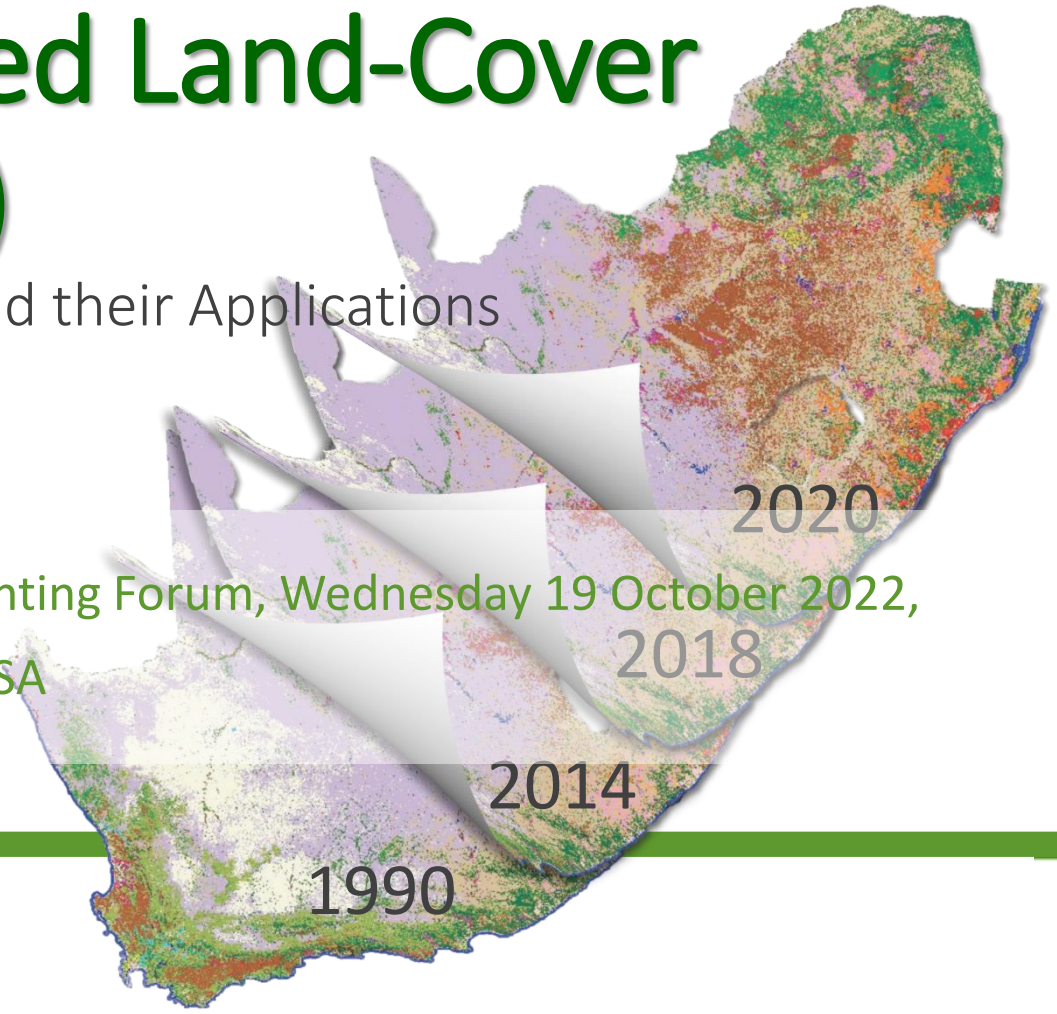
Computer Automated Land-Cover (CALC)

Land-Cover Change Products and their Applications



Presentation to National Natural Capital Accounting Forum, Wednesday 19 October 2022, STATS SA

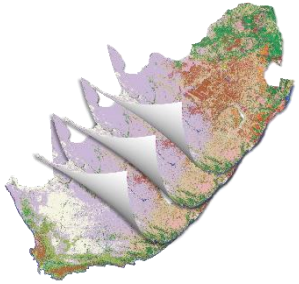
CHIEF DIRECTORATE: KNOWLEDGE AND INFORMATION MANAGEMENT

forestry, fisheries & the environment

Department:
Forestry, Fisheries and the Environment
REPUBLIC OF SOUTH AFRICA

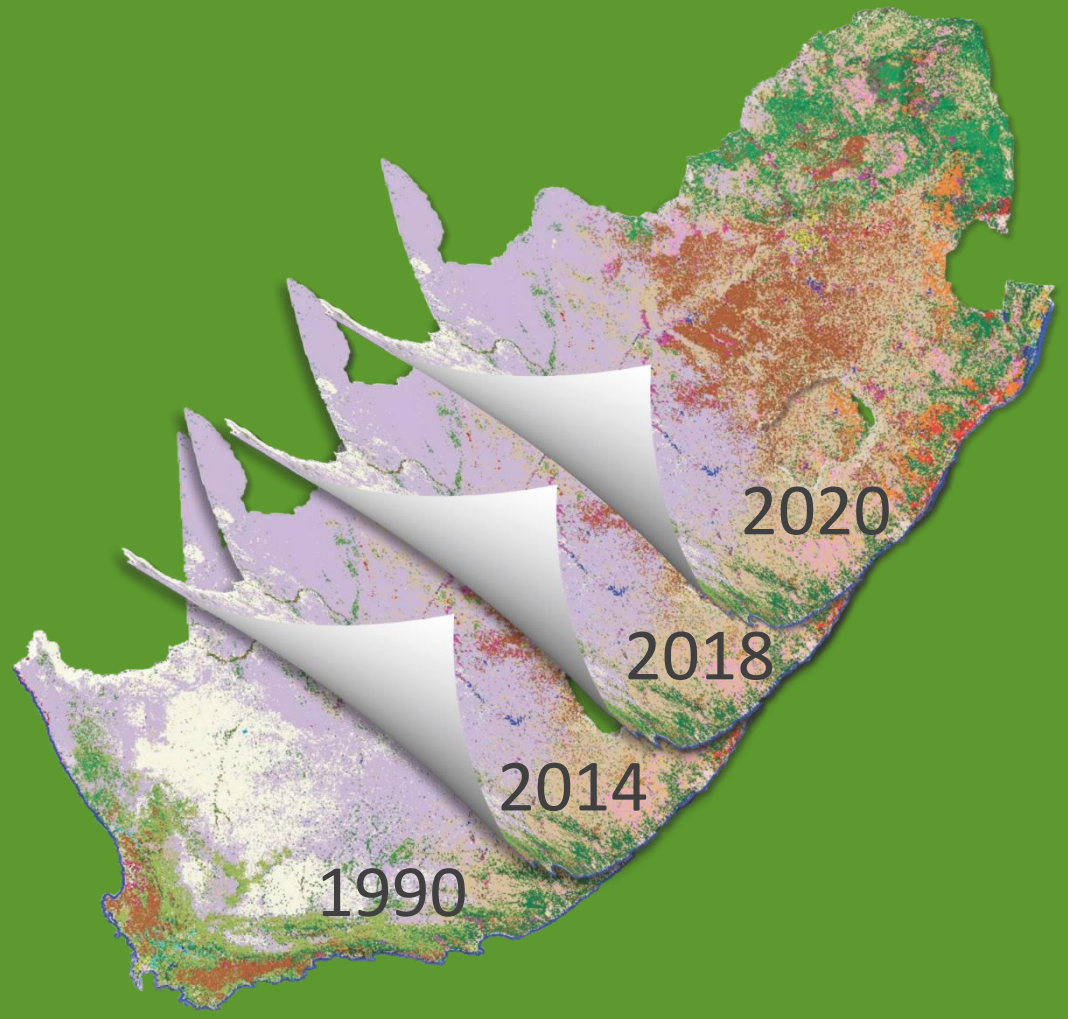
2030 NDP

Purpose



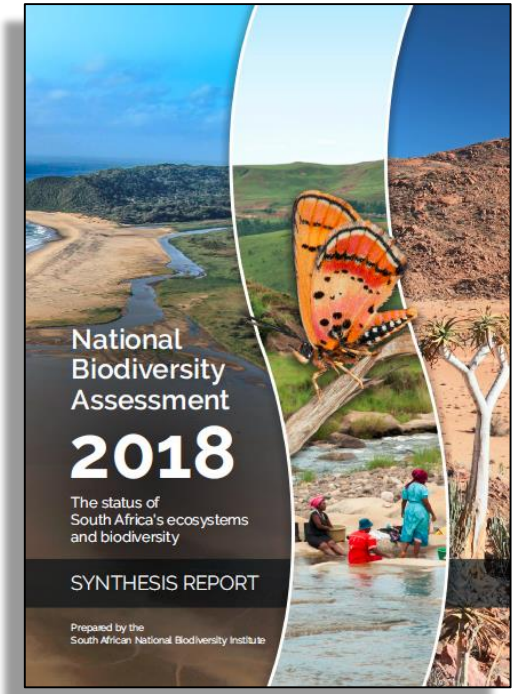
- To brief the National Natural Capital Accounting (NCA) forum on the Department's new Computer Automated Land-Cover (CALC) system and the landcover change derivatives
- To encourage discussion and debate on the use of biennial land-cover data updates for ecosystem accounts

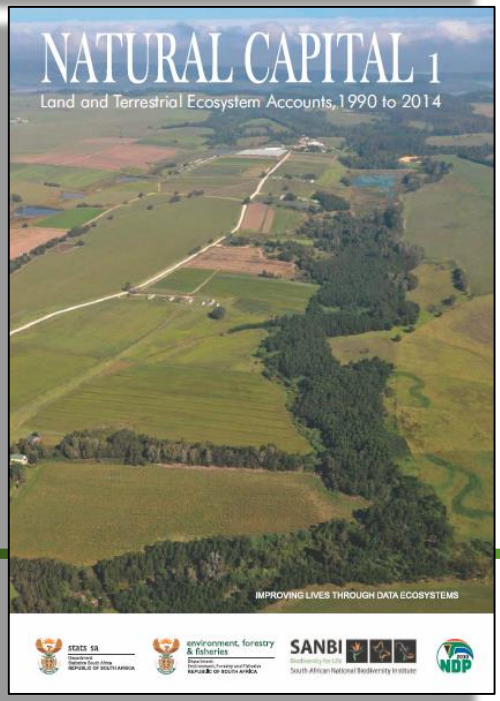
Background



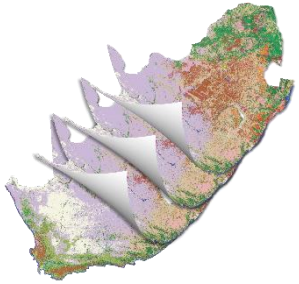
Introduction

- **Land-cover change** – the changes in the objects (infrastructure) and vegetation that covers South Africa's land over time – **provides the basic indicator of environmental change**.
- For this reason, land-cover datasets for specific periods provide the **foundational information for important reports** like the **National Biodiversity Assessment** required in terms of the Biodiversity Act and **Stats SA's Natural Capital Accounts**.
- Furthermore, land-cover provides an insight into **land-use and land-cover change**, e.g.
  - natural vegetation lost to agriculture, mining or urban sprawl,
- And provides an **insight into phenomena** like –
  - desertification, land degradation, plant invasions and the impacts of extreme weather events (e.g. droughts, floods, coastal storm surges).





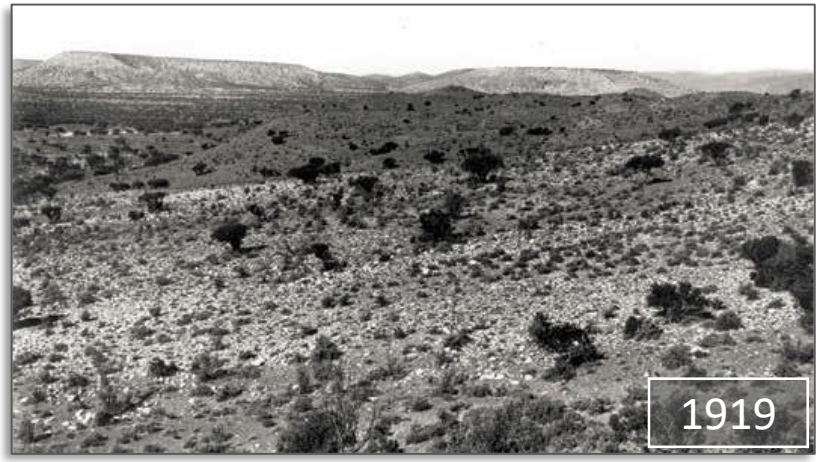
Introduction (Cont.)



Sometimes land-cover changes quickly and significantly

When protected from fire, trees tend to invade many fynbos areas such as the amphitheatre above Orange Kloof, Table Mountain where the increase in trees and tall woody plants is clearly evident.

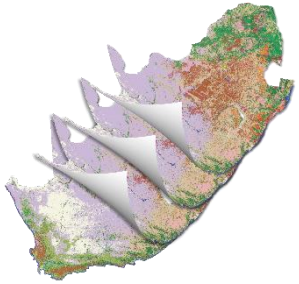
Sometimes things hardly change at all



Large parts of the Succulent Karoo have remained relatively stable over long time periods like this site south of the Touwsberg, near Ladismith. Most of the trees are still present and have grown taller, while the cover of the lower shrubs is largely unchanged.

