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Independent Audit: Credible Carbon Spier Mob Grazing Project



July 2013

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Registration number: 2010/025938/23

Executive Summary

The Spier Mob Grazing Project comprises the intensive management of 74 hectares of irrigated pasturelands under high-intensity 'mob grazing' on Spier Farm in Stellenbosch, South Africa. This management technique involves frequent stock rotations to use livestock to mimic nature and to restore soil organic matter. The adoption of mob-grazing and other associated land management techniques is likely to increase the rate of sequestration of carbon (C) in pasture soils as a result of: i) increased deposition and reduced decomposition of organic material; and ii) enhanced productivity of pastures. In order to estimate and monitor the rate of change of soil C sequestration as a result of land management practices, soil samples were collected in September 2011 and January 2013 and analysed for chemical content (including % Soil Organic Matter, SOM) by Brookside Laboratories. The background to the project is described in greater detail in the Project Idea Note (PIN) authored by Credible Carbon.

C4 EcoSolutions undertook an independent audit of the results of these chemical analyses and the estimated sequestration of C in Spier's pasture soils. This report represents the C4ES audit of the project's soil C sequestration as reported in the Credible Carbon PIN according to the four key criteria of the Credible Carbon Registry as described below.

Is the project real?

C4ES Conclusion: Yes. Two site visits were conducted on 28th May and 16th June 2013 to confirm that the land management and grazing practices are as reported in the PIN.

Is the described technology in place?

C4ES Conclusion: Yes. During the site visits, the authors observed both cattle and chickens grazing in various pasturelands at high densities and at a fast rate of rotation. Irrigated pastures invariably have a high proportion of groundcover, even in recently grazed plots. Although cattle are grazed at a high density in terms of stocking rate, animals are moved onto new land with sufficient frequency such that plant cover is maintained even in recently grazed pastures (see Annex 1).

Are the estimates of greenhouse gas emissions reduction reasonable?

C4ES Conclusion: No. The initial indicative estimates of greenhouse gas (GHG) emission reductions (measured as CO₂ Equivalents derived from increased sequestration of C in pasture soils) provided in the PIN are likely to have been overestimated. However, the project does have a discernible impact on soil C sequestration. As a result of project activities, an estimated **7,852.1** tonnes of CO₂ equivalent (CO₂e) have been sequestered as soil C in the period from September 2011 – January 2013.

Period	Sequestered CO ₂ (t)
September 2011 - September 2012	6,281.8
September 2012 - January 2013	1,570.4
Total	7,852.1

Proposed revisions to GHG emission reductions are summarised in further detail in the report.

Is there a discernible impact on poverty?

C4ES Conclusion: Yes. The project provides employment to 35 people, including 3 individuals who act as cattle herdsman. The project developer has committed to spending 50% of the carbon revenue on direct employee benefits, the nature of which is to be decided by the employee group in consultation with the project developer and project proponent.

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Section A: Introduction

The Spier Mob Grazing Project comprises the intensive management of 74 hectares of irrigated pasturelands under high-intensity ‘mob grazing’ on Spier Farm in Stellenbosch, South Africa. This management technique aims to use livestock to mimic nature and involves frequent stock rotations (cattle are moved up to 6 times a day). Pasture productivity and soil fertility is enhanced by: i) deposition of urine and dung by livestock and poultry; ii) improved aeration and water infiltration as a result of hoof indents; iii) fixation of atmospheric nitrogen by leguminous pasture plants; and iv) irrigation of pastures in the summer. The project’s pasture management is based on the high density grazing methodology developed in the 1980s and espoused by Andre Voison, Allan Savory and Ian Mitchell-Innes. The grazing of livestock at high densities for short periods of time results in significant deposits of organic material on the soil surface and results in healthy, vigorous pasture growth without the application of chemical fertilizer. Cattle are moved between four and six times per day. Laying hens are accommodated in “egg-mobiles” and are moved every two days. The project supplies chicken, beef and eggs to retail outlets and restaurants in the region, displacing the supply of industrially produced animal protein to these markets.

The activities of this project apply an alternative approach to agriculture which results in comparatively less emission of GHGs relative to conventional agriculture. No grains are farmed to provide animal feed and pastures have been recreated from highly compromised land on which the fertile topsoil has historically been degraded and depleted of nutrients.

The Credible Carbon Registry requires an independent audit of all projects in accordance with four key questions:

1. Is the project real?
2. Is the described technology in place and functioning in accordance with its design specification?
3. Are the estimates of greenhouse gas emissions reduction reasonable in terms of accepted international standards and unbiased towards buyer or seller?
4. Is there a discernible impact on poverty?

This report summarises the findings of an audit that was conducted by C4EcoSolutions from May 28th to June 18 2013. The audit answers the key questions as stated above and aims to provide expert opinion on the likely quantities of carbon that have been sequestered by the project during the period September 2011 – January 2013. Activities undertaken in support of the assessment included:

- Two site visits on 28 May and 6 June 2013;
- Assessment of site history through analysis of photography and Google Earth satellite imagery;
- Calculation of estimated changes in %SOM, soil C and sequestration of CO₂ based on soils analyses undertaken by Brookeside Laboratories; and
- A review of available literature and published figures on typical productivity and C sequestration in pastures.

Section B: Site descriptions and land use

History

Analysis of satellite imagery (Annex I), photographic records and interviews with Spier staff members (28 May & 6 June 2013) confirm that the project area has been cultivated extensively in the past. Prior to conversion to pasture, common land uses included: cultivation of carrots, potatoes and other vegetables; vineyards; various temperate and subtropical orchard crops such as plums, mangoes and avocados; and dryland pasture. Reportedly, fertile topsoil was previously removed from some of the areas which are currently under mob-grazed pastures. In consequence it is likely that most of the soils within the project area have been degraded by a long history of conventional agricultural practices, including use of synthetic fertilisers and agro-chemicals, monocropping, soil compaction and surface erosion (see Figure 1).



Figure 1: The degraded land prior to the project and the establishment of pastures using high density grazing. The machinery is being used to establish irrigation infrastructure.



Current land uses

A total area of 74 hectares is currently managed as irrigated mob-grazed pastures, producing beef, chicken and eggs (see Figures 2a-d).

