Llena, M., Simonelli, T., and Brardinoni, F., 2023, Inherited anthropogenic disturbance and decadal sediment dynamics in a mountain fluvial system: The case of the Marecchia River canyon, Northern Apennines: GSA Bulletin, https://doi.org/10.1130/B36720.1.

Supplemental Material

Table S1. Reach-wide, absolute and specific volume variations stratified into aggradation, degradation and net change. Changes in active channel width (ACW) are reported for reference.

Table S2. Reach-wide, absolute and cumulative net change in alluvial storage along the Marecchia River corridor considering volumetric changes above uncertainty thresholds (i.e., thresholded DoD) and considering all changes detected (i.e., raw DoD). Relevant differences between thresholded and raw evaluations are also reported.

Figure S1. Field-based views of: (a) reach 9 (Control 2); (b) reach 13, upstream of the canyon; (c) reach 15, within the canyon; and (d) reach 19, downstream of the canyon. The top panel illustrates the locations within the Marecchia River from which photographs were taken.

Figure S2. Spatial distribution of channel cross sections surveyed in 1994 and 1999 along the Marecchia River main stem. Mean inter-cross sectional distance = 500 m; cross-sectional mean point spacing = 15 m. Numbers refer to channel-reach unique identifiers.

Figure S3. Simplified plan views, imaged on 2019 orthophoto (top) and LiDAR-derived shaded relief (bottom), illustrating how lateral confinement is evaluated over a channel stretch. Given two channel banks, each 1000 m long, a 20% degree of confinement derives from the ratio of the confined channel margins (i.e., 400 m; dotted linework indicates banks confined by anthropogenic structures) to total bank length (2000 m).

Figure S4. Reach-based, 2009-2019 specific volume change (i.e., volume change divided by reach area) associated with bed aggradation, degradation, and the resulting net variation.

Figure S5. 2009-2019 DoD map of reach 21.

Figure S6. 2009-2019 DoD map of Mazzocco Creek.

Figure S7. Plan view of the Mazzocco Creek's distal portion, as imaged on orthophotos taken between 2006 and 2019. Note historical planimetric changes in active channel width.

Figure S8. Plan view of the San Marino Creek's distal portion, as imaged on orthophotos taken between 2006 and 2019. Note limited in-channel room for sediment storage and substantial planimetric channel stability, except close to the confluence with the Marecchia River (i.e., downstream of road SP-258).

Figure S9. Plan view of the sample canyon stretches shown in Figure 14 as seen in optical aerial photos taken in 2009 (left panels) and 2019 (right panels). WC indicates a canyon wall collapse; RL indicates a rotational landslide.

Figure S10. Reach-based, 2009-2019 volume change associated with bed aggradation and degradation, and the resulting net variation, considering: (a) changes above uncertainty thresholds (i.e., thresholded DoD); and (b) all changes (i.e., raw DoD). (c) Reach-based, thresholded (solid black linework) and raw (dashed linework) cumulative change in alluvial storage obtained from DoD analysis.

Llena, M., Simonelli, T., and Brardinoni, F., In review. Inherited anthropogenic disturbance and decadal sediment dynamics in a mountain fluvial system: the case of the Marecchia River canyon, Northern Apennines. *GSA Bulletin.*

SUPPLEMENTARY MATERIAL

Table S1.

Reach-wide, absolute and specific volume variations stratified into aggradation, degradation and net change. Changes in active channel width (ACW) are reported for reference.

Reach	Area (ha)	Volume change (m^3)			Specific volume change (m^3/m^2)			ACW change	
		Aggradation	Degradation	Net change	Aggradation	Degradation	Net change	(m)	%
1	9.76	18,940	20,630	-1,690	0.19	0.21	-0.02	-0.71	-1
2	67.46	180,870	123,290	57,580	0.27	0.18	0.09	-14.26	-9
3	6.74	7,450	4,290	3,160	0.11	0.06	0.05	-2.59	-6
4	25.63	56,310	84,570	-28,260	0.22	0.33	-0.11	-0.25	0
5	15.12	42,860	28,080	14,780	0.28	0.19	0.10	-22.68	-29
6	12.49	16,790	6,370	10,420	0.13	0.05	0.08	-24.53	-32
7	10.41	13,980	24,900	-10,920	0.13	0.24	-0.10	-20.76	-28
8	9.62	10,790	12,130	-1,340	0.11	0.13	-0.01	-15.82	-25
9	131.90	378,840	181,440	197,400	0.29	0.14	0.15	-14.54	-7
10	6.72	19,800	50,160	-30,360	0.29	0.75	-0.45	3.70	8
11	30.69	103,720	83,240	20,480	0.34	0.27	0.07	-6.50	-5
12	48.01	157,460	88,270	69,190	0.33	0.18	0.14	-5.61	-4
13	33.13	78,820	243,010	-164,190	0.24	0.73	-0.50	16.73	15
14	3.51	36,430	556,150	-519,720	0.15	2.25	-2.10	12.86	60
15	24.70	17,040	226,400	-209,360	0.09	1.23	-1.14	12.43	72
16	18.36	57,790	182,030	-124,240	0.26	0.82	-0.56	7.34	26
17	22.21	26,020	50,930	-24,910	0.13	0.26	-0.13	4.32	13
18	19.88	205,710	191,740	13,970	0.29	0.27	0.02	-6.00	-4
19	71.07	203,250	158,430	44,820	0.34	0.26	0.07	25.72	18
20	59.87	210,440	128,490	81,950	0.50	0.30	0.19	14.43	14
21	42.46	38,850	67,600	-28,750	0.28	0.49	-0.21	10.44	26

Table S2.

