

Supplementary Materials for 'Forest cover change and the effectiveness of Protected Areas in Himalayas since 1998'

Table S1. Statistics of the 108 PAs in Himalaya. Name, type and built year were specified by NAME, IUCN_CAT and STATUS_YEAR, respectively

FID	NAME	DESIG	DESIG_TY PE	IUCN_C AT	REP_AR EA	GIS_AR EA	STATUS_ YR	GOV_TYPE	MANG_AUTH
0	Biological Corridor 1	Biological Corridor	National	VI	149	150.3096	1999	Federal national or ministry or agency	Department of Forests and Park Services
1	Sakteng	Wildlife Sanctuary	National	IV	741	744.9259	1993	Federal national or ministry or agency	Department of Forests and Park Services
2	Jigme Singye Wangchuck	National Park	National	II	1730	1740.43	1995	Federal national or ministry or agency	Department of Forests and Park Services
3	Royal Manas	National Park	National	II	1057	1035.678	1966	Federal national or ministry or agency	Department of Forests and Park Services
4	Khaling	Wildlife Sanctuary	National	IV	334	336.805	1974	Federal national or ministry or agency	Department of Forests and Park Services
5	Phipsoo	Wildlife Sanctuary	National	IV	269	270.6314	1993	Federal national or ministry or agency	Department of Forests and Park Services
6	Bumdeling	Wildlife Sanctuary	National	IV	1521	1528.7	1995	Federal national or ministry or agency	Department of Forests and Park Services

7	Biological Corridor 8	Biological Corridor	National	VI	720	939.1009	1999	or agency Federal national ministry	or Department of Forests and Park Services
8	Wangchuck Centennial Park	National Park	National	II	4921	4939.602	2008	or agency Federal national ministry	or Department of Forests and Park Services
9	Biological Corridor 2	Biological Corridor	National	VI	275	277.0269	1999	or agency Federal national ministry	or Department of Forests and Park Services
10	Biological Corridor 7	Biological Corridor	National	VI	79	79.4944	1999	or agency Federal national ministry	or Department of Forests and Park Services
11	Biological Corridor 4	Biological Corridor	National	VI	501	503.474	1999	or agency Federal national ministry	or Department of Forests and Park Services
12	Biological Corridor 6	Biological Corridor	National	VI	160	160.8812	1999	or agency Federal national ministry	or Department of Forests and Park Services
13	Biological Corridor 3	Biological Corridor	National	VI	376	378.0877	1999	or agency Federal national ministry	or Department of Forests and Park Services
14	Biological Corridor 5	Biological Corridor	National	VI	212	212.8632	1999	or agency Federal national ministry	or Department of Forests and Park Services
15	Jigme Dorji	National	National	II	4316	4338.361	1974	or agency Federal	or Department of Forests and Park

		Park						national ministry or agency	Services
16	Thrumshingla	National Park	National	II	905	910.4804	1998	Federal national ministry or agency	Department of Forests and Park Services
17	Torsa	Strict Nature Reserve	National	Ia	609	613.0339	1993	Federal national ministry or agency	Department of Forests and Park Services
18	Raksham Chitkul	Sanctuary	National	IV	34.11	29.6246	1962	Not Reported	Not Reported
19	Khangchendzo nga	National Park	National	II	1784	1798.294	1977	Sub-national ministry agency	Chief Wildlife Warden, State Forest Department
20	Corbett	National Park	National	II	520.8	574.057	1936	Sub-national ministry agency	Chief Wildlife Warden, State Forest Department
21	Limber	Sanctuary	National	IV	26	11.24065	1987	Sub-national ministry agency	Chief Wildlife Warden, State Forest Department
22	Kedarnath	Sanctuary	National	IV	975.24	971.7332	1972	Sub-national ministry agency	Chief Wildlife Warden, State Forest Department
23	Govind Pashu Vihar	Sanctuary	National	IV	485.89	599.0555	1955	Sub-national ministry agency	Chief Wildlife Warden, State Forest Department
24	Renukaji	Sanctuary	National	IV	4.02	41.66527	1964	Sub-national	Chief Wildlife Warden, State

