Pedoarchaeology of Early Agricultural Period Irrigation Systems in the Tucson Basin of the American Southwest

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ARIZONA'S FIRST DEPARTMENT OF ANTHROPOLOGY


Tucson


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CHIHUAHUA


CORONADO NATIONAL FOREST
GALIURO MTNS
TORTOLITA MTNS
SANTA CATALINA MTNS
SAGUARO NAT'L MON
TUCSON MTNS
Tucson
RINCON MTNS
Las Capas & Sunset Road
Green Valley
Bensen
SIERRITA MTNS
WHETSTONE MTNS
SANTA RITA MTNS
TUMACACORI MTNS
CANELO HILLS
Sierra Vista
USA
MEXICO
PATAGONIA MTNS
HUACHUCA MTNS
Nogales
Nogales
0 10 20 30
SCALE IN MILES

Rationale for Studying Anthropogenic Effects on Desert Agricultural Soils

- Soil formation is slow in desert climates, so cultivation effects persist for millennia.
- Many ancient fields have remained uncultivated since they were abandoned, so historic farming has not masked long-term soil properties from past use.
- Agricultural features provide clues for identifying and sampling cultivated and control soils.
- Ancient farming systems are relevant to modern studies of agricultural sustainability.

Research Objectives

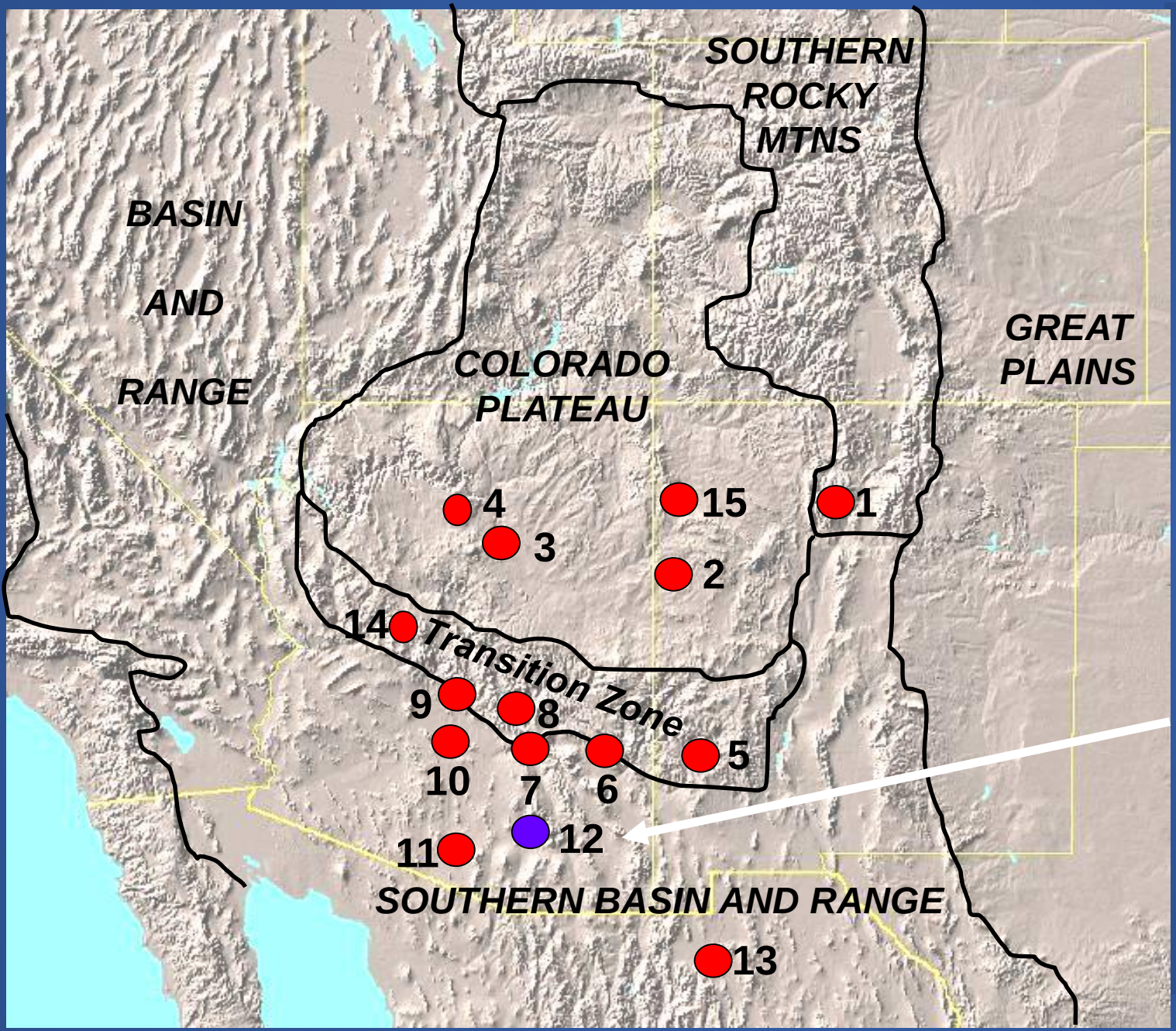
- Assess agricultural sustainability and anthropogenic effects of Early Agricultural period irrigation systems on soil quality in the Tucson Basin.

- Model possible prime agricultural agricultural suitability using GIS, NRCS SSURGO soil survey, and prehistoric agricultural features recorded in AZSITE.

Methods

- 238 soil samples were collected from cultivated and uncultivated contexts at Las Capas and 24 from Sunset Road.
- Soil pH, organic C, N, total and available P, EC, SAR, $CaCO_3$, bulk density, and particle-size analyses were analyzed.
- NRCS SSURGO map data and prehistoric field locations from AZSITE were analyzed in GIS to model agricultural suitability for land the Tucson Basin.

Previous Soil Studies of Ancient/Traditional Agriculture in the Southwest



1 – Bandelier
2 – Zuni
3 – Sunset Crater
4 – Coconino Plateau
5 – Mimbres
6 – Safford Basin
7 – Queen Creek Valley
8 – Tonto Basin
9 – Lower Verde
10 – Phoenix Basin
11 – Tohono O'odham
12 – Tucson Basin
13 – Casas Grandes
14 – Perry Mesa
15 – Southern Chuska Valley)

Diversity of U.S. Southwest Agricultural Strategies

Kind of Agriculture	Landforms
Irrigated:	Valley floodplains/terraces
• Canal	Floodplains/terraces mostly perennial rivers
• Flood recession	Lower Colorado and Gila Rivers
• Floodwater	Floodplain ephemeral stream
Dryland:	Uplands and valley margins
• Eolian materials	Loess uplands, stable dunes in valleys and uplands, tephra fields
• Rock grid, mulch, pile	Mostly valley margin, some upland hillslopes
• Runoff terrace	Valley margins (alluvial fans, footslopes), upland hillslopes

