Simulating and visualizing future land change trajectories in Europe

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Supplementary data.

Annex A. Scenario storylines

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Annex A. Scenario storylines

Libertarian Europe (V-A1). Land cover and land management changes in V-A1 are influenced by a globalizing world with strong economic growth, and moderate population growth. Food and feed demand is growing. In V-A1, global free trade is the main economic driver. Policy interventions, such as subsidies or quotas, are either weak or absent in this storyline. No commitments to climate change adaptation and mitigation are made.

Eurosceptic Europe (V-A2). Land cover and land management changes in V-A2 are influenced by a fragmented world with modest economic growth, strong population growth, and weak regulation of land use (change). Protectionism is established to obviate detrimental effects of global trade fluctuations on European markets. No commitments to climate change adaptation and mitigation are made.

Social Democracy Europe (V-B1). Land cover and land management changes in V-B1 are embedded in a sustainable world with modest economic growth, modest population growth, and strong policy intervention. While free trade plays a major role in the economy under V-B1, ecosystem service concepts are also implemented and global environmental treaties are accepted. Overall, people embrace a more sustainable lifestyle, which leads to a slower growth of food and feed demand.

European Localism (V-B2). Land cover and land management changes in V-B2 are embedded in a fragmented world with modest economic growth, modest population growth and moderate policy intervention. The solution to environmental issues is a priority, but like all other aspects of life in V-B2, its implementation is attempted regionally. Food and feed demands are modestly growing.

Annex B. Land use modeling

To implement scenario storylines in simulations of future land cover and land management, we used a chain of models that exchange information in a top-down, hierarchical manner (Fig. S1). We performed coupled macro-economic, multi-sector analyses to implement scenario storylines. The combined models ReMIND/MAgPIE (Lotze-Campen et al 2010a; Luderer et al 2013) simulated changes in population growth, trade (liberalization vs. regulation), food and bioenergy demands (reflecting changing meat consumption and climate mitigation targets), and land use regulation (e.g., the degree of forest protection) globally for each scenario. The outputs produced by ReMIND/MAgPIE (i.e., population numbers, gross domestic product (GDP) growth rates, diets and required areas for bioenergy crops) were fed into the LEITAP/MAGNET (Woltjer and Kuiper 2014) and EFI-GTM (Kallio et al 2004) models. LEITAP/MAGNET is a global general equilibrium model which covers all economic sectors. It simulates global changes in land use, agricultural production and consumption patterns, and regional sub-sector specific changes in bilateral trade flows. EFI-GTM is a global forest sector model which uses changes in GDP and population as main inputs to derive future trends in consumption, production and trade of wood products.

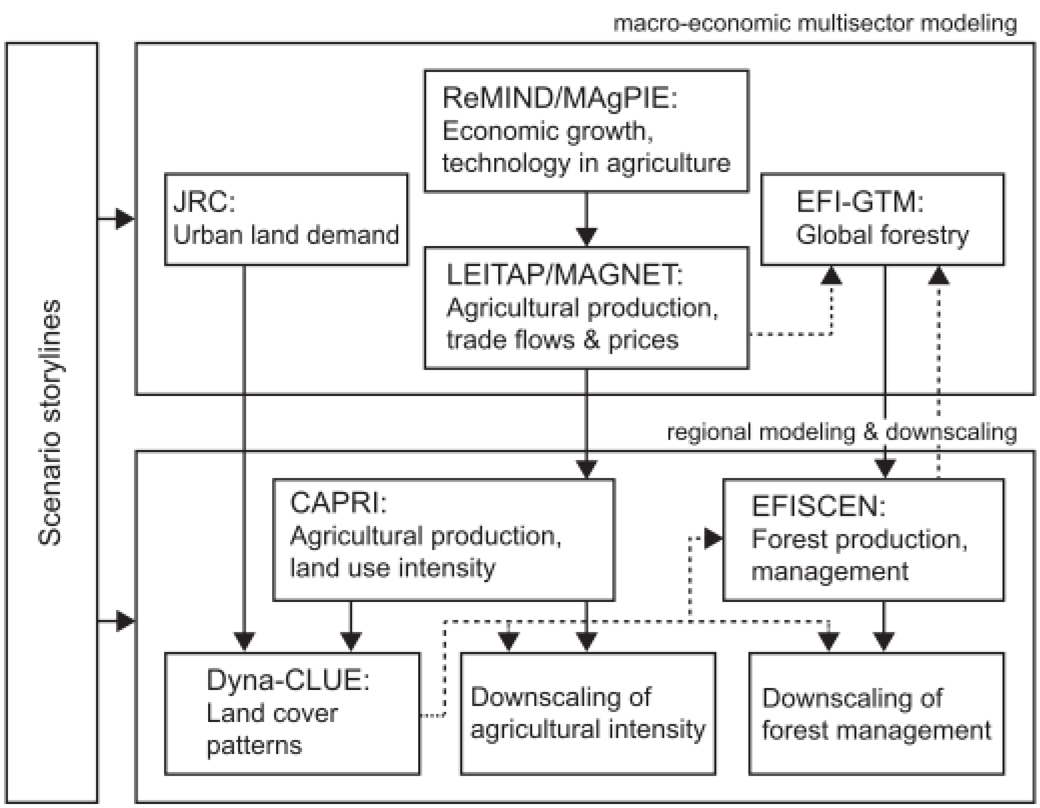

Fig. S1 Overview of the land use modeling chain

The simulations from these global models were fed into different regional models. The agricultural economic model CAPRI (Britz and Witzke 2014) calculated region- and product-specific outputs (e.g., yields and fertilizer use). The forest resource projection model EFISCEN (Sallnäs 1990; Schelhaas et al 2007) calculated the potential supply of woody biomass from European forests (Verkerk et al 2011) as input to EFI-GTM on the domestic demand for roundwood, as well as projected changes in forest area to project forest resource development. Changes in forest area originated from the detailed land allocation with the Dyna-CLUE model (Verburg and Overmars 2009). Country-level urban land demands were provided by JRC (Lotze-Campen et al. 2014).

We then disaggregated the simulation outcomes at the national or sub-national level to the grid level. To do so, the Dyna-CLUE model was used to simulate land cover change by accounting for a range of spatial scenario conditions (Verburg et al. 2012). Dyna-CLUE allocated the macro-level land use demands across 16 land cover categories according to empirically-based suitability maps, with a spatial resolution of $1km^2$ at yearly time steps from 2000 to 2040. We used four types of information to implement the scenario assumptions and outputs in Dyna-CLUE: (1) spatial policies and restrictions (e.g., nature reserves), (2) aggregate land cover conversion quantities for agricultural and urban areas derived from CAPRI and urban projections, (3) location characteristics determined by maps that define the suitability of a location for each land use type based on empirical analysis, and (4) a set of rules for possible land conversions reflecting the scenario conditions and policy regulations. Conversion elasticities are given in Table S1. A detailed description of the land cover allocation procedure can be found in Verburg & Overmars (2009).

Table S1 Conversion elasticities of the Dyna-CLUE model.

	V-A1scenario	V-A2 scenario	V-B1 scenario	V-B2 scenario
Built-up	1	1	1	1
Arable	0.4	0.4	0.5	0.5
Pasture	0.3	0.3	0.3	0.3
Semi-natural	0.7	0.7	0.8	0.9
Irrigated arable	1	1	1	1
Abandoned arable	0.3	0.3	0.3	0.3
Permanent crops	0.8	0.8	0.9	0.9
Forests	0.7	0.7	0.8	0.9
Abandoned pasture	0.3	0.3	0.3	0.3
Other	1	1	1	1

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Annex C. Land change trajectories, classification rules and mapping

Stability.

A grid cell was considered stable when no conversion occurred in either land cover or land management between two time steps. We quantified only land cover classes which were allowed to change in Dyna-CLUE simulations (built-up area, arable land and permanent crops, pasture, (semi-)natural vegetation and forest (see Table S2).

For these Dyna-CLUE land cover categories and, if applicable, their land management intensity, stability was calculated by comparing land cover and land management between the time steps 2000 and 2040 for each scenario. A grid cell was referred to as stable if both land cover class and land management did not change between both time steps. For the trajectory stability, no hotspots were mapped.

