure forest



[6] Village forest

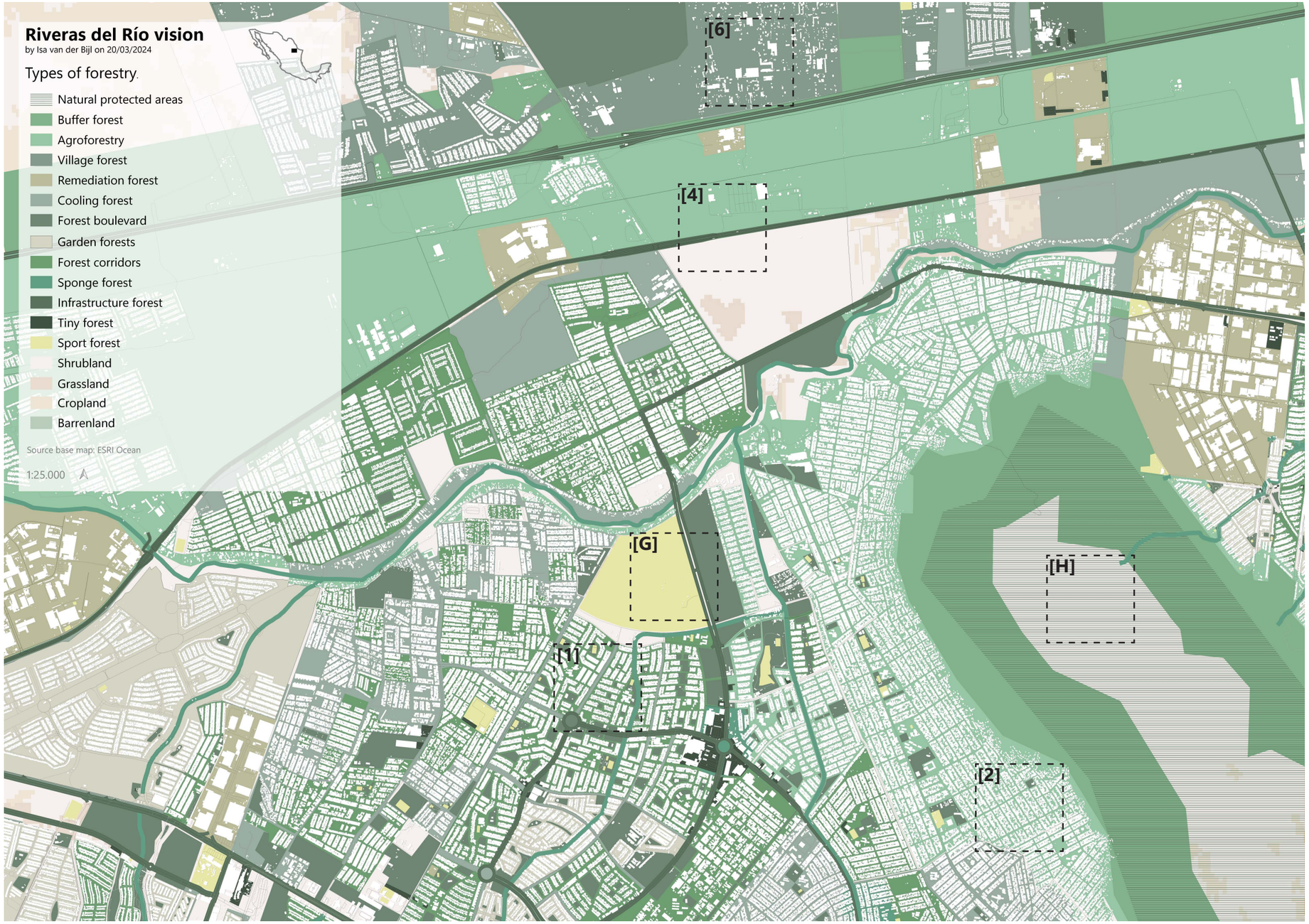


[G] Sport forest

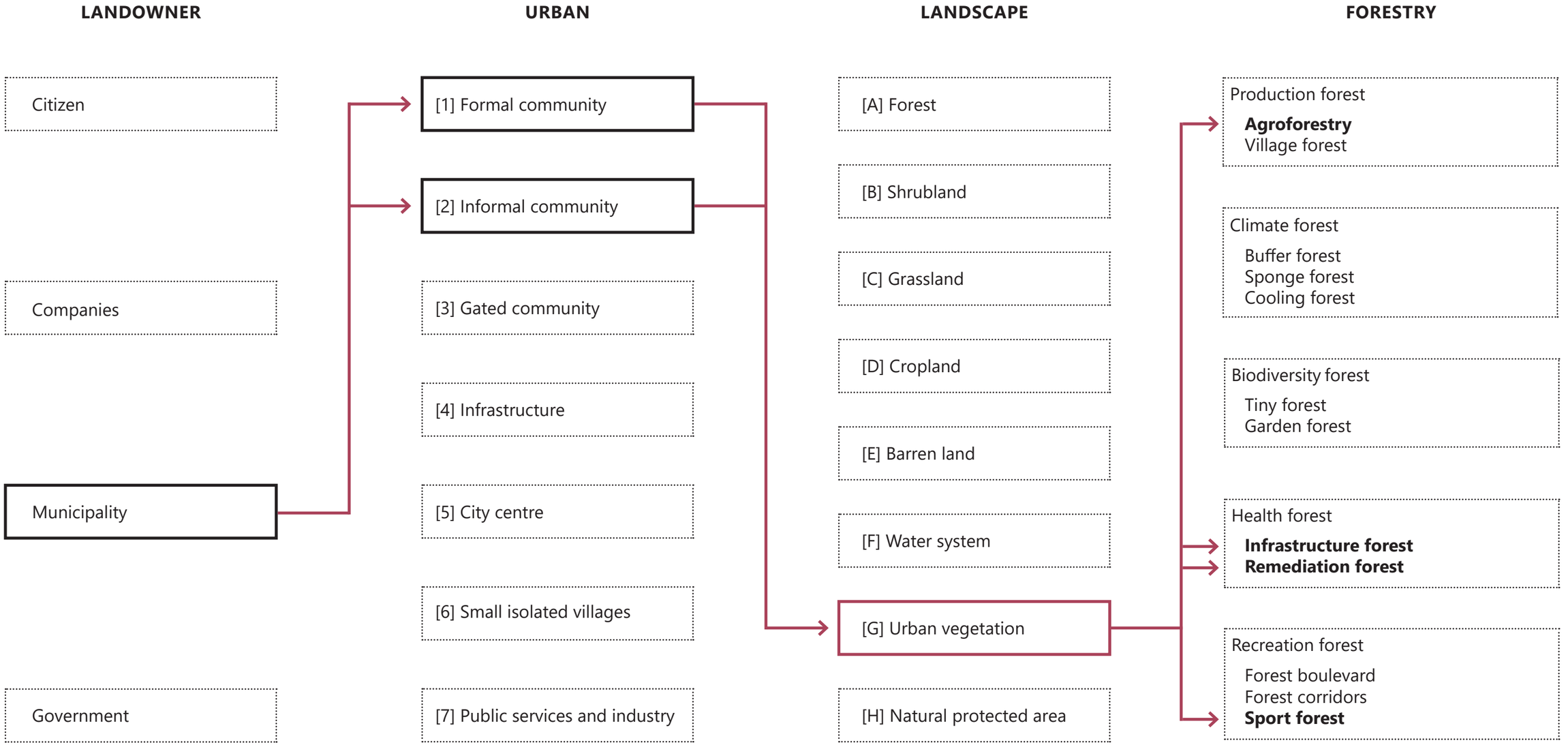


[H] Buffer forest





Strategy
Inventory



Existing situation

[G] Riveras del Río

Plain field





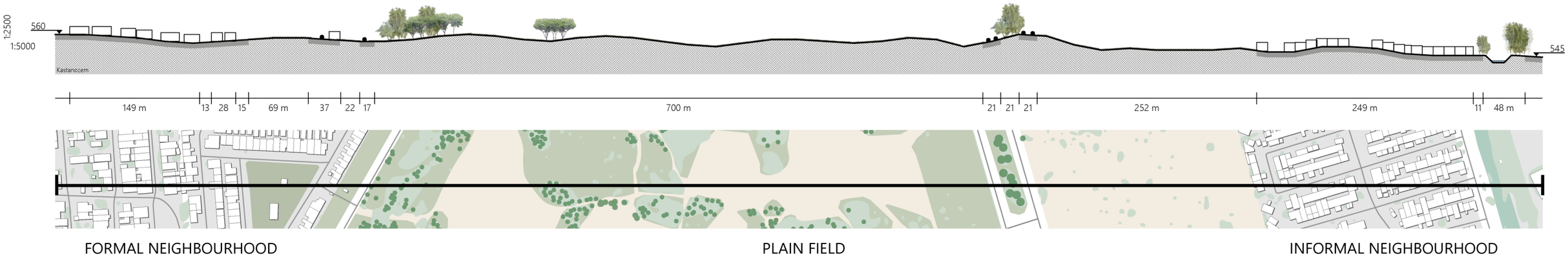
Park vision

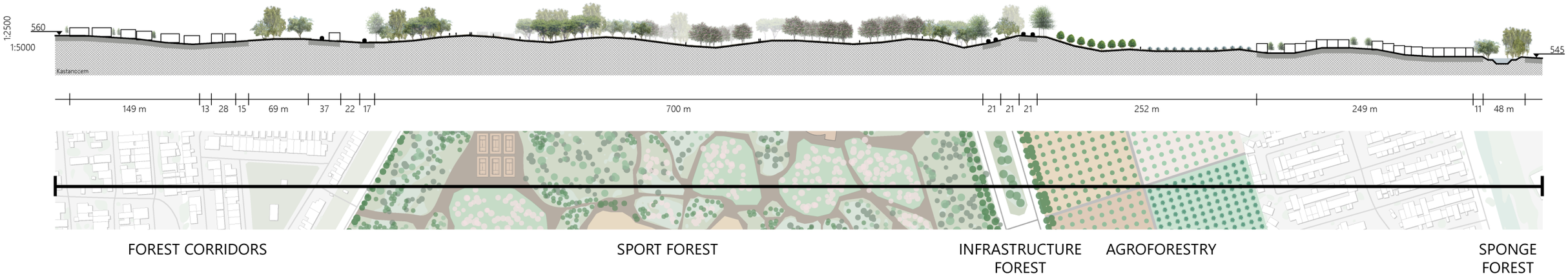
[G] Riveras del Río



Park vision

[G] Riveras del Río





Sport forest

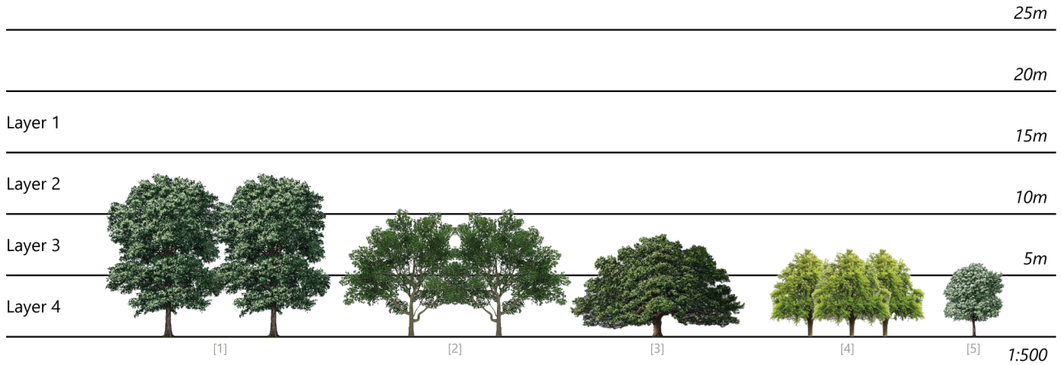
Recreation forestry



Natural patch

Ecosystem services

Recreation	Sense of place	Education	Community engagement	Ecotourism	Physical health benefits	Mental health benefits	Habitat provision	Species movement



Layer 1

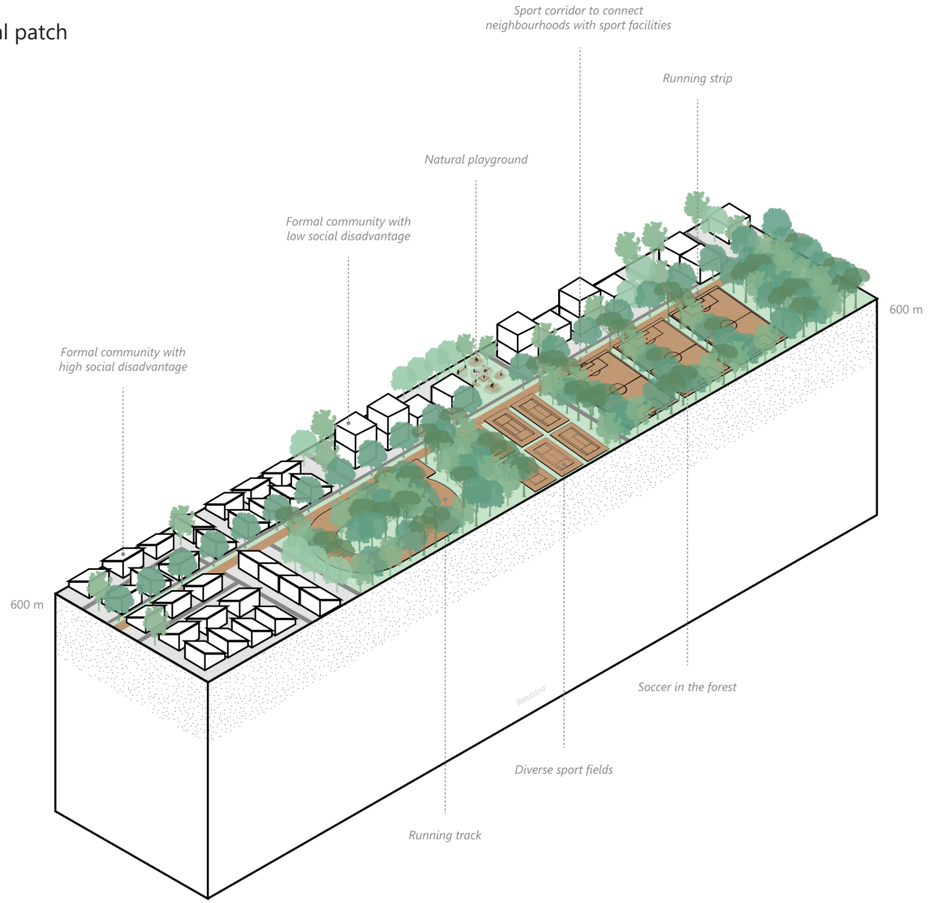
Layer 2

Quercus polymorpha [1]