Reach-wide, absolute and cumulative net change in alluvial storage along the Marecchia River corridor considering volumetric changes above uncertainty thresholds (i.e., thresholded DoD) and considering all changes detected (i.e., raw DoD). Relevant differences between thresholded and raw evaluations are also reported.

	Thresholded DoD		Raw DoD		Difference	
Reach	Change in storage	Cumulative change	Change in storage	Cumulative change	Change in storage	Cumulative change
1	-1.88	-1.88	-1.38	-1.38	-0.50	-0.50
2	61.11	59.23	46.54	45.11	14.57	14.12
3	26.84	86.07	13.05	41.86	13.79	44.22
4	-48.18	37.89	-37.51	29.50	-10.67	8.39
5	21.06	58.95	15.95	44.66	5.11	14.30
6	8.74	67.69	3.78	29.28	4.96	38.41
7	-17.81	49.88	-11.89	33.29	-5.92	16.59
8	-1.92	47.96	-1.03	25.79	-0.89	22.17
9	197.06	245.02	150.98	187.72	46.08	57.30
10	-30.33	214.69	-25.18	178.21	-5.15	36.47
11	20.23	234.91	16.98	197.22	3.25	37.69
12	69.06	303.97	53.33	234.71	15.74	69.26
13	-163.71	140.26	-142.32	121.93	-21.39	18.33
14	-129.75	10.51	-108.69	8.80	-21.06	1.71
15	-28.56	-18.05	-21.96	-13.88	-6.61	-4.18
16	-13.42	-31.48	-11.29	-26.48	-2.13	-5.00
17	2.28	-29.20	1.59	-20.38	0.69	-8.82
18	19.68	-9.52	16.83	-8.14	2.85	-1.38
19	44.49	34.97	38.45	30.22	6.04	4.75
20	82.06	117.03	73.25	104.46	8.81	12.56
21	-28.81	88.22	-22.19	67.96	-6.62	20.27

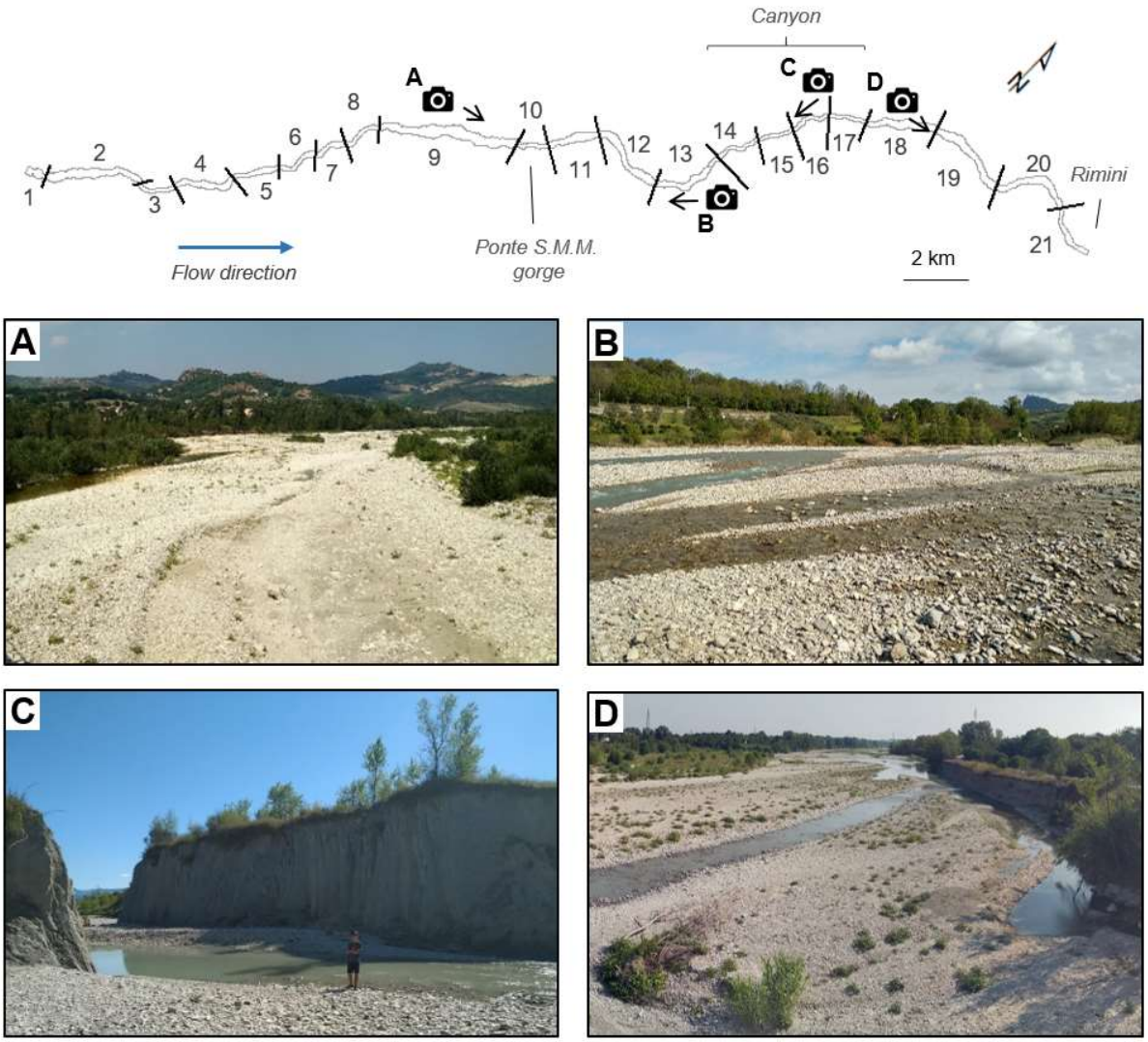


Figure S1.

