New Experiments in Grassland: REX I, II, LUX

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Acknowledgments

We acknowledge the friendly permission to do these experiments granted by the responsible land owners, land users, and authorities, and the excellent work of all LMTs and of Judith Hinderling, Svenja Kunze and Christoph Zwahlen in establishing these experiments.

Reduced Land-Use Intensity Experiment REX

Question1: Reduced Land-Use Intensity Experiment REX

1a: What are the consequences of a reduced land-use intensity for the diversity and function of grasslands?

1b: Is it necessary to sow additional plant species in order to increase diversity?

1c: Do grasslands with different base-line land use differ in their response to changes in land-use intensity and seed sowing?

Experimental design 1a: REX I

On 15 grassland sites per region, an additional plot of 30 x 30 m was marked, on which land use will be reduced to a minimum, i.e. fertilization will be stopped and it will be mown once a year. This plot is called **RP (reduced land-use intensity plot)** (Fig. 1, Tab. 1).

For the sowing of additional species, a sub-plot of 7 x 7 m was marked. This sub-plot was surface-scarified in autumn 2019 and seeds of new species were sown. Only species were sown that did not already occur on the site (see species list in Appendix 2).

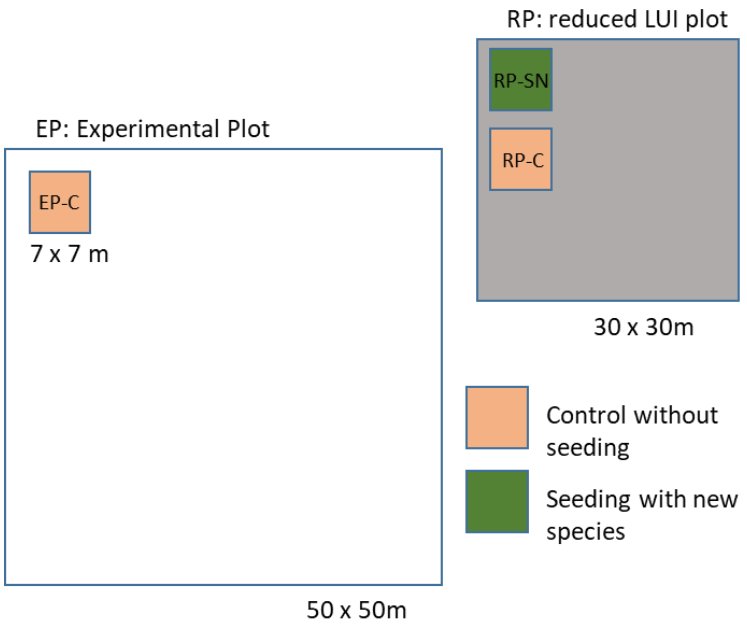


Fig. 1: Design of the reduced land-use intensity experiment REX with control subplots and seeded subplots in the EP und RP, respectively.

Tab. 1: Combinations in the experiment with reduced land use intensity and seed sowing. Normal land use denotes the land use practiced by the farmer on a site i.e. on the EP.

REX I	Sowing of new species	No sowing
normal land use		EP-C
reduced land use	RP-SN	RP-C

Experimental design 1b: REX II

On a sub-set of the 15 grassland sites, additional treatments were established. First, an additional seeded sub-plot was established into which species were sown that already occurred on a given site (called local species). This was done to test whether the introduction of seeds *per se* had an effect on the productivity both on normal and reduced land-use intensity. Second, to test whether sowing of new species has also an effect when land-use intensity was not reduced, a seeded subplot was additionally established on the EP (Fig. 2). Third, because all seeded sub-plots were surface-scraped before sowing, an additional sub-plot was established which was only surface-scraped to test whether this soil-surface treatment has an effect on diversity. Because scraping/scarifying took place in autumn and is expected to have a short-term effect only, it was established only on the RP (Tab. 2)

These additional treatments were established on 16 (4 in Schorfheide and 6 in Alb and 6 in Hainich) of the 45 selected grassland sites. These 16 sites are the same sites as for the land-use experiment (see below).

Attention: Because of mistakenly labelled bags in Alb and Hainich, the same mix of species was sown on the sub-plots with new and local species in REXII. A new sub-plot containing only local species will be established in autumn 2020. The sowing treatments of REXII thus are available from spring 2021.

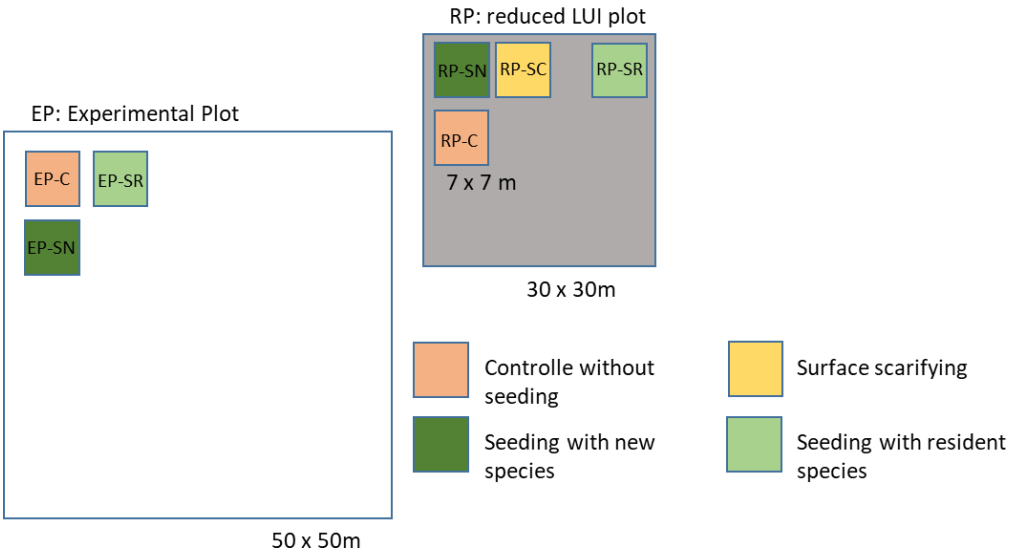


Fig. 2: Design of the reduced land-use intensity experiment REXII with additional treatment to control the effect of sowing and surface scarifying on 4 (Schorfheide) and 6 (in Alb and Hainich) grassland sites.