Intensity changes.

Intensification and de-intensification involved increases or decreases in fertilizer use on cropland, grazing intensity on pastures, or wood removals in forests. The intensity levels of each grid cell occupied by cropland and pasture in 2000 and the scenarios for 2040 were compared. Each grid cell which had a higher (lower) intensity than the reference year was considered intensifying (de-intensifying). Changes in wood removals of more than 25% compared to the reference year were considered intensification or de-intensification.

Intensification – cropland.

Intensity changes of cropland were based on changes in fertilizer use disaggregated to three classes with CLUE: 0-50kg/ha (low), >50-150 kg/ha (moderate), >150 kg/ha (high). Only grid cells which were covered with cropland both in 2000 and 2040 were used in this analysis.

For grid cell-based analyses as presented in Figure 5 and Figure 6, respectively, intensity maps of cropland were compared by comparing the intensity classes on the grid level between the time steps 2000 and 2040. If the cropland intensity was higher in 2040, a grid cell contributed to cropland intensification.

For the hotspot mapping, spatial characteristics (by using moving window analysis with a circle-shaped window and radius of 15km) and the magnitude of intensification were included in the analysis.

Step 1: Intensity change (1 intensity level up, 2 intensity levels up, no intensification (0)) was multiplied (weighted) with the original intensity class at the grid cell in the reference year. This ensured that an intensity change from moderate intensity (>50-150 kg/ha) towards high intensity (>150 kg/ha) was weighted more than an intensity increase from <50 kg/ha towards >50-100kg/ha.

Step 2: Focal statistics (circle-shaped moving window, mean value, radius 15km) of average intensification were prepared for each grid cell based on the map from step 1.

Step 3: A mask of cropland extent (in 2000) was prepared and focal statistics of cropland vs. other land cover (0-100%) were calculated using a circle-shaped search window of 15km radius.

Step 4: Focal statistics of intensification of cropland and coverage of cropland were multiplied.

Step 5: The map generated with step 4 was masked with a map representing focal statistics of average intensity change (including de-intensification), to ensure that only areas were represented in the final map which were also on average intensifying.

De-intensification – cropland.

For grid cell-based analysis as used for Figs. 5 and 6, respectively, intensity categories of cropland were compared on the grid level. If the cropland intensity was lower in 2040 than in 2000, a grid cell contributed to cropland de-intensification.

For the hotspot mapping, spatial characteristics (by using moving window analysis with a circle-shaped window and radius of 15km) and the magnitude of de-intensification were included in the analysis.

Step 1: Intensity change (1 level down, 2 levels down, no de-intensification (0)) was reclassified according to the original intensity class in the reference year (high → low (2); high → moderate (1); moderate → low (2)). This ensured that an intensity change from high intensity (>150 kg/ha) towards moderate intensity (>50-150 kg/ha) was weighted less than an intensity decrease from >50-100kg/ha towards <50 kg/ha.

Step 2: Focal statistics of average de-intensification were prepared for each grid cell based on the prior map.

Step 3: A mask of cropland extent (in year 2000) was prepared and focal statistics of cropland vs. other land cover (0-100%) were calculated using a circle-shaped search window of 15km radius.

Step 4: Focal statistics of de-intensification of cropland and coverage of cropland were multiplied.

Step 5: The map generated with step 4 was masked with a map representing focal statistics of average intensity change (including intensification), to ensure that only areas are represented in the final map which were also on average de-intensifying.

Intensity changes – pasture.

Intensity changes of pasture were based on changes in grazing intensity, derived from the density of livestock units (LSU) per km^2, which was reclassified to two classes: 0-25 LSU/km^2 (low) and >25 LSU/km^2 (high). Only grid cells which were covered with pasture in 2000 and 2040 were used in this analysis. The calculation was identical to the calculation of cropland intensity changes both on grid cell level as for the hotspot mapping, only step 1 was omitted as there were only two classes to delineate.

Intensity changes – forest.

Intensity changes of forest were based on changes in wood removals (m^3/ha/yr) between 2000 and 2040 disaggregated from NUTS 2 level on a 1km^2 grid. Change ratio of wood removal between the reference and the scenario are compared: Change ratios lower than 75% of the wood removal in the reference year is mapped as de-intensification, change ratios larger than 125% is mapped as intensification. Only grid cells which were covered with forest both in 2000 and 2040 were used in this analysis. The calculation followed the calculation of cropland intensity changes both on grid level and for the hotspot mapping.

Expansion and decline.

These trajectories include land cover conversions from any of the dynamic land cover classes simulated in Dyna-CLUE to another one during a scenario.

The expansion and decline of cropland, pasture, (semi-)natural vegetation and forest was calculated by comparing neighborhood statistics of the reference year and the scenarios. For the land cover category cropland, CLUE land cover classes arable land and permanent crops were joint. These trajectories have not been mapped on the grid cell level because all possible land conversions (e.g. arable loss due to conversion to pasture) were covered with more detailed land change trajectory models.

For the hotspot mapping, forest expansion and contraction was included in the summary hotspot maps as an example, other changes of this category were omitted. The calculation of expansion and decline was identical for all land cover classes.

Expansion.

Step 1: Land cover maps for 2000 and 2040 were masked for the respective land cover and focal statistics were made for both 2000 and 2040 to calculate the average coverage (0-100%) of the respective land cover in both time steps within a circle-shaped moving window of 15km radius.

Step 2: An overlay of both time steps was made to identify and single out growth and decline grid cells and focal statistics were made for average growth and decline (-100-100%) of the respective land cover between both time steps within a circle-shaped moving window of 15km radius. A conditional raster was prepared which only represents areas which exhibit an average expansion.

Step 3: The focal land cover map of 2040 was multiplied (weighted) with the conditional raster prepared in step 2, indicating (weighted) expansion. The weighting process was necessary to inhibit the overestimation of growth in sparsely covered areas and to pronounce expansion in already widely covered areas.

Decline.

Step 1: Land cover maps for 2000 and 2040 were masked for the respective land cover and focal statistics were made for both 2000 and 2040 to calculate the average coverage (0-100%) of the respective land cover in both time steps within a circle-shaped moving window of 15km radius.

Step 2: An overlay of both time steps was made to identify and single out growth and decline grid cells and focal statistics were made for average growth and decline (-100-100%) of the respective land cover between both time steps within a circle-shaped moving window of 15km radius. A conditional raster was prepared which only represents areas which exhibit an average decline.

Step 3: The focal land cover map of 2000 was multiplied (weighted) with the conditional raster prepared in step 2, indicating (weighted) decline. The weighting process was necessary to inhibit the overestimation of decline in areas sparsely covered by the respective land cover and to pronounce decline in larger areas.

Land abandonment.

Land abandonment as a trajectory addresses all grid cell conversions of cropland and pasture (=agriculture) to (semi-)natural vegetation and forest (=green space). For the grid level analysis, necessary e.g. for Figs. 5 and 6, all grid cells which were covered by agriculture in 2000 and by green space in 2040 were identified as land abandonment. For the hotspot summary maps, the following approach was applied.

Step 1: The coverage (0-100%) of agriculture for the time steps 2000 and 2040 was calculated using focal statistics with a circle-shaped moving window with a radius of 15km.

Step 2: grid cells converting from agriculture coverage in 2000 to green space coverage in 2040 were singled out and focal statistics were calculated according to step 1 (coverage of converted grid cells 0-100%).

Step 3: Focal land cover maps made in step 1 were used to identify areas were agriculture was declining between the two time steps. A conditional raster was prepared indicating extents of agriculture decline based on the focal maps (-100-<0%).

Step 4: Focal statistics of land abandonment (step 2) were multiplied (weighted) with the average coverage of agriculture in 2000, and masked with the map of agriculture decline prepared in step 3.

Cropland to pasture.

This trajectory quantified the conversion of arable land or permanent crops to pasture. For the grid level analysis necessary for Figs. 5 and 6, all grid cells which were covered by cropland classes in 2000 and by pasture in 2040 were identified as "cropland to pasture". For the hotspot summary maps, the following approach was applied.

