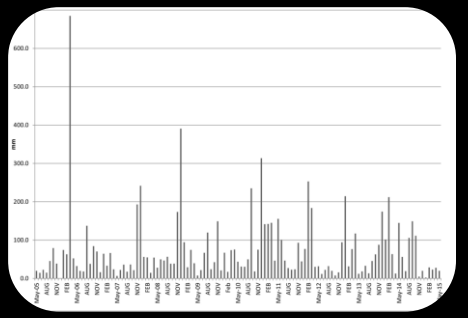
Restoring Native Plants in an Abandoned Quarry under Changing Climate



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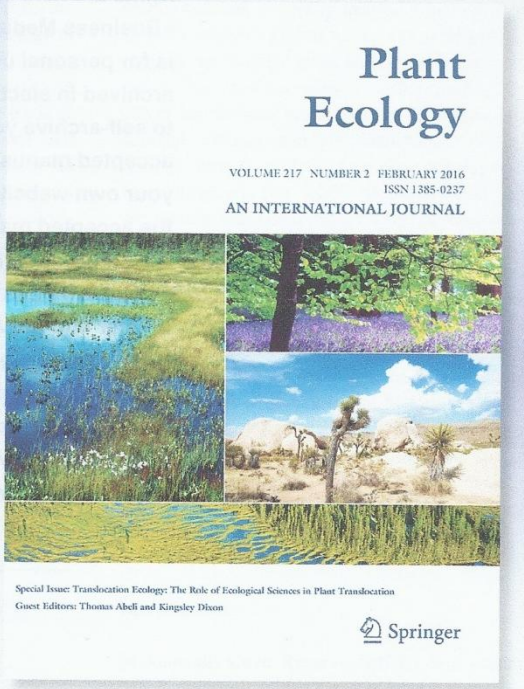

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Monitoring results from a decade of native plant translocations at Makauwahi Cave Reserve, Kaua'i

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Abstract At Makauwahi Cave Reserve, on the south shore of Kaua'i, translocation decisions have been guided to a unique degree by the richly detailed fossil record of biota of recent centuries, which occurs on the site. To evaluate the efficacy of this strategy, ecological conditions and individual life histories for 3388 translocated native plants of 81 species have been monitored since 2005. Many species were selected on the basis of their prevalence as subfossils in the adjacent late Holocene cave sediments. Most of these species no longer occur on or near the abandoned farmlands and mine spoil used as a substrate for transplanted individuals. Records for each plant included location, date outplanted, flowering, fruiting, and, if applicable, mortality, including known or inferred cause. Also recorded was unaided recruitment, survival of transplanted recruits, and quantity of seed collected. Plant species selected for reintroduction on the basis of present occurrence near the site (many of which also occur there as fossils), and species not present but selected solely on the basis of fossil occurrence before European arrival, both show high survival rates in most cases. Species that fit neither of these criteria, but are judged suitable on the basis of their occurrence elsewhere on the island in similar habitats, generally showed lower survival rates. Primary mortality factors for nursery stock not surviving outplanting included transplant shock, irrigation failure, and human error (accidental cutting, pulling, or trampling). Much lower mortality rates were linked to insect damage, disease, and pig disturbance. Phenological records show that 80 % of translocated native species have flowered and 70 % produced seed. Unaided recruitment was observed for 43 % of the species with some rare species producing large numbers of volunteer seedlings. Translocated volunteer seedlings showed high survival rates. Insights from the fossil record have provided perspective on the site's potential and limitations and enriched interest in a restoration by almost doubling the list of plant species used in restoration programs and adding a living history element to the interpretation of the site through the juxtaposition of the fossil evidence and the translocated native species.

Keywords Hawaiian Islands · Plant conservation · Survival · Phenology · Fossils · Rewilding

Communicated by Prof. Michael Lawes, Prof. Ross Bradstock and Prof. David Keith.