								ministry agency	or	Forest Department
25	Khokhan	Sanctuary	National	IV	22.45	17.44175	1954	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
26	Itanagar	Sanctuary	National	IV	140.3	186.038	1978	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
27	Pakke (Pakhui)	Sanctuary	National	IV	861.95	858.4723	1977	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
28	Sonai-Rupai	Sanctuary	National	IV	220	163.702	1998	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
29	Simbalbara	Sanctuary	National	IV	19.03	163.3549	1958	Not Reported		Not Reported
30	Gamgul Siahbehi	Sanctuary	National	IV	124	90.22727	1962	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
31	Tundah	Sanctuary	National	IV	64.22	106.5646	1962	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
32	Manali	Sanctuary	National	IV	32	98.78882	1954	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
33	Dachigam	National Park	National	II	141	333.1638	1981	Sub-national ministry	or	Chief Wildlife Warden, State Forest Department

34	Kugti	Sanctuary	National	IV	414	511.3638	1962	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
35	Kishtwar	National Park	National	II	425	1521.896	1981	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
36	Shri Nainadevi	Sanctuary	National	IV	123	38.96101	1982	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
37	Nargu	Sanctuary	National	IV	318	286.3923	1962	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
38	Shikari Devi	Sanctuary	National	IV	72	77.21388	1962	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
39	Bandli	Sanctuary	National	IV	41.32	12.88442	1962	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
40	Gobindsagar	Sanctuary	National	IV	100.34	179.0798	1962	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
41	Majathal	Sanctuary	National	IV	57.55	23.92697	1954	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
42	Daranghati	Sanctuary	National	IV	176.12	33.1389	1962	agency Sub-national		Chief Wildlife Warden, State

								ministry agency	or	Forest Department
43	Shilli	Sanctuary	National	IV	2.13	2.01395	1963	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
44	Shimla Water Catchment	Sanctuary	National	IV	10.25	36.40374	1958	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
45	Talra	Sanctuary	National	IV	46	36.05815	1962	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
46	Darlaghat	Sanctuary	National	IV	6	115.6079	1962	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
47	Kanawar	Sanctuary	National	IV	121.79	80.9031	1954	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
48	Chail	Sanctuary	National	IV	109	126.8039	1976	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
49	Tirthan	Sanctuary	National	IV	61.12	61.79479	1992	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
50	Lachipora	Sanctuary	National	IV	80	79.76844	1987	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department

51	Mahananda	Sanctuary	National	IV	127.22	160.9536	1976	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
52	Great Himalayan	National Park	National	II	754.5	744.7835	1962	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
53	Neora Valley	National Park	National	II	88	92.72931	1992	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
54	Rupi Bhaba	Sanctuary	National	IV	738	857.8752	1982	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
55	Baltal-Thajwas	Sanctuary	National	IV	210.5	149.3182	1987	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
56	Overa-Aru	Sanctuary	National	IV	425	456.0403	1981	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
57	Hirapora	Sanctuary	National	IV	110	120.0515	1987	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
58	Fambong Lho	Sanctuary	National	IV	51.76	68.38626	1984	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
59	Gulmarg	Sanctuary	National	IV	180	126.297	1987	Sub-national ministry	or	Chief Wildlife Warden, State Forest Department

60	Askot Deer	Musk	Sanctuary	National	IV	599.93	224.0852	1986	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
61	Sonanadi		Sanctuary	National	IV	301.18	196.9338	1987	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
62	Kais		Sanctuary	National	IV	14.19	12.16441	1954	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
63	Kyongnosla Alpine		Sanctuary	National	IV	31	19.53793	1977	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
64	Nameri		Sanctuary	National	IV	75.6	88.73771	1985	Not Reported		Not Reported
65	Singalila		National Park	National	II	78.6	78.38895	1992	Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
66	Maenam		Sanctuary	National	IV	35.34	42.93714	1987	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
67	Churdhar		Sanctuary	National	IV	66	77.91351	1985	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department
68	Govind		National Park	National	II	472.08	495.3745	1990	agency Sub-national ministry	or	Chief Wildlife Warden, State Forest Department

