International Master of Science in Rural Development

Assessing the Vulnerability of Dehesa Systems to Global Change using GIS and RS Technology: Insights from Morillas Farm

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IMRD 2023-Applications of Geographic Information System and Remote Sensing Tools on Rural Areas under a Global Change Scenario
https://sentinelshare.page.link/7PxN （2016-2023）

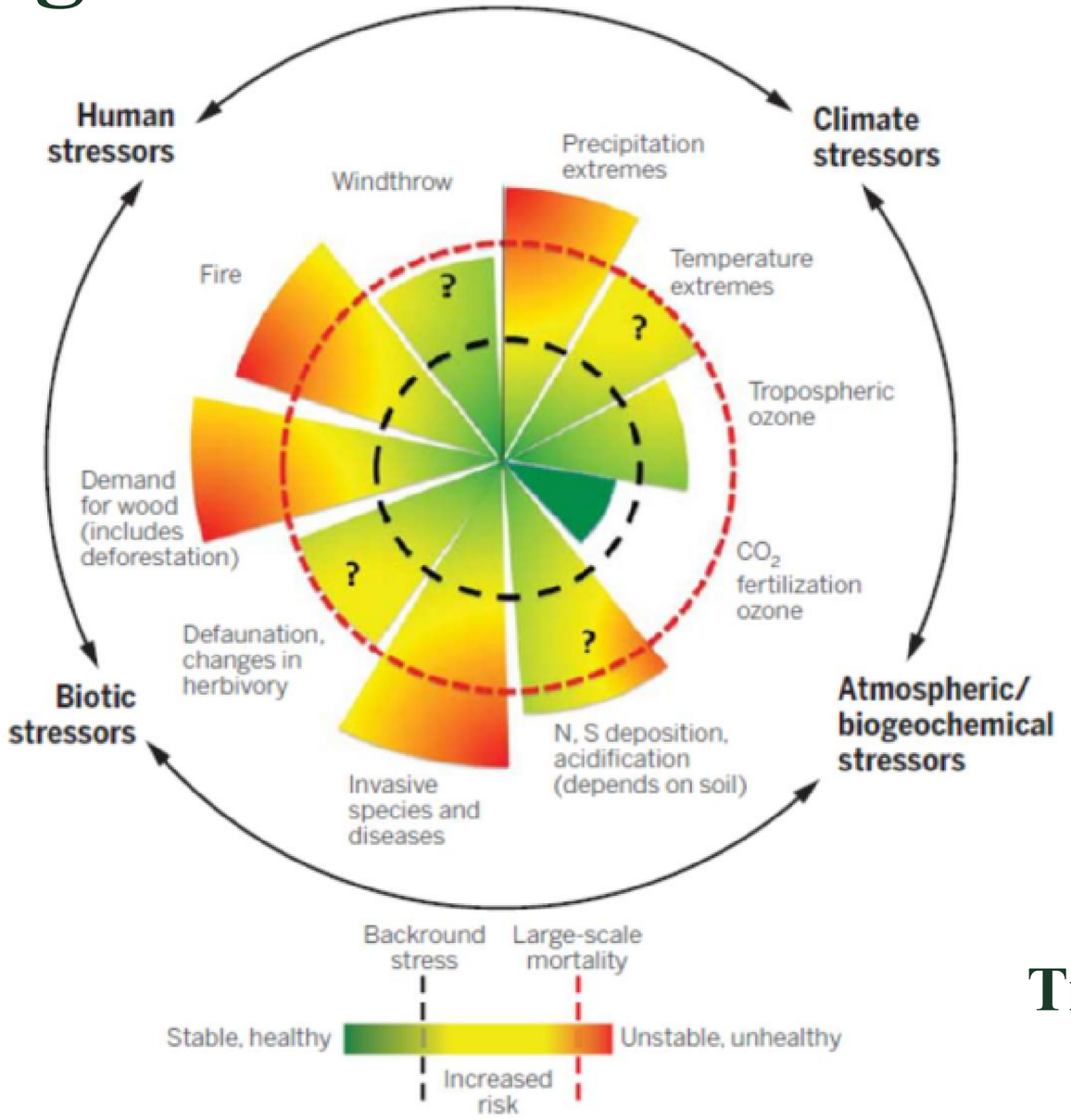
Contents

Introduction

Dehesa System

- Agro-silvo-pastoral ecosystems found in the Iberian Peninsula
- Savannah-like systems integrating pasturelands, open woodlands, livestock grazing, cultivation of landscapes
- Economic importance: production of crops (oat), animals (cows and pigs), and oaks (*Quercus ilex*)
- Ecological value: biodiversity conservation, soil conservation, carbon sequestration and culture heritage (Andreu et al., 2009)

Global Change Framework

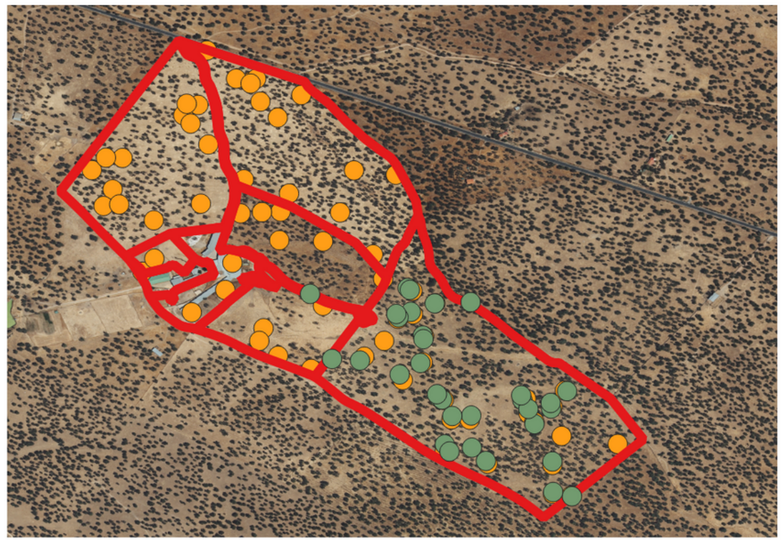


Trumbore et al. (2015)

Global Change Pressures

- Biodiversity and sustainability of the system endangered by changes in rainfall patterns (e.g, drought)
- Occurence of invasive species like soil fungi (*Phytophtora cinnamomi*) (Duque-Lazo et al., 2018; Sánchez-Cuesta et al., 2021)
- Acorn insect pests (*Curculio* spp. weevils, *Cydia* spp. moths) (Canelo et al., 2021)
- Land degradation and desertification risk exacerbated by anthopogenic factors (overgrazing, land use changes) (Grilli et al., 2021)
- Decline in overall farm productivity

Profile of the Morillas Farm



Location: Northern part of Cordoba province, Andalusia, Spain

Coordinates : 38.21°N，4.51°W

Area : 92 hectares

Year of establishment: ~ 1993

Farm type: Family farm

Farming system : Dehesa agroforestry

Vegetation : Oak, grassland, oat for feed (1/4 of the farm and rotation of land)

Livestock : Dairy cows (120 of all ages), Iberian pigs (130 usually)