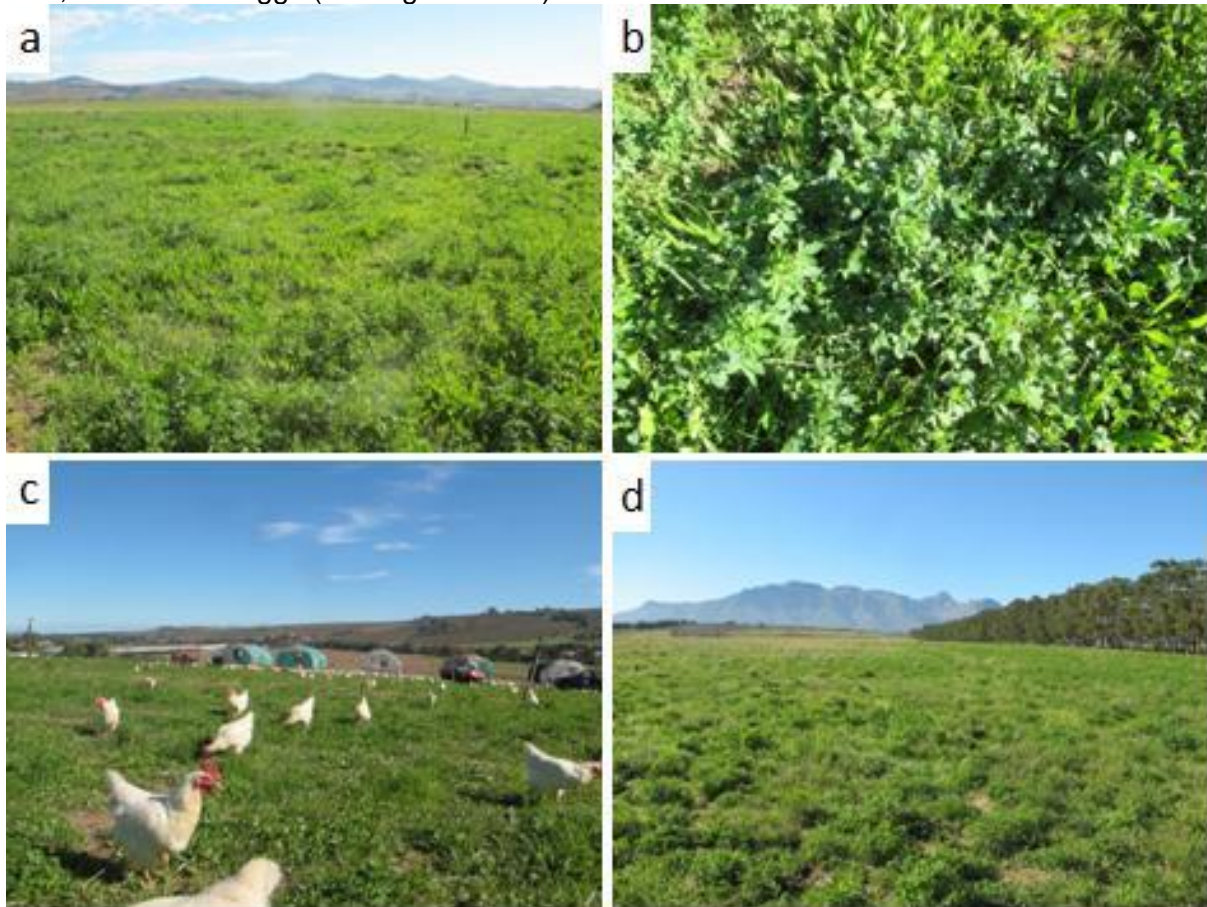


Figure 2a – d. Irrigated pastures of mixed grass and legume species are subjected to periodic high-intensity ‘mob-grazing’.

Newly established pasture areas are enclosed by a ‘shelterbelt’ border of mixed indigenous tree and shrub species (see Figures 3a-b). These shelter belt areas are currently established to a width of 5m but this will be extended to 15m in the future.



Figure 3a – b. Shelterbelts of mixed indigenous vegetation are established as an alternative to conventional windbreaks.

Extensive areas of vineyards are established, some of which are also subjected to periodic grazing during the winter periods when grapevines have senesced (see Figures 4a – d).

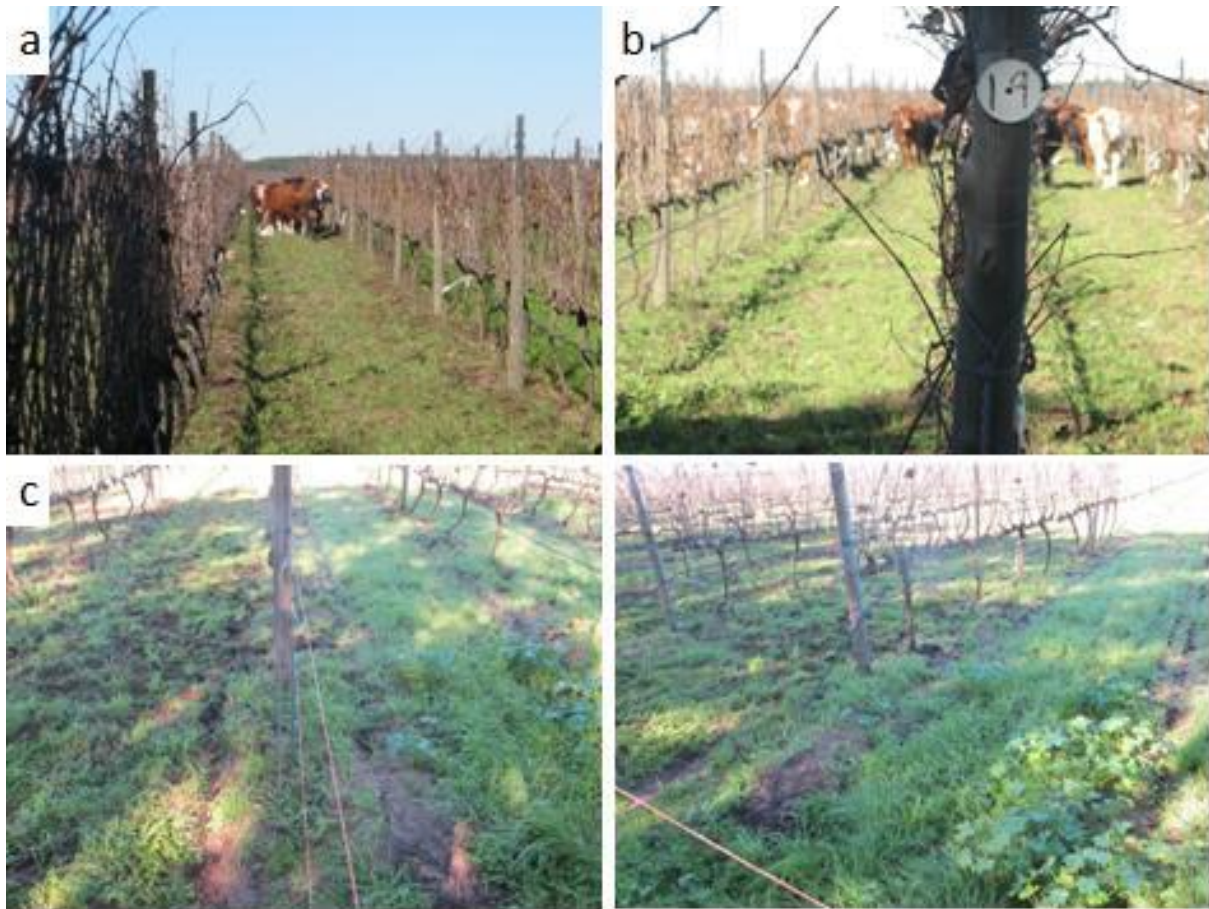


Figure 4a – d. Mob-grazing is also practiced periodically on vineyard covercrops. 4c and 4d demonstrate the amount of forage cover remaining after grazing (left row) relative to an ungrazed row (right row).

Some areas of land are currently fallowing but are likely to be converted to irrigated pastures in the short- to mid-term future. These fallow land areas are currently supporting mixed assemblages of low-density scrub-like vegetation.

The northern boundary of Spier Farms towards the Eerste Rivier occurs on a transition between ferricrete fynbos and renosterveld vegetation types which host a patch of vegetation of significant biodiversity and carbon value, including 4 IUCN Red Data-listed species. It is not known whether this vegetation can be termed 'pristine', in that it may have been cultivated at some remote time preceding the available historical record, but at present this area is treated by Spier management as a conservation area and is unlikely to be cultivated in the foreseeable future.

Historic Satellite Imagery

GoogleEarth imagery from 2005 – 2012 was used to study land use changes within the project area. Based on visual examination of these datasets, it was determined that pastures within the project area have been established on land that was previously used for some form of agriculture, and that no significant areas of pristine/native vegetation have been cleared for pasture since 2005. Previous land uses in the project include production of carrots, orchard crops and vineyards. Land use trends of sampled sites are summarized in Annex I.

Section C: Sampling and analysis of soils

Soil samples were collected by the farm manager, Angus McIntosh, from 16 sites within the project area during two periods, namely September 2011 and January 2013. At each site, 25 soil samples were taken to a depth of 0.3 m with a 30 mm soil auger and aggregated together to form a composite sample for each site. Site descriptions and the results of analyses of SOM are summarized in Table 1.

Table 1. Soil analyses of % Soil Organic Matter in sampled Spier soils in 2011 and 2013.