69	Eagle Nest	Sanctuary	National	IV	217	216.1938	1989	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
70	Sessa Orchid	Sanctuary	National	IV	100	99.64866	1989	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
71	Mouling	National Park	National	II	483	436.7957	1986	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
72	Barsey Rhododendron	Sanctuary	National	IV	104	138.1825	1998	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
73	Kane	Sanctuary	National	IV	31	54.84326	1991	Sub-national ministry agency	or	Chief Wildlife Warden, State Forest Department
74	Makalu-Barun - Buffer Zone	□□□□□□ □□	National	VI	830	782.7542	1999	Federal national ministry or agency	or	Department of National Parks and Wildlife Conservation (DNPWC)
75	Kanchanjunga	□□□□□□ □□□□□□	National	VI	2035	2044.916	1998	Local communities		Department of National Parks and Wildlife Conservation (DNPWC)
76	Dhorpatan	□□□□□ □□□□□	National	VI	1325	1196.808	1987	Federal national ministry or agency	or	Department of National Parks and Wildlife Conservation (DNPWC)
77	Chitwan Buffer Zone	- □□□□□□ □□	National	VI	750	732.6649	1996	Federal national ministry	or	Department of National Parks and Wildlife Conservation

78	Chitwan	□□□□□□ □□□□□□ □□□	National	II	932	1217.694	1973	or agency Federal or national ministry or agency	(DNPWC) Department of National Parks and Wildlife Conservation (DNPWC)
79	Parsa	□□□□□□ □□□□□□ □□□□□□	National	IV	499	559.3702	1984	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
80	Parsa - Buffer Zone	□□□□□□ □□ □□□□□□	National	VI	298.17	299.3581	2005	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
81	Khaptad - Buffer Zone	□□□□□□ □□ □□□□□□	National	VI	216	270.5383	2006	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
82	Khaptad	□□□□□□ □□□ □□□□□	National	II	225	208.4355	1984	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
83	Shey- Phoksundo - Buffer Zone	□□□□□□ □□ □□□□□□	National	VI	1349	1312.829	1998	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
84	Shey- Phoksundo	□□□□□□ □□□ □□□□□	National	II	3555	3611.226	1984	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
85	Suklaphanta - Buffer Zone	□□□□□□ □□ □□□□□□	National	VI	243.5	292.8903	2004	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
86	Suklaphanta	□□□□□□	National	IV	305	393.2275	1976	Federal or	Department of National Parks

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87	Api - Nampa	□□□□□□ □□□□□□	National	VI	1903	1905.284	2010	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
88	Annapurna	□□□□□□ □□□□□□	National	VI	7629	7789.783	1992	Non-profit organisations	Department of National Parks and Wildlife Conservation (DNPWC)
89	Shivapuri-Nagarjun	□□□□□□ □□□	National	II	159	107.755	1985	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
90	Banke - Buffer Zone	□□□□□□ □□	National	VI	343	328.2709	2010	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
91	Krishnasar	□□□□□□ □□□□□□	National	VI	16.95	16.7647	2009	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
92	Salkhala	Wildlife Sanctuary	National	IV	8.1	7.744741	1982	Not Reported	Not Reported
93	Lantang - Buffer Zone	□□□□□□ □□	National	VI	420	469.433	1998	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)
94	Gauri-Shankar	□□□□□□ □□□□□□	National	VI	2179	2214.733	2010	Non-profit organisations	Department of National Parks and Wildlife Conservation (DNPWC)
95	Manaslu	□□□□□□	National	VI	1663	1652.417	1998	Non-profit	Department of National Parks

			□□□□□□						organisations	and Wildlife Conservation (DNPWC)
96	Sagarmatha - Buffer Zone	□□□□□□ □□	National	VI	275	345.388	2002	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)	
97	Sagarmatha	□□□□□□ □□□□	National	II	1148	1136.219	1976	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)	
98	Makalu-Barun	□□□□□□ □□□□	National	II	1500	1393.035	1991	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)	
99	Rara	□□□□□□ □□□□	National	II	106	107.1151	1976	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)	
100	Rara - Buffer Zone	□□□□□□ □□ □□□□□□□	National	VI	198	198.556	2006	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)	
101	Langtang	□□□□□□ □□□ □□□□□	National	II	1710	1664.761	1976	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)	
102	Banke	□□□□□□ □□□ □□□□□	National	II	550	570.0928	2010	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)	
103	Bardia - Buffer Zone	□□□□□□ □□ □□□□□□□	National	VI	507	557.5105	1996	Federal or national ministry or agency	Department of National Parks and Wildlife Conservation (DNPWC)	