Irrigation : No

Land use change in the past : No

Dairy production : 35 litres/cow/day

Client: COVAP

Objectives

01

Understanding the vulnerability of Dehesa systems to global change

02

Identifying adaptation strategies to counteract this vulnerability

Research question

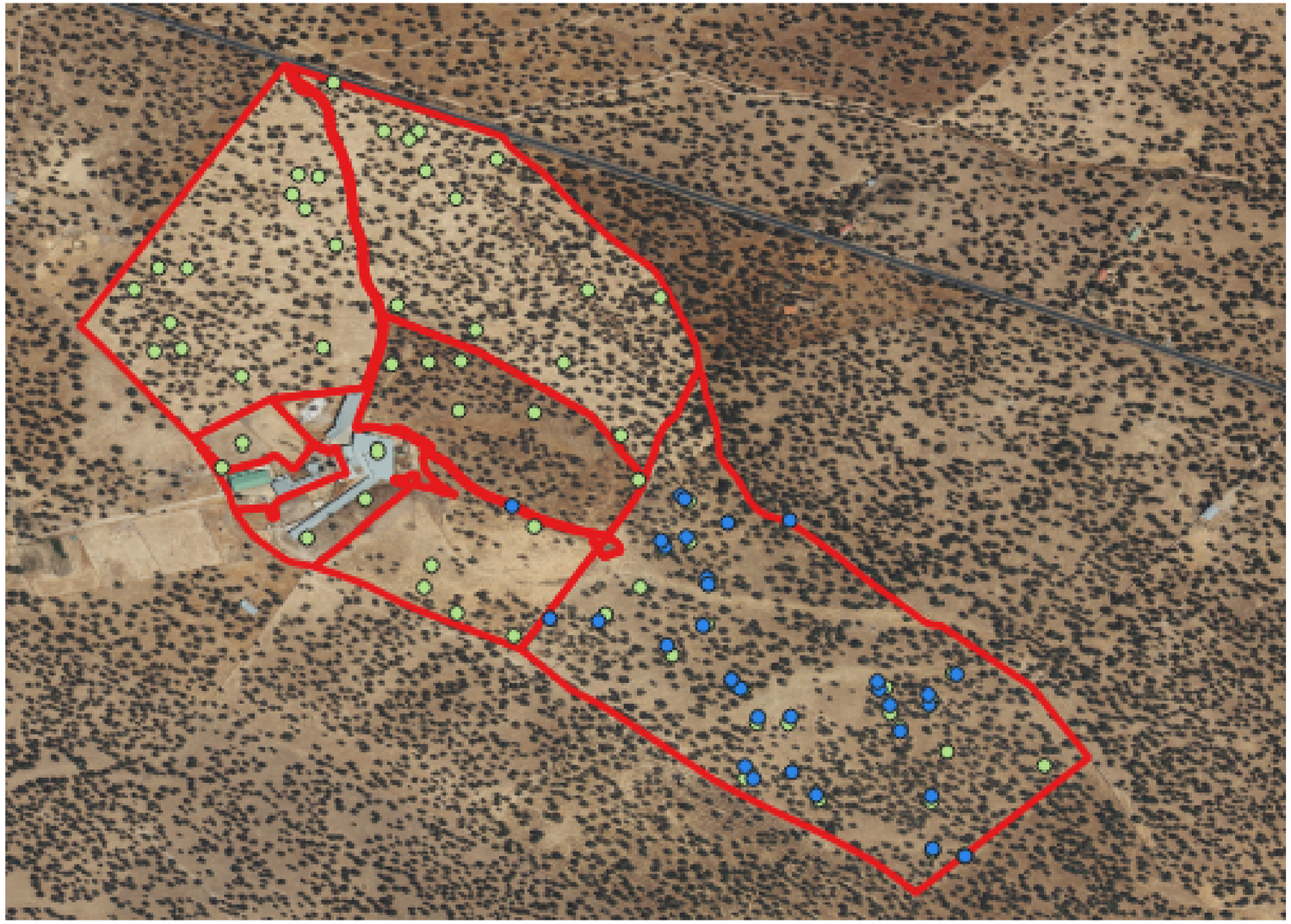
What are the drivers behind the decay of oak trees in the Morillas Farm?

Methodology

- Literature review
- Farmer interview
- Field survey
- QGIS
  - Mapping
  - Normalized Difference Vegetation Index (NDVI)

