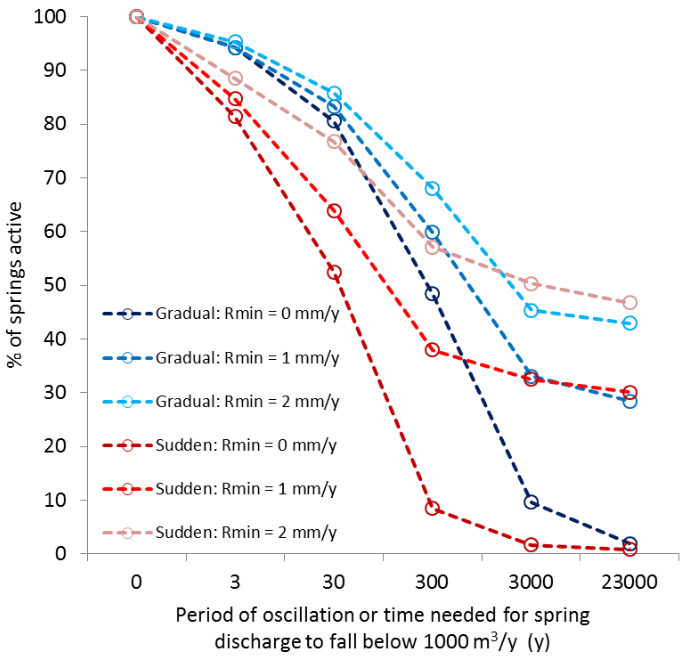
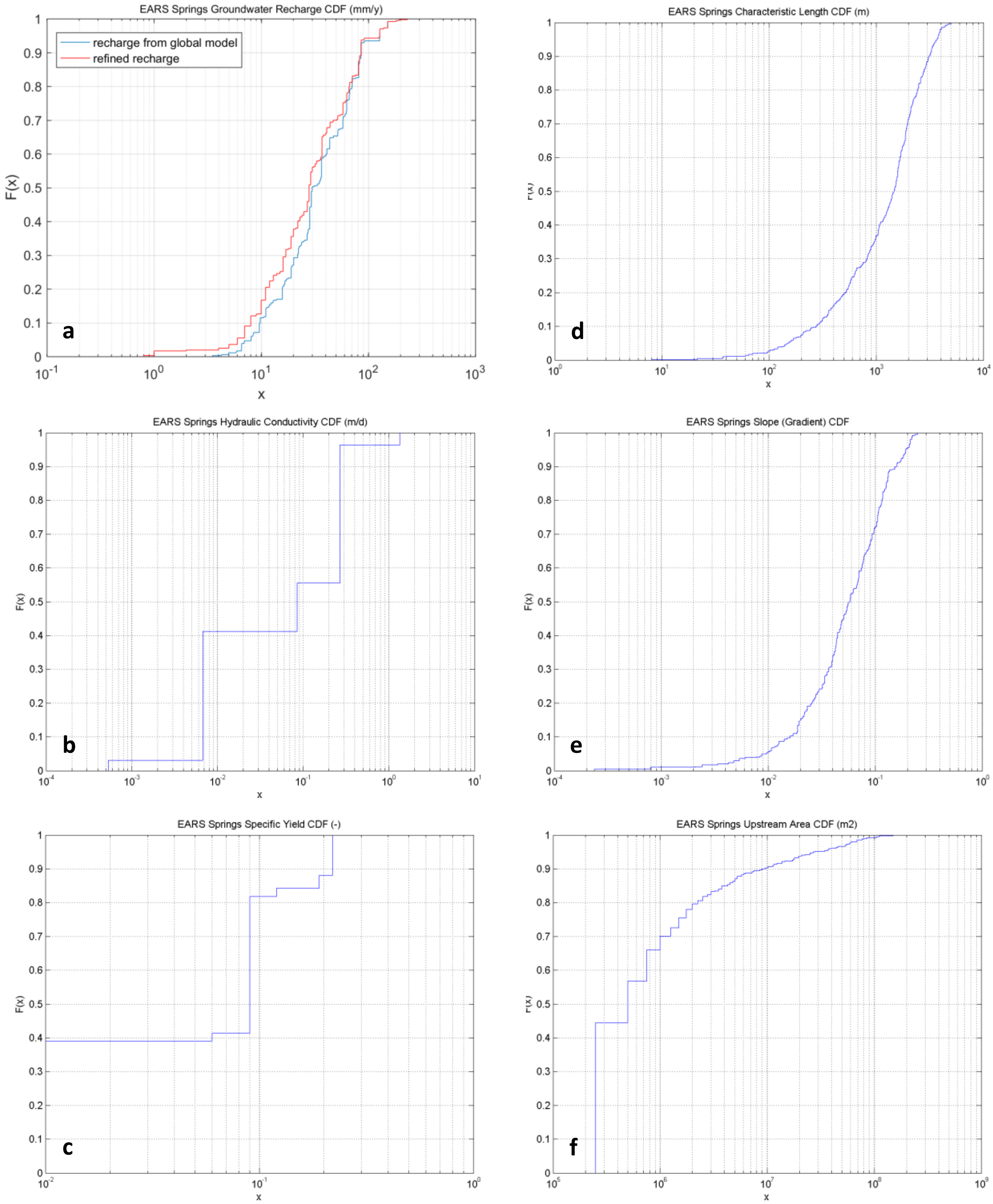
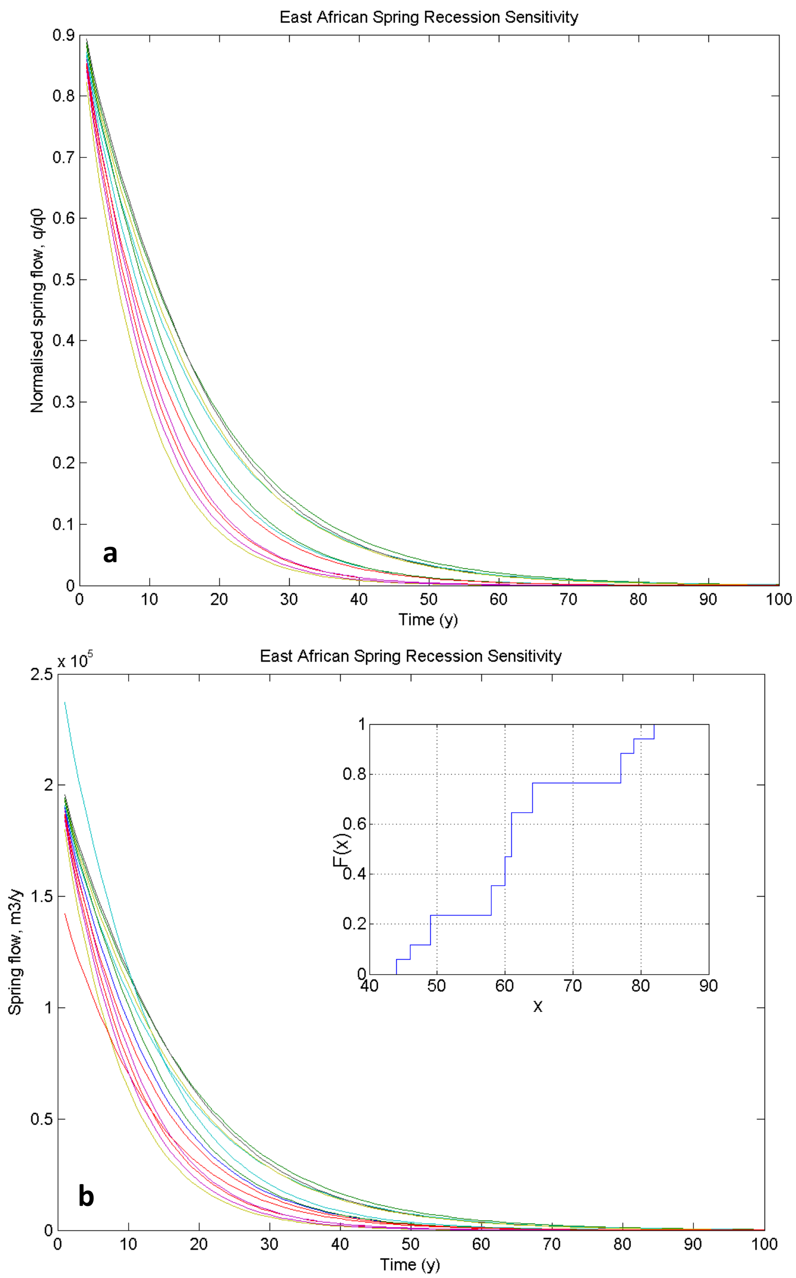