Field-based views of: (a) reach 9 (Control 2); (b) reach 13, upstream of the canyon; (c) reach 15, within the canyon; and (d) reach 19, downstream of the canyon. The top panel illustrates the locations within the Marecchia River from which photographs were taken.

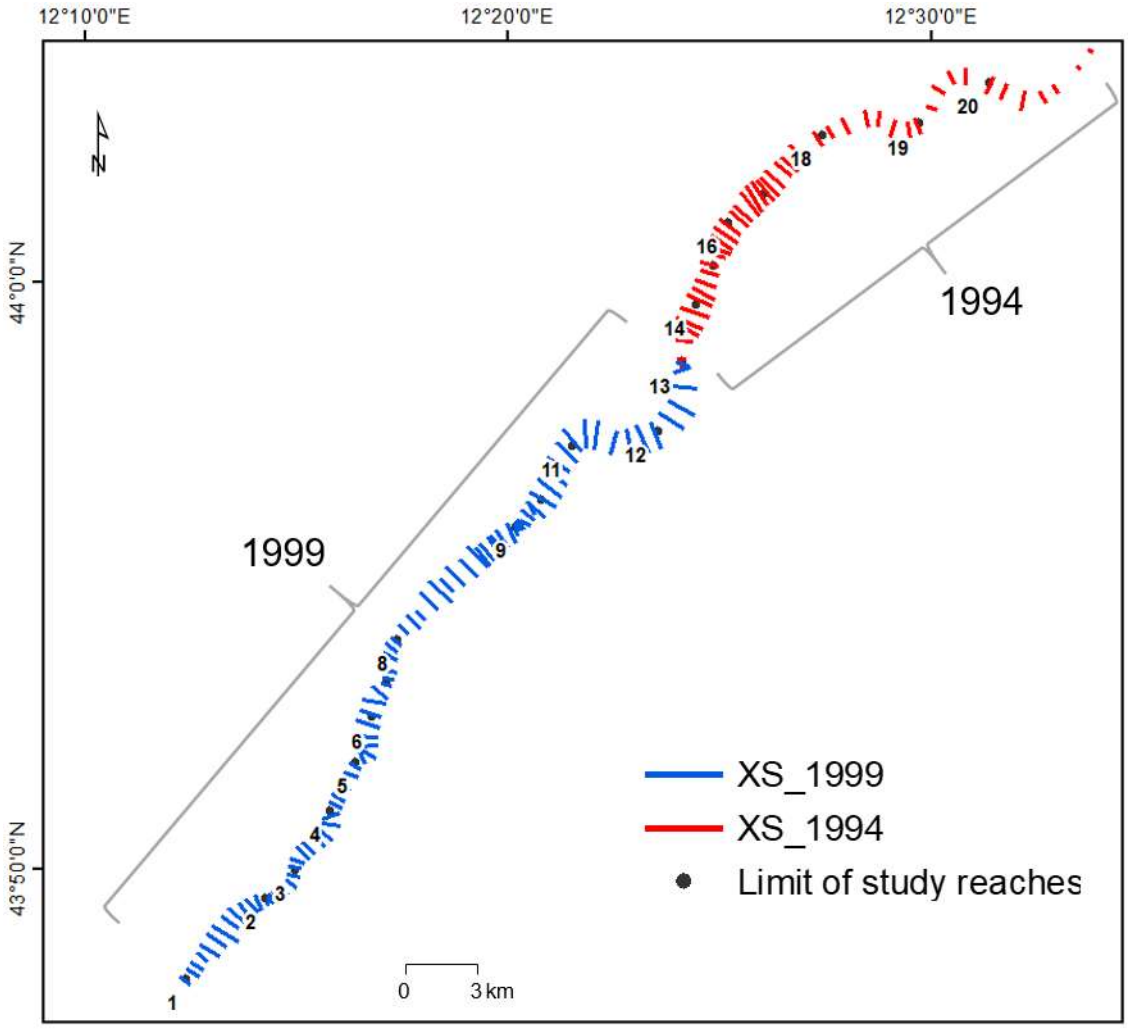
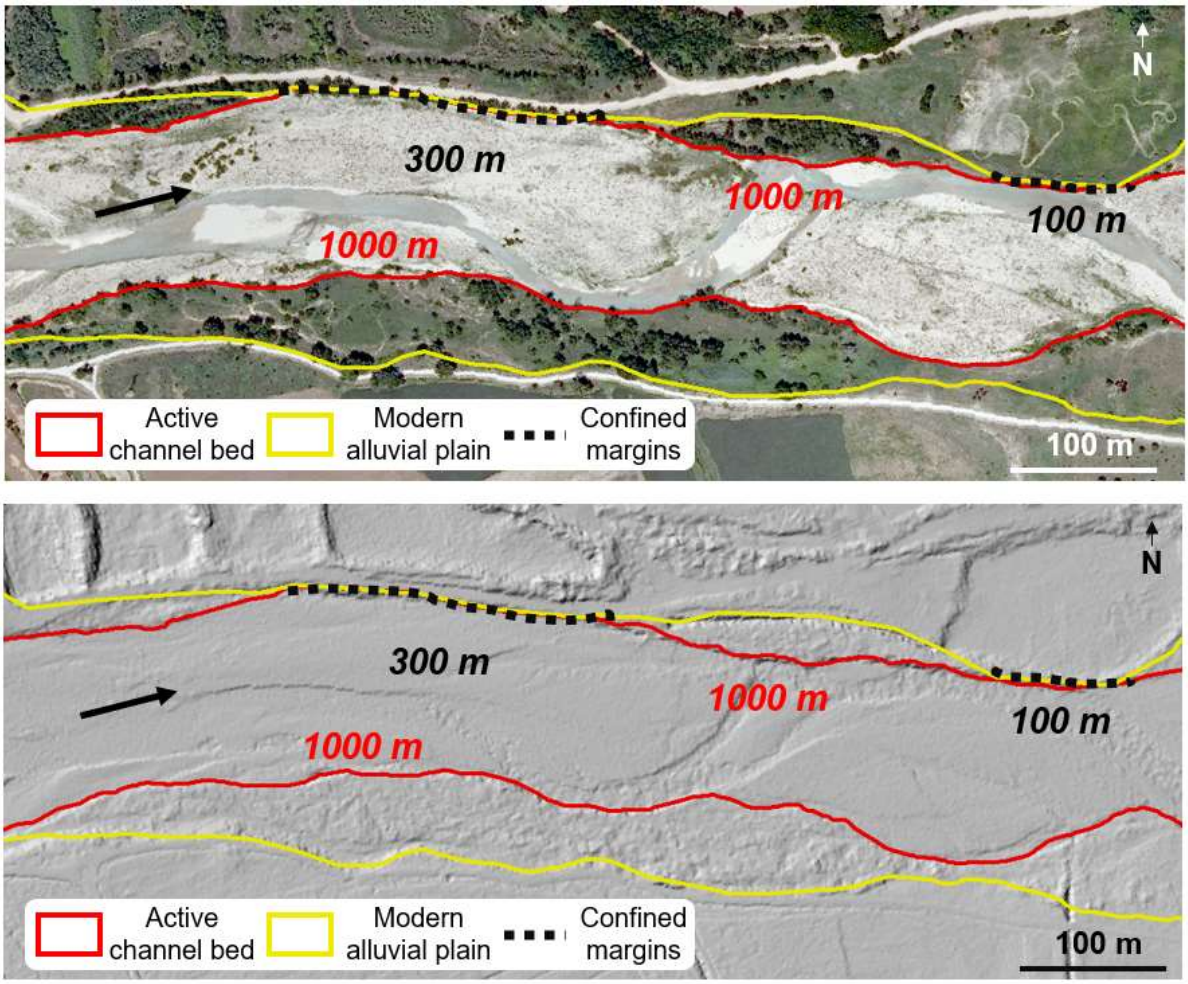