Tab. 2: Factorial combinations in REXII of a reduction in land-use intensity and seed sowing of new species and local species that were already present on the plot. Additionally, a sub-plot tested the effect of surface scarifying.

REX II	Sowing of new species	Sowing of resident species	No sowing	Surface scarifying
normal land use	EP-SN	EP-SR	EP-C	
reduces land-use intensity	RP-SN	RP-SR	RP-C	RP-SC

Land-Use Experiment (LUX)

Question 2: Land-use experiment (LUX)

What are the consequences of changes in the individual components of land use (mowing, grazing, and fertilization) on diversity and ecosystem function?

Design 2: Land-use experiment

For the land-use experiment, an additional plot of 30 x 30 m was established, where fertilization will stop in 2020, but the other components of land use (mowing, grazing, and other management measures) will continue as normal. Thereby, land use differs from the EP use only in the cessation of fertilization. For this experiment, grassland sites

were chosen which were regularly fertilized by farmers. This new plot is called **UP (unfertilized plot).**

For this experiment, an additional sub-plot of 7 x 7 m was established, on which the fertilization will be done manually, in order to combine the land-use components "fertilization" and "mowing/grazing" factorially (Table 3).

Tab. 3: Factorially combined reduction in mowing/grazing and a reduction in fertilization. Normal mowing/grazing and normal fertilization denotes the land use practiced by the farmer on a site, i.e. on the EP.

LUX	Normal fertilization	no fertilization
normal mowing/grazing	EP-C	UP-C
mown once a year	RP-F	RP-C

This experiment was established on 4 (Schorfheide) and 6 (in Alb and Hainich) grassland sites. For practical reasons, these are the same sites on which the additional sowing treatments were established (see Appendix 1).

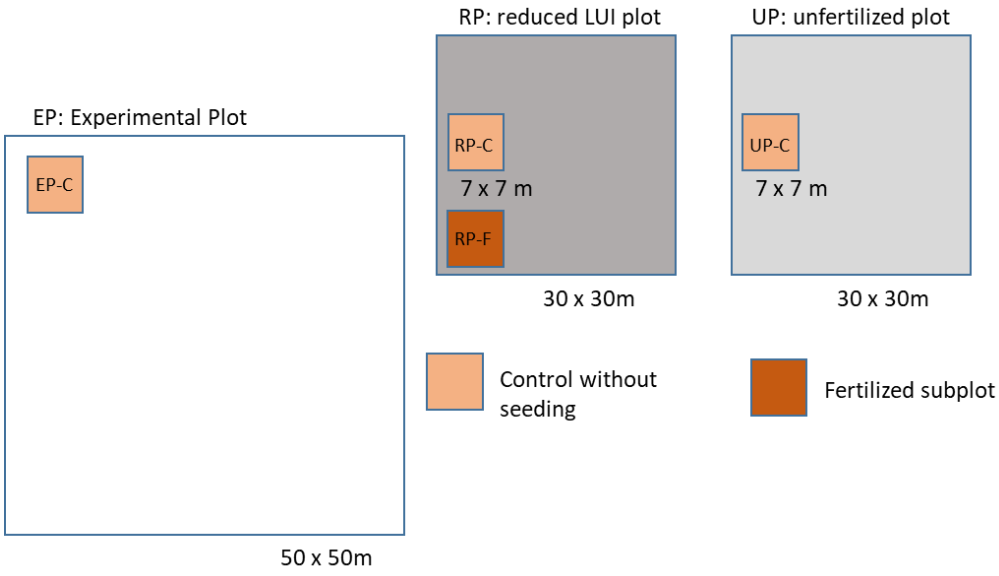


Fig. 3: Design of the land-use experiment LUX with an additional plot with no fertilization but normal mowing or grazing (UP) and a sub-plot with normal fertilization mown only once a year (RP-D) on 4 (Schorfheide) and 6 (in Alb and Hainich) grassland sites.

Appendix 1: List of plots for the reduced land use experiments REX and the land-use experiment LUX together with the land-use components «grazing», «mowing», «fertilizing» of the years 2016 to 2018 (averaged, not standardized).

