ACCOUNTING FOR ALBEDO CHANGE TO IDENTIFY CLIMATE-POSITIVE TREE COVER RESTORATION

DR. SUSAN COOK-PATTON, LEAD REFORESTATION SCIENTIST
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Accounting for albedo change to identify climate-positive tree cover restoration

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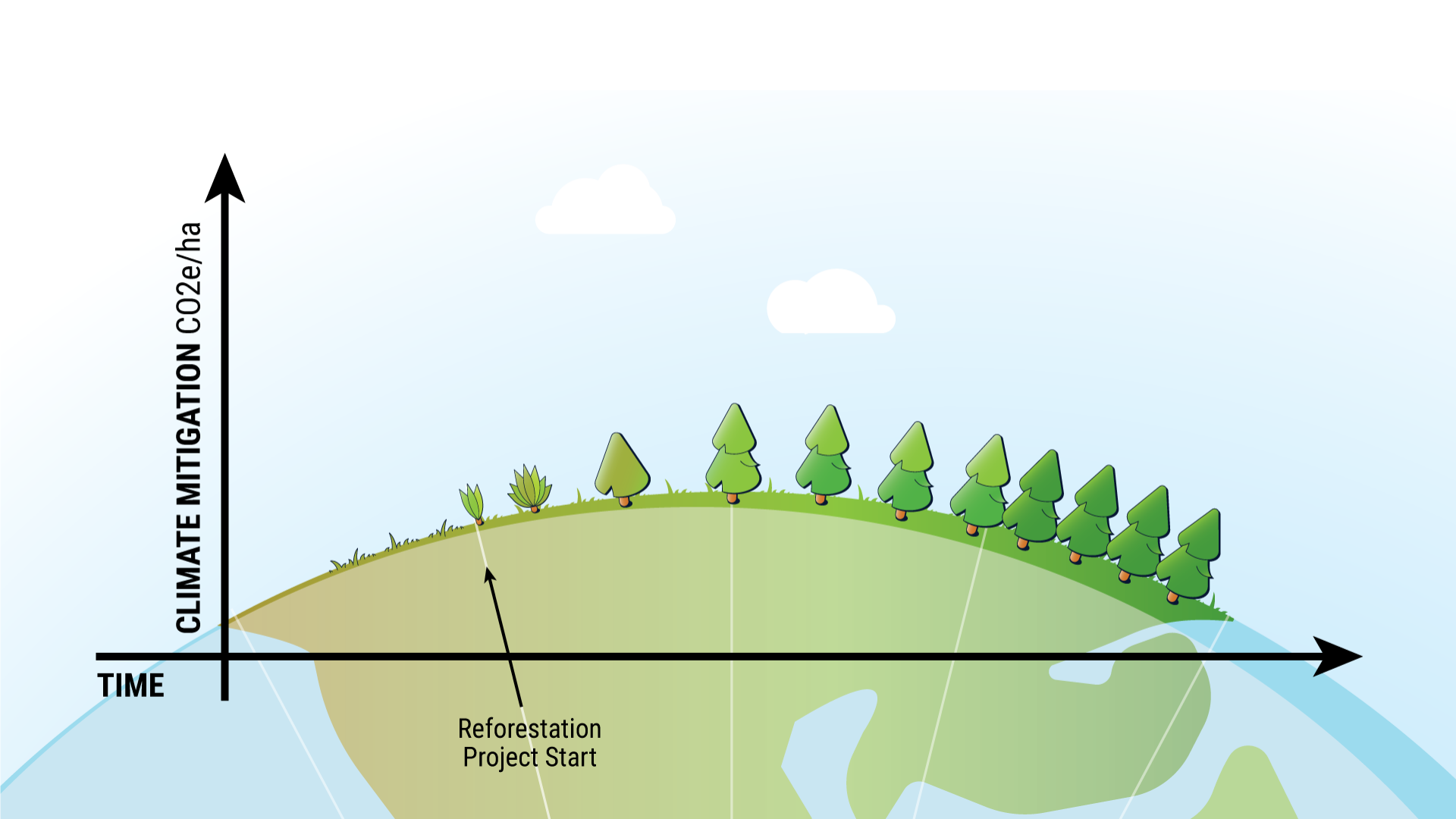
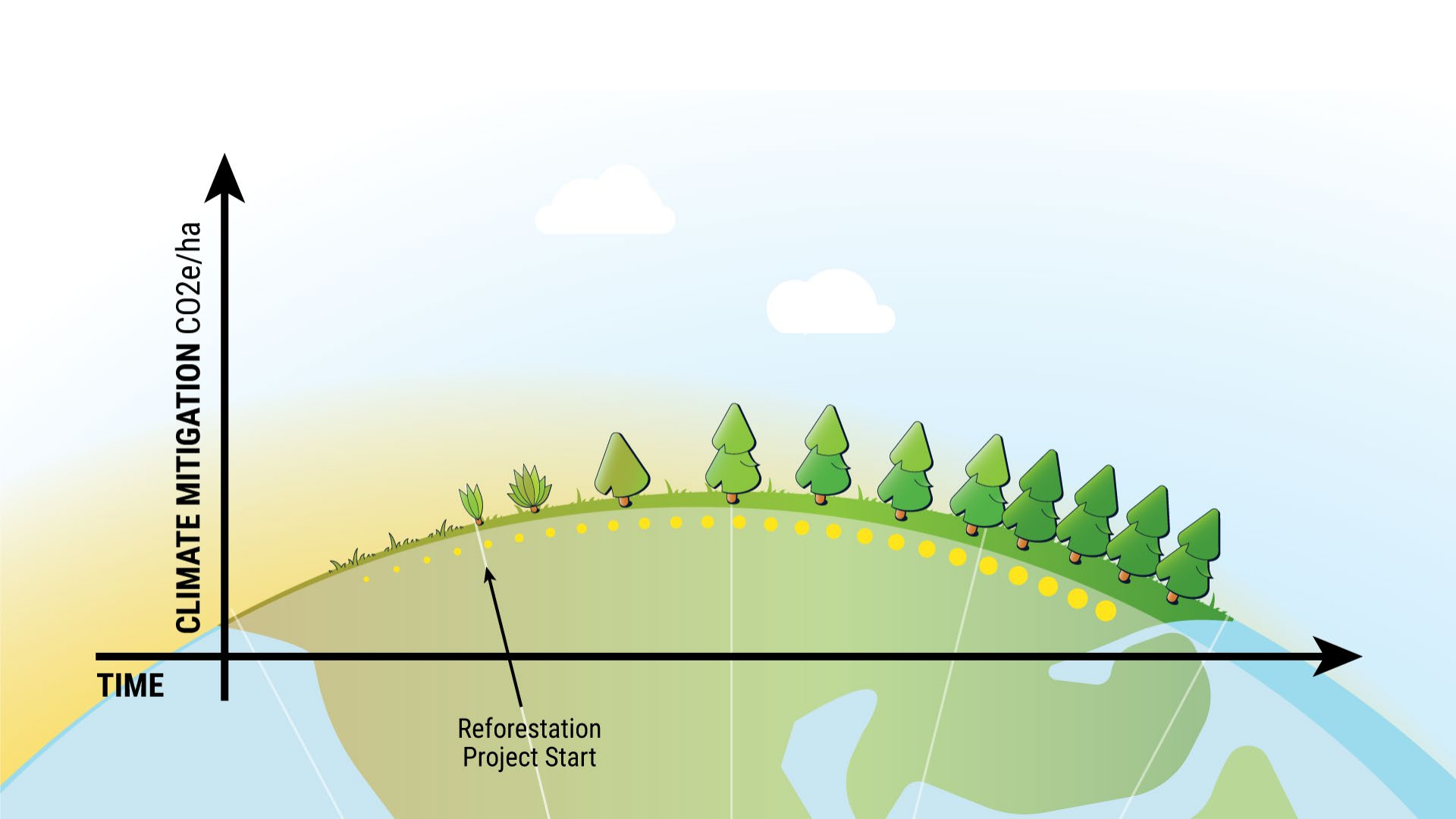
Check for updates

