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PROJECTIONS OF FUTURE AGRICULTURAL ABANDONMENT: IMPACTS TO BIODIVERSITY, CARBON, AND HUMAN WELL-BEING

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OBJECTIVES

Dynamic socio-economic and climatic circumstances have resulted in abandoned farmlands worldwide, and climate change and population growth will alter where this occurs and what the repercussions will be for people and the environment. Natural or assisted recovery of abandoned farmlands to natural areas can provide habitat for biodiversity, combat climate change, and support human well-being. Science-based recommendations to conservation investments and policy can influence where agricultural abandonment occurs, and therefore its social and environmental impacts. Conservation International (CI) supports research that sets global conservation priorities and develops solutions that mobilize long-term investments.

This project will support Conservation International in setting global priorities for conservation investments by completing the following objectives:

1. **Examine projected abandoned agricultural lands globally under different future scenarios to determine biodiversity, carbon, and human impacts of projected abandonment.**
2. **Analyze where strategic use of abandoned lands could occur in the Neotropics for highest benefits to biodiversity, carbon, and human well-being while meeting food demand.**
3. **Identify mismatches among results from objectives 1 and 2 to evaluate policy options to close the gap between projected and optimal areas for agricultural abandonment.**

SIGNIFICANCE

Twenty-first century climate change and human population growth will add complexity to biodiversity conservation and sustainable land use planning. Growing food demand and a changing climate are likely to drive large-scale land use change, altering the distribution of land used for agriculture. Depending on the social, economic, and physical environments, these shifts can take several courses (Stoate et al., 2009). Intensification or expansion can occur in more economically or climatically productive areas, whereas less productive areas can result in abandonment, freeing land for restoration to natural ecosystems or other climate change mitigation strategies (Yang et al., 2020).

Conservation, restoration, and improved management actions, or 'natural climate solutions', can increase carbon storage and avoid greenhouse gas emissions on agricultural and natural lands (Griscom et al., 2017). Conservation International, a global nonprofit, uses natural climate solutions to protect and restore ecosystems that prevent catastrophic impacts from climate change. This proposed project will directly support the UCSB-CI Climate Solutions Collaborative project, Spatial Planning for Area Conservation, Land Use, and Energy in Response to Climate Change. This project aims to identify where strategic allocation of land for area-based conservation, agriculture, and energy can support humans and biodiversity under climate change. Understanding where agricultural abandonment will occur and where it will overlap with areas of high environmental and social importance can meaningfully support conservation and land use planning, and CI will socialize results with national-level planners to support programmatic decision-making.

BACKGROUND

Mitigating global temperature rise is necessary to avoid catastrophic impacts (IPCC, 2021), and most nations have pledged to take necessary actions to limit temperature increases below 2°C. Natural climate solutions can provide over a third of the cost-effective climate mitigation needed to stabilize warming below this threshold with reforestation of disturbed landscapes representing by far the greatest potential contribution to mitigation (Griscom et al., 2017). Since 2003, agricultural abandonment or conversion has affected over 100 million hectares globally (Potapov, 2022), and these lands taken out of production provide potential valuable space for reforestation or restoration to a natural state. Abandoned agricultural lands that are managed for conservation can reduce extinction risk across many thousands of species and ensure a continued or renewed flow of vital ecosystem services, without sacrificing the space required to sustainably support a growing population.

Agricultural abandonment is a global phenomenon and assessing the biodiversity and climate-mitigation benefits of abandonment at that scale can provide guidance for globalized decision-making, inform international- and national-level goals, and provide broader context for local planning (Chaplin-Kramer et al., 2019). However, to date, research has primarily focused on the negative repercussions of agricultural expansion rather than the opportunity for environmental benefits from strategic use of abandoned lands. Molotoks et al., 2018 examined projections of future cropland expansion and the impact on biodiversity and carbon storage, but a complementary analysis has not been completed for projections of agricultural abandonment.

