



Supplementary Materials

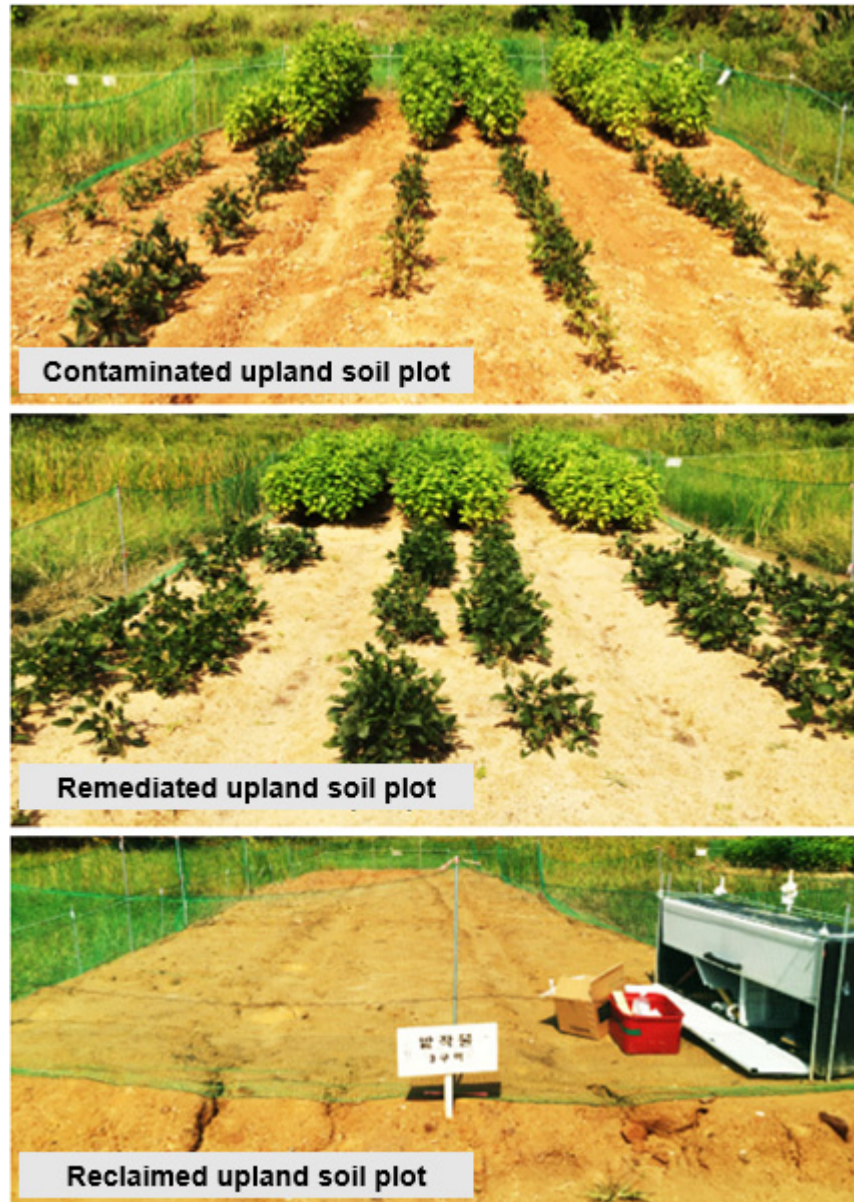


Fig. S1. Upland soil plots (contaminated, remediated, and reclaimed) after crop cultivation.

Table S1. Measurement data of each indicator on reference soil, paddy, and upland soils (contaminated, C; remediated, Rm; reclaimed; Rc).