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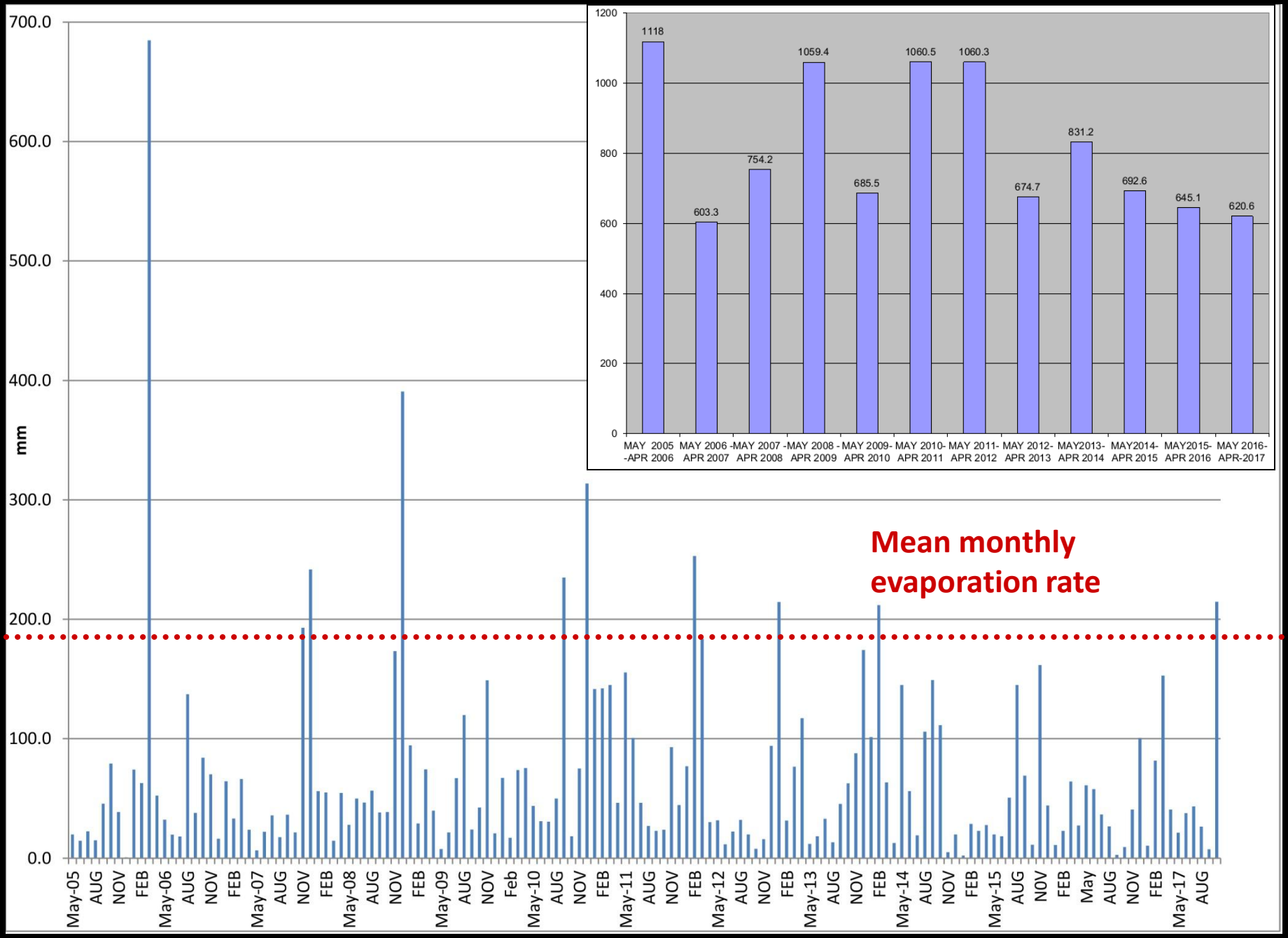
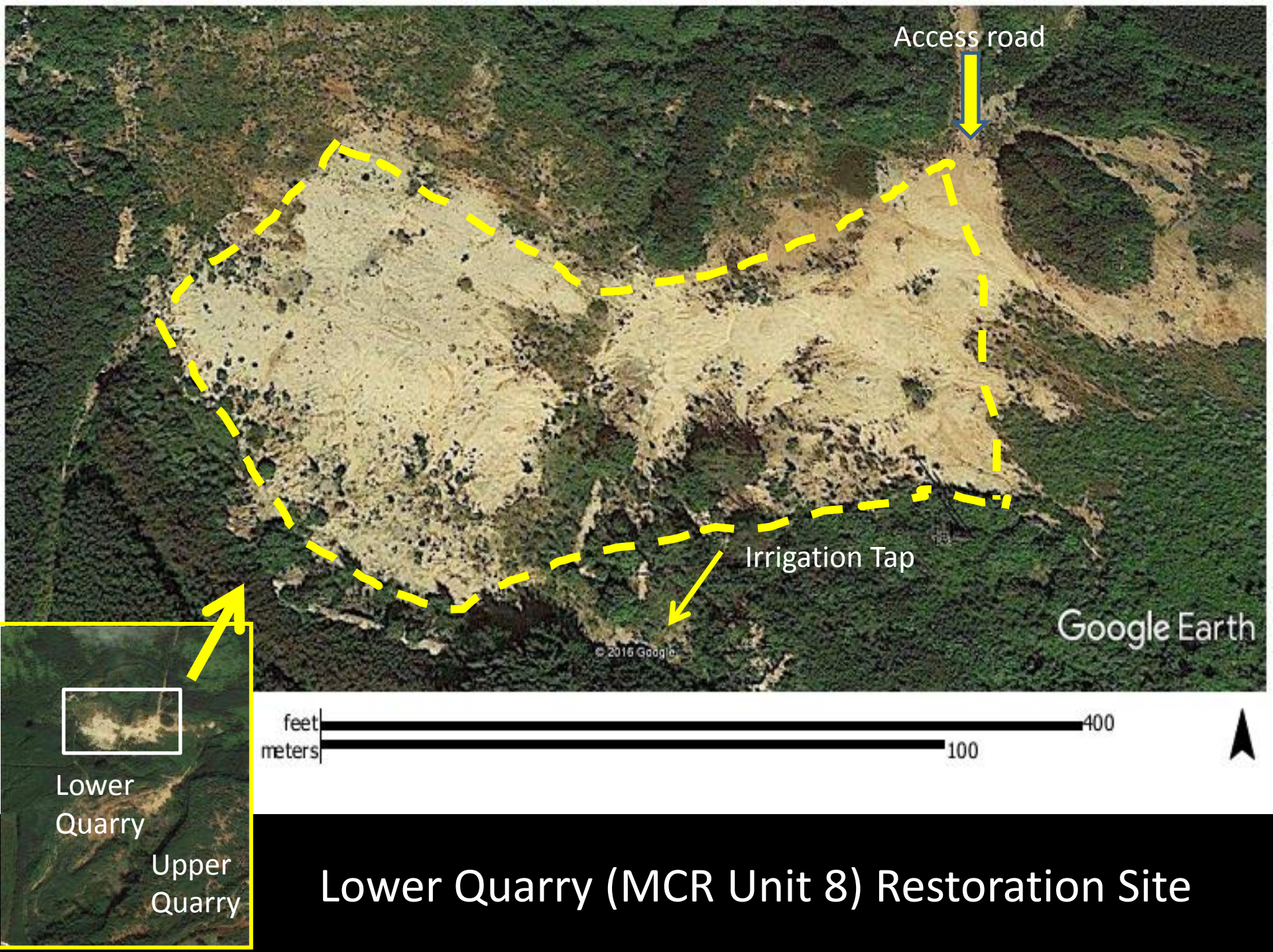
Introduction