Step 1: Land cover maps for 2000 and 2040 were masked for cropland cover classes and focal statistics were made for both 2000 and 2040 to calculate the average coverage (0-100%) of cropland cover in both time steps within a circle-shaped moving window of 15km radius.

Step 2: For the time step 2040, an overlay was made to identify pastures which were covered by cropland in 2000, and focal statistics were calculated according to step 1.

Step 3: Focal land cover maps made in step 1 are used to identify areas were cropland was declining between the two time steps. A conditional raster was prepared indicating extents of declining pasture based on the focal maps (-100-<0%).

Step 4: Focal statistics of "arable to pasture" (step 2) were multiplied (weighted) with the average coverage of cropland in 2000, and masked with the map of cropland decline prepared in step 3.

Recultivation of green space and *recultivation of pasture*.

Recultivation of green space and recultivation of pasture were based on the conversion of green space to agriculture, and pasture to cropland. The delineation of these trajectories allowed for identifying the source land cover type of agricultural expansion.

Recultivation of green space.

This land change trajectory describes the conversion of (semi-)natural vegetation cover and forest (=green space) in the reference year to pasture or arable (= agriculture) land cover classes in the 2040 projections of the scenarios. For the grid level analyses, necessary e.g. for Fig. 5 and 6, all grid cells which were covered by green space in 2000 and by cropland or pasture in 2040 were identified as recultivation of green space. For the hotspot summary maps, the following approach was applied.

Step 1: For both land cover groups of "green space" and "agriculture", masks were prepared indicating their coverage (0-100%) based on a circle-shaped moving window (r = 15km).

Step 2: grid cells converting from green space to agriculture between 2000 and 2040 were singled out and focal statistics were calculated according to step 1 (coverage of converted grid cells 0-100%).

Step 3: Focal land cover maps made in step 1 were used to identify areas were green space was declining between the two time steps. A conditional raster was prepared indicating extents of green space decline based on the focal maps (-100-<0%).

Step 4: Focal statistics of "recultivation of green space" (step 2) were multiplied (weighted) with the average coverage of green space in 2000, and masked with the map of green space decline prepared in step 3.

Recultivation of pasture.

This land change trajectory describes the conversion of pasture in the reference year to cropland cover classes in the 2040 projections of the scenarios. On the grid cell level analysis, necessary e.g. for Figure 5 and Figure 6, all grid cells which were covered by pasture in 2000 and by cropland in 2040 were identified as recultivation of pasture. For the hotspot summary maps, the following approach was applied.

Step 1: For both land cover classes pasture and cropland, masks were prepared indicating their coverage (0-100%) based on a circle-shaped moving window (r = 15km).

Step 2: grid cells converting from pasture to cropland between 2000 and 2040 were singled out and focal statistics were calculated according to step 1 (coverage of converted grid cells 0-100%).

Step 3: Focal land cover maps made in step 1 were used to identify areas were pasture was declining between the two time steps. A conditional raster was prepared indicating extents of pasture decline based on the focal maps (-100-<0%).

Step 4: Focal statistics of “recultivation of pasture” (step 2) were multiplied (weighted) with the average coverage of pasture in 2000, and masked with the map of pasture decline prepared in step 3.

Polarization of rural land.

Polarization of rural land addresses the regional conversion of cropland and pasture (=agriculture) to (semi-)natural vegetation and forest (=green space) with a parallel increase in agricultural intensity on remaining neighboring agricultural areas. As this trajectory is highly dependent on two-sided neighborhood characteristics (land abandonment in vicinity of intensification and vice versa), this model also includes neighborhood statistics for grid level analyses, necessary for e.g. Figs. 5 and 6 in this article. As in the other models presented here, a moving window of 15km radius was used in this analysis as well. However, as polarization of rural land could be very sensitive towards neighborhood settings, variable window sizes of 5 to 50km radius have been used to test for sensitivity of the results on neighborhood settings, which yielded no substantial changes in the location of polarization hotspots across the EU (Fig. S2), however, the overall extent increases with increasing moving window extents. Considerable overlaps between hotspots based on different neighborhood settings exist. 59% to 79% of hotspot area based on a 5km-moving window lied within 50- and 15-km moving window based hotspots, respectively. 84% and 68% of hotspot area based on a 15-km moving window lied within 25- and 50-km moving window hotspots, and 77% of 25-km hotspots lied within 50-km moving window hotspots.

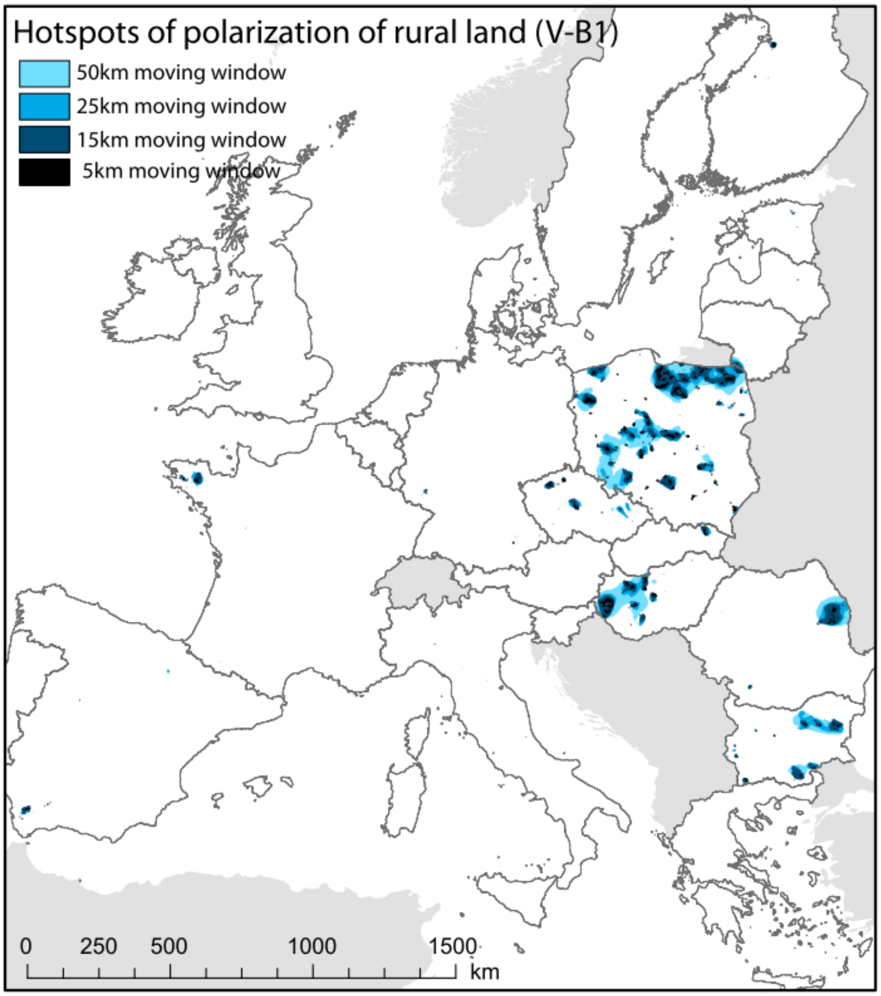

Fig. S2 Overlap of hotspots of the land change trajectory polarization of rural land in V-B1 scenario.

Step 1: Intensity changes in cropland and pasture between 2000 and 2040 were calculated according to the intensity change models.

Step 2: Focal statistics were calculated for a map of intensity change (based on step 1). A circle-shaped moving window with a radius of 15km was used in this analysis. A conditional raster was made to extract all grid cells with an intensifying neighborhood (conditional value > 0.01).

Step 3: A map representing conversion of agriculture to green space (=land abandonment) was prepared and joint with a map representing agriculture conversion to built-up land. A conditional map was made in which all areas were excluded which showed higher values of conversion to built-up land than “true” land abandonment.

Step 4: The land abandonment map made in step 3 was multiplied (weighted) with a focal map of agriculture extent (0-100% in a moving window with radius =15km) in 2000. All values above 0.01 were considered for later analysis.