Similarly, an analysis of which lands may be strategically abandoned to maximize co-benefits for biodiversity, carbon, and people has not been completed. The Neotropical region stands out in its abundance of carbon (Noon et al., 2021), biodiversity (Jenkins et al., 2013), and nature-dependent people (Fedele et al., 2021), making it a high priority for conservation (Jung et al., 2021) and restoration (Strassberg et al., 2020). Further, rapid agricultural expansion and deforestation have made the Neotropics an active area of dynamic land cover change (Song et al., 2018; Feng et al., 2021), which may worsen with climate change (Hannah et al., 2020). These factors combine to make the region ideal for identification of strategic abandonment.

EQUITY

Conservation International's mission is to support societies to responsibly and sustainably care for nature for the well-being of humanity. Agricultural abandonment has both social and environmental drivers and impacts (Beilin et al., 2014), which can include significant ramifications for rural communities and workers whose economic or cultural livelihoods are dependent on farming systems. This project addresses environmental justice by explicitly including human well-being in the analyses, with consideration of data on human vulnerability, exposure, and benefits from nature's contributions. By not only considering impacts to biodiversity and carbon when prioritizing areas to dedicate resources, but also communities, we aim to inspire inclusive and equitable conservation solutions.

DATA

The following are publicly available global spatial datasets that this project could utilize.

Agriculture

- *Cropland extent and change* (Potapov et al., 2022). Other options for current global cropland include Lu et al., 2020 and Tuanmu & Jetz, 2014.
- *Cropland projections* (Cao et al., 2021). Spatial data under future scenarios. Other options include M Chen et al., 2020, and G Chen et al., 2020.
- *Yield gaps* (Mueller et al., 2012). Considering spatially explicit yield gaps will be necessary in determining how to meet global food demand.

Biodiversity

- *Species ranges*. The IUCN Red List of Threatened Species contains spatial data for over 100,000 species, including mammals, birds, amphibians, reptiles, fishes, and plants.
- *Species-level climate change projections*. Spatial data from the CI project, Spatial Planning for Area Conservation in Response to Climate Change (SPARC).
- *Key Biodiversity Areas* (IUCN, 2016). Sites of global significance for conservation of threatened and range-restricted species in terrestrial, freshwater, and marine ecosystems.
- *Biodiversity hotspots* (Myers et al., 2000). Highly modified areas with exceptional concentrations of endemic species.

Carbon

- *Manageable and irrecoverable carbon* (Noon et al., 2021). Carbon whose management is under human purview and that which, if lost, could not be recovered by 2050.

