

Supplementary Appendix for:
The Environmental Impacts of
Scaling a Microfinancial Product:
Index-Based Livestock Insurance and
East African Rangelands

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A Supplementary Figures and Tables: IBLI roll-out, study area and units of Observation, and IBLI exposure

A.1 Trends in IBLI roll-out and adoption at the index unit level.

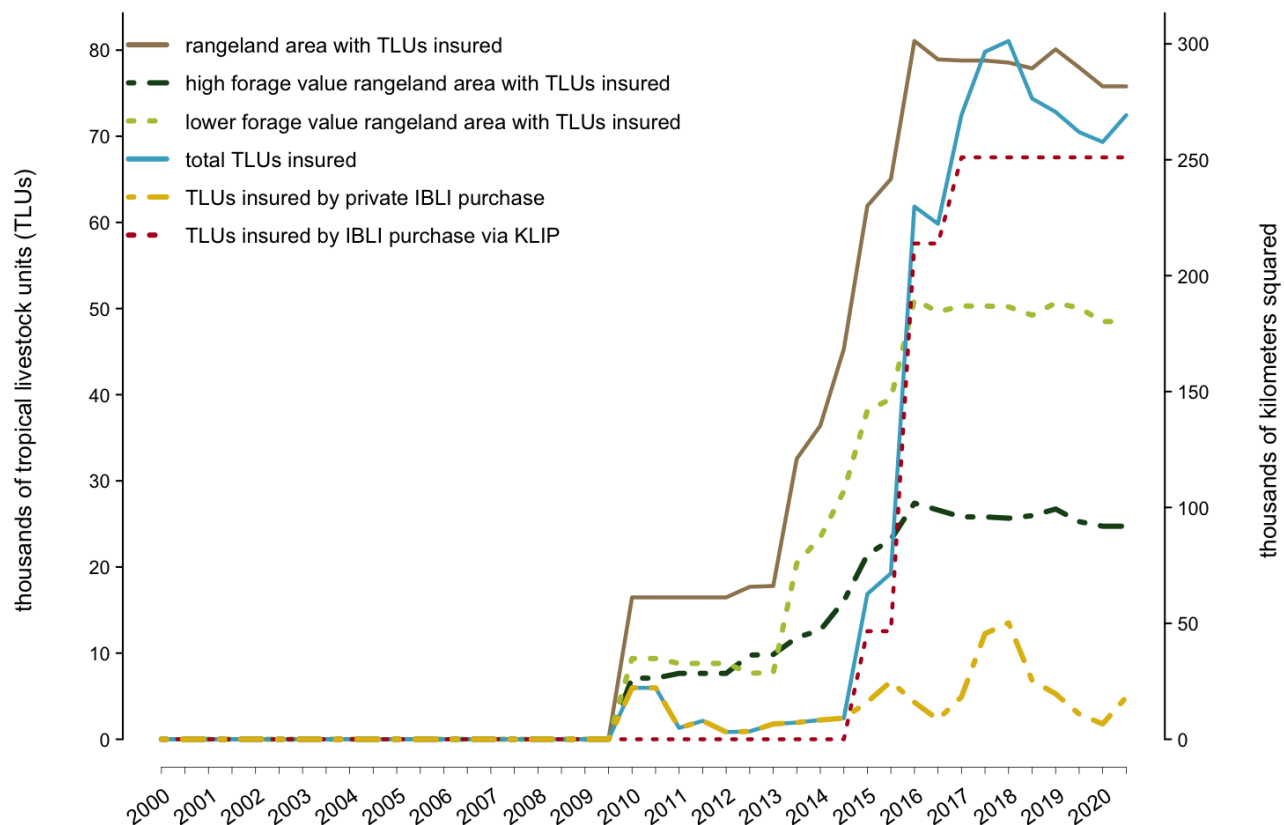


Figure A.1.1: IBLI expansion in thousands of TLUs insured and area of rangelands exposed in thousands km² in terms of total rangeland area, as well as rangeland area exposed by ‘low’ and ‘high’ forage quality rangelands. Higher exposure to low forage quality rangelands reflects that these rangeland types are dominant in the region. Definitions of ‘low’ and ‘high’ forage quality rangeland types are detailed in Section 3.3.