Natalia Hasler[1], Christopher A. Williams[2] ✉, Vanessa Carrasco Denney[3], Peter W. Ellis[4], Surendra Shrestha[2], Drew E. Terasaki Hart[3,5], Nicholas H. Wolff[6], Samantha Yeo[3], Thomas W. Crowther[7], Leland K. Werden[7] & Susan C. Cook-Patton[3] ✉

Restoring tree cover changes albedo, which is the fraction of sunlight reflected from the Earth's surface. In most locations, these changes in albedo offset or even negate the carbon removal benefits with the latter leading to global warming. Previous efforts to quantify the global climate mitigation benefit of restoring tree cover have not accounted robustly for albedo given a lack of spatially explicit data. Here we produce maps that show that carbon-only estimates may be up to 81% too high. While dryland and boreal settings have especially severe albedo offsets, it is possible to find places that provide net-positive climate mitigation benefits in all biomes. We further find that on-the-ground projects are concentrated in these more climate-positive locations, but that the majority still face at least a 20% albedo offset. Thus, strategically deploying restoration of tree cover for maximum climate benefit requires accounting for albedo change and we provide the tools to do so.


CLIMATE MITIGATION CO2e/ha
TIME
Reforestation
Project Start


CLIMATE MITIGATION CO2e/ha
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Reforestation
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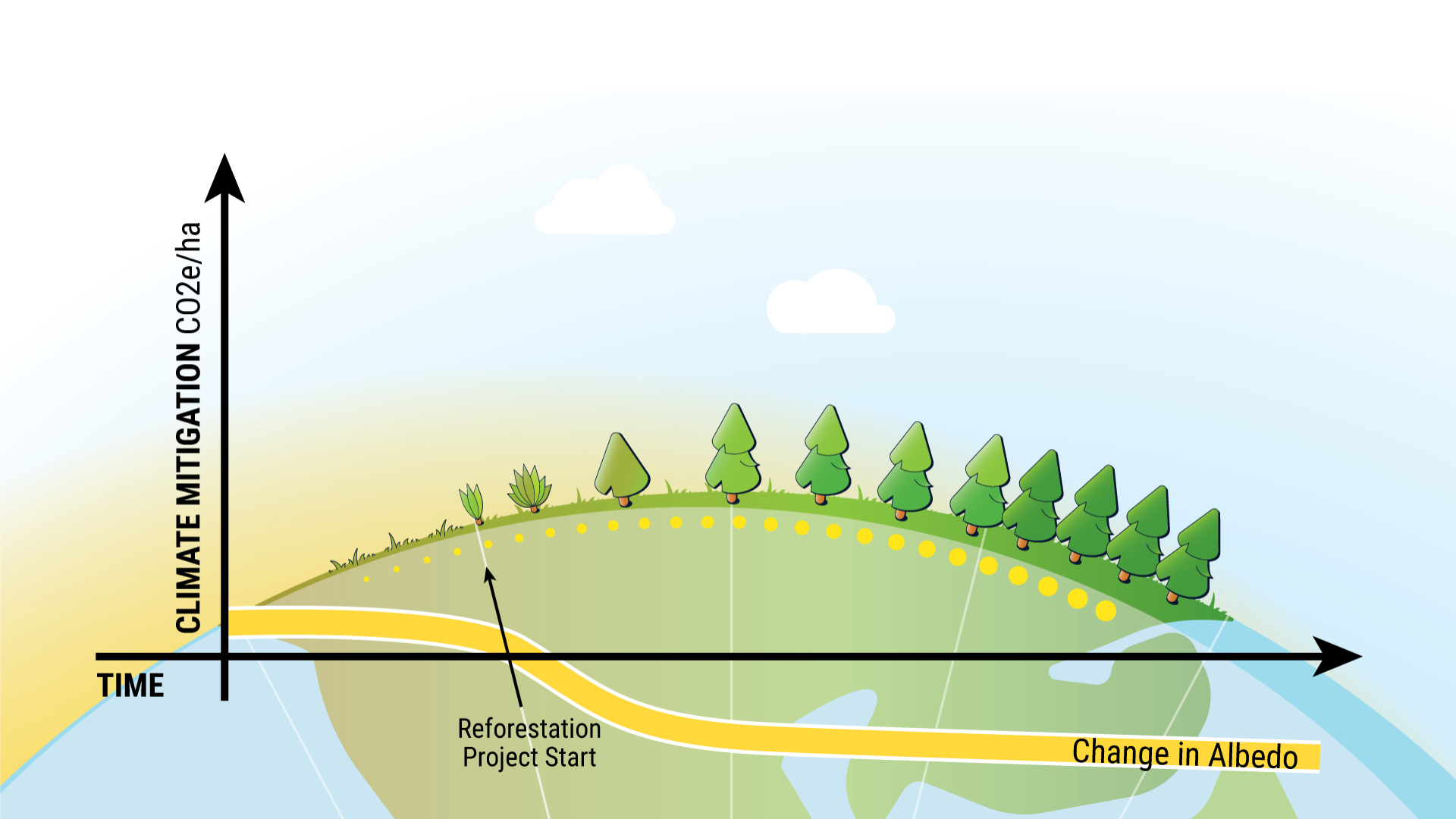
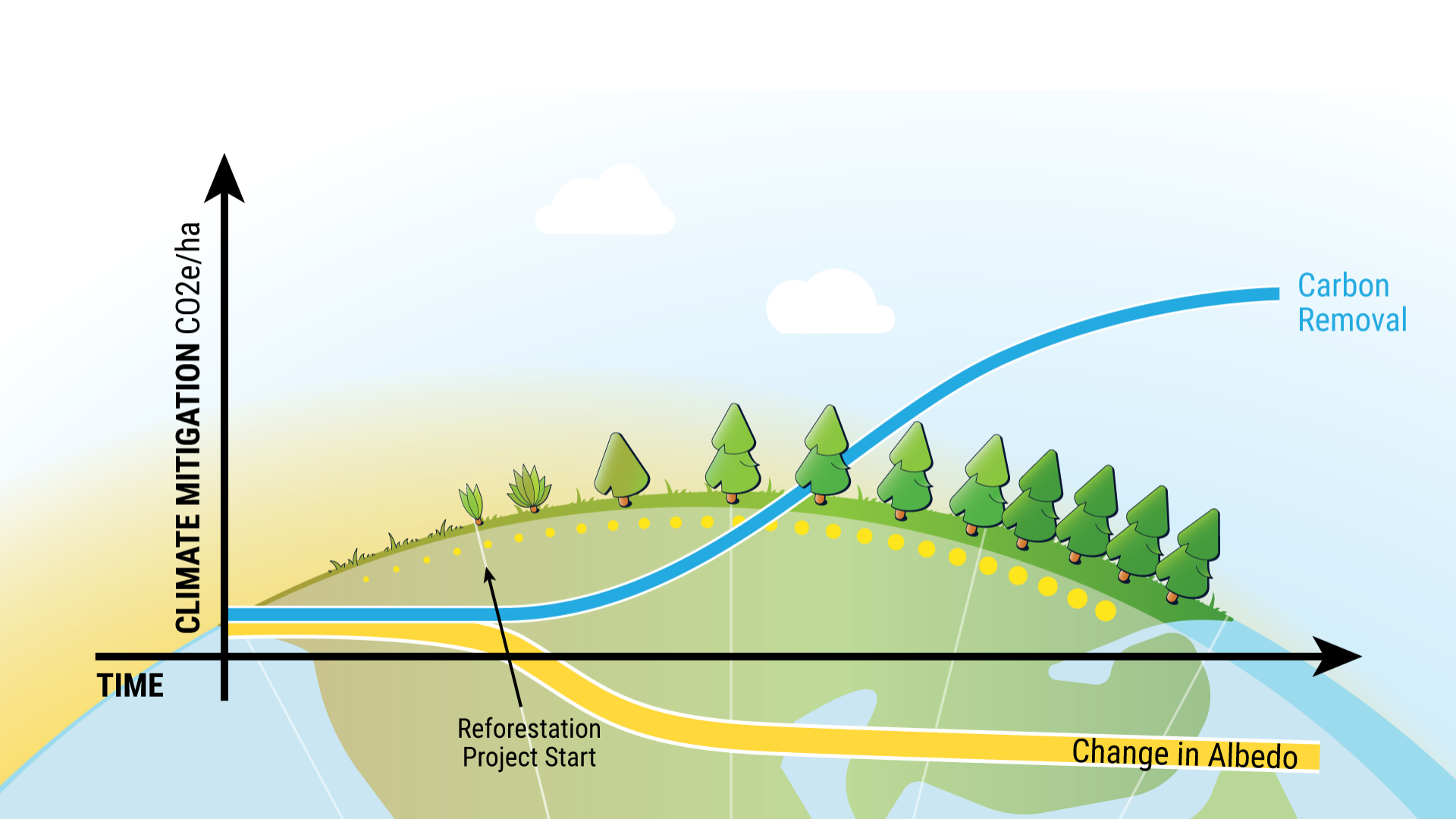
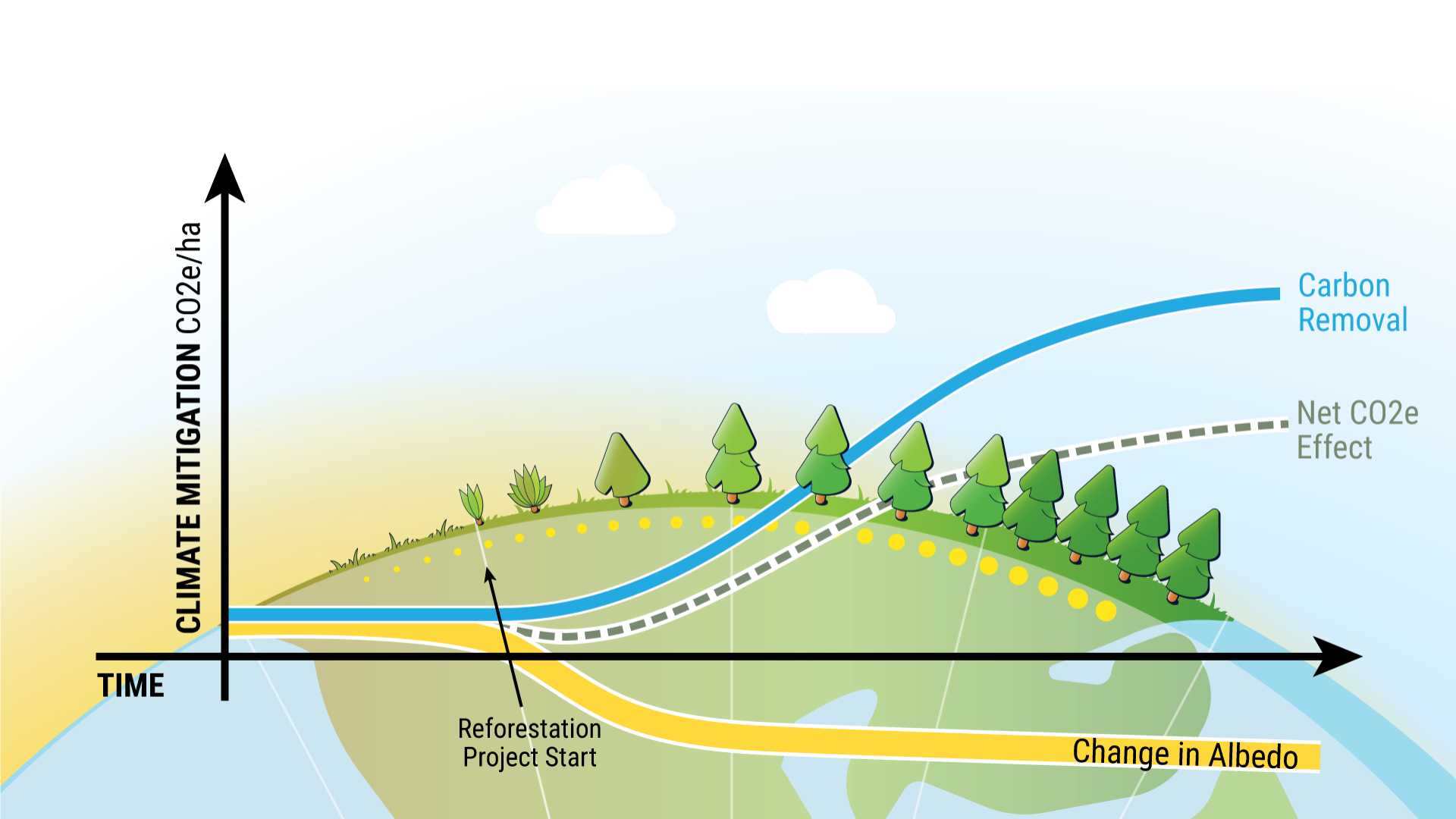
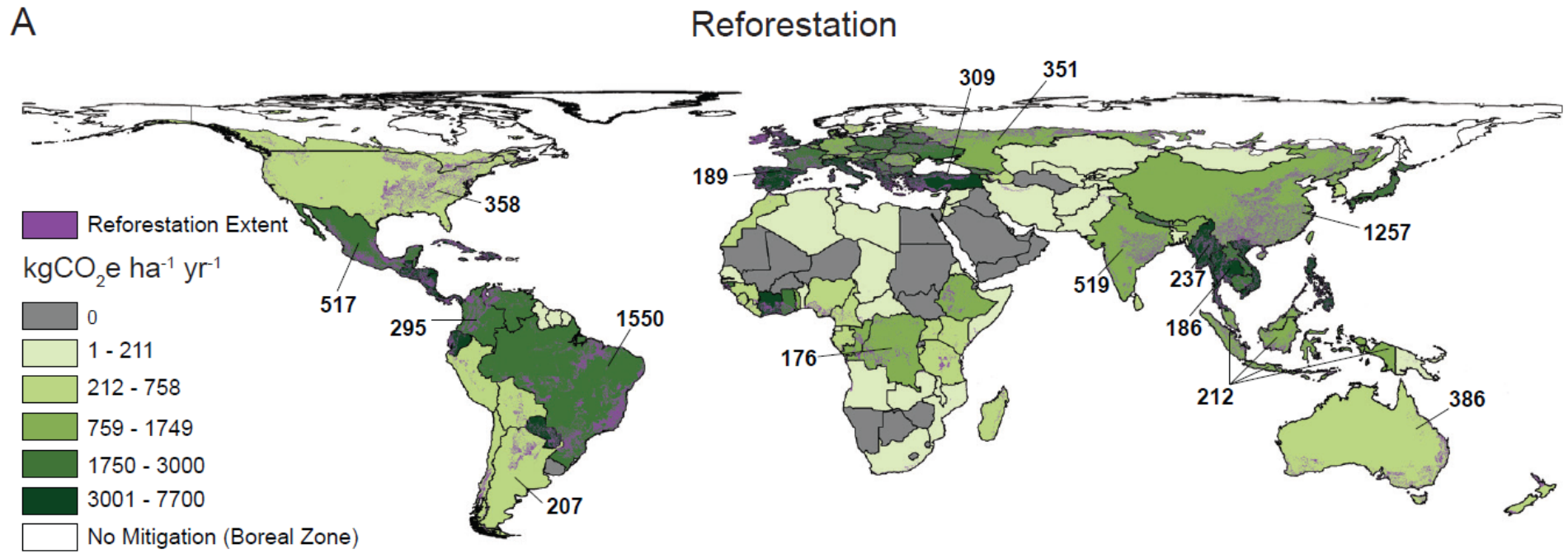