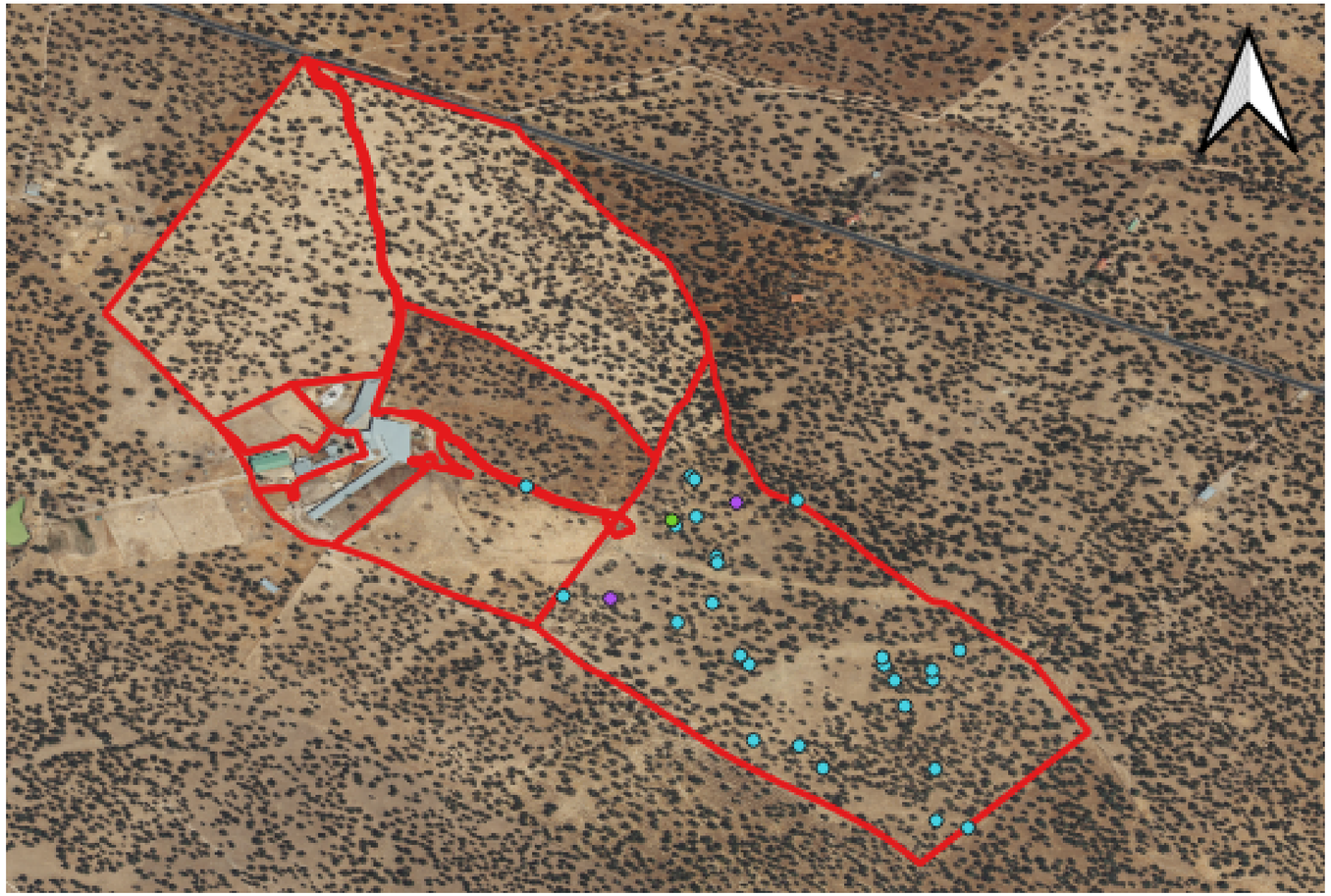
Analysis

GIS Analysis-Sampling



Dehesa System-Morillas Farm indicating sampling design and collected data

GIS Analysis-Defoliation

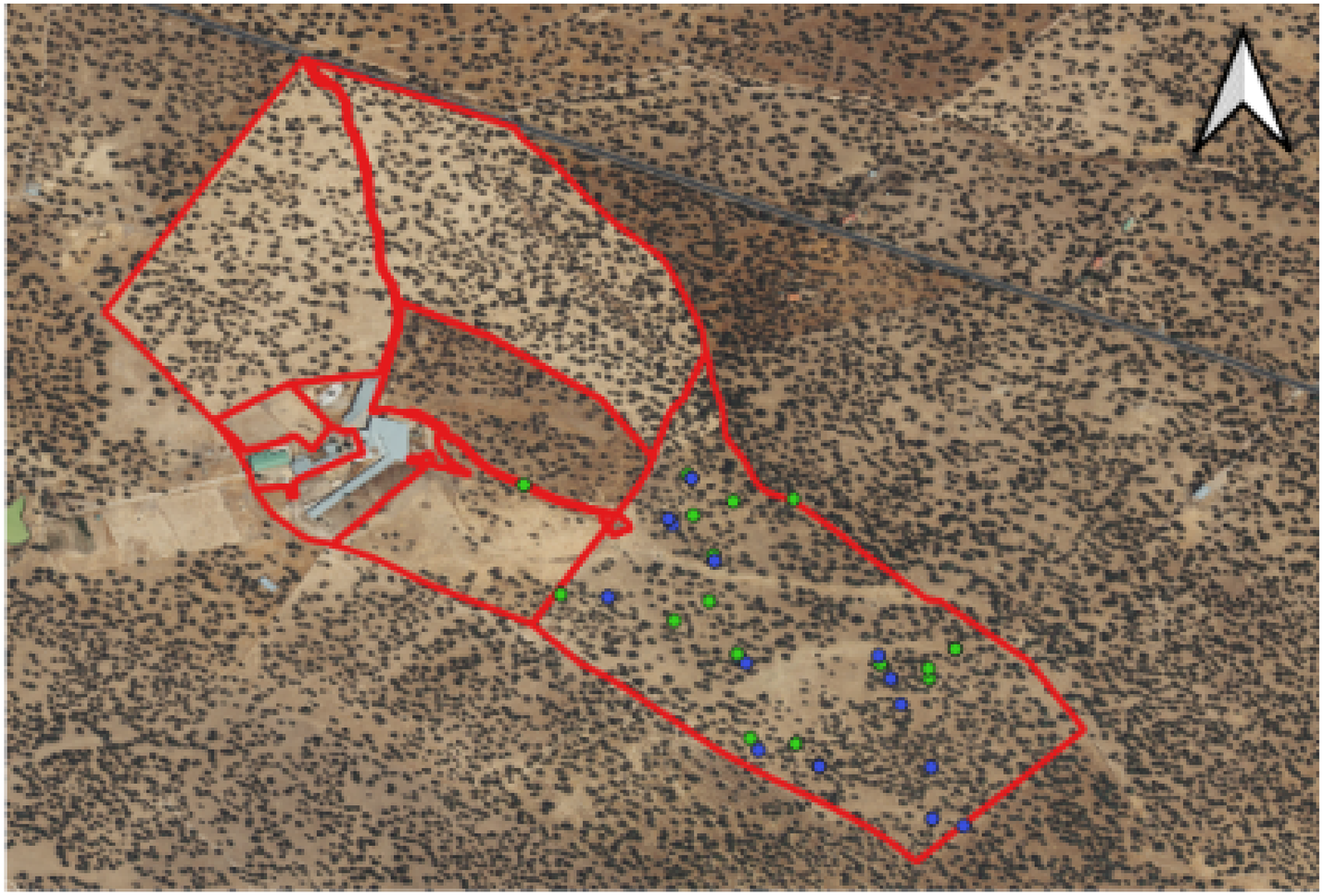


Dehesa System-Morrillas Farmland
Tree Defoliation

Moderate defoliation is prevalent and some high defoliation can also be seen

We also observed that most branches can cover about 60% of the shadows

GIS Analysis-Disease ocurence

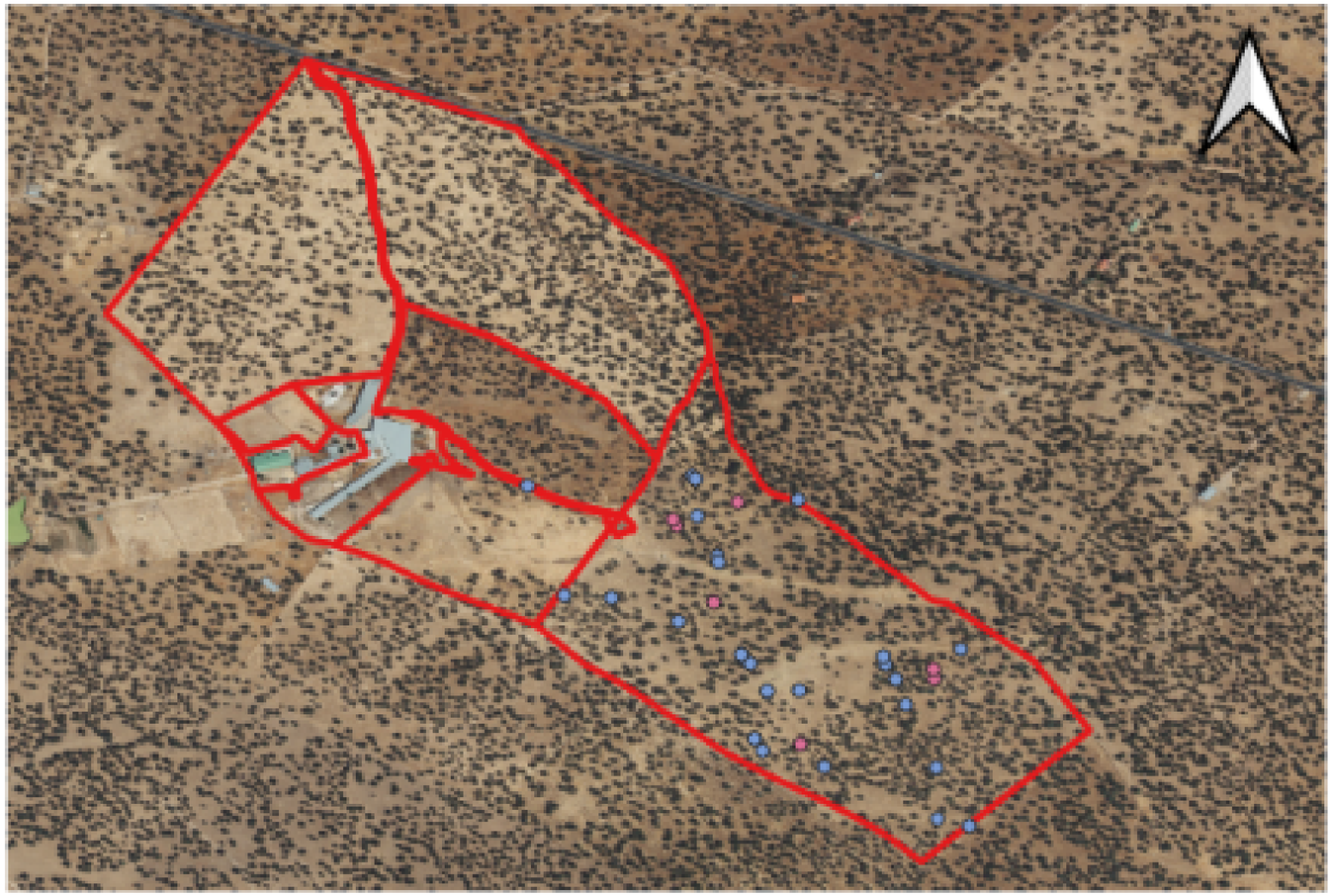


Dehesa System-Morrillas Farmland
Tree with Disease

High disease prevalence can be observed almost everywhere in the study area

The prolonged drought has probably caused most of the tree trunks to begin to be infested with insects and fungi