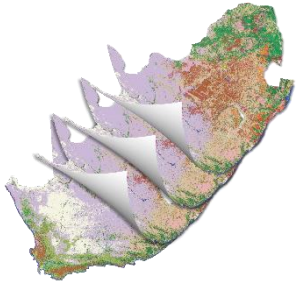
Extracted from: Nicola Stevens, William Bond, Timm Hoffman & Guy Midgley. (2015). *Change is in the air – Ecological trends and their drivers in South Africa*. Pretoria: South African Environmental Observation Network (SAEON)

Background



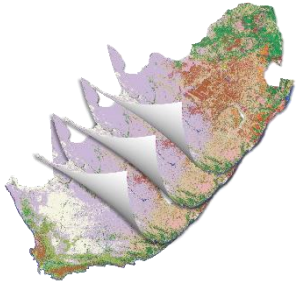
- Land-cover datasets are typically generated from **satellite images** of the earth – a highly **technical**, relatively **complex** and, historically, **expensive** undertaking.
- Hence, by 2018 South Africa had only generated two comprehensive national land-cover datasets – **1990 and 2014** – and both of these were generated by specialist contractors.
- Although the Department of Agriculture, Land Reform and Rural Development (DALRRD) is the coordinating custodian for land-cover data, the DFFE is a key contributing custodian of the National Land-Cover Dataset – hence there is a strong and vibrant partnership between the two departments.
- DFFE's 2014 update was broadly welcomed, especially the fact that it was **made freely available to anyone who wanted it**.

Background (Cont.)



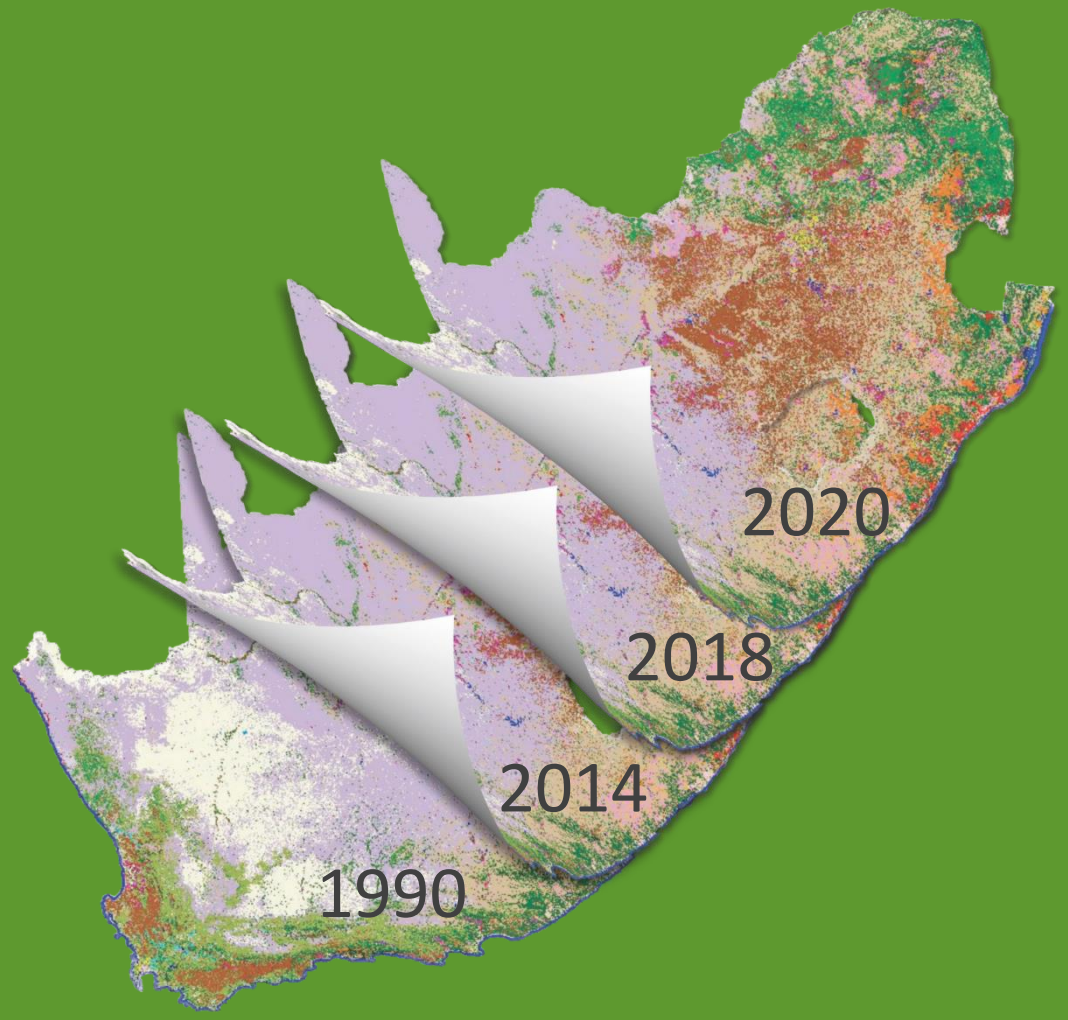
- At the end of 2018, the Department implemented the **National Land-Cover Update and Automation Project** aimed at **providing an update of the land-cover dataset** and **creating the necessary in-house systems and capacity** required to generate periodic national land-cover datasets and land-cover change reports.
- This project was successfully concluded in March 2021 having –
  - Designed, developed, tested and operationalised the bespoke **Computer Automated Land-Cover (CALC) system**;
  - Generated, launched and made freely available full national land-cover datasets for **2018 and 2020**;
  - Fully **institutionalised the CALC system** within the Department's Directorate: Sector Spatial Information Management (D: SSIM); and
  - Ensured that D: SSIM **staff are fully capacitated to operate the CALC system** efficiently and effectively

Expectations



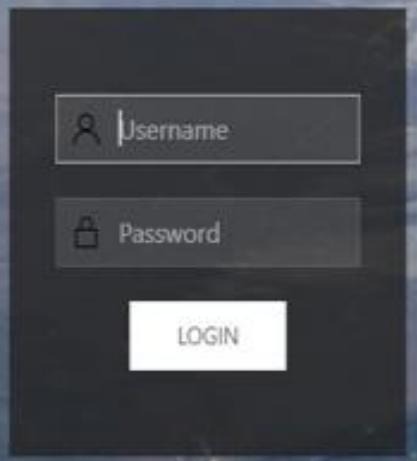
- With the CALC system fully operational within the Department, the following outputs are planned –
  - The generation and publication of a **new National Land-Cover Dataset every two years** along with detailed land-cover change data
  - The analysis, compilation, work-shopping and presentation of a biennial **Land-Cover Change Summary for Policy-makers every other year**

CALC SYSTEM



Computer Automated Land Cover (CALC)

A Land Cover Generation Tool for South Africa



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2020

rgb_2020_1 — 31 May 2021 — 31 May 2021 — COMPLETE

Land Cover Products (LC) — ADD NEW

2018

lc_2018_4 — 31 May 2021 — 31 May 2021 — COMPLETE

2020

lc_2020_3 — 31 May 2021 — 31 May 2021 — COMPLETE

Land Cover Accuracy (LCA) — ADD NEW

2020

acc_2020_3 — 31 May 2021 — COMPLETE

Land Cover Change (LCC) — ADD NEW

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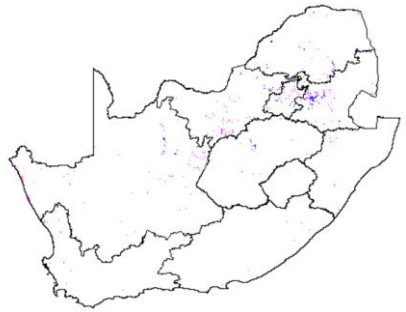
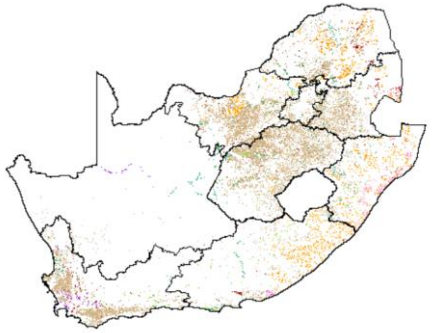
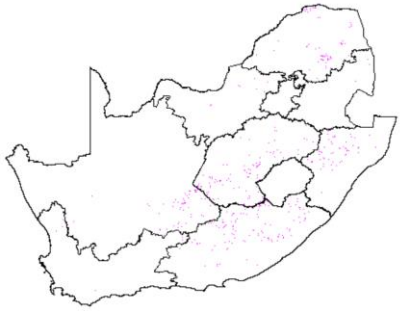
SENTINEL MOSAIC (RGB)



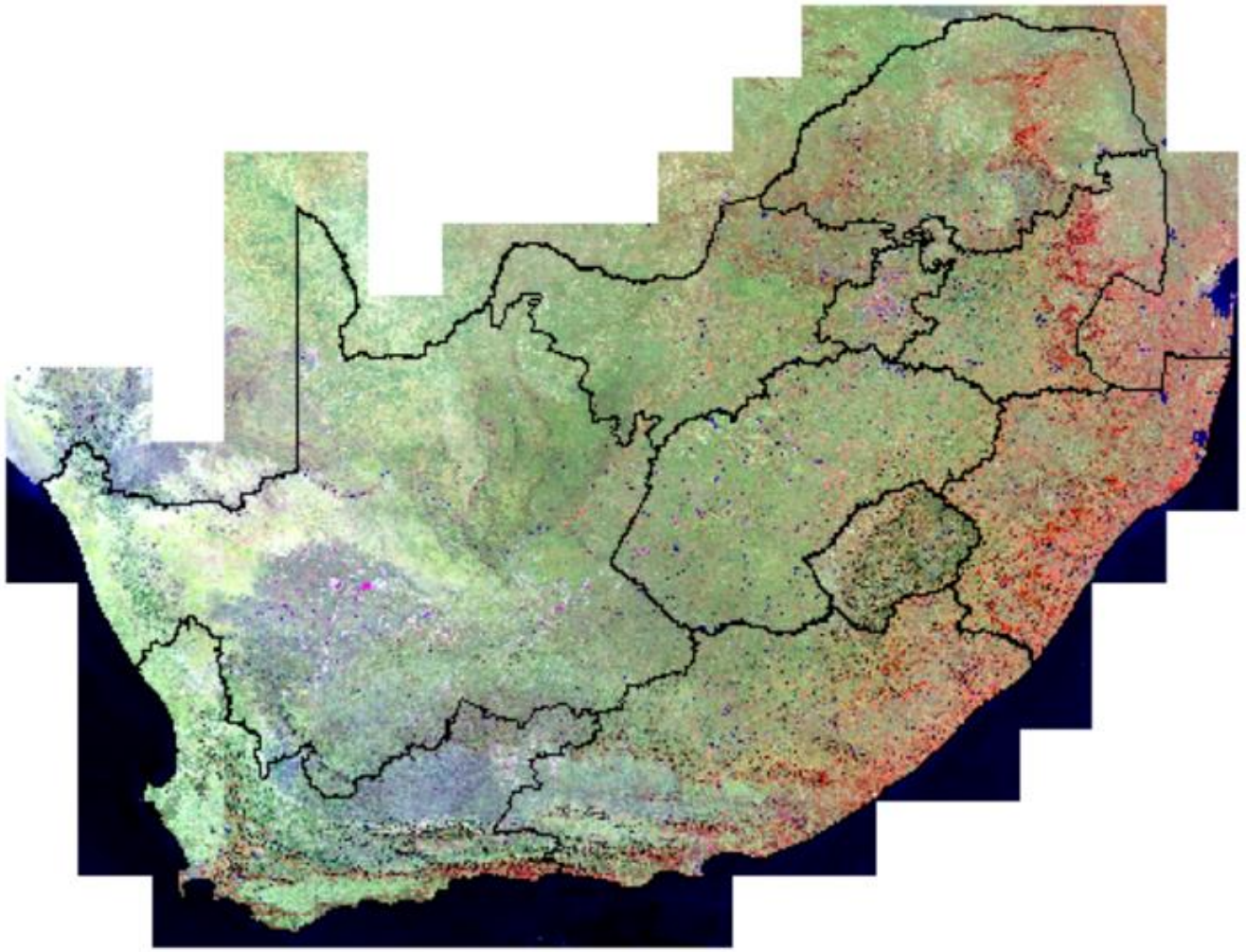
MINING MASK

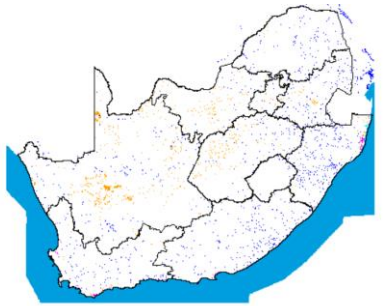


FIELD CROP BOUNDARY MASK

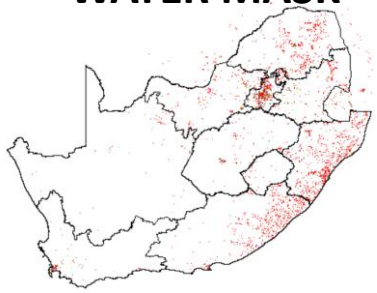


EROSION MASK

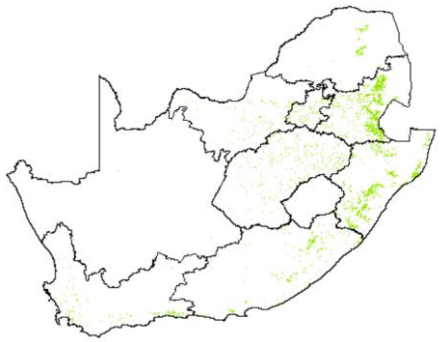




WATER MASK



URBAN MASK



PLANTATION MASK

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acc_2020_3 — 31 May 2021 — COMPLETE

