

## **CHANGES IN FOREST BIOMASS AND CARBON STORAGE IN A TROPICAL ECOSYSTEM AS A FUNCTION OF LAND USE AND SOIL TEXTURE**

### **VERÄNDERUNG VON BIOMASSE UND KOHLENSTOFFSPEICHERUNG ALS FUNKTION VON LANDNUTZUNG UND BODENTEXTUR IN EINEM TROPISCHEN ÖKOSYSTEM**

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#### **SUMMARY**

Assessing anthropogenic impacts on carbon storage in terrestrial ecosystems is of great value for increasing the resilience of soil resources and ecosystem sustainability of tropical Small Island Developing States (SIDS) that are known to be vulnerable to the impacts of climate change. We used historic air photos to assess land use/land cover changes and the natural capital project InVest model for carbon storage and sequestration to evaluate the carbon storage in the Aripo Savannas Scientific Reserve of Trinidad. We also presented a framework that examined the critical soil quality factors that determine soil ecosystem health for the Aripo Forest Reserve and investigated the effect of texture on soil carbon content.

Comparing 1969 and 1994 photos, there was an evident heavy disturbance in key areas of the forest reserves associated with quarrying and construction of pipelines with an estimated 5 % of grassland area affected. Carbon storage reduced by 80157.93 Mg of carbon over a 16 year period in the Aripo Savannas Scientific Reserve due to a reduction in forest extent and coverage because of land conversion activities encroaching into forested areas. Generally, carbon storage in tropical forests is a function of forest extent and density. Soil clay content had a strong linear relationship ( $r^2 = 0.83$ ) with carbon content, hence areas with high clay content had high carbon storage. The InVest carbon storage and sequestration model is suited for the evaluation of carbon in tropical forest ecosystems. It provides information on the soil ecosystem that lead to changes in the provision of ecosystem services to people. Planners should view it as effective tool for exploring alternative management decisions among sectors and services.

**Keywords:** Tropical forest ecosystems, soil ecosystem health, carbon storage change, land use, land management

## REFERENCES

- ATWELL, M. A., WUDDIVIRA, M. N. & WILSON, M. (2018): Sustainable management of tropical small island ecosystems for the optimization of soil natural capital and ecosystem services: a case of a Caribbean soil ecosystem—Aripo savannas Trinidad. *Journal of Soils and Sediments* 18(4): 1654-1667.
- BUNKER, D. E., DECLERCK, F., BRADFORD, J. C., COLWELL, R. K., PERFECTO, I., PHILLIPS, O. L. & NAEEM, S. (2005): Species loss and aboveground carbon storage in a tropical forest. *Science* 310(5750): 1029-1031.
- CANADELL, J. G. & RAUPACH, M. R. (2008): Managing Forests for Climate Change Mitigation. *Science* 320:1456-1457.
- CAPOOR, K. & AMBROSI, P. (2008): State and Trends of the Carbon Market 2008. Washington, D.C.: World Bank Institute, 2008 May.
- CARPENTER, S. R., MOONEY, H. A., AGARD, J., CAPISTRANO, D., DEFRIES, R. S., DÍAZ, S. & PERRINGS, C. (2009): Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. *Proceedings of the National Academy of Sciences* 106(5): 1305-1312.
- DAILY, G. C., POLASKY, S., GOLDSTEIN, J., KAREIVA, P. M., MOONEY, H. A., PEJCHAR, L. & SHALLENBERGER, R. (2009): Ecosystem services in decision making: time to deliver. *Frontiers in Ecology and the Environment* 7(1): 21-28.
- DAVIDSON, E. A. (1995): Spatial covariation of soil organic carbon, clay content, and drainage class at a regional scale. *Landscape Ecology* 10(6): 349-362.
- DONATO, D. C., KAUFFMAN, J. B., MACKENZIE, R. A., AINSWORTH, A., & PFLEGER, A. Z. (2012): Whole-island carbon stocks in the tropical Pacific: Implications for mangrove conservation and upland restoration. *Journal of environmental management* 97: 89-96.
- FANG, J., CHEN, A., PENG, C., ZHAO, S. & CI, L. (2001): Changes in forest biomass carbon storage in China between 1949 and 1998. *Science* 292(5525): 2320-2322.
- FAO (2010): Global Forest Resources: Country Report Trinidad and Tobago. Rome.
- GEE, G. W. & BAUDER, J. W. (1986): Particle-size analysis 1 (No. methods of soil an 1: 383-411). Soil Science Society of America, American Society of Agronomy.