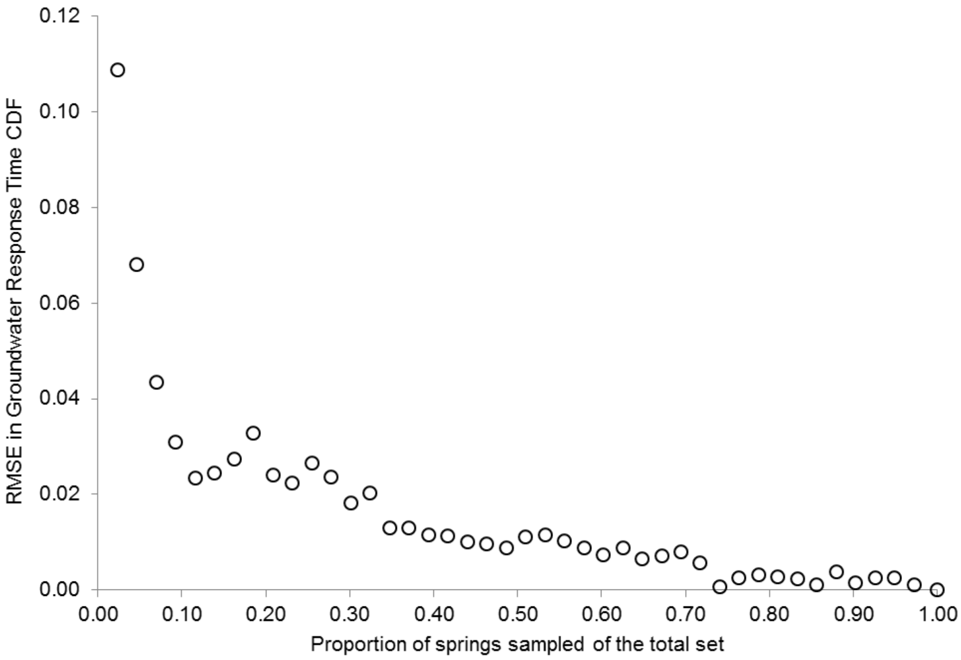
Supplementary Figure 1: Frequency of springs still active (i.e. flow rate still above 1000 m^3/y) at the driest part of climate cycles under gradual (periodic) and sudden (step) changes in recharge from modern day values to various minimum values (Rmin). All figures and calculations in the paper use the results for Rmin = 1 mm/y unless stated. While this is a conservative value for an arid climate, the Rmin = 0 end member provides a useful indication of the decline in active springs during any prolonged periods of zero rainfall (and therefore zero recharge).



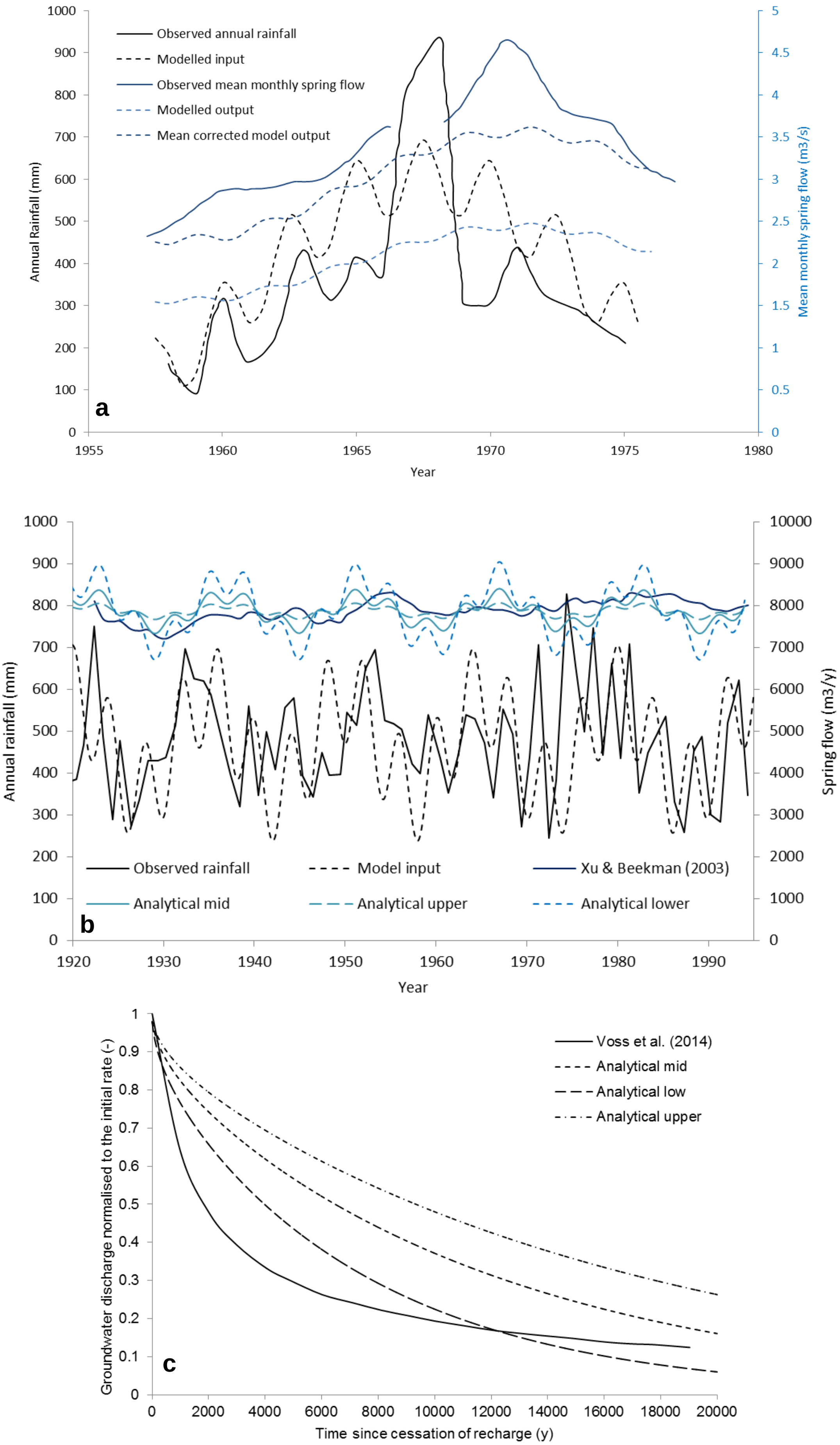
Supplementary Figure 2: Cumulative probability distributions (F(x)) for all mapped spring characteristic input parameters (x) used for modelling. **a**. groundwater recharge. **b**. hydraulic conductivity. **c**. specific yield. **d**. characteristic length. **e**. slope. **f.** catchment area.



Supplementary Figure 3: Sensitivity of spring discharge, to a +/-25% variation from a baseline defined by an average of all parameters, to the sudden cessation of recharge from steady state conditions for **a.** normalised spring flow (q/q0) and **b**. absolute spring flow. The CDF (F(x)) for x = time in years to reach 1000 m^3/y is shown as an inset. At the 95% confidence interval (i.e. 2 standard deviations), the range in x is +/-37%.

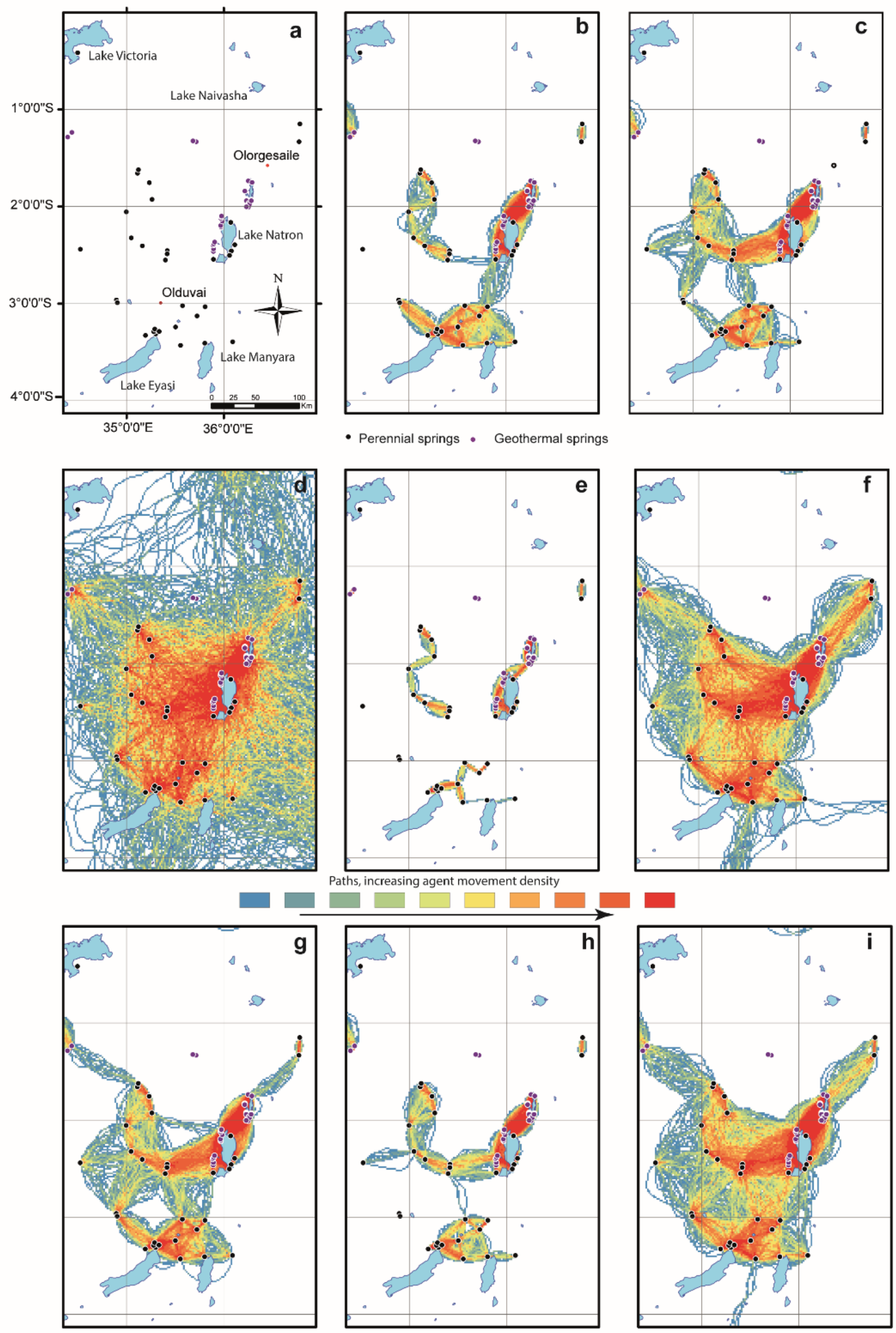


Supplementary Figure 4: Results of the statistical test for representativeness of spring sampling. Root mean squared error (RMSE) in the cumulative distribution function (CDF) of the groundwater response times plotted against increasing size of random subsamples as a proportion of the total mapped spring population.