GIS Analysis-Tree decay



Dehesa System-Morrillas Farmland
Dead Tree

There is degraded grassland around the dead trees usually, the rate of bare soil is higher

We found reduced traces of livestock activity and organic fertilizer nutrients around tree decay points

Normalized Difference Vegetation Index - NDVI

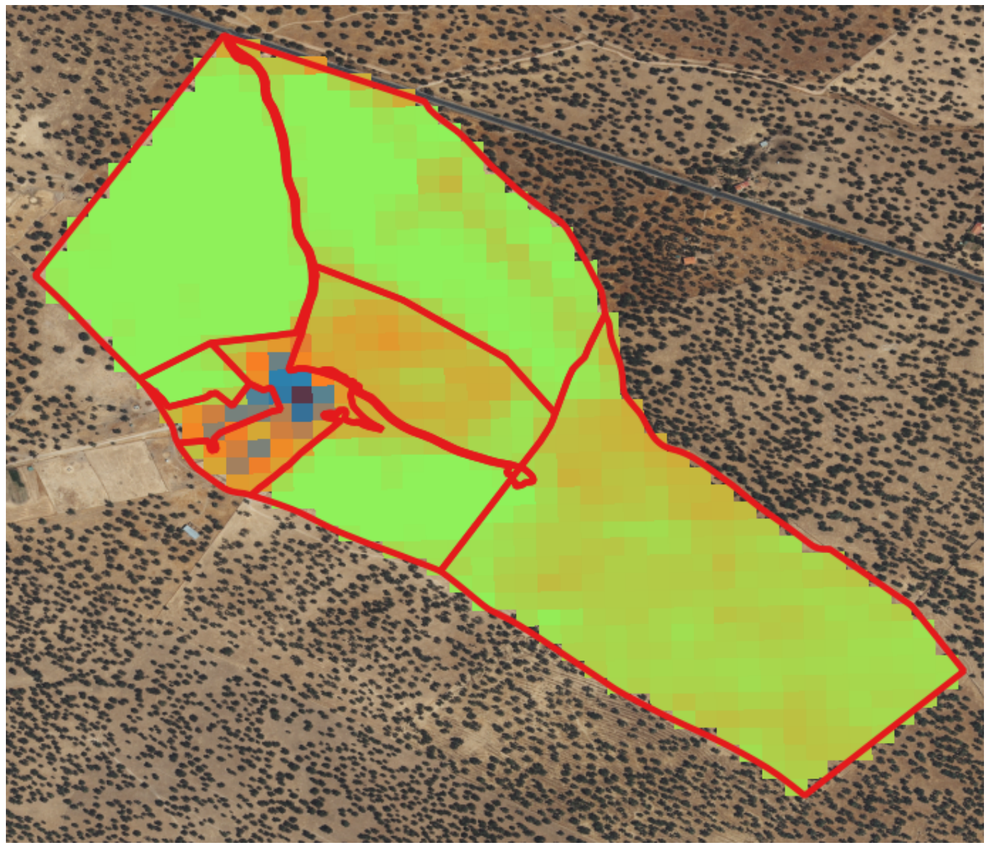
- NDVI values were calculated using the following formula:

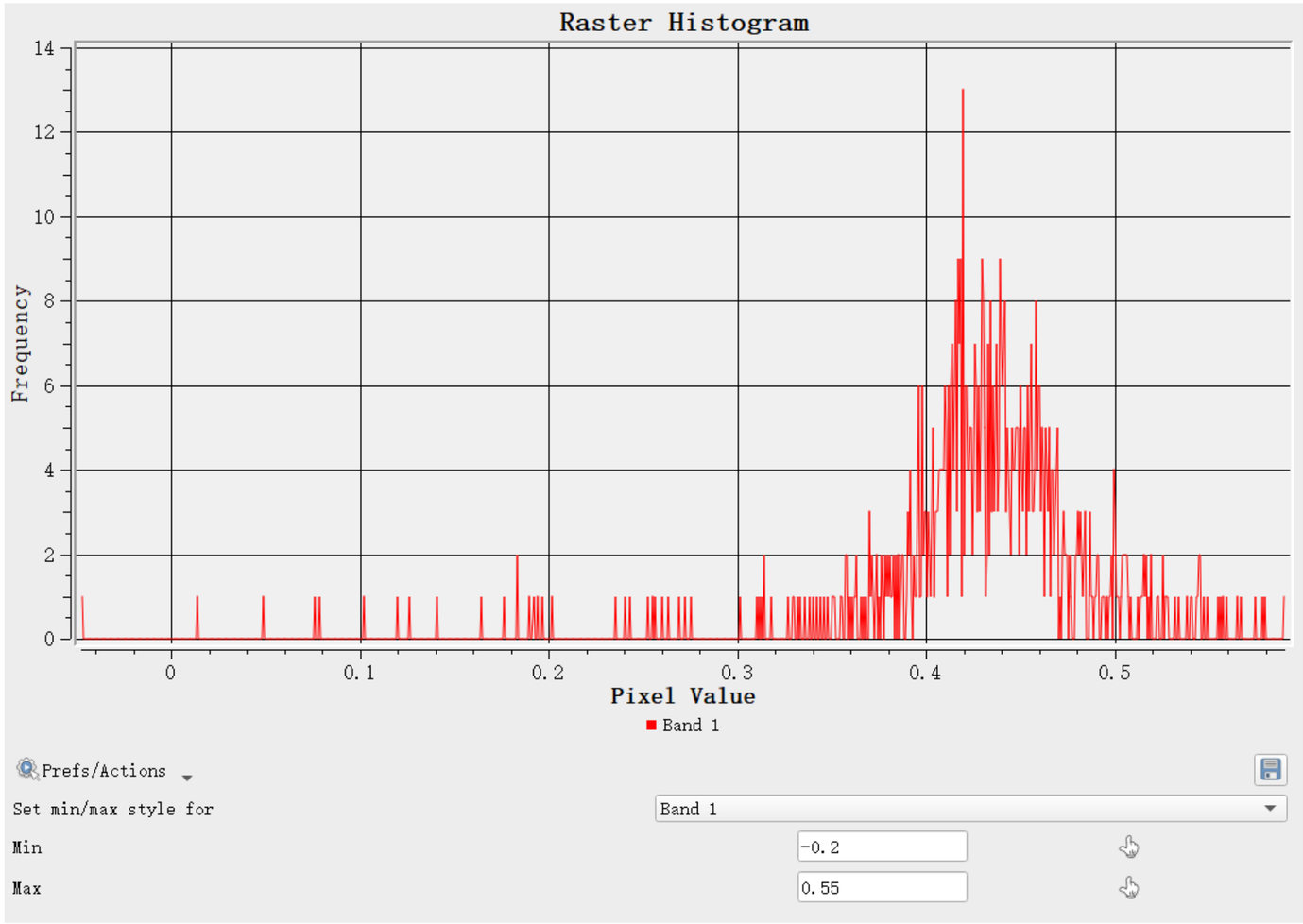
$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Rouse et al. (1974)