CLIMATE MITIGATION CO2e/ha
TIME
Reforestation
Project Start
Change in Albedo


CLIMATE MITIGATION CO2e/ha
TIME
Carbon Removal
Reforestation Project Start
Change in Albedo


CLIMATE MITIGATION CO2e/ha
TIME
Carbon Removal
Net CO2e Effect
Reforestation Project Start
Change in Albedo



Griscom et al. (2017) *PNAS*

HOW DO WE ESTIMATE ALBEDO CHANGE?

Use the albedo atlas (Gao et. al 2014) – monthly albedo estimates for 17 different land covers

This step accounts for factors like snow cover and geographic location

Multiscale climatological albedo look-up maps derived from moderate resolution imaging spectroradiometer BRDF/albedo products

Feng Gao,[a,*] Tao He,[b] Zhuosen Wang,[c,d] Bardan Ghimire,[e] Yanmin Shuai,[d] Jeffrey Masek,[d] Crystal Schaaf,[c] and Christopher Williams[e]

[a]USDA-ARS, Hydrology and Remote Sensing Laboratory, 10300 Baltimore Avenue, Beltsville, Maryland 20705, United States

[b]University of Maryland, Department of Geography, College Park, 2181 LeFrak Hall, Maryland 20742, United States

[c]University of Massachusetts Boston, School for the Environment, 100 Morrissey Boulevard, Boston, Massachusetts 02125, United States

[d]NASA, Goddard Space Flight Center, Biospheric Sciences Laboratory, Greenbelt, 8800 Greenbelt Road, Maryland 20771, United States

[e]Clark University, Graduate School of Geography, 950 Main Street, Worcester, Massachusetts 01610, United States

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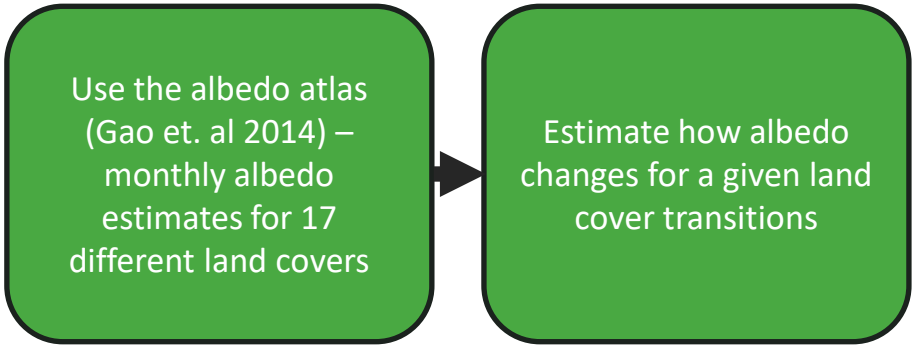
HOW DO WE ESTIMATE ALBEDO CHANGE?



This step accounts for factors like snow cover and geographic location

This step accounts for reforestation transitions (from an open to a forested land cover)

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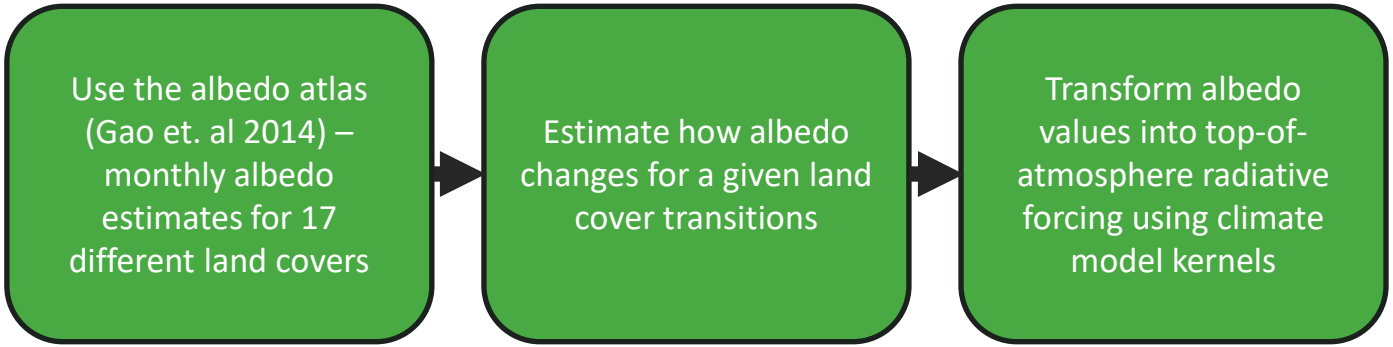
PHOTO CREDIT: Adriano Gambarini
INITIAL LAND COVER
(1) Open shrublands
(2) Grasslands
(3) Croplands
(4) Cropland/natural vegetation mosaic


PHOTO CREDIT: Scott Warren
FINAL CONDITIONS
(1) Evergreen needleleaf forests
(2) Evergreen broadleaf forests
(3) Deciduous needleleaf forests
(4) Deciduous broadleaf forests
(5) Mixed forests
(6) Woody savannas

HOW DO WE ESTIMATE ALBEDO CHANGE?