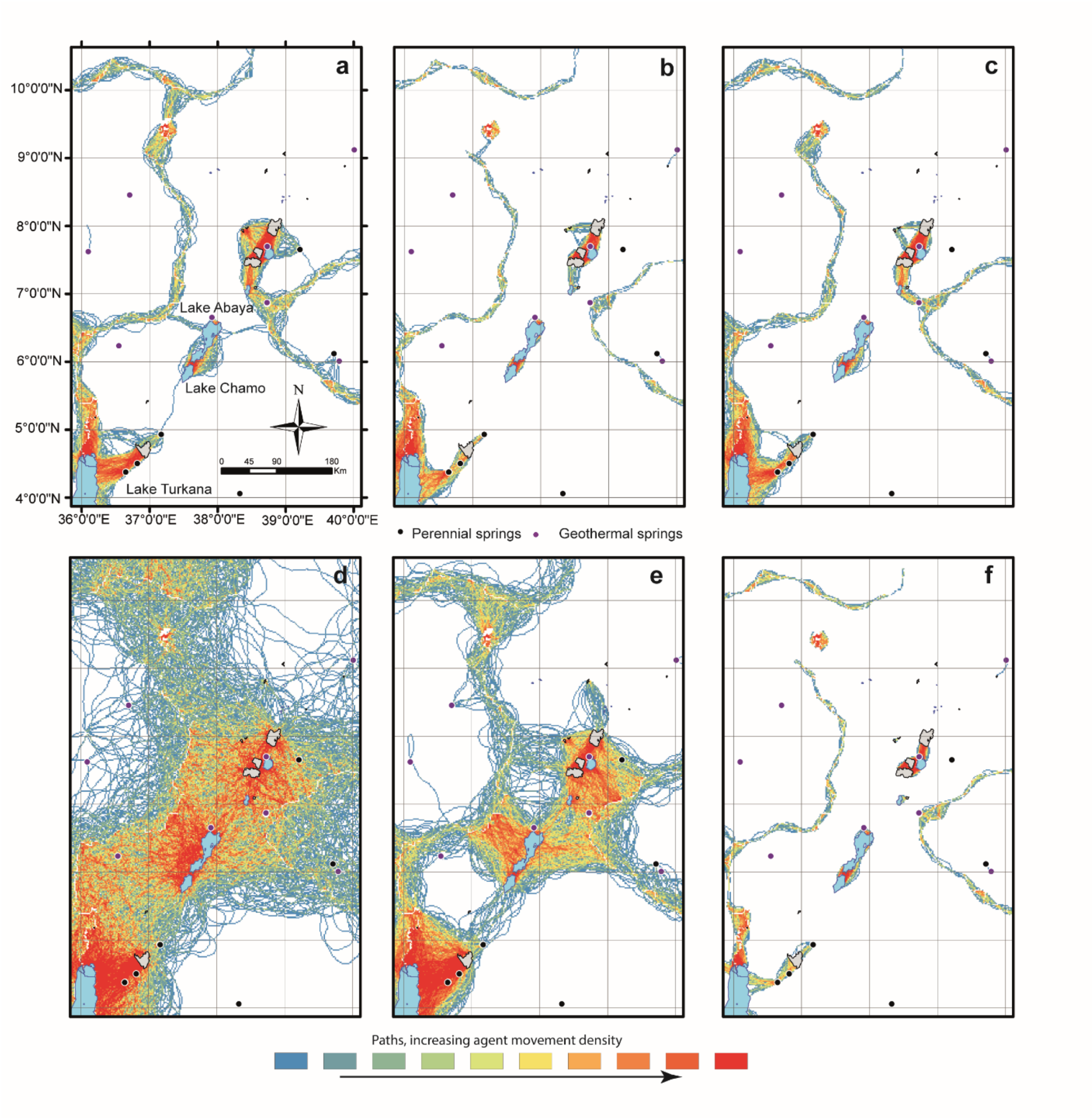


Observed annual rainfall
Modelled input
Observed mean monthly spring flow
Modelled output
Mean corrected model output
Annual Rainfall (mm)
Mean monthly spring flow (m3/s)
Year
a
Observed rainfall
Model input
Xu & Beekman (2003)
Analytical mid
Analytical upper
Analytical lower
Annual rainfall (mm)
Spring flow (m3/y)
Year
b
Voss et al. (2014)
Analytical mid
Analytical low
Analytical upper
Groundwater discharge normalised to the initial rate (-)
Time since cessation of recharge (y)
c

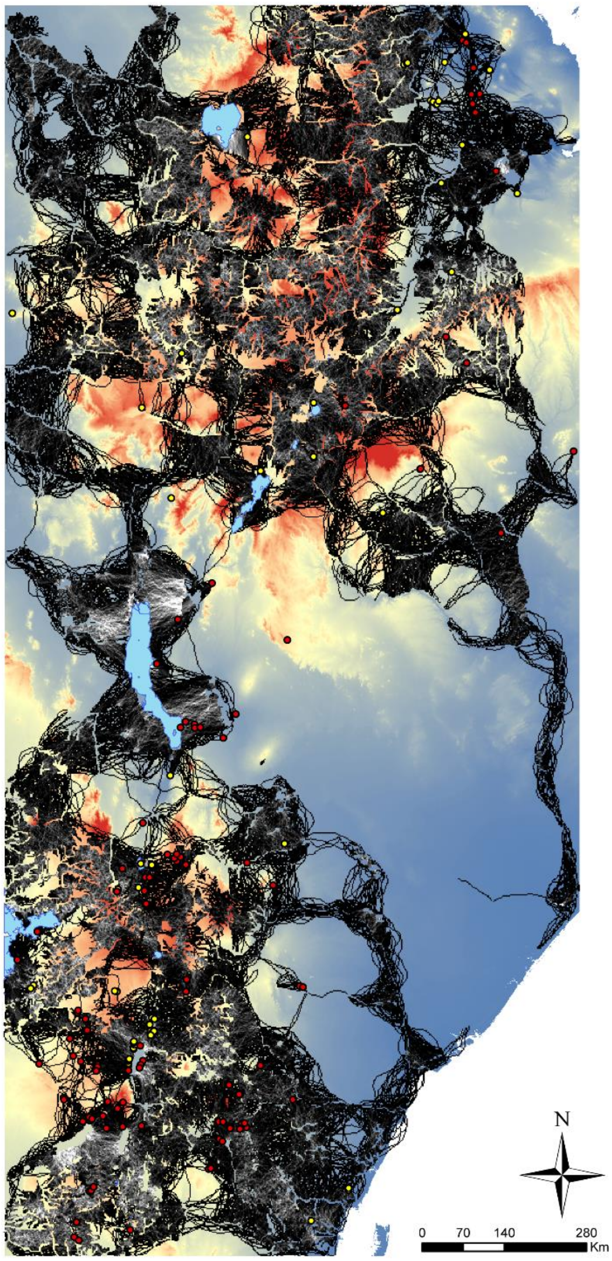
Supplementary Figure 5: Results of analytical model testing compared against: **a**. observed flows for Mzima Springs, Tanzania[54]. 'Modelled input' used signals with periods of 2.5 and 25 years with a ratio of amplitudes of 1:3, and hydraulic parameters uncalibrated from GIS mapping (see Methods) yielding a groundwater response time (GRT) of 37.5 y. 'Mean corrected model output' is a shifted plot of the raw model output to enable a better comparison to be made in the observed and modelled amplitude and attenuation despite the difference in observed and modelled absolute spring flow. **b**. naturalised flows for Uitenhage Spring, South Africa[55]. 'Modelled input' used signals with periods of 4 and 15 years with a ratio of amplitudes of 1:1 and the published range of hydraulic parameters yielding a GRT range of 17 y, 74 y and 530 y for 'Analytical low', 'mid' and 'upper' respectively. **c**. modelled flows for North African Nubian Aquifer System[56]. The published input parameters from the model were used as input parameters with estimates of average flowpath lengths of 300 km, 400 km and 500 km yielding GRT ranges of 25 ky, 44 ky and 68 ky for 'Analytical low', 'mid' and 'upper' respectively.



