

Biochar potential as a soil enhancer for forest restoration in areas degraded by gold mining in the Peruvian Amazon

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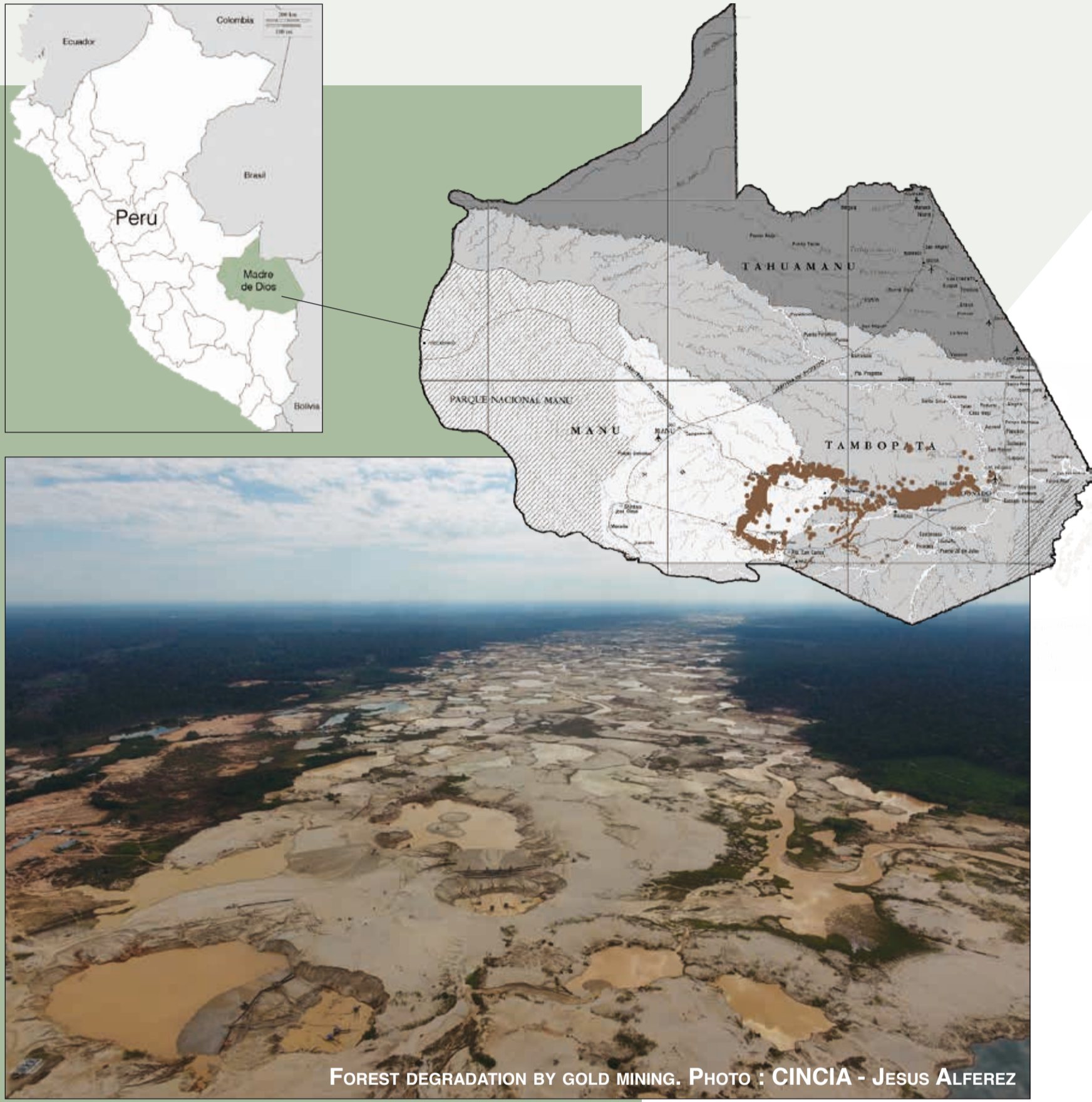
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INTRODUCTION

Biochar (pyrolyzed organic matter) is increasingly investigated as a potential alternative for enhancing soil fertility and water-holding capacity while improving soil organic carbon sequestration¹. Indeed, biochar application in soils is known to reduce nutrient leaching, increase water retention², increase density and diversity of soil biota³, reduce greenhouse gas emissions from soil⁴, increase soil pH, and, depending on the soil's conditions and the quality of the biochar, significantly increase plant aboveground productivity⁵⁻⁷.