Sample number	Reported area (ha)	Description	% SOM 2011	% SOM 2013	% SOM Increase
1	2.40	Chenin vineyard	1.24	3.83	2.59
2	1.44	Chenin vineyard	1.16	4.06	2.9
3	0.50	Olives	1.47	2.3	0.83
4	1.92	Banded fields west	0.76	1.83	1.07
5	4.44	Banded fields east	0.73	1.91	1.18
10	3.94	Pasture blocks 11 to 13	1.29	2.65	1.36
11	12.01	Pasture blocks 1 to 5, 9, 10	1.4	2.37	0.97
12	3.28	Pasture blocks 6 to 8	1.1	2.28	1.18
13	9.43	Pasture blocks 14 to 20	0.84	2.74	1.9
15	1.74	Old Pinotage vineyard	1.36	1.58	0.22
16	17.94	De Rus lands, North	1.45	2.95	1.5
17	3.55	Old Sauvignon Blanc vineyard	0.78	1.42	0.64
18	14.79	De Rus, South	0.83	1.8	0.97
19	5.79	Old carrots	0.99	1.62	0.63
20	6.50	Paul Roux, ex Sauvignon Blanc, West	2.69	1.43	-1.26
21	5.50	Paul Roux, ex Sauvignon Blanc, East	1.11	2.5	1.39

Table 1 shows that soil organic matter increased in all but one sampled site in the period between the two sampling periods. To ensure that only the most representative datasets are used to estimate the impact of mob-grazing on irrigated pastures, and given that the above analyses include sites which are devoted to other land uses in addition to grazing, data from the following sites were excluded from calculations:

- Sites 1 – 2, on the grounds that they are currently vineyards and are not directly comparable to the project area's pastures, and have a relatively high SOM content which cannot be attributed solely to grazing practices and would result in biased results;
- Site 3, on the grounds that this site is currently an olive orchard and is not directly comparable to the project area's pastures;
- Sites 20 – 21, on the grounds that site 20 is the only site where SOM has decreased whereas SOM in the adjoining site 21 has increased. These two sites appear to be anomalous and this may indicate a potential source of error in sampling or analysis which could result in biased results.

The 11 remaining sampled sites were used as a basis for calculating increased C sequestration as a result of project activities. The location of these sampled sites and their relative increases in %SOM are presented in Figure 5 below.

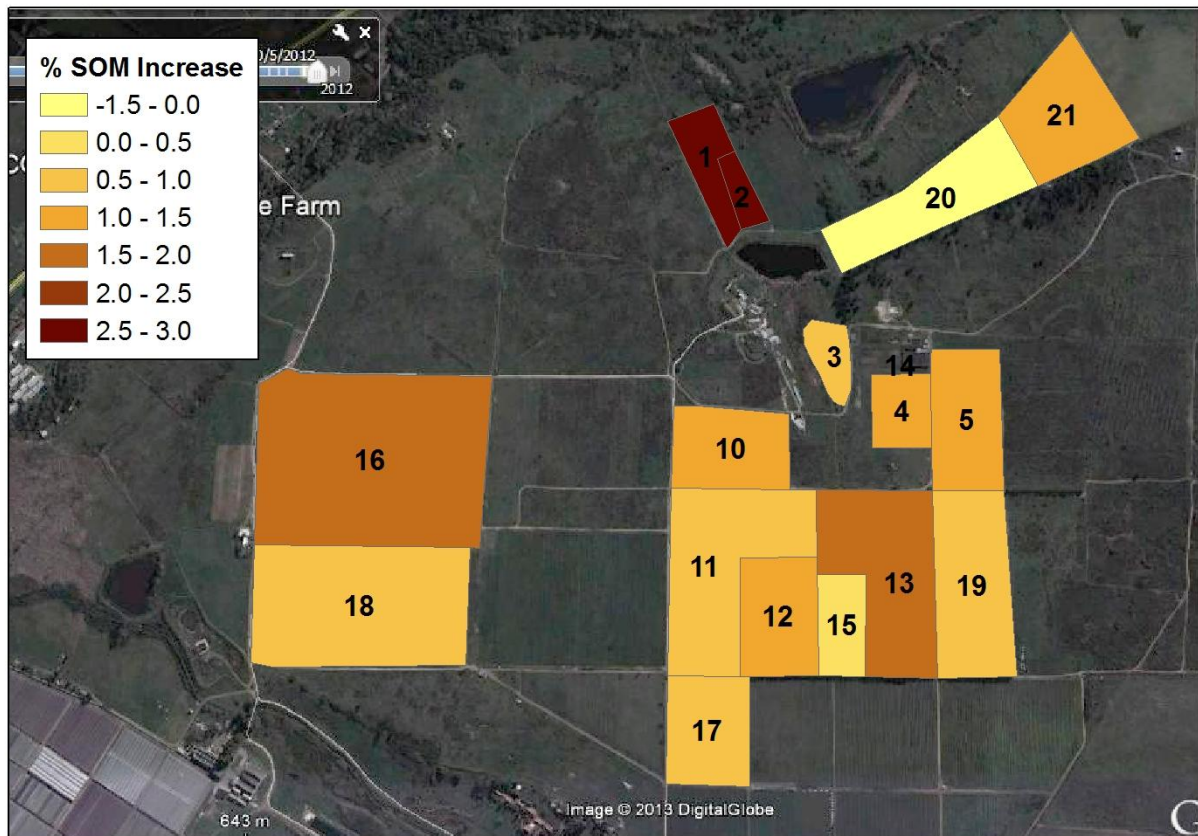


Figure 5. Location of sampled sites and changes in %SOM.

The basic approach to estimating soil carbon sequestration between Time Periods 1 and 2 is as follows:

$$\text{Change in carbon sequestered (tonnes/ha)} = (\%C_2 - \%C_1) * \text{Bulk Density} * \text{Soil Volume}$$

%C can be determined from %SOM based on the assumption that SOM is ~58% C by mass^[1]. For these calculations, an average bulk density of soil of 1.4 g/cm³ has been assumed^[2] as representative of Western Cape soils. Soil samples were taken from a depth of 30 cm.

Current sequestration of C (January 2013)

Calculations summarizing sequestration of %SOM and C are presented in Table 2 below.

Table 2. Change in %SOM and calculation of soil C and CO₂e sequestration as a result of project activities between 2011 and 2013.

Sample number	Area (ha)	% change Soil OM	% change Soil C	Increase C sequestered (t/ha) *	Increase CO ₂ sequestered (t/ha) *	Increase CO ₂ sequestered per plot (t) *
4	1.9	1.07	0.62	26.1	95.6	183.2
5	4.4	1.18	0.68	28.7	105.4	467.8
10	3.9	1.36	0.79	33.1	121.5	478.1
11	12.0	0.97	0.56	23.6	86.6	1,040.7
12	3.3	1.18	0.68	28.7	105.4	345.3
13	9.4	1.9	1.10	46.3	169.7	1,600.8
15	1.7	0.22	0.13	5.4	19.7	34.2
16	17.9	1.5	0.87	36.5	134.0	2,403.8
17	3.6	0.64	0.37	15.6	57.2	202.8
18	14.8	0.97	0.56	23.6	86.6	1,281.6
19	5.8	0.63	0.37	15.3	56.3	325.8
Average		1.06	0.61	25.7	94.4	
Total	78.8					8,364.1

*The volume of soil is assumed to be 3,000 m³ (100 m x 100 m x 0.3 m) with a mass of 4,200 tonnes.

Soil C increased by an average of 0.61% as a result of project activities. Based on an assumed volume of soil of 3,000 m³ per hectare (100 m x 100m x 0.3 m) and a bulk density of 1.4 g/cm³, this is equivalent to an increase of 25.7 tonnes of C per hectare, or 94.4 tonnes CO₂e. The total increase in CO₂e sequestered within the sampled sites is calculated as 8,364.1 tonnes over a sampled area of 78.8 hectares. Given that the sum of areas sampled is greater than the defined project area of 74 hectares, and assuming that project activities are carried out consistently across the 74 hectare project area, this rate of SOM accumulation results in an estimated sequestration of **7,852.1 tonnes CO₂e** in the period September 2011 – January 2013¹.

¹ 8,364.1t CO₂E x (74 hectares / 78.8 hectares) = 7,852.1 t CO₂E

Section D. Estimated C sequestration rate at Spier relative to figures reported in peer-reviewed literature

It is important to note that the changes in total %SOM and corresponding total sequestration of C calculated for Spier are within an expected and realistic range. However, the calculated rate of soil C sequestration (~16.7 t C/ha/year²) i.e. the rapidity of C sequestration, is high relative to figures published in peer-reviewed literature. Examples from this literature are listed below.

D.1 Soil C sequestration rate at Spier in comparison with available published figures

Franzluebbers, A.J. (2010) Soil organic carbon in managed pastures of the southeastern United States of America. In: Grassland Carbon Sequestration: Management, Policy And Economics.