Dryland Agricultural Rock Features

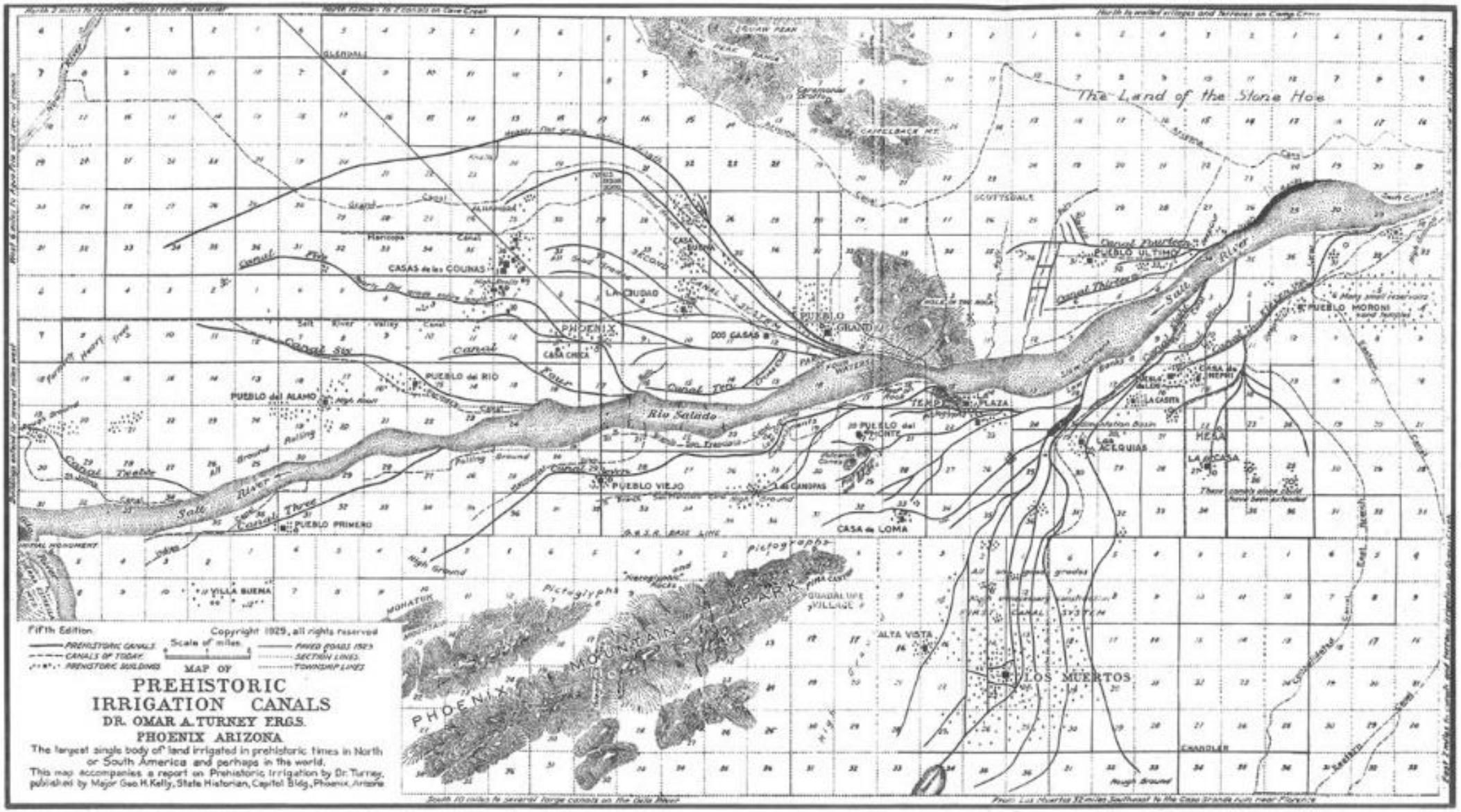
Rock mulch

Rock grid

Rock pile

Rock alignments for terraces

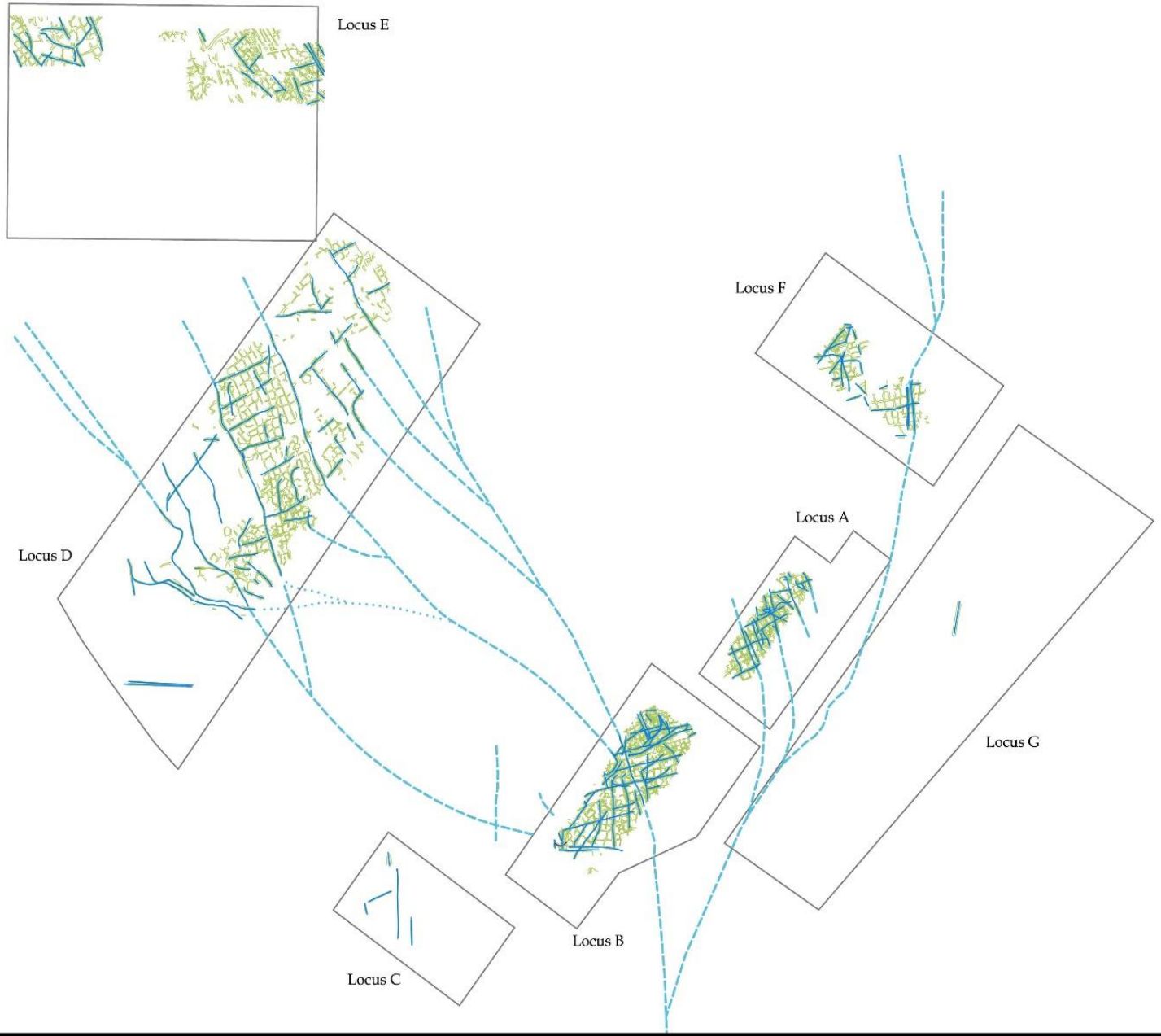
Turney (1929) Map of Hohokam Canals in the Phoenix Basin



Canal Building in the Salt River Valley with a stone hoe held in the hand without a handle. These were the original engineers, the true pioneers who built, used and abandoned a canal system when London and Paris were a cluster of wild huts.

Las Capas

Las Capas aerial overview, 2008.
2008 年遗址全景鸟瞰



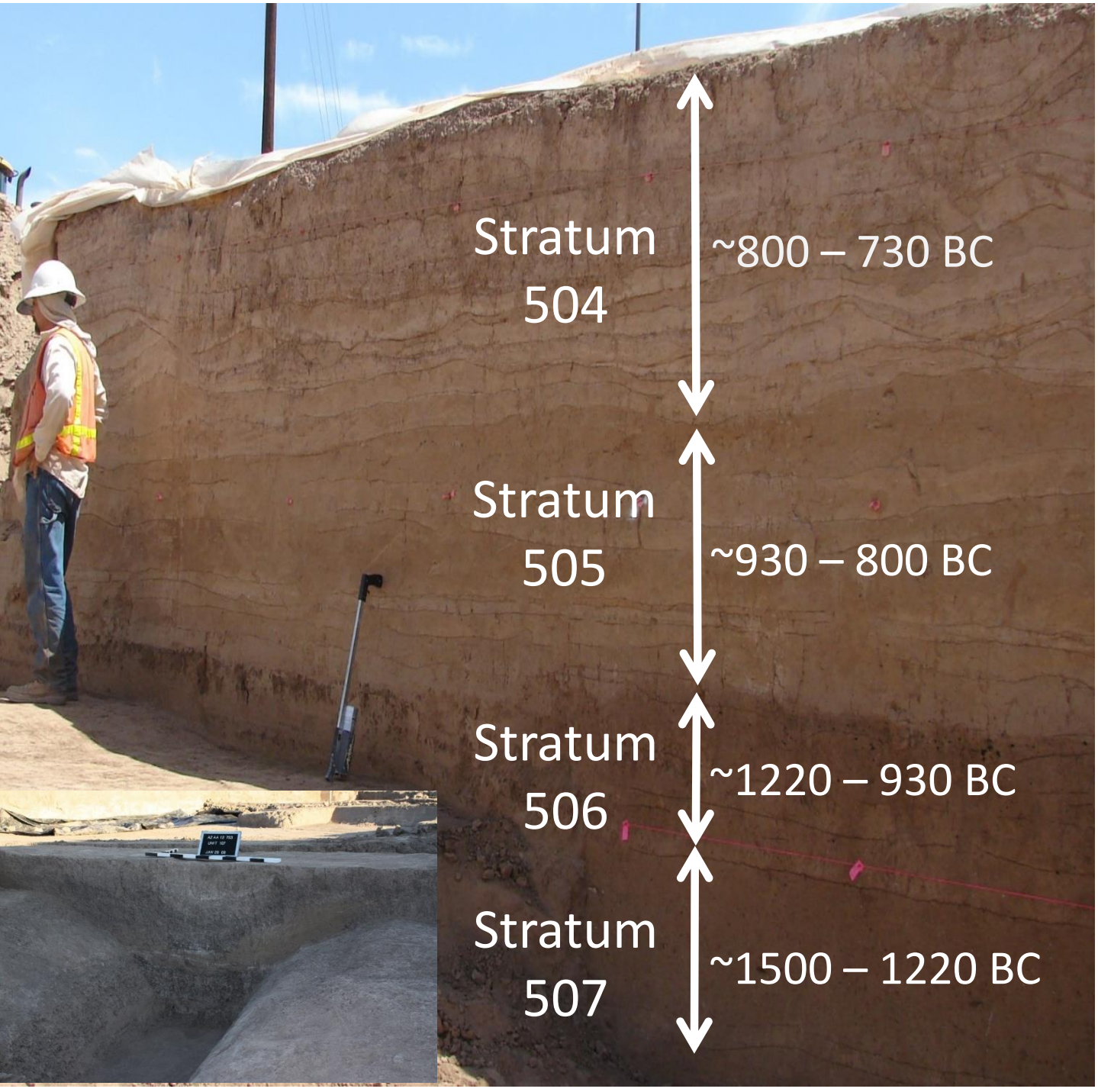
Las Capas
AZ AA:12:111 (ASM)
Town of Marana, Pima County, AZ