Indicator (unit)	Reference soil	Paddy soils			Upland soils		
		C	Rm	Rc	C	Rm	Rc
AS (%)	77.1	60.0	60.0	53.0	57.0	54.0	63.0
AvP (mg/kg)	35.0	75.0	388.0	39.0	39.0	244.0	24.0
AvS (mg/kg)	60.9	240.0	229.0	54.0	49.0	294.0	105.0
BD (g/cm ³)	1.5	1.2	1.3	1.4	1.2	1.4	1.2
CEC (Cmol ⁺ /kg)	7.0	23.0	24.0	16.0	8.0	4.0	7.0
E (%)	80.0	90.0	100.0	100.0	85.0	70.0	0.0
EA (CAT) (mL KMnO ₄ /g dry soil)	0.7	1.5	1.2	0.5	0.6	0.2	0.1
EA (UA) (μg NH ₄ /g dry soil)	4.8	2.9	4.3	2.9	0.0	0.2	0.0
EA (βGA) (μg p-nitrophenol/g dry soil)	16.9	2.1	1.1	0.6	0.9	1.2	0.3
EC	0.5	2.8	3.1	0.5	0.9	1.9	20.8
ExC (Ca) (Cmol ⁺ /kg)	5.0	5.1	4.8	3.9	0.8	6.1	8.8
ExC (K) (Cmol ⁺ /kg)	1.4	0.8	1.0	0.4	1.2	0.3	0.5
ExC (Mg) (Cmol ⁺ /kg)	0.3	4.1	4.7	1.5	6.2	7.0	10.6
NR (%)	100.0	41.0	24.0	13.0	12.0	80.0	39.0
OM (g/kg)	4.7	5.2	6.3	6.0	5.8	2.2	5.5
P (B) (%)	100.0	119.0	89.0	126.0	109.0	102.0	0.0
P (R) (%)	100.0	104.0	152.0	114.0	111.0	77.0	0.0
P (S) (%)	100.0	97.0	109.0	112.0	107.0	109.0	0.0
P (W) (%)	100.0	85.0	66.0	118.0	151.0	81.0	0.0
pH	6.2	6.3	6.3	5.3	5.4	7.5	5.4
SAB (Ci) (%)	100.0	23.0	16.0	29.0	12.0	47.0	5.0
SAB (Cr) (%)	100.0	27.0	23.0	7.0	3.0	16.0	0.0
SAP (Ci) (%)	100.0	22.0	14.0	28.0	13.0	46.0	4.0
SAP (Cr) (%)	100.0	21.0	17.0	4.0	2.0	7.0	0.0
TN (mg/kg)	1187.7	733.0	691.0	84.0	384.0	226.0	68.0
TP (mg/kg)	265.1	473.0	563.0	317.0	578.0	572.0	552.0
WHC (ml/g)	0.4	0.7	0.7	0.5	0.5	0.4	0.5

Table S2. Scoring of each indicator on reference soil and each paddy soil plot (contaminated, C; remediated, Rm; reclaimed; Rc).

Paddy plots	With ecotoxicological indicators				Without ecotoxicological indicators			
	Reference soil	Paddy soils			Reference soil	Paddy soils		
		C	Rm	Rc		C	Rm	Rc
AS	0.79	0.64	0.64	0.58	0.79	0.64	0.64	0.58
AvP	0.23	0.37	1.00	0.24	0.23	0.37	1.00	0.24
AvS	0.40	1.00	1.00	0.37	0.40	1.00	1.00	0.37
BD	0.16	0.31	0.27	0.22	0.16	0.31	0.27	0.22
CEC	0.52	1.48	1.00	1.00	0.52	1.00	1.00	1.00
E	0.82	0.91	1.00	1.00	-	-	-	-
EA (CAT)	1.00	1.00	1.00	0.76	1.00	1.00	1.00	0.76
EA (UA)	1.00	0.65	0.91	0.64	1.00	0.65	0.91	0.64
EA (β GA)	1.00	0.21	0.16	0.13	1.00	0.21	0.16	0.13
EC	0.70	0.10	1.00	0.10	0.70	0.10	1.00	0.10
ExC (Ca)	0.74	0.75	0.72	0.61	0.74	0.75	0.72	0.61
ExC (K)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.67
ExC (Mg)	0.24	1.00	1.00	0.79	0.24	1.00	1.00	0.79
NR	1.00	0.47	0.32	0.22	-	-	-	-
OM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
P (B)	1.00	1.00	0.90	1.00	-	-	-	-
P (R)	1.00	1.00	1.00	1.00	-	-	-	-
P (S)	1.00	0.97	1.00	1.00	-	-	-	-
P (W)	1.00	0.87	0.69	1.00	-	-	-	-
pH	1.00	1.00	0.10	1.00	1.00	1.00	0.10	1.00
SAB (Ci)	1.00	0.31	0.24	0.36	-	-	-	-
SAB (Cr)	1.00	0.34	0.31	0.16	-	-	-	-
SAP (Ci)	1.00	0.30	0.23	0.35	-	-	-	-
SAP (Cr)	1.00	0.29	0.25	0.14	-	-	-	-
TN	0.81	0.54	0.51	0.15	0.81	0.54	0.51	0.15
TP	0.34	0.53	0.61	0.39	0.34	0.53	0.61	0.39
WHC	0.61	0.97	0.95	0.74	0.61	0.97	0.95	0.74

Table S3. Results of principal component analysis (PCA) for reference soil and each paddy soil plot.