Makauwahi Cave Reserve (MCR) is a community-based nonprofit under Garden Island Resource Conservation and Development, Inc., in cooperation with


mm
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Mean monthly evaporation rate
May-05 AUG NOV FEB May-06 AUG NOV FEB May-07 AUG NOV FEB May-08 AUG NOV FEB May-09 AUG NOV Feb May-10 AUG NOV FEB May-11 AUG NOV FEB May-12 AUG NOV FEB May-13 AUG NOV FEB May-14 AUG NOV FEB May-15 AUG NOV FEB May AUG NOV FEB May-17 AUG
1200
1000
800
600
400
200
0
1118
603.3
754.2
1059.4
685.5
1060.5
1060.3
674.7
831.2
692.6
645.1
620.6
MAY 2005 -APR 2006
MAY 2006 APR 2007
MAY 2007 APR 2008
MAY 2008 APR 2009
MAY 2009 APR 2010
MAY 2010 APR 2011
MAY 2011 APR 2012
MAY 2012 APR 2013
MAY2013 APR 2014
MAY2014 APR 2015
MAY2015 APR 2016
MAY 2016 APR-2017


Makauwahi
Cave Reserve
Lower Quarry
MCR Unit 8
Upper Quarry
MCR Unit 7
Sinkhole
1
2
3
4
5
6