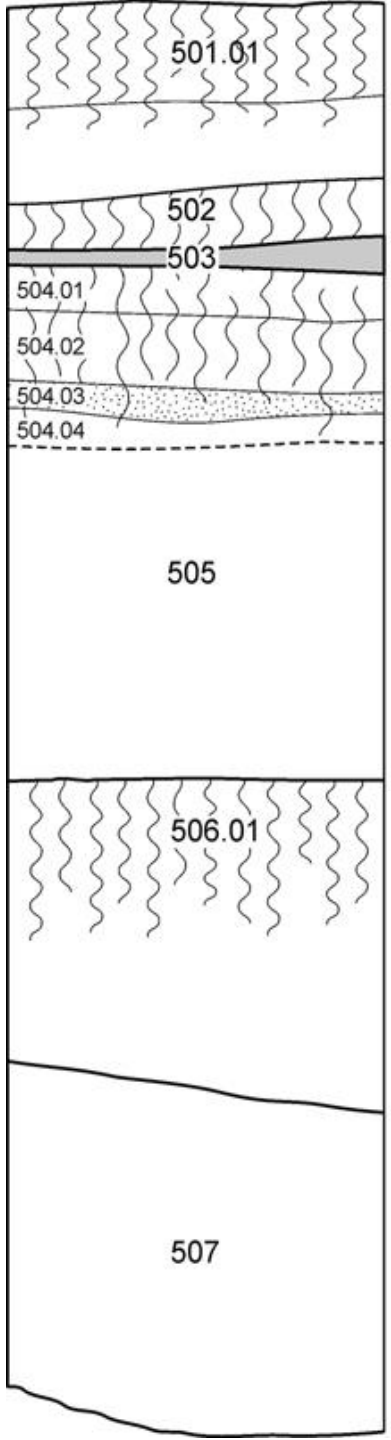
Overview of Project Area: Canals and Fields

Key
- Canal
- Estimated Canal Alignment
- Original Projected Alignment
- Agricultural Fields/Berms