This step accounts for factors like snow cover and geographic location

This step accounts for reforestation transitions (from an open to a forested land cover)

This step figures out the planetary warming effect

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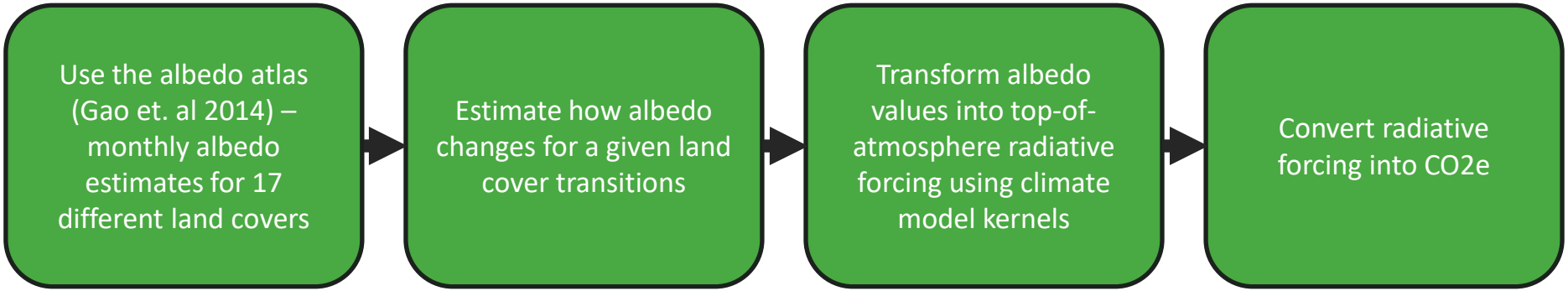
HOW DO WE ESTIMATE ALBEDO CHANGE?



This step accounts for factors like snow cover and geographic location

This step accounts for reforestation transitions (from an open to a forested land cover)

This step figures out the planetary warming effect

This step turns warming into carbon dioxide equivalents, which helps to compare against carbon storage

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4 initial conditions x 6 forest conditions =

24 maps

(+ minimum and maximum versions too)

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HOW MUCH DOES ALBEDO AFFECT MY PROJECT?

1. What is my initial land cover?

   Example: “open shrublands” (OSH)

2. What is my projected forest land cover?

   Example: “Evergreen Needle Leaf Forest” (ENF)

3. Use the OSH2ENF_median.tif to get the expected maximum albedo effect in Mg CO_2e ha^{-1} for your project

4. Compare to the expected carbon storage

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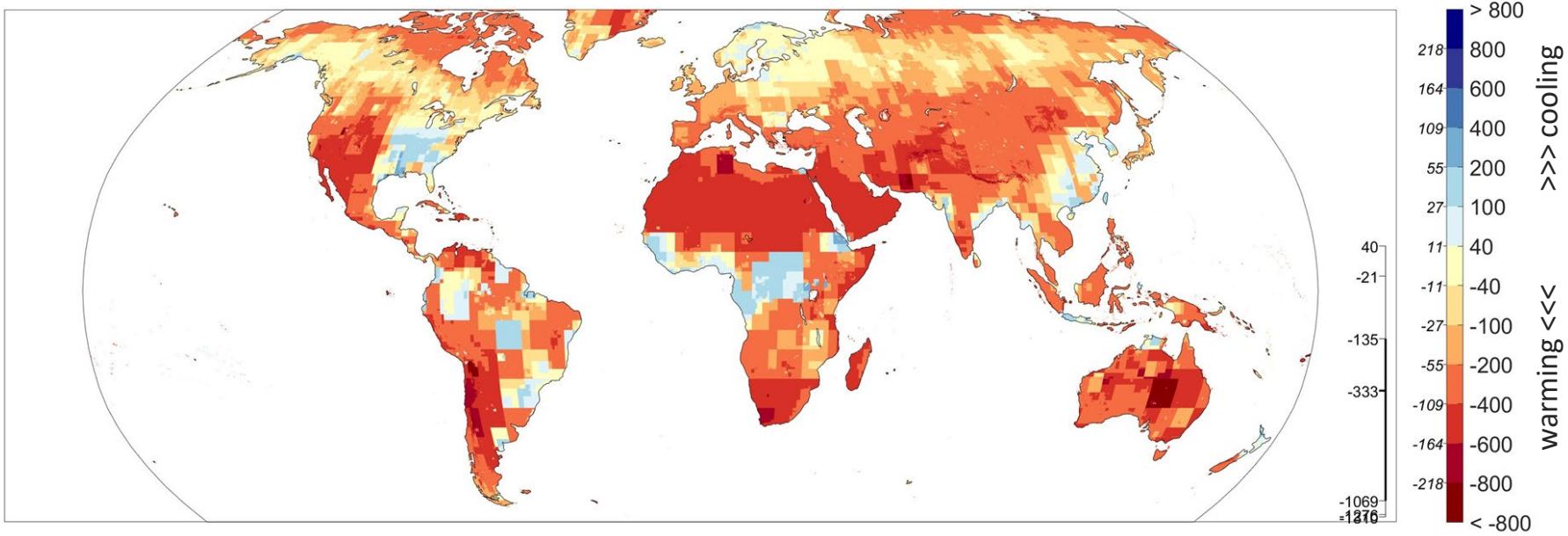

This estimates the albedo change if every pixel started as open shrubland and ended as evergreen needleleaf forest

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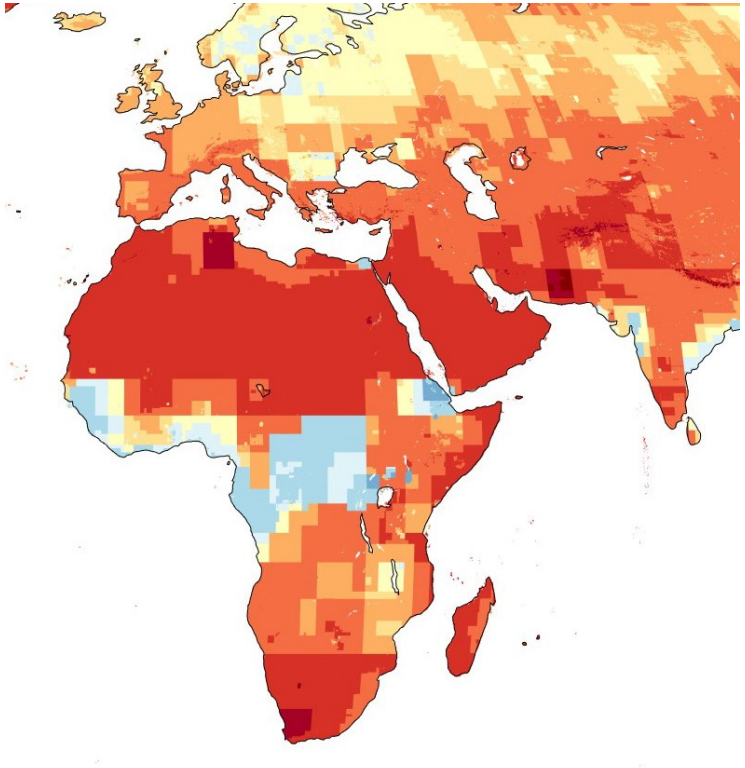
Single transition vs single map

- Single transition maps (N = 24!)
  - work well if you know starting and ending land cover
  - BUT show unrealistic values where transitions cannot happen
- To study the importance of albedo worldwide, we wanted to create a single composite map of the most likely transitions