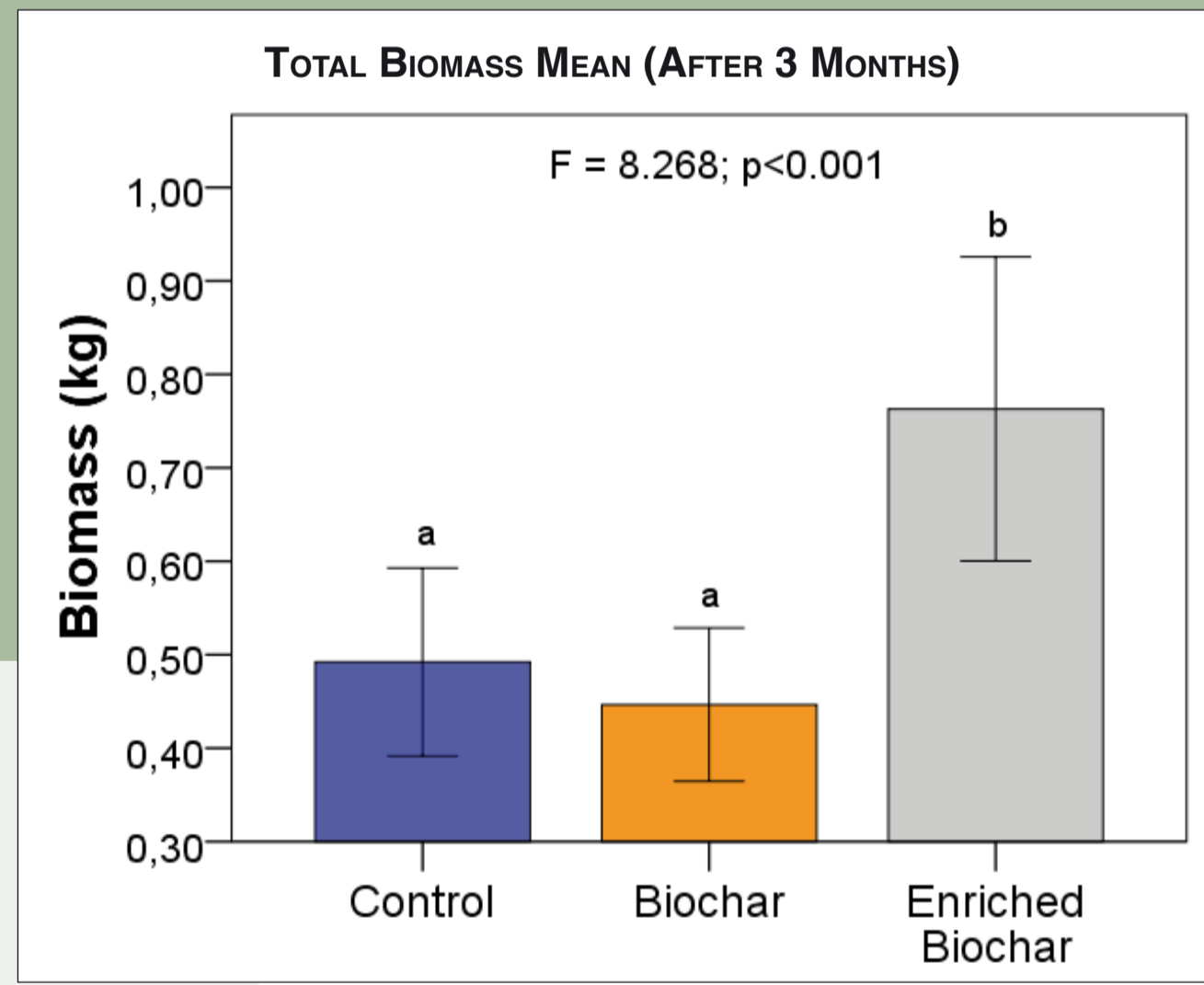
The CINCIA biochar project aims to produce quality biochar from two locally available feedstocks, sawdust from tropical timber and Brazil nut husks, to tackle the soil restoration demands specific to areas degraded by industrial and artisanal scale gold mining. We will then use the scientific results on increased plant production and enhanced soil quality to evaluate the potential of biochar as a reforestation tool. Finally, we seek to promote the use of sustainably produced biochar as a safe and biologically-sound soil amendment.