Typically, soil C sequestration rate in pasture soils does not exceed 1 t C/ha/year, for example “optimally stocked pastures can lead to SOC sequestration of 0.78 t C/ha/year compared with unharvested pasture during the first five years of management”, and “Establishment of perennial grass pastures in the southeastern United States can sequester SOC at rates of 0.25 to 1.0 t C/ha/year”^[3]. It should be noted that the figures cited above are derived from various pasture management systems and are therefore not directly comparable to the mob-grazing method practised at Spier. Notwithstanding the different land management techniques, the calculated rate of C sequestration at Spier is at least 17.2 times faster than in conventional pasture systems.

Growing soil carbon in Australia’s grazing rangelands. SCR Pty Ltd.

The likely maximum soil C and CO₂ rate of change per annum was modelled for Australian pastures, assuming optimal management on various soil types. The range of C sequestration rates determined by this method was in the range of 0.12 – 1.48 t C/ha/year^[4]. The authors note that appropriate management techniques could conceivably increase the rate of C sequestration beyond the indicative modelled figures. Notwithstanding these differences, the calculated rate of C sequestration of Spier is 11.6 times more rapid.

McKenzie, D. (2010) Soil Carbon Sequestration under Pasture in Australian Dairy Regions. Dairy Australia.

This study cited figures derived from an initiative established by the Portuguese government which aims to sequester carbon in grassland soils through improved pasture management. This includes the use of a technique known as “sown biodiverse permanent pastures rich in legumes” (SBPPRL), where no-till seeding of rainfed pastures with a biodiverse mix of grasses and legumes that contains up to 20 different species and cultivars is followed by “careful management with sustainable stocking rates”. Trials of SBPPRL across 84 properties showed that SOM increased on average by 0.2% a year, which corresponded to 5 t/ha/year CO₂e (~1.36 t C/ha/year). The aforementioned system is more directly comparable to the management techniques practised at Spier, namely the use of biodiverse legume and grass species and sustainable stocking rates. However, these management systems differ in that: i) irrigation is applied at Spier, whereas the Portuguese system is rainfed; and ii) the grazing intensity and frequency practiced in Spier’s mob-grazing regime is likely to differ from Portugal’s SBPPRL system. Nevertheless, the calculated rate of C sequestration at Spier is approximately 12.6 times faster than the average C sequestration rate in Portugal’s SBPPRL system^[5].

Shewmaker, G.E., Entry, J.A., and Sojka, R.E. Carbon sequestration in irrigated pastures. United States Department of Agriculture.

² 25.4 t C/ha / 1.5 years = 16.7 t C/ha/yr



The influence of irrigation on soil C sequestration in pasture soils will vary depending on environmental and management factors. It is anticipated that supplemental irrigation of pastures at Spier will increase the C sequestration rate as a result of increased plant growth. However, it should be noted that in some instances irrigation is associated with a negligible change or even a decrease in sequestered soil C, even when pasture productivity is enhanced by irrigation^{[6][7]}. A long-term experiment in Idaho, USA, monitored the change in soil C content over a 30 year time period following the conversion of native sagebrush vegetation and irrigated ploughed cropland to irrigated pastures. The conversion to irrigated pasture resulted in increased soil C sequestration of 27.6 – 29.1 t C/ha, equivalent to a rate of C sequestration of 0.92 – 0.97 t C/ha/year^[8]. The calculated rate of C sequestration at Spier is at least 17.2 times more rapid than reported in this study.

D.2 Pasture productivity at Spier in comparison with available published figures

There are few published studies available on the influence of mob-grazing on pasture productivity. As a result of the relative absence of peer-reviewed publications assessing the short and long-term effects of mob-grazing on pasture productivity and soil C sequestration, there are limited datasets available for comparison to determine whether the increased soil C sequestration observed at Spier is plausible. It is evident that productivity of pastures can be increased by multiple management interventions currently practised at Spier, including irrigation of pastures, increased application of fertilising manure, use of diverse grass and legume forage species, and management of high-intensity short-duration grazing regimes. However the effect of these practices on forage productivity, deposition of dry matter, and turnover of organic C cannot be calculated cumulatively as the sum of these individual effects. A comparison of the productivity of mob-grazed pastures relative to conventional pastures is a useful alternative to comparisons of soil C. The C sequestration rate calculated for Spier of 16.7 t C/ha/year is equivalent to approximately 34.4 t dry matter /ha/year. If it is assumed that half of organic matter (animal manure, soil microbes, plant litter and living plant material) is decomposed^[5], the calculated rate of C sequestration at Spier is equivalent to approximately 68.8 t dry matter/ha/year.

USDA. (2011) The Effect of Mob Grazing on Soil Health. United States Department of Agriculture.

A comparison of pasture productivity after conversion from conventional to mob-grazing methods in Montana, USA, indicated that forage production was doubled upon conversion to mob-grazed pastures, from ~2.48 t dry matter/ha/year to ~6.7 t dry matter/ha/year (2,205 pounds versus 5,950 pounds per acre)^[9]. These figures indicate that mob grazing techniques may increase deposition of pasture dry matter by approximately 4.2 t dry matter/ha/year, equivalent to a carbon content of approximately 2.1 t C/ha/year. If it is assumed that ~50% of plant matter is decomposed, these figures indicate that the mob grazing technique could be expected to increase C sequestration by approximately 1.05 t C/ha/year. These figures are consistent with the literature cited above, where the maximum increase in soil C sequestration in pastures is of the order of 1 – 1.35 t C/ha/year, compared to the calculated rate of C sequestration of 17.2 t C/ha/year at Spier.

However, it should be noted that there are examples in peer-reviewed literature of ecosystems achieving comparable rates of productivity to that inferred for Spier's pastures. Selected examples are presented below.

Orodho, A.B. (2006) The role and importance of Napier grass in the smallholder dairy industry in Kenya. Food and Agriculture Organisation, United Nations.

Napier grass, *Pennisetum purpureum*, is a commonly grown tropical forage grass species. In a study of production of Napier grass in Kenya, on-farm dry matter yields varied from 16 – 40 t

dry matter/ha/year^[10]. If it is assumed that aboveground biomass is roughly equal to belowground biomass, it is possible that optimally managed Napier grass can accumulate as much as 80 t dry matter/ha/year in below- and above-ground biomass. In exceptional instances, it is reported that Napier grass may yield up to 85 t (aboveground) dry matter/ha/year^[10]. These figures are of a similar order of magnitude to the calculated rate of C sequestration at Spier of 68.8 t dry matter/ha/year.

Sharpe, P. (1998) Sugar cane: past and present. Southern Illinois University.

An analysis of studies of production of sugarcane (*Saccharum* sp.) from around the world indicate that the average yield of sugarcane stalk is approximately 60 – 70 t dry matter/ha/year but in optimal tropical conditions and intensive management this may exceed 200 t/ha/year^[11]. These figures are of a similar order of magnitude to the calculated rate of C sequestration at Spier of 68.8 t dry matter/ha/year.

Various references cited in Ramachandran Nair, P.K. (1993) An introduction to agroforestry. Kluwer Academic Publishers.

A review of studies investigating the potential maximum productivity of ecosystems indicates that the rate of C sequestration and implicit biomass production at Spier is remarkably high but not implausible^[12]. For example, a 1963 study on the hypothetical maximum dry matter production rate, based on optimal environmental conditions, suggested that the maximum potential dry matter production in the USA is approximately 281 t dry matter/ha/year^[13]. Although this rate of productivity was not observed under field conditions, several crop species have been observed to achieve productivity equivalent to 17 – 54% of the aforementioned hypothesised maximum (48 – 150 t dry matter/ha/year)^[14]. The meta-study also noted that extremely high short-term productivities have been reported from some natural grassland ecosystems. Notably, above-ground net primary productivity (ANPP) in the Serengeti grasslands of Tanzania has been observed to be equivalent to ~146 t dry matter/ha/year. While this production rate is a maximum, productivity was consistently higher than half of the aforementioned value (equivalent to greater than 70 t dry matter/ha/year)^[15]. These figures indicate that the calculated rate of C sequestration at Spier of 68.8 t dry matter/ha/year is achievable in specific environmental conditions.