Explo	EP_PlotID	REX I	REX II + LUX	G16.18	M16.18	F16.18
ALB	AEG1	yes	yes	0	2	76.05
ALB	AEG4	yes	yes	116.6982	1	64.33333
ALB	AEG5	yes		108.6921	0.666667	66.1
ALB	AEG6	yes	yes	135.9471	1	51.4
ALB	AEG11	yes		0	3.333333	93
ALB	AEG12	yes	yes	0	2	57
ALB	AEG13	yes		0	2	96.51667
ALB	AEG16	yes		155.5863	1	35.93333
ALB	AEG18	yes		0	3	206.9667
ALB	AEG20	yes		175.1903	0	0
ALB	AEG35	yes	yes	0	2.666667	121.3333
ALB	AEG36	yes	yes	0	2.666667	136
ALB	AEG37	yes		0	2	113.6167
ALB	AEG39	yes		0	2	73.01667
ALB	AEG46	yes		222.6409	1	5.88
HAI	HEG1	yes	yes	44.98153	2	289.6667
HAI	HEG2	yes	yes	13.3636	2	146.4
HAI	HEG3	yes	yes	13.3636	2.333333	146.4
HAI	HEG6	yes	yes	13.2355	1.333333	164.02
HAI	HEG7	yes		686.3158	0	0
HAI	HEG10	yes		16.31367	1	69.06667
HAI	HEG13	yes		43.57933	2.333333	32.08333
HAI	HEG14	yes	yes	0	1.333333	126.6667
HAI	HEG15	yes	yes	103.3415	1	70.86667
HAI	HEG27	yes		17.94873	1.666667	56.66667
HAI	HEG40	yes		300.9091	0	0
HAI	HEG47	yes		72.86563	1	72.1
HAI	HEG48	yes		28.55407	1	54.36667
HAI	HEG49	yes		0	1.666667	57.16667
HAI	HEG50	yes		36.378	1	41.11217
SCH	SEG3	yes		148.6029	0.666667	0
SCH	SEG13	yes	yes	16.8205	2	33.6
SCH	SEG14	yes		16.8336	1.666667	0
SCH	SEG25	yes		0	2	0
SCH	SEG30	yes		4.9976	1.333333	0
SCH	SEG31	yes		4.9976	1.333333	0
SCH	SEG32	yes		4.9976	1.333333	0
SCH	SEG33	yes		291.9525	0.333333	0
SCH	SEG35	yes		222.2032	0.333333	16.93333
SCH	SEG36	yes		209.9546	0.666667	0
SCH	SEG38	yes		875.5015	0.666667	0
SCH	SEG42	yes	yes	588.4251	0	18.33333

SCH	SEG43	yes	yes	206.286	0	70.14747
SCH	SEG44	yes	yes	178.3592	0	20.2496
SCH	SEG50	yes		224.4028	0.333333	0

Appendix 2: List of species for the seed addition experiment

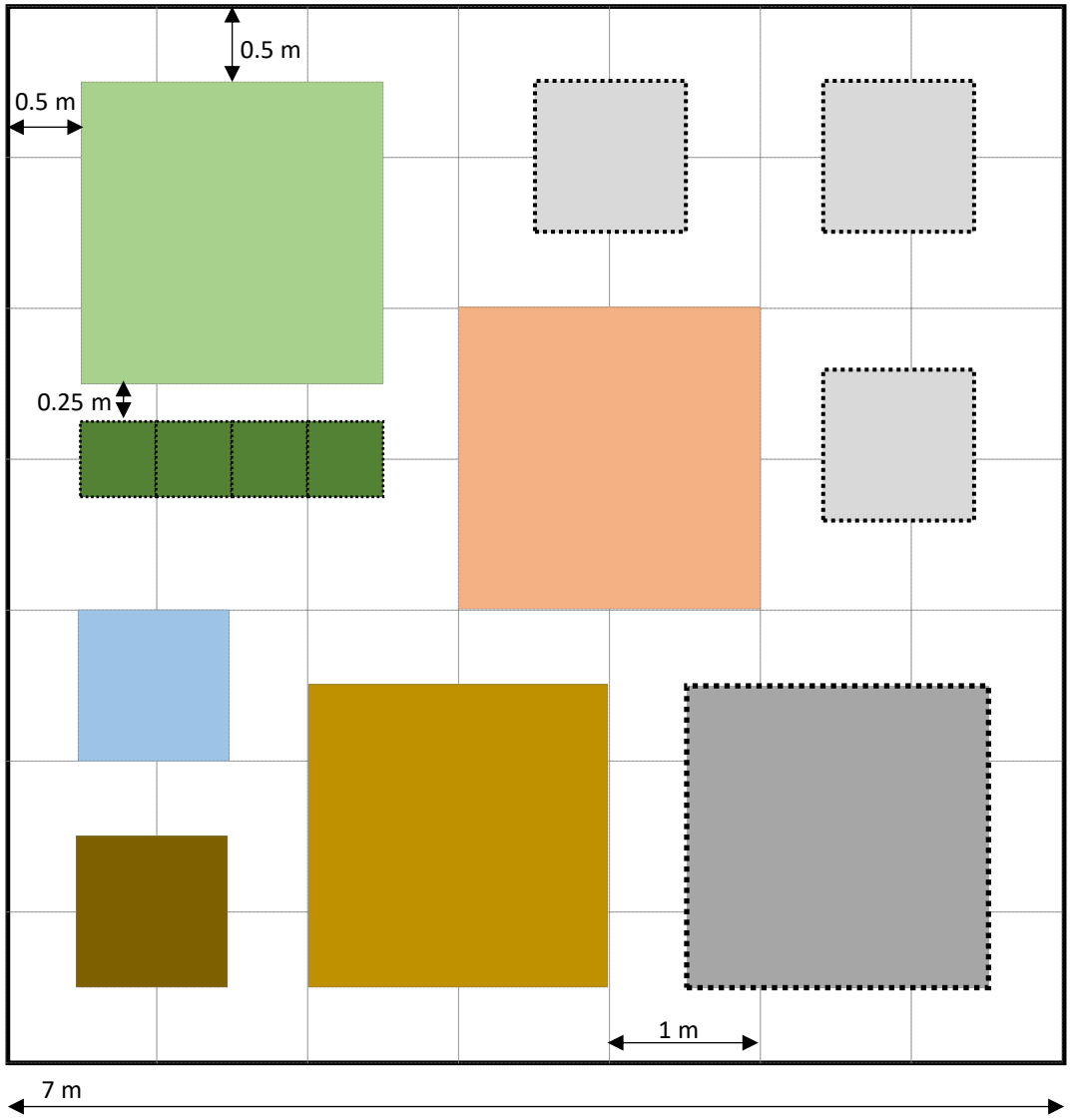
Arten	A	H	S	TKG	N seeds/m2	Seed mass (mg) /m2
Achillea millefolium L.	x	x	x	0.2	100	20
Agrimonia eupatoria L.	x	x	x	23	20	460
Agrostis capillaris L.	x	x	x	0.05	100	5
Anthoxanthum odoratum L.	x	x		0.6	100	60
Anthriscus sylvestris (L.) Hoffm.	x	x	x	4	40	160
Arrhenatherum elatius (L.) P.Beauv.	x	x	x	2.7	40	108
Briza media L.	x	x		0.5	100	50
Bromus erectus Huds.	x	x	x	1.9	40	76
Bromus hordeaceus L.	x	x	x	4.5	40	180
Campanula rotundifolia L.	x	x	x	0.06	100	6
Cardamine pratensis L.			x	0.6	100	60
Centaurea jacea L.	x	x	x	2.1	40	84
Centaurea scabiosa L.	x	x	x	5.7	40	228
Cichorium intybus L.	x	x	x	1.2	40	48
Cirsium oleraceum L.	x	x	x	2.5	40	100
Clinopodium vulgare L.	x	x		0.4	100	40
Crepis biennis Lapeyr.	x	x		0.9	100	90
Cynosurus cristatus L.	x	x	x	0.6	100	60
Dactylis glomerata L.	x	x	x	1	100	100
Daucus carota L.	x	x	x	1	100	100
Deschampsia cespitosa (L.) P.Beauv.	x		x	0.23	100	23
Dianthus carthusianorum L.	x			1	100	100
Falcaria vulgaris Bernh.			x	0.9	100	90
Festuca pratensis Huds.	x	x	x	0.7	100	70
Festuca rubra L.	x	x	x	0.9	100	90
Galium album Mill.	x	x	x	0.6	100	60
Geranium pratense L.	x	x		8	40	320
Helictotrichon pubescens (Huds.) Schult. & Schult.f.	x	x		1.9	40	76
Heracleum sphondylium L.	x	x	x	5.9	40	236
Holcus lanatus L.	x	x	x	0.4	100	40
Hypericum perforatum L.	x	x	x	0.1	100	10