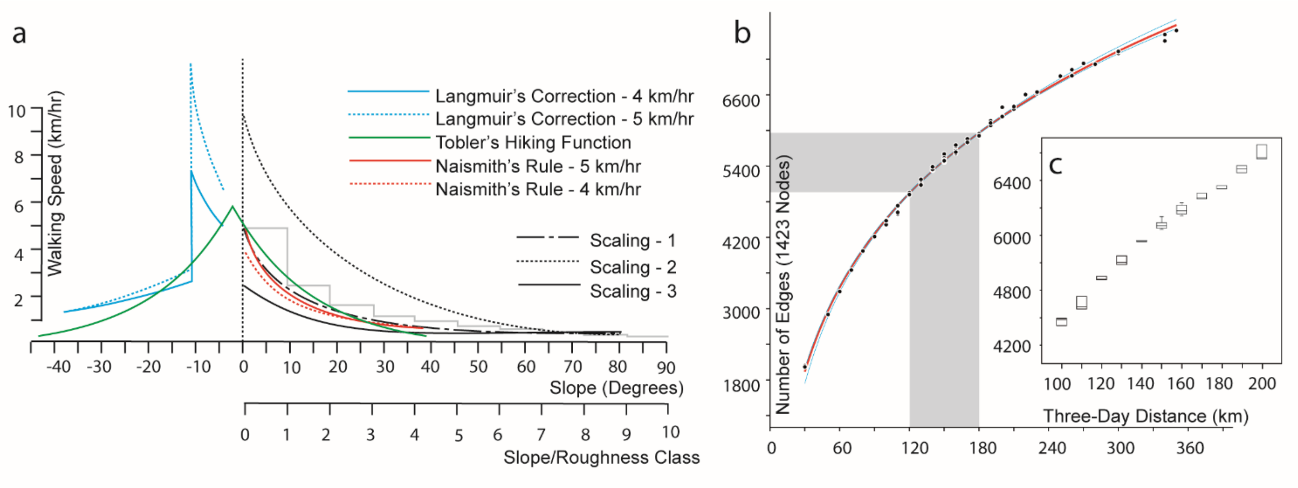
Supplementary Figure 6: Sensitivity of spring networks (hydro-refugia) to various cost maps and cost scaling in southern Kenya and northern Tanzania to demonstrate that spring networks exist in some form across all modelling scenarios. The scenarios shown are based on the springs persistent at 23 ky as the only active 'water patch'. **a**. Location details. **b**. Scenario using slope [Cost-1] as the cost layer. **c**. Scenario using roughness [Cost-2] as the cost layer. **d**. Scenario using no cost layer [Cost-0]. **e**. Scenario using roughness [Cost-2] with increased scaling [Scaling-2]. **f**. Scenario using roughness [Cost-2] with decreased scaling [Scaling-3]. **g**. Scenario using roughness [Cost-2] and a total three day travel distance of 180 km. **h**. Scenario using roughness [Cost-2] and a total three day travel distance of 120 km. **i**. Scenario using slope + roughness as the cost layer [Cost-5]. Unless otherwise stated all three day travel distances are 150 km and the turn angle is 20 degrees.



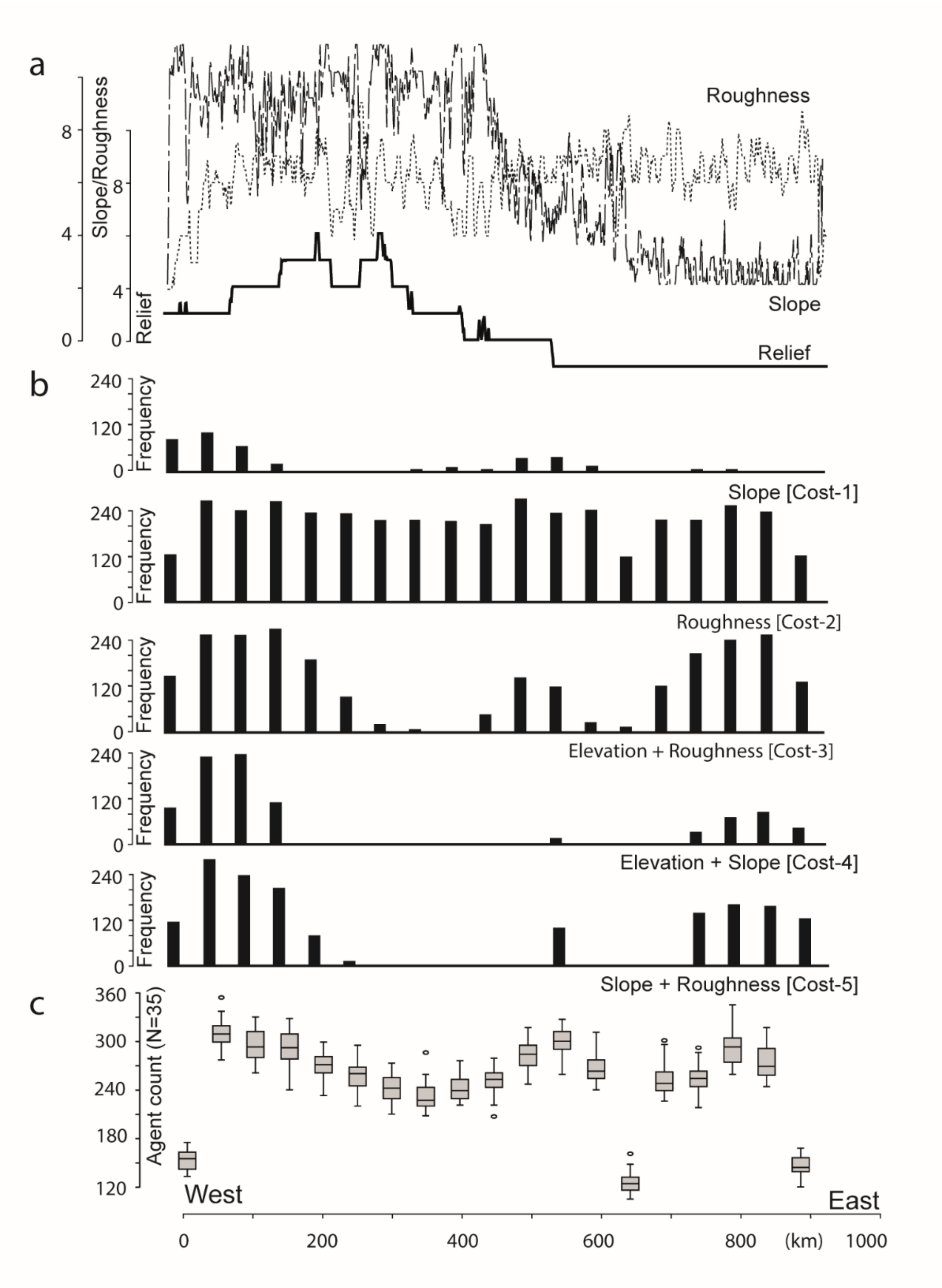
Supplementary Figure 7: Sensitivity of dispersal routes to various cost maps and cost scaling in southern Ethiopia and northern Kenya. The scenarios shown are based on the present day springs, lakes (fresh and saline), perennial wetlands, major rivers with flow >0 km^3/y. Three-day travel distance is set at 150 km unless otherwise stated. Note that the potential for east-west dispersal routes is sensitive to the model parameters used. **a**. Location details, plus paths using roughness [Cost-2] as the cost layer with the standard scaling [Scaling-1]. **b**. Same scenario but using slope [Cost-1] as the cost layer with the standard scaling [Scalling-1]. **c**. Same scenario but using slope [Cost-5] as the cost layer with the standard scaling [Scalling-1]. **d**. Same scenario but using no [Cost-0] cost layer. e. Location details, plus paths using roughness [Cost-2] as the cost layer with the standard scaling [Scaling-3]. **f**. Location details, plus paths using roughness [Cost-2] as the cost layer with the standard scaling [Scaling-3].