Meters
0 60
Feet
0 240

Desert Archaeology, Inc. 2014





Modern soil

Rapid deposition

Floodplain stabi

CDO flood

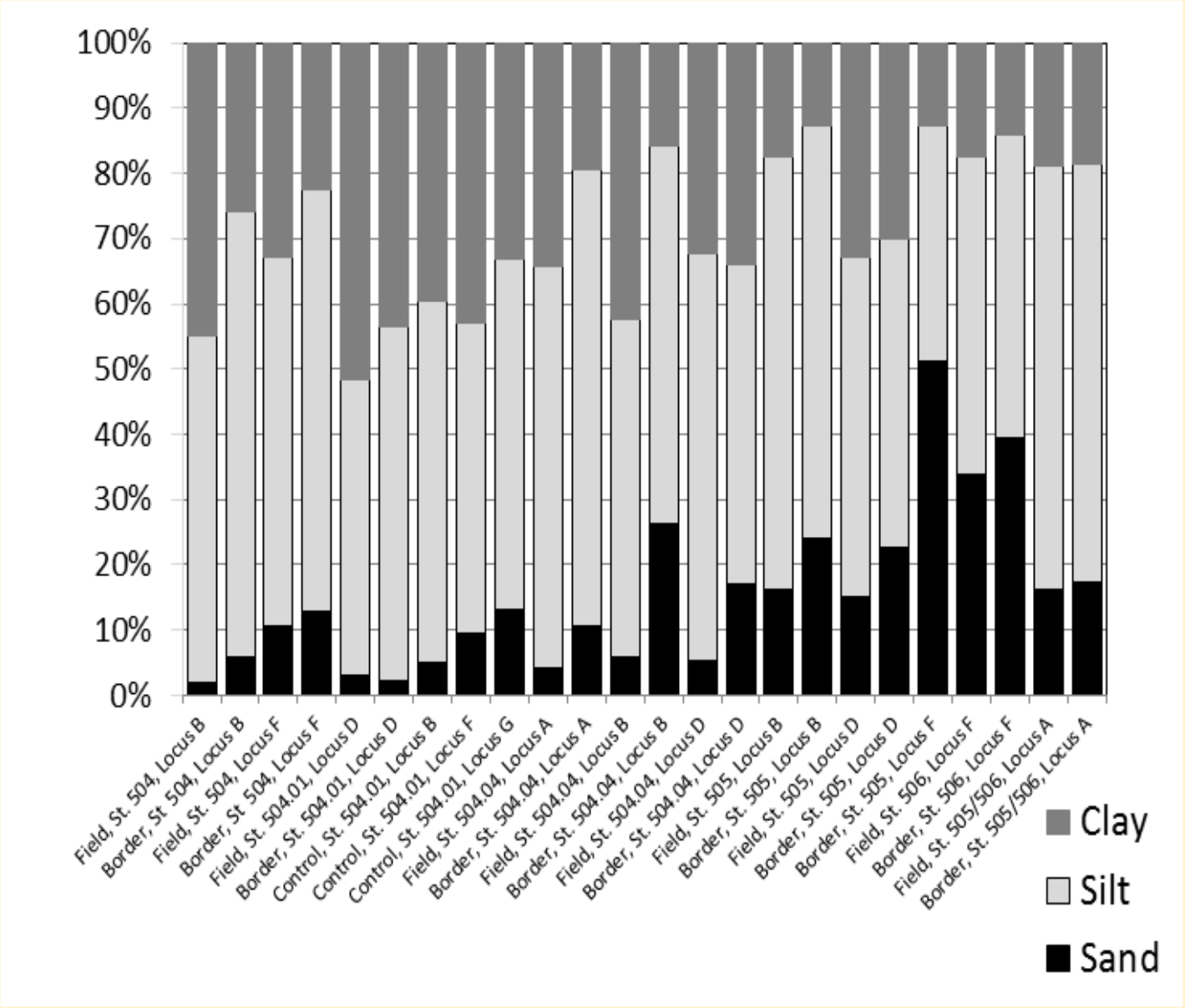
Floodplain stabi

Very rapid deposition

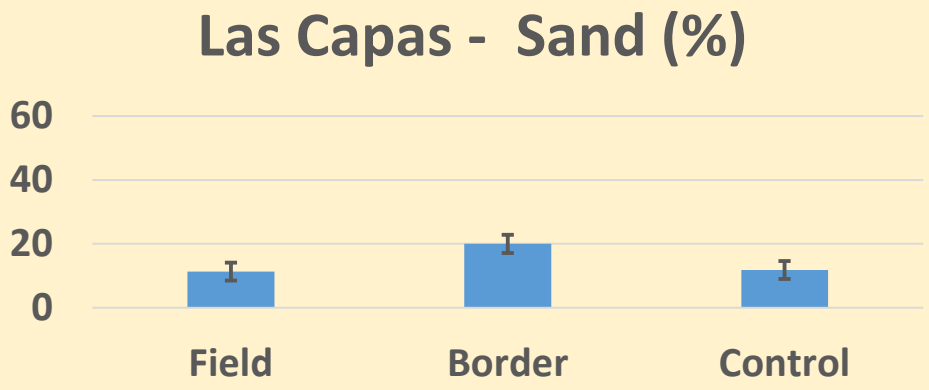
Floodplain stabi

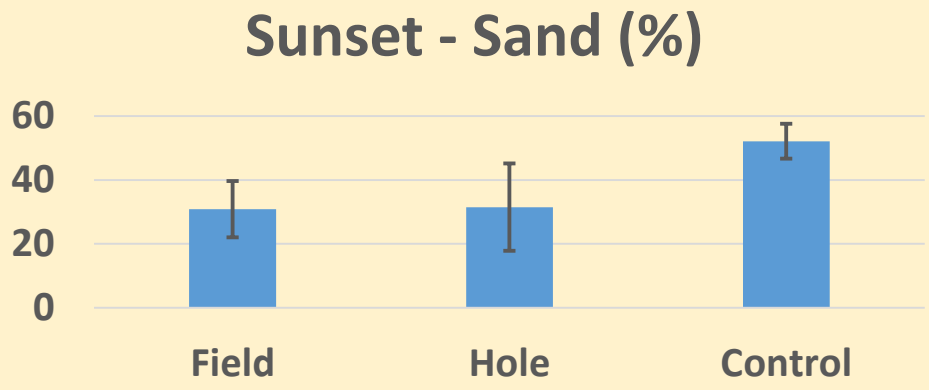
Very rapid deposition

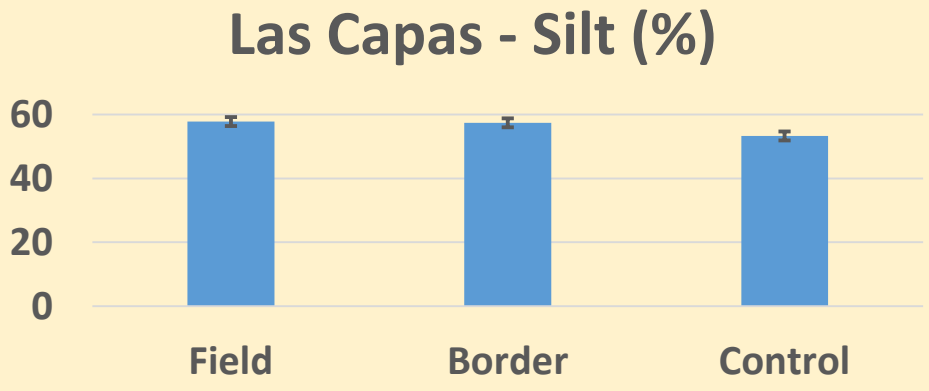
Sunset Road

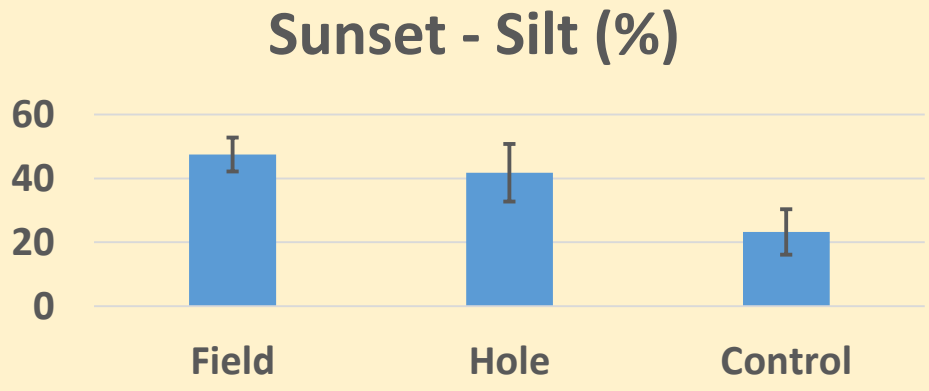


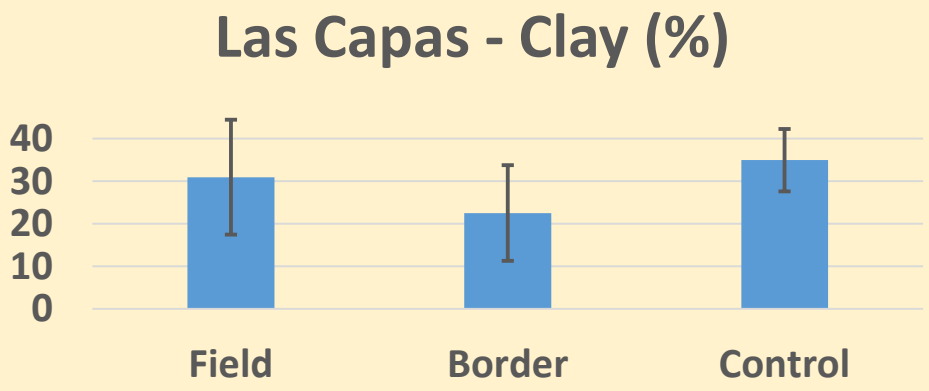
- **<u>Las Capas</u> - SiCL for fields and controls; SiL for borders.**
- **<u>Sunset</u> – Loam for field and controls and SL for planting holes.**
- **These textures typically have high moisture- and nutrient-holding properties.**