Figure S2.

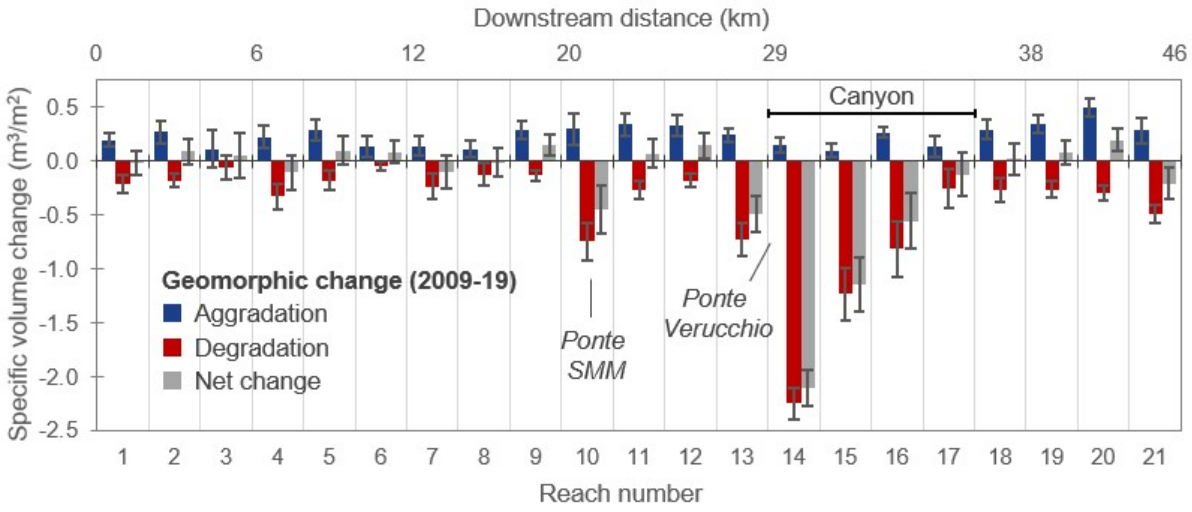
Spatial distribution of channel cross sections surveyed in 1994 and 1999 along the Marecchia River main stem. Mean inter-cross sectional distance = 500 m; cross-sectional mean point spacing = 15 m. Numbers refer to channel-reach unique identifiers.



(300+100) / (1000 + 1000) * 100 = 20 % Degree of confinement

Figure S3.

Simplified plan views, imaged on 2019 orthophoto (top) and LiDAR-derived shaded relief (bottom), illustrating how lateral confinement is evaluated over a channel stretch. Given two channel banks, each 1000 m long, a 20% degree of confinement derives from the ratio of the confined channel margins (i.e., 400 m; dotted linework indicates banks confined by anthropogenic structures) to total bank length (2000 m).



42

43 **Figure S4.**

44 Reach-based, 2009-2019 specific volume change (i.e., volume change divided by reach area) associated with
45 bed aggradation, degradation, and the resulting net variation.