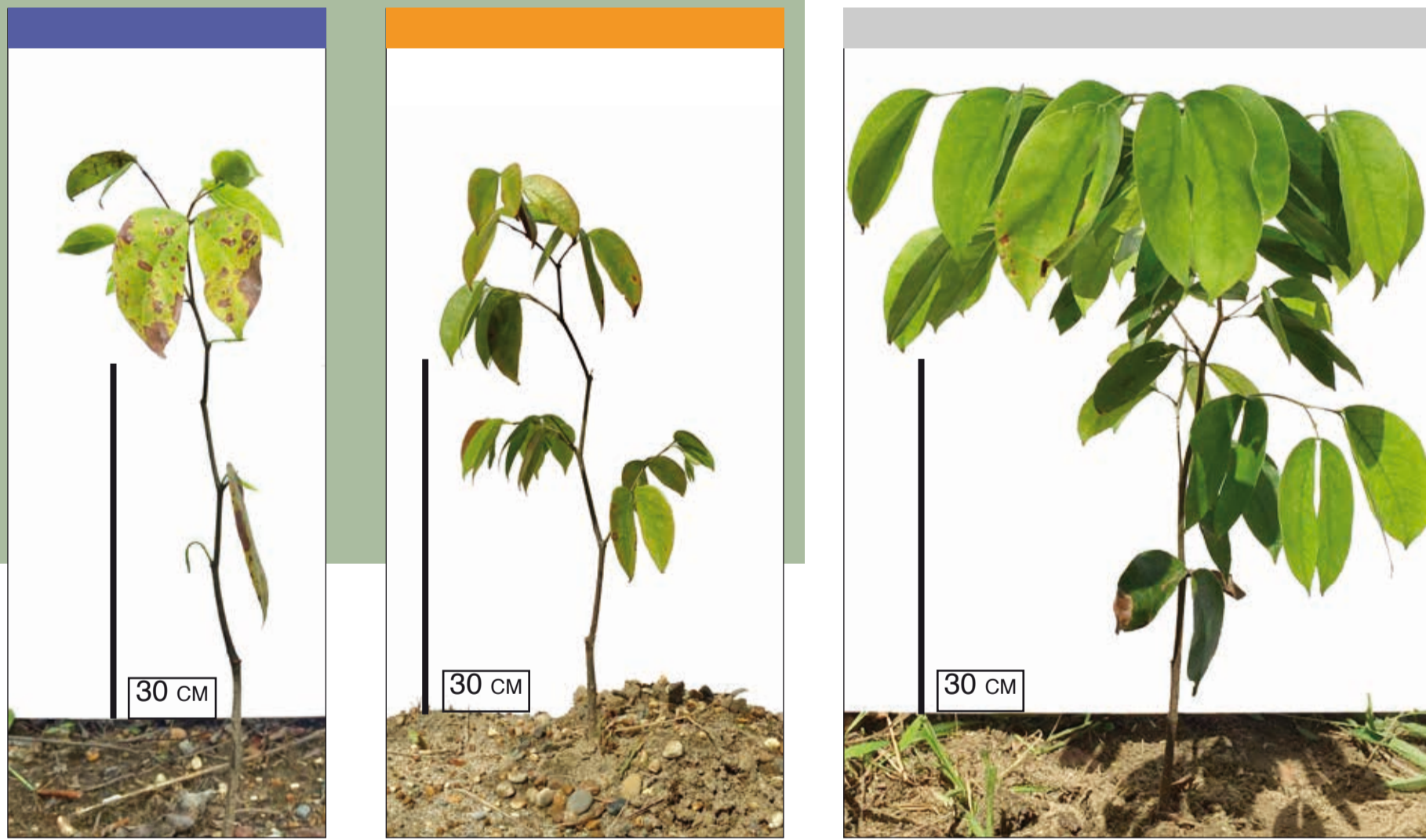
FOREST DEGRADATION BY GOLD MINING. PHOTO : CINCIA - JESUS ALFEREZ

RESULTS

We found an average increase in biomass of 55.4% and 64.8% for enriched biochar as compared to control and biochar only respectively when looked at across all species. Plants with biochar, and particularly enriched biochar, appear leafier and, overall, in better health than in the control plot (as seen in the pictures). Theses preliminary results support our hypothesis that enriched biochar would have an increased effect than biochar alone and control. The project is ongoing, and the data from additional plots and growth periods will allow us to refine the growth and survival effect estimates of soil amendments based on biochar for use in restoration of gold mining degraded areas.