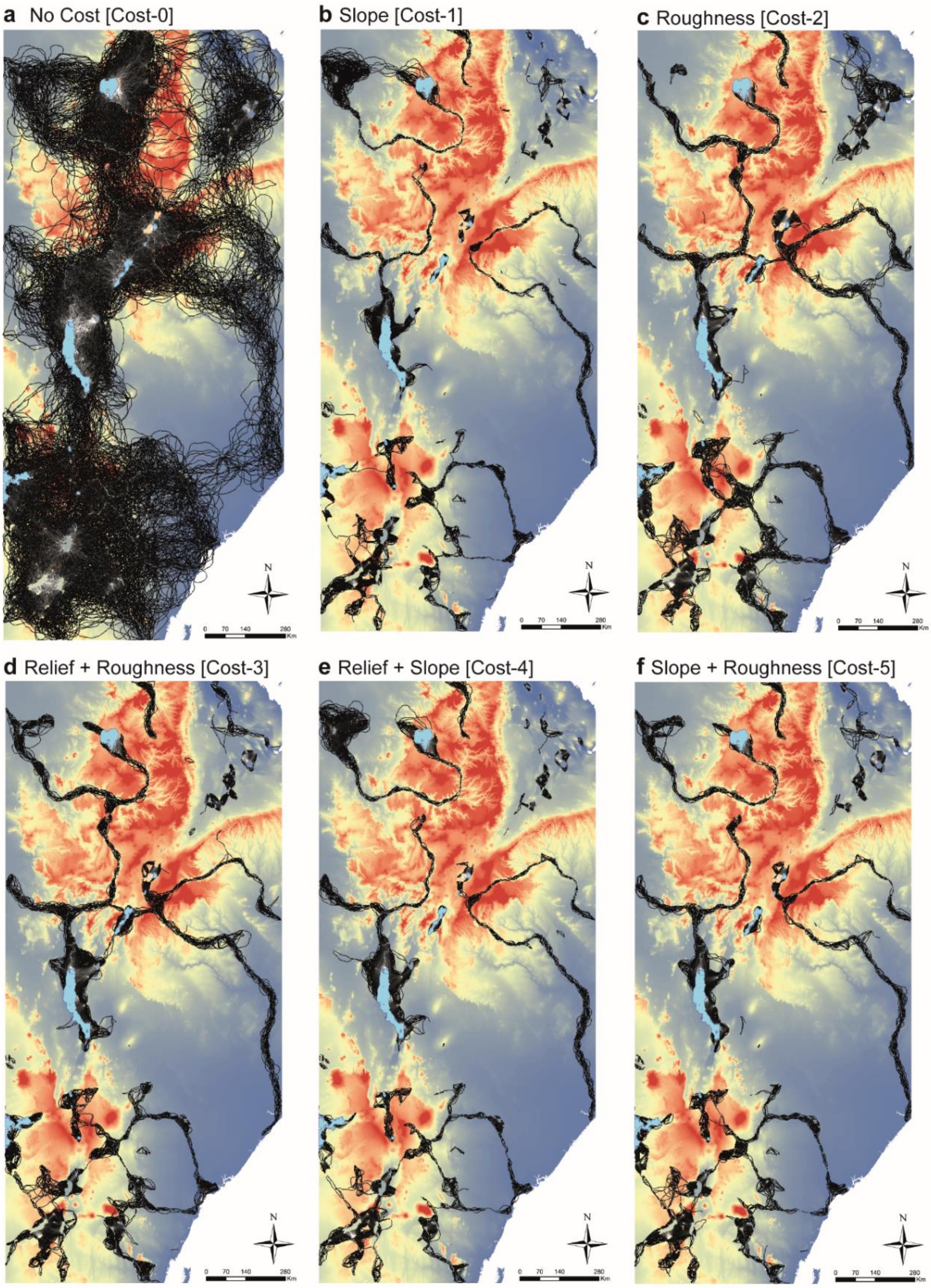
Supplementary Figure 8: Fourth modelled scenario based on the present day wet scenario (Run-2). Agent based modelling results based on a dry hydrological scenario using a maximum three-day travel distance of 150 km and surface roughness as the cost layer scaled according to Supplementary Figure 11. This scenario uses modern springs (seasonal, perennial + geothermal), wetlands (perennial), lakes (fresh + saline), major rivers with a flow >0 km^3/y, and perennial streams mapped from the 1:500,000 scale maps. The black lines shown represent the tracks of agents in the model. Note the potential for widespread dispersal.



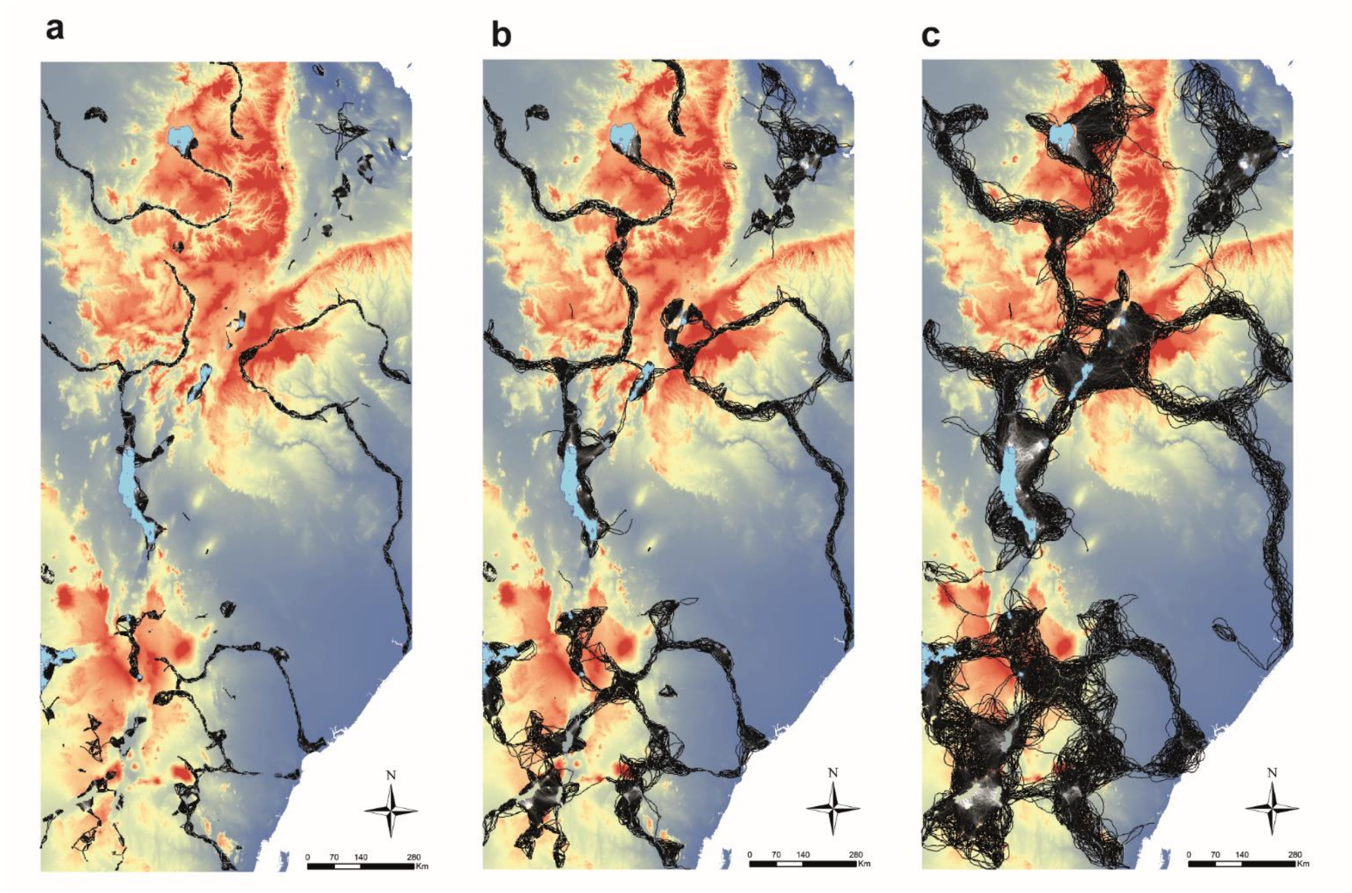
Supplementary Figure 9: Cost calibrations for slope and roughness and model sensitivity. a. Shows the impact on walking speed of slope based on Naismith's Rule as expressed by Rees *et al.* (2004)[61]. Three possible scaling scenarios are also shown. Scaling-2 was used for both slope and roughness as the default modelling option. The grey stepped line shows its transformation to modelling data classes. **b**. Variation of network density with travel distance and comparison of the modelled scenarios. a. shows the relationship between three day travel distance and the number of edges within a network (Run-3). The data follows a power function, with 95% confidence limits shown (N=63). **c.** Inter-run variation at a given distance (N=5). Note the inter-run variation is less than the variation between each increase in distance step (10 km).