46

47

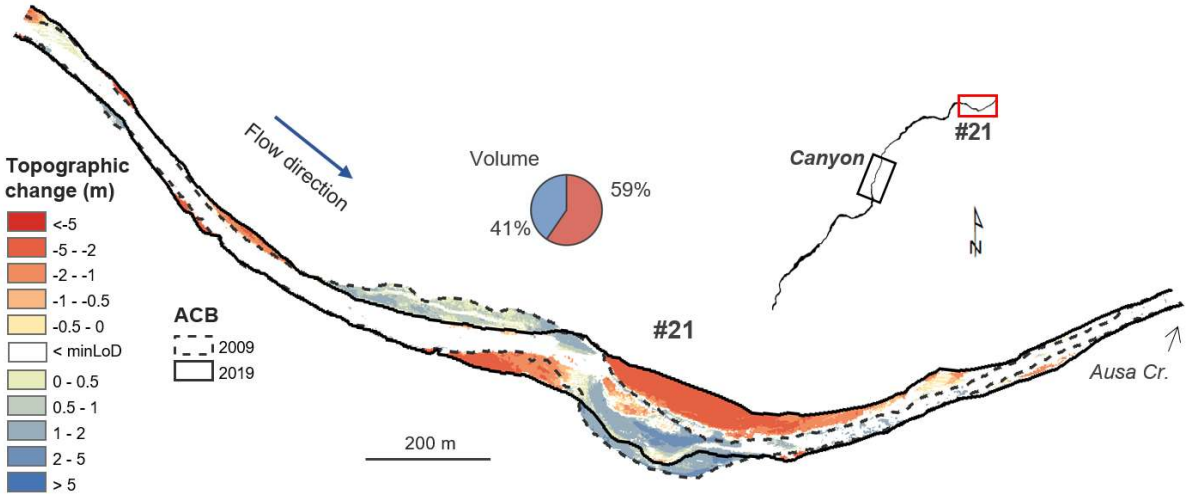


Figure S5.

2009-2019 DoD map of reach 21.

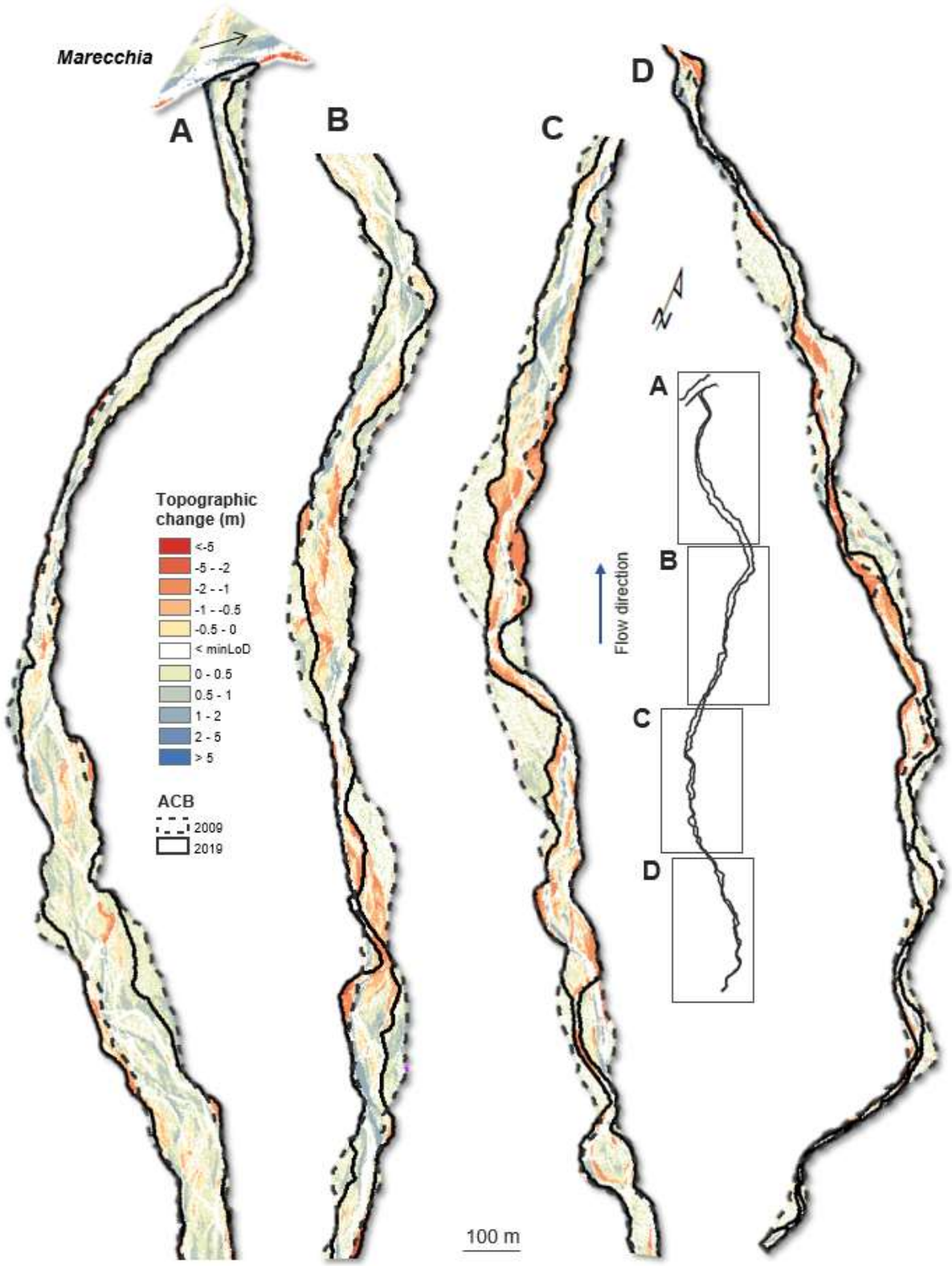


Figure S6.