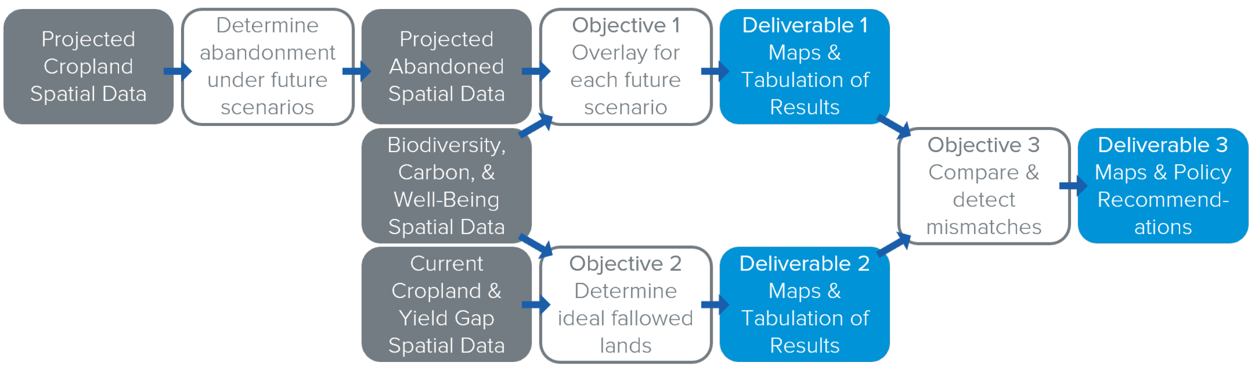
Human Well-Being

- *Nature's contributions to people*. Chaplin-Kramer et al., 2019 and Chaplin-Kramer et al., 2022 model ecosystem services such as water quality regulation and crop pollination.
- *Vulnerability indices*. Indices and data are to be determined by students, but could include WorldBank rates of employment in agriculture, WorldBank rates of secondary school completion, and/or other livelihood and vulnerability variables on CI's Resilience Atlas.
- *Dust*. Abandoned agricultural areas can negatively impact air quality by producing airborne dust. Satellite data can capture this phenomenon, such as that produced by NASA.

RESEARCH APPROACH

The research approach will be informed by a literature review of agricultural abandonment and its drivers and impacts. The review can include but is not limited to: global analyses' influence on policy and conservation investments; policy and conservation investments' influence on abandoned lands; global agricultural abandonment projections under different future scenarios; methods and assumptions in projecting agricultural land use; effectiveness of restoration of abandoned lands for people and the environment; and social costs and benefits of abandonment.

Geospatial analyses will be conducted to inform recommendations for prioritizing nature-positive management of abandoned lands. A possible approach for the geospatial analyses to achieve the three objectives is below. Future scenarios will include several pathways (i.e., SSPs and RCPs) to reflect a diversity of potential socio-economic and climatic futures. Studies that have demonstrated this type of work at the global scale (i.e., Molotoks et al., 2018; Molotoks et al., 2020) can be used as additional guiding references for methodology.



DELIVERABLES

1. Global maps of projected agricultural abandonment overlaid with biodiversity, carbon, and well-being datasets under future scenarios, with recommendations and tabulation of results regarding where conservation investments in abandoned lands could benefit nature and people.
2. Neotropics maps of favorable areas for agricultural abandonment based on biodiversity, carbon, and well-being co-benefits, with recommendations and tabulation of results regarding where strategic use of abandoned lands could benefit nature and people while meeting food demand.
3. Maps identifying mismatches among deliverables 1 and 2 and policy recommendations to close the gap between projected and optimal areas for abandonment.
4. Interactive visual of the results with a narrative of the background, results, and recommendations, such as an ArcGIS StoryMap, for relevant CI and external stakeholders.

INTERNSHIPS

Conservation International will support at least one intern in Summer 2022 with funding of $6,000.

BUDGET & BUDGET JUSTIFICATION

Expenses for this project will not exceed the $1,300 allotment from the Bren School.

CITATIONS

Beilin, R., Lindborg, R., Stenseke, M., Pereira, H. M., Llausàs, A., Slätmo, E., Cerqueira, Y., Navarro, L., Rodrigues, P., Reichelt, N., Munro, N., & Queiroz, C. (2014). Analysing how drivers of agricultural land abandonment affect biodiversity and cultural landscapes using case studies from Scandinavia, Iberia and Oceania. *Land Use Policy*, 36, 60–72. https://doi.org/10.1016/j.landusepol.2013.07.003

Cao, B., Yu, L., Li, X., Chen, M., Li, X., Hao, P., & Gong, P. (2021). A 1 km global cropland dataset from 10 000 BCE to 2100 CE. *Earth System Science Data*, 13(11), 5403–5421. https://doi.org/10.5194/essd-13-5403-2021

Campbell, J. E., Lobell, D. B., Genova, R. C., & Field, C. B. (2008). The global potential of bioenergy on abandoned agriculture lands. *Environmental science & technology*, 42(15), 5791-5794.