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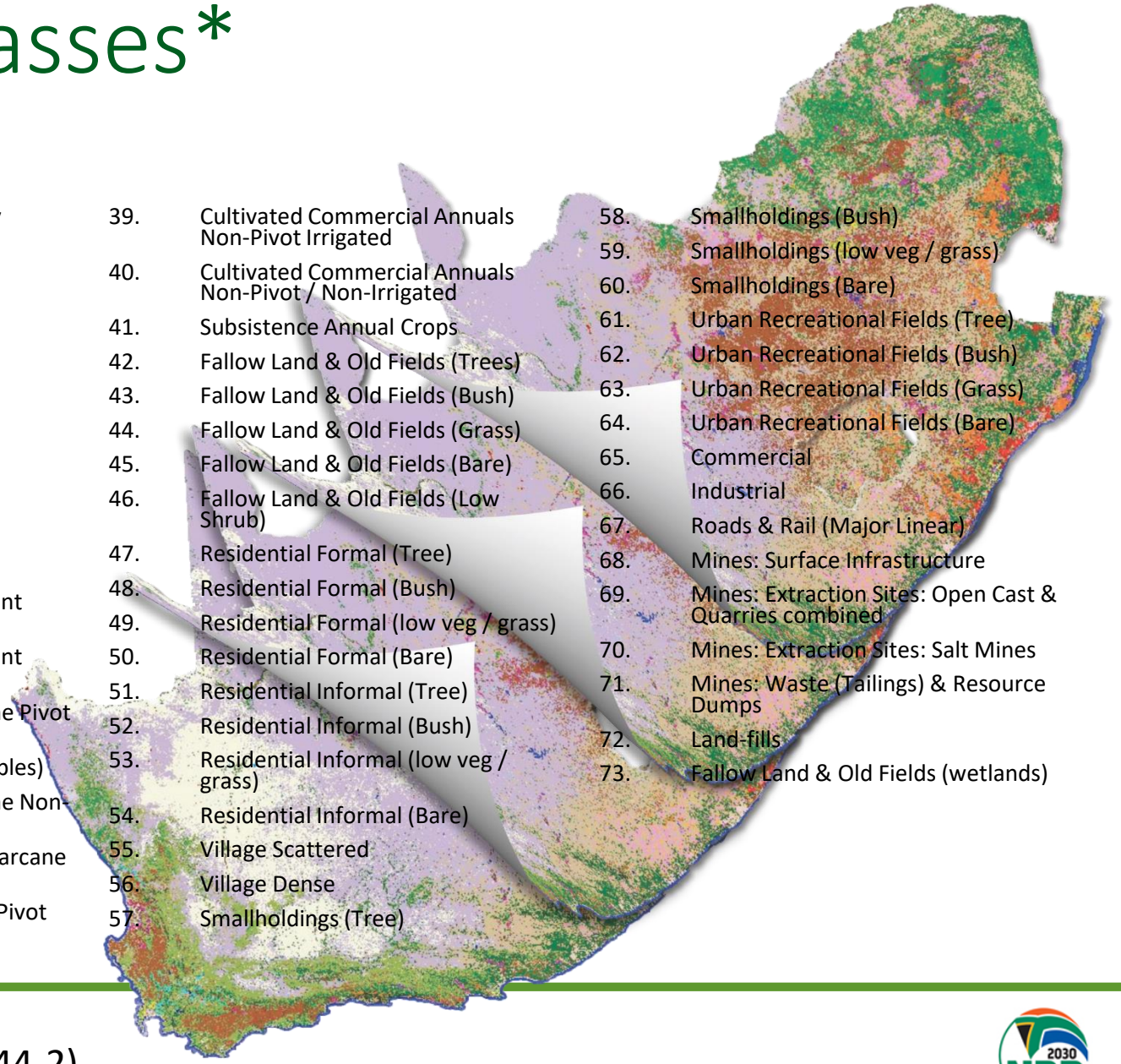
change_2018_2020_1

The 73 Land-Cover Classes*

1. Contiguous Forest (combined very high, high, medium)
2. Contiguous Low Forest & Thicket
3. Dense Forest & Woodland
4. Open Woodland
5. Contiguous & Dense Planted Forest
6. Open & Sparse Planted Forest
7. Temporary Unplanted Forest
8. Low Shrubland (other regions)
9. Low Shrubland (Fynbos)
10. Low Shrubland (Succulent Karoo)
11. Low Shrubland (Nama Karoo)
12. Sparsely Wooded Grassland
13. Natural Grassland
14. Natural Rivers
15. Natural Estuaries & Lagoons
16. Natural Ocean
17. Natural Lakes
18. Natural Pans (flooded)
19. Artificial Dams
20. Artificial Sewage Ponds
21. Artificial Flooded Mine Pits
22. Herbaceous Wetlands (currently mapped)
23. Herbaceous Wetlands (previous mapped extent)
24. Mangrove Wetlands
25. Natural Rock Surfaces
26. Dry Pans
27. Eroded Lands
28. Sand Dunes (terrestrial)
29. Coastal Dunes & Beach Sand
30. Bare Riverbed Material
31. Other Bare
32. Cultivated Commercial Permanent Orchards
33. Cultivated Commercial Permanent Vines
34. Cultivated Commercial Sugarcane Pivot Irrigated
35. Commercial Permanent (Pineapples)
36. Cultivated Commercial Sugarcane Non-Pivot (all other)
37. Cultivated Emerging Farmer Sugarcane Non-Pivot (all other)
38. Cultivated Commercial Annuals Pivot Irrigated
39. Cultivated Commercial Annuals Non-Pivot Irrigated
40. Cultivated Commercial Annuals Non-Pivot / Non-Irrigated
41. Subsistence Annual Crops
42. Fallow Land & Old Fields (Trees)
43. Fallow Land & Old Fields (Bush)
44. Fallow Land & Old Fields (Grass)
45. Fallow Land & Old Fields (Bare)
46. Fallow Land & Old Fields (Low Shrub)
47. Residential Formal (Tree)
48. Residential Formal (Bush)
49. Residential Formal (low veg / grass)
50. Residential Formal (Bare)
51. Residential Informal (Tree)
52. Residential Informal (Bush)
53. Residential Informal (low veg / grass)
54. Residential Informal (Bare)
55. Village Scattered
56. Village Dense
57. Smallholdings (Tree)
58. Smallholdings (Bush)
59. Smallholdings (low veg / grass)
60. Smallholdings (Bare)
61. Urban Recreational Fields (Tree)
62. Urban Recreational Fields (Bush)
63. Urban Recreational Fields (Grass)
64. Urban Recreational Fields (Bare)
65. Commercial
66. Industrial
67. Roads & Rail (Major Linear)
68. Mines: Surface Infrastructure
69. Mines: Extraction Sites: Open Cast & Quarries combined
70. Mines: Extraction Sites: Salt Mines
71. Mines: Waste (Tailings) & Resource Dumps
72. Land-fills
73. Fallow Land & Old Fields (wetlands)



*Gazetted land-cover classes (SANS 19144-2)

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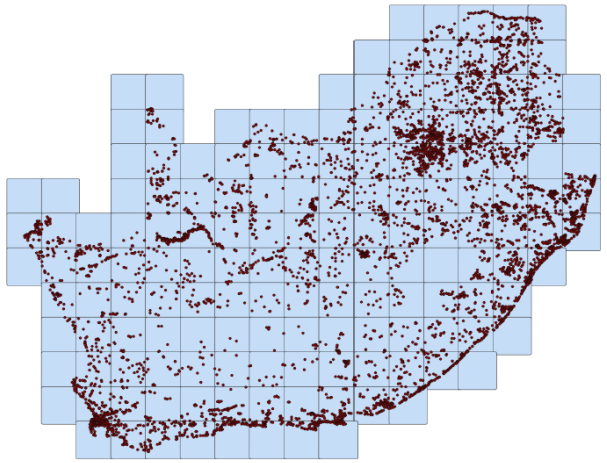
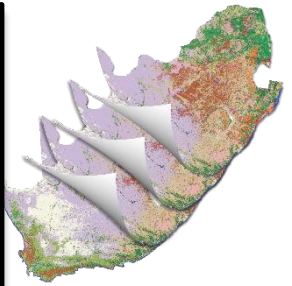


Figure 1: The spatial distribution of the 6835 sample points used to determine the SANLC 2020 map accuracy, against the 1×1 degree framework.

Overall Summary	SANLC 2020	
Overall Map Accuracy %	85.47	
Mean Class Accuracy %	84.66	
90% confidence limits	84.91	86.03
	low	*high*
Kappa Index	85.13	
Number of classes present	47	
Number of sample sites	6835	

Table 1: Map Accuracy Summary Statistics for SANLC 2020.

South African National Land-Cover 2020 Accuracy Assessment Report
(Public Release Report)



This is an automatically generated report from the Department of Environment, Forestry & Fisheries (DEFF) Computer Automated Land-Cover (CALC) System. Version v1.0.4, March 14, 2021

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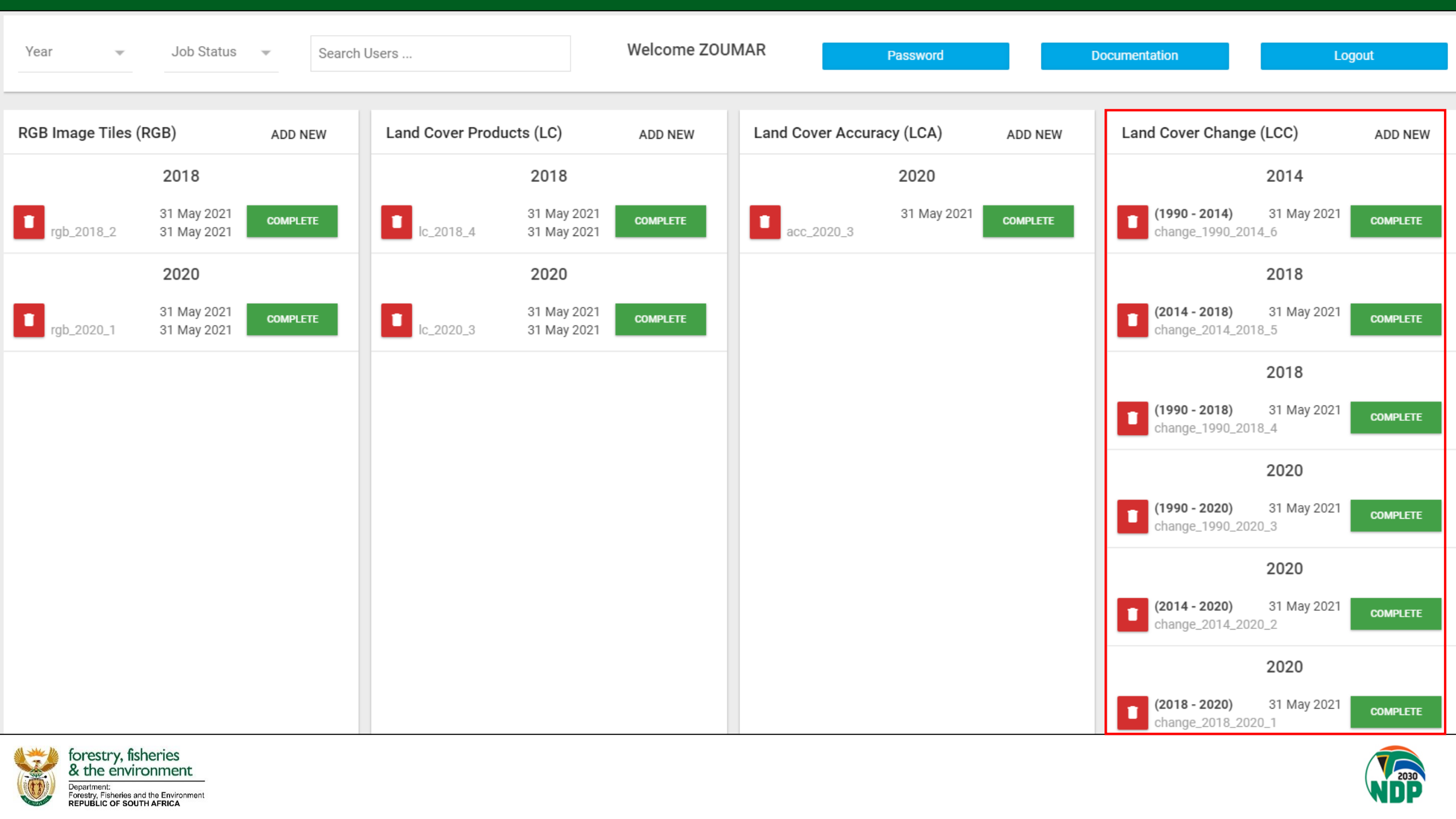
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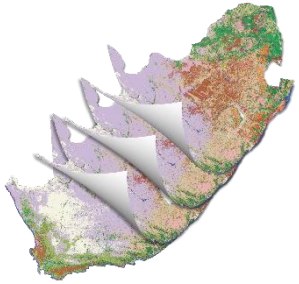
For Clarity and Simplicity 20 Aggregated Classes are used for change detection



1. Indigenous Forest (1)*
2. Thicket / dense Bush (2)
3. Natural Wooded Land (3,4,42,43)
4. Planted Forest (5,6,7)
5. Shrubland (8,9,10,11,46)
6. Grasslands (12,13,44)
7. Waterbodies (14-21)
8. Wetlands (22,23,24,73)
9. Barren Land (25,26,28,29,30,31,45)
10. Eroded Lands (27)
11. Cultivated Commercial Permanent Orchards (32,35)
12. Cultivated Commercial Permanent Vines (33)
13. Commercial Annuals Pivot Irrigated (34,38)
14. Commercial Annuals Non-Pivot (36,37,39,40)
15. Cultivated Subsistence (41)
16. Built-up Residential All (47-56,61-64)
17. Built-up Smallholdings (57-60)
18. Built-up Commercial (65)
19. Built-up Industrial (66)
20. Mines (68-72)