E.3 Conclusion

The above references demonstrate that the calculated rate of soil C sequestration at Spier is very high relative to published data on pastures under various management regimes. However, it is also clear that ecosystem productivity and dry matter accumulation is highly dependent on multiple environmental and management variables, and that natural ecosystems have the capacity to accumulate dry matter at rates even higher than those estimated at Spier. Land management practices at Spier are distinctly different from conventional pasture management and it is apparent that these differences are likely to influence soil C dynamics significantly. Therefore the calculated rate of C accumulation at Spier, while remarkable relative to available data for comparable pasture systems, is technically plausible and feasible when compared with known maximum rates of ecosystem productivity.

Section F: Limitations and assumptions

Wherever possible, conservation assumptions have been maintained in order to account for any possible bias.

The available data is limited in that it only covers a relatively brief sampling period, and soil samples were not taken at a consistent time of year. As a result there may be inconsistencies between the two periods as a result of temporal flux of soil C in variable environmental conditions. However, it is likely that the timing of the sample selection will have resulted in a more conservative estimate of increased soil C, given that: i) the first samples were taken in September when soil OM is likely to be relatively high as a result of cool temperatures and high soil moisture; and ii) the second samples were taken in January when soil C is likely to be lower as a result of high temperature and reduced moisture. For the above reasons it is recommended that future soil samples are collected at a consistent time of year.

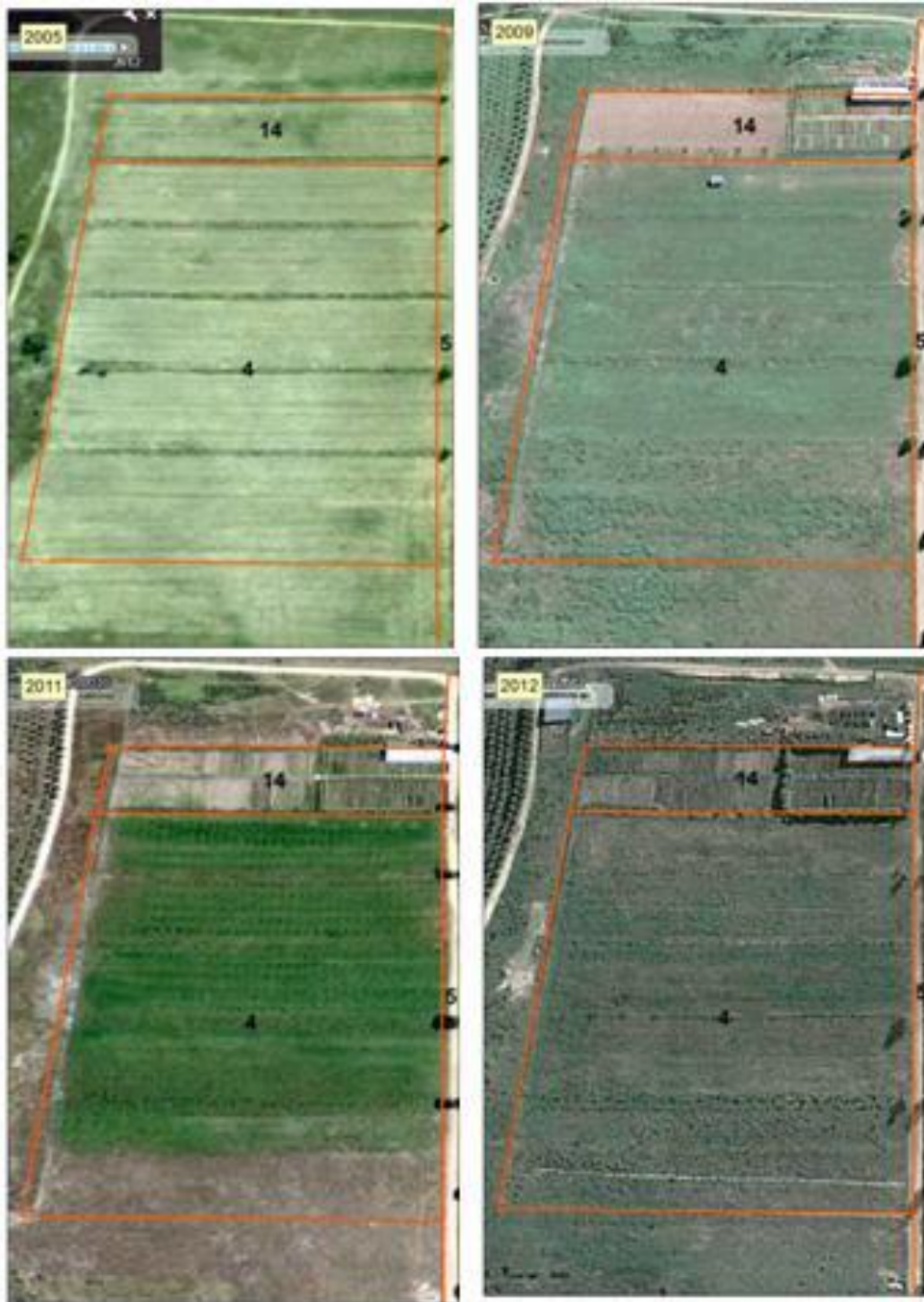
The calculations above have used assumed values for bulk density and %C content of SOM in the absence of experimentally derived values. The determination of soil bulk density and texture at all sites is recommended in future soil analyses in order to develop a more precise estimate of soil C sequestration.

The calculations relating to projected carbon sequestration over the project lifespan have assumed that sequestration rate will decrease gradually as SOM reaches an equilibrium state. The assumed maximum %SOM content has been estimated conservatively as the average of the 8 highest %SOM contents measured within the sampled area. This is based on the observation that soils within the project area are heterogeneous and are likely to vary in terms of maximum %SOM content. It is recommended to maintain a consistent soil sampling and analysis program to determine the optimum %SOM and C content of the soils in the project area.