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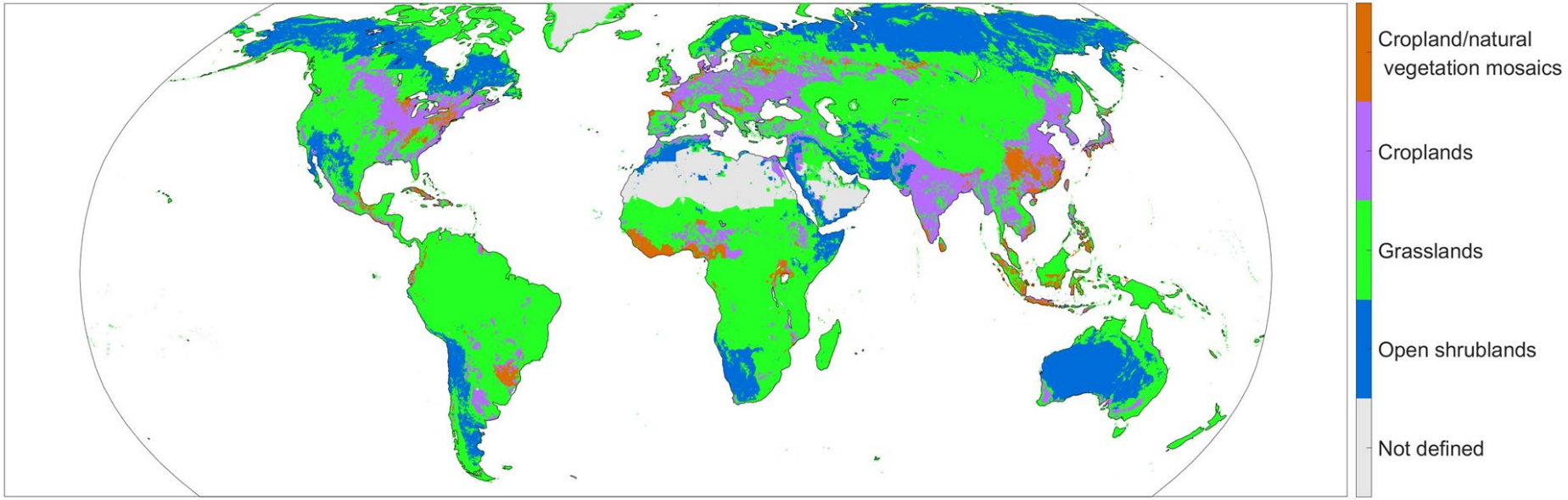
Determine the most likely starting condition based on most common open land types in an area



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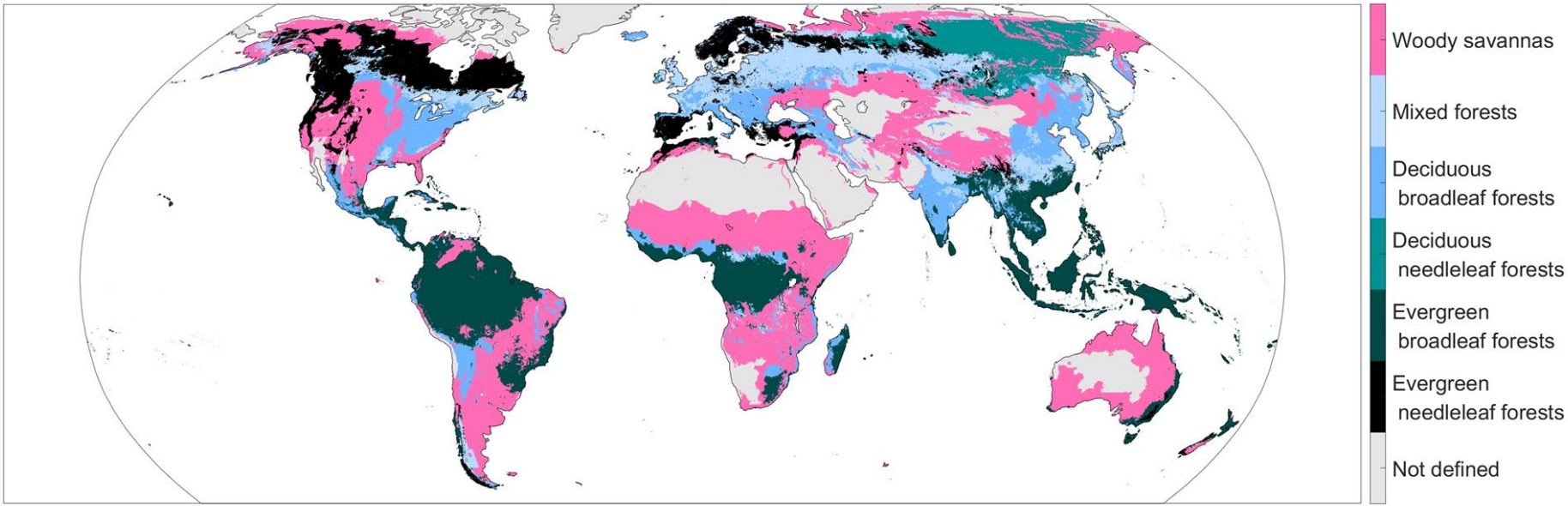
Determine the most likely forest condition based on most common forest types in an area



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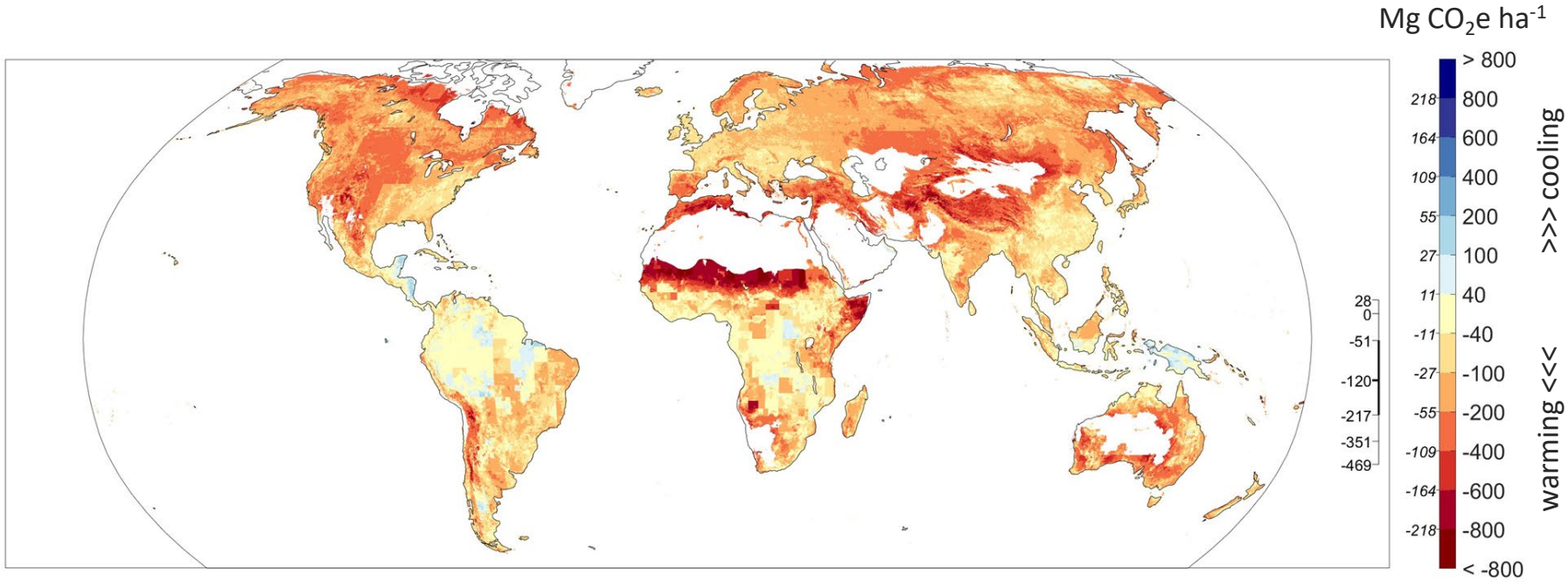
ALBEDO GENERALLY CAUSES **WARMING**