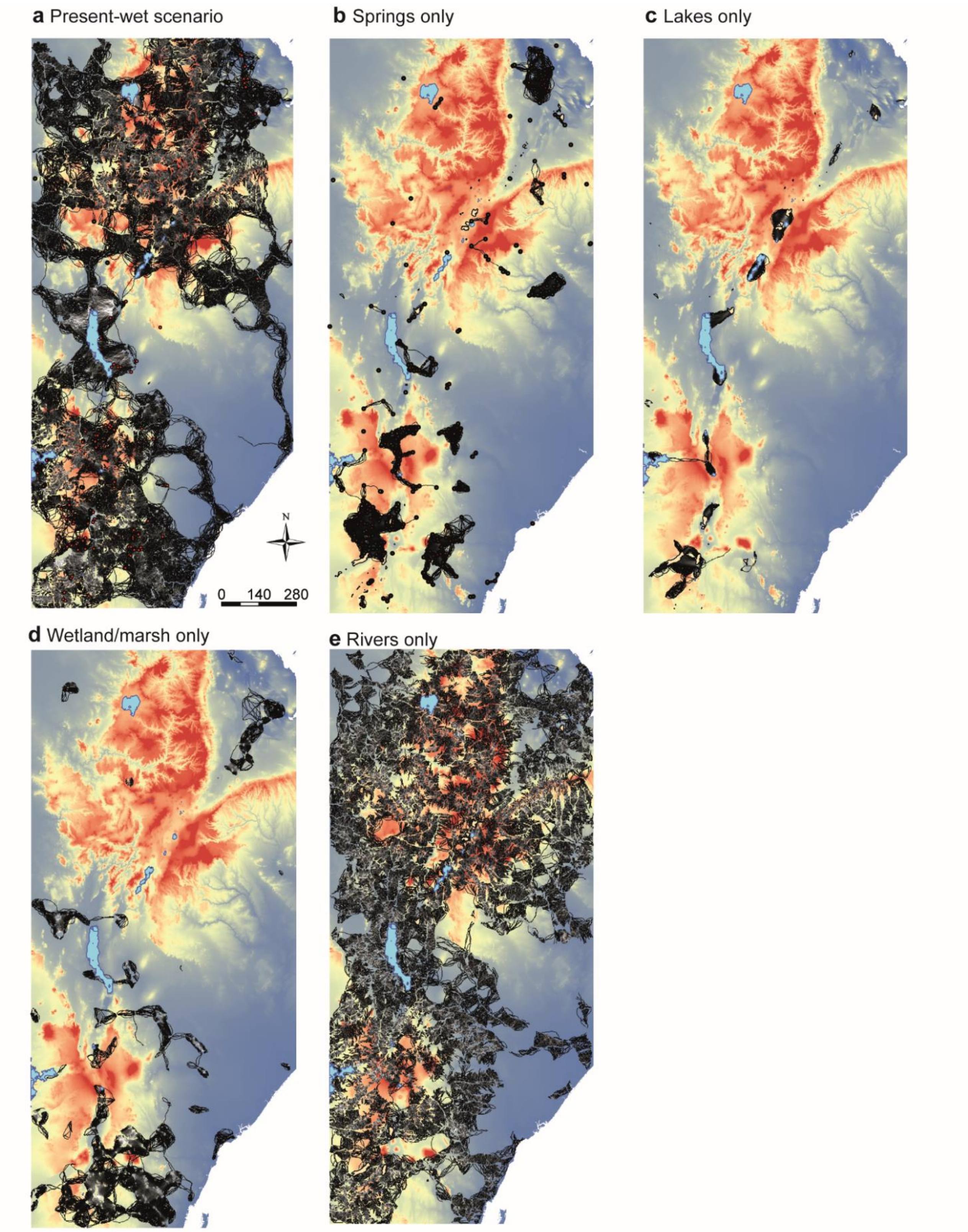
Supplementary Figure 10: Results of a sensitivity experiment conducted along a horizontal transect across the southern rift. Water-patches were placed at regular 10 km intervals along this transect and the agent number moving between patches output. Agent movements are the sum of those moving in either direction. **a**. Relief, slope and roughness data in ten equal classes along the transect. **b**. Frequency histograms of agent movements using various possible cost layers. Note that 'zero-cost' is not shown since agents 'leap-frog' stations along the transect. **c**. Replication experiment using roughness [Cost-2] as the cost layer. Note the absolute number of agents does vary but the relative proportion is always constant as is the network pattern. Roughness [Cost-2] was used as the default cost layer since it offered the least conservative option and therefore tests for possible population isolation.



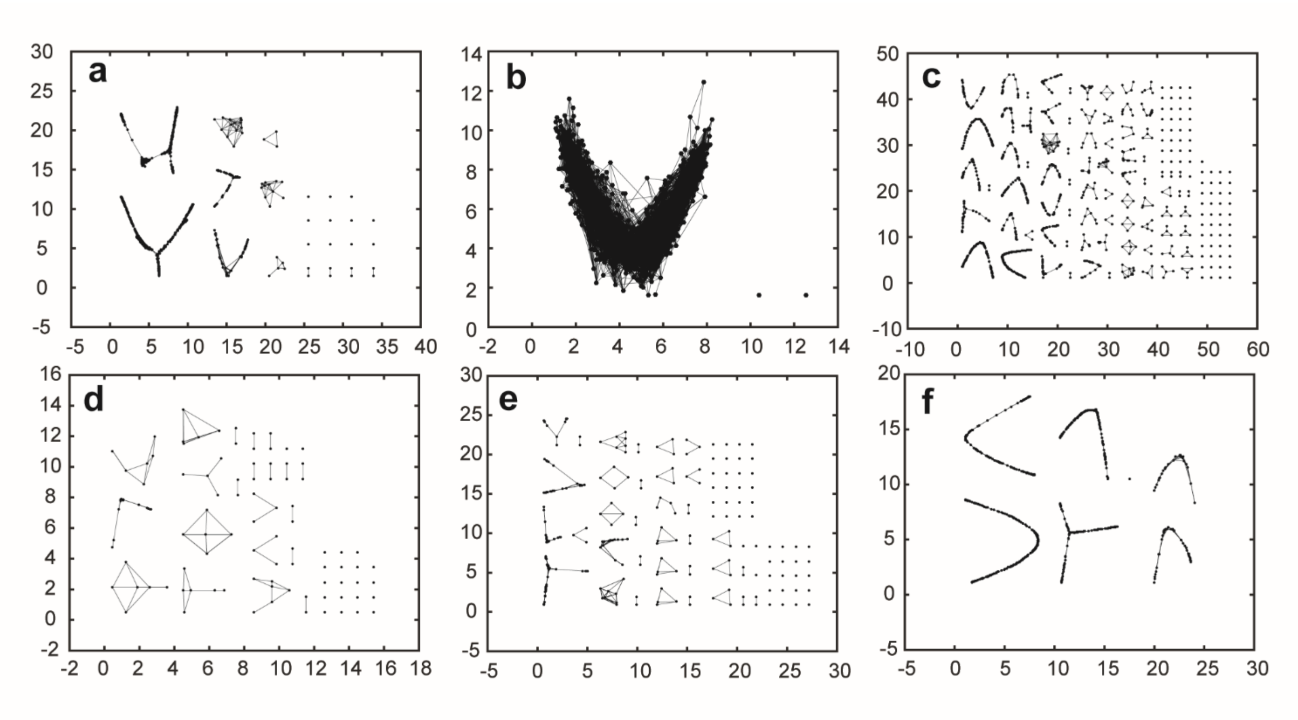
Supplementary Figure 11:
Runs to illustrate sensitivity to different cost layers. The hydrological system is based on the present day perennial springs, wetlands, lakes (saline + fresh) and major rivers with a flow rate greater than zero. In all cases a three day travel distance of 150 km, turn angle of 20 degrees and roughness as the cost layer with the standard [Scaling-2] was used. **a**. No-cost layer (Cost-0). **b**. Slope as the cost layer (Cost-1). **c**. Roughness as the cost layer (Cost-2). **d**. Relief and roughness as the cost layer (Cost-3). **e**. Relief and slope as the cost layer (Cost-4). f. Slope and roughness as the cost layer (Cost-5).



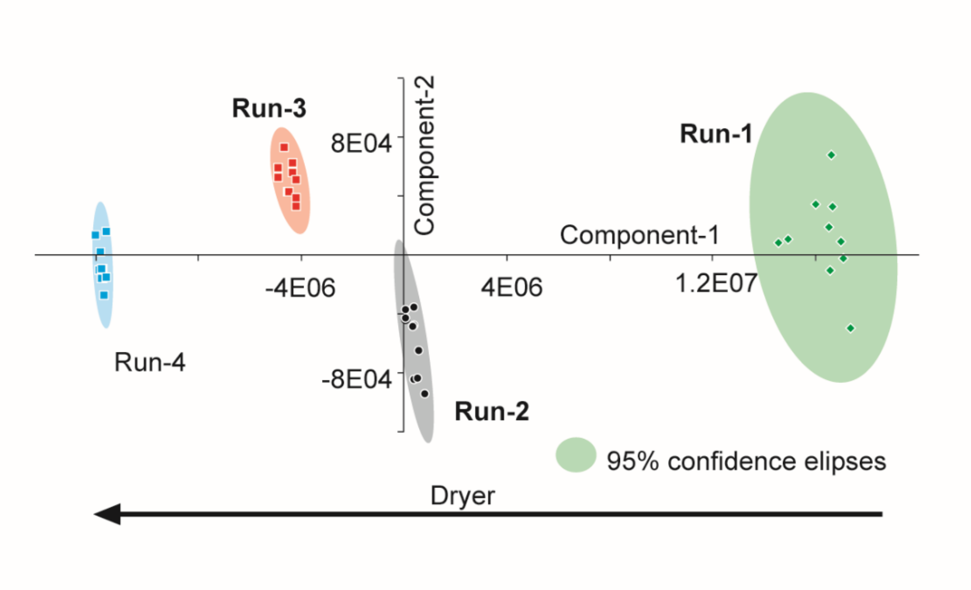
Supplementary Figure 12: Runs to illustrate sensitivity to different scaling of cost layers, in this case roughness [Cost-2]. The hydrological system is based on the present day perennial springs, wetlands, lakes (saline + fresh) and major rivers with a flow rate greater than zero. In all cases a three day travel distance of 150 km, turn angle of 20 degrees. **a**. Scenario with scaling 1. **b**. Scenario with scaling 2. **c**. Scenario with scaling 3.



Supplementary Figure 13: Component parts of the hydrological system modelled with a three day travel distance of 150 km, turn angle of 20 degrees and using roughness as the cost layer with the standard [Scaling-2]. **a**. Present-day wet scenario. **b**. Springs only. **c**. Lakes only. d. Wetland/marsh only. **e**. Rivers only.



