Supplementary Materials:

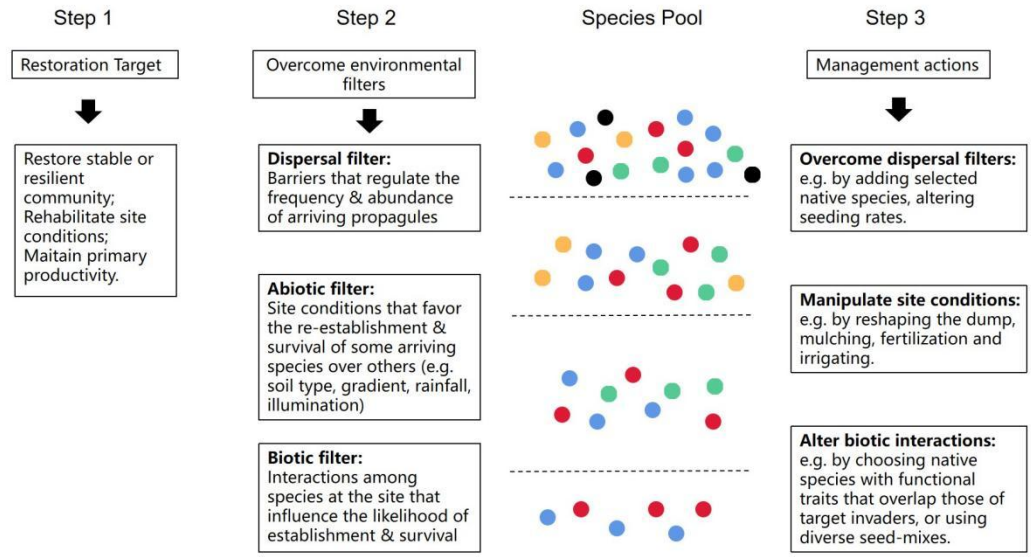


Figure S1. The framework for open-pit coal mine reclamation includes three main steps. Step 1, the reclamation target should be set in advance. Step 2, ecological filters theory used, including dispersal filter, abiotic and biotic filters determined how re-vegetation was established and evolved. Step 3, manipulative actions for reclamation which overcame filters applied to recreate suitable conditions for planting. During the reclamation process, environmental filters can be purposely manipulated to alter the floristic composition of restored sites. Ecological filters (dispersal, abiotic, and biotic) determine how species are sorted from regional species pools and form the local communities. Here, species represented by a black circle have poor dispersal, while species represented by a green circle have poor competitors and cannot overcome the biotic filter.



Figure S2. Re-shaping the dump in the research mining area.

Table S1. Function traits were selected and used for this study.

Trait	Abbreviation	Description	Scale	Function
Plant height	PH	Mean individual height (in cm)	numerical	Competitive ability
Specific leaf area	SLA	Leaf area per dry mass (in mm^2 mg^{-1})	numerical	Competitive ability
Leaf dry matter content	LDMC	Leaf dry mass per leaf fresh mass (in mg g^{-1})	numerical	Competitive ability
Root dry matter content	RDMC	Mean weight of one quadrat (in cm^3 g^{-1})	numerical	Regeneration
Seed mass	SM	Mean weight of one seed (in mg)	numerical	Regeneration
Lifespan	LS	Classes of actual life span: annual or biennial; perennial; shrub or sub-shrub	categorical	Regeneration

Table S2. Basic physical and chemical properties of topsoil (0-10cm) before and after the reclamation of waste dump in open-pit coal mine.

Type	SOM (g/kg)	TN (g/kg)	AP (g/kg)	TK (g/kg)	pH	Seed bank	Soil bulk density(g/cm^3)
original dump soil	0.71	0.13	0.07	1.01	9.69	0	1.51
restored soil	24.47	12.15	1.43	3.12	9.01	0	1.48

Table S3. The sowing species list in the research mine dump.