Layer 3

Quercus virginiana [2]
Quercus fusiformis [3]
Ebenopsis ebano [4]
Ehretia anacua [5]
Sargentia greggii

Layer 4



Sport forest

[G] Riveras del Río







Sport forest

[G] Riveras del Río



Google Maps. (2022, September). *Av. Luis Donaldo Colosio Murrieta 2765.* [Street view]. Google Maps. https://maps.app.goo.gl/oxKniK7FXArm7ShU8



Enhance ecosystem services



Defragment the natural landscape

Harmonize human-nature relationships



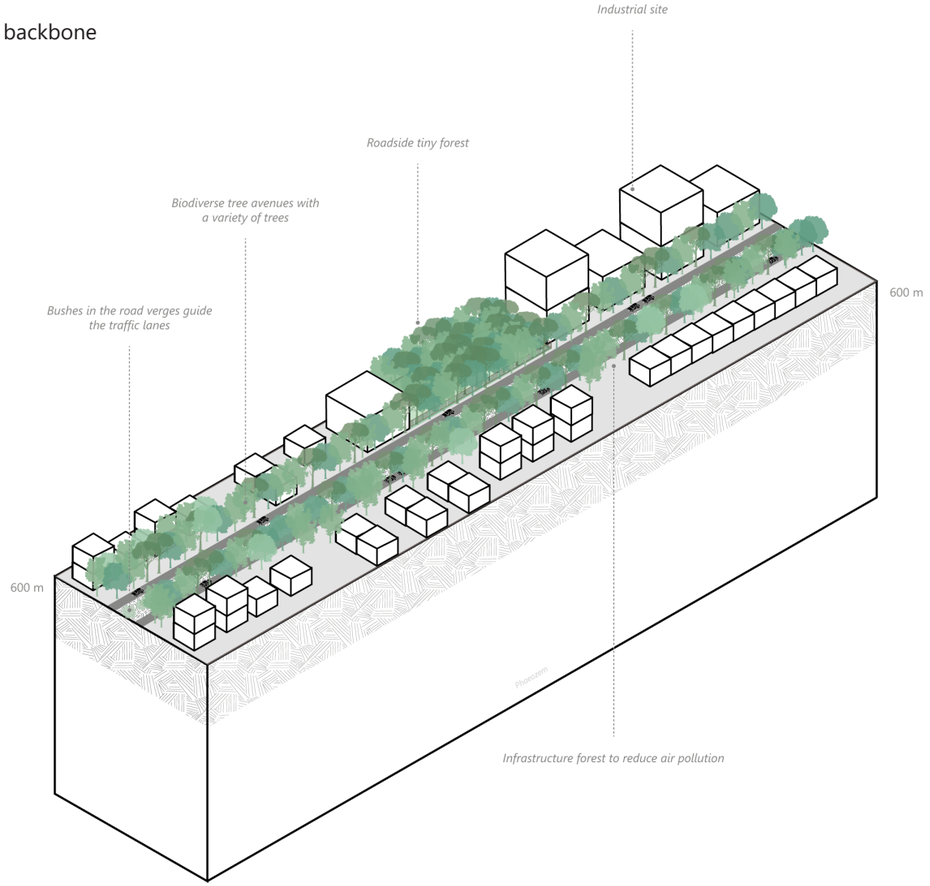


Infrastructure forest

Health forestry



Industrial backbone



Ecosystem services

Urban heat island mitigation	Air quality improvement	Soil remediation	Noise reduction	Physical health benefits	Soil formation	Detoxification of pollutants	Species movement