Supplementary Figure 14: Sub-network shapes derived from successful journey matrices across various model runs. **a.** Run-4 (Supplementary Table 3) in which a cost layer based on topographic roughness was used. Water elements correspond to the present day scenario. **b.** Run-9 (Supplementary Table 3) in which no cost layer was used. Water elements correspond to the present day scenario as in (a). **c.** Run-5 (Supplementary Table 3) in which a cost layer based on slope was used. Water elements correspond to the present day scenario as in (a). Note the increase in the number of sub-networks with use of slope as the coast layer compared to roughness (a). **d.** Run-15 (Supplementary Table 3) in which lakes were included as the only water source in the scenario. **e.** Run-14 (Supplementary Table 3) in which perennial springs were included as the only water source in the scenario. **f.** Run-14 (Supplementary Table 3) in which major were included as the only water source in the scenario.



Supplementary Figure 15: Principle components analysis of the network and Fragstats connectivity metrics recorded for the four principle scenarios modelled based on a minimum of ten repetitions. The first component explains over 99.2% of the variance and gives good statistical separation as shown by the 95% confidence ellipses. The 95% confidence ellipses show the significant level of difference between the three primary runs modelled.

Supplementary Table 1: Coefficient of determination matrix calculated by applying linear regressions between all modelled spring variables. This indicates the primary control of the groundwater response time on the spring flow recession characteristics (R^2=0.23 to 0.64) as well as the lack of correlation between climatic (actual recharge) and spring recession timescales (R^2=0.01 to 0.02).

	Time to recede to 1000 m^3/a	**Time to recede to 90% of initial flow**	**Groundwater response time**	**Potential Recharge**	**Actual Recharge**	**Catchment Area**	**Hydraulic conductivity**	**Slope**	**Catchment length (B_x)**	**Specific yield**
Time to recede to 1000 m^3/a	1.00									
Time to recede to 90% of initial flow	0.25	1.00								
Groundwater response time	0.23	0.64	1.00							
Potential Recharge	0.00	0.00	0.00	1.00						
Actual Recharge	0.01	0.02	0.02	0.71	1.00					
Catchment Area	0.00	0.00	0.00	0.00	0.00	1.00				
Hydraulic conductivity	0.01	0.01	0.01	0.01	0.00	0.01	1.00			
Slope	0.01	0.02	0.00	0.00	0.00	0.00	0.02	1.00		
Catchment length (B_x)	0.00	0.00	0.01	0.00	0.02	0.03	0.00	0.01	1.00	
Specific yield	0.03	0.04	0.05	0.02	0.05	0.00	0.03	0.00	0.01	1.00

Supplementary Table 2: Typical network metrics and Fragstat output for selected model runs, showing the differences between the four modelled hydrological scenarios. Mean data is shown for a minimum of ten model repeats. See Supplementary Table 3 for the run definitions and Supplementary Table 4 for description of the metrics.

	Network Numbers	Nodes	Edges	% Path by Area	NP - Total	NP-Paths	PD	PD [Path Class]	LPI-Path	TE [Path Class]	ED [Path Class]	LSI	AREA_AM	AREA_AM [Path Class]	PROX_AM	PROX_AM [Path Class]	CONNECT	CONNECT [Path Class]	COHESION	COHESION [Path Class]
Run_1	Wet scenario; 150 km in three days; 20º turn angle; cost map-2 (roughness) with normal scaling; all perennial and seasonal water bodies.																			
Min	2	1664	10199	47.7971	4717	39	29249500	241833	45.67	2755.55	170868.2	55.19	0.0064	0.007	5182	2619.663	73.6737	74.0056	99.8803	99.9249
Max	6	1664	10557	49.0522	5168	59	32046090	365851	47.55	2846.94	176535.3	56.99	0.007	0.0074	9948	4832.677	74.4237	79.8335	99.8996	99.9339
Mean	3.7	1664	10305.4	48.1976	5002.	48	31022330	297641	46.37	2807.20	174071.2	56.20	0.00675	0.00719	7278	3591.396	74.06493	76.58844	99.89101	99.9281
Std. error	0.495535	0	36.6082	0.12194	46.40	1.68	287735.6	10458	0.178	9.36999	581.0208	0.184	6.87184E-05	4.06885E-05	476	253.2112	0.08726276	0.6881662	0.001979251	0.000851535
Stand. dev	1.567021	0	115.7653	0.38563	146.7	5.33	909899.7	33071	0.563	29.6305	1837.349	0.583	0.000217307	0.000128668	1505	800.724	0.2759491	2.176173	0.00625894	0.002692789
95% +/-	1.121		82.5	0.2755	105	3.81	651000	23660	0.403	21.2	1315	0.417	0.0001555	9.2E-05	1076	572.8	0.197	1.5565	0.004	0.002
N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Run_2	Present-day wet scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; permanent springs (+hydrothermal) major rivers, perennial rivers, saline lakes, perennial wetlands, and fresh lakes.																			
Min	11	935	5322	26.8003	2382	43	14770470	266637.4	14.0531	1721.088	106722.4	34.8385	0.0082	0.0014	3349.775	1607.645	70.0161	79.0909	99.8366	99.6255
Max	17	935	5523	27.4832	2504	53	15526980	328646.1	16.3565	1758.848	109063.9	35.5819	0.0085	0.0018	5680.048	4952.547	71.8227	89.258	99.8588	99.7128
Mean	13.6	935	5430.7	27.16322	2430	46.7	15068110	289580.6	15.04826	1739.594	107869.9	35.20564	0.00842	0.0016	4232.159	3605.783	70.96984	85.8662	99.84932	99.67257
Std. error	0.6	0	19.85898	0.0765512	12.50866	1.183685	77564.59	7339.878	0.2045157	4.520855	280.3323	0.08968132	2.90593E-05	3.65148E-05	239.7338	315.1601	0.1947095	0.9426458	0.002123823	0.008224112
Stand. dev	1.897367	0	62.79959	0.2420761	39.55587	3.743142	245280.8	23210.73	0.6467356	14.2962	886.4886	0.2835973	9.18937E-05	0.00011547	758.1047	996.6238	0.6157256	2.980908	0.006716117	0.02600692
95% +/-	1.357		44.9	0.173	28.3	2.678	175500	16600	0.4625	10.2	630	0.203	6.57E-05	8.26E-05	542.35	712.95	0.4405	2.1325	0.0045	0.0185
N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Supplementary Table 2: Continued.

	Network Numbers	Nodes	Edges	% Path by Area	NP - Total	NP-Paths	PD	PD [Path Class]	LPI-Path	TE [Path Class]	ED [Path Class]	LSI	AREA_AM	AREA_AM [Path Class]	PROX_AM	PROX_AM [Path Class]	CONNECT	CONNECT [Path Class]	COHESION	COHESION [Path Class]
Run_3	Present-day scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.																			
Min	36	1423	7360	10.6608	1590	22	9859382	136419.1	2.7947	895.36	55520.1	18.6754	0.0126	0.0003	1657.192	264.8213	69.5816	67.3333	99.8283	99.1715
Max	45	1423	7695	10.9226	1704	29	10566280	179825.2	4.7081	940.544	58321.9	19.5696	0.0126	0.0005	2135.501	2109.173	72.7804	78.6325	99.8442	99.3901
Mean	41.18182	1423	7497.091	10.79555	1656.727	25.81818	10273150	160095.2	4.383609	918.368	56946.8	19.12879	0.0126	0.000454546	1889.233	981.5265	71.31398	74.43701	99.83795	99.32158
Std. error	0.7724598		29.11652	0.02554877	12.15139	0.6152336	75349.16	3814.983	0.1657019	4.426748	274.4969	0.08746044	0	2.07305E-05	57.57262	157.2008	0.3461581	0.9476671	0.001550036	0.01837311
Stand. dev	2.561959		96.56858	0.0847357	40.30159	2.040499	249904.9	12652.87	0.549571	14.68186	910.4032	0.2900735	0	6.87552E-05	190.9468	521.3761	1.148076	3.143056	0.005140888	0.0609367
95% +/-	1.721		64.9	0.0565	27.05	1.371	168000	8505	0.3692	9.865	611.5	0.195	0	0.00004619	128.25	350.27	0.771	2.112	0.003	0.041
N	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Run_4	Dry scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; 23ka permanent springs low flow rivers and fresh lakes.																			
Min	34	563	2792	3.1442	440	26	2728382	161222.6	0.888	277.408	17201.71	6.5309	0.015	0.0001	395.3072	3.6466	78.3896	69.8851	99.8544	98.0315
Max	45	563	2947	3.2999	510	33	3162443	204628.7	1.0574	301.408	18689.92	7.0031	0.0151	0.0001	545.2174	61.0123	82.5537	77.5132	99.8648	98.2058
Mean	39.6	563	2868.8	3.24589	482	29.6	2988819	183545.7	0.98136	293.6032	18205.95	6.84925	0.01502	0.0001	475.5652	33.77266	80.01442	74.11673	99.85791	98.1179
Std. error	1.0873	0	15.28456	0.01603512	6.492731	0.718022	40260.58	4452.36	0.01909467	2.407098	149.261	0.04737585	1.33333E-05	4.51751E-21	13.96711	7.591681	0.3902411	0.900199	0.000966489	0.01950178
Stand. dev	3.438346	0	48.33402	0.05070752	20.53182	2.270585	127315.1	14079.6	0.06038264	7.611912	472.0047	0.1498156	4.21637E-05	1.42856E-20	44.16789	24.007	1.234051	2.846679	0.003056305	0.06167005
95% +/-	2.46	0	34.6	0.0363	14.69	1.624	91100	-92000	0.043215	5.445	338	0.10715	3E-05	0	31.595	17.1735	0.8825	2.0365	0.002	0.044
N	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Supplementary Table 3: Main model runs used, bold text highlights the significant difference between each run.