Life form	Species	Sowing rate	Type of seeding	Row spacing	Time of sowing
Annual and biennial plant	*Brassica rapa*	3.2 kg/ha	Sowing in drill	40cm	2007
	Hordeum vulgare	3.2 kg/ha	Sowing in drill	40cm	2007
	Melilotus suaveolens	3.2 kg/ha	Sowing in drill	40cm	2007
	Avena chinensis	3.2 kg/ha	Sowing in drill	40cm	2007
	Agriophyllum squarrosum	3.2 kg/ha	Sowing in drill	40cm	2007

Perennial plant	*Avena sativa*	3.2 kg/ha	Sowing in drill	40cm	2007
	Bromus catharticus	3.2 kg/ha	Sowing in drill	40cm	2007
	Elymus dahuricus	2.6 kg/ha	Sowing in drill	40cm	2007
	Bromus inermis	2.6 kg/ha	Sowing in drill	40cm	2007
	Poa sphondylodes	2.6 kg/ha	Sowing in drill	40cm	2007
	Astragalus adsurgens	2.6 kg/ha	Sowing in drill	40cm	2007
	Medicago sativa	2.6 kg/ha	Sowing in drill	40cm	2007
	M. falcata	2.6 kg/ha	Sowing in drill	40cm	2007
	Astragalus melilotoides	2.6 kg/ha	Sowing in drill	40cm	2007
	M. ruthenica	2.6 kg/ha	Sowing in drill	40cm	2007
Shrub and sub-shrub	*Caragana microphylla*	6.25 kg/ha	Sowing in drill	40cm	2007
	C. korshinskii	6.25 kg/ha	Sowing in drill	40cm	2012
	Lespedeza davurica	6.25 kg/ha	Sowing in drill	40cm	2007
	Artemisia halodendron	6.25 kg/ha	Sowing in drill	40cm	2007

Figure S3. (A) The layout of 5 research dumps in different directions: North Dump, West Dump, South Dump 2, South Dump, East Dump. (B) Reference sites layout in 8 directions in un-mined grassland area.

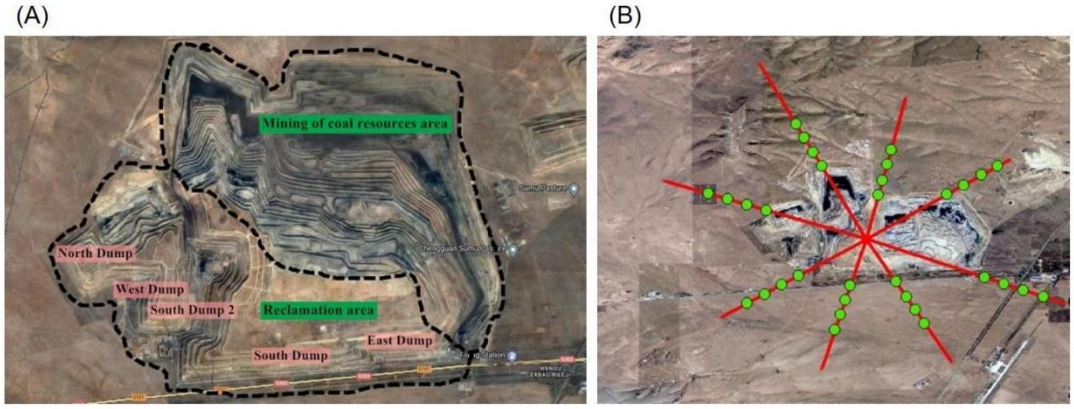


Table S4. The basic information for 5 research dumps in different directions in open-pit mine.

Number	Research dump	Direction	Slope(°)	Slope surface length (m)	Research Plot
1	North Dump	north	28	31	Containing 12 plots with 4 different treatments which repeated 3 times
2	West Dump	west	30	33	Containing 12 plots with 4 different treatments which repeated 3 times
3	South Dump 2	south	30	36	Containing 12 plots with 4 different treatments which repeated 3 times
4	South Dump	south	32	40	Containing 12 plots with 4 different treatments which repeated 3 times
5	East Dump	east	33	37	Containing 12 plots with 4 different treatments which repeated 3 times

Table S5. List of plant species, recorded in the reclamation treatments during the observation period, with un-mined grassland as the reference site. Degree of presence (frequency) is given in classes, showing the percent proportion of plots in which a species occurred: I: < 10 %, II: < 20 %, III: < 40 %, IV: < 65 %, V:＜85 %, Ⅵ:>= 85 %. Species end with "*" means sowing species.