Layer 1

Platanus occidentalis mexicana [1]

Layer 2

Quercus polymorpha [2]

Layer 3

Quercus virginiana
Quercus canbyi
Quercus laceyi [3]
Quercus graciliformis
Quercus fusiformis
Ulmus crassifolia [4]

Ebenopsis ebano
Ehretia anacua [5]
Prosopis glandulosa [6]

Layer 4

Infrastructure forest

[G] Riveras del Río







Entrance from neighbourhood

[G] Riveras del Río



Google Maps. (2022, August). *5350 Av. Camino del Pastizal.* [Street view]. Google Maps. https://maps.app.goo.gl/oGA2yNW83M2fnWws6

Enhance ecosystem services



Defragment the natural landscape



Harmonize human-nature relationships

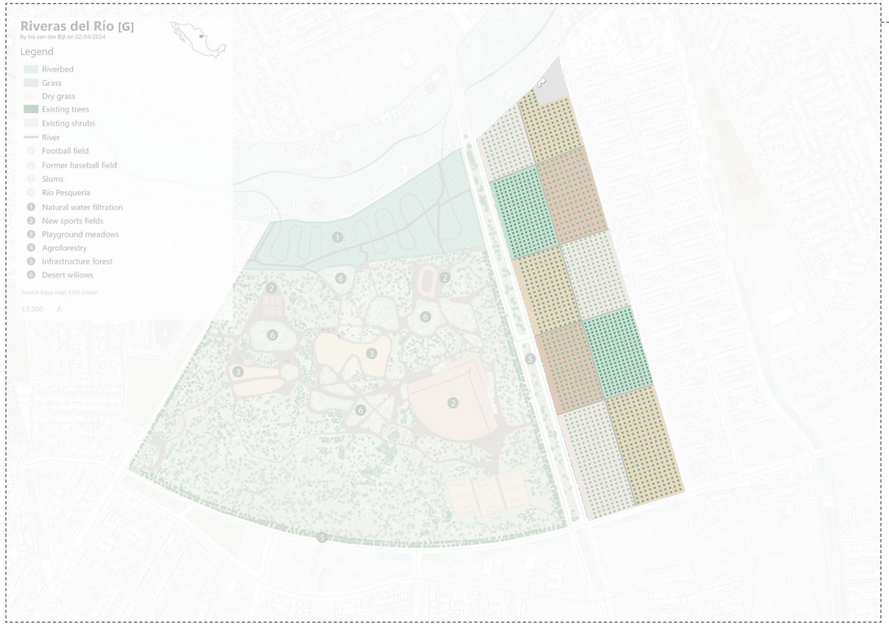


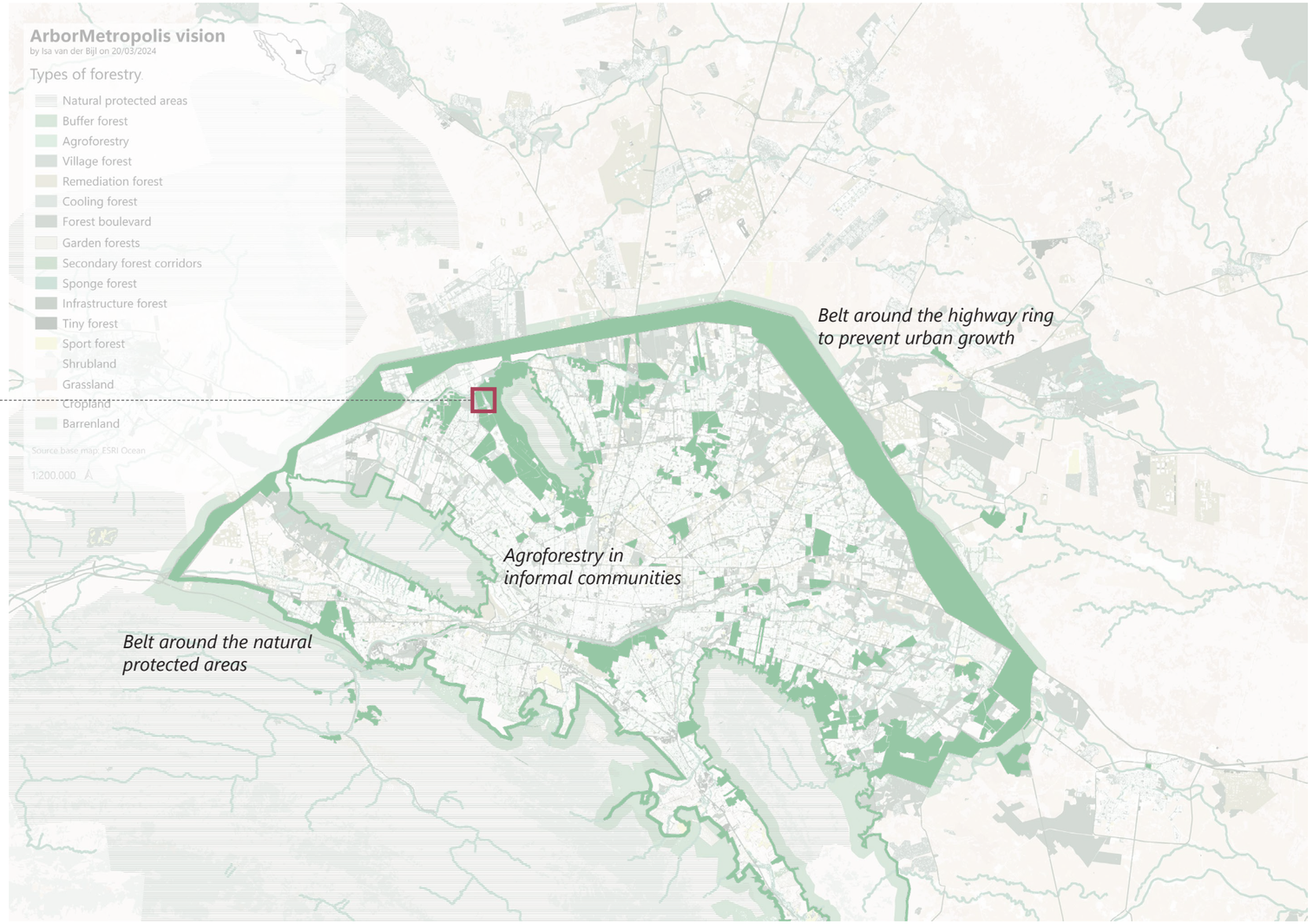


Agroforestry

[G] Riveras del Río







Agroforestry

[G] Riveras del Río



Google Maps. (2019, June). *Antiguo Camino Real.* [Street view]. Google Maps. https://maps.app.goo.gl/FCybqr9dgsmzzBWt6