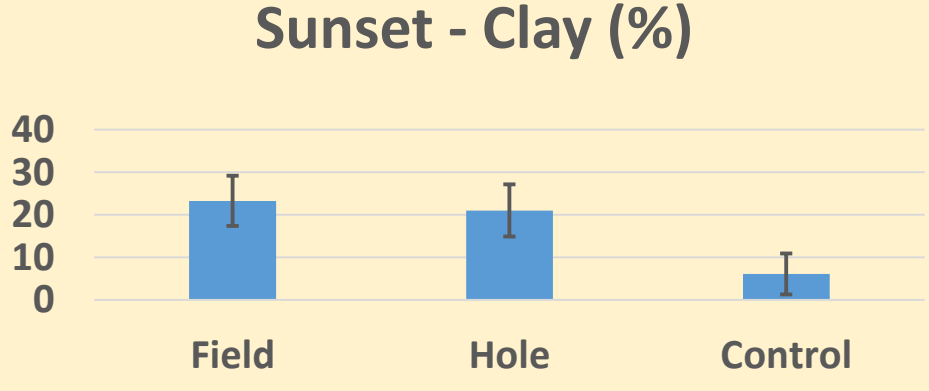

Las Capas - Sand (%)
60
40
20
0
Field
Border
Control

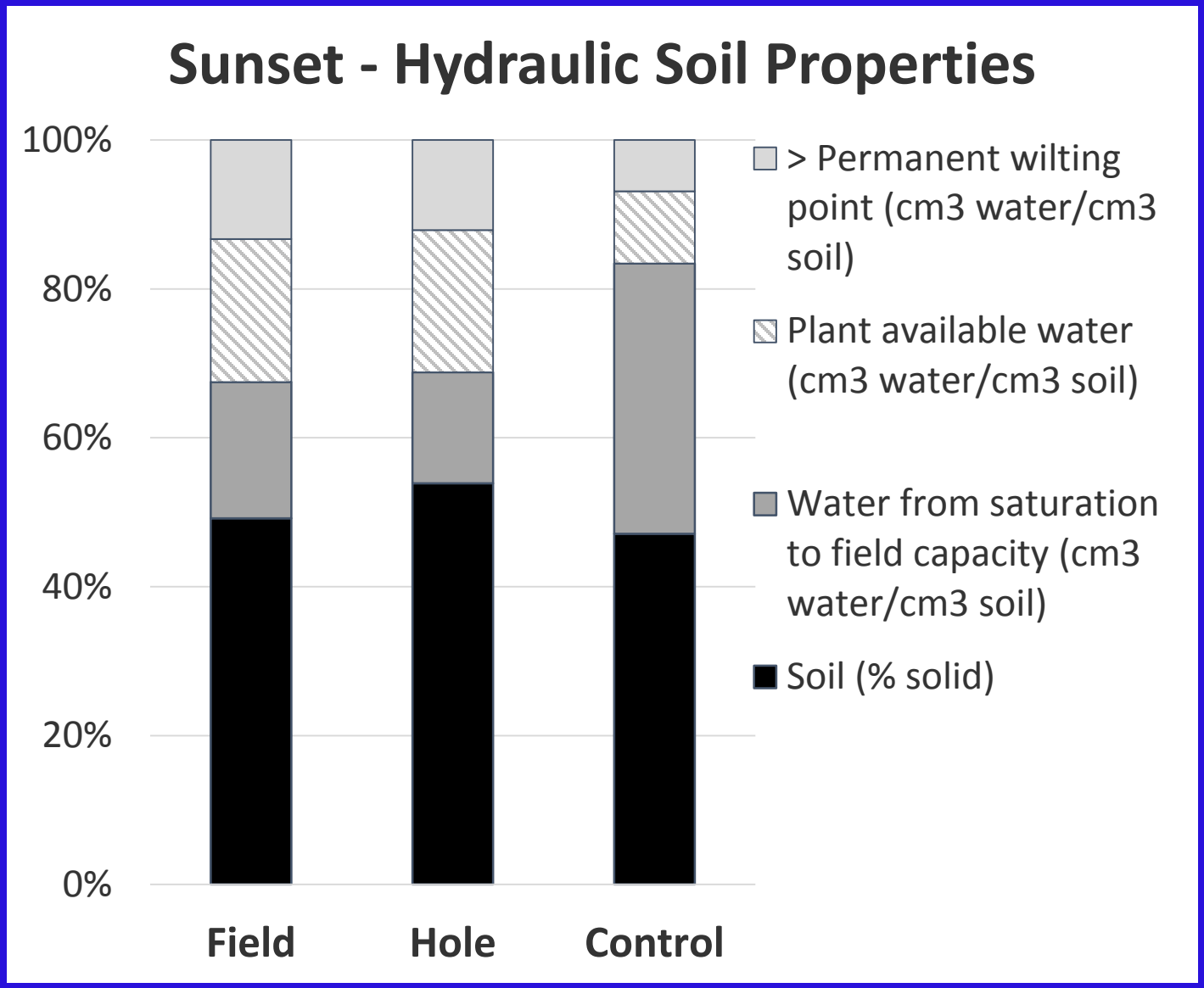

Sunset - Sand (%)
60
40
20
0
Field
Hole
Control


Las Capas - Silt (%)
60
40
20
0
Field
Border
Control


Sunset - Silt (%)
60
40
20
0
Field
Hole
Control

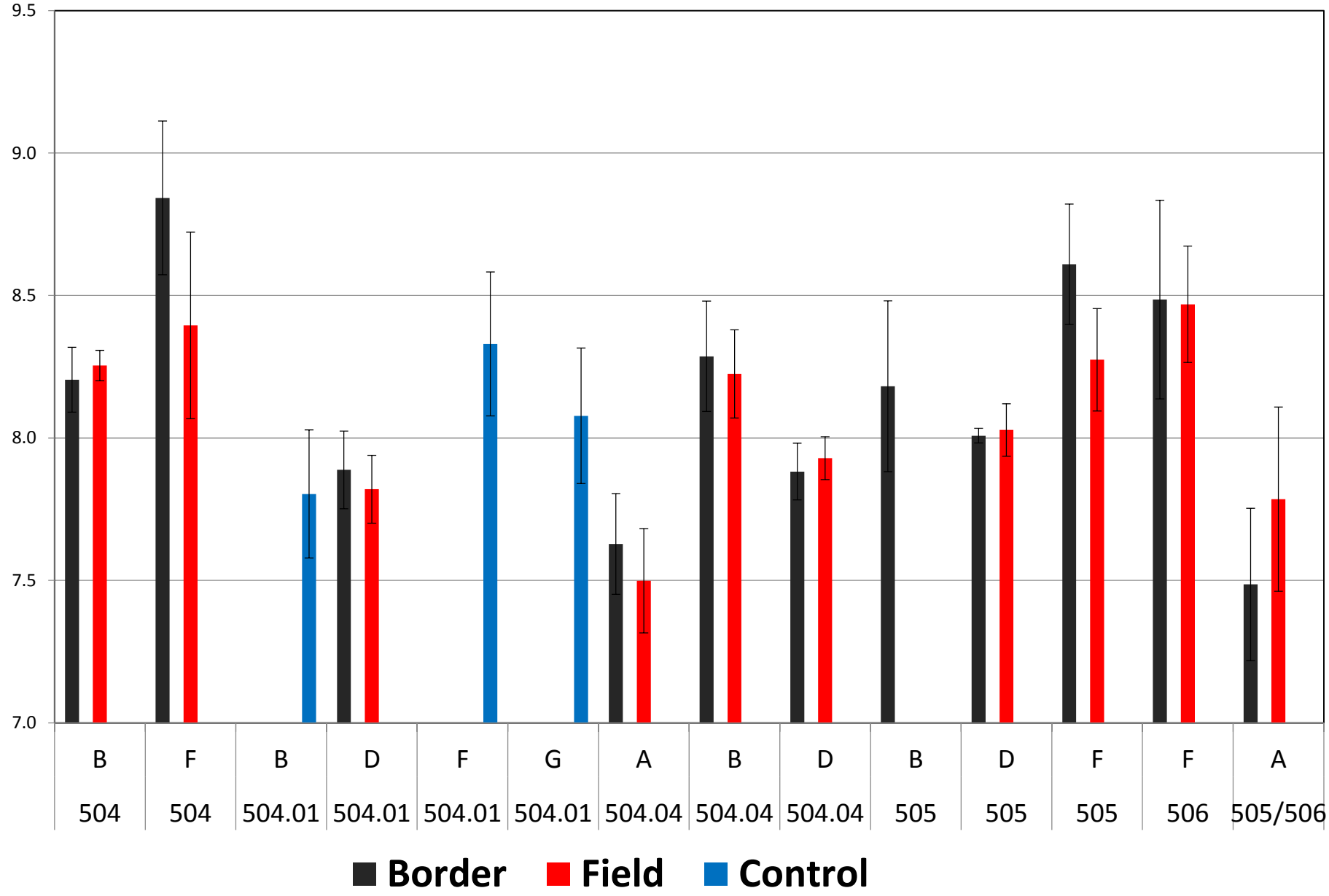

Las Capas - Clay (%)
40
30
20
10
0
Field
Border
Control

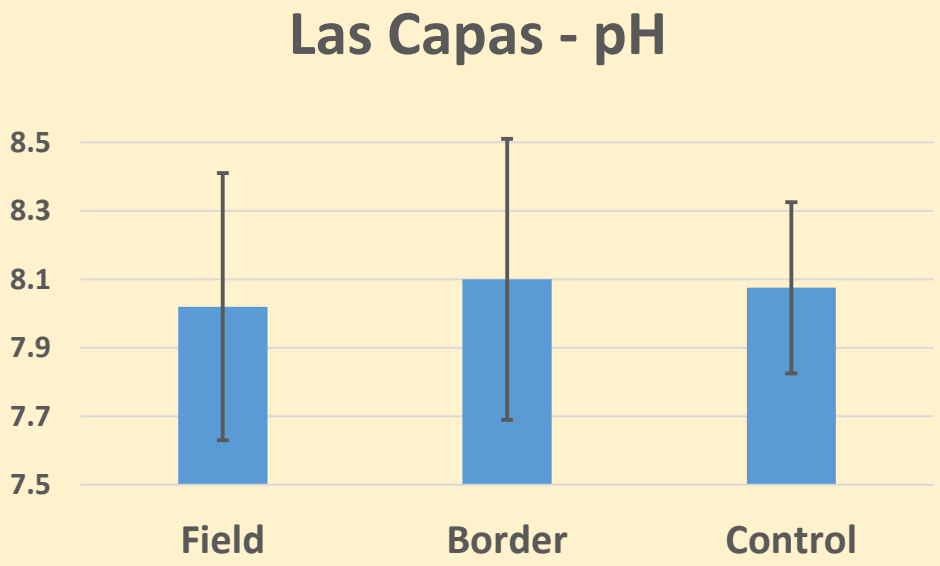

Sunset - Clay (%)
40
30
20
10
0
Field
Hole
Control

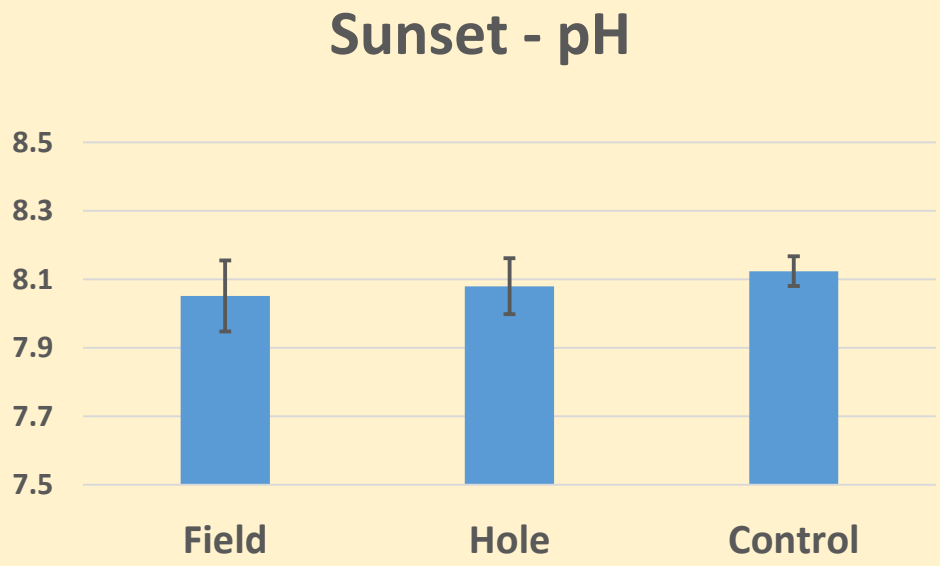


Cultivated soils have about twice the available water capacity of the controls at Sunset Road.

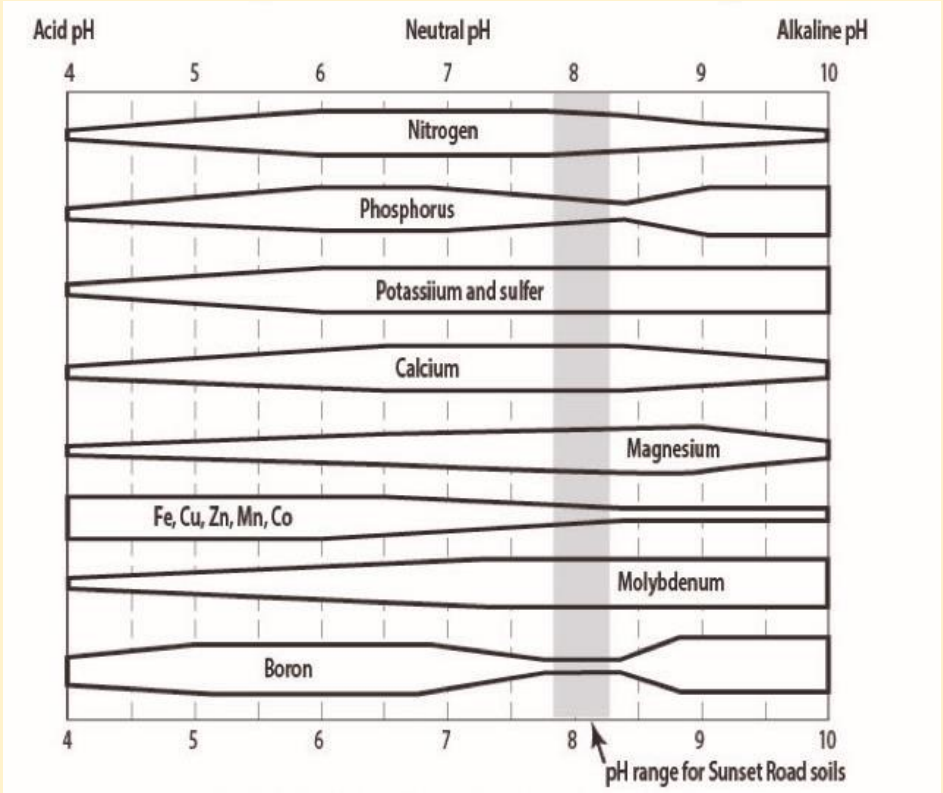
Las Capas - pH (1:1 soil:water)