2009-2019 DoD map of Mazzocco Creek.

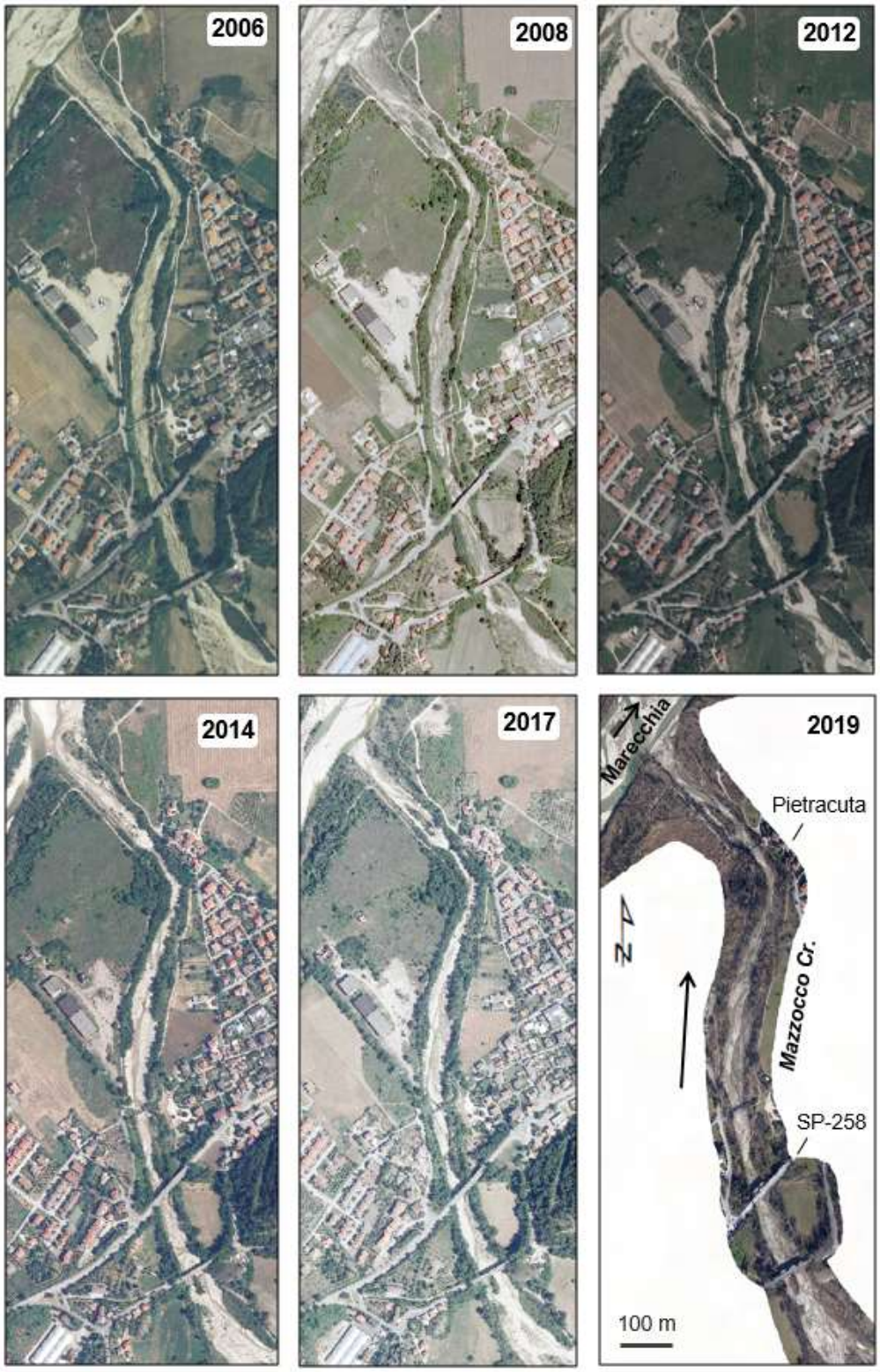


Figure S7.

Plan view of the Mazzocco Creek's distal portion, as imaged on orthophotos taken between 2006 and 2019. Note historical planimetric changes in active channel width.