		Species	Species ID	BFS				PBS				SOW				CK				Reference sites
				5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	
Target species	herbs （perennial）	*Melilotus officinalis**	1	.	I	.	I	.	IV	.	I	.	I	.	I	.	.	I	I	.
		*Medicago sativa**	2	IV	II	II	I	V	V	III	I	IV	II	III	I	.	.	I	I	.
		*Astragalus adsurgens**	3	III	IV	V	III	III	Ⅵ	IV	IV	III	III	III	IV	.	.	I	I	I
		*Medicago falcata**	4	IV	I	I	IV	IV	II	II	IV	V	II	.	IV	.	.	.	I	I
		Melilotus albus Medic	5	.	I	I	.	.	I	I	.	.	I	.	I	.	.	.	.	.
		*Bromus inermis Leyss**	6	.	.	.	I	.	I	.	III	.	III	.	II	.	.	.	.	.
		*Caragana microphylla**	7	II	III	IV	IV	I	IV	IV	IV	III	IV	IV	III	.	.	I	I	I
	shrubs	*C. korshinskii**	8	.	.	I	II	.	.	I	II	.	I	.	I	.	.	I	I	.
		*Lespedeza daurica**	9	.	.	II	I	.	.	I	III	.	.	I	.	.	.	.	I	II
	shrub sor sub-	*Kochia prostrata**	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	II
		Artemisia halodendron	11	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	I	II
		Artemisia capillaris	12	.	.	IV	II	.	.	III	II	.	.	IV	II	.	.	.	I	I
		*Artemisia desertorum Spreng**	13	.	.	.	I	.	.	.	I	.	.	.	I	.	.	.	I	.
	native dominant grasses	*Cleistogenes squarrosa*	14	I	II	.	III	I	II	.	III	I	II	.	III	.	.	.	I	Ⅵ
		Stipa grandis	15	.	I	I	III	.	I	I	III	.	I	I	II	.	.	.	I	Ⅵ
		Agropyron cristatum	16	.	I	II	II	.	II	I	III	.	II	I	I	.	.	.	I	III
		Leymus chinensis	17	.	II	I	I	.	II	I	I	.	II	I	I	.	.	.	I	V
		L. secalinus	18	.	.	II	.	.	.	I	.	.	.	I	.	.	.	.	.	.
		*Medicago falcata**	19	.	.	I	I	.	.	.	I	.	.	I	.	.	.	.	.	I
		*Elymus dahuricus**	20	.	II	.	III	.	II	.	I	.	I	.	II	.	.	.	.	I
		E. nutans	21	.	.	.	I	.	.	.	.	.	.	.	I	.	.	.	.	.
		*Astragalus melilotoides**	22	.	I	.	II	.	II	.	II	.	I	.	I	.	.	.	I	I

Continued

		Species	Species ID	BFS				PBS				SOW				Control				Reference sites
				5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	
Non-target species	herbs (annual)	*Chenopodium glaucum*	23	II	.	III	I	.	.	IV	.	.	.	III	I	I	I	II	I	IV
		Chenopodium acuminatum	24	.	II	.	.	.	I	.	.	.	II	.	.	.	.	.	I	I
		Fallopia convolvulus	25	.	II	.	.	.	.	.	.	.	II	.	.	.	.	.	.	.
		Schizonepeta tenuifolia	26	.	.	I	II	.	.	I	I	.	.	I	.	.	.	.	.	.
		Grubovia dasyphylla	27	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		*Agriophyllum squarrosum**	28	V	V	.	.	V	IV	.	.	V	IV	.	.	.	.	.	.	.
		*Avena chinensis**	29	V	.	.	.	IV	.	.	.	V	.	.	.	.	.	.	.	.
		Salsola collina	30	II	II	V	IV	I	IV	V	V	I	I	V	IV	IV	VI	V	III	V
		Chenopodium glaucum	31	.	IV	VI	VI	.	V	V	VI	.	V	V	V	III	V	III	VI	III
		Setaria pumila	32	.	.	.	II	.	.	.	II	.	.	.	I	I	I	II	I	.
		Artemisia sieversiana	33	.	III	III	IV	.	IV	III	V	.	IV	II	III	II	II	II	III	II
		Carpesium abrotanoides	34	.	.	I	.	.	.	II	.	.	.	I	.	.	.	.	.	I
		Chloris virgata	35	.	.	II	IV	.	.	III	IV	.	.	III	IV	.	I	II	II	III
		Neopallasia petinata	36	.	.	.	II	.	.	.	.	.	.	.	I	.	.	.	I	I
		Leonurus artemisia	37	.	.	I	.	.	.	I	.	.	.	I	.	.	.	.	.	.
		Dracocephalum moldavica	38	.	.	.	.	.	.	.	I	.	.	.	I	.	.	.	.	.
		Avena sativa	39	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.	.	.
		Amaranthus tricolor	40	.	I	.	I	.	II	.	.	.	I	.	.	.	.	.	I	.
		Portulaca oleracea	41	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	II
		Eriochloa villosa	42	.	.	.	.	.	.	.	.	.	.	.	I	.	.	.	.	.
		Fagopyrum tataricum	43	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.
		Calystegia hederacea	44	.	I	.	.	.	I	.	.	.	I	.	.	.	.	.	.	.
		Erodium stephanianum	45	.	I	.	I	.	I	.	.	.	I	.	.	.	.	.	.	.
		Eragrostis pilosa	46	.	.	II	III	.	.	II	IV	.	.	II	II	.	.	I	II	III
		Lepidium apetalum	47	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.
		Chenopodium aristatum	48	.	II	I	.	.	II	II	.	.	II	I	I	.	.	II	I	IV
	herbs (perennial)	*Gueldenstaedtia verna*	49	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.
		Cynanchum chinense	50	.	.	.	.	.	.	.	I	.	.	.	.	.	.	.	.	.	.
	forbs	*Blassikakapestris**	51	II	II	II	I	I	II	II	III	IV	I	I	III	.	I	.	I	.

