Potential Global Sequestration of Atmospheric Carbon Dioxide by Drylands Forestation

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ABSTRACT

Drylands forestation, a component of earth sciences, ecology, and ecosystems, offers the potential for long-term sequestration of atmospheric CO_2. Israel's Yatir Forest is a 28 km^2 planted Aleppo pine forest growing at the semi-arid timberline, having 280 mm average annual precipitation (with no irrigation or fertilization). The organic and inorganic carbon sequestration rates (assumed representative of global drylands) were measured at Yatir to be ~550 g CO_2 m^{-2} yr^{-1} (150 g C) organic carbon in the tree's biomass, and ~132 g CO_2 m^{-2} yr^{-1} as calcite ($CaCO_3$) precipitates (primarily from root exhaled CO_2 to ~6 meter depth) [1, 2, 3]. Drylands trees have deeper roots compared to temperate regions, therefore providing greater active volume for inorganic sequestration. In addition, microbial processes in soil organic materials also precipitate calcite [4, 5]. The root exhaled CO_2 combines with soil H_2O to form bicarbonate (HCO_3^-), which combines with soil Ca^{2+} to form calcite. Low rainfall precludes dissolving the precipitated calcite. The potential maximal efficacy of global forestation for reducing global warming and ocean acidification depends on the maximal area available for sustainable forestation. The dominant limitation, particularly in the vast drylands regions, is the apparent lack of water. This would reduce the potential area for sustainable forestation to a published estimate of roughly 4.5 million km^2, ~10% of global hot drylands. However, in many drylands areas, plentiful water is available from immediately underlying local paleowater (fossil) aquifers [6]. Using such water, until now not previously taken into consideration, would yield a functional dryland forestation area of ~9.0 million km^2. This would yield a potential total annual sequestration rate of at least ~7.0 Gt CO_2 yr^{-1}, divided between 5.0 Gt CO_2 yr^{-1} (organic) and 2.0 Gt CO_2 yr^{-1} (inorganic); a respectable ~35% of the annual rate of atmospheric CO_2 increase. Significantly, this quantity removed from the atmosphere would also reduce ocean acidification. Note however that the transformation of bright high albedo deserts to darker forests could reduce the positive projected climate cooling effects attained by as much as ~25% [7, 8]. For a 7.0 Gt yr^{-1} total rate, based on published estimates, the total CO_2

“equivalent” atmospheric cooling sequestration rate would be reduced to 5.0 Gt yr^{-1}. The effective reduction may be less, considering that increased forestation evapotranspiration would decrease surface temperature; and increase albedo via increased cloud cover. Note also that drylands forestation does not reduce food supply by decreasing productive temperate-region agricultural land; provides steady employment in economically depressed areas instead of marginal herding and agriculture; and would generate valuable annual carbon reduction credits. Our sequestration estimate demonstrates the global potential, the need for further measurements, and the need to begin implementing a global land management policy of widespread tree planting in drylands regions. Summarizing, dryland forests have the potential to sequester carbon, produce wood, fruits, nuts, increase biodiversity, improve soil structure and health, reduce erosion, increase rainfall, improve water quality, and provide wildlife habitat.

Keywords: Carbon Sequestration, Drylands Forests, Climate Change, Fossil Water

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