*Numbers in brackets reflect the number assigned to each of the 73 Gazetted land-cover classes (SANS 19144-2)

The National 1990/2020 Land-Cover Change Matrix

The 20 aggregated land-cover classes used in land-cover change analysis

The figures in the matrix represent hectares (ha) of a particular land-cover class in a given year

The row totals provide the total 2020 hectares of the row land-cover class

Area in hectares

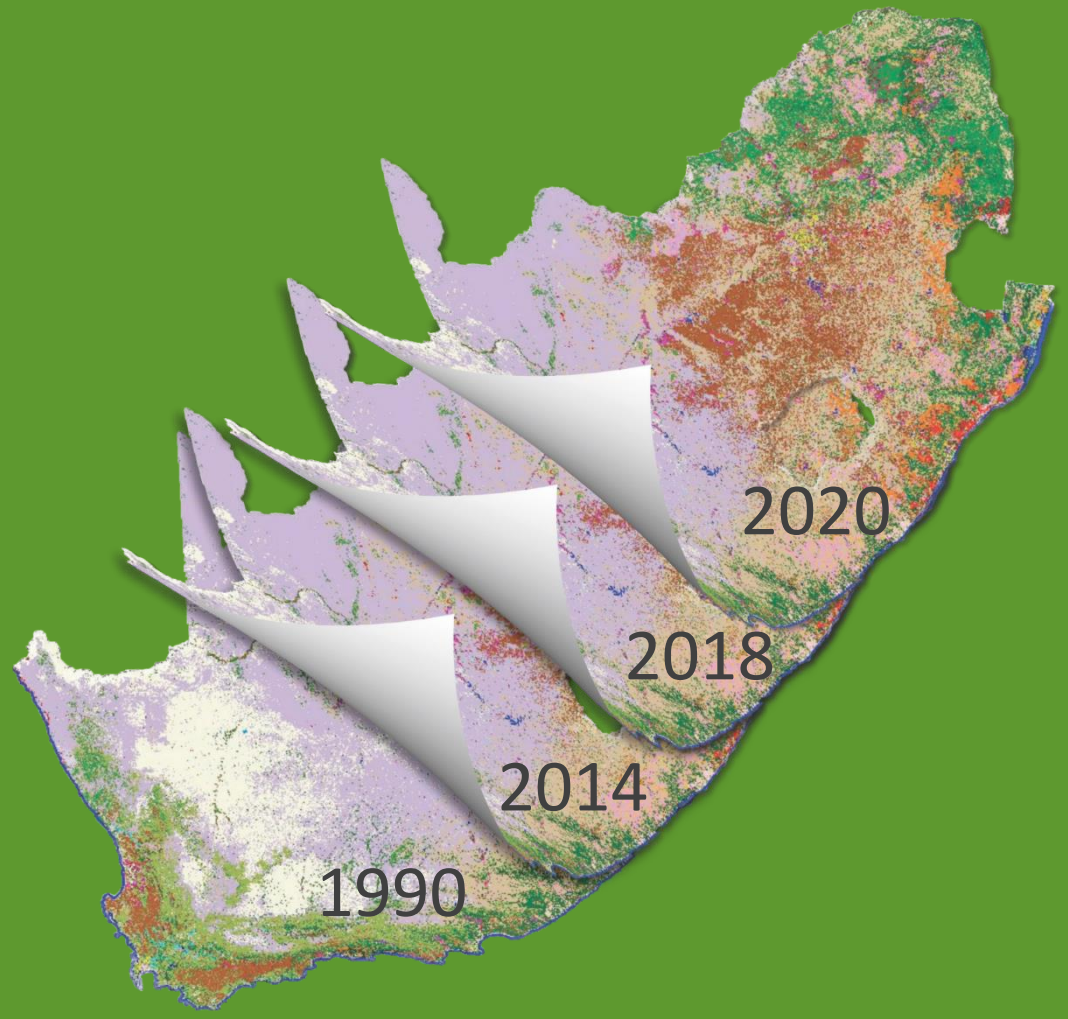
1990 National	Indigenous Forest (1)	Thicket / dense Bush (2)	Natural Wooded Land (3,4,42,43)	Planted Forest (5,6,7)	Shrubland (8,9,10,11,46)	Grasslands (12,13,44)	Waterbodies (14-21	(2 ...nds ...73)	Barren (25,26,28,29, 5)	Eroded Lands (27)	Cultivated Commercial Permanent Orchards (32,35)	Cultivated Commercial Permanent Vines (33)	Commercial Annuals Pivot Irrigated (34,38)	Commercial Annuals Non-Pivot (36,37,39,40)	Cultivated Subsistence (41)	Built-up Residential All (47-56,61-64)	Built-up Smallholdings (57-60)	Built-up Commercial (65)	Built-up Industrial (66)	Mines (68-72)	
2020 National	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	**Total 2020 Areas**
Indigenous Forest (1)	1	320995	1938	12878	43615	9168	27426	639	9263	1005	0	108	0	0	1110	217	4151	235	63	33	28	**432870**
Thicket / dense Bush (2)	2	77011	717614	76761	61723	75178	172673	3882	32050	3209	26	3486	430	282	12964	5835	11845	868	375	424	112	**1256748**
Natural Wooded Land (3,4,42,43)	3	35953	3359080	6941931	65528	2247786	4700107	24206	176903	52834	25584	22723	3933	10106	388618	250645	65232	6560	3818	3300	18491	**18403339**
Planted Forest (5,6,7)	4	3088	45707	49218	1470628	22180	396790	1628	22625	651	110	1946	302	151	39287	1611	6458	1459	61	123	2617	**2066640**
Shrubland (8,9,10,11,46)	5	1047	364993	920259	27265	24006745	1357161	31435	85701	4577212	134471	9449	9932	2480	185128	961	2857	397	202	436	19217	**31737345**
Grasslands (12,13,44)	6	18379	1530541	2252783	140478	11273439	18773041	55012	481293	174598	94518	10458	1580	8601	836610	132054	63061	4414	6373	9192	91589	**35958011**
Waterbodies (14-21)	7	233	21576	18697	2123	20759	48445	1940924	31221	35052	759	232	131	83	6238	1220	1037	322	38	82	4534	**2133706**
Wetlands (22,23,24,73)	8	822	63843	34771	17197	32024	274920	21719	562127	4460	1698	674	329	341	29298	1943	4462	982	153	274	2230	**1054268**
Barren Land (25,26,28,29,30,31,45)	9	993	118274	267187	4135	2841472	518027	105693	29614	8624180	9623	1175	700	262	17715	10228	3400	224	204	451	4740	**12558296**
Eroded Lands (27)	10	42	5759	14067	184	114358	117508	396	4063	5395	169203	11	3	26	967	2644	743	2	2	1	699	**436072**
Cultivated Commercial Permanent Orchards (32,35)	11	496	21989	11597	7804	12521	9572	294	2419	400	11	189018	10562	6684	43355	684	545	933	4	33	13	**318935**
Cultivated Commercial Permanent Vines (33)	12	0	2847	1119	323	11167	1359	115	1804	3738	0	1153	114504	775	5001	1	118	492	7	24	3	**144552**
Commercial Annuals Pivot Irrigated (34,38)	13	19	10719	40137	875	80409	89566	172	7456	2027	336	4813	908	184009	477208	1784	89	616	1	5	145	**901295**
Commercial Annuals Non-Pivot (36,37,39,40)	14	1249	76898	94278	21824	259593	612350	3329	45683	3095	580	57658	15762	24588	9314940	32572	4770	14430	32	138	1204	**10584973**
Cultivated Subsistence (41)	15	2245	34089	66361	3403	62703	136747	939	15473	295	4754	4248	0	980	21527	1511336	22555	2292	7	3	376	**1890334**
Built-up Residential All (47-56,61-64)	16	5	92577	118505	32772	106890	364758	940	9929	7663	3119	1930	1019	596	33036	25839	2151734	17258	3949	981	1620	**2976730**
Built-up Smallholdings (57-60)	17	6	1810	9364	9456	2748	12823	119	327	32	153	68	72	5	9554	256	3161	191593	67	133	60	**241805**
Built-up Commercial (65)	1	7	2629	1565	748	3664	6329	73	332	300	10	66	94	23	967	88	3	1277	28456	1377	129	**80666**
Built-up Industrial (66)	1	5	3983	3190	794	10839	11542	957	540	3535	47	2249	231	765	6697	104	93	1103	554	39218	1377	**97044**
Mines (68-72)	2	3	10120	14908	4355	25988	46421	4001	1773	10153	648	34	39	452	33529	2107	344	239	241	2198	128053	**289222**
Total 1990 Areas			6486986	10949573	1915227	41219629	27677564	2196473	1520598	13509835	445652	311501	160532	241208	11463749	1982130	2391470		44607	58425	277237	

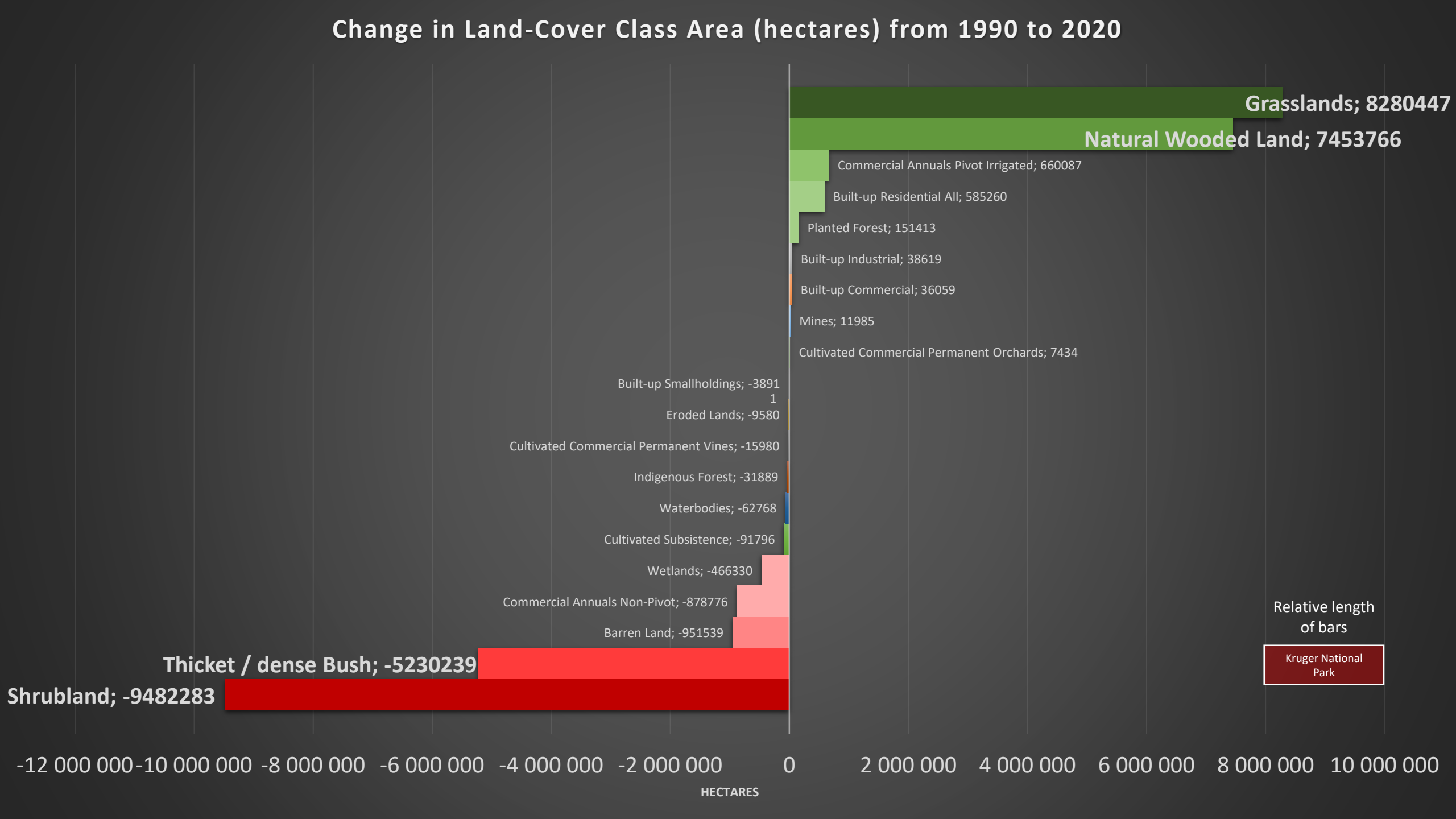
The individual numbers provide the hectares of the 1990 land class that were converted to the corresponding 2020 class. In this example, 2245 ha of Indigenous Forest was converted to Cultivated Subsistence from 1990 to 2020