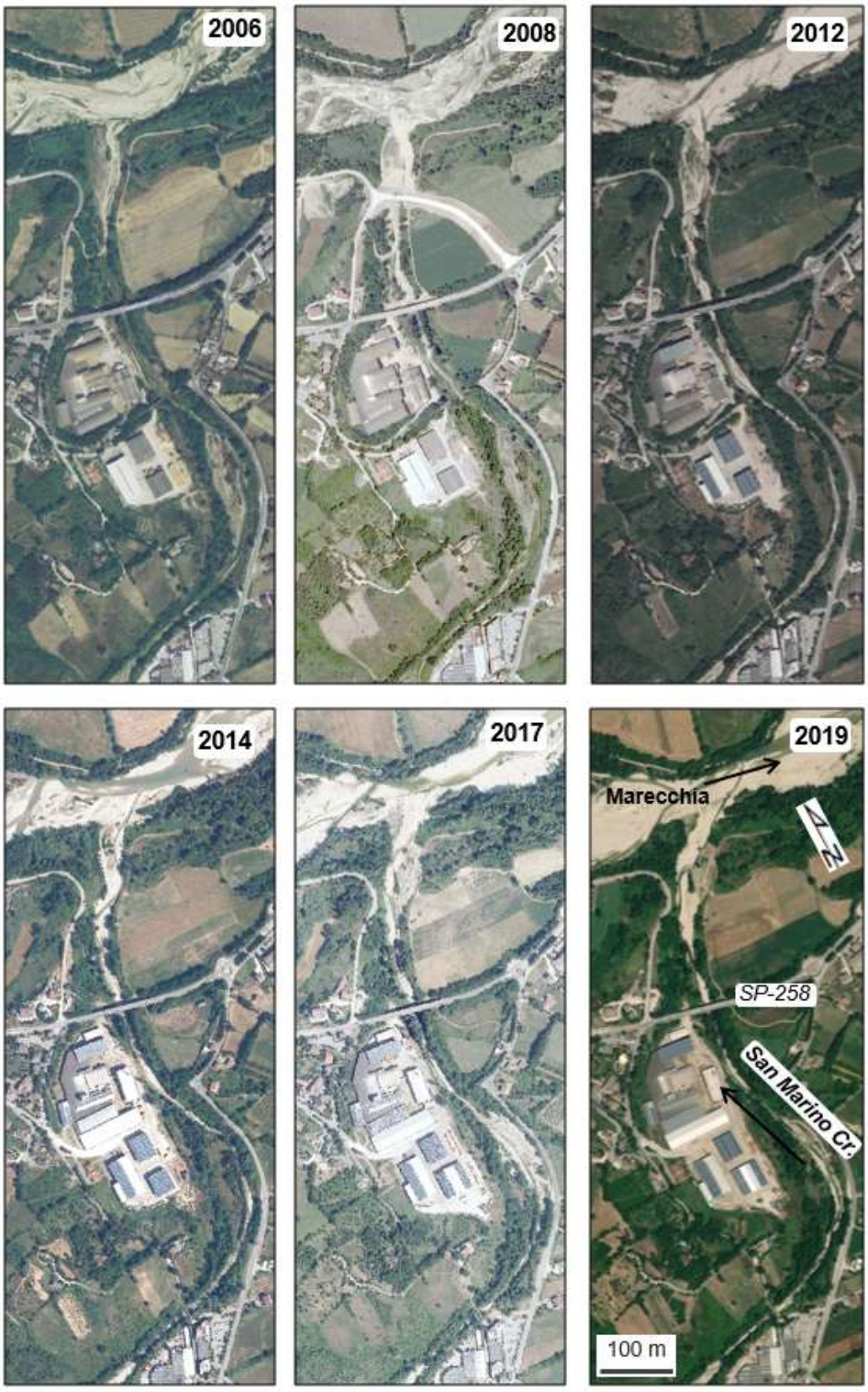


Figure S8.

Plan view of the San Marino Creek's distal portion, as imaged on orthophotos taken between 2006 and 2019. Note limited in-channel room for sediment storage and substantial planimetric channel stability, except close to the confluence with the Marecchia River (i.e., downstream of road SP-258).