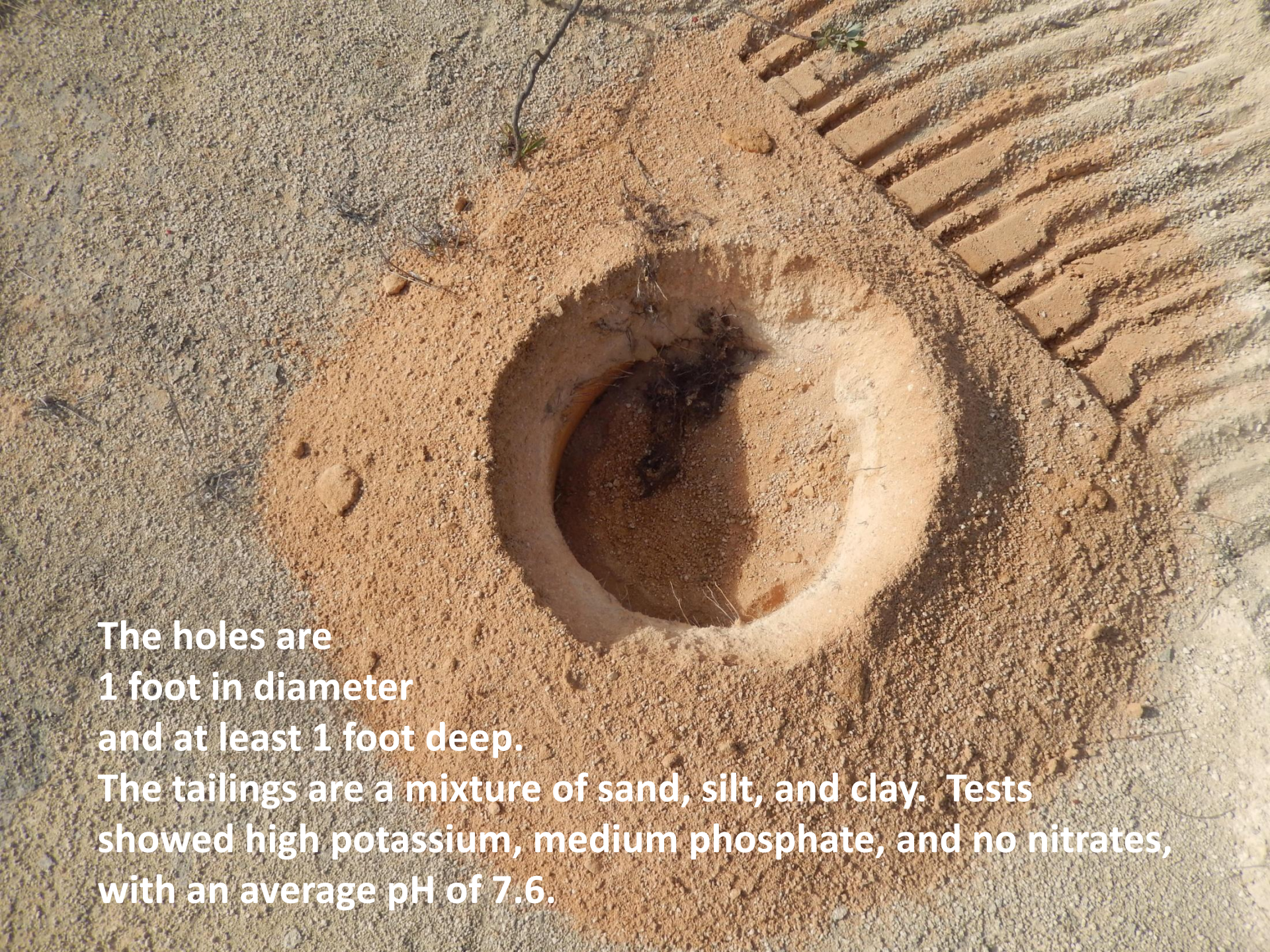
The abandoned quarry is subject to periodic flooding with heavy runoff to Mill Ditch and subsequent pollution and siltation



Lower Quarry (MCR Unit 8) Restoration Site


About 400 holes were
marked on ground
12 feet or more apart,
taking advantage
of shelter provided by
existing vegetation


TAKEUCHI
TB235



The holes are
1 foot in diameter
and at least 1 foot deep.
The tailings are a mixture of sand, silt, and clay. Tests showed high potassium, medium phosphate, and no nitrates, with an average pH of 7.6.


Soil amendments are mixed in wheelbarrow: peat moss, chicken manure, sulfur, ammonium sulfate, triple 16 fertilizer, and Osmocote slow-release fertilizer. Sulfur products help correct the high pH (7.6) to neutral value so plants can take up nutrients more readily.
TRUE TEMPER

Amendments are mixed 50:50 with soil from hole and tree is planted with root crown well below external soil surface, with a rim that forms a dam to keep rainwater or irrigation water *in,* and erosive sheet-flow *out.*

Each tree is watered via ¾ or ½ “ Polypipe with a flexible ¼” line that terminates in a spiked emitter that delivers ca. 2 gph.

Timers are currently set to water 1 hr daily. Amount will be reduced in coming weeks. Holes fully percolate in 1 hr or less.


DJI Mavic Pro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