The column totals provide the total 1990 hectares of the column land-cover class

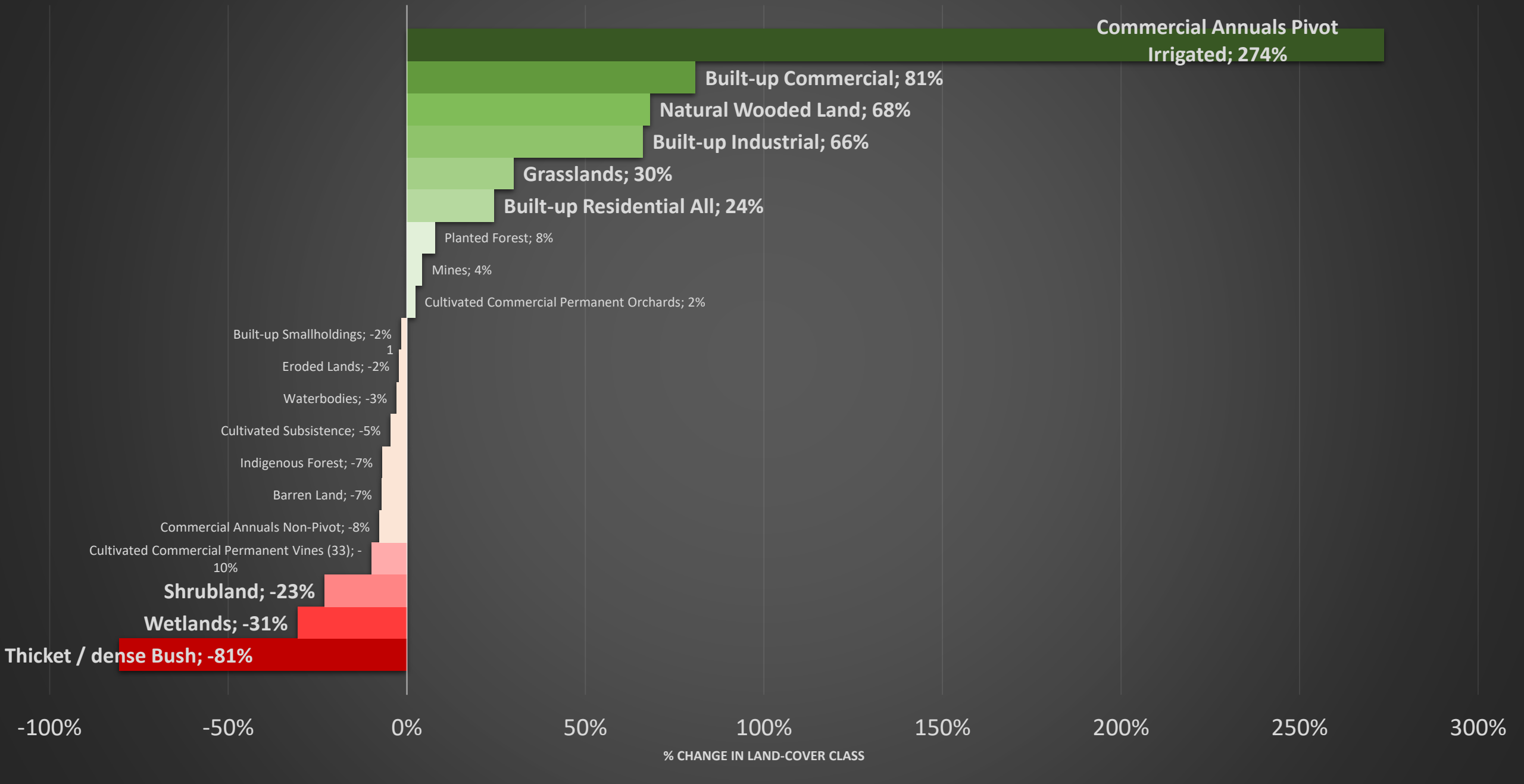
The 1990/2020 class intercept provides the 'unchanged' hectares of that land-cover class

Overall Land Cover Change

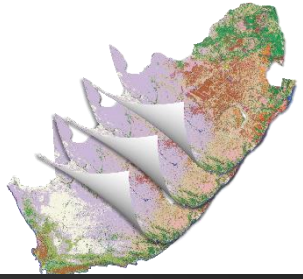


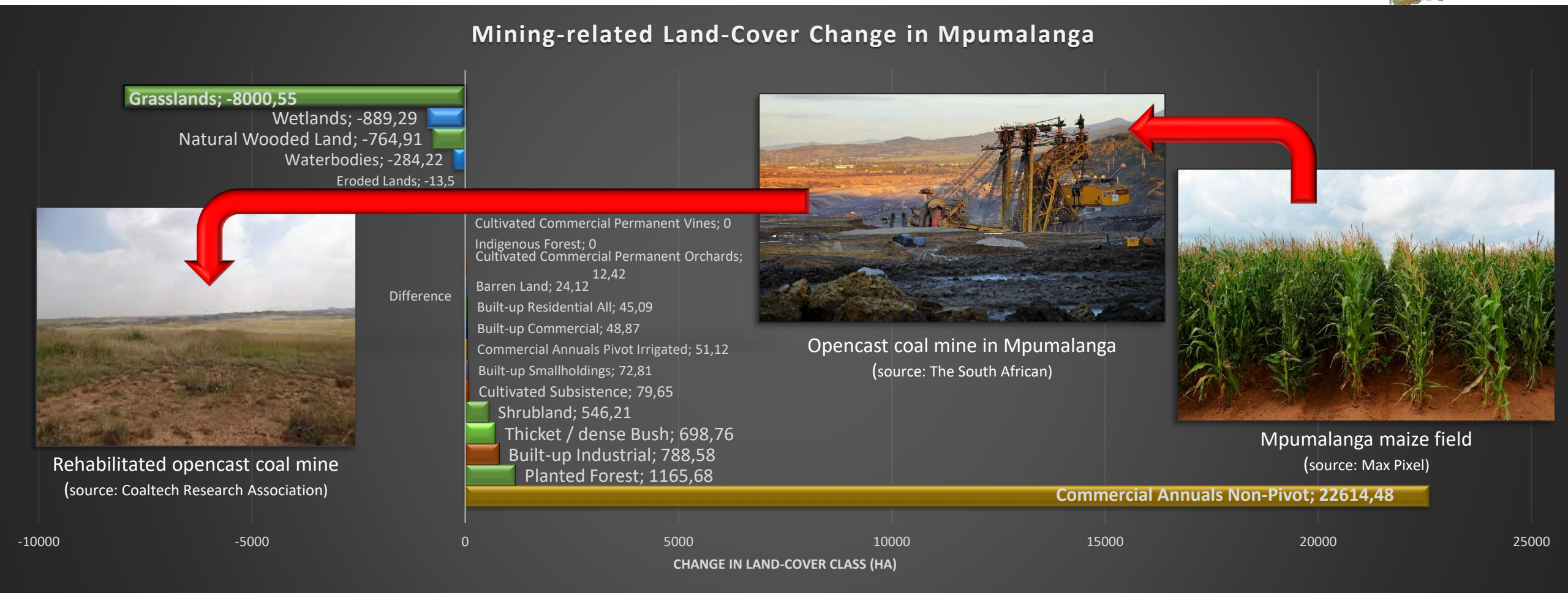

Change in Land-Cover Class Area (hectares) from 1990 to 2020
Grasslands; 8280447
Natural Wooded Land; 7453766
Commercial Annuals Pivot Irrigated; 660087
Built-up Residential All; 585260
Planted Forest; 151413
Built-up Industrial; 38619
Built-up Commercial; 36059
Mines; 11985
Cultivated Commercial Permanent Orchards; 7434
Built-up Smallholdings; -38911
Eroded Lands; -9580
Cultivated Commercial Permanent Vines; -15980
Indigenous Forest; -31889
Waterbodies; -62768
Cultivated Subsistence; -91796
Wetlands; -466330
Commercial Annuals Non-Pivot; -878776
Barren Land; -951539
Thicket / dense Bush; -5230239
Shrubland; -9482283
Relative length of bars
Kruger National Park
-12 000 000
-10 000 000
-8 000 000
-6 000 000
-4 000 000
-2 000 000
0
2 000 000
4 000 000
6 000 000
8 000 000
10 000 000
HECTARES

Percent Change in Land-Cover Class from 1990 to 2020



Mining: Converting cropland to grassland in Mpumalanga



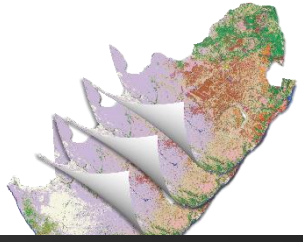


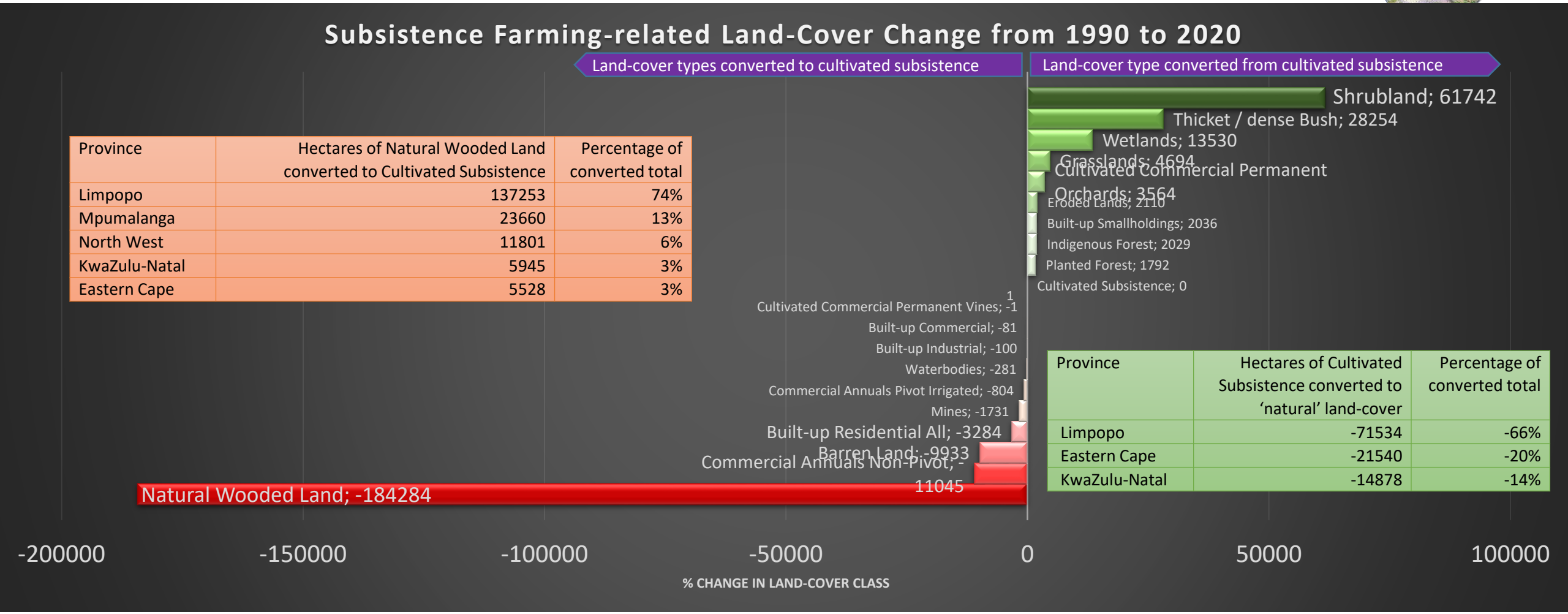
Rehabilitated opencast coal mine
(source: Coaltech Research Association)

Opencast coal mine in Mpumalanga
(source: The South African)

Mpumalanga maize field
(source: Max Pixel)

Subsistence farming / Natural land cycling

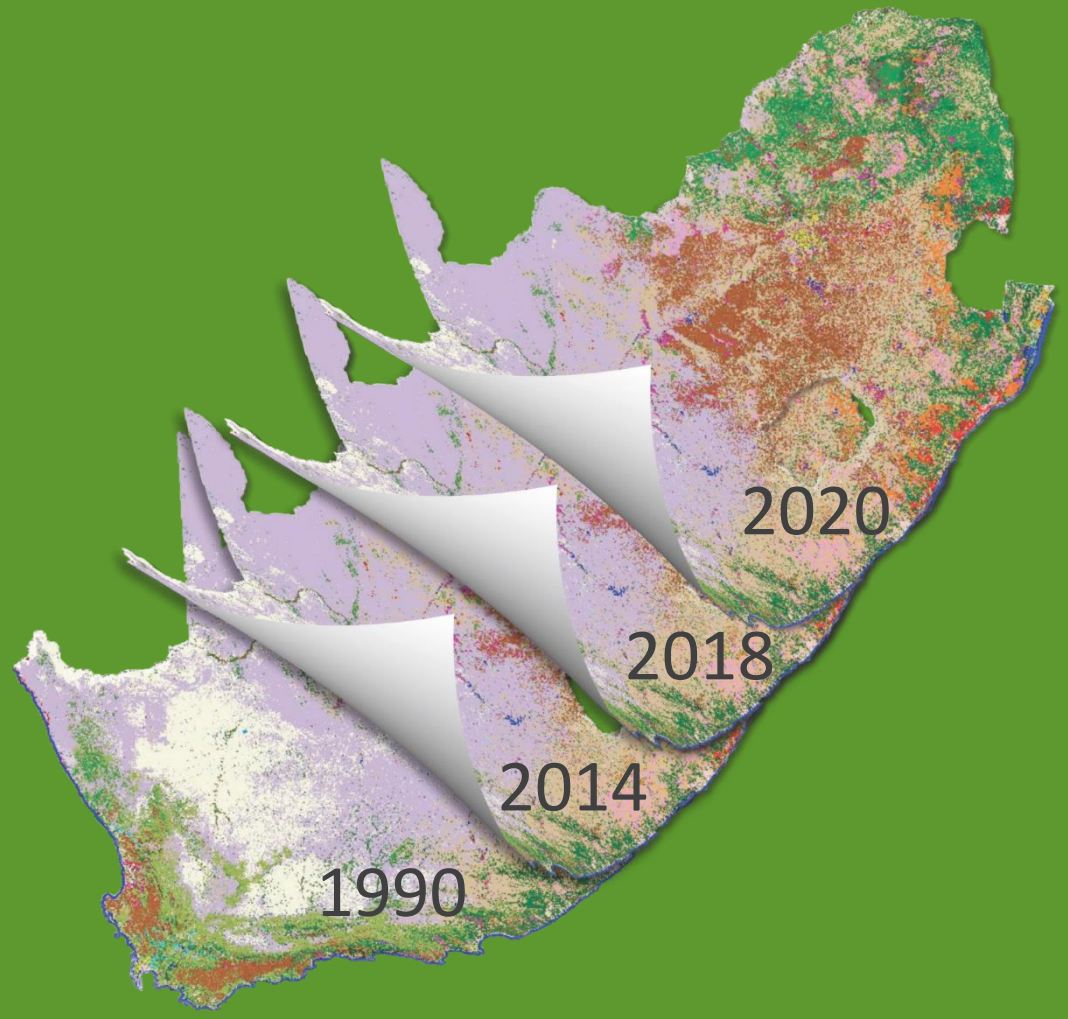




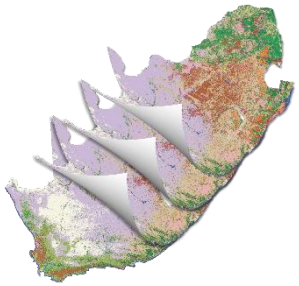
Province	Hectares of Natural Wooded Land converted to Cultivated Subsistence	Percentage of converted total
Limpopo	137253	74%
Mpumalanga	23660	13%
North West	11801	6%
KwaZulu-Natal	5945	3%
Eastern Cape	5528	3%