Step 5: Weighted maps of intensification (step 2) and land abandonment (step 4) were multiplied (weighted) to retrieve focal maps of polarization of rural land used in hotspot mapping.

For pixel-based analyses, land abandonment grid cells and intensification grid cells were addressed separately according to the following approach.

Step 6: Intensification and land abandonment maps were masked with the final polarization map made in step 5.

Urban growth.

Urban growth addresses the growth of agglomerations of built-up area, either by urban densification or by urban sprawl into the periphery. To delineate urban agglomerations for the reference year, urban cores were derived from DGUR (degree of urbanization typology) available from Eurostat (2001), and merged with the extent of built-up area in the reference year to distinguish urban land from other built-up areas. DGUR used information on minimum population and population density to define urban cores. Expansion of built-up area was only identified as urban growth if it led to the expansion of an urban core in immediate adjacency.

Step 1: All built-up area within the urban cores derived from DGUR, or intersecting, connected patches of built-up area in 2000 were defined as “urban land”.

Step 2: For 2040, all built-up area within the boundaries of “urban land” in 2000, as well as adjoining groups of built-up area, were addressed as “urban land” in 2040.

Step 3: New “urban land” in 2040 was identified based on the maps created in step 1 and step 2.

For hotspot maps, focal statistics were involved:

Step 4: The average coverage (0-100%) of “urban land” in 2040 was calculated by means of a moving window (r=15km) and multiplied (weighted) with the average coverage (0-100%) of new “urban land” in 2040 to derive the trajectory urban growth.

Peri-urban growth.

Neither peri-urban growth as a process, nor peri-urban land are very well defined in the literature. We used the term “peri-urban” to address built-up area located in the rural-urban fringe adjacent to an urban agglomeration. The rural-urban fringe hence captured an area between the urban outskirts and the countryside. We varied the size of the rural-urban fringe with respect to the size of the urban cores by using a diameter of twice the radius of the respective urban core to delineate the extent of the rural-urban fringe, which made the rural-urban fringe proportional to the urban core. When an urban core expanded in a scenario, its associated rural-urban fringe expanded proportionally. Thus, new built-up area located within the expanding rural-urban fringe in a scenario was addressed as peri-urban growth.

Step 1: The boundary of “urban land” in 2000 (step 1 from “urban growth” trajectory”) served as an inner margin of the peri-urban zone in 2000.

Step 2 The boundary of “urban land” in 2040 (step 1 from “urban growth” trajectory”) served as an inner margin of the peri-urban zone in 2040.

Step 3: The diameter of each “urban land” zone from 2000 was calculated, and a proportionate buffer (twice the diameter of “urban land” in 2000) was applied to define the peri-urban zone in 2000.

Step 4: The diameter of each “urban land” zone from 2040 was calculated, and a proportionate buffer (twice the diameter of “urban land” in 2040) was applied to define the peri-urban zone in 2040.

In the grid level analyses, as shown in Figs. 5 and 6, only “new” built-up area was accounted for. For hotspot maps focal statistics were involved:

Step 5: All built-up area within the peri-urban zones of 2000 and 2040 were addressed as peri-urban land cover, and peri-urban growth (new peri-urban grid cells in 2040 with respect to the reference year) were extracted. For the hotspot maps, these might also include formerly existing, but “rural” (outside of peri-urban and urban land) grid cells.

Step 6: A map of focal statistics of the coverage (0-100%) of peri-urban growth delineated in step 5 (based on a moving window of 15km radius) was multiplied (weighted) with a map of the coverage of peri-urban land in 2040.

Expansion of wild areas.

Similar to the land abandonment trajectory, expansion of wild areas describes the conversion of former cropland and pasture to a more natural vegetation cover. For land abandonment to be considered as a contribution to expansion of wild areas, it had to increase the area of a patch of wild land. To model this process, first, we delineated the extent of wild areas for each scenario. In this model, following the working definition of “wilderness” by Wild Europe (2013), wild areas were defined as contiguous patches of nature larger than 1000 km^2. Here, “nature” could comprise all land cover which was not covered by built-up area, agriculture and pastures. Furthermore, we excluded forests which were intensively harvested from “nature”. To exclude high intensity forest, we chose a cut-off value of wood removals greater 5 m^3/ha/yr, which equaled approximately the 80^{th} percentile of wood removals across the EU in the reference year. Nature in adjacency to built-up area or agriculture (i.e., within 1km) was also not considered eligible as a part of wild area. The identified wild area patches were compared to their extent in the reference year. Only patches showing net growth of wild area were taken into account. Grid cells which contributed to the growth of the identified wild area patches were considered as expansion of wild areas.

Step 1: Land cover maps were reclassified to (semi-)natural vegetation and low intensity forest (= “nature”) for both time steps. Nature grid cells directly adjoining to agriculture or built-up area were removed from this analysis.

Step 2: Areas of connected “nature” grid cells were calculated for 2040. Areas which were smaller than 1000km^2 were removed from the analysis to retrieve the extent of wilderness in 2040.

Step 3: Areas of connected “nature” grid cells were calculated for 2000. Areas which were smaller than 1000km^2 were removed from the analysis to retrieve the extent of wild areas in 2000.

Step 4: The extents of wild areas in 2040 was compared to the maximum extents of overlapping wilderness in 2000. If the wild areas in 2040 were smaller than the wild areas in 2000, they were removed from the analysis. This approach left only net-growing wild areas in the analysis.

Step 5: The map of growing wilderness in 2040 was used as a mask to extract all grid cells contributing to expansion of wild areas (through land abandonment and de-intensification of forestry).

For the hotspot maps, also connectivity of grid cells was accounted for. For example, if an agricultural patch was entirely abandoned between 2000 and 2040, its former margins (if covered by "nature") could now also count as expansion of wild areas when all conditions were met.

Step 6: Coverage of expansion of wild areas grid cells (0-100%) were multiplied (weighted) with coverage of wild areas in 2040 (0-100%) using a moving window of 15km radius.

Contraction of wild areas.

Contraction of wild areas was a trajectory which indicated a decline of wild areas as compared to the reference year. To model this process, patches of wild areas larger than 1000 km^2 were identified for the reference year. Grid cells which were part of wild areas in the reference year, but converted to agriculture, high intensity forest, or built-up area in 2040, were considered as contraction of wild areas.

Step 1: Land cover maps were reclassified to (semi-)natural vegetation and low intensity forest (= "nature") for both time steps. Nature grid cells directly adjoining to agriculture or built-up area were removed from this analysis.

Step 2: Areas of connected "nature" grid cells were calculated for 2000. Areas which were smaller than 1000km^2 were removed from the analysis to retrieve the extent of wilderness in 2000.

Step 3: Intensification of forest, new built-up area and new agriculture were masked with the extents of wild areas in 2000 to calculate contraction of wild areas.

For hotspot maps, focal statistics were introduced to the approach:

Step 4: Contraction of wild areas was quantified by extracting agriculture, built-up area, and high intensity forest in 2040 which overlaid with wild areas of 2000.

For the hotspot mapping, the following steps were performed.

Step 5: Contraction of wild areas was quantified by comparing the "negatives" of the nature maps of 2000 and 2040: An overlay was made for areas which were covered by nature in 2000 and no nature in 2040, and this overlay was masked with the wild area mask of 2000.

Step 6: the area of the remaining patch was calculated. If it was smaller than 1000 km^2, the entire wild area patch lost that status and was addressed as contraction of wild areas entirely.

Step 7: Coverage of contracting wild areas (0-100%) based on the map of step 4 was multiplied (weighted) with coverage of wild areas in 2000 (0-100%) using a moving window of 15km radius.