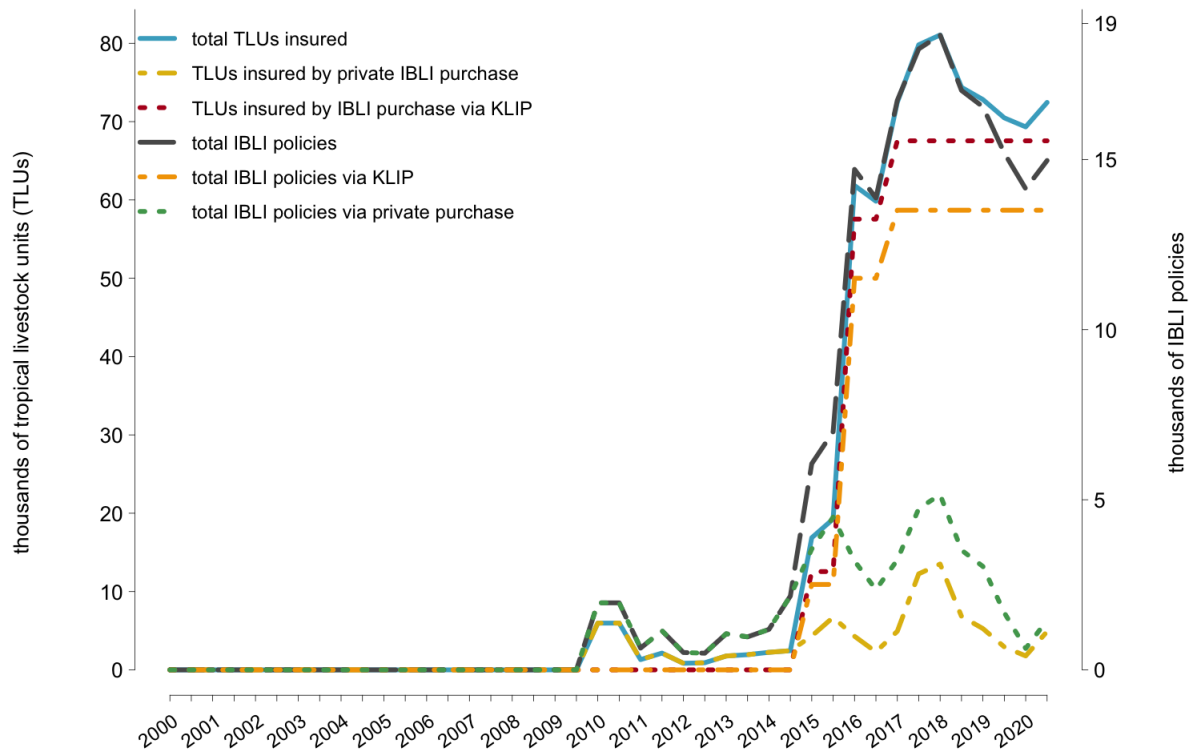


Figure A.1.2: Trends for the number of TLUs insured and number of policies.