Continued

		Species	Species ID	BFS				PBS				SOW				Control				Reference sites
				5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	5 yr	8 yr	11 yr	14 yr	
Common grassland species	herbs (annual)	*Silene conoidea*	52	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Corispermum mongolicum	53	I	III	I	III	I	III	I	III	.	II	I	I	I	II	I	III	III
	herbs (perennial)	*Elymus sibiricus*	54	.	I	I	.	.	.	I	.	.	I	.	.	.	.	.	.	.
		Asparagus cochinchinensis	55	.	I	.	.	.	II	.	.	.	I	.	.	.	.	.	.	III
		Allium tenuissimum	56	.	I	.	.	.	I	.	.	.	.	.	.	.	.	.	.	III
		Allium ramosum	57	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.	.	III
		Iris tenuifolia	58	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	II
		Astragalus luteolus	59	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Oxytropis hirta	60	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Cymbopogon distans	61	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Plantago major	62	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Artemisia annua	63	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.
		Convolvulus ammannii	64	.	I	.	.	.	III	.	.	.	II	.	.	.	.	.	.	.
		Aster altaicus	65	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	I
		Artemisia argyi	66	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.
		Astragalus galactites	67	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
		Scutellaria scordifolia	68	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Artemisia frigida	69	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Allium bidentatum	70	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
		Allium anisopodium	71	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Carex duriuscula	72	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	IV
		Cymbaria daurica	73	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Allium polyrhizum	74	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Scorzonera austriaca	75	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Potentilla bifurca	76	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Cynanchum thesioides	77	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
	sub-shrub	*Ephedra sinica*	78	.	I	.	.	.	I	.	I	.	.	.	.	.	.	.	.	I
	forbs	*Potentilla tanacetifolia*	79	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
		Parthenocissus tricuspidata	80	.	.	.	I	.	.	.	.	.	.	.	.	.	.	.	.	.
		Phlomis dentosa	81	.	I	.	.	.	I	.	.	.	I	I	.	.	.	.	.	.

Table S6. Linear mixed model test results for differences between reclamation treatments and reference sites for species' diversity, cover, number, richness, height, SLA, LDMC, RDMC and SM. Estimates (Est.) showed the difference for all treatments and the reference site during reclamation chronosequence. Differences among factor treatments, year, and interaction between treatments and time were tested by the Tukey-Kramer multiple comparisons test and are given in the lowercase, the same letters indicate values displayed no significant difference.