Table S2 Extent (in km^2) of land cover and land management categories per scenario in 2040

Land cover	**2000**	**V-A1 2040**	**V-A2 2040**	**V-B1 2040**	**V-B2 2040**
Built-up area	180829	237617	229799	236892	216136
Arable land	1230296	1104385	1193377	1113459	1189964
Pasture	567891	490300	544207	482167	544378
(Semi-)natural vegetation	398823	363548	282073	368518	264671
Inland wetlands	83336	83336	83336	83336	83336
Glaciers and snow	1661	1661	1661	1661	1661
Irrigated arable land	36887	36887	36887	36887	36887
Recently abandoned arable land	--	20669	2424	8191	3785
Permanent crops	144724	128651	138421	129784	138159
Forest	1418893	1575500	1546638	1585829	1579057
Sparsely vegetated areas	58037	58037	58037	58037	58037
Beaches, dunes, and sands	3612	3612	3612	3612	3612
Salines	726	726	726	726	726
Water and coastal flats	130878	130878	130878	130878	130878
Heather and moorlands	88720	88720	88720	88720	88720
Recently abandoned pasture	--	20786	4517	16616	5306
Cropland intensity	**2000**	**V-A1 2040**	**V-A2 2040**	**V-B1 2040**	**V-B2 2040**
(N fertilizer use)					
0-50 kg/ha	390152	261508	237321	262003	278862
>50-150 kg/ha	640545	605645	602174	603272	657858
>150 kg/ha	381210	402770	529190	414855	428290
Pasture intensity	**2000**	**V-A1 2040**	**V-A2 2040**	**V-B1 2040**	**V-B2 2040**
(Livestock density)					
0-25 LSU/km^2	289288	250539	285854	247005	283692
>25 LSU/km^2	278603	239761	258353	235162	260686
Forest intensity	**2000/2010**	**V-A1 2040**	**V-A2 2040**	**V-B1 2040**	**V-B2 2040**
(Wood removals)					
0-5 m^3/ha/yr	1120420	1218894	1193702	1198453	1180665
>5 m^3/ha/yr	298473	356606	352936	387376	398392

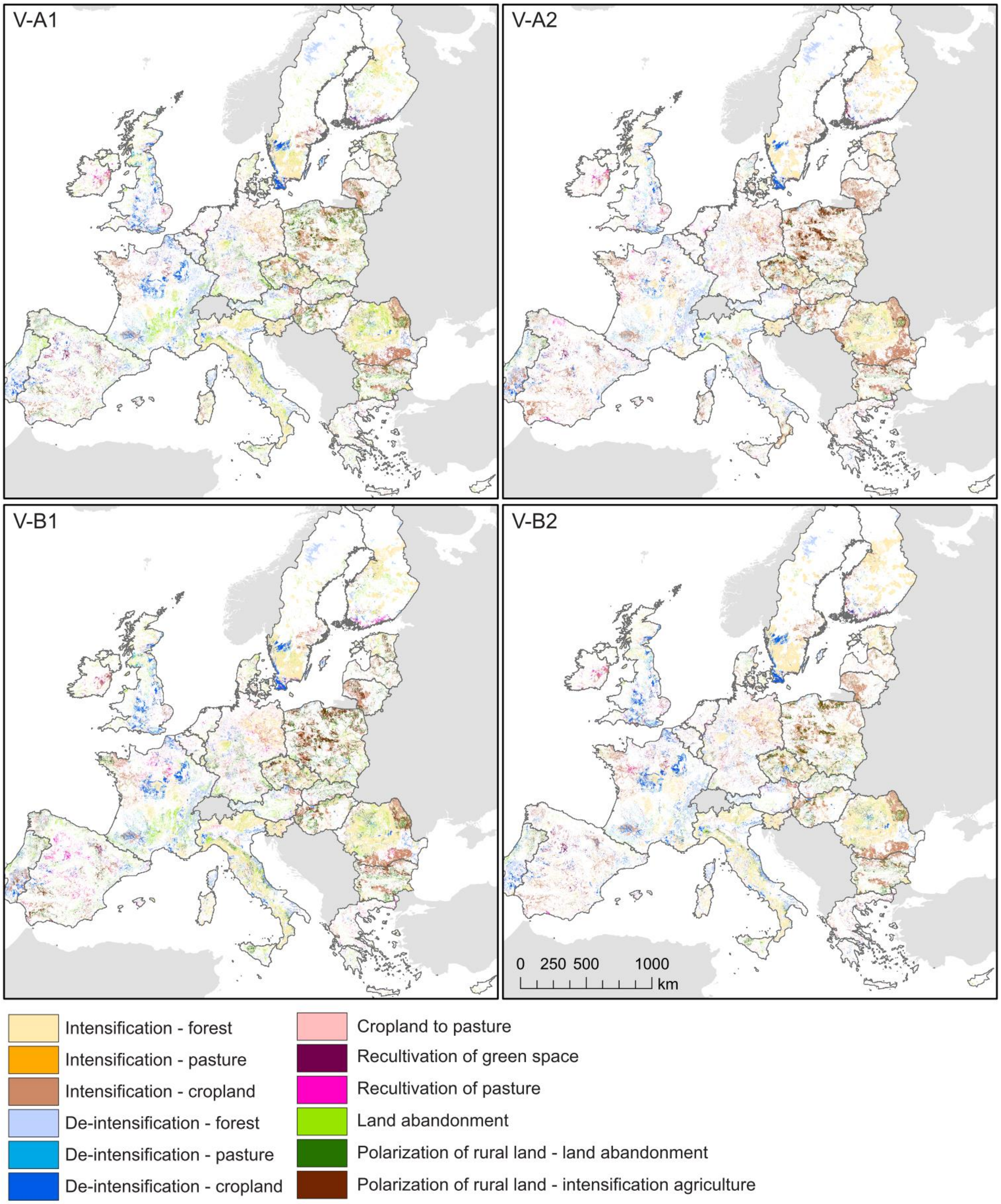

Fig. S3 Pixel-level land change trajectories (subset) for all land use simulations (2000-2040)