Paddy plots	With ecotoxicological indicators			Without ecotoxicological indicators		
	PC1	PC2	PC3	PC1	PC2	PC3
Eigenvalue	13.518	6.718	3.764	7.794	6.223	1.983
Percentage of Variance	0.563	0.280	0.157	0.487	0.389	0.124
Cumulative	0.563	0.843	1.000	0.487	0.876	1.000
AS	0.243	0.165	0.071	-0.322	0.169	0.084
AvP	-0.149	0.290	-0.189	0.179	0.280	-0.364
AvS	-0.177	0.254	0.197	0.231	0.292	0.166
BD	-0.237	0.065	0.239	0.317	0.106	0.270
CEC	-0.220	-0.035	0.300	0.355	-0.049	-0.017
E	-0.234	-0.062	-0.250	-	-	-
EA (CAT)	0.056	0.341	0.217	-0.077	0.374	0.203
EA (UA)	0.172	0.263	-0.190	-0.241	0.240	-0.309
EA (β GA)	0.267	0.070	0.034	-0.352	0.065	0.065
EC	0.056	0.320	-0.268	-0.094	0.292	-0.449
ExC (Ca)	0.068	0.301	0.296	-0.089	0.343	0.324
ExC (K)	0.000	0.000	0.000	-0.077	0.374	0.203
ExC (Mg)	-0.269	0.035	0.066	0.354	0.055	0.040
NR	0.252	0.106	0.134	-	-	-
OM	0.000	0.000	0.000	0.000	-0.000	0.000
P (B)	0.123	-0.281	0.265	-	-	-
P (R)	0.000	0.000	0.000	-	-	-
P (S)	0.090	-0.002	-0.487	-	-	-
P (W)	0.172	-0.296	0.054	-	-	-
pH	0.123	-0.281	0.265	-0.143	-0.260	0.461
SAB (Ci)	0.272	0.007	0.003	-	-	-
SAB (Cr)	0.256	0.121	0.062	-	-	-
SAP (Ci)	0.272	0.004	0.006	-	-	-
SAP (Cr)	0.260	0.107	0.051	-	-	-
TN	0.180	0.261	0.166	-0.240	0.281	0.176
TP	-0.212	0.240	0.039	0.272	0.260	-0.048
WHC	-0.235	0.147	0.170	0.310	0.181	0.153

Table S4 Calculated communality and weight values of indicators for reference soil and each paddy soil plot.

Paddy plots	With ecotoxicological indicators			Without ecotoxicological indicators		
	Communality	Weights	Ranking	Communality	Weights	Ranking
AS	0.091	0.030	18	0.139	0.046	13
AvP	0.142	0.047	7	0.243	0.081	3
AvS	0.134	0.045	10	0.166	0.055	10
BD	0.117	0.039	14	0.185	0.062	8
CEC	0.140	0.047	8	0.129	0.043	16
E	0.121	0.040	12	-	-	-
EA (CAT)	0.166	0.055	4	0.187	0.062	6
EA (UA)	0.135	0.045	9	0.211	0.070	5
EA (β GA)	0.077	0.026	22	0.132	0.044	14
EC	0.177	0.059	3	0.296	0.099	2
ExC (Ca)	0.183	0.061	2	0.230	0.077	4
ExC (K)	0.000	0.000	25	0.187	0.062	6
ExC (Mg)	0.078	0.026	21	0.130	0.043	15
NR	0.093	0.031	17	-	-	-
OM	0.000	0.000	25	0.000	0.000	17
P (B)	0.164	0.055	5	-	-	-
P (R)	0.000	0.000	25	-	-	-
P (S)	0.245	0.082	1	-	-	-
P (W)	0.120	0.040	13	-	-	-
pH	0.164	0.055	5	0.300	0.100	1
SAB (Ci)	0.074	0.025	24	-	-	-
SAB (Cr)	0.084	0.028	19	-	-	-
SAP (Ci)	0.074	0.025	23	-	-	-
SAP (Cr)	0.082	0.027	20	-	-	-
TN	0.128	0.043	11	0.167	0.056	9
TP	0.104	0.035	16	0.144	0.048	12
WHC	0.106	0.035	15	0.152	0.051	11

The ranking was determined according to weights.