Hypochaeris radicata Falk	x	x	x	0.7	100	70
Knautia arvensis (L.) Coult.	x	x	x	4.7	40	188
Lathyrus pratensis L.	x		x	11	20	220
Leontodan hispidus	x		x	1.1	40	44
Leucanthemum ircutianum (Turcz.) Turcz. ex DC.	x	x	x	0.4	100	40
Linaria vulgaris Mill.	x	x	x	0.14	100	14
Lotus corniculatus L.	x	x	x	1.2	40	48
Luzula campestris (L.) DC.	x	x	x	0.7	100	70
Medicago lupulina L.	x	x	x	2.2	40	88
Origanum vulgare L.	x	x	x	0.1	100	10
Pastinaca sativa L.	x	x	x	3.9	40	156
Pimpinella major (L.) Huds.	x		x	2	40	80
Pimpinella saxifraga L.	x	x	x	1.2	40	48
Plantago lanceolata L.	x	x	x	1.7	40	68
Plantago media L.	x	x	x	0.4	100	40
Poa pratensis L.	x	x	x	0.3	100	30
Potentilla erecta (L.) Raeusch.	x		x	0.4	100	40
Primula veris L.	x	x		1.1	40	44
Prunella vulgaris L.	x	x	x	0.7	100	70
Ranunculus acris L.	x	x	x	1.6	40	64
Ranunculus bulbosus L.	x			2.5	40	100
Rumex acetosa L.	x	x	x	0.5	100	50
Rumex acetosella L.	x	x	x	0.36	100	36
Salvia pratensis L.	x	x	x	2.4	40	96
Sanguisorba minor Scop.	x	x	x	6.8	40	272
Sanguisorba officinalis L.		x	x	2.2	40	88
Scabiosa columbaria L.		x	x	1.9	40	76
Scorzoneroides autumnalis (L.) Moench	x		x	0.7	100	70
Silaum silaus (L.) Schinz & Thell.	x		x	2.8	40	112
Silene flos-cuculi (L.) Greuter & Burdet	x	x	x	0.18	100	18
Silene latifolia Poir.	x	x	x	0.8	100	80
Silene vulgaris (Moench) Garcke	x	x	x	0.9	100	90
Stachys officinalis (L.) Trevis.	x	x		5	40	200
Succisa pratensis Moench			x	1.6	40	64
Thymus pulegioides L.	x		x	0.14	100	14
Tragopogon pratensis L.	x	x	x	7	40	280
Trifolium arvense L.			x	0.3	100	30
Trifolium campestre	x	x	x	0.5	100	50

Schreb.						
Trifolium medium L.	x	x	x	2.1	40	84
Trifolium pratense L.	x	x	x	1.8	40	72
Trisetum flavescens (L.) P.Beauv.	x	x	x	0.26	100	26
Veronica chamaedrys L.	x	x	x	0.2	100	20
Veronica officinalis L.	x	x	x	0.1	100	10
Vicia cracca L.	x	x	x	40	20	800

Subplot-Plotchart for REX and LUX-experiments

Subplot of
7 x 7 m



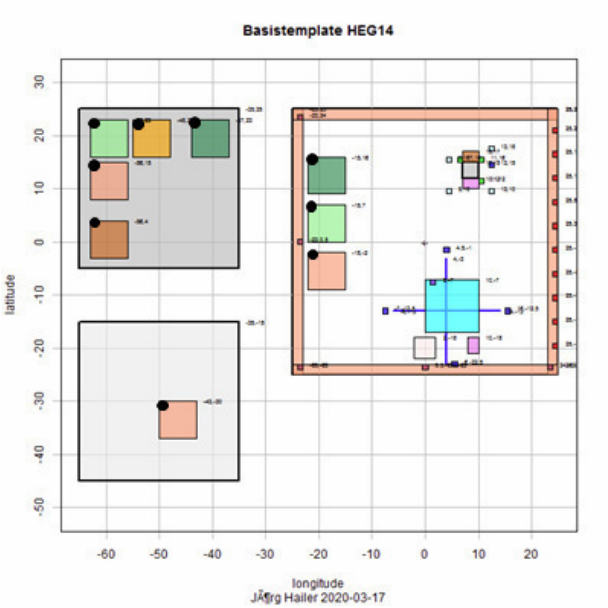
List of projects with allocated sub-sub-plots