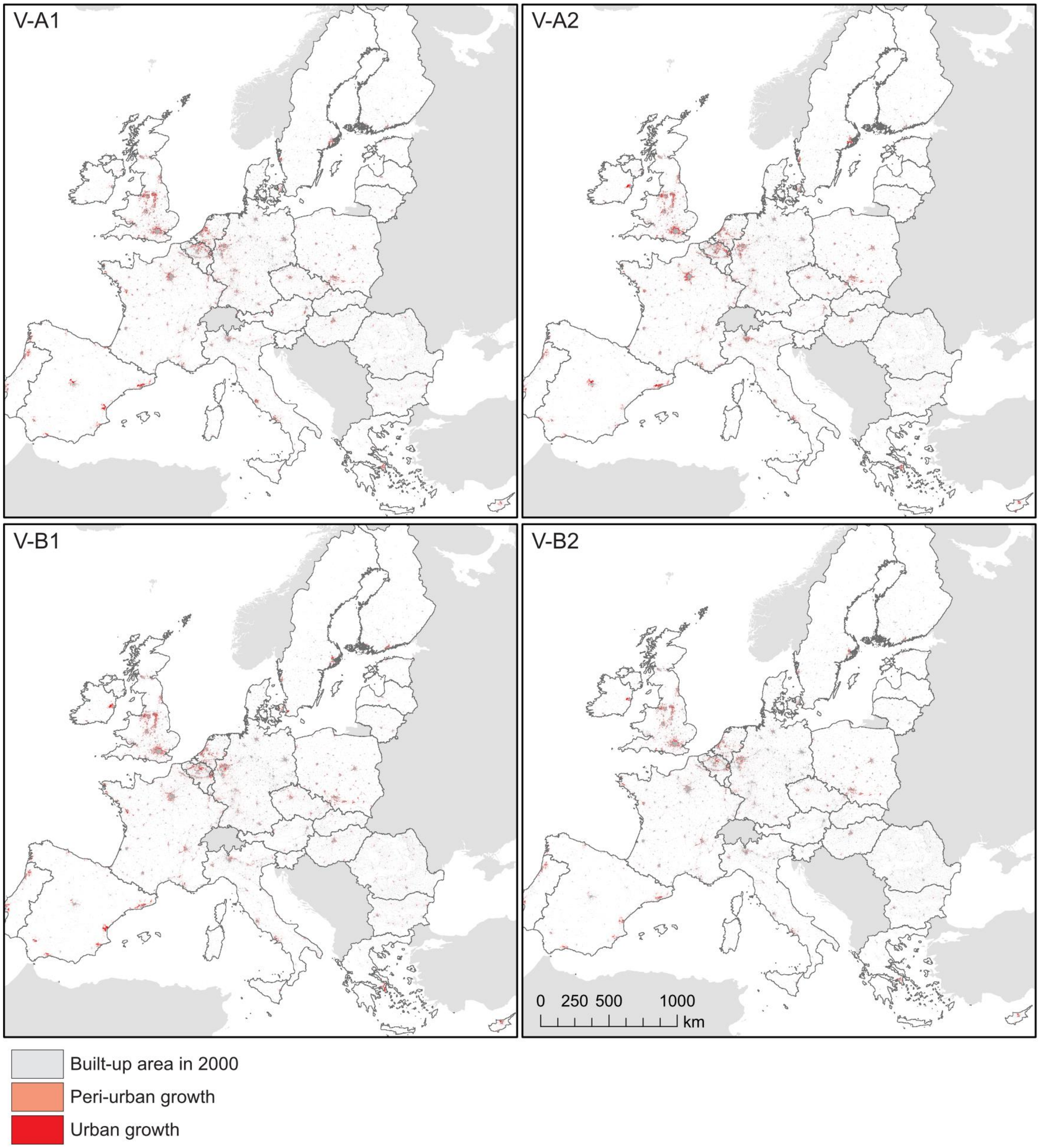

Fig. S4 Pixel-level land change trajectories (subset) for all land use simulations (2000-2040)

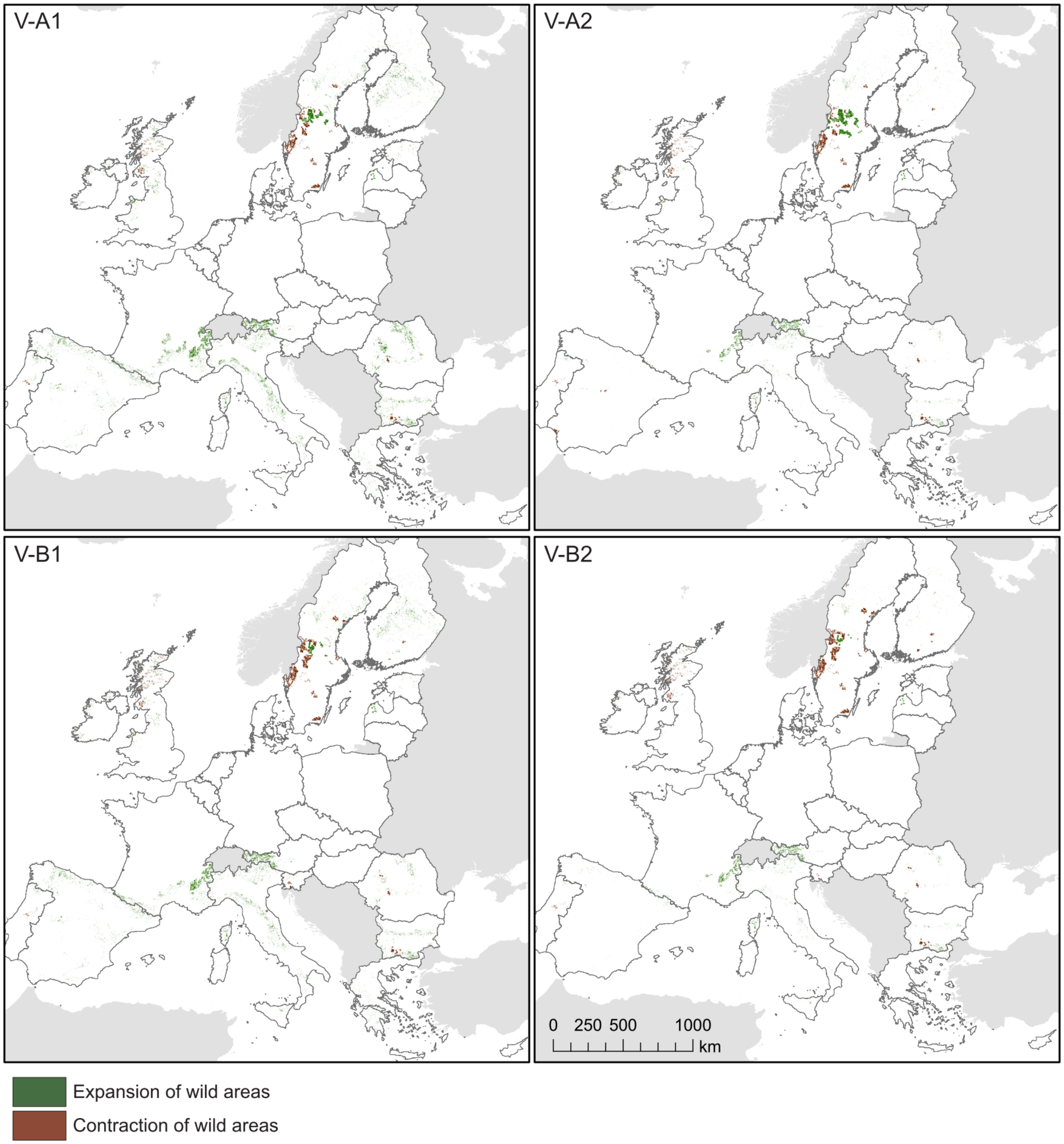

Fig. S5 Pixel-level land change trajectories (subset) for all land use simulations (2000-2040)

References

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Wild Europe (2013) A Working Definition of European Wilderness and Wild Areas.

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Annex D. Location characteristics