104	Bardia	□□□□□□ □□□ □□□□□	National	II	968	899.7583	1976	Federal or national ministry or agency	Department of Wildlife Conservation (DNPWC)	National Parks
105	Haleji	Wildlife Sanctuary	National	IV	3.24	2.82032	1977	Not Reported	Not Reported	
106	Manshi	Wildlife Sanctuary	National	IV	23.21	22.77441	1977	Not Reported	Not Reported	
107	Ayubia	National Park	National	V	16.84	135.4594	1984	Not Reported	Not Reported	

Table S2. The data source and resolution of 8 control variables

Control Variables	Source and resolution
elevation	http://srtm.csi.cgiar.org/srtmdata/,90m
slope	derived from DEM
soil organic carbon	https://www.openlandmap.org/,250m
annual precipitation	https://www.worldclim.org/,1km
annual average temperature	https://www.worldclim.org/,1km
distance to the nearest major road	https://www.globio.info/download-grip-dataset
distance to the nearest major settlement	https://sedac.ciesin.columbia.edu/data/set/grump-v1-settlement-points
distance to the nearest river	https://www.hydrosheds.org/page/hydrorivers

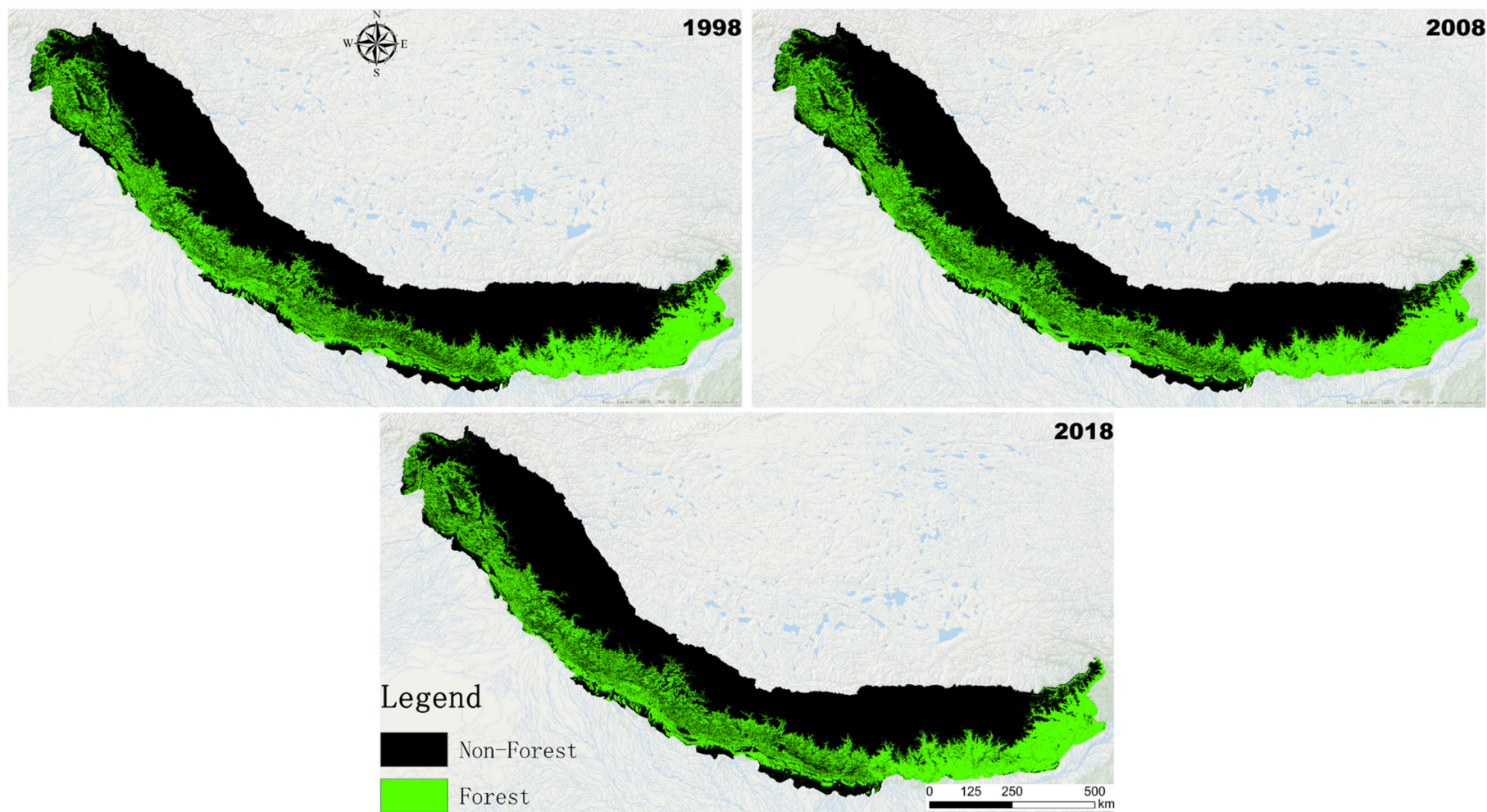


Figure S1. Forest cover map of Himalaya in 1998, 2008 and 2018.