							Differences to mean reference for the restoration chronosequence											
	Treatment		Year		Treatment × Year		CK			BFS			PBS			SOW			RFE		
	F	P	F	P	F	P	Est.	P		Est.	P		Est.	P		Est.	P		Est.	P	
Shannon-Diversity	89.47	***	43.10	***	53.26	***	0.032	***	d	0.044	***	b	0.044	***	b	0.042	***	c	0.048	***	a
Species cover(%)	31.99	***	358.40	***	80.85	***	1.374	***	c	1.943	***	a	1.651	***	b	1.651	***	b	2.033	***	a
Target species	38.74	*	119.00	***	39.24	***	1.054	***	d	1.490	***	b	1.489	*	bc	1.231	***	c	1.559	***	a
Non-target species	8.11	***	136.30	***	21.59	***	1.347	***	b	1.347	***	b	1.347	***	b	1.347	***	b	1.409	***	a
Comm. grassland species	5.99	***	21.82	***	18.79	***	0.258	***	c	0.389	***	ab	0.316	***	b	0.258	***	c	0.408	***	a
Species number	85.79	***	52.54	***	64.81	***	0.193	***	d	0.272	***	bc	0.273	***	b	0.264	***	cd	0.300	***	a
Target species	71.94	***	2.91	n.s.	36.28	***	0.094	***	d	0.133	**	b	0.133	**	b	0.129	*	c	0.147	***	a
Non-target species	134.90	**	134.90	***	34.71	***	0.213	***	a	0.187	*	bc	0.187	*	bc	0.156	*	c	0.194	***	b
Comm. grassland species	37.40	**	30.50	***	32.10	***	0.127	***	c	0.166	***	b	0.166	***	b	0.152	*	bc	0.168	***	a
Species richness	68.89	***	69.47	***	44.71	***	14.170	***	b	14.170	***	b	14.170	***	b	14.170	***	b	14.820	***	a
Target species	262.40	***	8.88	***	112.60	***	3.601	***	bc	3.621	***	b	3.621	***	b	3.621	***	b	3.789	***	a
Non-target species	3.02	*	112.90	***	15.36	***	7.348	***	d	10.390	***	ab	10.391	***	a	10.390	***	ab	10.874	***	a
Comm. grassland species	49.94	***	2.55	*	22.80	***	7.225	***	b	7.225	***	b	7.225	***	b	7.225	***	b	7.561	***	a
Height	8.34	***	116.90	***	32.20	***	11.817	***	c	15.780	***	ab	15.780	***	ab	14.637	*	bc	16.210	***	a
Target species	14.32	***	0.16	n.s.	14.73	***	2.853	***	c	5.767	***	a	5.767	***	a	3.562	***	b	4.035	***	ab
Non-target species	10.53	***	29.51	***	37.11	***	2.762	*	bc	3.043	***	b	2.152	***	c	2.152	***	c	4.349	***	a
Comm. grassland species	78.36	***	0.003	***	35.55	**	0.561	***	c	0.792	***	b	0.792	***	b	0.792	***	b	1.132	***	a
SLA	12.69	***	73.29	***	34.67	***	42.800	***	b	60.530	***	a	60.530	***	a	60.530	***	a	60.530	***	a
Target species	13.71	***	24.32	***	16.11	***	12.880	***	c	26.030	***	a	26.030	***	a	18.210	***	b	26.030	***	a
Non-target species	8.03	***	218.50	***	60.50	***	29.360	***	a	20.540	***	b	20.540	***	b	20.540	***	b	20.540	***	b
Comm. grassland species	68.90	***	0.08	n.s.	32.95	***	2.138	***	c	3.024	***	b	3.024	***	b	3.024	***	b	4.323	***	a
LDMC	4.16	*	113.00	***	36.51	***	57.480	***	c	81.280	***	ab	81.280	***	ab	67.580	***	b	81.280	***	a
Target species	60.38	***	25.15	***	37.46	***	6.787	***	c	9.033	***	b	9.033	***	b	8.395	***	bc	12.910	***	a
Non-target species	0.59	n.s.	170.12	***	27.58	**	4.263	***	a	4.263	***	a	4.263	***	a	4.263	***	a	4.263	***	a
Comm. grassland species	72.69	***	0.15	n.s.	37.67	**	1.581	***	c	2.335	***	b	2.335	***	b	2.335	***	b	3.194	***	a
RDMC	141.40	***	12.31	***	102.10	***	31.560	***	c	41.270	***	b	32.750	***	c	40.780	***	bc	45.210	***	a
SM	211.20	***	3.10	n.s.	13.30	n.s.	0.027	***	c	0.036	***	b	0.036	***	bc	0.027	***	c	0.038	***	a