Remediation forest

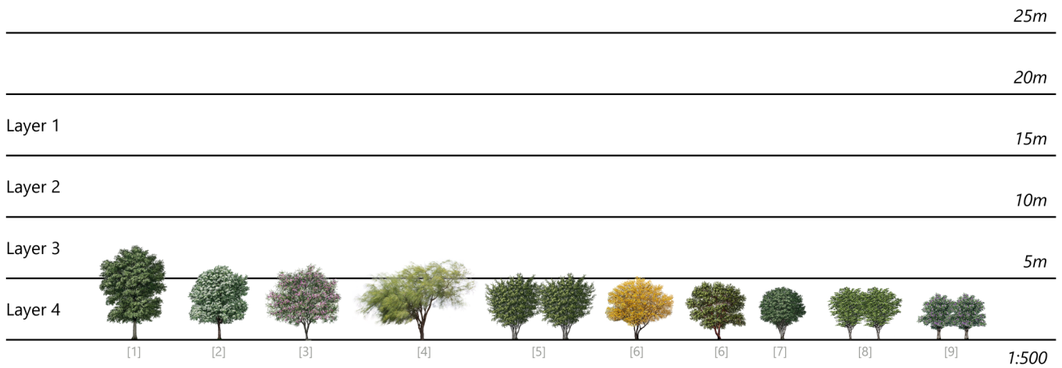
Health forestry

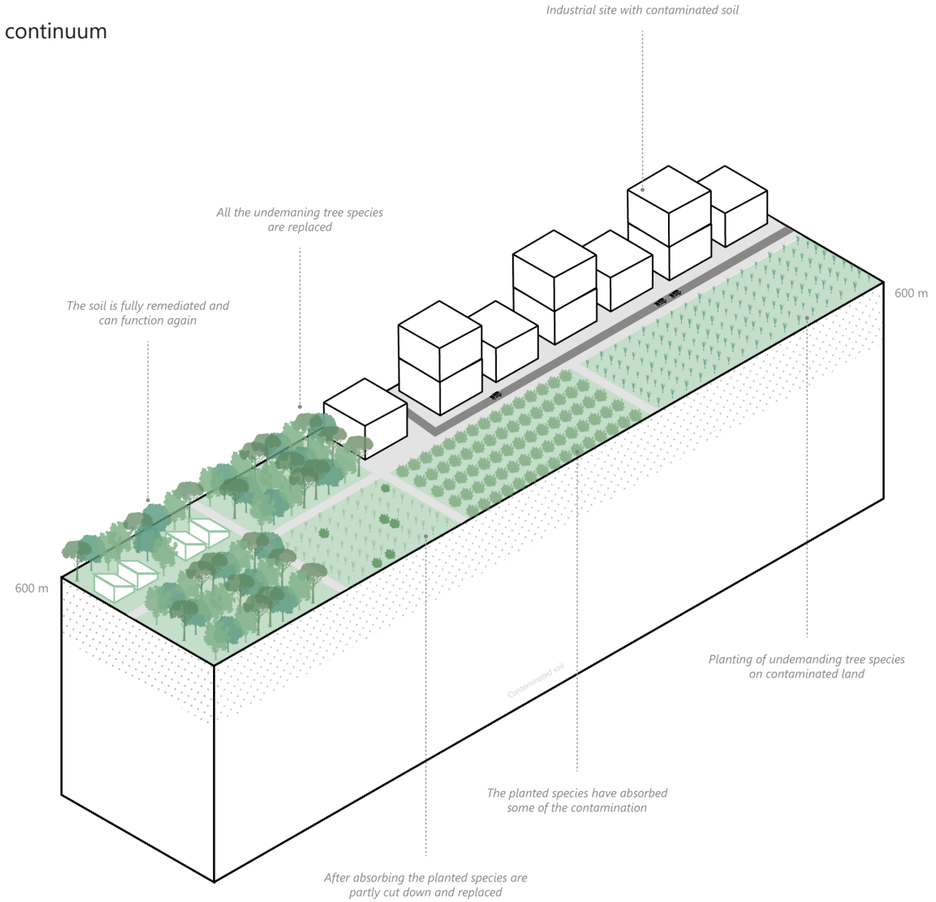


Industrial continuum

Ecosystem services

Forest products	Air quality improvement	Soil remediation	Creation of jobs	Education	Soil formation	Waste de-composition	Detoxification of pollutants





Adapted from Flux (2023).

Layer 1

Layer 2

Layer 3

Celtis laevigata [1]
Ehretia anacua [2]
Sapindus saponaria
Prosopis glandulosa
Chilopsis linearis [3]
Pinus cembroides
Parkinsonia aculeata [4]
Sargentia greggii
Sideroxylon celastrinum [5]
Caesalpinia mexicana
Parkinsonia texana

Layer 4

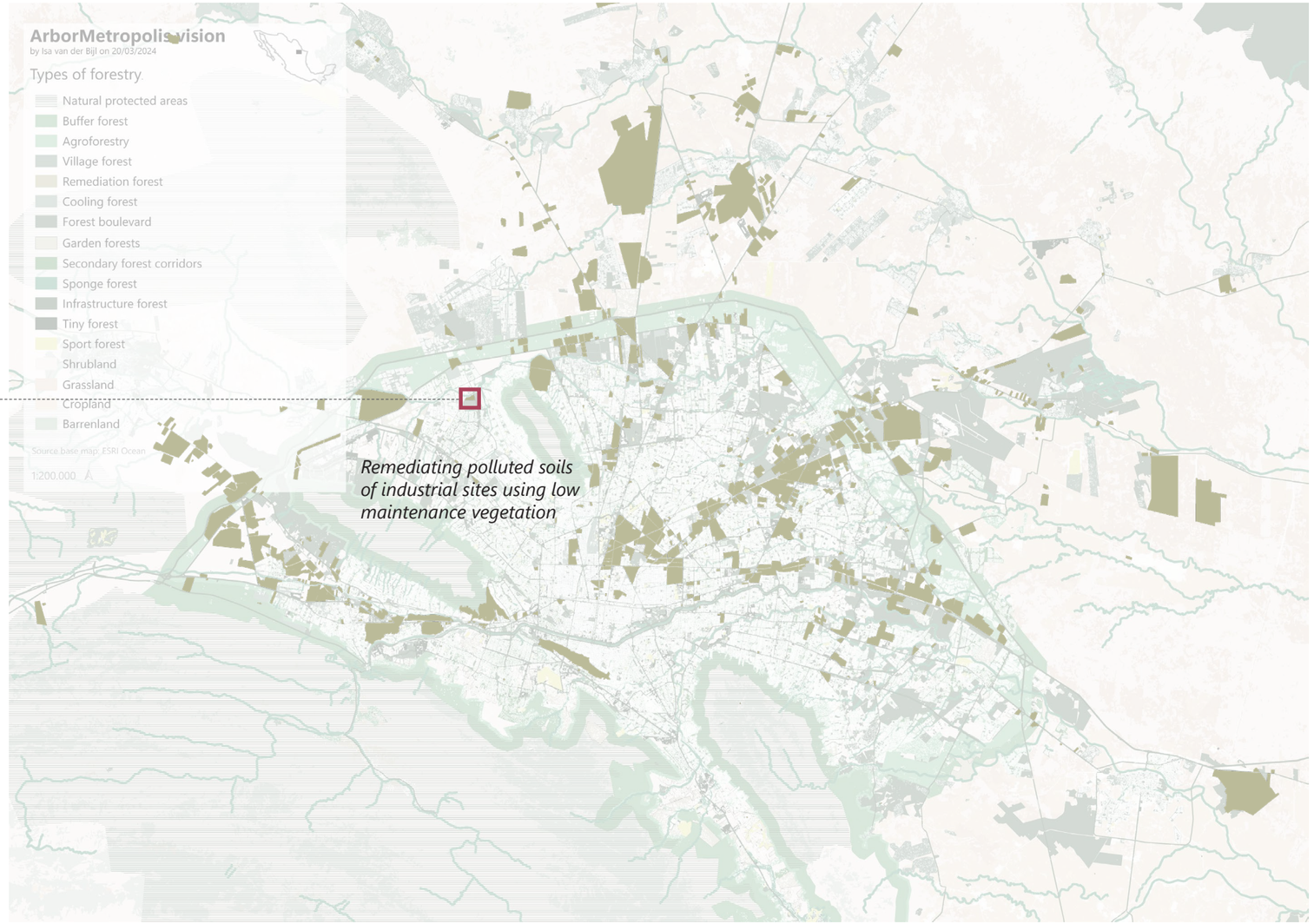
Acacia farnesiana [6]
Arbutus texana [7]
Cordia boissieri
Diospyros texana
Ungnadia speciosa [8]
Tecoma stans
Acacia rigidula
Sophora secundiflora [9]
Acacia berlandieri
Dodonaea viscosa
Celtis ehrenbergiana

Natural water filtration

[G] Riveras del Río







Natural water filtration

[G] Riveras del Río



Google Maps. (2019, June). *Monterrey, Nuevo Leon.* [Street view]. Google Maps. https://maps.app.goo.gl/Az35iVJw8NTBrDye6