- Core Botany: Vegetation (2 x 2 m)
- Core Botany: Biomass (2 x 0.5 m)
- BEF-Loops (1 x 1 m)
- Core Soil, Core Microorganisms (2 x 2 m)
- Core Arthropods (suction sampling) (2 x 2 m)
- SPRINT 2020-2022 (pitfall traps) (3 x (1 x 1 m))
- SPRINT 2021/2022 (Cafeteria Exp) (2 x 2 m))
- SMaTI (1 x 1 m)

Important note:

RP (reduced land use plot) and UP (unfertilized plots) are sometimes slightly rotated. While the treatment plots are indicated on the plot chart of BExIS, it is unclear how to place the sub-plot-chart. Here is the proposed procedure:

If the RP and UP are rotated, you imagine to rotate the RP and UP clockwise until they are along the north-south-axis, and then you place the sub-plot chart such that top-left corner of the sub-plot is the top-left corner of the sub-plot chart. I indicated this in three examples below where the black dots refer to the top-left corner of the sub-plot chart:



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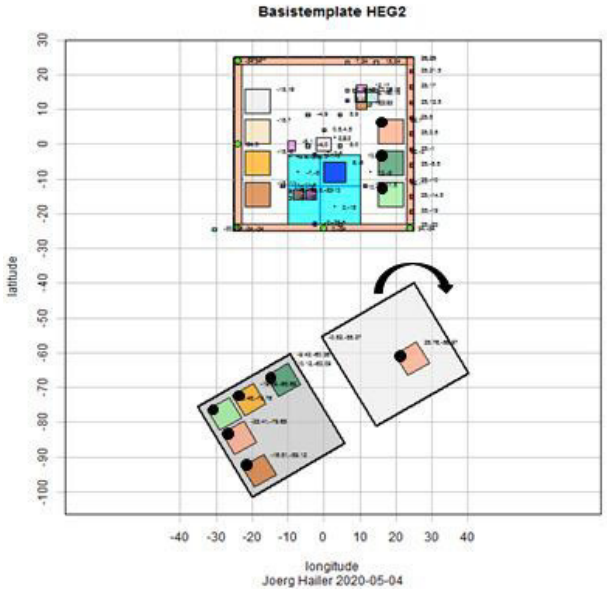
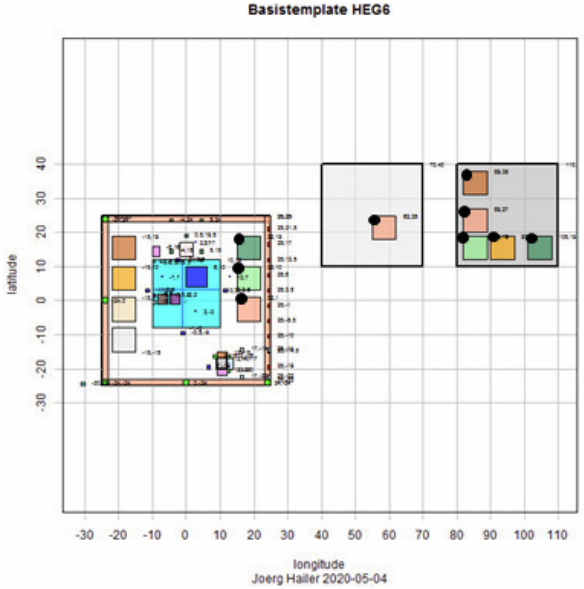