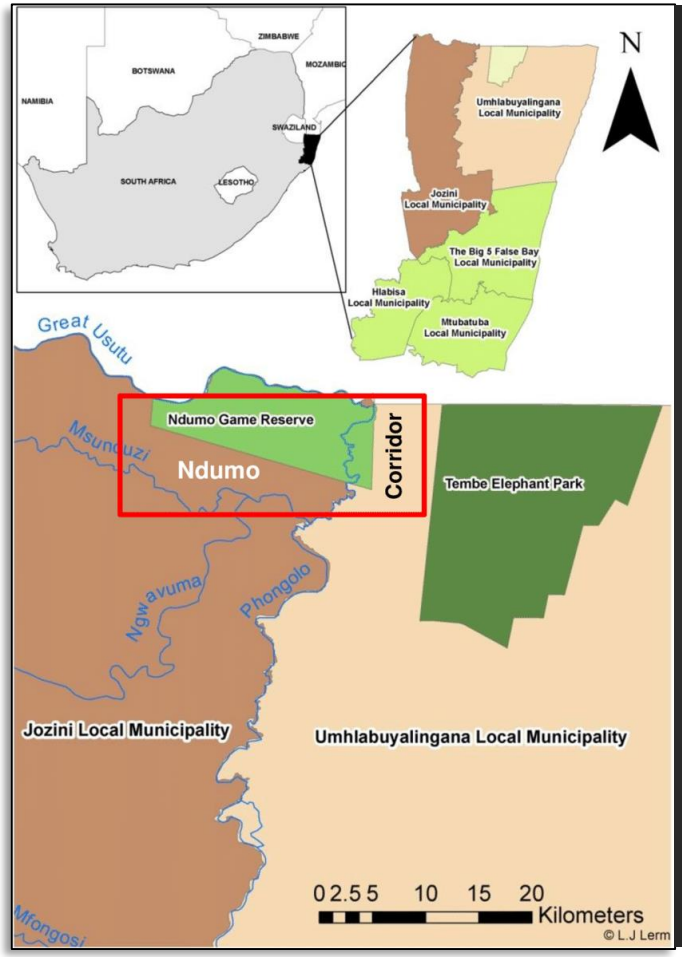
Province	Hectares of Cultivated Subsistence converted to 'natural' land-cover	Percentage of converted total
Limpopo	-71534	-66%
Eastern Cape	-21540	-20%
KwaZulu-Natal	-14878	-14%

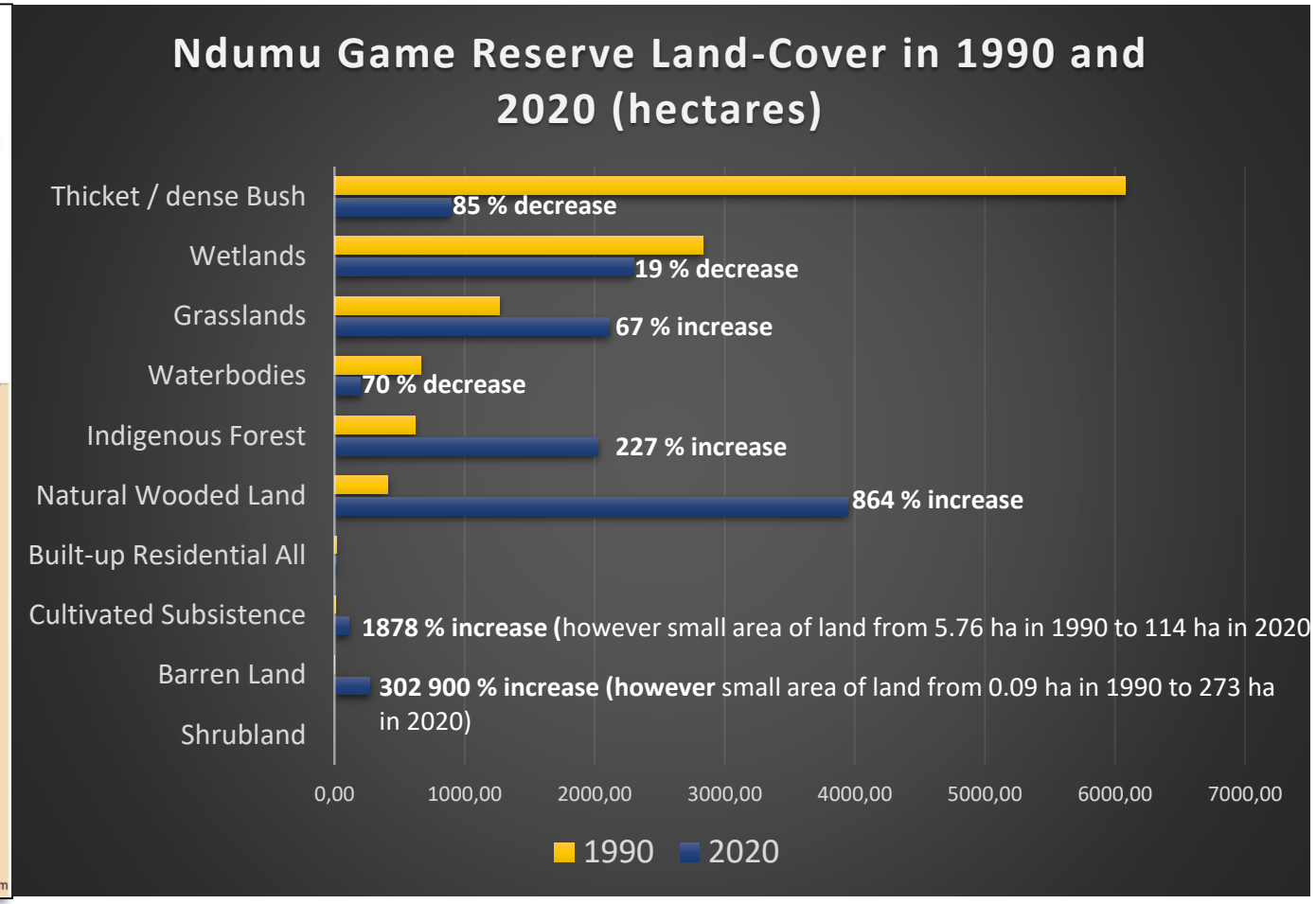
Applications



Ndumu Game Reserve – Radical change (with some somewhat disturbing)







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Disclaimer: This is a very early analysis which the Sector Spatial Information Management team would like to discuss with Ezemvelo KZN Wildlife before these findings are more broadly disseminated

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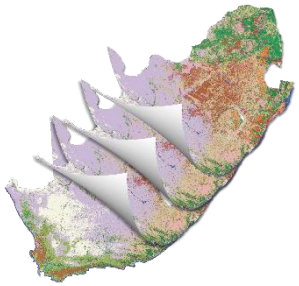
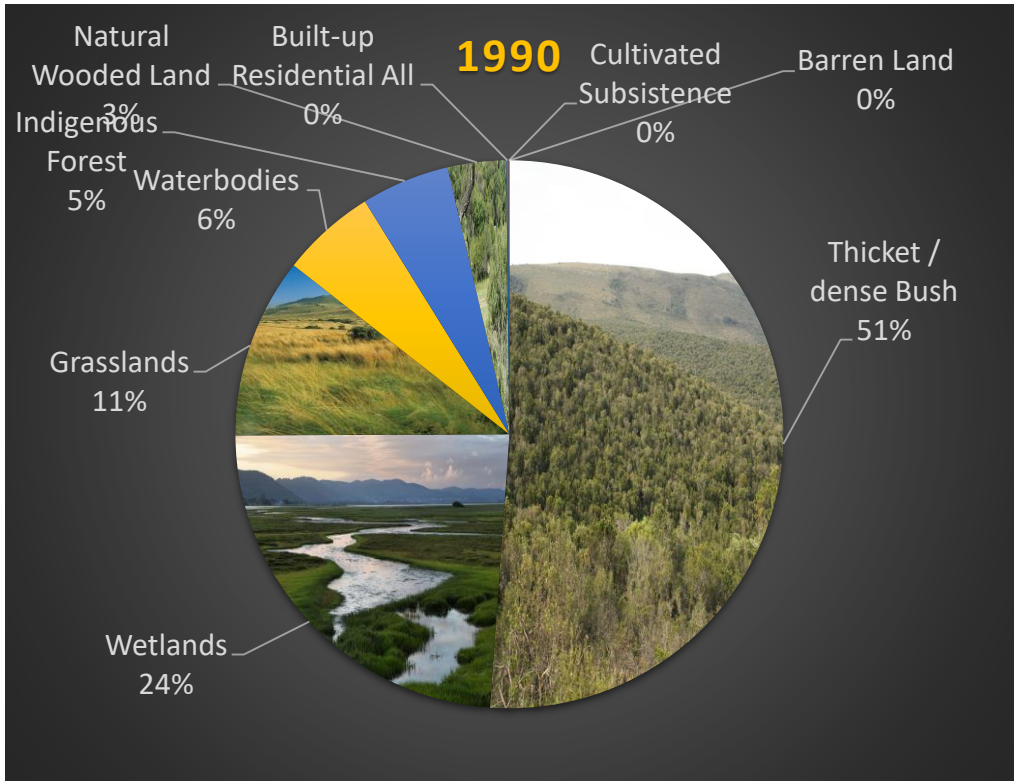
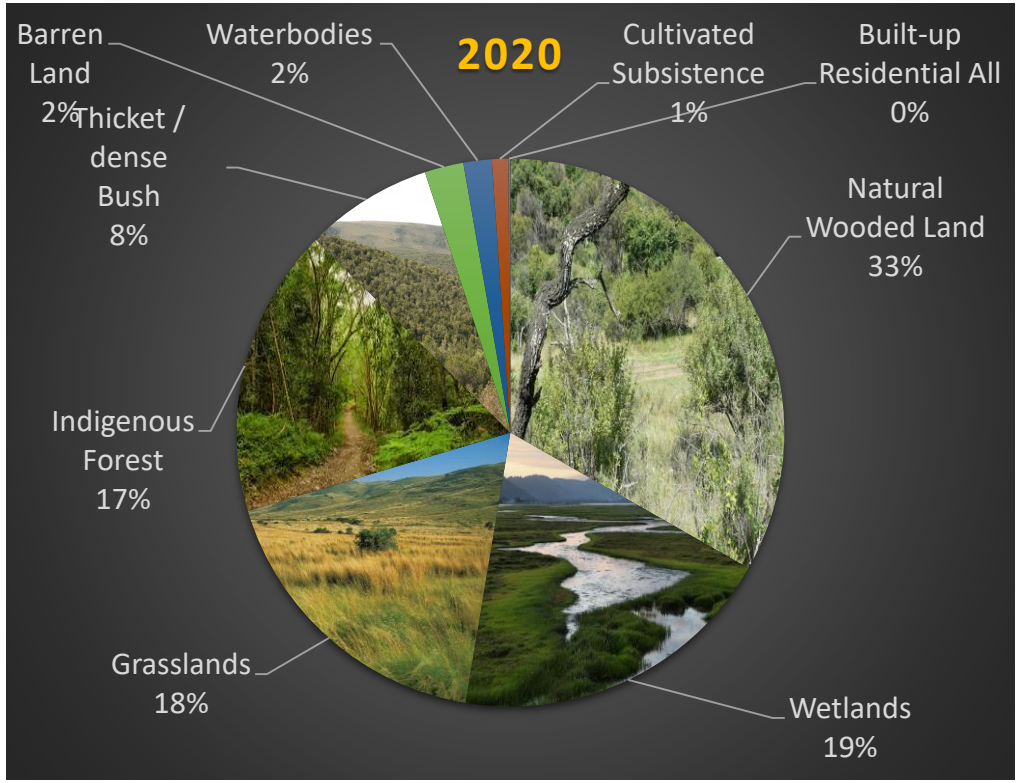
Ndumu Game Reserve – Radical change (with some somewhat disturbing)



In 30 years it appears that the reserve's land-cover has changed from predominant bush and wetlands to more diverse woodlands, forests, wetlands and grasslands.