Enhance ecosystem services

Defragment the natural landscape



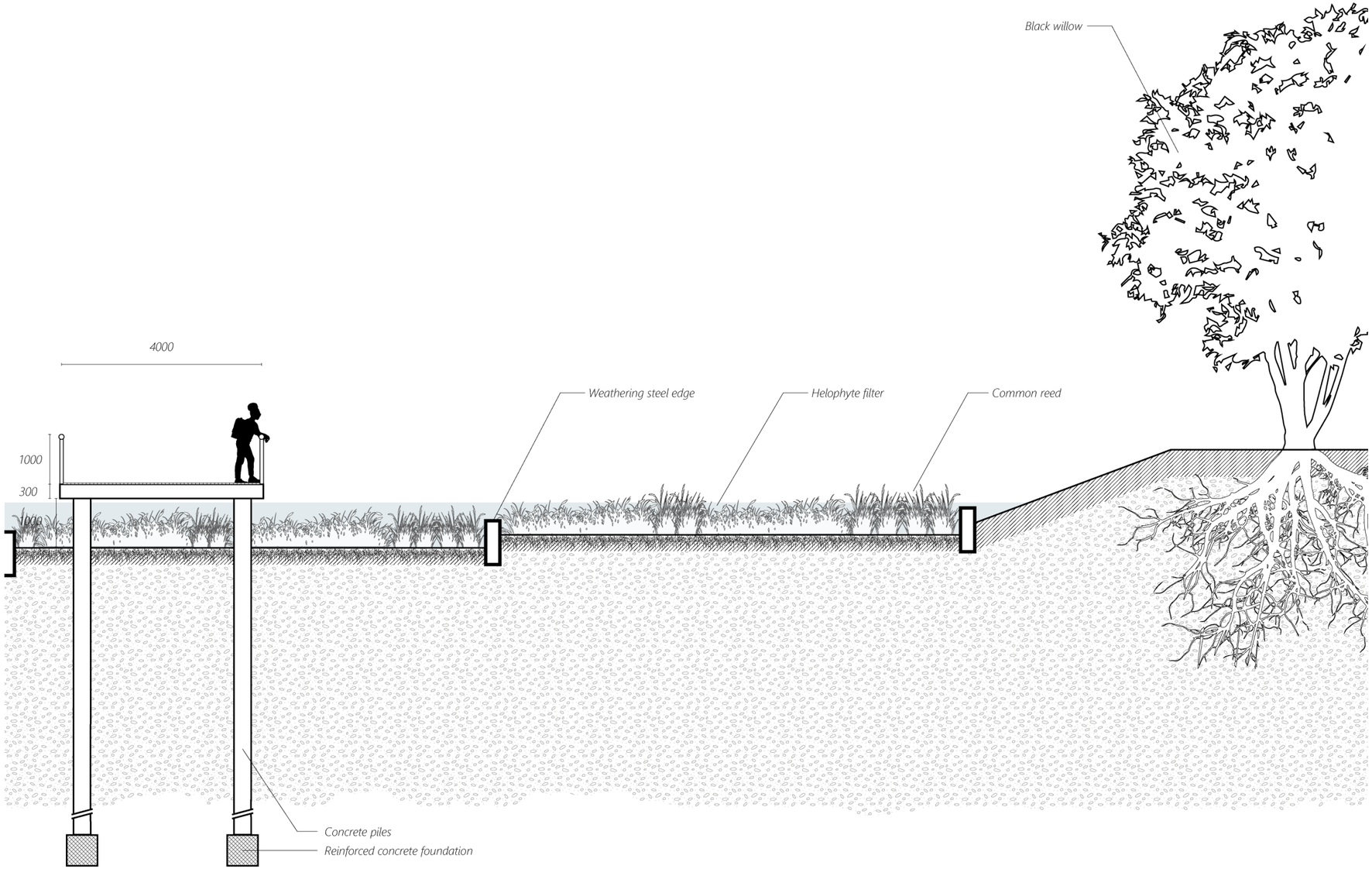
Harmonize human-nature relationships





Natural water filtration

[G] Riveras del Río



Timescale of the forests

Miyawaki method

Consider each forest patch as a separate project that first needs to be functioning and then jointly managed at its appropriate scale.



[1]
Densely planting trees

[2]
Survival of the fittest

[3]
Mature forest by 15-20 years

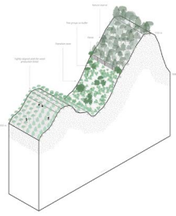
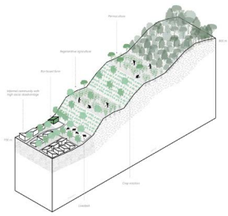
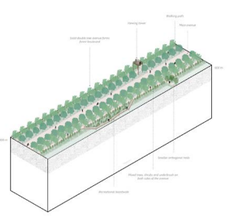
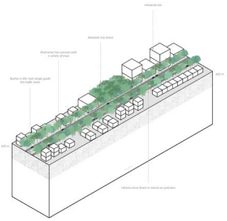
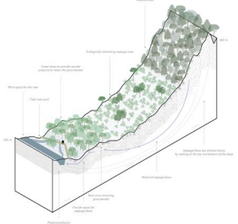
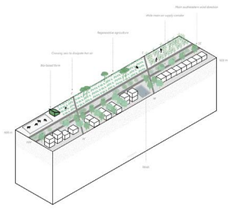
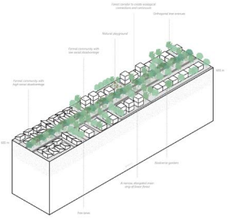
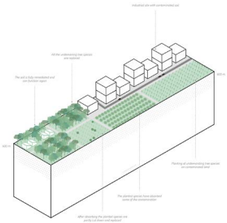
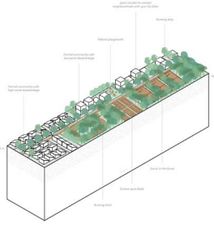
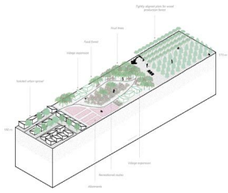
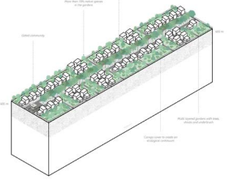
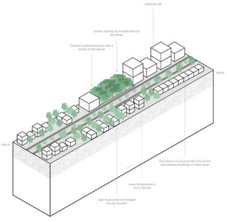


Urban Forests. (2023, November 14). Urban Forests use the Miyawaki method to create native forests. https://urban-forests.com/miyawaki-method/

5.
SYSTEMIC DESIGN

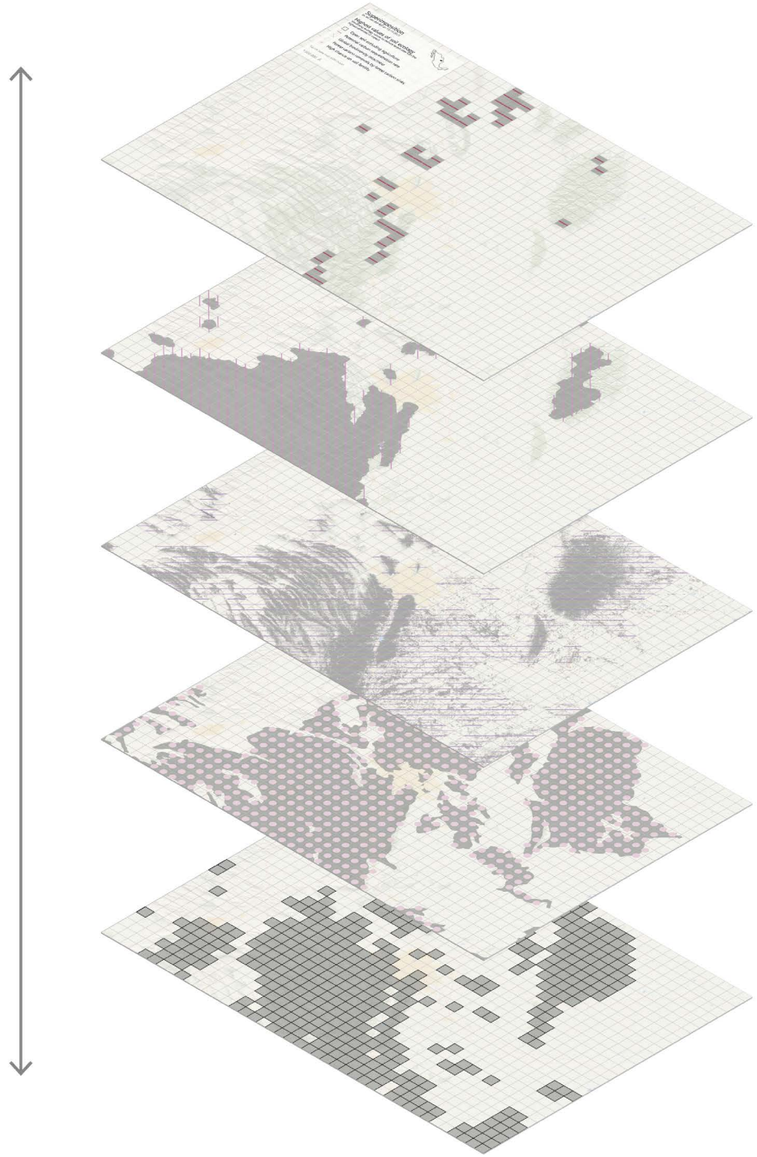
Forestry categories

- Trans-scalar
- Context specific

	NATURAL	AGRICULTURAL	URBAN	INDUSTRIAL
BACKBONE	 *Buffer forest*	 *Agroforestry*	 *Forest boulevard*	 *Infrastructure forest*
CONTINUUM	 *Sponge forest*	 *Cooling forest*	 *Forest corridor*	 *Remediation forest*
PATCH	 *Sport forest*	 *Village forest*	 *Garden forest*	 *Tiny forest*

Systemic design

- Integral design based on soil ecology
- Local conditions of the site
- Ecosystem-based approach