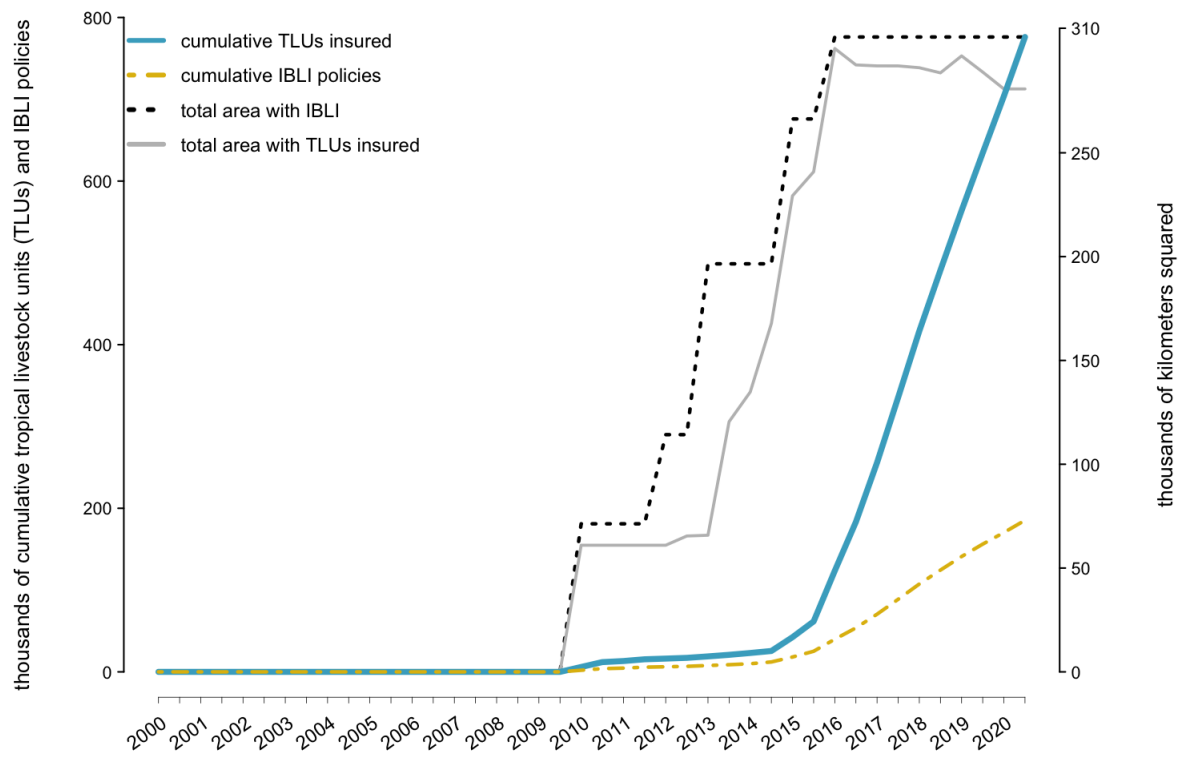


Figure A.1.3: Trends for the cumulative number of TLUs insured and cumulative number of policies, along with the corresponding rangeland area exposed.

2009 -- Long Rain Long Dry (LRLD)