(only part of the story)



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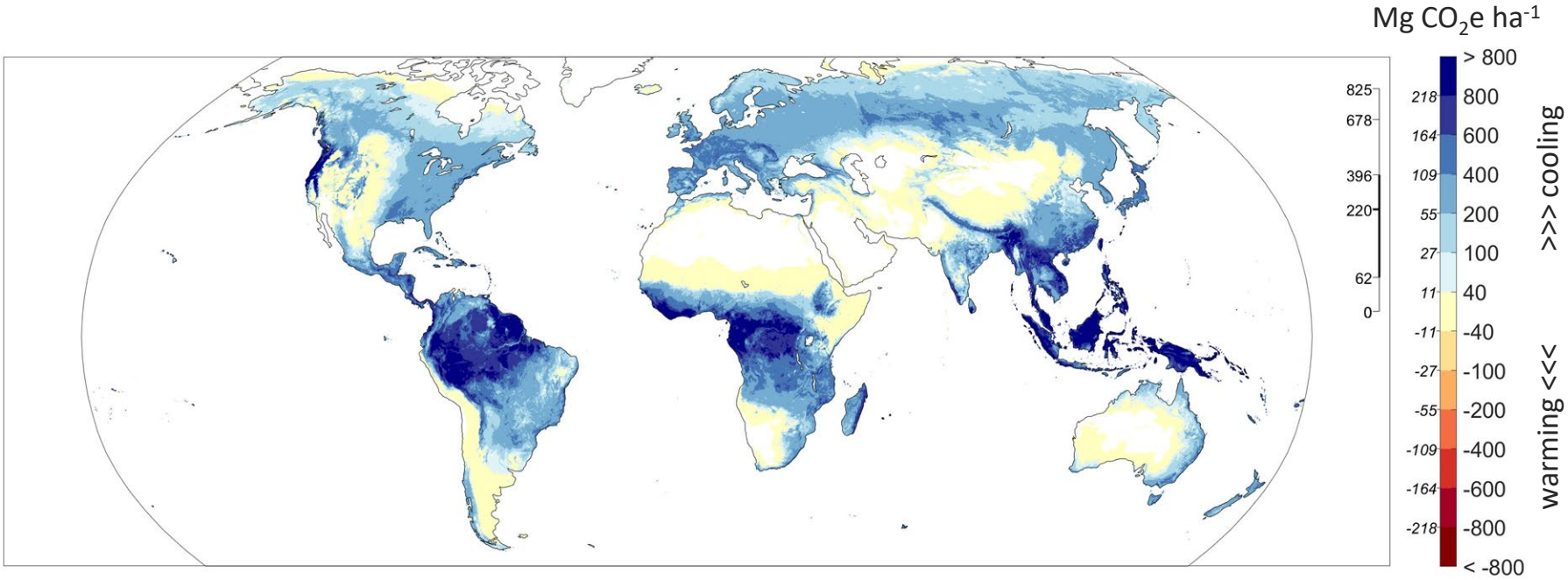
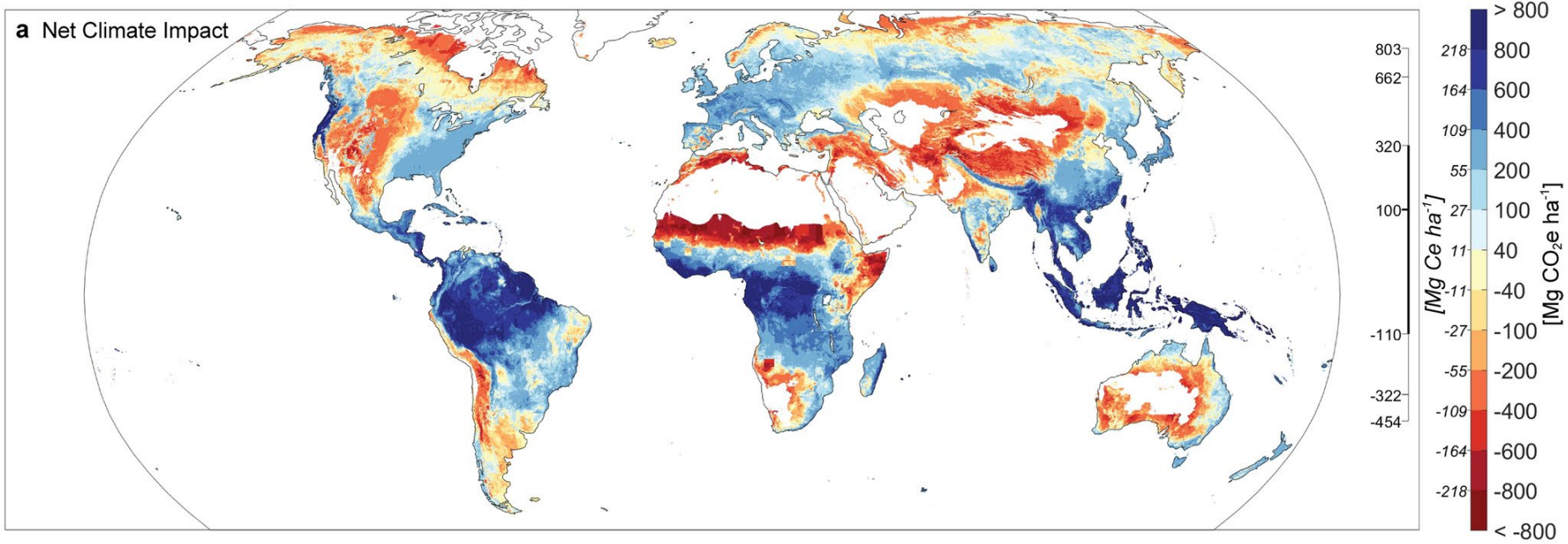
ALSO NEED TO ACCOUNT FOR CARBON STORAGE GENERALLY CAUSES **COOLING**



Walker et al. (2022) *PNAS*

MOST LIKELY ALBEDO + CARBON CHANGE MAP



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SCIENTIFIC REPORTS

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SUBJECT AREAS:
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CLIMATE-CHANGE ECOLOGY