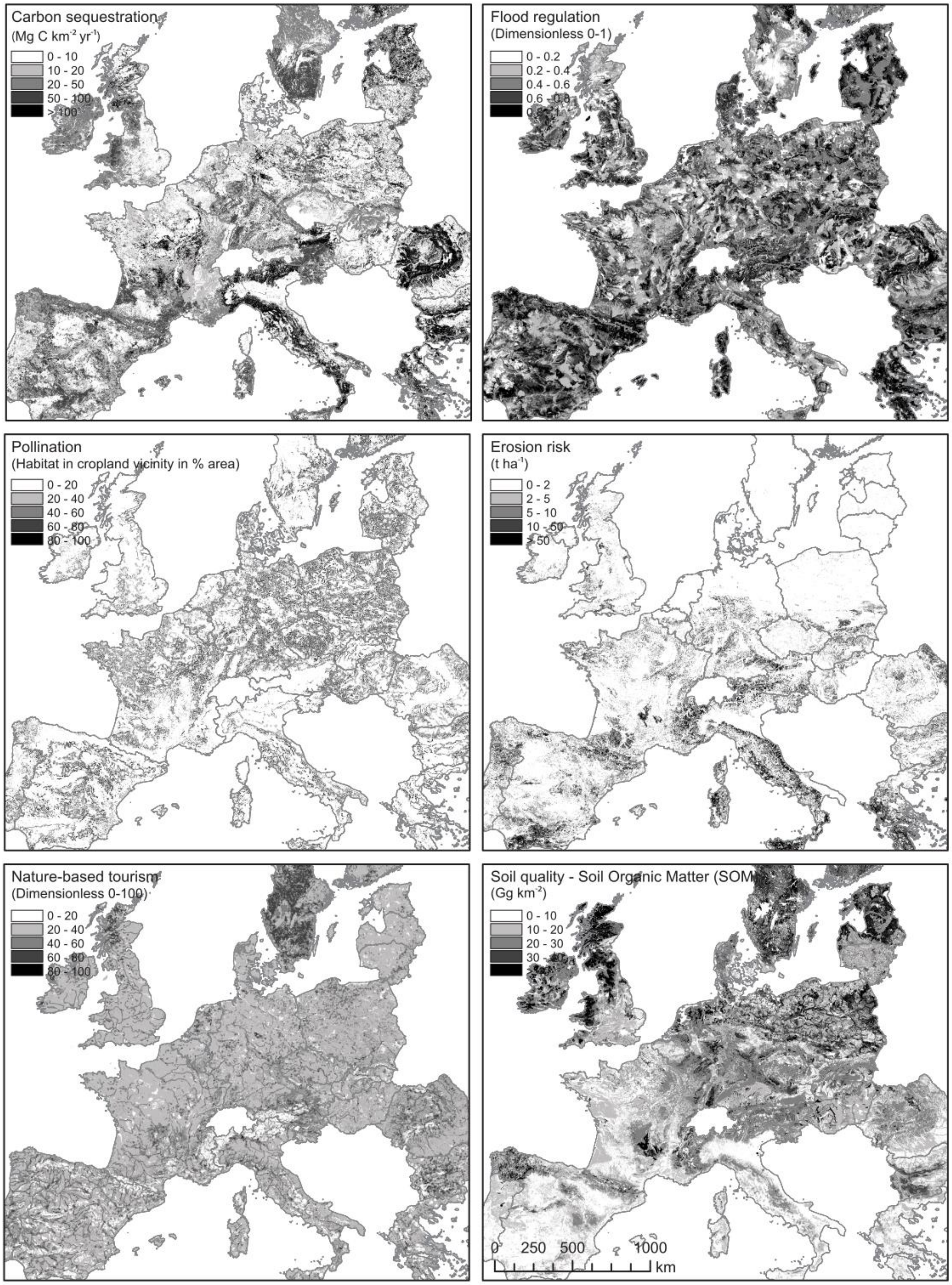

Fig. S6 Location characteristics in the reference year (2000)

Table S3 Location characteristics (mean) of land change trajectories in V-A1

	Carbon sequestration	Erosion risk	Nature-based tourism	Polli-nation	Soil quality	Flood regulation
Cropland de-intensification	7.2	4.8	33.2	42.3	15.2	0.44
Cropland intensification	3.3	3.3	33.3	45.3	16.5	0.51
Pasture de-intensification	14.7	1.4	35.5	NA	18.6	0.52
Pasture intensification	10.0	2.0	35.4	NA	18.0	0.62
Forest de-intensification	18.2	0.5	35.1	NA	22.8	0.65
Forest intensification	113.5	0.2	36.2	NA	24.6	0.60
Recultivation of green space	71.2	0.4	33.3	NA	15.6	0.58
Recultivation of pasture	16.6	2.0	36.0	NA	21.2	0.57
Land abandonment	9.2	10.5	37.7	38.1	23.0	0.54
Peri-urban growth	18.6	4.8	34.2	33.7	16.6	0.51
Urban growth	27.4	3.0	32.8	19.2	14.6	0.54
Contraction of wild areas	71.9	0.3	46.9	NA	31.8	0.51
Expansion of wild areas	14.3	8.1	39.5	16.1	26.9	0.62
Cropland to pasture	60.0	6.1	35.2	41.0	15.7	0.49
Subset: Land abandonment (w/o expansion of wild areas)	8.6	10.3	37.0	42.5	22.2	0.53
Subset: Land abandonment: only expansion of wild areas	11.5	11.1	40.2	22.7	25.5	0.60
Stability	27.1	3.1	34.0	12.2	19.9	0.51
Subset: Polarization of rural land (Intensification of cropland)	3.5	3.6	34.3	54.6	18.3	0.51
Subset: Polarization of rural land (Intensification of pasture)	6.4	5.9	35.7	NA	15.0	0.65
Subset: Polarization of rural land (land abandonment)	5.1	9.7	35.7	50.3	22.1	0.54

Table S4 Location characteristics (mean) of land change trajectories in V-A2

	Carbon sequestration	Erosion risk	Nature-based tourism	Polli-nation	Soil quality	Flood regulation
Cropland de-intensification	7.8	7.1	34.1	44.6	15.1	0.45
Cropland intensification	3.7	4.6	33.5	47.3	16.3	0.51
Pasture de-intensification	13.5	1.8	35.9	NA	19.1	0.53
Pasture intensification	10.7	2.2	35.0	NA	17.4	0.61
Forest de-intensification	13.2	0.5	36.4	NA	23.3	0.66
Forest intensification	112.4	0.1	36.2	NA	25.7	0.60
Recultivation of green space	68.9	0.4	34.4	NA	15.7	0.59
Recultivation of pasture	15.2	7.3	36.5	NA	18.5	0.62
Land abandonment	14.2	13.4	37.1	46.8	20.6	0.52
Peri-urban growth	28.5	3.6	32.9	23.3	15.9	0.53
Urban growth	34.3	2.3	31.7	15.4	14.4	0.54
Contraction of wild areas	74.5	0.3	45.7	NA	29.9	0.50
Expansion of wild areas	19.7	3.3	41.8	5.9	29.6	0.61
Cropland to pasture	120.2	7.3	35.8	39.7	15.5	0.49
Subset: Land abandonment (w/o expansion of wild areas)	14.2	13.6	36.6	49.6	20.0	0.52
Subset: Land abandonment: only expansion of wild areas	14.8	11.5	41.0	22.5	25.9	0.59
Stability	27.7	3.2	34.1	12.0	20.2	0.51
Subset: Polarization of rural land (Intensification of cropland)	3.4	6.2	34.6	48.0	17.6	0.50
Subset: Polarization of rural land (Intensification of pasture)	8.5	5.8	34.8	NA	15.6	0.63
Subset: Polarization of rural land (land abandonment)	6.5	13.7	36.4	54.3	19.8	0.51

Table S5 Location characteristics (mean) of land change trajectories in V-B1

	Carbon sequestration	Erosion risk	Nature-based tourism	Polli-nation	Soil quality	Flood regulation
Cropland de-intensification	7.9	4.5	33.2	42.3	15.3	0.44
Cropland intensification	4.3	3.1	33.3	45.9	16.5	0.51
Pasture de-intensification	14.6	1.5	35.6	NA	19.0	0.52
Pasture intensification	10.4	1.9	35.4	NA	17.8	0.62
Forest de-intensification	13.7	0.5	35.9	NA	22.5	0.65
Forest intensification	111.0	0.2	36.2	NA	24.7	0.60
Recultivation of green space	69.4	0.4	33.0	NA	14.7	0.58
Recultivation of pasture	16.4	2.2	36.2	NA	18.5	0.59
Land abandonment	9.9	12.0	37.4	39.1	21.6	0.53
Peri-urban growth	16.1	5.9	35.3	29.0	16.2	0.52
Urban growth	20.8	3.2	33.7	19.4	14.4	0.53
Contraction of wild areas	65.2	0.3	46.6	NA	32.5	0.55
Expansion of wild areas	13.5	8.8	38.6	17.3	26.4	0.64
Cropland to pasture	31.4	22.0	35.8	61.9	18.0	0.50
Subset: Land abandonment (w/o expansion of wild areas)	9.8	12.0	37.0	41.4	21.0	0.52
Subset: Land abandonment: only expansion of wild areas	10.4	12.3	40.0	25.2	25.0	0.60
Stability	26.2	2.9	34.0	12.2	20.0	0.50
Subset: Polarization of rural land (Intensification of cropland)	3.8	3.6	34.0	51.9	18.1	0.51
Subset: Polarization of rural land (Intensification of pasture)	8.3	2.6	34.1	NA	19.2	0.62
Subset: Polarization of rural land (land abandonment)	6.1	12.4	36.2	47.9	20.9	0.52