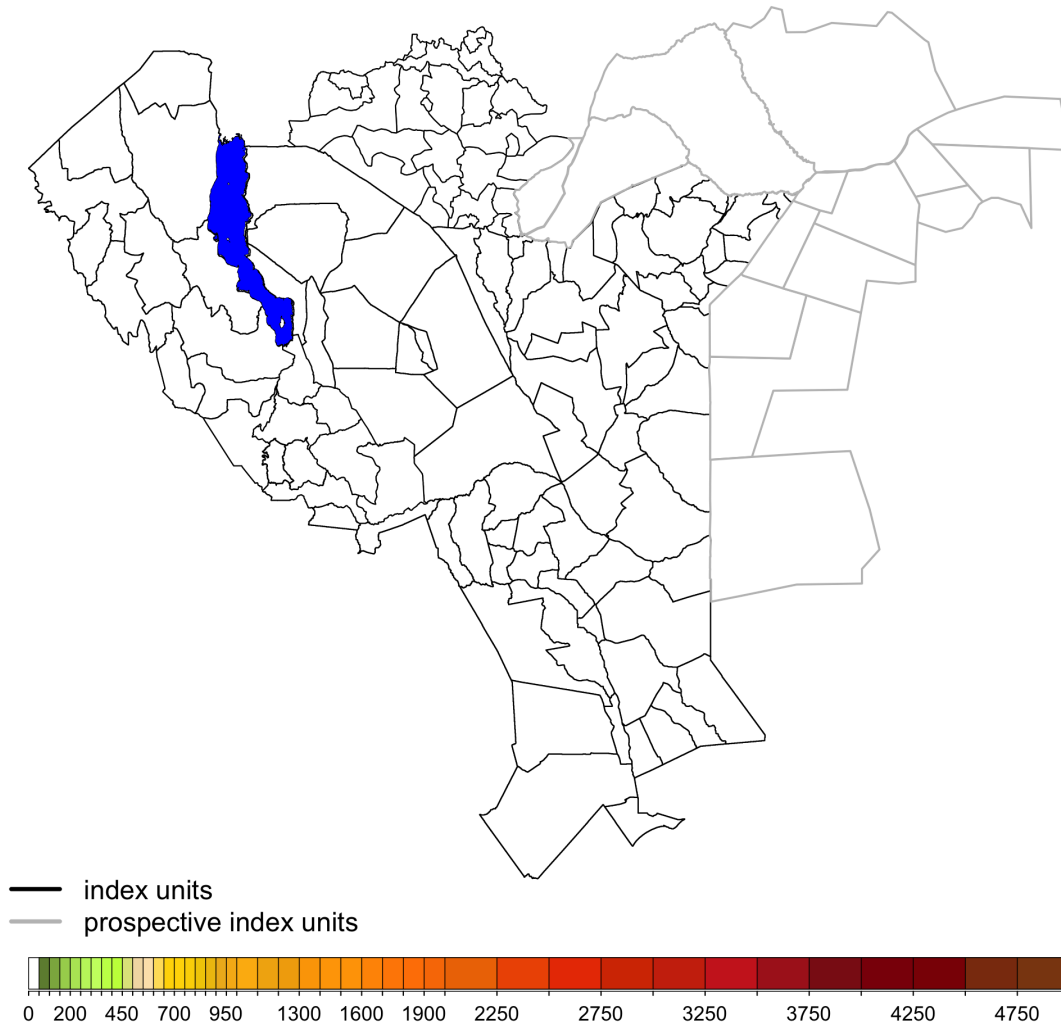


Figure A.1.4: Animation of observed, *contemporaneous* TLUs insured by index unit, year, and season over 2009-2020. Note that Adobe Acrobat reader may be required to view the full animation as intended.

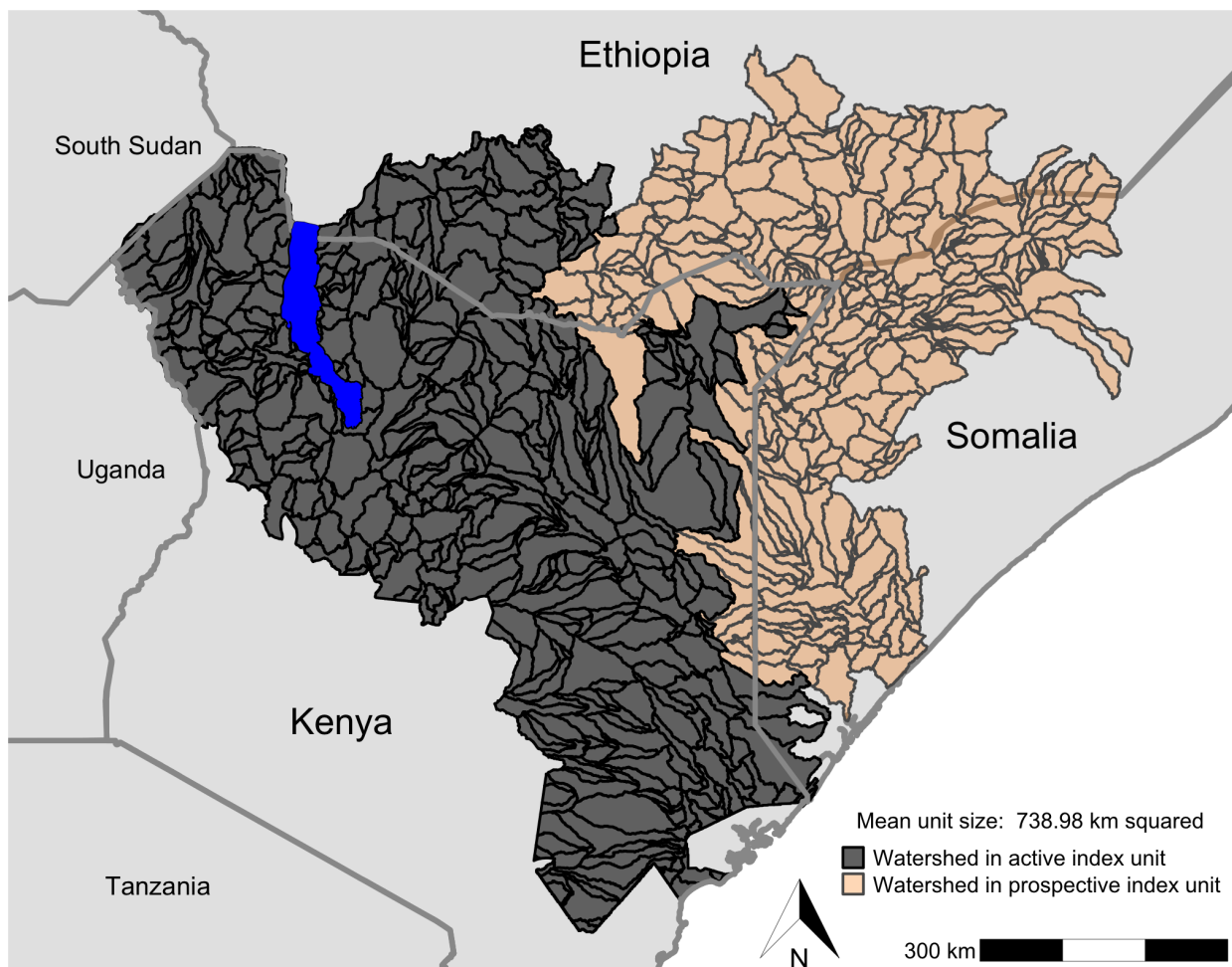


Figure A.1.5: Map of study area and intersecting HUC-8 units from Lehner and Grill (2013).