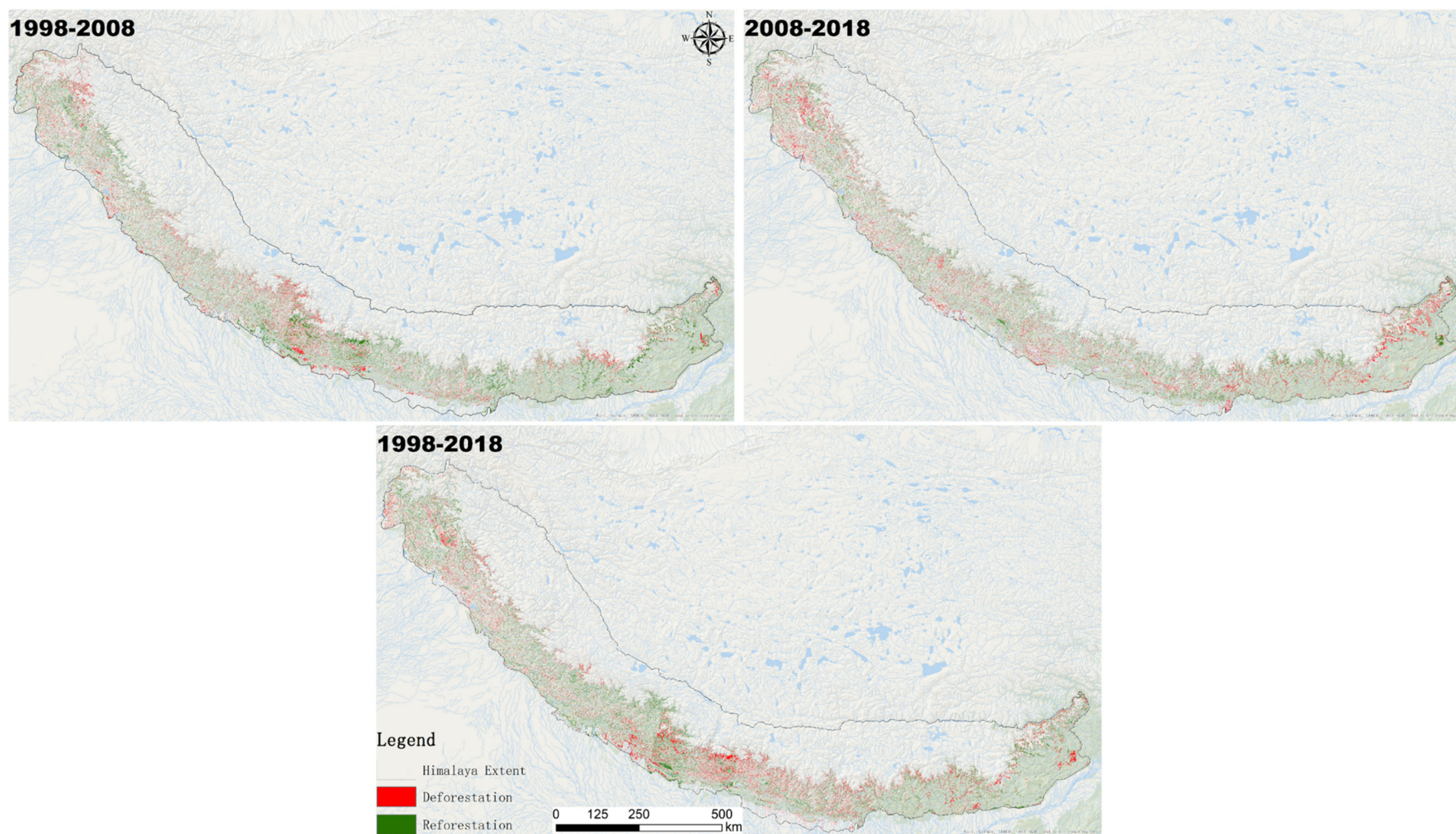


Figure S2. Deforestation and reforestation in three periods of Himalaya