Table S5 Calculation of soil quality index (SQI) of reference soil and each paddy soil plot (contaminated, C; remediated, Rm; reclaimed; Rc).

Paddy plots	With ecotoxicological indicators				Without ecotoxicological indicators			
	Reference soil	Paddy soils			Reference soil	Paddy soils		
		C	Rm	Rc		C	Rm	Rc
AS	0.024	0.019	0.019	0.018	0.037	0.030	0.030	0.027
AvP	0.011	0.018	0.047	0.011	0.018	0.030	0.081	0.019
AvS	0.018	0.045	0.045	0.017	0.022	0.055	0.055	0.020
BD	0.006	0.012	0.011	0.009	0.010	0.019	0.017	0.014
CEC	0.024	0.069	0.047	0.047	0.022	0.043	0.043	0.043
E	0.033	0.037	0.040	0.040	-	-	-	-
EA (CAT)	0.055	0.055	0.055	0.042	0.062	0.062	0.062	0.047
EA (UA)	0.045	0.029	0.041	0.029	0.070	0.046	0.064	0.045
EA (β GA)	0.026	0.005	0.004	0.003	0.044	0.009	0.007	0.006
EC	0.041	0.006	0.059	0.006	0.069	0.010	0.099	0.010
ExC (Ca)	0.045	0.046	0.044	0.037	0.057	0.058	0.055	0.047
ExC (K)	0.000	0.000	0.000	0.000	0.062	0.062	0.062	0.042
ExC (Mg)	0.006	0.026	0.026	0.021	0.010	0.043	0.043	0.034
NR	0.031	0.014	0.010	0.007	-	-	-	-
OM	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
P (B)	0.055	0.055	0.049	0.055	-	-	-	-
P (R)	0.000	0.000	0.000	0.000	-	-	-	-
P (S)	0.082	0.079	0.082	0.082	-	-	-	-
P (W)	0.040	0.035	0.028	0.040	-	-	-	-
pH	0.055	0.055	0.005	0.055	0.100	0.100	0.010	0.100
SAB (Ci)	0.025	0.008	0.006	0.009	-	-	-	-
SAB (Cr)	0.028	0.010	0.009	0.005	-	-	-	-
SAP (Ci)	0.025	0.007	0.006	0.009	-	-	-	-
SAP (Cr)	0.027	0.008	0.007	0.004	-	-	-	-
TN	0.035	0.023	0.022	0.006	0.045	0.030	0.029	0.008
TP	0.012	0.018	0.021	0.013	0.016	0.025	0.029	0.018
WHC	0.022	0.034	0.033	0.026	0.031	0.050	0.048	0.038
SQI	0.770	0.714	0.716	0.589	0.678	0.673	0.735	0.520

Table S6 Scoring of each indicator on reference soil and each upland soil plot (contaminated, C; remediated, Rm; reclaimed; Rc).