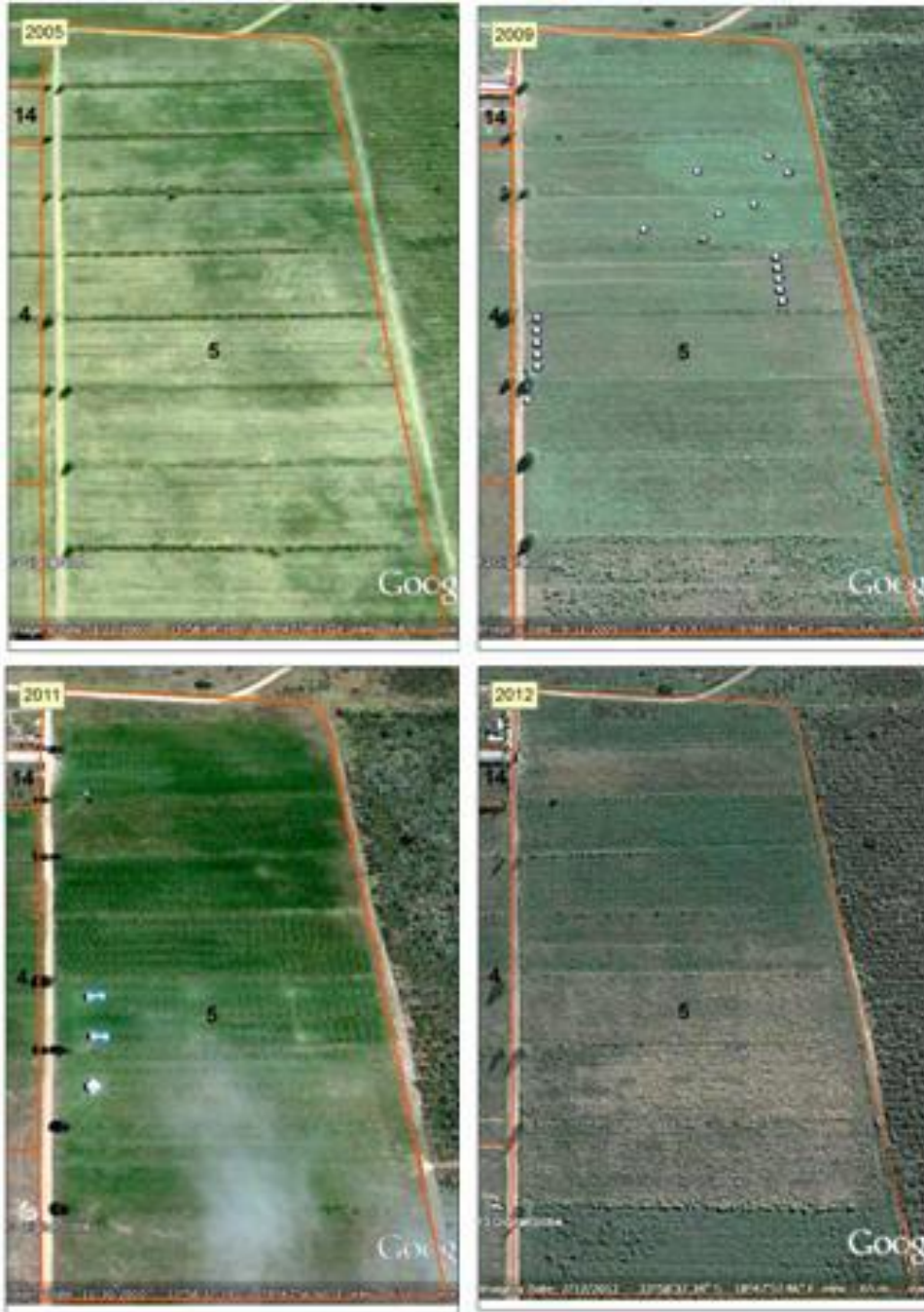
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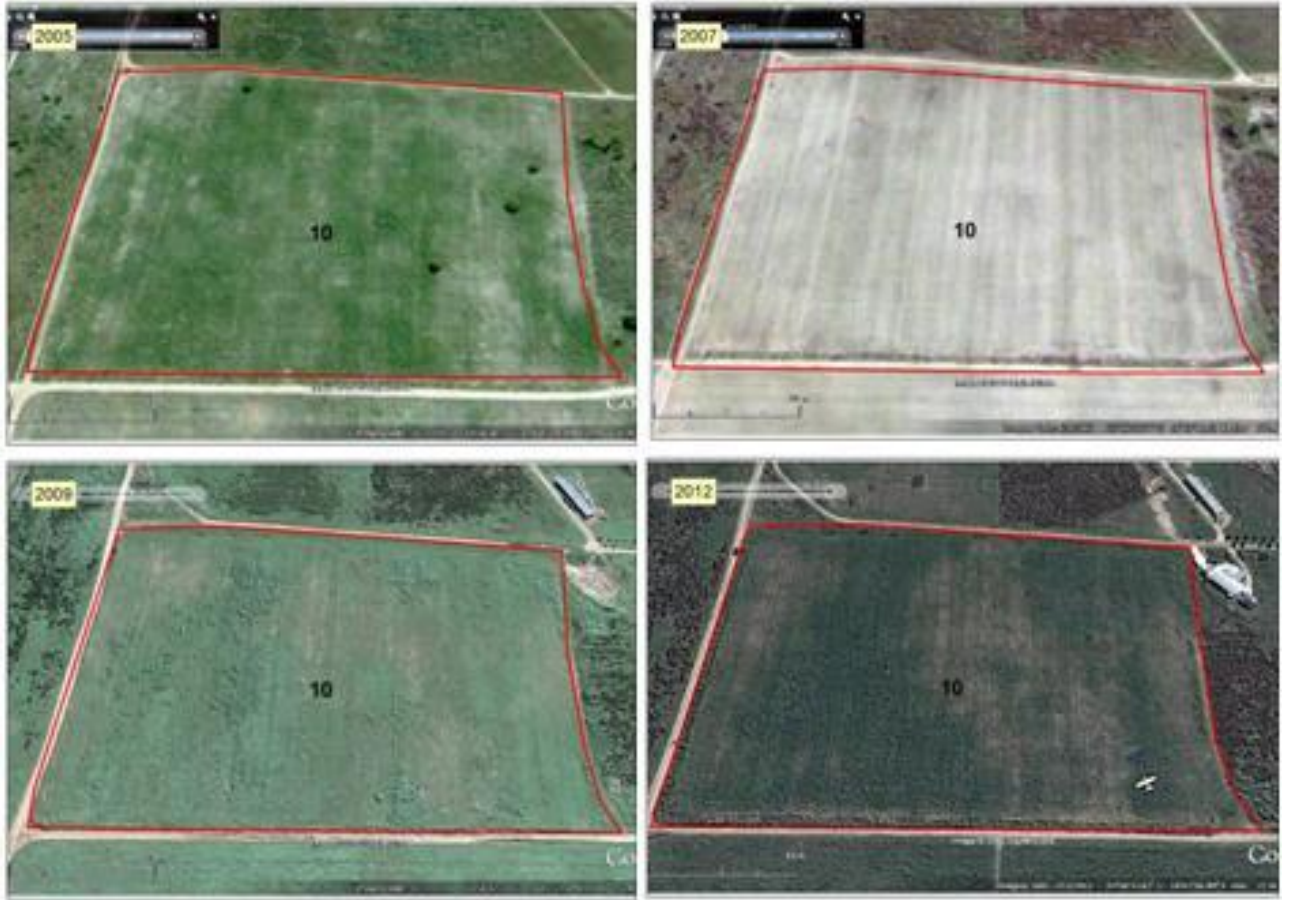
Annex I: Assessment of land use changes in the project area using time-scaled Google Earth imagery (2005 – 2012)
A.1: Field 4