Data source: Landsat 8

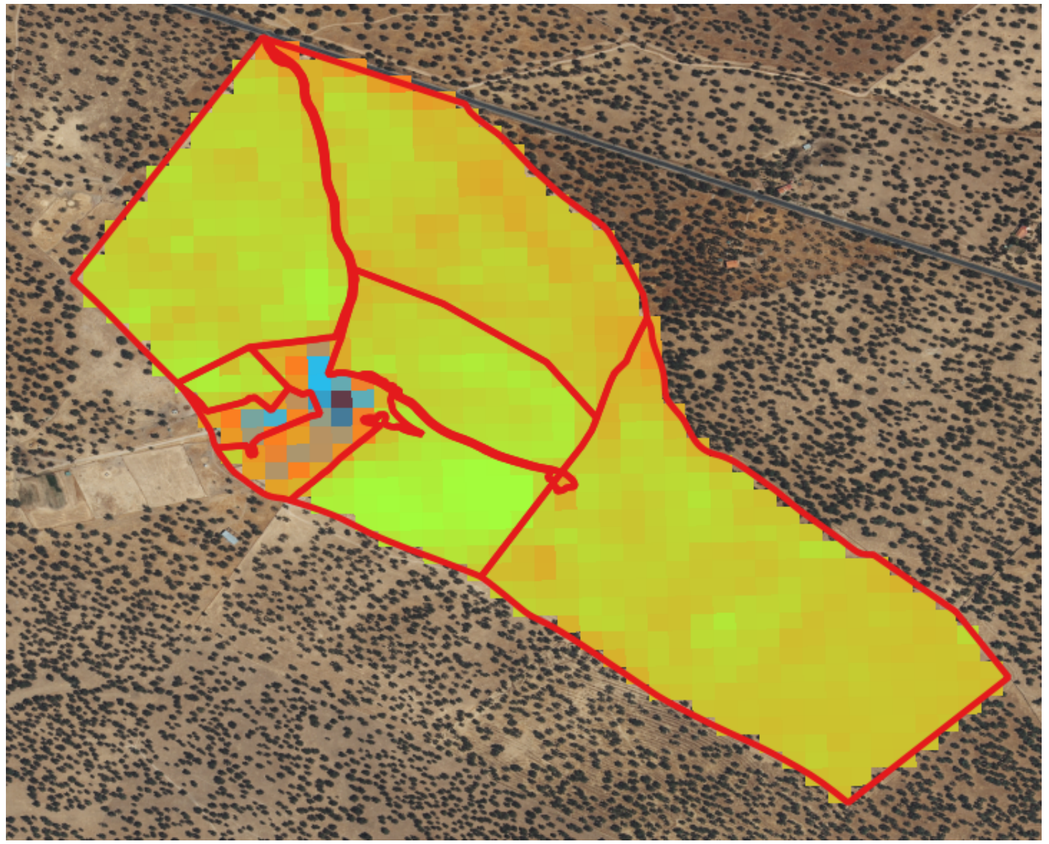
NDVI April 2015

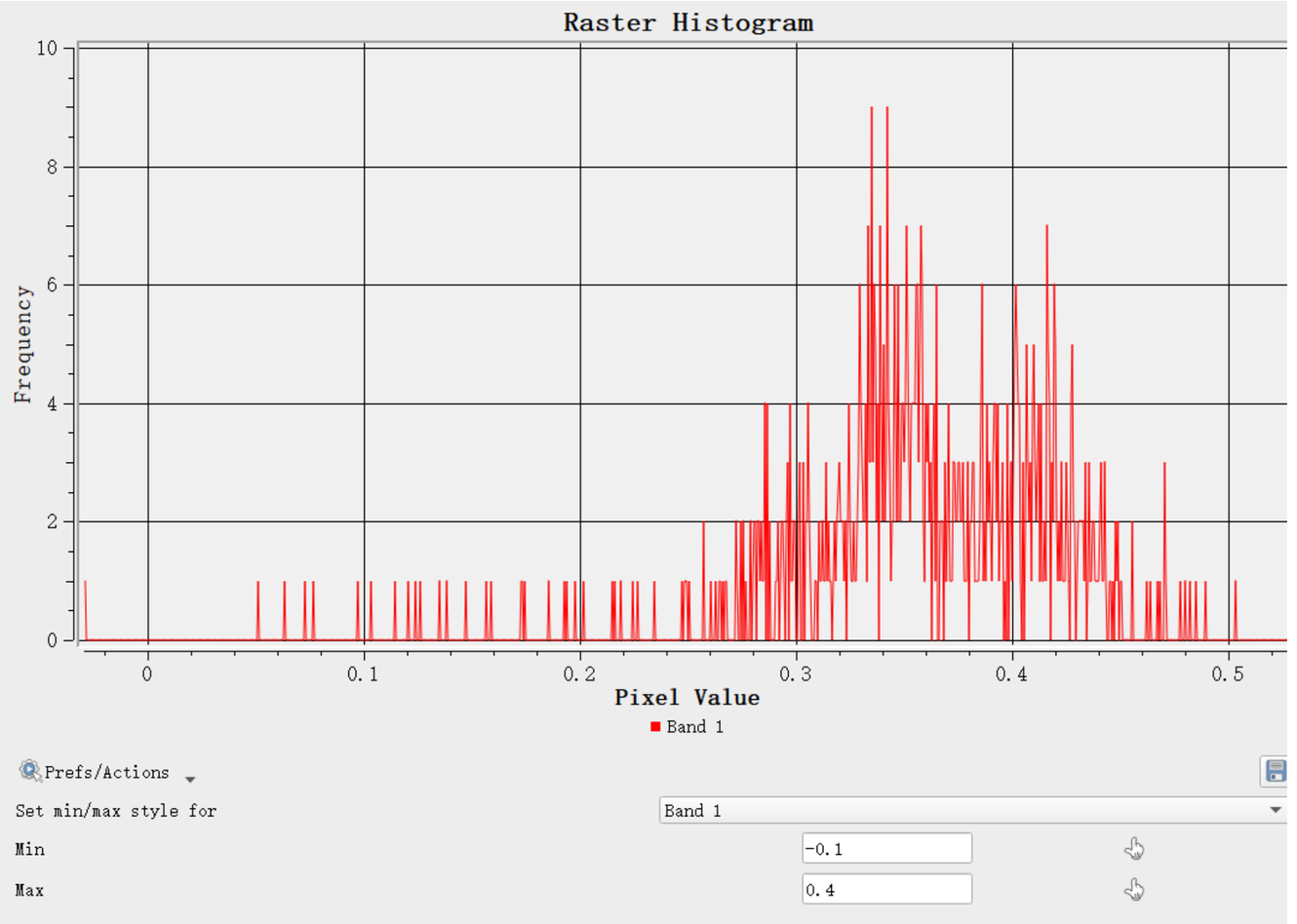




Average precipitation (April 2015) - 1.24 inches (IFAPA)