Upland soil plots	With ecotoxicological indicators				Without ecotoxicological indicators			
	Reference soil	Upland soils			Reference soil	Upland soils		
		C	Rm	Rc		C	Rm	Rc
AS	0.79	0.61	0.59	0.67	0.79	0.61	0.59	0.67
AvP	0.23	0.24	0.98	0.19	0.23	0.24	0.98	0.19
AvS	0.40	0.35	1.00	0.63	0.40	0.35	1.00	0.63
BD	0.16	0.31	0.19	0.34	0.16	0.31	0.19	0.34
CEC	0.52	0.58	0.34	0.52	0.52	0.58	0.34	0.52
E	0.91	0.87	0.73	0.10	-	-	-	-
EA (CAT)	0.38	0.82	0.41	0.25	0.38	0.82	0.41	0.25
EA (UA)	0.31	0.10	0.14	0.10	0.31	0.10	0.14	0.10
EA (βGA)	0.79	0.15	0.17	0.11	0.79	0.15	0.17	0.11
EC	0.70	0.10	1.00	0.10	0.70	0.10	1.00	0.10
ExC (Ca)	0.74	0.21	0.89	1.00	0.74	0.21	0.89	1.00
ExC (K)	1.00	1.00	0.61	0.85	1.00	1.00	0.61	0.85
ExC (Mg)	0.24	1.00	1.00	1.00	0.24	1.00	1.00	1.00
NR	1.00	0.21	0.82	0.45	-	-	-	-
OM	1.00	1.00	0.75	1.00	1.00	1.00	0.75	1.00
P (B)	1.00	1.00	1.00	0.10	-	-	-	-
P (R)	1.00	1.00	0.79	0.10	-	-	-	-
P (S)	1.00	1.00	1.00	0.10	-	-	-	-
P (W)	1.00	1.00	0.83	0.10	-	-	-	-
pH	1.00	1.00	0.10	1.00	1.00	1.00	0.10	1.00
SAB (Ci)	1.00	0.21	0.52	0.15	-	-	-	-
SAB (Cr)	1.00	0.13	0.24	0.10	-	-	-	-
SAP (Ci)	1.00	0.22	0.51	0.14	-	-	-	-
SAP (Cr)	1.00	0.12	0.16	0.10	-	-	-	-
TN	0.81	0.33	0.24	0.14	0.81	0.33	0.24	0.14
TP	0.34	0.62	0.61	0.60	0.34	0.62	0.61	0.60
WHC	0.61	0.76	0.59	0.69	0.61	0.76	0.59	0.69

Table S7 Results of principal component analysis (PCA) for reference soil and each upland soil plot.

Upland soil plots	With ecotoxicological indicators			Without ecotoxicological indicators		
	PC1	PC2	PC3	PC1	PC2	PC3
Eigenvalue	13.132	8.403	5.465	8.199	6.875	1.926
Percentage of Variance	0.486	0.311	0.202	0.482	0.404	0.113
Cumulative	0.486	0.798	1.000	0.482	0.887	1.000
AS	0.201	0.161	-0.215	0.256	-0.238	-0.197
AvP	0.003	-0.334	0.108	-0.318	-0.109	0.212
AvS	-0.061	-0.332	-0.068	-0.336	-0.080	-0.123
BD	-0.245	0.159	-0.013	0.037	0.358	-0.238
CEC	-0.018	0.344	0.026	0.313	0.169	-0.012
E	0.192	-0.003	0.307			
EA (CAT)	-0.026	0.116	0.401	0.075	0.190	0.606
EA (UA)	0.267	0.031	-0.098	0.159	-0.338	0.057
EA (β GA)	0.262	0.080	-0.091	0.201	-0.310	0.060
EC	0.166	-0.276	0.013	-0.183	-0.309	0.186
ExC (Ca)	-0.004	-0.179	-0.366	-0.150	-0.168	-0.568
ExC (K)	0.074	0.331	0.037	0.343	0.055	0.083
ExC (Mg)	-0.256	-0.093	0.110	-0.212	0.303	-0.023
NR	0.221	-0.163	-0.158			
OM	0.005	0.338	-0.086	0.325	0.108	-0.171
P (B)	0.173	-0.068	0.323			
P (R)	0.183	0.010	0.320			
P (S)	0.173	-0.068	0.323			
P (W)	0.182	-0.004	0.321			
pH	0.005	0.338	-0.086	0.325	0.108	-0.171
SAB (Ci)	0.271	-0.047	-0.051			
SAB (Cr)	0.267	0.047	-0.091			
SAP (Ci)	0.272	-0.042	-0.044			
SAP (Cr)	0.261	0.075	-0.100			
TN	0.262	0.108	0.000	0.222	-0.274	0.202
TP	-0.249	-0.096	0.139	-0.213	0.302	0.030
WHC	-0.160	0.256	0.144	0.159	0.338	0.072

Table S8 Calculated communality and weight values of indicators for reference soil and each upland soil plot.