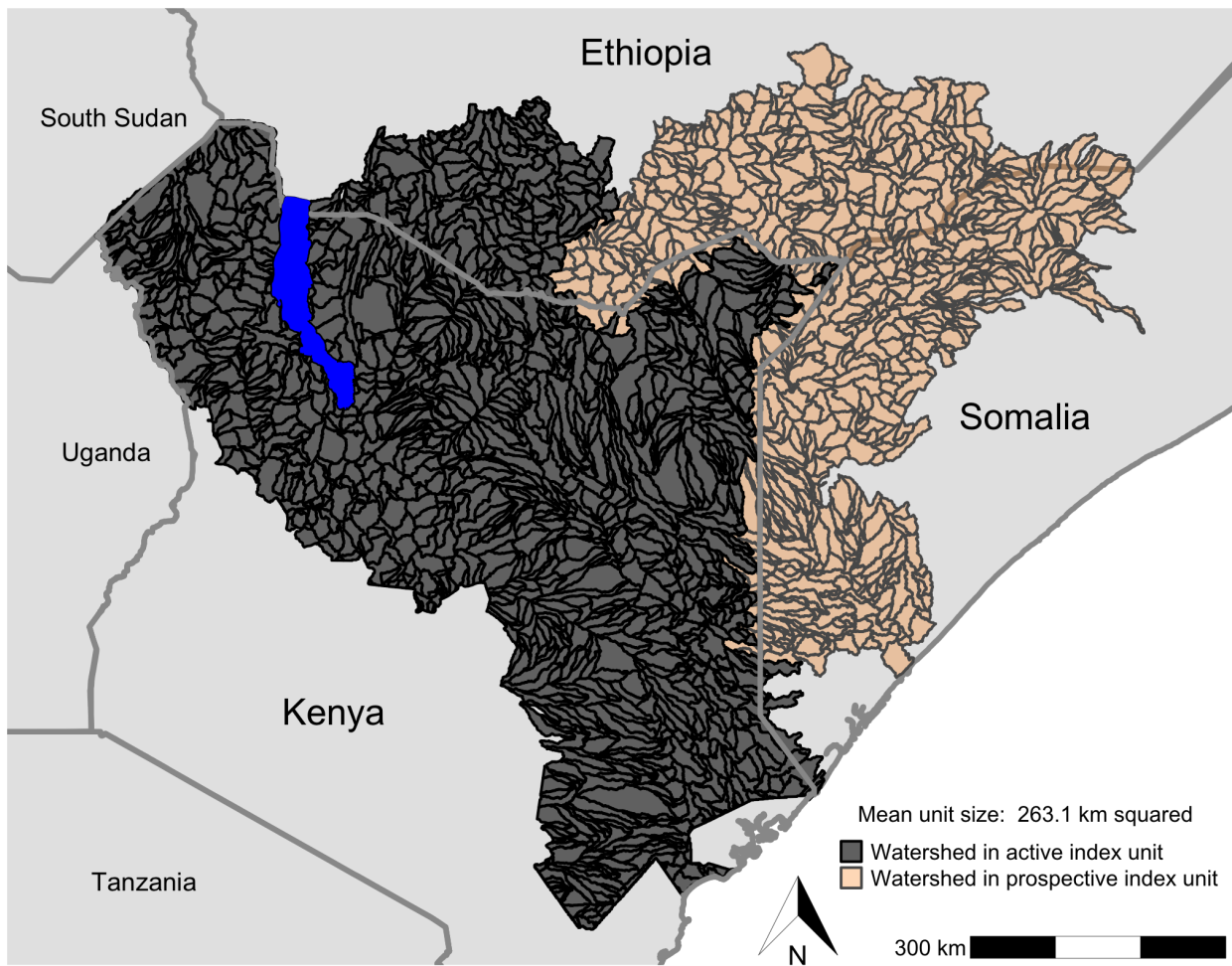


Figure A.1.6: Map of study area and intersecting HUC-9 units from Lehner and Grill (2013).