Potential carbon sequestration rate

Global biodiversity intactness

Forest carbon removals

Soil fertility

Open soil

Backbone

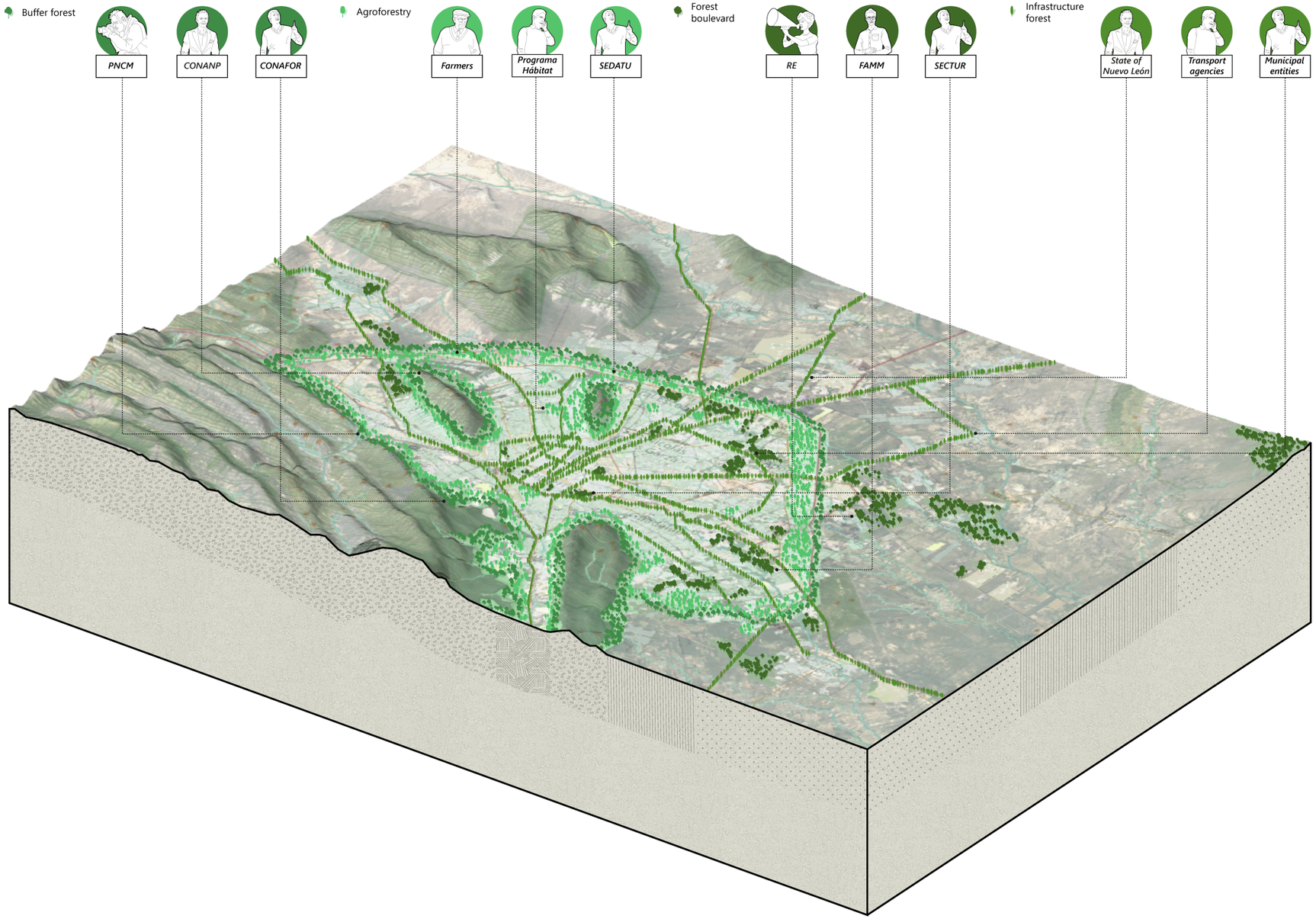
- Mainly Top-Down stakeholders
- Large-scale interventions
- Policies and long-term plans



Backbone legend

Buffer forest	*natural*
Agroforestry	*agricultural*
Forest boulevard	*urban*
Infrastructure forest	*industrial*

TOP-DOWN APPROACH



Patch

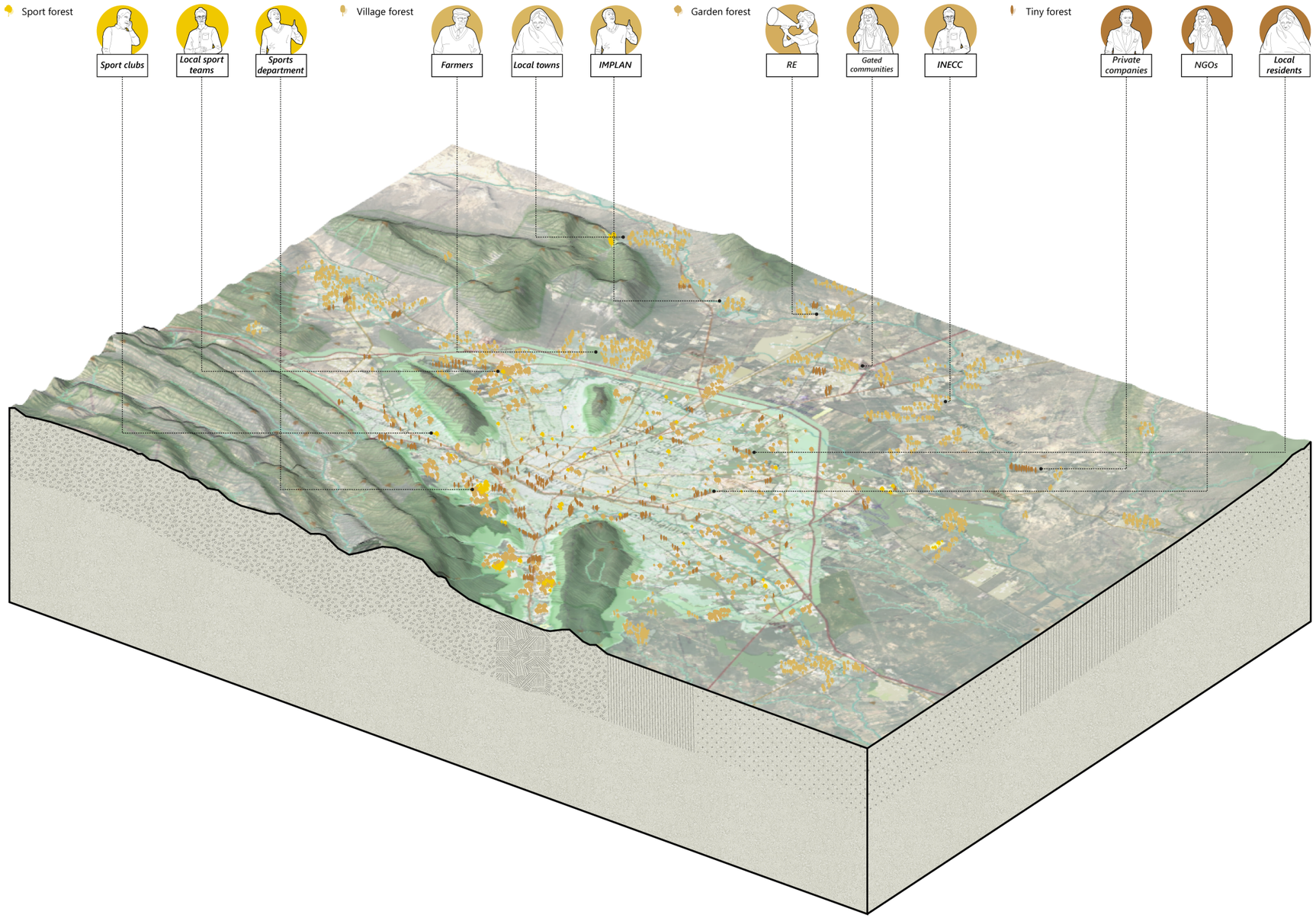
- Mainly Bottom-Up stakeholders
- Small-scale interventions
- Plot-related initiatives
- Smaller and faster on-site interventions



Patch legend

Sport forest	*natural*
Village forest	*agricultural*
Garden forest	*urban*
Tiny forest	*industrial*