- GUO, L. B., & GIFFORD, R. M. (2002): Soil carbon stocks and land use change: a meta analysis. *Global change biology* 8(4): 345-360.
- GUPTA, R. K. & RAO, D. L. N. (1994): Potential of wastelands for sequestering carbon by reforestation. *Current science*: 378-380.
- HAMILTON, K., SJARDIN, M., MARCELLO, T. & XU, G. (2008): Forging a Frontier: State of the Voluntary Carbon Markets 2008. Washington, D.C.: Ecosystem Marketplace and New Carbon Finance; 2008.
- IPCC (The Intergovernmental Panel on Climate Change) (2006): IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use. Prepared by the National Greenhouse Gas Inventories Programme, EGGLESTON, H. S., BUENDIA, L., MIWA, K., NGARA, T. & TANABE, K. [eds.] Institute for Global Environmental Strategies (IGES), Hayama, Japan. <<http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html>>.
- JACKSON, R. B., LAJTHA, K., CROW, S. E., HUGELIUS, G., KRAMER, M. G. & PIÑEIRO, G. (2017): The Ecology of Soil Carbon: Pools, Vulnerabilities, and Biotic and Abiotic Controls, *Annu. Rev. Ecol. Evol.* 48: 419–445.
- JIANG, P., ANDERSON, S. H., KITCHEN, N. R., SADLER, E. J. & SUDDUTH, K. A. (2007): Landscape and conservation management effects on hydraulic properties of a claypan-soil toposequence. *Soil Science Society of America Journal* 71(3): 803–811.
- LE BISSONNAIS, Y. & ARROUAYS, D. (1997): Aggregate stability and assessment of soil crustability and erodibility: II. Application to humic loamy soils with various organic carbon contents. *European Journal of Soil Science* 48(1): 39-48.
- PAGIOLA, S. (2008): Payments for environmental services in Costa Rica. *Ecological Economics* 65(4): 712-724.
- PANTON, W. P. (1953): Field and Laboratory Studies of the Soils of the Aripo Savannah District (Doctoral dissertation, Imperial College of Tropical Agriculture, Trinidad and Tobago).
- PERCIVAL, H. J., PARFITT, R. L. & SCOTT, N. A. (2000): Factors controlling soil carbon levels in New Zealand grasslands is clay content important? *Soil Science Society of America Journal* 64(5): 1623-1630.

- RICHARDSON, W. D. (1963): Observations on the vegetation and ecology of the Aripo Savannas, Trinidad. *The Journal of Ecology*: 295-313.
- SCHLEUSS, P.-M. (2012): "Can forest soil organic carbon storages be better explained by variable tree species diversities or fine soil contents?", (Diploma thesis, Georg-August Universität Göttingen.
- SEIDL, R., SCHELHAAS, M. J., RAMMER, W., & VERKERK, P. J. (2014): Increasing forest disturbances in Europe and their impact on carbon storage. *Nature climate change* 4(9): 806.
- SHARP, R., TALLIS, H. T., RICKETTS, T., GUERRY, A. D., WOOD, S. A., CHAPLIN-KRAMER, R., NELSON, E., ENNAANAY, D., WOLNY, S., OLWERO, N., VIGERSTOL, K., PENNINGTON, D., MENDOZA, G., AUKEMA, J., FOSTER, J., FORREST, J., CAMERON, D., ARKEMA, K., LONSDORF, E., KENNEDY, C., VERUTES, G., KIM, C. K., GUANNEL, G., PAPENFUS, M., TOFT, J., MARSIK, M., BERNHARDT, J., GRIFFIN, R., GLOWINSKI, K., CHAUMONT, N., PERELMAN, A., LACAYO, M. MANDLE, L., HAMEL, P., VOGL, A. L., ROGERS, L., BIERBOWER, W., DENU, D. & DOUGLASS, J. (2018): InVEST 3.5.0.post358+he23ea3e79185 User's Guide. The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund.
- SIX, J., PAUSTIAN, K., ELLIOTT, E. T. & COMBRINK, C. (2000): Soil structure and organic matter I. Distribution of aggregate-size classes and aggregate-associated carbon. *Soil Science Society of America Journal* 64(2): 681-689.
- SMITH, T. M., LEEMANS, R. & SHUGART, H. H. (1992). Sensitivity of terrestrial carbon storage to CO<sub>2</sub>-induced climate change: comparison of four scenarios based on general circulation models. *Climatic Change* 21(4): 367-384.
- STERN, N. (2007): *The Economics of Climate Change: The Stern Review*. Cambridge and New York: Cambridge University Press.

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