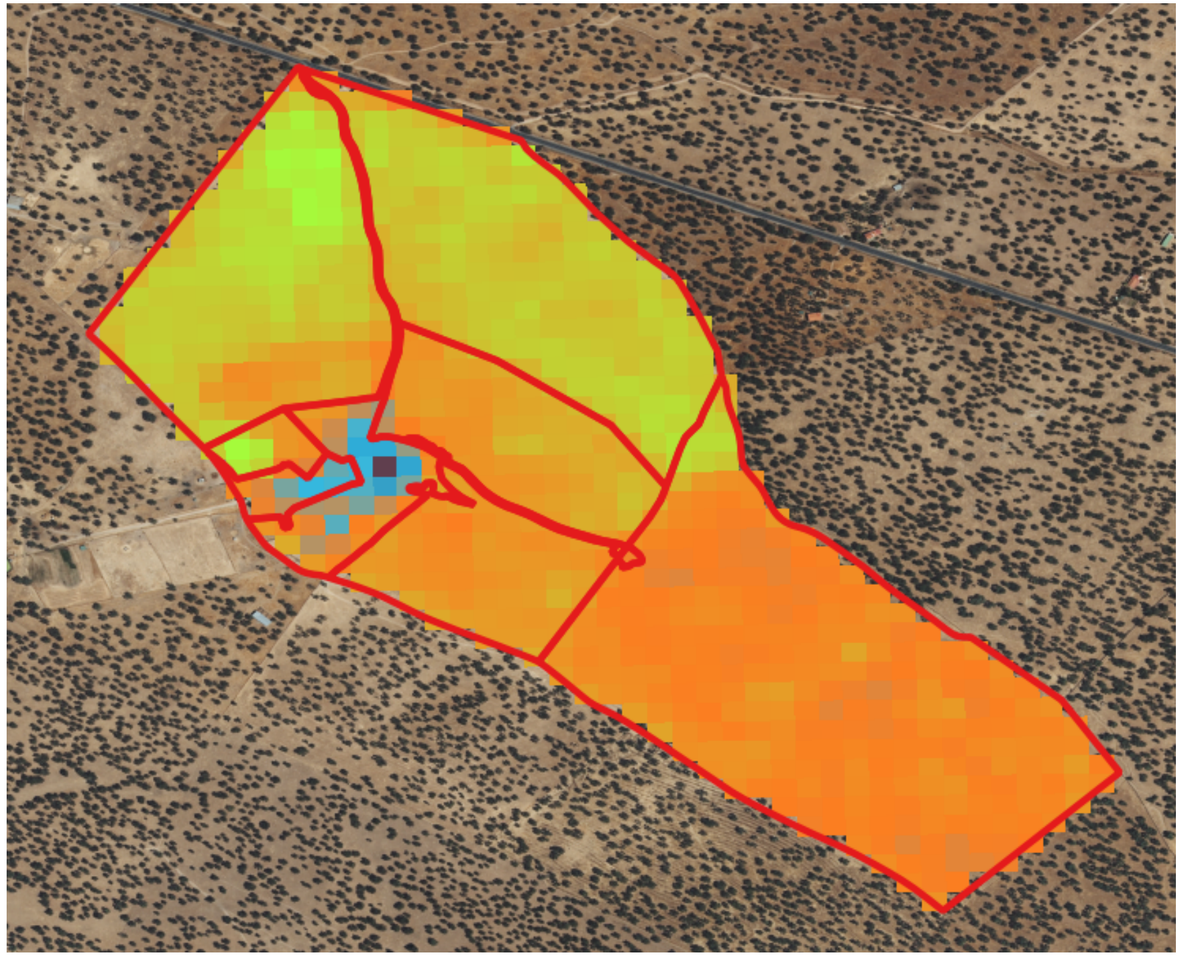
NDVI April 2019

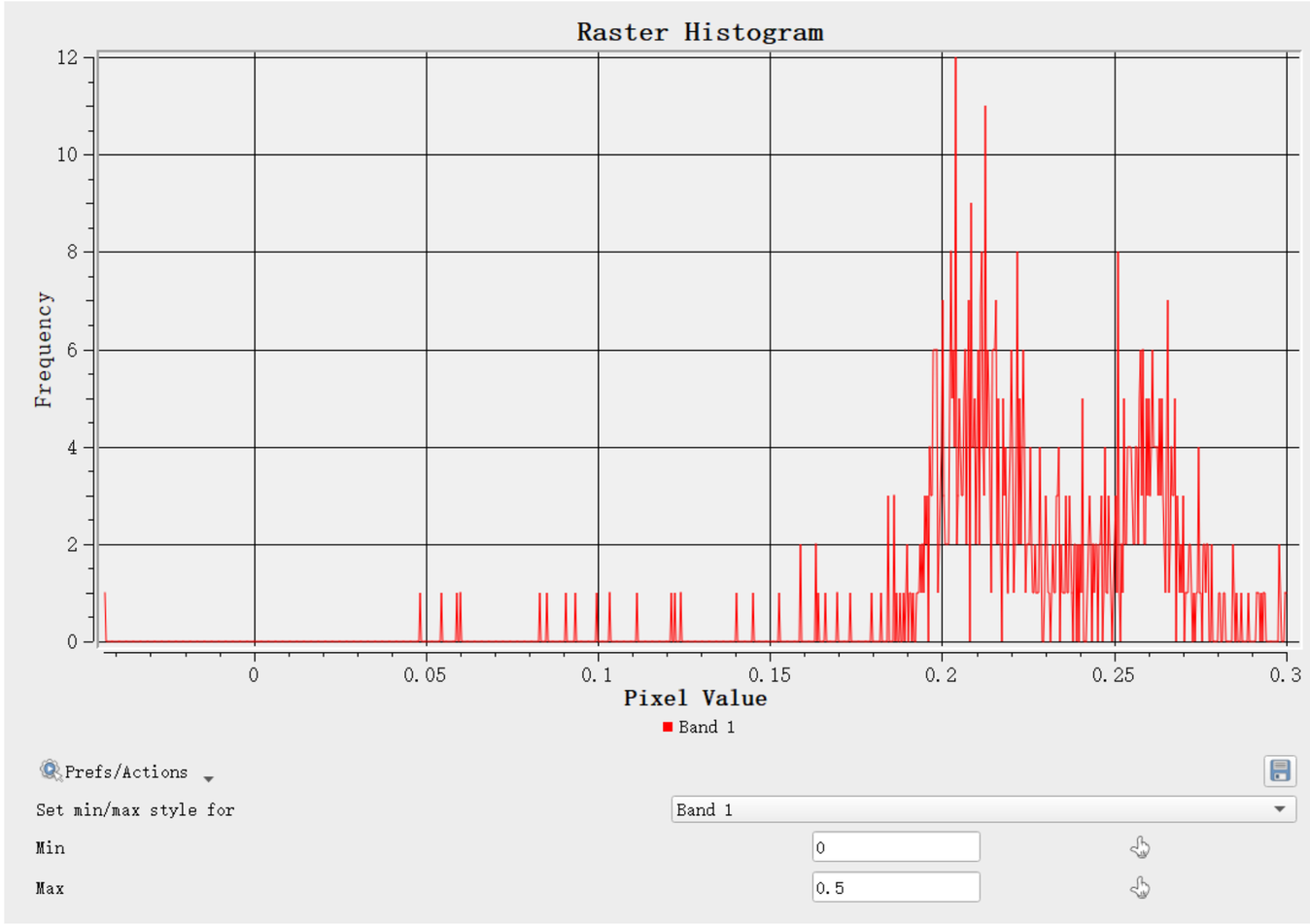




Average precipitation (April 2019) - 1.63 inches (IFAPA)