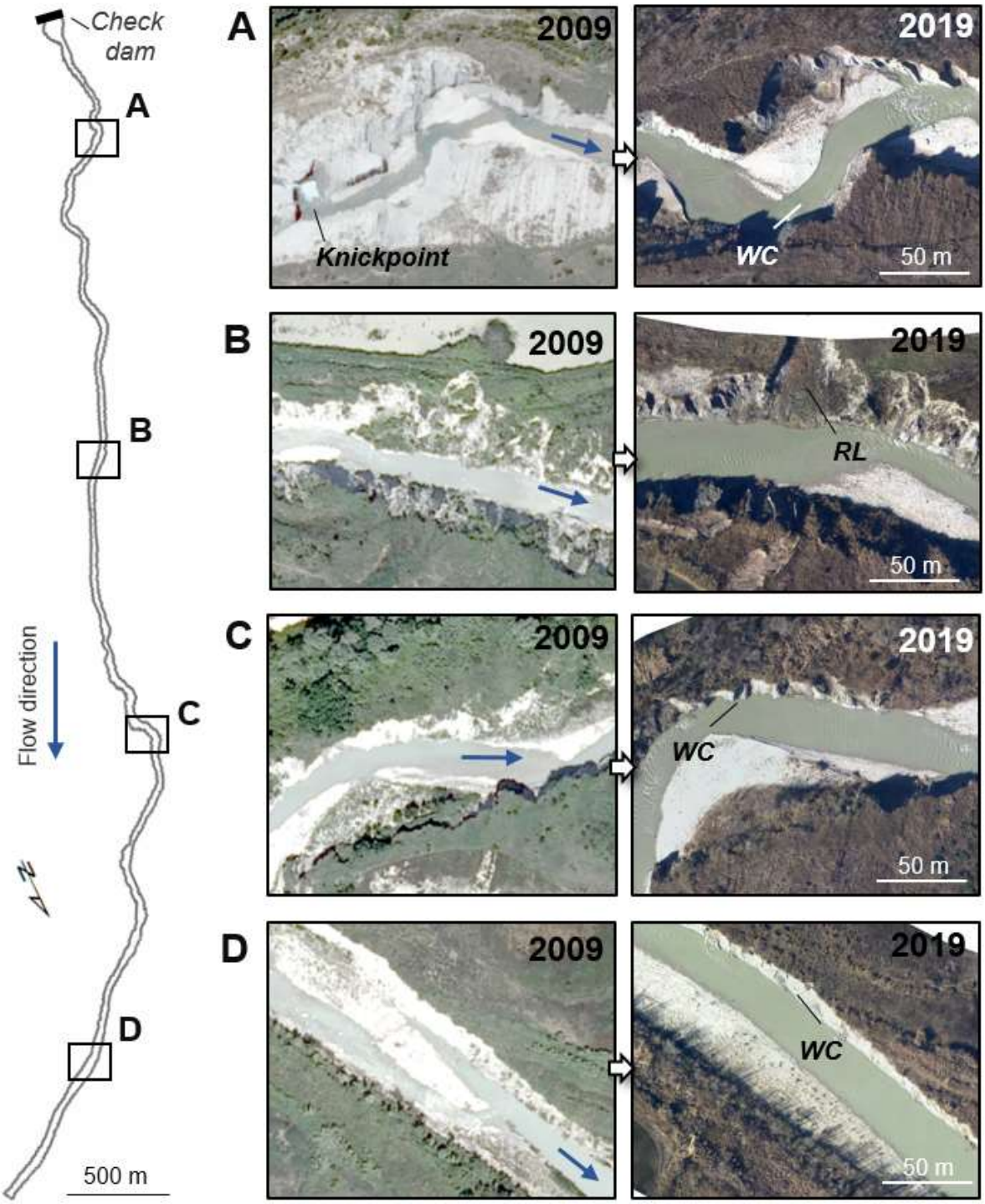


Figure S9.

Plan view of the sample canyon stretches shown in Figure 14 as seen in optical aerial photos taken in 2009 (left panels) and 2019 (right panels). WC indicates a canyon wall collapse; RL indicates a rotational landslide.

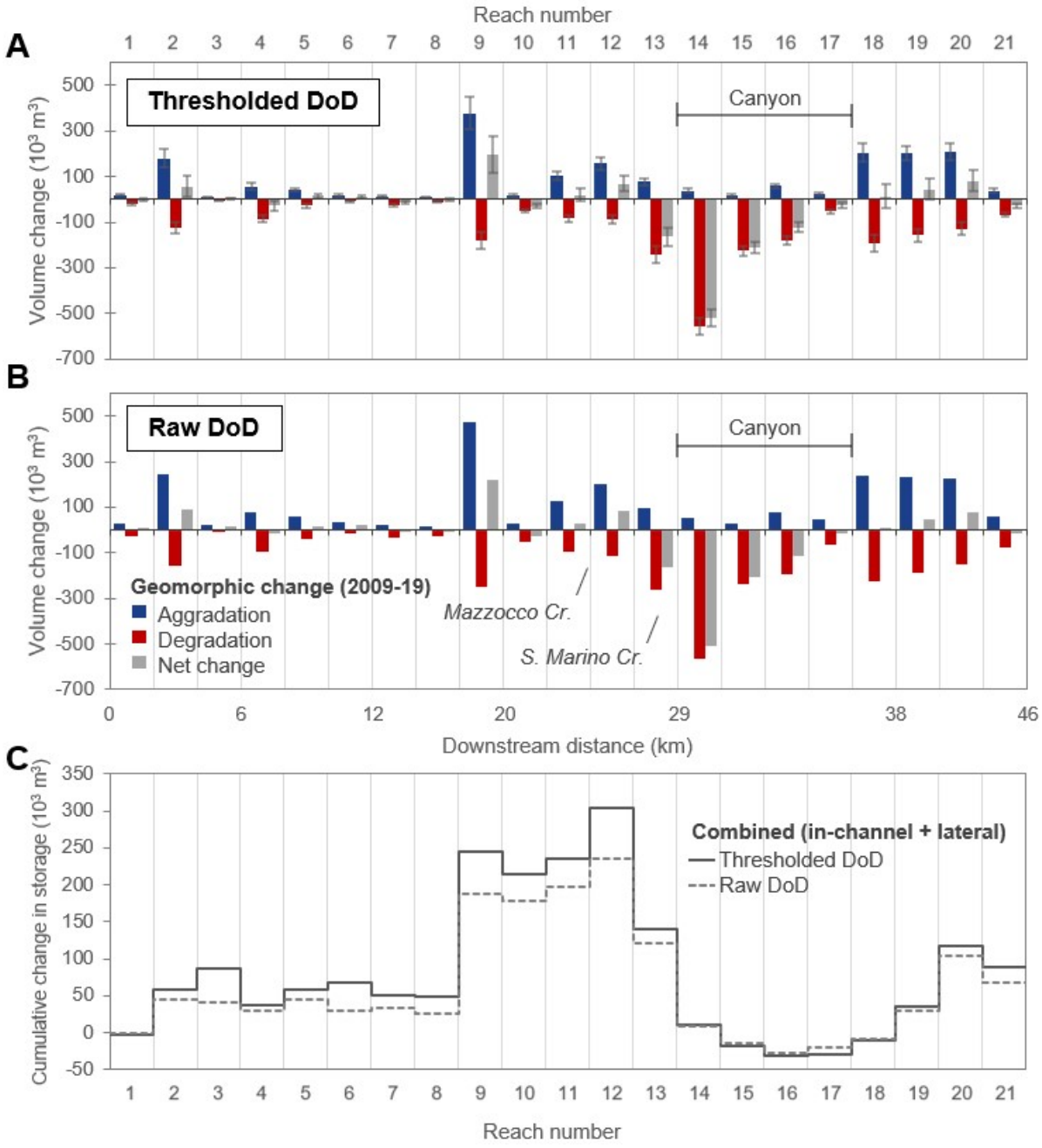


Figure S10.

Reach-based, 2009-2019 volume change associated with bed aggradation and degradation, and the resulting net variation, considering: (a) changes above uncertainty thresholds (i.e., thresholded DoD); and (b) all changes (i.e., raw DoD). (c) Reach-based, thresholded (solid black linework) and raw (dashed linework) cumulative change in alluvial storage obtained from DoD analysis.