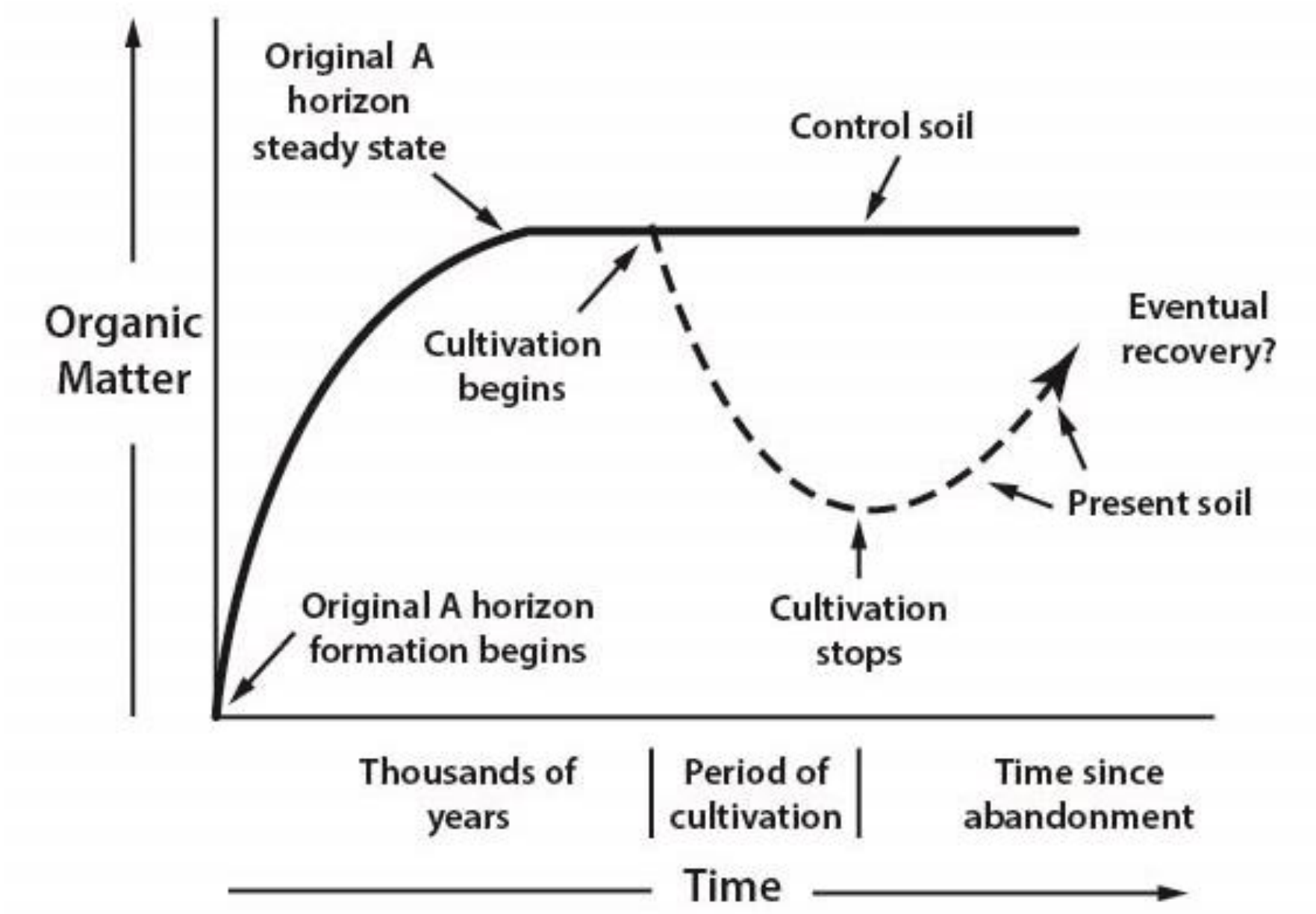


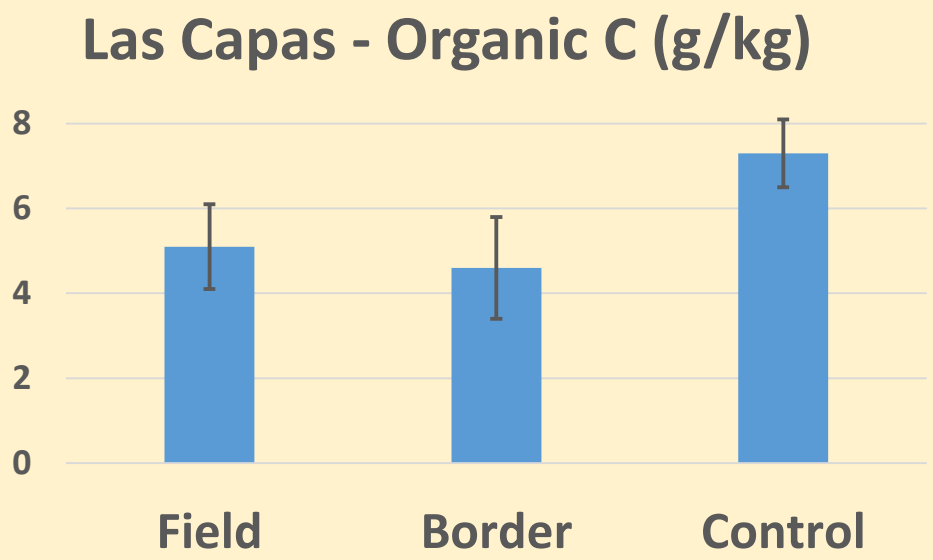


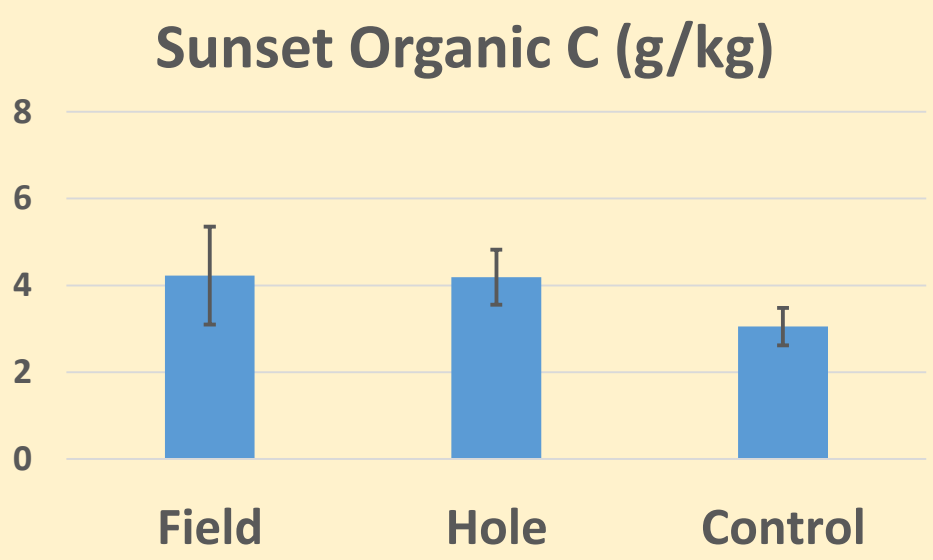
- **Soils are slightly (pH 7.4–7.8) alkaline to moderately (pH 7.9–8.4), levels suitable for maize cultivation adapted to SW.**
- **Differences between the fields, borders, holes and controls are insignificant.**



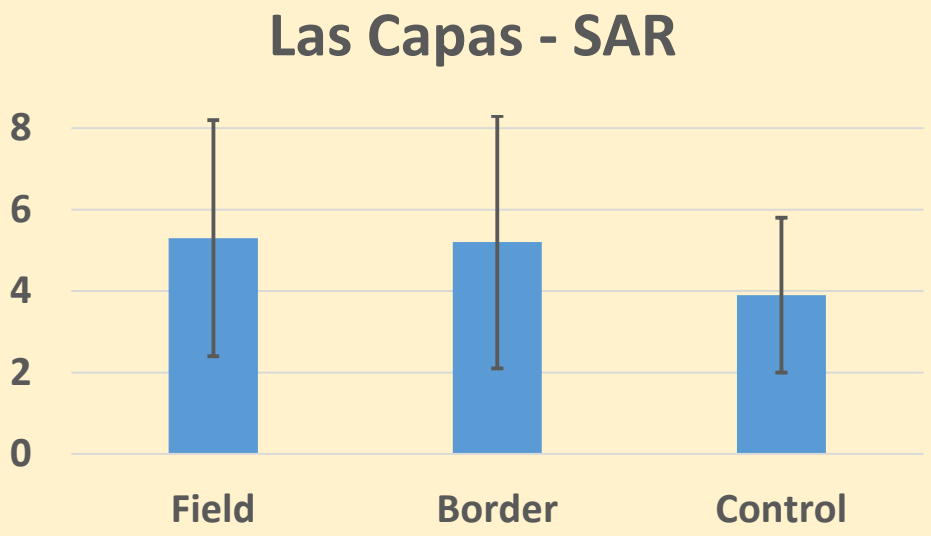
Model of Organic Matter Change Over Time (after Sandor 1983)