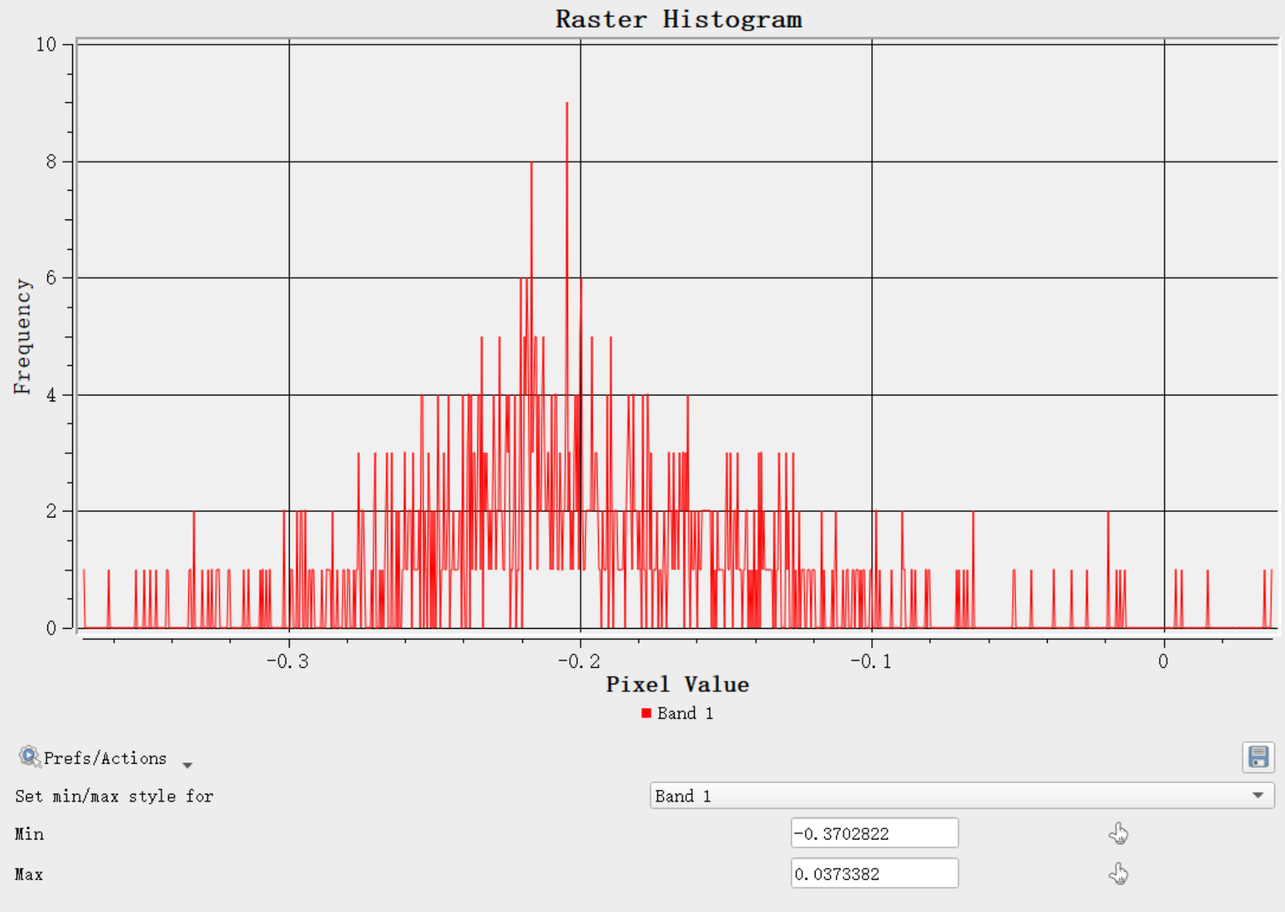
NDVI April 2023

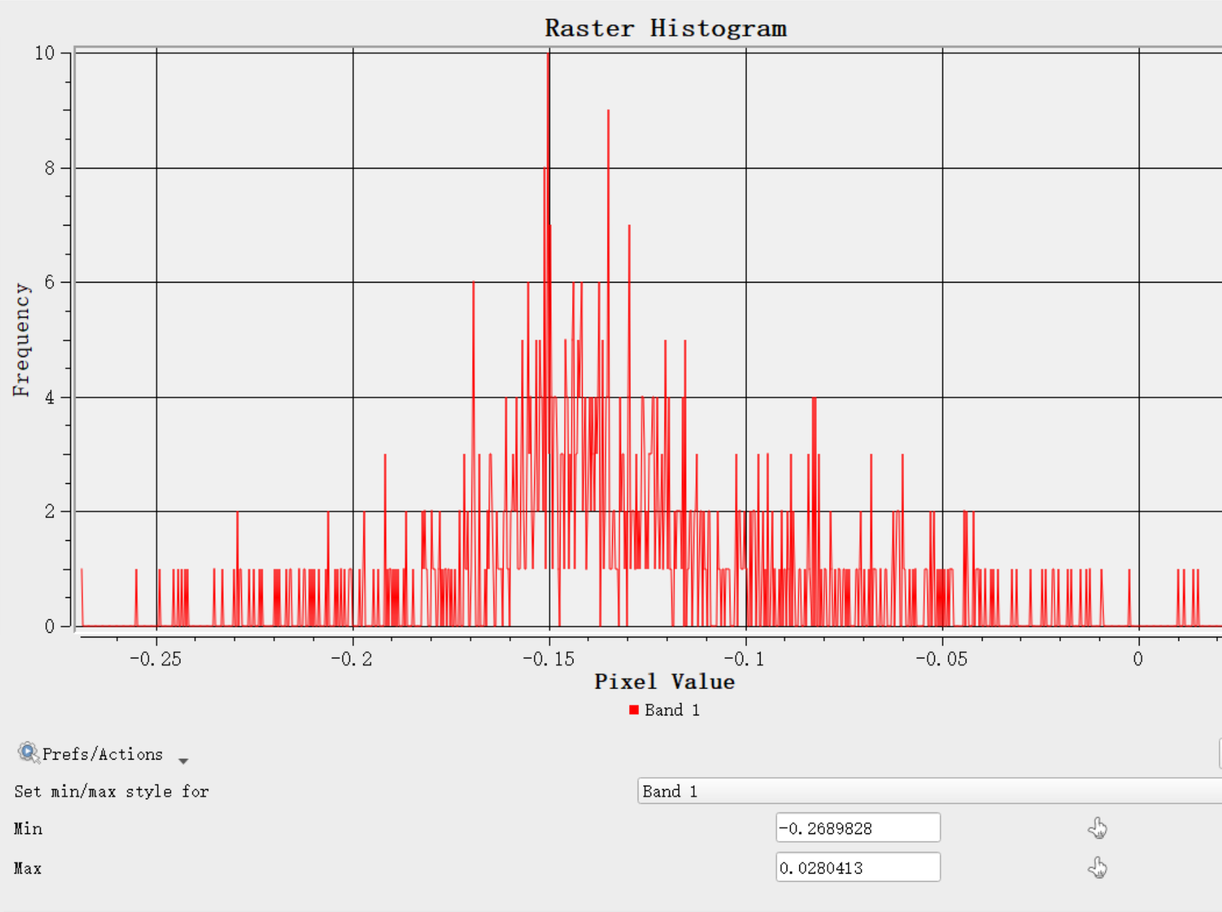




Average precipitation (April 2023) - 0.14 inches (IFAPA)