rotated



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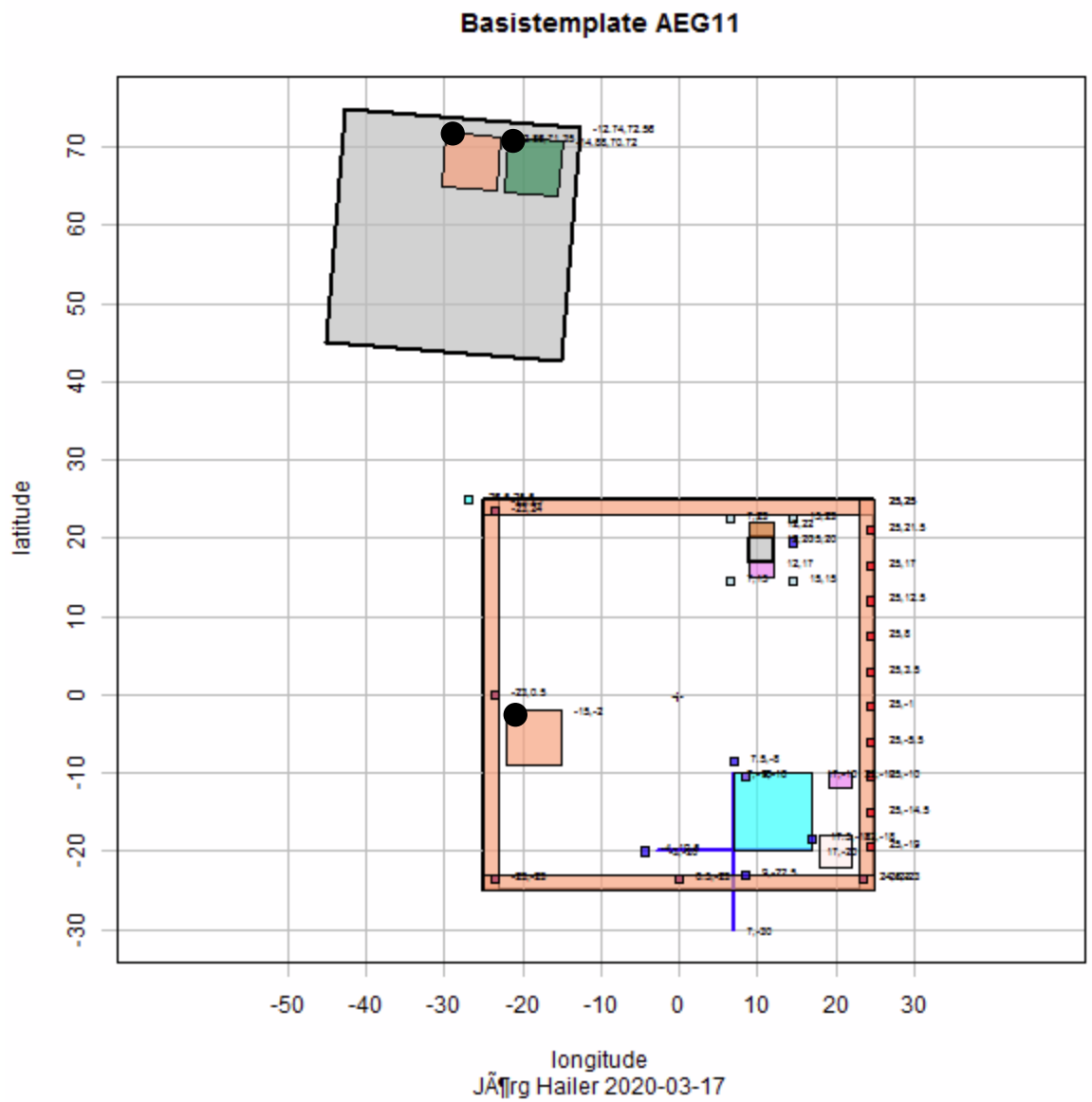
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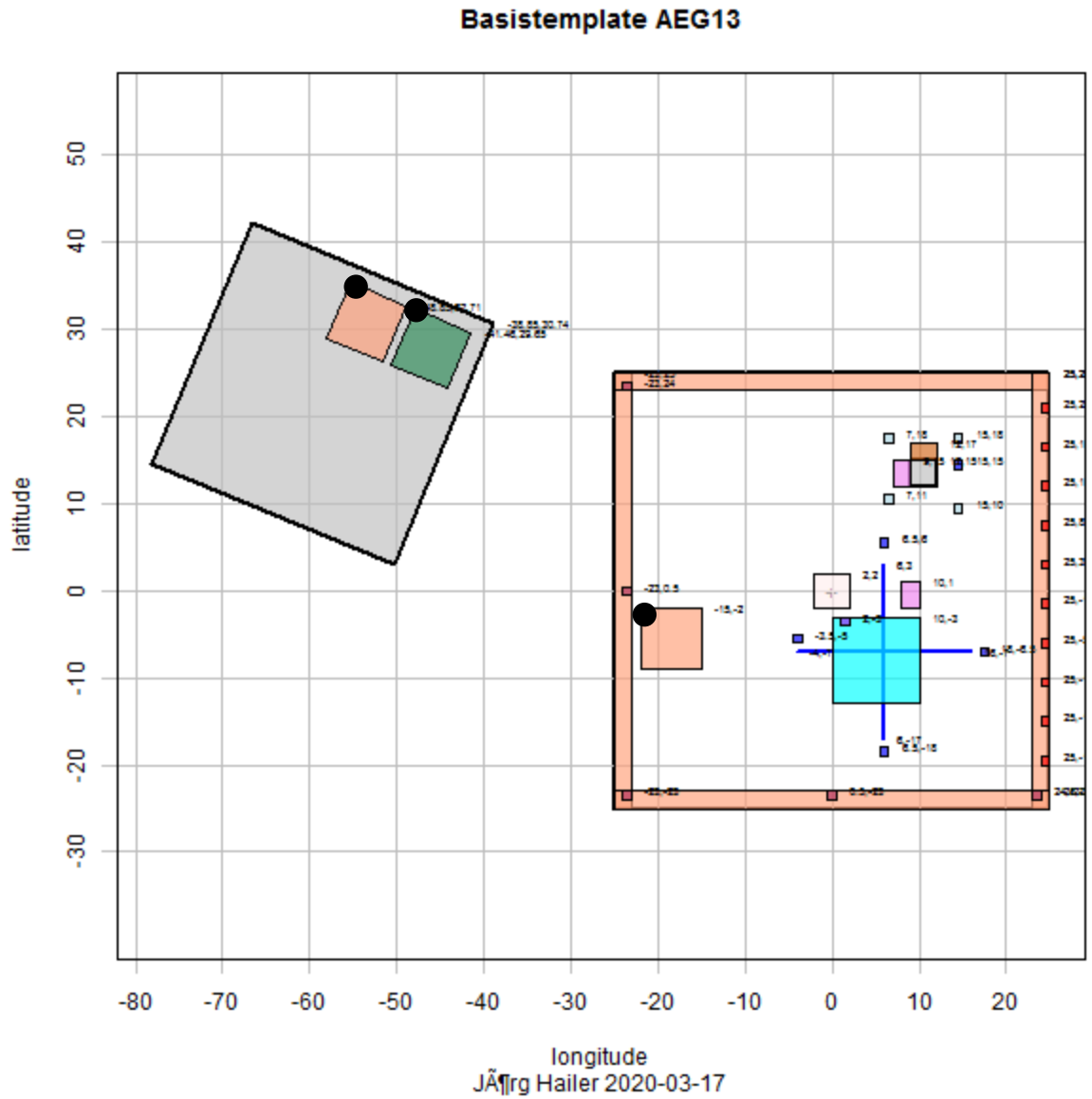