TREATMENT EFFECTS ON MEAN BIOMASS, ALL SPECIES INCLUDED. DIFFERENT LETTERS ABOVE ERROR BARS MEAN STATISTICALLY SIGNIFICANT DIFFERENCES (ANOVA, TUKEY TEST).



SEEDLINGS (*HYDROPHILA COURBARIL*) STATUS COMPARISON BETWEEN CONTROL (LEFT), BIOCHAR (CENTER), AND ENRICHED BIOCHAR (RIGHT). PHOTOS : CINCIA - JESUS ALFEREZ

DISCUSSION

Enriched biochar increased plant production by approximately 50% as compared to pure biochar or control. While not presented here, additional evidence indicates that the result is due to the combination of biochar and fertilizer/microbes, rather than a fertilizer effect alone⁸.

The lower biomass mean witnessed in Biochar plot over Control could be due to the negative priming effect of Biochar. Indeed, pure biochar increase labile carbon stock in soil, making it available for microorganisms, leading to a sudden increase in microbes' populations. This effect can have deleterious consequences on soil pH, nutrient availability and aggregate stability; but usually does not last longer than 90 days. Adding nitrogen along with biochar is known to reduce the negative priming effect which could explain the efficacy of the enriched biochar treatment^{9,10}.

Biochar's positive effect is known to increase over time¹¹. The slow oxidation of the recalcitrant biochar increases its cation exchange capacity¹², and colonization by microorganisms and fungi increases their density and diversity, bringing life back in the exhausted soils of deserted mining areas¹³. Biochar is also known to improve the soil's structure by enhancing the soil's aggregates stability and thus its water retention ability¹⁴. A particular advantage of biochar in areas with high rain fall may be soil nutrient retention. We expect the biochar to increase nutrient retention ability and prevent leaching of scarce nutrients during the coming austral rainy season, increasing its effectiveness and further increasing the positive effect on plant growth.