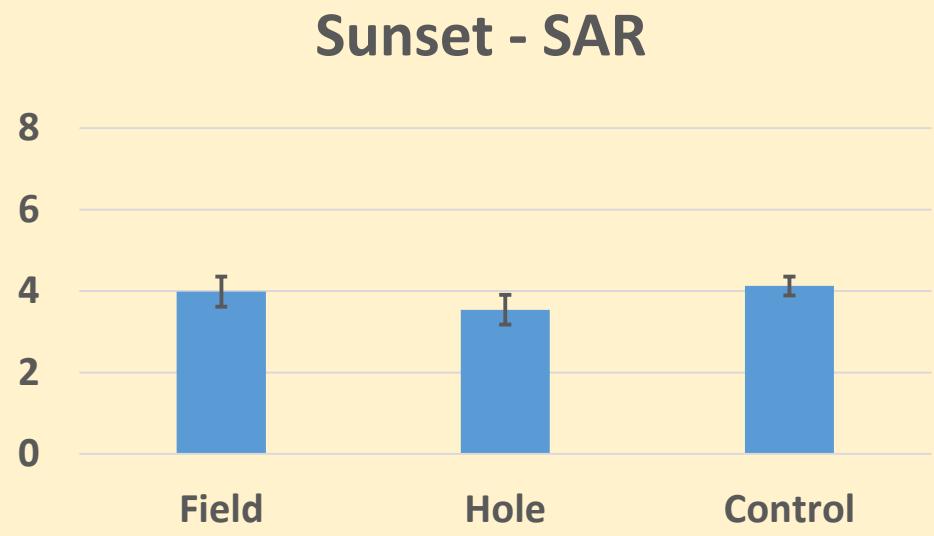




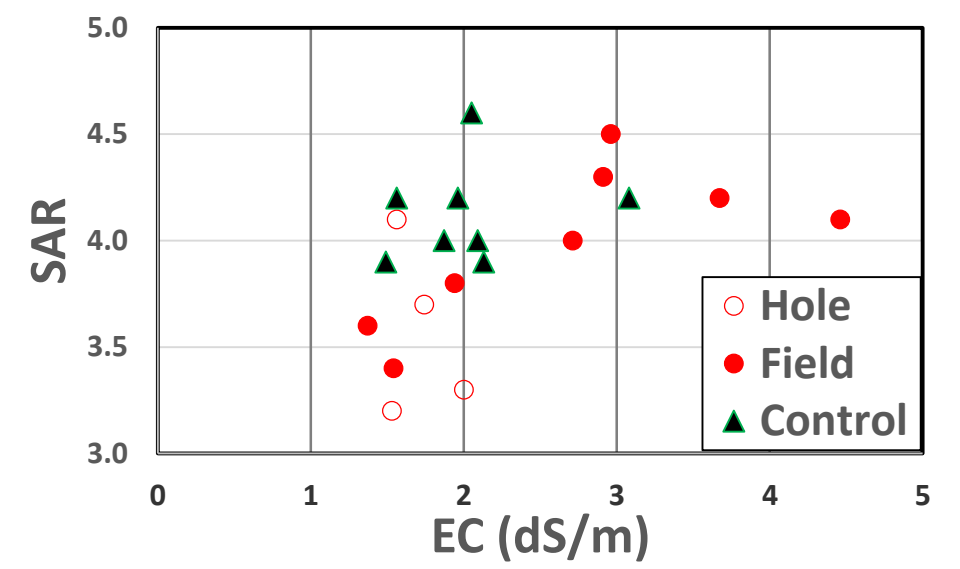


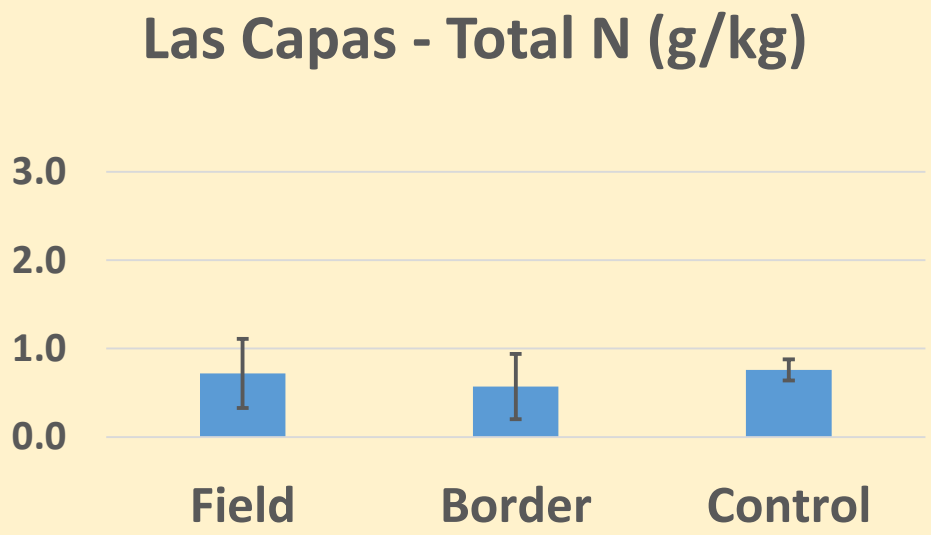
- **Organic C is significantly lower in the fields and borders than controls at Las Capas and higher in the fields and holes than controls at Sunset.**
- **Organic C is relatively low at both sites, but it is noteworthy that the Hopi successfully farm at similarly low levels in northern Arizona.**

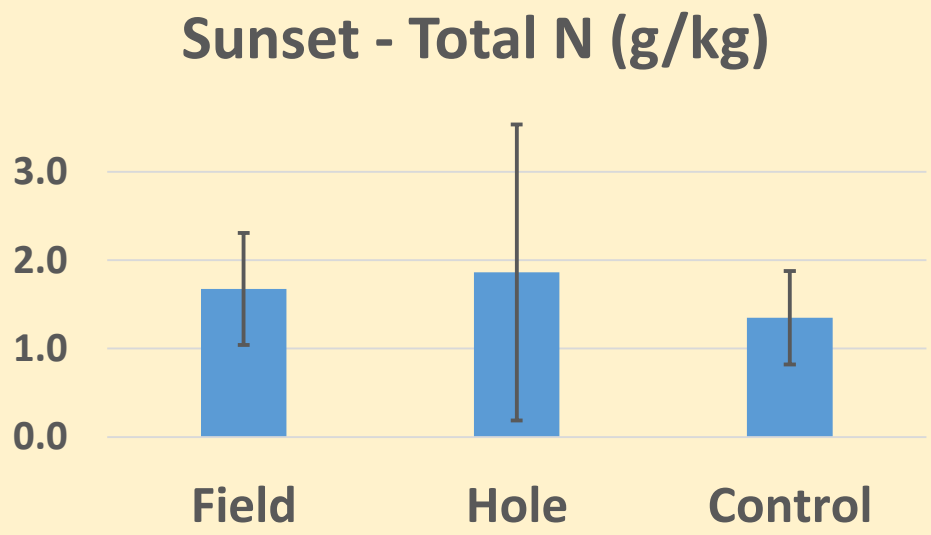




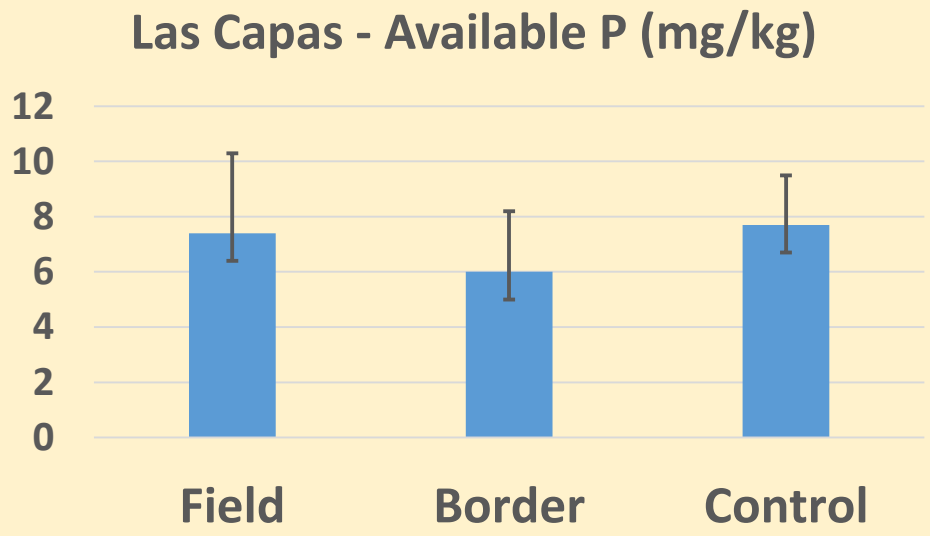
- **Maize productivity may have been reduced ~10% at these SAR and EC levels.**
- **Higher SAR levels in deeper strata may be caused by capillary rise above the water table and/or accumulation of Na leached from above from historic irrigation.**