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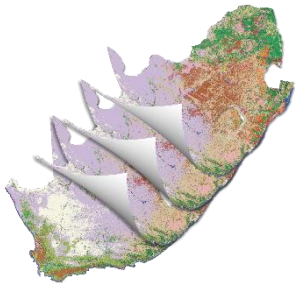

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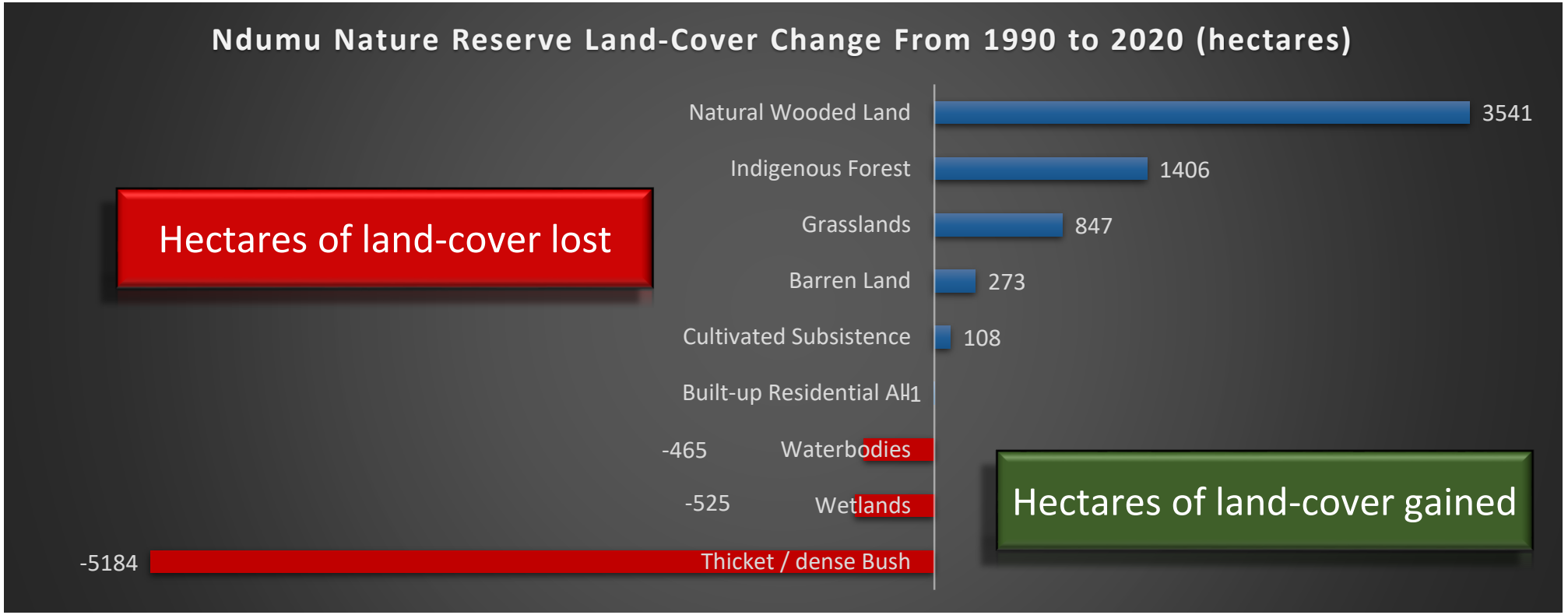

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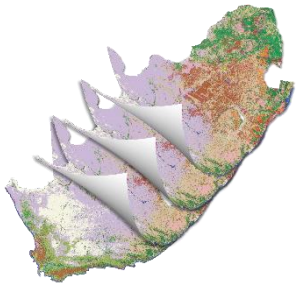
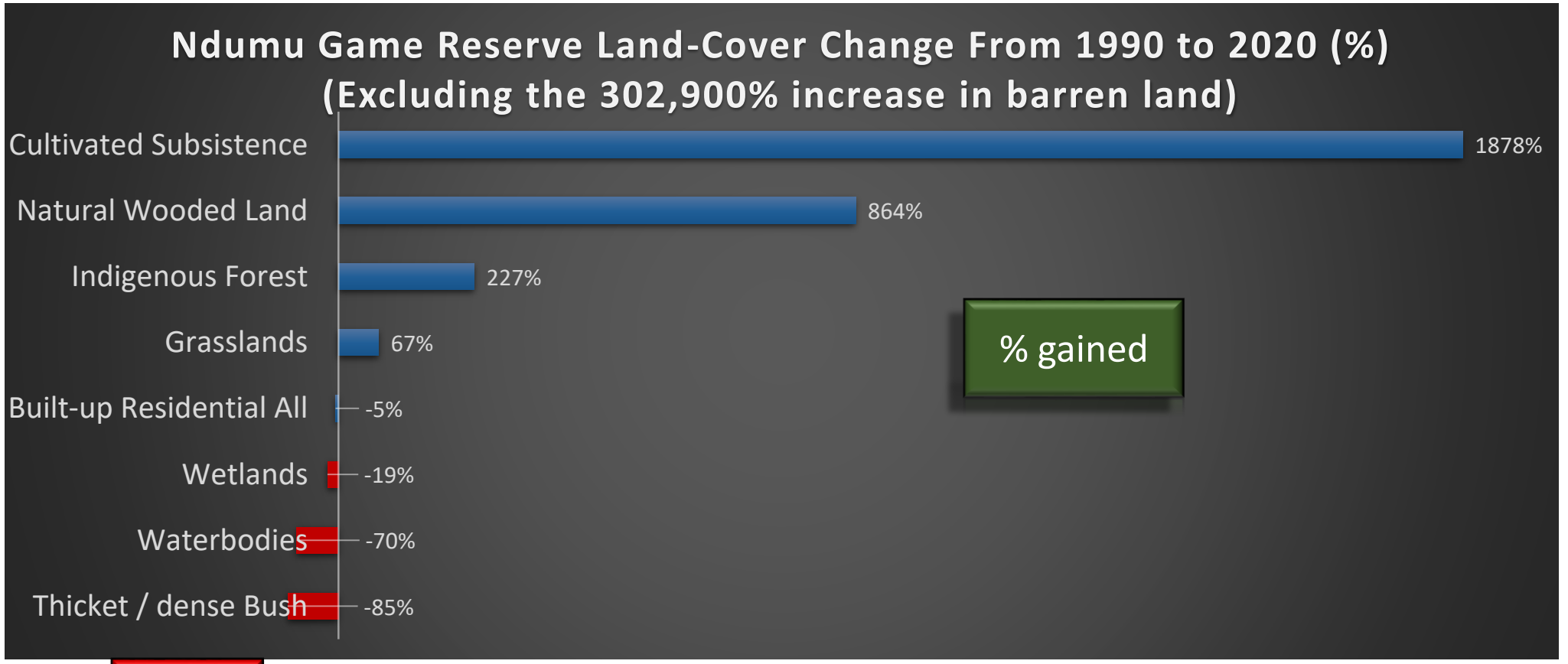


In 30 years there appears to be clear evidence of 'woodification' and land invasion



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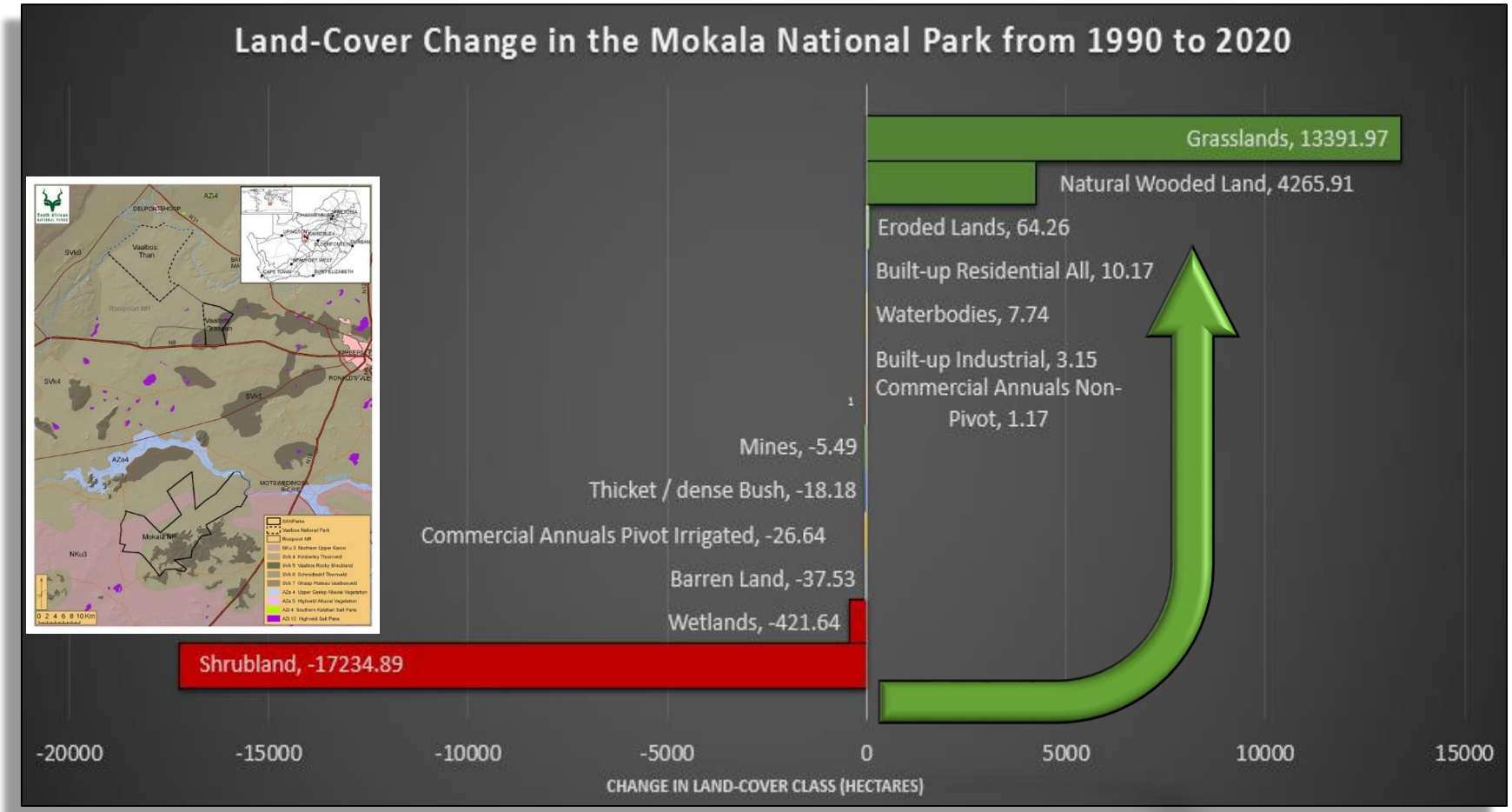
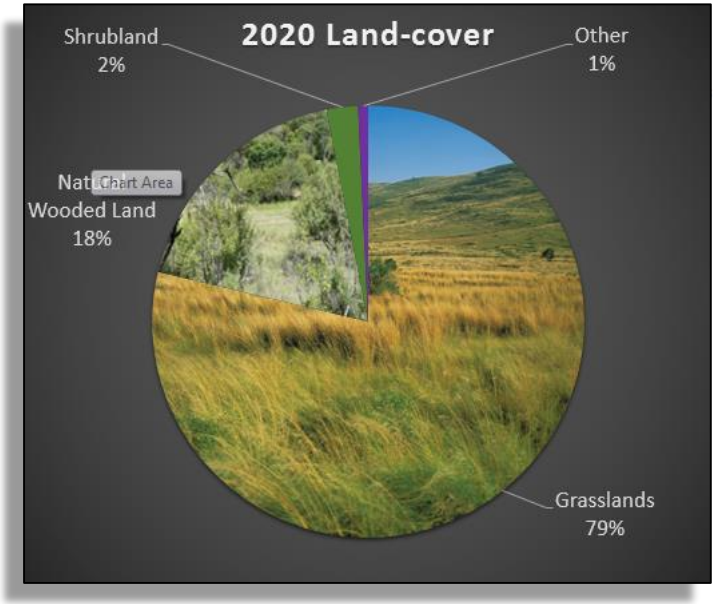
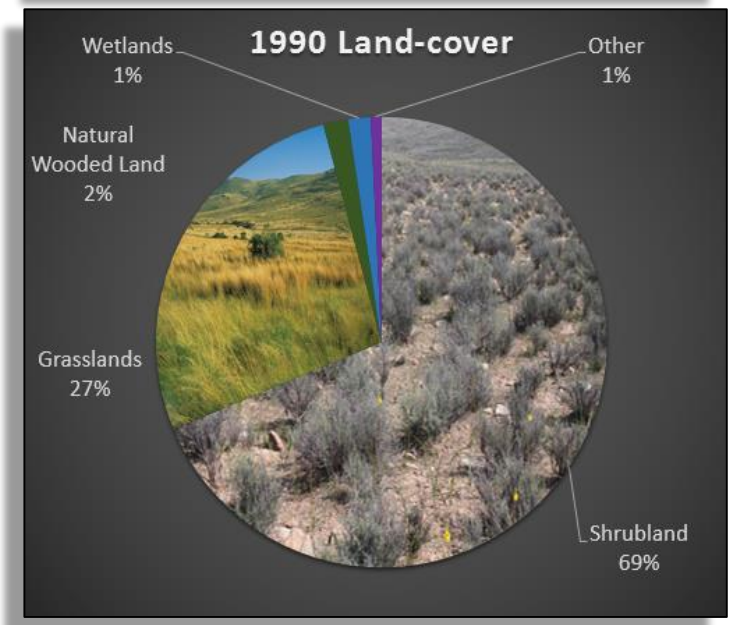
Mokala National Park – A conservation transformation?