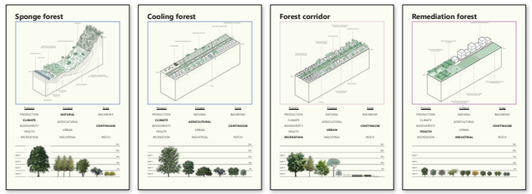
BOTTOM-UP APPROACH



Continuum

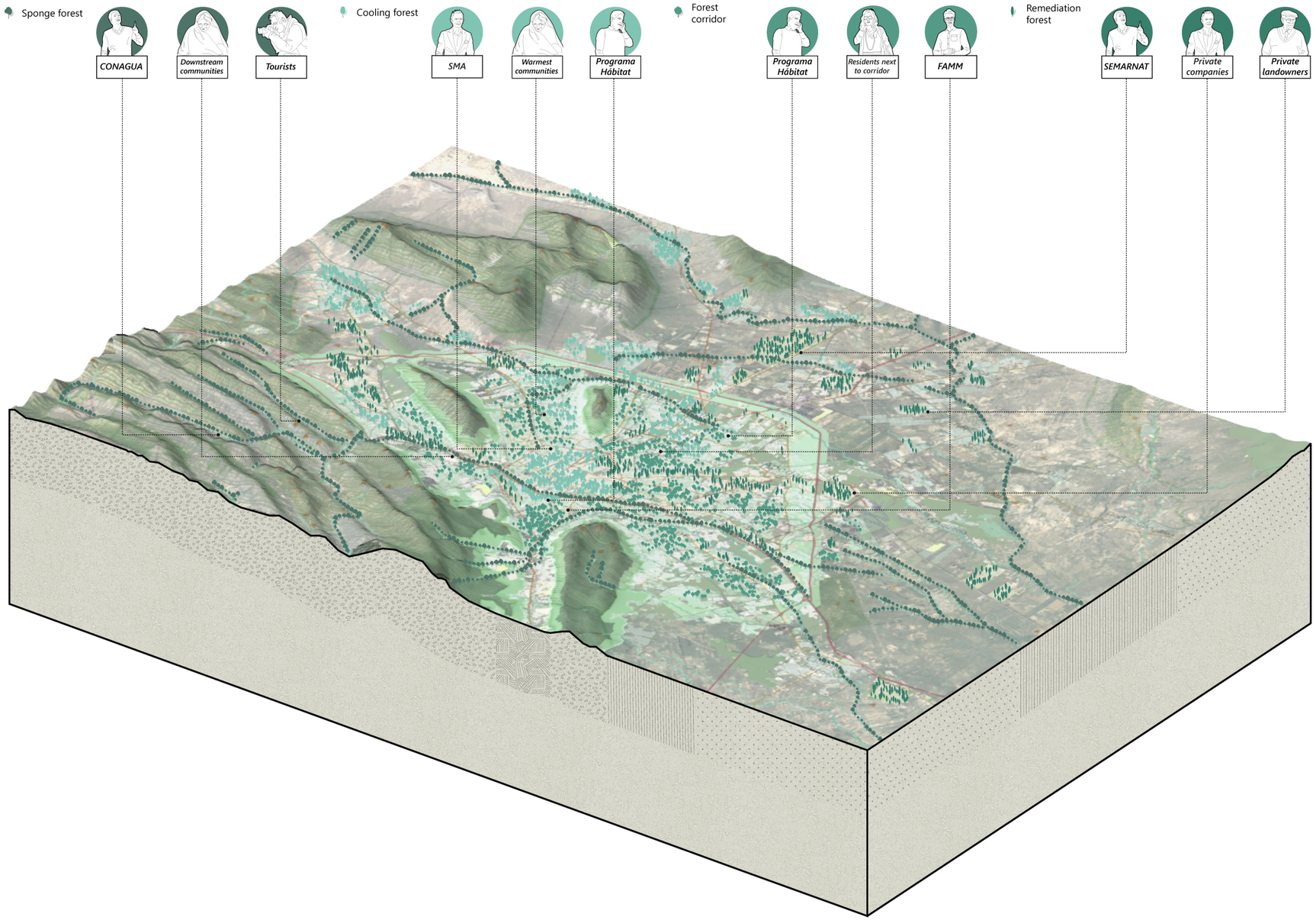
HYBRID APPROACH

- Hybrid stakeholders
- Interventions to connect from the large-scale backbones to the small-scale patches

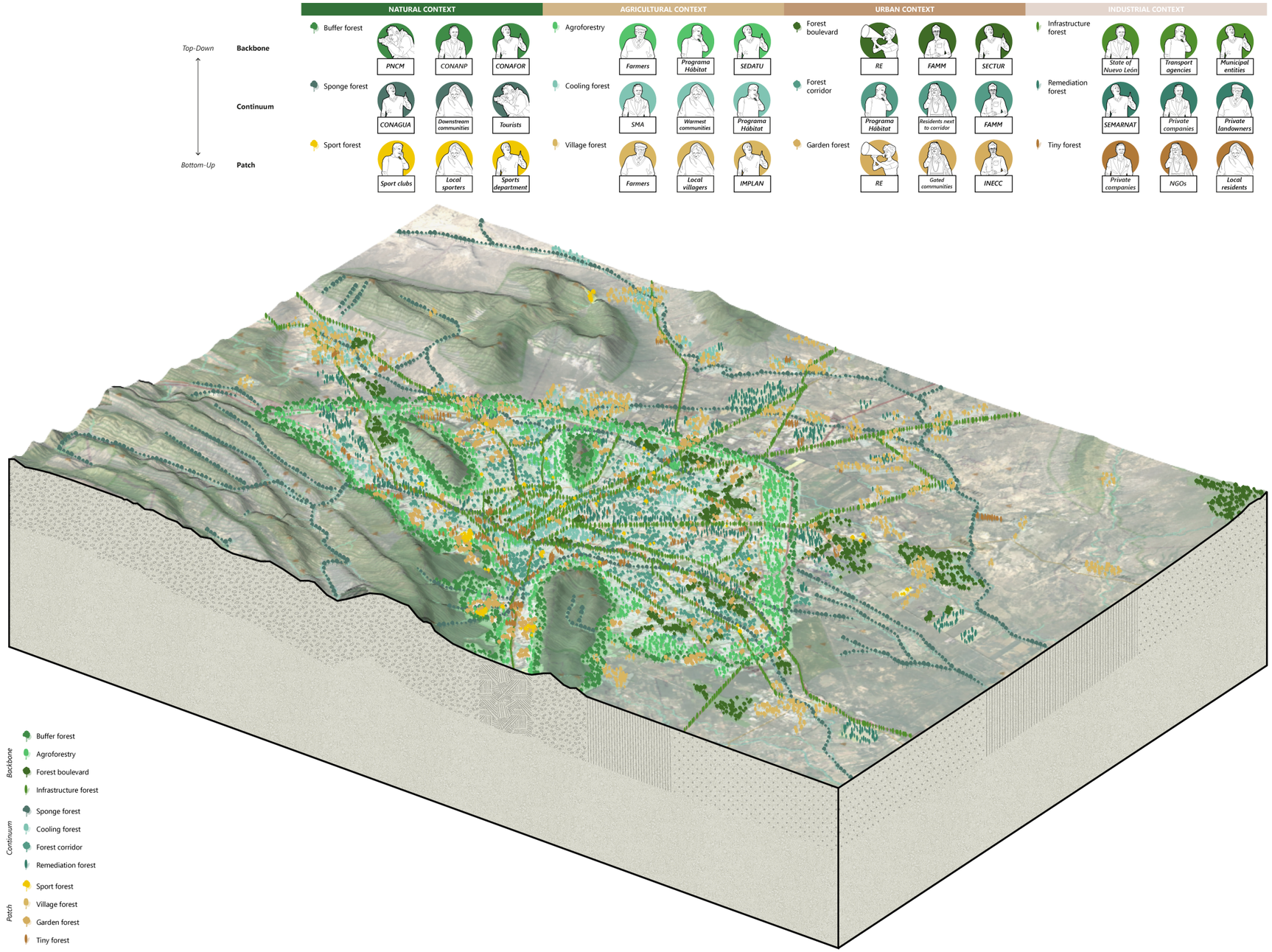


Continuum legend

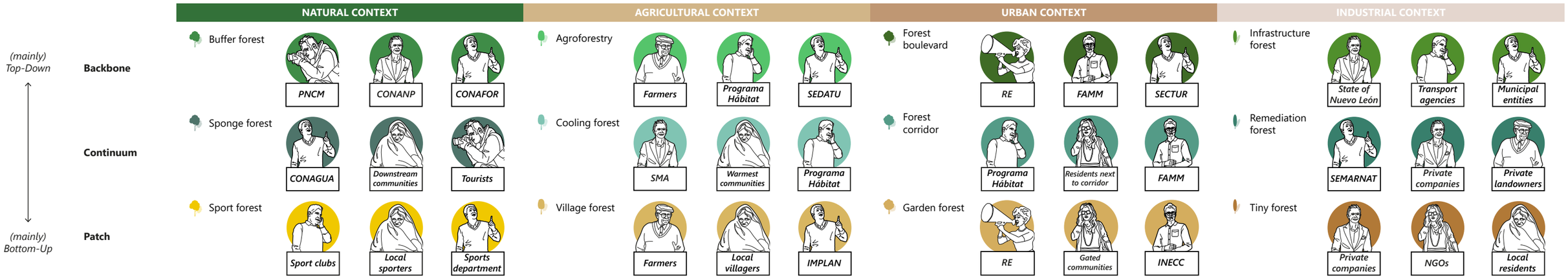
Sponge forest	*natural*
Cooling forest	*agricultural*
Forest corridor	*urban*
Remediation forest	*industrial*