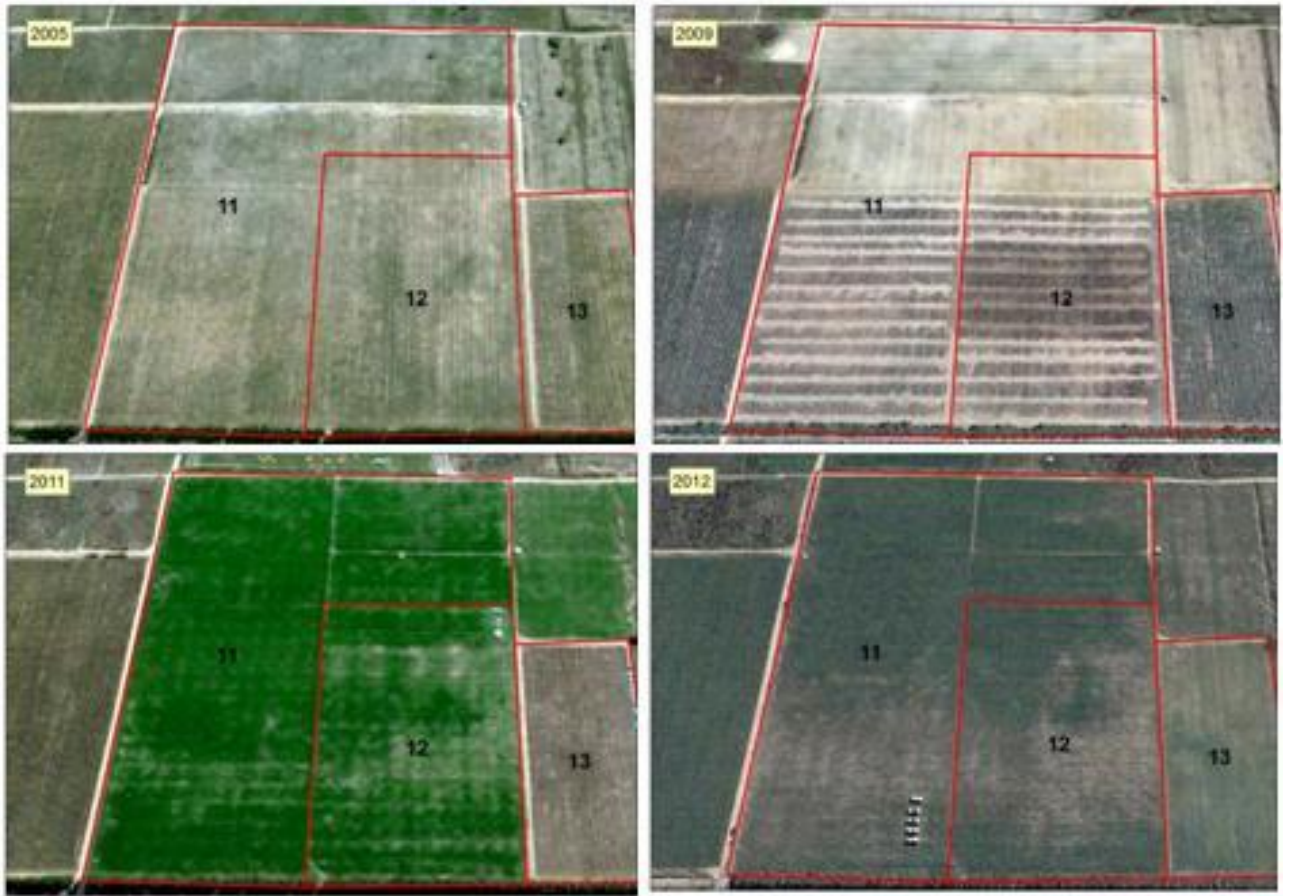
A.2: Field 5



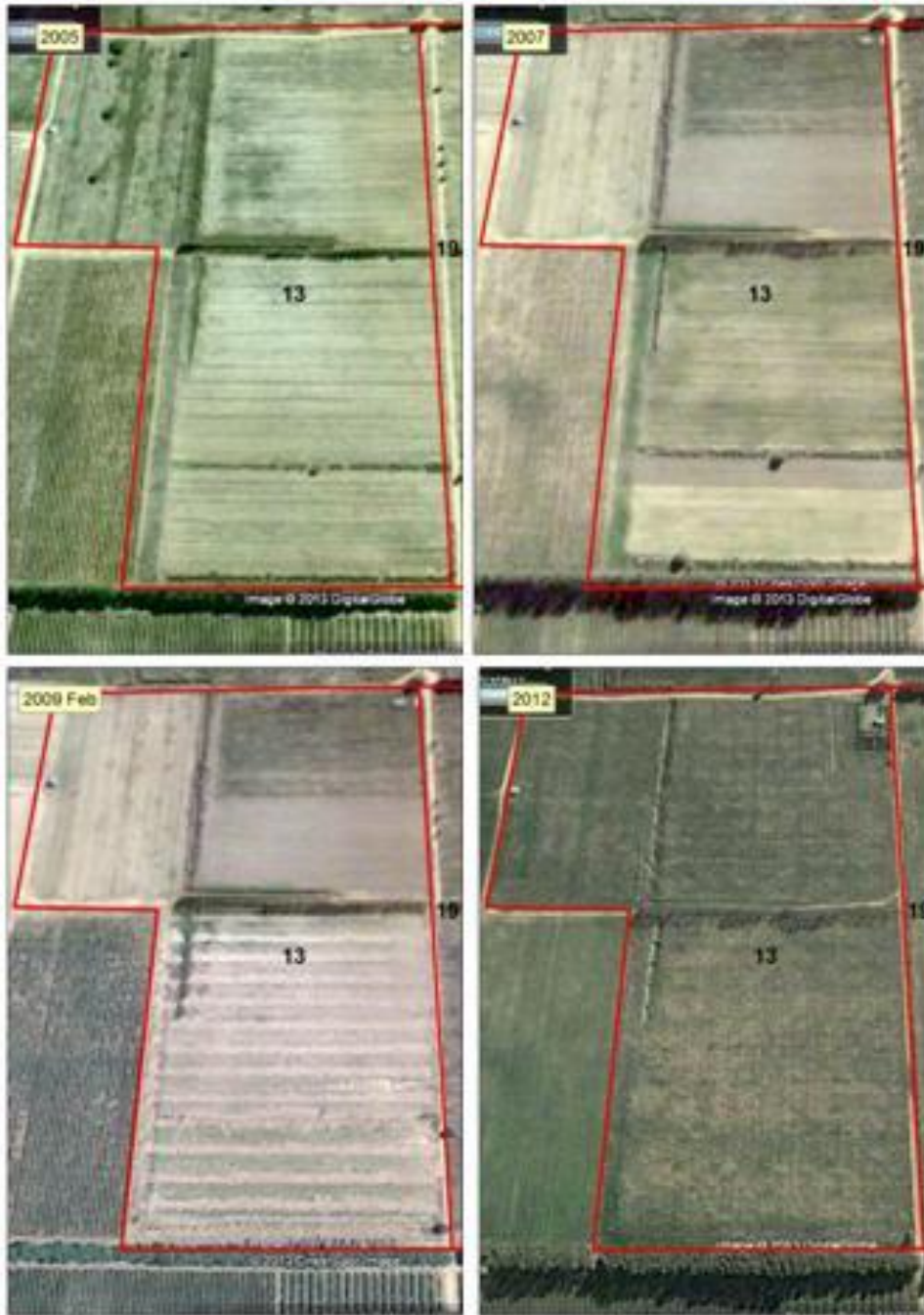
A.3: Field 10



A.4: Field 11 – 12



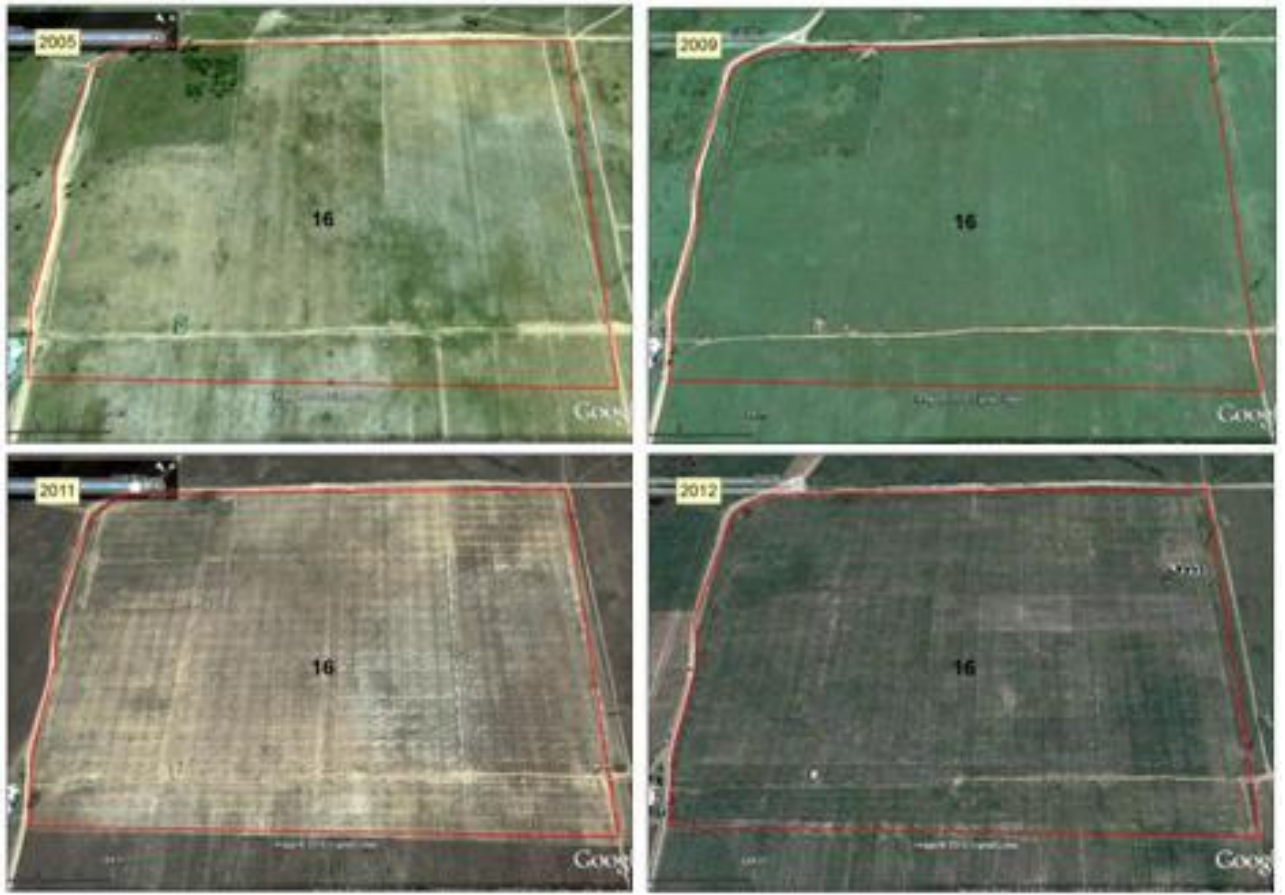
A.5: Field 13