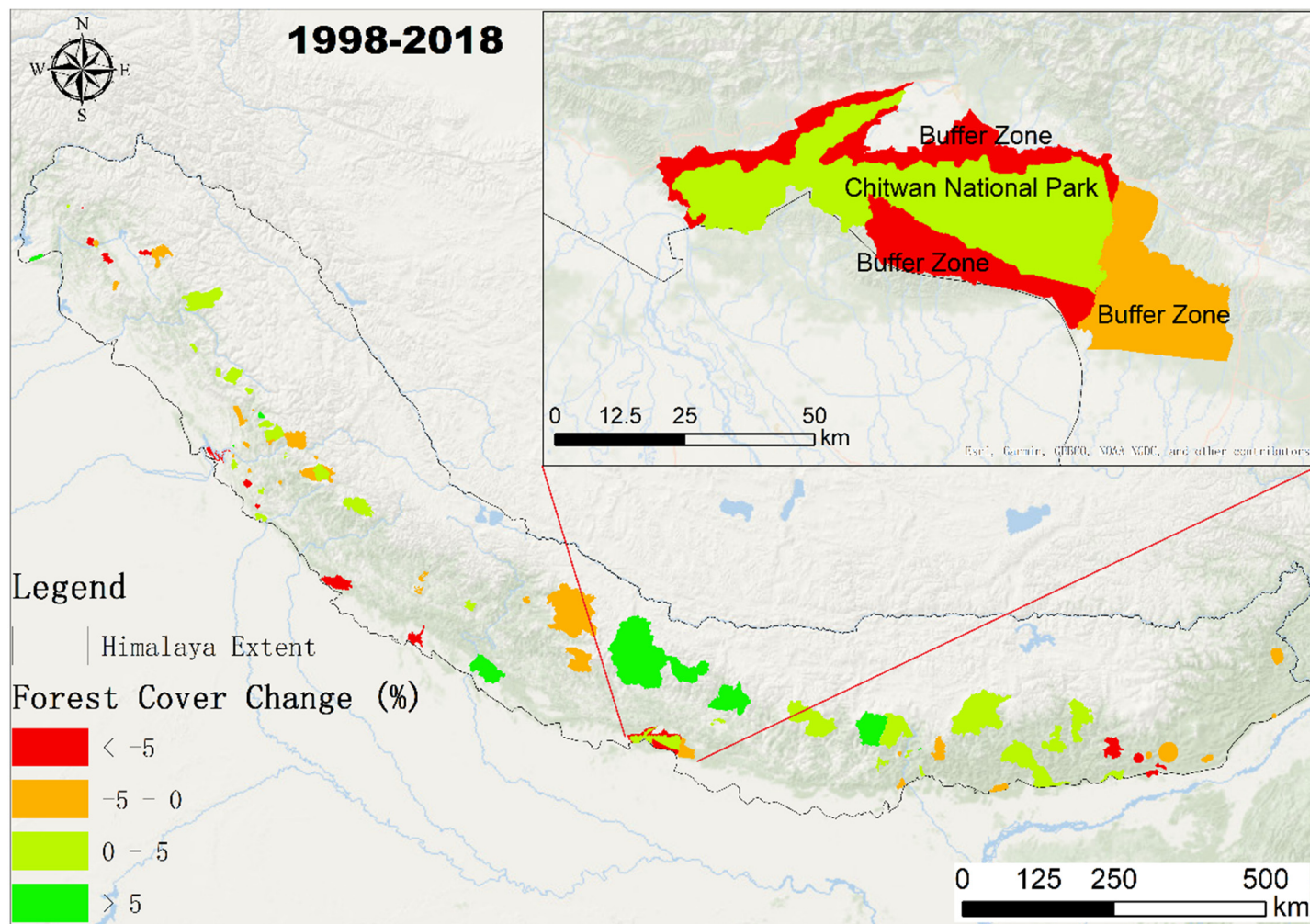


Figure S3. Amplification map of forest cover change in Chitwan National Park