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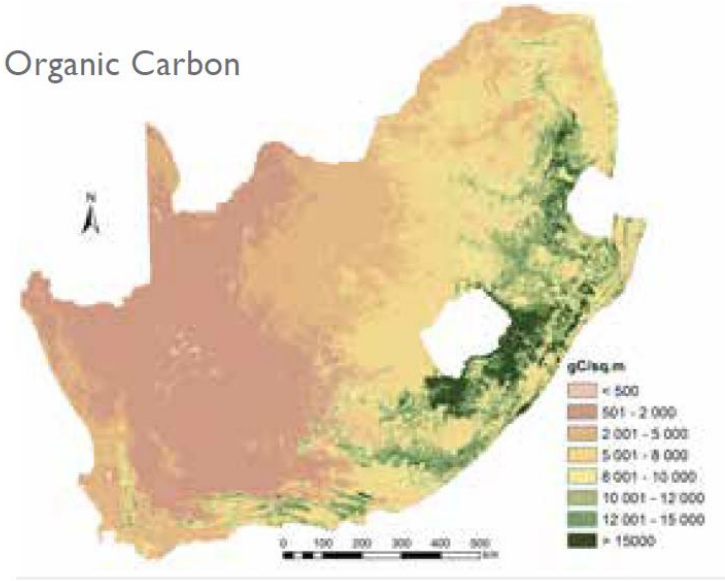
Carbon Tracking

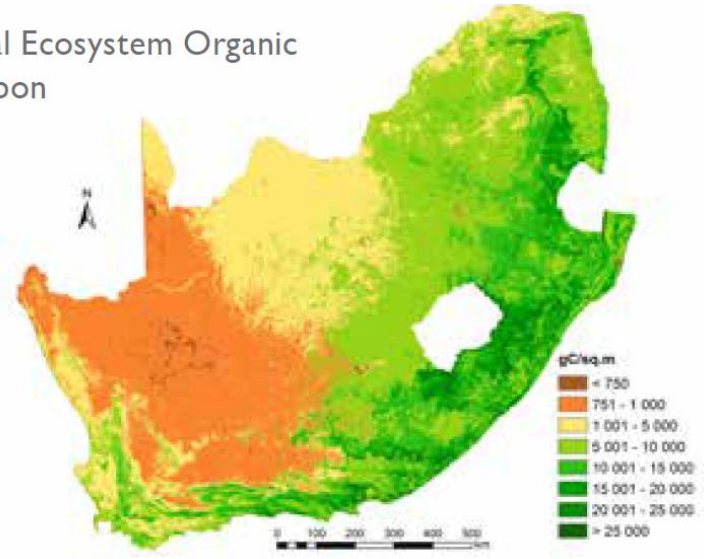
Elements	Reference	1990	2014	2018	Reference - 1990	1990 - 2014	2014 - 2018	Reference - 2018
Province	Total topsoil carbon in Tg				% change			
Northern Cape	537	530	530	527	-1.32	-0.13	-0.58	-2.02
Mpumalanga	407	381	383	374	-6.42	0.66	-2.49	-8.15
KwaZulu-Natal	627	590	585	574	-5.88	-0.96	-1.78	-8.44
Gauteng	66	62	62	60	-7.53	0.24	-2.03	-9.19
Free State	432	382	383	377	-11.74	0.41	-1.53	-12.74
Eastern Cape	830	790	797	781	-4.85	0.78	-1.99	-6.02
Western Cape	436	418	417	413	-4.42	-0.14	-1.03	-5.54
North West	237	216	219	212	-9.11	1.26	-2.97	-10.70
Limpopo	425	409	410	402	-3.97	0.45	-2.11	-5.57
Total	**4 001**	**3 777**	**3 785**	**3 720**	**-5.60**	**0.21**	**-1.73**	**-7.03**

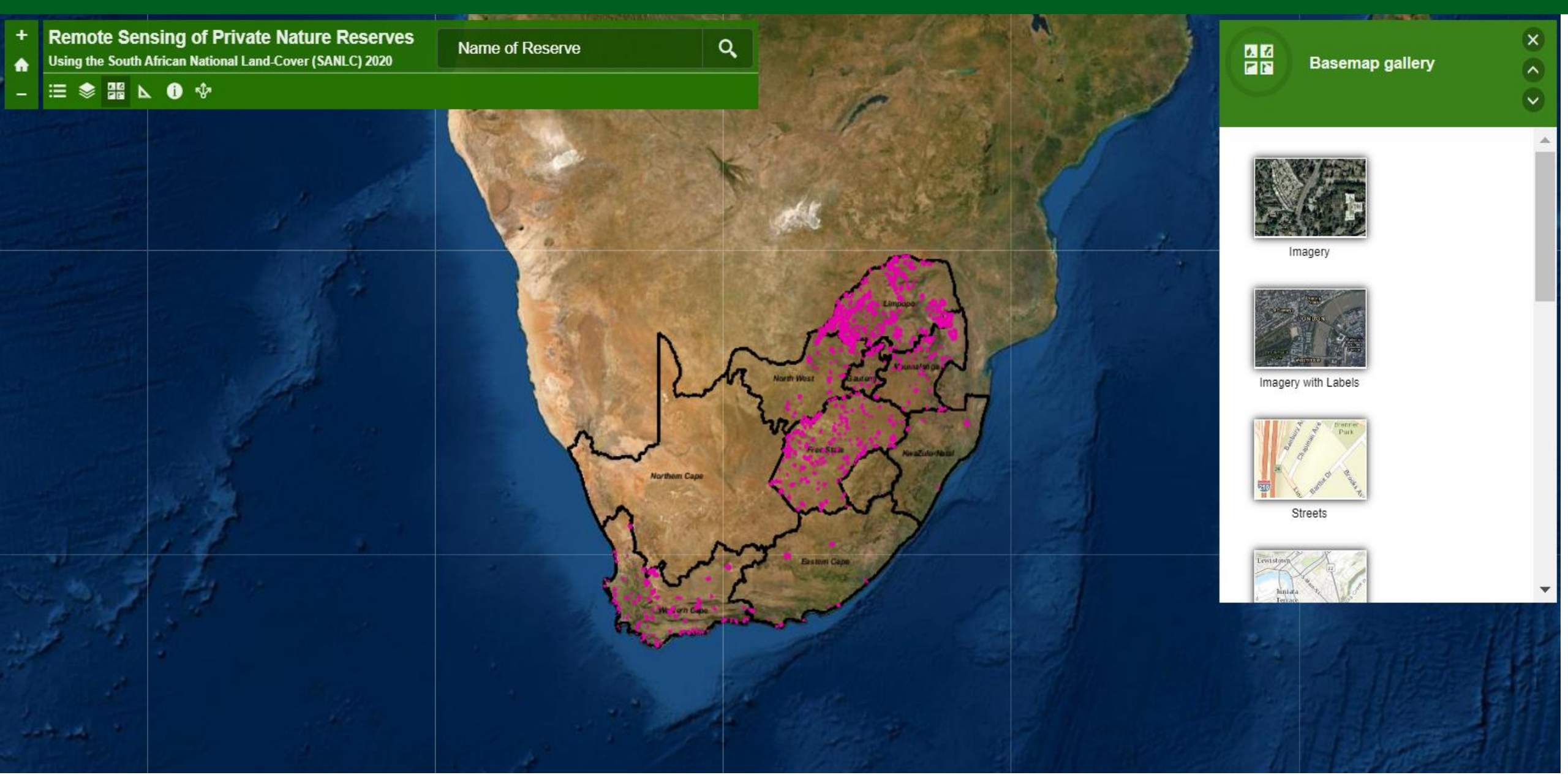
The mean reduction in SOC for the country due to cultivation of cropland soils

Soil Organic Carbon



Total Ecosystem Organic Carbon




Remote Sensing of Private Nature Reserves
Using the South African National Land-Cover (SANLC) 2020
Name of Reserve
Basemap gallery
Imagery
Imagery with Labels
Streets
Limpopo
North West
Gauteng
Mpumalanga
Free State
KwaZulu-Natal
Northern Cape
Eastern Cape
Western Cape


Remote Sensing of Private Nature Reserves
Using the South African National Land-Cover (SANLC) 2020
Name of Reserve
Layers
Private Nature Reserves
Landcover 2020
Sublayers
Legend
Opacity
South African National Landcover 2020
artificial dams (including canals)
artificial flooded mine pits
artificial sewage ponds
bare riverbed material
coastal sand & dunes
commercial
commercial annual crops non-pivot irrigated
commercial annual crops pivot irrigated
Limpopo

South African National Land Cover Change

Datasets 1990 compared to 2018 and 2013/14 compared to 2018

brought to you by

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rural development & land reform
Department:
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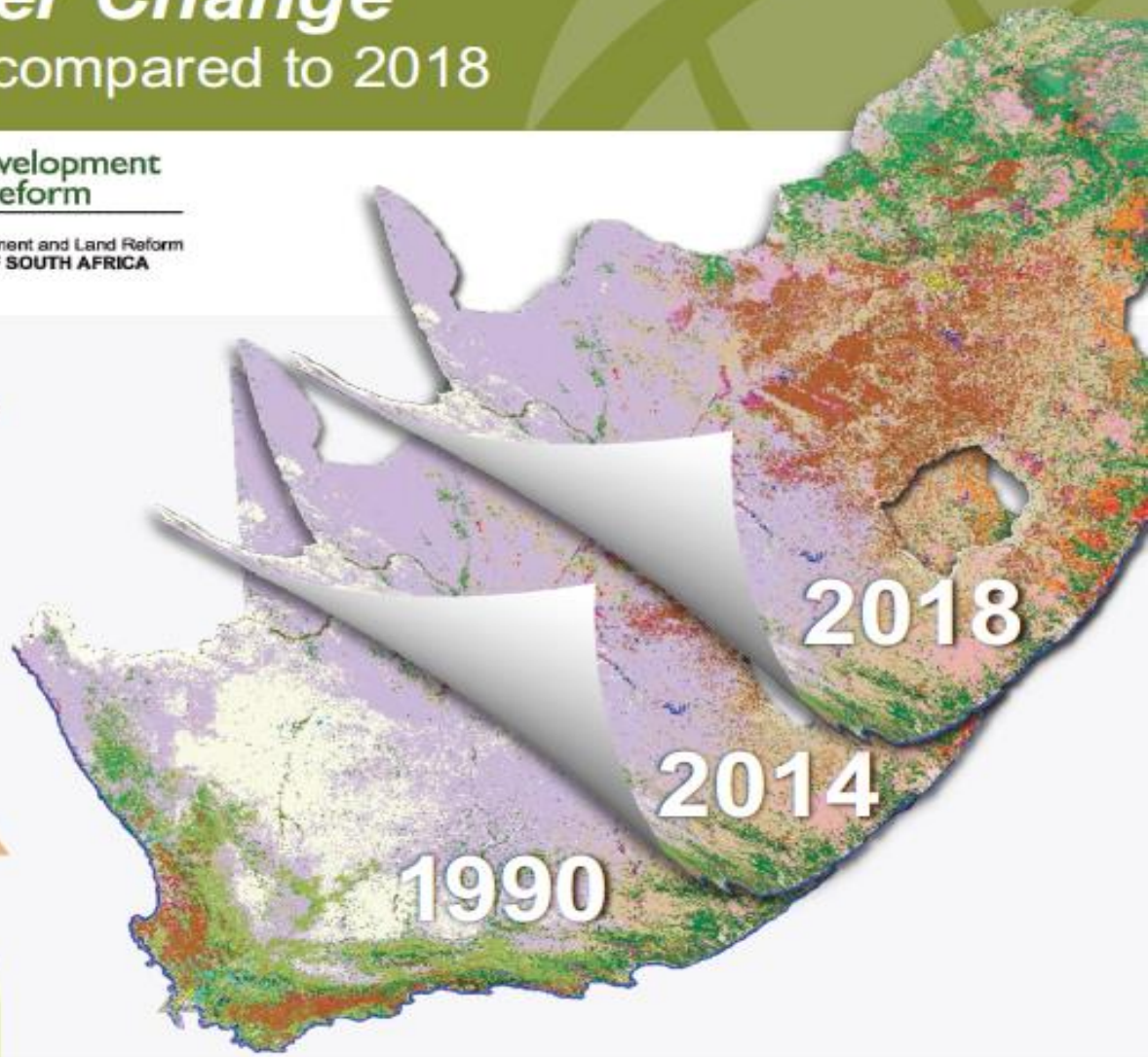
1990-2018
2013/14-2018

National land-use changes between 1990 vs 2018 and 2013/14 vs 2018. The graphs show the percentage increase in areas Nationally for the indicated land-use classes in 2018, compared to the historical reference year.



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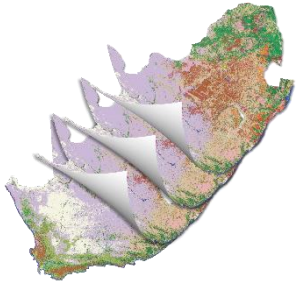
2030 NDP

Conclusion



- The Department now has the in house ability to generate National Land-Cover on a regular basis via the CALC system
- Able to undertake year-on-year land-cover change assessments and geo-statistical reporting for eco-system accounts
- Ability to have time series of environmental change from the baseline of 1990 and into the future
- By having a synoptic view of our resources, we are able to quickly assess, monitor change and make informed decisions

THANK YOU!

"…sustainable development is only possible if it is underpinned and informed by an environmentally literate society"

(Minister Barbara Creecy's address at the Ecologic Awards at Table Bay hotel, Cape Town, Wednesday 5 June 2019)

Land-cover data provided by: the Directorate Sector Spatial Information Management

Compiled by: the Chief Directorate: Sector Knowledge and Information Management

Presented by: Dr Zakariyyaa Oumar
(*Pr.Sci.Nat & PrGIS*)