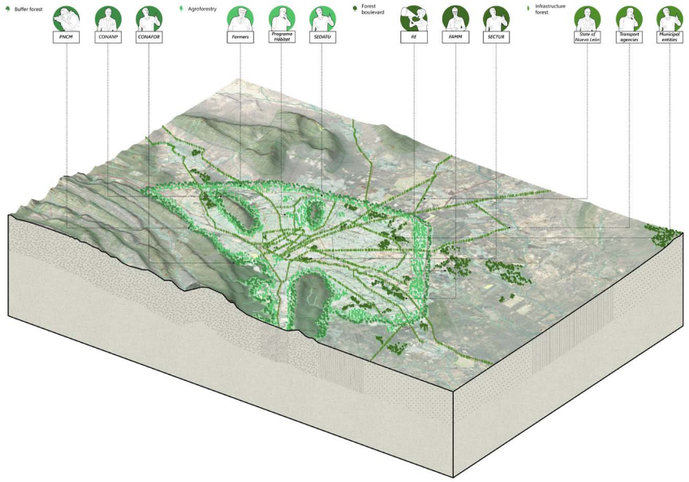
Systemic design



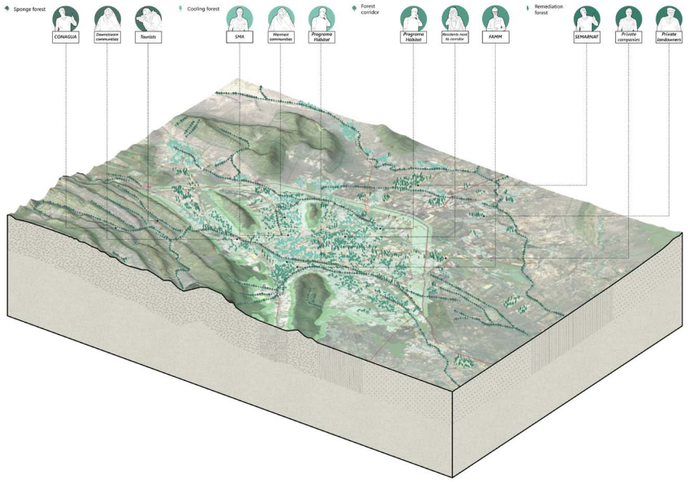
Systemic design



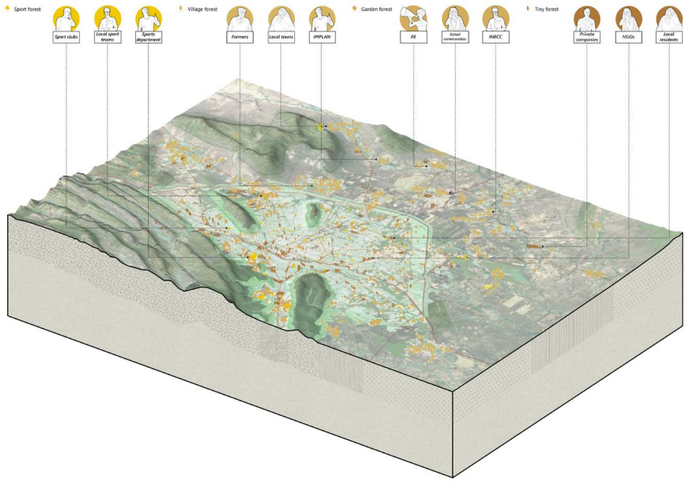
TOP-DOWN APPROACH



HYBRID APPROACH



BOTTOM-UP APPROACH

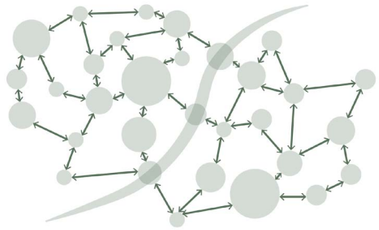


Systemic design

URBAN FORESTRY AND REGIONAL AFFORESTATION



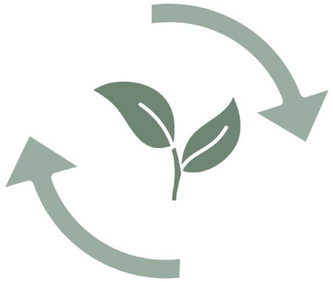
Enhance ecosystem services



Defragment the natural landscape



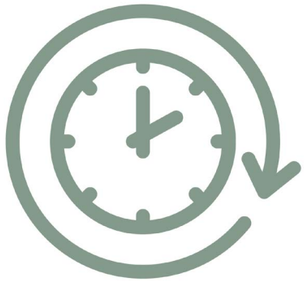
Harmonize human-nature relationships



Ecological restoration using ecosystem-based solutions

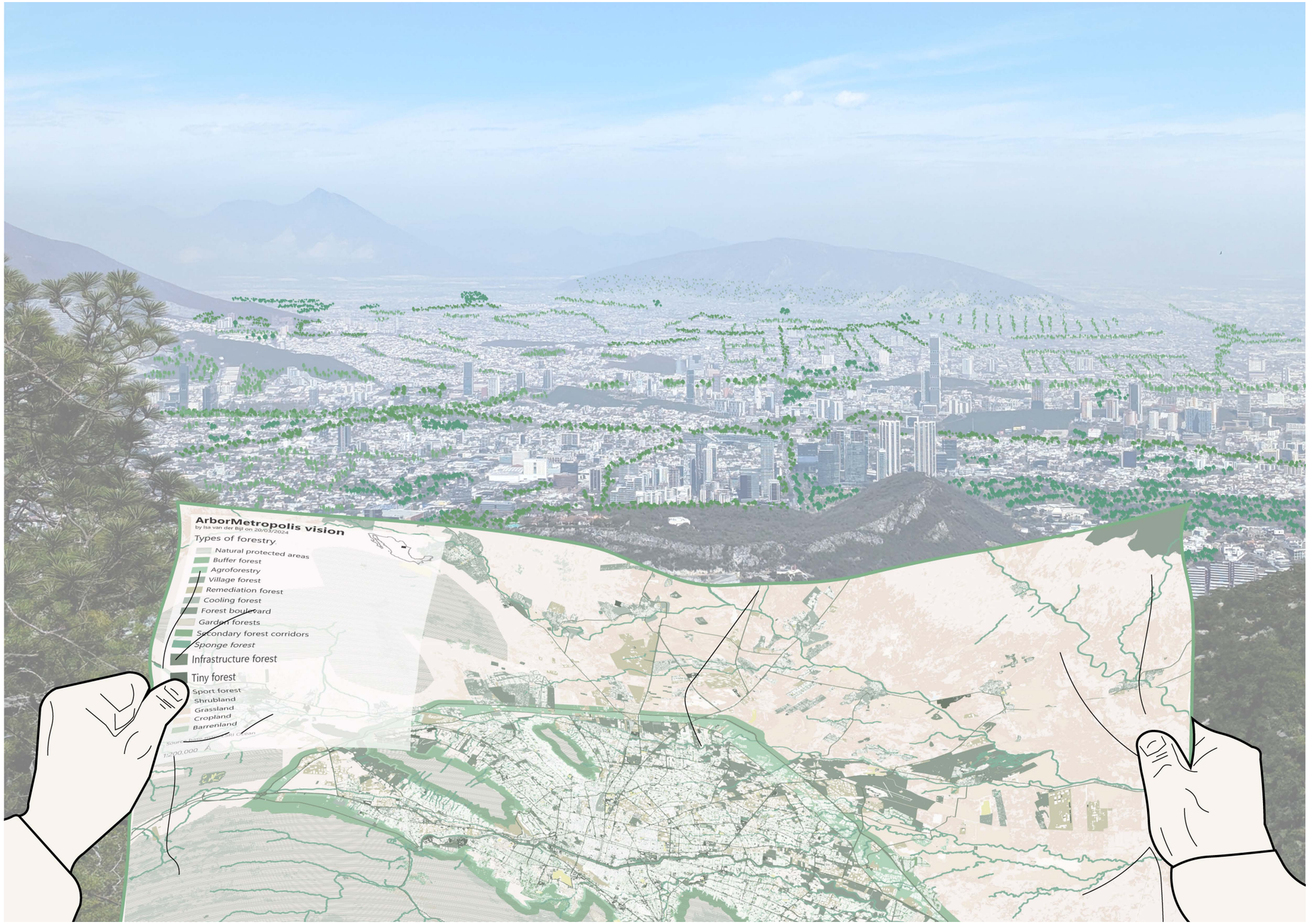


An integrated **system of care**



Long-term plan for green-blue infrastructures

View from the National Park



Thank you!



A r b o r M e t r o p o l i s

Regional afforestation as a backbone for ecosystem-based adaptation in the metropolitan area of Monterrey

Urban Ecology
Isa van der Bijl
21.06.2024