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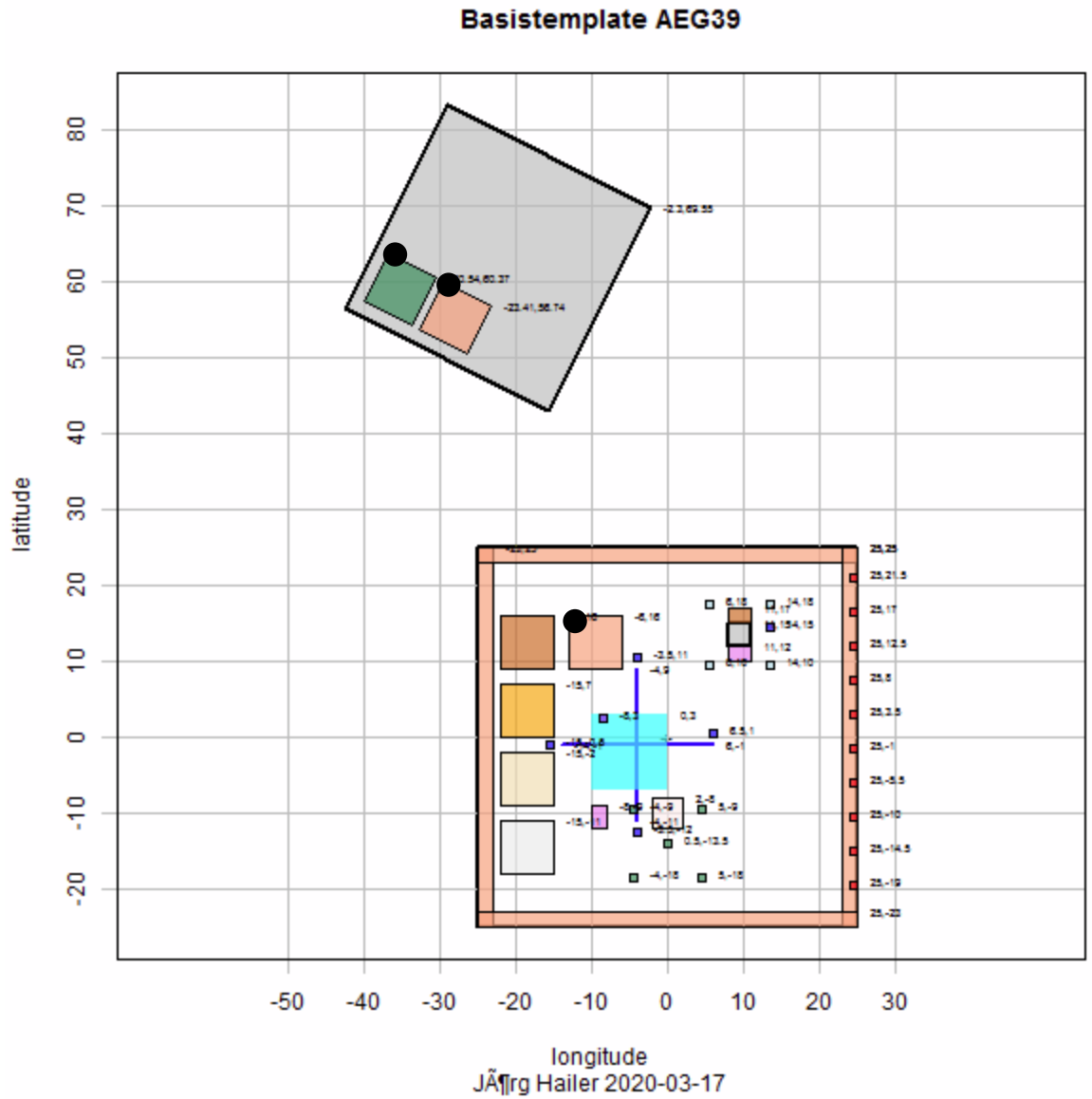
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