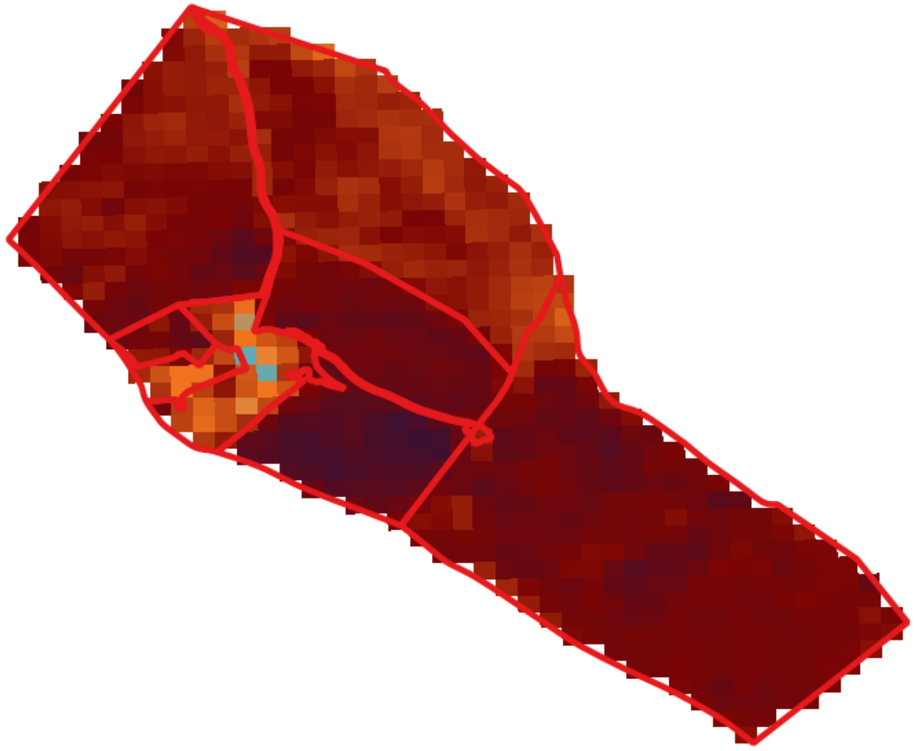
NDVI Change Differences



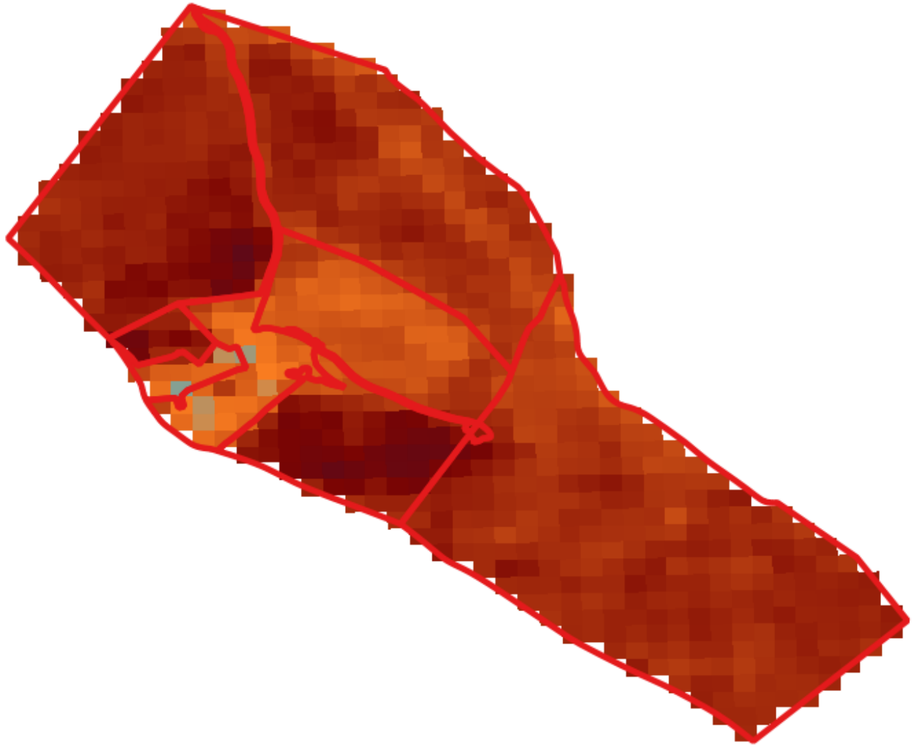


2023-2015

2023-2019



2023-2015



2023-2019

Interpretation of NDVI Outputs

- NDVI in 2015 is normally distributed around 0.42
- NDVI in 2019 is concentrated around 0.35-0.4
- NDVI in 2023 has two peaks, 0.22 and 0.27
- NDVI Differences: NDVI changes are more significant in the last four years
  - NDVI 2023 - NDVI 2019: concentrated around -1.5
  - NDVI 2023 - NDVI 2015: concentrated around -0.2

Discussions

Farm Management and Productivity

- Decline in oat production - no harvest this year
    - Purchasing processed feed from COVAP (high cost of production)
    - Seeking for sources in other regions of the country to purchase hay
- Delays in pig raising (potential reduction in yearly productivity)
- Potential alternatives: secondary production products and activities like cheese production and eco-tourism

Farmer's Perception on Drivers

- Drought is the main reason behind the decay of the trees
- Drought is a cyclic climatic event and will be overcome naturally in the coming years
- Underestimation of the key role of invasive species in tree decaying

Other Drivers (Literature Review)

- **Duque-Lazo et al. (2018)**
  - *Phytophtora cinnamomi* and changes in land uses as main drivers causing oak decline in Dehesa
  - High temperature and soils with acidic pH favor the occurrence of this soil pathogen
- **Ruiz-Gómez et al. (2019)**
  - Main drivers: *Phytophtora cinnamomi*, land use changes (overgrazing), insect pests, variations in climate patterns (e.g, drought)
  - Tree defoliation and mortality: 75% of xylem vessels affected by the fungus; nutrient uptake as well as water transport by plant roots are impeded (in line with Sánchez-Cuesta et al., 2021)
- **Sánchez-Cuesta et al. (2021)**
  - Drought, land use changes
  - Soil organic matter negatively correlated with tree defoliation and mortality

Conclusion

In Short

- Morillas Farm is negatively affected by drought as well as soil pathogens: no oat production, delays in pig production, defoliation, tree decay, reduced availability of acorns

- Change in vegetation (NDVI differences) occured more during the last years (NDVI 2023-2015 vs NDVI 2023-2019); global change (more drought these recent years)

- Potential economic impacts: high production costs, decline in farm productivity

- Implementation of innovative and sustainable strategies is imperative to make formidable adaptation in Morillas Farm and other Dehesa farms

Recommendations

1. **Adaptation to global change impacts (e.g, drought)**
- Investing in rainwater harvesting techniques (rooftop, cisterns...) to cope with potential upcoming droughts
- Plant drought-resistant tree species to improve resilience to drought conditions
- Use agroforestry techniques such as alley cropping and intercropping to increase productivity and provide additional income streams

2. **Strategies for fighting *Phytophtora cinnamomi***
- Chemical methods: fungicides (potassium phosphonate), liming, injecting trunks
- Afforestation (resistant species)
- Biological control: *Trichoderma* spp, ectomycorrhiza
- Integrated pest management techniques which involve biological, chemical, others together

3. **Government role**
- Strengthening extension education to increase farmers awareness about climate change and its impacts
- Limiting the infection via strategies that aim at reduing the transfer (anthropogenic) of the pathogens from highly affected Dehesa to least affected zones
- Provide financial incentives to farmers to cope with the drought conditions

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Thank You