Run_1	**Wet scenario; 150 km in three days; 20º turn angle; cost map-2 (roughness) with normal scaling; all perennial and seasonal water bodies.**
Run_2	**Present-day wet scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; permanent springs (+hydrothermal) major rivers, perennial rivers, saline lakes, perennial wetlands, and fresh lakes.**
Run_3	**Present-day scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.**
Run_4	**Dry scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; 23ka permanent springs low flow rivers and fresh lakes.**
Run_5	Dry scenario; 150 km in three days; 20º turn angle; cost map-2 roughness with normal scaling; 23ka permanent springs **(+hydrothermal)** low flow rivers and fresh lakes.
Run_6	Present-day scenario; 150 km in three days; 20º turn angle; **cost map 1 (slope)** with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run_7	Present-day scenario; 150 km in three days; 20º turn angle; **cost map 3 (relief + roughness**) with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run_8	Present-day scenario; 150 km in three days; 20º turn angle; **cost map 4 (relief+ slope)** with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run-9	Present-day scenario; 150 km in three days; 20º turn angle; **cost map 5 (slope + roughness)** with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run_10	Present-day scenario; 150 km in three days; 20º turn angle; **cost map zero (no cost)** with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run_11	Present-day scenario; **180 km in three days**; 20º turn angle; cost map 2 (roughness) with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run_12	Present-day scenario; **120 km in three days**; 20º turn angle; cost map 2 (roughness) with normal scaling; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run_13	Present-day scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with **low scaling;** permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run_14	Present-day scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with **very low scaling**; permanent springs (+hydrothermal) major rivers, saline lakes, perennial wetlands, and fresh lakes.
Run_15	Present-day scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; **permanent springs (+hydrothermal) only**.
Run_16	Present-day scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; **saline lakes and fresh lakes only.**
Run_17	Present-day scenario; 150 km in three days; 20º turn angle; cost map 2 (roughness) with normal scaling; **major rivers only.**

Supplementary Table 4: Metric definitions.

Metrics	Description
Network Types	Classification of sub-network types [Matlab output]
Network Numbers	Total number of sub-networks [Matlab output]
Nodes	Number of nodes [Matlab output]
Edges	Number of edges between nodes [Matlab output]
% PATH by Area	Percentage landcover patch area containing successful routes [PATH; Fragstats output]
NP -Total	Total number of landcover patches [PATH and Non-PATH; Fragstats output]
NP-PATH	Total number of landcover patches [PATH only; Fragstats output]
PD	Total patch density all types [PATH and Non-PATH; Fragstats output]
PD [PATH Class]	Total patch density of patches contains successful routes [PATH only; Fragstats output]
LPI [PATH Class]	Larges patch index for patches containing successful routes [PATH only; Fragstats output]
TE [PATH Class]	Total edge length of patches containing successful routes [PATH only; Fragstats output]
ED [PATH Class]	Total edge density of patches containing successful routes [PATH only; Fragstats output]
LSI	Landscape shape index [PATH and Non-PATH; Fragstats output]
AREA_AM	Area-weighted mean patch size [PATH and Non-PATH; Fragstats output]
AREA_AM [PATH Class]	Area-weighted mean patch size [PATH only; Fragstats output]
PROX_AM [PATH Class]	Area-weighted mean proximity index [PATH only; Fragstats output]
CONNECT	Patch connectance index [PATH and Non-PATH; Fragstats output]
CONNECT [Path Class]	Patch connectance index [PATH only; Fragstats output]
COHESION	Patch cohesion index [PATH and Non-PATH; Fragstats output]
COHESION [Path Class]	Patch cohesion index [PATH only; Fragstats output]

Supplementary Table 5: Typical network metrics and Fragstat output for selected model runs, showing the impact of different costing and scaling scenarios. See Supplementary Table 3 for the run definitions and Supplementary Table 4 for description of the metrics.

Run ID	Network #	Nodes	Edges	% Path by Area	NP - Total	NP-Paths	PD	PD [Path Class]	LPI-Path	TE [Path Class]	ED [Path Class]	LSI	AREA_AM	AREA_AM [Path Class]	PROX_AM	PROX_AM [Path Class]	CONNECT	CONNECT [Path Class]	COHESION	COHESION [Path Class]
Run_5	40	563	2792	3.1836	451	26	2796592	161223	0.9315	306.496	19005	7.1033	0.0151	0.0001	490.524	34.7232	81.3094	80.9231	99.8604	98.0503
Run_6	151	1423	4725	3.3536	569	262	3528295	1624628	0.5343	350.784	21751	7.9707	0.015	0	310.2586	17.1406	70.7462	73.8323	99.8671	95.1152
Run_7	116	1423	5726	4.2208	543	120	3367072	744104	0.497	417.312	25876	9.2771	0.0147	0	483.8752	73.9674	75.4266	70.7423	99.8625	96.8689
Run_8	145	1423	4905	3.6225	548	208	3398076	1289781	0.6143	360.032	22325.1137	8.1524	0.0149	0	310.057	43.0555	70.6599	70.5732	99.8659	95.9574
Run-9	120	1423	5363	3.4614	446	167	2765588	1035545	0.3105	366.912	22751.7335	8.2875	0.015	0	274.0212	57.3465	74.7198	69.7208	99.8728	94.9773
Run_10	3	1423	9631	87.0912	10212	4	6.3E+07	24803.5	87.0887	1813.73	112466.9022	36.449	0.0123	0.014	125.3557	7.9998	68.3978	100	99.8687	99.9909
Run_11	80	1423	6514	5.7147	703	82	4359211	508471	1.1163	522.72	32413.1839	11.3454	0.0142	0.0001	832.146	237.7534	76.4149	67.9012	99.8546	98.1108
Run_12	126	1423	5490	3.4211	462	153	2864802	948733	0.1776	368.8	22868.8059	8.3246	0.015	0	332.7373	63.669	74.2088	69.0488	99.8688	94.8065
Run_13	36	1423	7559	10.8873	1693	22	1E+07	136419	4.6923	931.2	57742.4947	19.3785	0.0126	0.0005	1886.1834	710.0526	72.8022	74.8918	99.8413	99.3703
Run_14	15	1423	9703	24.3934	4454	8	2.8E+07	49607	24.265	1751.23	108591.607	35.5047	0.0073	0.0039	8385.3464	282.2207	74.3005	78.5714	99.822	99.8665
Run_15	80	356	2094	1.5587	192	38	1190567	235633	0.5227	85.024	5272.2271	2.745	0.0156	0	225.3965	12.2607	68.2153	74.3954	99.8943	97.31
Run_16	42	107	210	0.3848	46	29	285240	179825	0.0473	36.48	2262.0771	1.7897	0.016	0	10.392	4.7789	68.6347	67.734	99.9471	91.4097
Run_17	7	865	5249	2.5892	286	14	1773449	86812.2	0.7697	228.96	14197.5103	5.5749	0.0153	0.0001	270.1602	72.5317	83.5359	71.4286	99.8803	98.141

Supplementary Table 6: Typical network metrics and Fragstat output for selected model runs, showing the impact of different costing and scaling scenarios. All results are statistically different at 95% except for those indicated with *.

Metrics	Run_1 [N=10]		Run_2 [N=10]		Run_3 [N=11]		Run_4 [N=10]	
	Mean	95% +/-	Mean	95% +/-	Mean	95% +/-	Mean	95% +/-
Network Numbers	3.7	1.121	13.6	1.357	41.18182*	1.721*	39.6*	2.46*
Edges	10305.4	82.5	5430.7	44.9	7497.091	64.9	2868.8	34.6
% Path by Area	48.19762	0.2755	27.16322	0.173	10.79555	0.0565	3.24589	0.0363
NP -Total	5002.9	105	2430	28.3	1656.727	27.05	482	14.69
PD	3100000	651000	1510000	175500	10273150	168000	2988819	91100
LPI-Path	46.37813	0.403	15.04826	0.4625	4.383609	0.3692	0.98136	0.043215
TE [Path Class]	2807.206	21.2	1739.594	10.2	918.368	9.865	293.6032	5.445
ED [Path Class]	174071.2	1315	107869.9	630	56946.8	611.5	18205.95	338
LSI	56.20748	0.4175	35.20564	0.203	19.12879	0.195	6.84925	0.10715
AREA_AM	0.00675	0.0001555	0.00842	6.57E-05	0.0126	0	0.01502	3E-05
PROX_AM	7278.063	1076.95	4232.159	542.35	1889.233	128.25	475.5652	31.595
PROX_AM [Path Class]	3591.396	572.8	3605.783	712.95	981.5265	350.27	33.77266	17.1735
CONNECT [Path Class]	76.58844	1.5565	85.8662	2.1325	74.43701	2.112	74.11673	2.0365
COHESION [Path Class]	99.9281	0.002	99.67257	0.0185	99.32158	0.041	98.1179	0.044