Chaplin-Kramer, R., Sharp, R. P., Weil, C., Bennett, E. M., Pascual, U., Arkema, K. K., Brauman, K. A., Bryant, B. P., Guerry, A. D., Haddad, N. M., Hamann, M., Hamel, P., Johnson, J. A., Mandle, L., Pereira, H. M., Polasky, S., Ruckelshaus, M., Shaw, M. R., Silver, J. M., … Daily, G. C. (2019). Global modeling of nature's contributions to people. *Science*, 366(6462), 255–258. https://doi.org/10.1126/science.aaw3372

Chaplin-Kramer, R., Neugarten, R., Sharp, R., Collins, P., Polasky, S., Hole, D., Schuster, R., Strimas-Mackey, M., Mulligan, M., Brandon, C., Diaz, S., Fluet-Chouinard, E., Gorenflo, L., Johnson, J., Keys, P., Longley-Wood, K., McIntyre, P., Noon, M., Pascual, U., … Watson, R. (2022). Mapping the planet's critical natural assets for people. https://doi.org/10.21203/rs.3.rs-1102108/v1

Chen, G., Liu, X., & Li, X. (2021). Future global land datasets with a 1-km resolution based on the SSP-RCP scenarios [Data set]. *Zenodo*. https://doi.org/10.5281/zenodo.4584775

Chen, M., Vernon, C. R., Graham, N. T., Hejazi, M., Huang, M., Cheng, Y., & Calvin, K. (2020). Global land use for 2015–2100 at 0.05° resolution under diverse socioeconomic and climate scenarios. *Scientific Data*, 7(1), 320. https://doi.org/10.1038/s41597-020-00669-x

Fedele, G., Donatti, C. I., Bornacelly, I., & Hole, D. G. (2021). Nature-dependent people: Mapping human direct use of nature for basic needs across the tropics. *Global Environmental Change*, 71, 102368. https://doi.org/10.1016/j.gloenvcha.2021.102368

Feng, X., Merow, C., Liu, Z., Park, D. S., Roehrdanz, P. R., Maitner, B., Newman, E. A., Boyle, B. L., Lien, A., Burger, J. R., Pires, M. M., Brando, P. M., Bush, M. B., McMichael, C. N. H., Neves, D. M., Nikolopoulos, E. I., Saleska, S. R., Hannah, L., Breshears, D. D., … Enquist, B. J. (2021). How deregulation, drought and increasing fire impact Amazonian biodiversity. *Nature*, 597(7877), 516–521. https://doi.org/10.1038/s41586-021-03876-7

Griscom, B. W., Adams, J., Ellis, P. W., Houghton, R. A., Lomax, G., Miteva, D. A., Schlesinger, W. H., Shoch, D., Siikamäki, J. V., Smith, P., Woodbury, P., Zganjar, C., Blackman, A., Campari, J., Conant, R. T., Delgado, C., Elias, P., Gopalakrishna, T., Hamsik, M. R., … Fargione, J. (2017). Natural climate solutions. *Proceedings of the National Academy of Sciences*, 114(44), 11645–11650. https://doi.org/10.1073/pnas.1710465114

IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis,

M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

Jenkins, C. N., Pimm, S. L., & Joppa, L. N. (2013). Global patterns of terrestrial vertebrate diversity and conservation. *Proceedings of the National Academy of Sciences*, 110(28), E2602–E2610. https://doi.org/10.1073/pnas.1302251110

IUCN (2016). A Global Standard for the Identification of Key Biodiversity Areas, Version 1.0. First edition. Gland, Switzerland: IUCN.

Lu, M., Wu, W., You, L., See, L., Fritz, S., Yu, Q., Wei, Y., Chen, D., Yang, P., & Xue, B. (2020). A cultivated planet in 2010 – Part 1: The global synergy cropland map. *Earth System Science Data*, 12(3), 1913–1928. https://doi.org/10.5194/essd-12-1913-2020

Molotoks, A., Stehfest, E., Doelman, J., Albanito, F., Fitton, N., Dawson, T. P., & Smith, P. (2018). Global projections of future cropland expansion to 2050 and direct impacts on biodiversity and carbon storage. *Global Change Biology*, 24(12), 5895-5908.