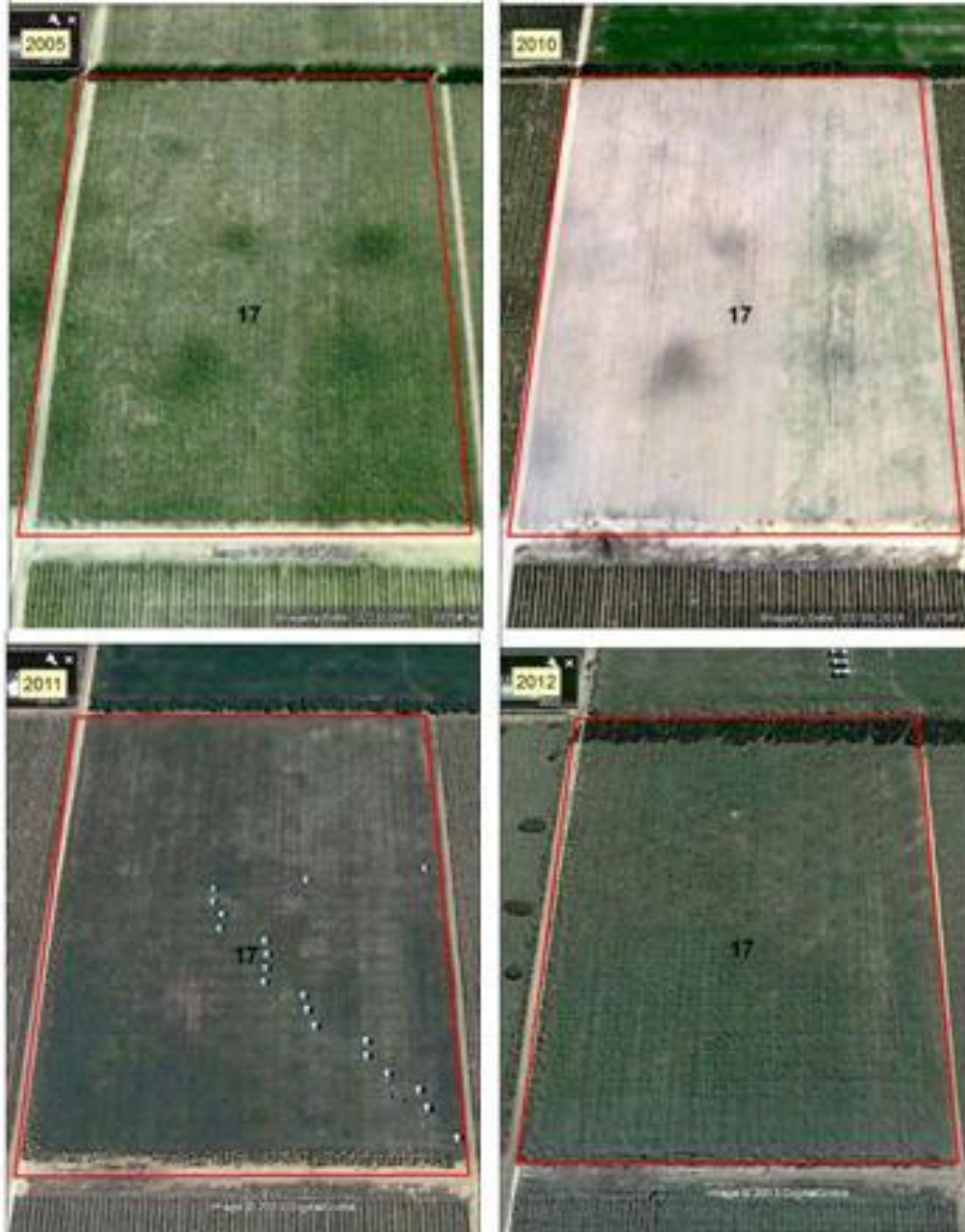
A.6: Field 15



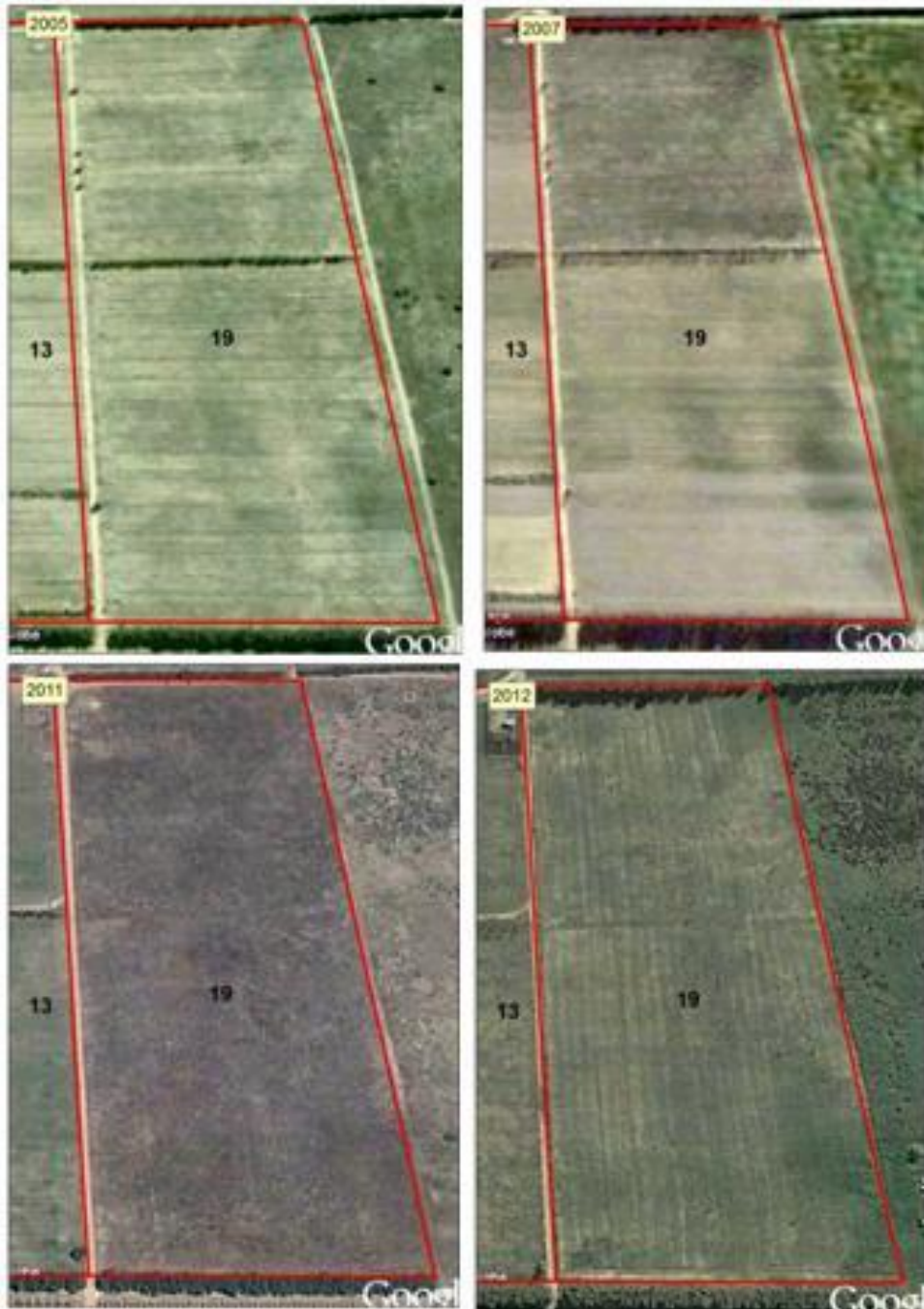
A.7: Field 16



A.8: Field 17



A.9: Field 19





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