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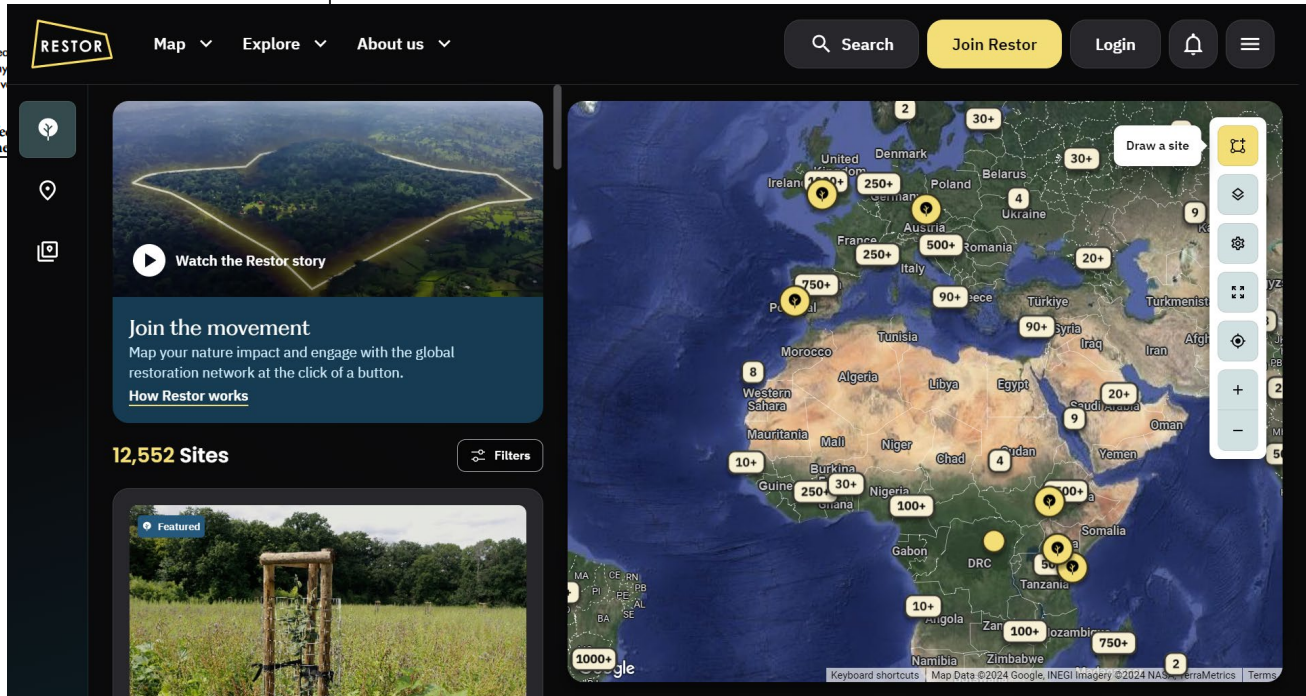
''Grain for Green'' driven land use change and carbon sequestration on the Loess Plateau, China

Lei Deng[1,2], Zhou-ping Shangguan[1,2] & Sandra Sweeney[3]

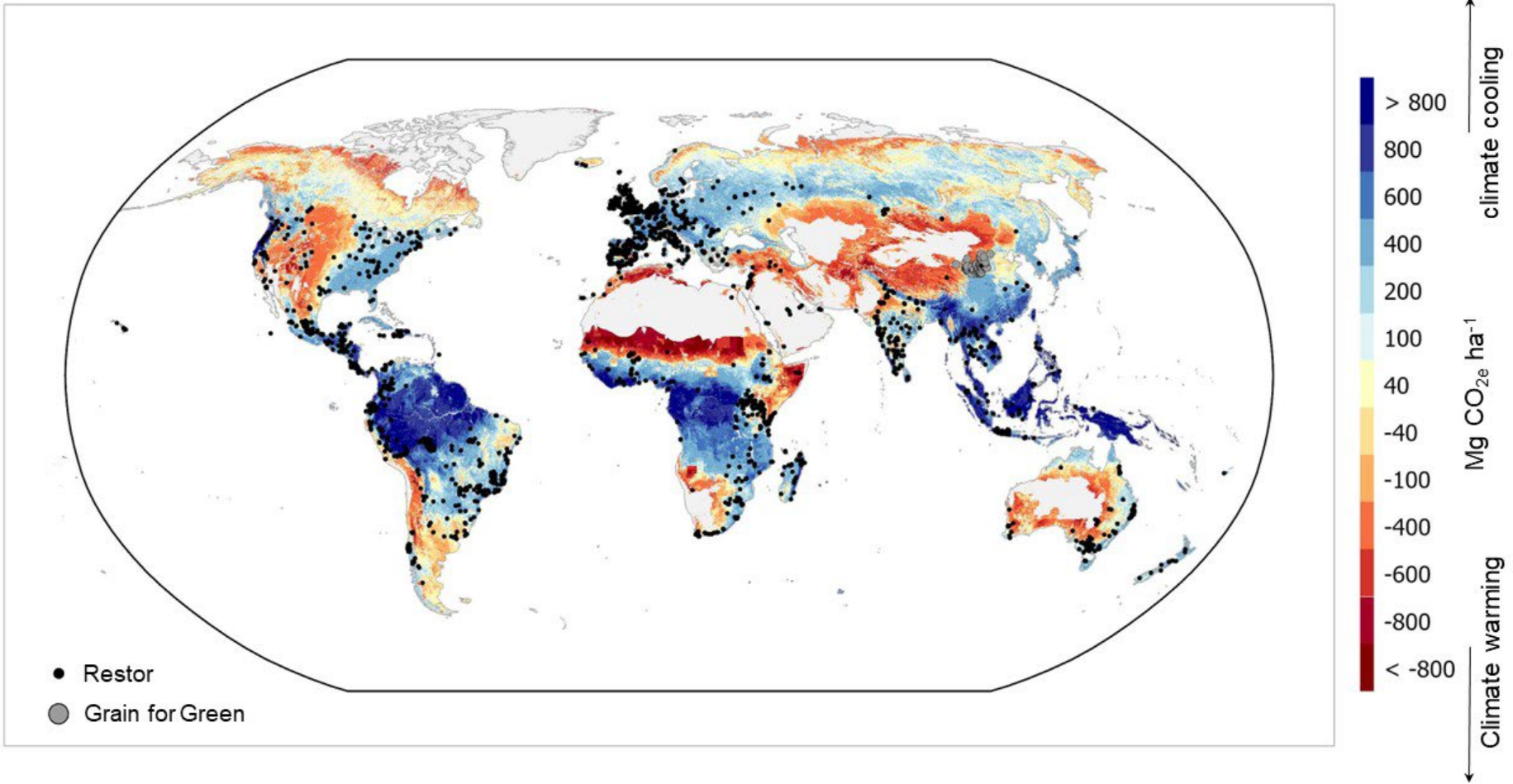
[1]State Key Laboratory of Soil Erosion and Dryland Farming on the Loess Plateau, [2]Institute of Soil and Water Conservation, Chinese Academy of Sciences, Yangling, Shaanxi 712100, China, [3]Institute of Environmental Sciences, Univ

Land-use change is widely considered to be a major factor affe
This paper studied changes to soil C stocks (C_s) following the

We identified 815,654 sites where restoration occurred, is occurring, or is planned



>80% PROJECTS IN CLIMATE-POSITIVE LOCATIONS



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Addressing critiques refines global estimates of reforestation potential for climate change mitigation

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Kurt A. Fesenmyer[1], Erin E. Poor[2], Drew E. Terasaki Hart[3,4], Joseph W. Veldman[5], Forrest Fleischman[6], Pooja Choksi[6], Sally Archibald[7], Mohammed Armani[8], Matthew E. Fagan[9], Evan C. Fricke[10], César Terrer[10], Natalia Hasler[11], Christopher A. Williams[12], Peter W. Ellis[13] & Susan C. Cook-Patton[3]

Accounting for albedo change to identify climate-positive tree cover restoration

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THANK YOU! QUESTIONS?

susan.cook-patton@tnc.org