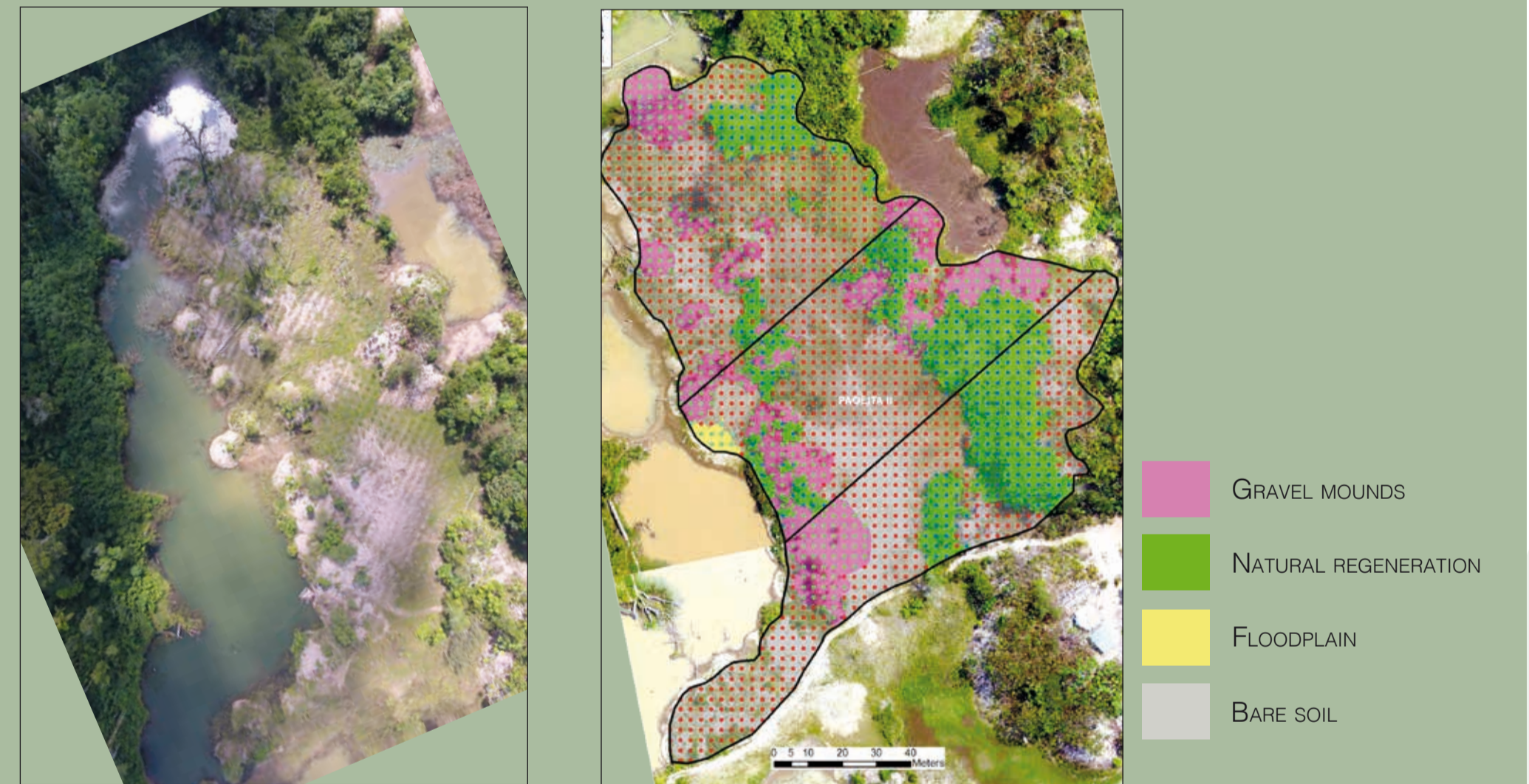
METHODS

Through a cycle of testing and production with Peruvian private-sector partner Grupo Alimenta, we developed a continuous, industrial scale, pyrolyser able to process up to 100 kg of biomass per hour. The project has also built and employed small-scale, robust, and cheap biochar ovens (TLUD and Kon-Tiki) for additional on-site biochar production and initial trials/experimentation with alternative feedstocks.



PYROLYSER MODEL TLUD (LEFT), INDUSTRIAL CONTINUOUS PYROLYSER (CENTER), PYROLYSER MODEL KON-TIKI (RIGHT). PHOTOS : CINCIA - DAVID LEFEBVRE

The project is in the process of reforesting a total of 42 ha of degraded mining areas. Each study site has been divided in three treatments (1: Control; 2: Biochar; 3: Enriched Biochar). More than 50 different tree species, both native and exotic, have been planted at a rate of approximately 1100 plants/ha. One kg of biochar was amended to each plant at planting. The enriched biochar treatment consists of biological fertilizer (a fermentation of various natural products applied to biochar at a rate of 100 l/t), NPK 20/20/20 (100 kg/t), and a mixture of microorganisms (1 l/t). All fertilizers and amendments are added to the biochar prior to its field application.



DRONE AERIAL VIEW OF A DEGRADED MINING SITE. PHOTO : CINCIA - JESUS ALFEREZ

GIS REPRESENTATION OF A REFORESTATION PARCEL. ILLUSTRATION : CINCIA - MARTIN PILLACA



BRAZIL NUT HUSKS (LEFT) AND BIOCHAR FROM BRAZIL NUT HUSKS (RIGHT). PHOTO : CINCIA - DAVID LEFEBVRE

To date, a total of 7.2ha in 5 different sites have been reforested. Only three of these sites have been amended with biochar, and only one of them has been subject to data collection, presented here. Species specific biomass was calculated using the formula: Biomass = Basal Area * Height * Wood Density.

CONCLUSION

Although our study is still at an early stage, the preliminary positive results paired to the reported usual increase of biochar's beneficial effect over time lead to promising outcomes for biochar to be adopted as a reforestation tool on degraded gold mining sites in the Peruvian Amazon.

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