Table S6 Location characteristics (mean) of land change trajectories in V-B2

	Carbon sequestration	Erosion risk	Nature-based tourism	Polli-nation	Soil quality	Flood regulation
Cropland de-intensification	8.7	4.9	33.4	43.6	15.6	0.45
Cropland intensification	3.8	3.8	33.5	48.8	17.1	0.51
Pasture de-intensification	14.1	1.9	35.9	NA	19.3	0.53
Pasture intensification	10.4	2.1	34.8	NA	17.7	0.61
Forest de-intensification	11.5	0.5	36.0	NA	22.0	0.65
Forest intensification	106.3	0.2	36.4	NA	24.8	0.60
Recultivation of green space	66.7	0.4	33.0	NA	15.4	0.59
Recultivation of pasture	15.0	3.0	35.5	NA	15.8	0.58
Land abandonment	10.3	16.7	36.8	44.7	21.0	0.52
Peri-urban growth	15.8	6.9	35.3	28.8	16.1	0.52
Urban growth	20.5	3.4	33.5	18.3	14.4	0.53
Contraction of wild areas	63.0	0.3	46.8	NA	32.4	0.55
Expansion of wild areas	15.8	6.9	36.1	9.1	27.4	0.67
Cropland to pasture	28.2	28.6	35.9	63.7	16.4	0.50
Subset: Land abandonment (w/o expansion of wild areas)	10.3	16.9	36.5	47.3	20.5	0.51
Subset: Land abandonment: only expansion of wild areas	10.3	15.2	39.2	21.3	25.2	0.60
Stability	25.6	3.1	34.1	12.9	20.0	0.50
Subset: Polarization of rural land (Intensification of cropland)	3.1	4.2	34.6	48.6	18.5	0.50
Subset: Polarization of rural land (Intensification of pasture)	10.3	9.8	35.6	0.0	19.8	0.63
Subset: Polarization of rural land (land abandonment)	7.9	17.6	36.5	52.9	19.7	0.51

Table S7 Comparison of carbon sequestration at locations of change in V-B1 (p-values from Mann-Whitney *U* test)

	only exp WA	Cont WA	Cropl de-int	Cropl int	Crop2 Past	For de-int	For int	LA	Past de-int	Past int	Peri-urb	Pol crop int	Pol past int	Pol LA	Rec nat	Rec past	Exp WA	Stability	urban
LA w/o exp WA	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
only exp WA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cont WA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl de-int	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl int	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Crop2Past	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
For de-int	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
For int	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Past de-int	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00
Peri-urb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00
Pol crop int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00
Pol past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.83	.70	.68
Pol LA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00
Rec nat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00
Rec past	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00
Exp WA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00
Stability	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00

Table S8 Comparison of erosion risk at locations of change in V-B1 (p-values from Mann-Whitney *U* test)

	only exp WA	Cont WA	Cropl de-int	Cropl int	Crop2Past	For de-int	For int	LA	Past de-int	Past int	Peri-urb	Pol crop int	Pol past int	Pol LA	Rec nat	Rec past	Exp WA	Stability	urban
LA w/o exp	.00	.00	.00	.00	.00	.00	.00	.29	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
only exp WA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.60	.00	.00	.00	.00	.00
Cont WA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl de-int	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl int	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.68	.00	.00	.21
Crop2Past	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
For de-int	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
For int	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00
Past de-int	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00
Peri-urb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00
Pol crop int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.99	.00	.00	.00	.00	.00	.00
Pol past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	.89	.00	.00	.00	.00	.00	.00
Pol LA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00
Rec nat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00
Rec past	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.76
Exp WA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00
Stability	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00

Table S9 Comparison of nature-based tourism at locations of change in V-B1 (p-values from Mann-Whitney *U* test)

	only exp WA	Cont WA	Cropl de-int	Cropl int	Crop2Past	For de-int	For int	LA	Past de-int	Past int	Peri-urb	Pol crop int	Pol past int	Pol LA	Rec nat	Rec past	Exp WA	Stability	urban
LA w/o exp	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
only exp WA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cont WA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl de-int	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.36	.00	.00	.00	.00	.00	.00
Cropl int	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.13	.00	.00	.00	.00	.00	.00
Crop2Past	NA	NA	NA	NA	1	.07	.64	.00	.00	.01	.00	.00	.00	.85	.00	.44	.00	.00	.00
For de-int	NA	NA	NA	NA	NA	1	.32	.00	.00	.00	.00	.00	.00	.81	.00	.49	.00	.00	.00
For int	NA	NA	NA	NA	NA	NA	1	.00	.25	.00	.00	.00	.00	.00	.00	.11	.00	.00	.00
LA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Past de-int	NA	NA	NA	NA	NA	NA	NA	NA	1	.11	.00	.00	.00	.02	.00	.03	.00	.00	.00
Past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.12	.00	.04	.00	.00	.00	.00	.00	.00
Peri-urb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.06	.00	.00	.00	.00	.00	.00
Pol crop int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.86	.00	.00	.00	.00	.00	.00
Pol past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.72	.01
Pol LA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.17	.00	.00	.00
Rec nat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00
Rec past	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00
Exp WA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00
Stability	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00

Table S10 Comparison of pollination at locations of change in V-B1 (p-values from Mann-Whitney *U* test)

	only exp WA	Cont WA	Cropl de-int	Cropl int	Crop2Past	For de-int	For int	LA	Past de-int	Past int	Peri-urb	Pol crop int	Pol past int	Pol LA	Rec nat	Rec past	Exp WA	Stability	urban
LA w/o exp	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
only exp WA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02
Cont WA	NA	NA	.00	.00	.00	NA	1	.00	NA	NA	.00	.00	NA	.00	NA	NA	.00	.00	.00
Cropl de-int	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl int	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Crop2Past	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
For de-int	NA	NA	NA	NA	NA	NA	NA	.00	NA	NA	.00	.00	NA	.00	NA	NA	.00	.00	.00
For int	NA	NA	NA	NA	NA	NA	NA	.00	NA	NA	.00	.00	NA	.00	NA	NA	.00	.00	.00
LA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Past de-int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	.00	.00	NA	.00	NA	NA	.00	.00	.00
Past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	.00	.00	NA	.00	NA	NA	.00	.00	.00
Peri-urb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00
Pol crop int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00
Pol past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	.00	NA	NA	.00	.00	.00
Pol LA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00
Rec nat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	.00	.00	.00
Rec past	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	.00	.00	.00
Exp WA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00
Stability	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00

Table S11 Comparison of maintenance of soil quality at locations of change in V-B1 (p-values from Mann-Whitney *U* test)

	only exp WA	Cont WA	Cropl de-int	Cropl int	Crop2Past	For de-int	For int	LA	Past de-int	Past int	Peri-urb	Pol crop int	Pol past int	Pol LA	Rec nat	Rec past	Exp WA	Stability	urban
LA w/o exp	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.99	.00	.00	.00	.00	.00
only exp WA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cont WA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl de-int	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl int	NA	NA	NA	1	.00	.00	.00	.00	.00	.59	.79	.00	.01	.00	.00	.00	.00	.00	.00
Crop2Past	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.36	.00	.00	.86	.00	.00	.00
For de-int	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
For int	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Past de-int	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.18	.00	.00	.00	.00	.08	.00
Past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.89	.00	.02	.00	.00	.00	.00	.00	.00
Peri-urb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00
Pol crop int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.70	.00	.00	.00	.00	.00	.00
Pol past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.34	.00	.24	.00
Pol LA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00
Rec nat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00
Rec past	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00
Exp WA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00
Stability	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00

Table S12 Comparison of flood regulation supply at locations of change in V-B1 (p-values from Mann-Whitney *U* test)

	only exp WA	Cont WA	Cropl de-int	Cropl int	Crop2Past	For de-int	For int	LA	Past de-int	Past int	Peri-urb	Pol crop int	Pol past int	Pol LA	Rec nat	Rec past	Exp WA	Stability	urban
LA w/o exp	.00	.00	.00	.00	.00	.00	.00	.00	.20	.00	.84	.00	.00	.01	.00	.00	.00	.00	.00
only exp WA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cont WA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl de-int	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
Cropl int	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.20	.04	.00	.00	.00	.00	.43	.00
Crop2Past	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
For de-int	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
For int	NA	NA	NA	NA	NA	NA	1	.00	.00	.02	.00	.00	.00	.00	.00	.00	.00	.00	.00
LA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.24
Past de-int	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.58	.00	.00	.01	.00	.00	.00	.00	.00
Past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00	.00	.00	.00	.00
Peri-urb	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.16	.00	.00	.00	.00	.00
Pol crop int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.51	.00	.00	.00	.00	.90	.00
Pol past int	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	.00	.00	.00	.00	.00	.00	.00
Pol LA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00	.00	.00
Rec nat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.06	.00	.00	.00
Rec past	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00	.00
Exp WA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00	.00
Stability	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1	.00

Fig. S7 Location characteristics per land change trajectory and land use scenario