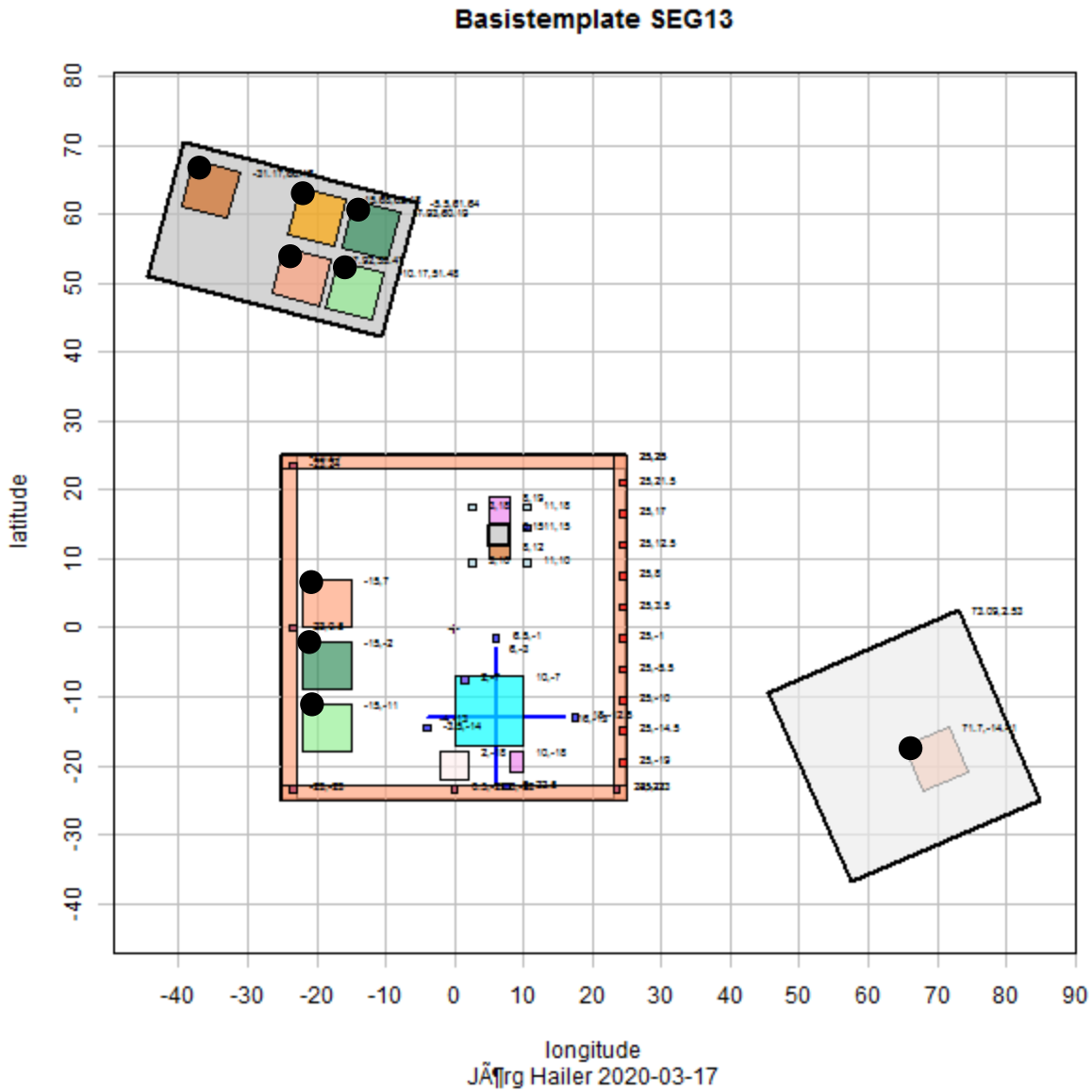
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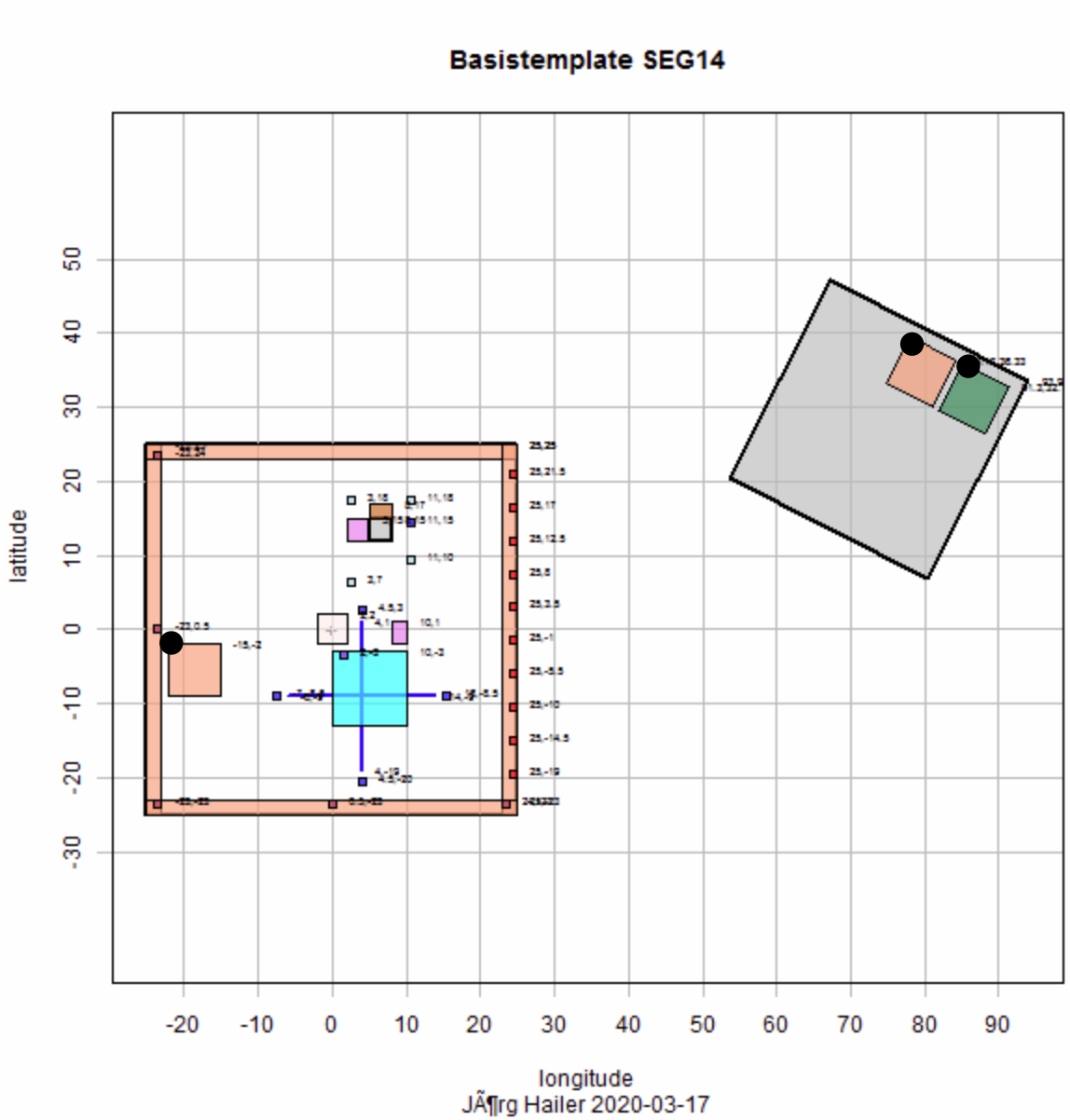
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