Upland soil plots	With ecotoxicological indicators			Without ecotoxicological indicators		
	Communality	Weights	Ranking	Communality	Weights	Ranking
AS	0.112	0.037	14	0.161	0.054	6
AvP	0.123	0.041	8	0.158	0.053	7
AvS	0.119	0.040	12	0.134	0.045	15
BD	0.085	0.028	20	0.186	0.062	3
CEC	0.119	0.040	11	0.127	0.042	17
E	0.131	0.044	7	-	-	-
EA (CAT)	0.175	0.058	1	0.409	0.136	1
EA (UA)	0.082	0.027	23	0.143	0.048	11
EA (β GA)	0.083	0.028	22	0.140	0.047	12
EC	0.104	0.035	16	0.164	0.055	5
ExC (Ca)	0.166	0.055	2	0.374	0.125	2
ExC (K)	0.116	0.039	13	0.128	0.043	16
ExC (Mg)	0.086	0.029	19	0.137	0.046	14
NR	0.100	0.033	17	-	-	-
OM	0.122	0.041	9	0.146	0.049	8
P (B)	0.139	0.046	3	-	-	-
P (R)	0.136	0.045	6	-	-	-
P (S)	0.139	0.046	3	-	-	-
P (W)	0.136	0.045	5	-	-	-
pH	0.122	0.041	9	0.146	0.049	8
SAB (Ci)	0.078	0.026	26	-	-	-
SAB (Cr)	0.082	0.027	24	-	-	-
SAP (Ci)	0.078	0.026	27	-	-	-
SAP (Cr)	0.084	0.028	21	-	-	-
TN	0.080	0.027	25	0.165	0.055	4
TP	0.091	0.030	18	0.137	0.046	13
WHC	0.112	0.037	15	0.144	0.048	10

The ranking was determined according to weights.

Table S9 Calculation of soil quality index (SQI) of reference soil and each upland soil plot (contaminated, C; remediated, Rm; reclaimed; Rc).

Upland soil plots	With ecotoxicological indicators				Without ecotoxicological indicators			
	Reference soil	Upland soils			Reference soil	Upland soils		
		C	Rm	Rc		C	Rm	Rc
AS	0.030	0.023	0.022	0.025	0.043	0.033	0.031	0.036
AvP	0.009	0.010	0.040	0.008	0.012	0.013	0.052	0.010
AvS	0.016	0.014	0.040	0.025	0.018	0.015	0.045	0.028
BD	0.004	0.009	0.005	0.010	0.010	0.019	0.012	0.021
CEC	0.021	0.023	0.013	0.021	0.022	0.024	0.014	0.022
E	0.040	0.038	0.032	0.004	-	-	-	-
EA (CAT)	0.022	0.048	0.024	0.015	0.051	0.111	0.056	0.034
EA (UA)	0.008	0.003	0.004	0.003	0.015	0.005	0.007	0.005
EA (βGA)	0.022	0.004	0.005	0.003	0.037	0.007	0.008	0.005
EC	0.024	0.003	0.035	0.003	0.038	0.005	0.055	0.005
ExC (Ca)	0.041	0.011	0.049	0.055	0.093	0.026	0.110	0.125
ExC (K)	0.039	0.039	0.024	0.033	0.043	0.043	0.026	0.036
ExC (Mg)	0.007	0.029	0.029	0.029	0.011	0.046	0.046	0.046
NR	0.033	0.007	0.027	0.015	-	-	-	-
OM	0.041	0.041	0.030	0.041	0.049	0.049	0.037	0.049
P (B)	0.046	0.046	0.046	0.005	-	-	-	-
P (R)	0.045	0.045	0.036	0.005	-	-	-	-
P (S)	0.046	0.046	0.046	0.005	-	-	-	-
P (W)	0.045	0.045	0.038	0.005	-	-	-	-
pH	0.041	0.041	0.004	0.041	0.049	0.049	0.005	0.049
SAB (Ci)	0.026	0.005	0.014	0.004	-	-	-	-
SAB (Cr)	0.027	0.003	0.007	0.003	-	-	-	-
SAP (Ci)	0.026	0.006	0.013	0.004	-	-	-	-
SAP (Cr)	0.028	0.003	0.005	0.003	-	-	-	-
TN	0.022	0.009	0.006	0.004	0.045	0.018	0.013	0.008
TP	0.010	0.019	0.019	0.018	0.016	0.028	0.028	0.027
WHC	0.023	0.028	0.022	0.026	0.030	0.036	0.028	0.033
SQI	0.743	0.598	0.634	0.408	0.579	0.528	0.572	0.539