Mueller, N. D., Gerber, J. S., Johnston, M., Ray, D. K., Ramankutty, N., & Foley, J. A. (2012). Closing yield gaps through nutrient and water management. *Nature*, 490, 254. doc: 10.1038/nature11420

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, 403(6772), 853–858. https://doi.org/10.1038/35002501

Noon, M. L., Goldstein, A., Ledezma, J. C., Roehrdanz, P. R., Cook-Patton, S. C., Spawn-Lee, S. A., Wright, T. M., Gonzalez-Roglich, M., Hole, D. G., Rockström, J., & Turner, W. R. (2021). Mapping the irrecoverable carbon in Earth's ecosystems. *Nature Sustainability*, 1–10. https://doi.org/10.1038/s41893-021-00803-6

Ramankutty, N., Mehrabi, Z., Waha, K., Jarvis, L., Kremen, C., Herrero, M., & Rieseberg, L. H. (2018). Trends in global agricultural land use: implications for environmental health and food security. *Annual review of plant biology*, 69, 789-815.

Stoate, C., Báldi, A., Beja, P., Boatman, N. D., Herzon, I., van Doorn, A., de Snoo, G. R., Rakosy, L., & Ramwell, C. (2009). Ecological impacts of early 21st century agricultural change in Europe – A review. *Journal of Environmental Management*, 91(1), 22–46. https://doi.org/10.1016/j.jenvman.2009.07.005

Thorn, J., Snaddon, J., Waldron, A., Kok, K., Zhou, W., Bhagwat, S., Willis, K., & Petrokofsky, G. (2015, April 22). How effective are on-farm conservation land management strategies for preserving ecosystem services in developing countries? A systematic map protocol - environmental evidence. *BioMed Central*. Retrieved January 19, 2022, from https://environmentalevidencejournal.biomedcentral.com/articles/10.1186/s13750-015-0036-5

Tuanmu, M.-N., & Jetz, W. (2014). A global 1-km consensus land-cover product for biodiversity and ecosystem modelling. *Global Ecology and Biogeography*, 23(9/10), 1031–1045.

Yang, Y., Hobbie, S. E., Hernandez, R. R., Fargione, J., Grodsky, S. M., Tilman, D., Zhu, Y.-G., Luo, Y., Smith, T. M., Jungers, J. M., Yang, M., & Chen, W.-Q. (2020, August 21). Restoring abandoned farmland to mitigate climate change on a full Earth. *One Earth*. Retrieved January 19, 2022, from https://www.sciencedirect.com/science/article/pii/S2590332220303638

CONSERVATION INTERNATIONAL

January 21, 2022

Group Project Committee
Bren School of Environmental Science & Management
University of California, Santa Barbara

Re: Group Project Proposal, *Projections of future agricultural abandonment: impacts to biodiversity, carbon, and human well-being*

Dear Group Project Committee:

On behalf of the Moore Center for Science (MCS) at Conservation International (CI), we are pleased to endorse the proposed master's project proposal, "Projections of future agricultural abandonment: impacts to biodiversity, carbon, and human well-being". This project aims to create science-based recommendations for where to prioritize conservation resources in abandoned agricultural lands, therefore influencing the impacts to biodiversity, natural assets, and human well-being. The MCS supports research that sets global conservation priorities and develops solutions that mobilize long-term investments, and we are excited to leverage the interdisciplinary skills of Bren School students and faculty to inform our work. As Bren graduates, we understand firsthand the value of the hard work put into the group projects; This experience puts us in a strong position to serve as clients and mentors to the students.

This letter serves to confirm CI's support for the Bren Group Project and for funding support of at least one internship to enable Bren students to continue working closely on this project over Summer 2022. Payment will be made directly to the student at an hourly rate of $15/hour for a total of $6,000.

We look forward to your consideration of our proposal.

Sincerely,

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