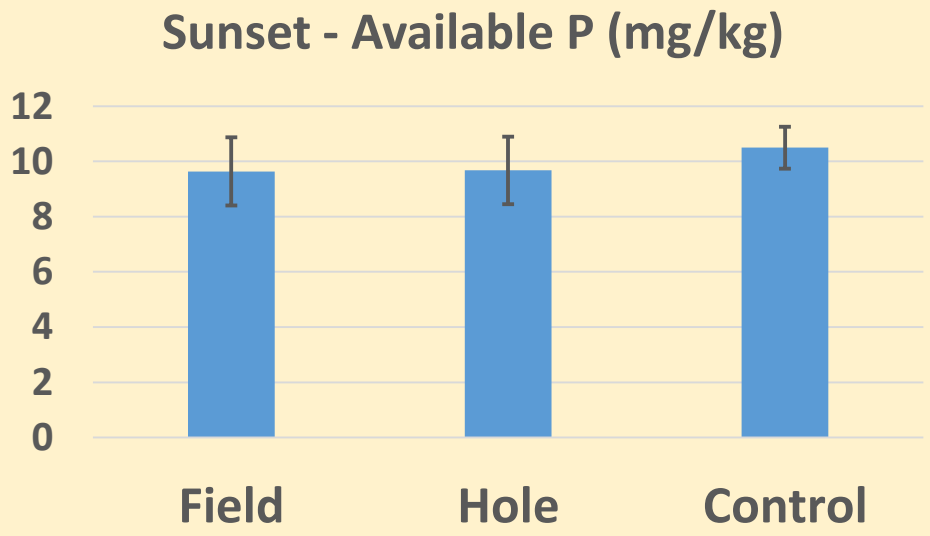




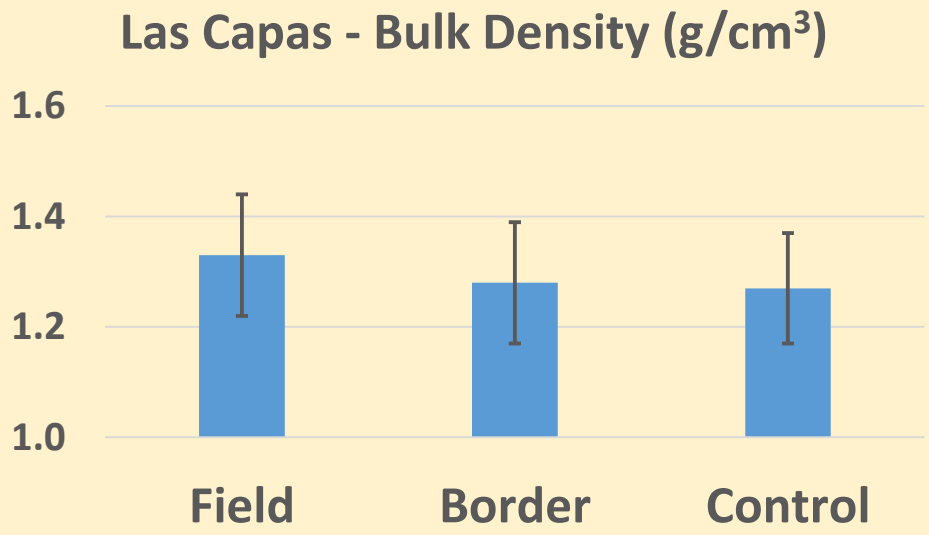


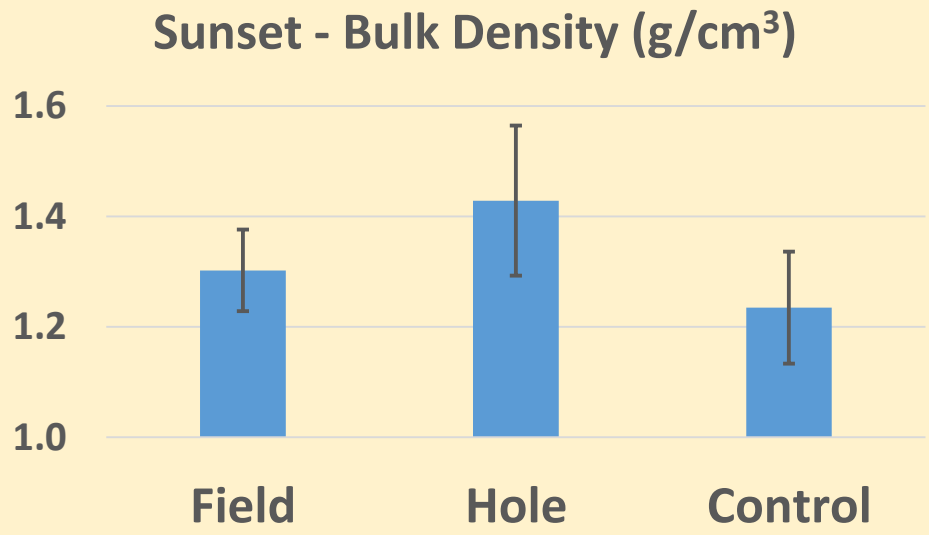
- **Compared to controls, total N is similar in the fields and borders at Las Capas and higher in the fields and holes at Sunset.**
- **Sunset has higher total N levels than Las Capas, possibly from later historic irrigation.**



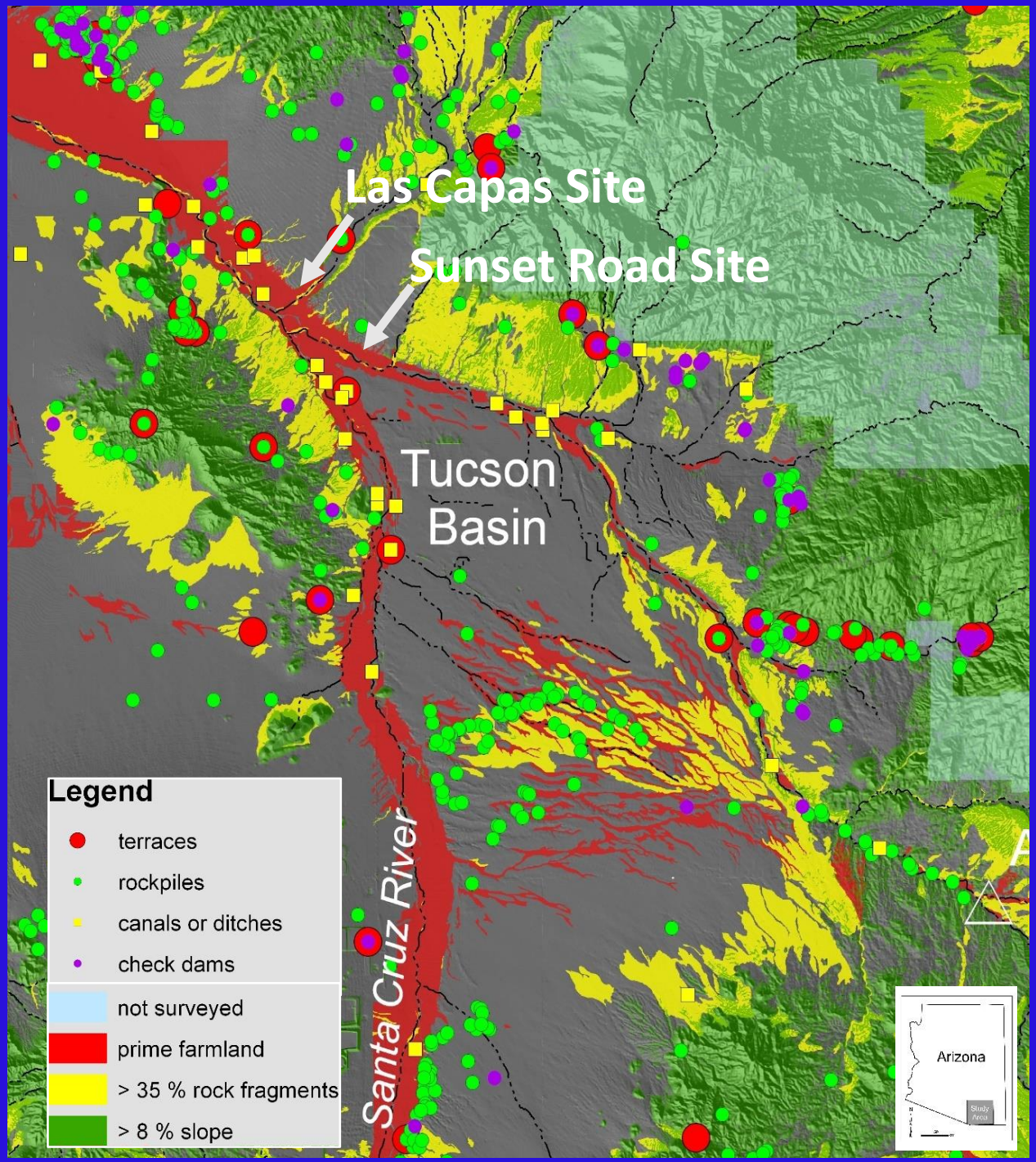


- **Available P is significantly elevated in the fields and controls relative to the borders at Las Capas.**
- **There is little difference between samples at Sunset. Levels above 5 mg/kg likely indicate P is not deficient.**





- **Bulk densities are higher in the fields than the controls at both sites and significantly higher in the planting holes at Sunset.**
- **Compaction at such low levels would not have an adverse effect on maize productivity levels for the textures at both sites.**



Predictive model of prime farmland (in red) in the Tucson Basin in relation to ancient agricultural fields identified by archaeological surveys.

Conclusions

- Early Agricultural Period fields have elevated organic C, N, and available P levels, indicating that the ancient farming system was sustainable.
- Canals supplied enough nutrient-rich silt and clay to renew soil fertility and counter losses caused by crop uptake, leaching, volatilization, and oxidation.
- SAR levels, though elevated in the fields, are below levels that could significantly reduce maize productivity.
- Much more research is needed on soil hydraulic properties irrigation.
- Subterranean erosion (piping) was likely a factor in field abandonment. Natural alluvium at the site is highly dispersive and prone to piping.

Recommendations

- It is important for future studies of ancient irrigation systems to search for the agricultural fields, not just the canals.
- The Las Capas and Sunset Road studies are important milestones, but much more research is needed on ancient irragric soils of the Southwest.

Acknowledgements

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