A.2 IBLI exposure via inverse distance weighting

Equation (A.2.1) defines the IBLI exposure variable of interest at the unit level that accounts for herder movement:

$$WIBE_i = IBE_i + \sum_{j \neq i} \frac{(\mathbb{1}_j w_{ij})}{\sum_{j \neq i} \mathbb{1}_j w_{ij}} IBE_j \quad (\text{A.2.1})$$

$WIBE_i$ represents the estimated weighted total IBLI exposure of unit i (i.e., IUs, HUCs) for a given time period (time and pixel-level summations are omitted for simplicity). IBE_i is the total rangeland-area weighted exposure (in TLUs insured) observed within spatial unit i for some year and season, w_{ij} is a weighting function that scales the observed rangeland-area weighted exposure within another unit $j \neq i$, and the indicator function $\mathbb{1}_j$ is a binary variable equal to 1 if unit j is within the pre-defined neighborhood of unit i . Weights are normalized such that $\sum_{j \neq i} \frac{\mathbb{1}_j w_{ij}}{\sum_{j \neq i} \mathbb{1}_j w_{ij}} = 1$.

We operationalize equation (A.2.1) using inverse distance weighting (IDW) for w_{ij} and we use referenced GPS livestock collar data (Section 3.2) to define a neighborhood distance for each unit for each of our four levels of aggregation (Clark et al. 2006; Liao et al. 2017, 2018). Specifically, we apply a neighborhood distance of 63 km, which reflects the sum of the mean and standard deviation of observed herding distances during each SRSD season over 2011-2015. This is a conservative distance as herding distances tend to be a bit larger in the SRSD (see boxplots below in Figure A.2.1). To weight adjacent exposure within this neighborhood for units $j \neq i$ we use a series of 9 evenly spaced (7 km) concentric buffers b_j emanating from the border of each unit i . To accomplish this, we down-scale IBLI exposure from IUs to Landsat-scale (30m) pixels via an ‘all’ rangelands mask (described in Section 3.3) since movement is likely to occur through all land types. Intersecting rangeland-area weighted IBLI exposure within each buffer is therefore weighted by the inverse of distance $b_j - (7 \text{ km}/2)$, which is the midway distance in meters between each buffer’s inner and outer boundaries.¹

To study IBLI exposure we focus on cumulative TLUs insured at the extensive and intensive margins and we study exposure as an irreversible state. Specifically, we consider a unit to be exposed to IBLI in the first period when cumulative $WIBE_i \geq 1$, so once one cumulative TLU is insured within a unit. Cumulative exposure accounts for the fact that any effects on rangelands are likely to be a function of the livestock units insured over time and the aggregate effects of herders’ exposure to IBLI. Treating exposure as an irreversible state also accounts for the fact that there have been no disruptions to IBLI exposure during our study period.

Below we detail each of the steps in our algorithm for implementing our IDW approach to account for spill-overs in IBLI exposure.

¹For example, for any unit i the outside border of the farthest buffer b_9 , is 63 km away from the border of unit i . Hence the sum of IBLI exposure within the intersecting pixels of the farthest buffer is weighted by the inverse of, $63 \text{ km} - (7 \text{ km} / 2) = 59.5 \text{ km}$.

- Step 1: For each year, season, index unit (IU) and control area (CA) (i.e., prospective index unit) convert IBLI exposure into a raster grid using the respective ‘all’ rangelands mask derived from Landsat scale (i.e., 30 m²) land cover data from Soto et al. (2024) (see further details in Section 3.3).
- Step 2: For each year, season, IU and CA, count the number of pixels that result within each IU and CA from Step 1 and store the data.
- Step 3: For each year, season, IU and CA, divide the IBLI exposure variable of interest (i.e., cumulative TLUs insured) by the number of pixels from Step 2 and store the data. Step 3 produces rangeland area weighted IBLI exposure per pixel within IUs and CAs per year and season.
- Step 4: For each year, season, IU and CA, convert the rangeland area weighted data from Step 3 into a raster grid using the respective ‘all’ rangelands mask derived from Landsat scale (i.e., 30 m²) land cover data from Soto et al. (2024), to produce a raster of rangeland area weighted IBLI exposure and store the data.
- Step 5: Using data from Step 4, for each unit, in each year and season, apply equation (A.2.1) by summing across all pixels within each unit, summing across pixels within each unit’s respective concentric buffers and weight by the inverse distance, then add the two sums, and store the data for each unit (IUs and CAs (n = 130), HUC-8 (n = 870), HUC-9 (n = 2339), HUC-12 (n = 4753)).

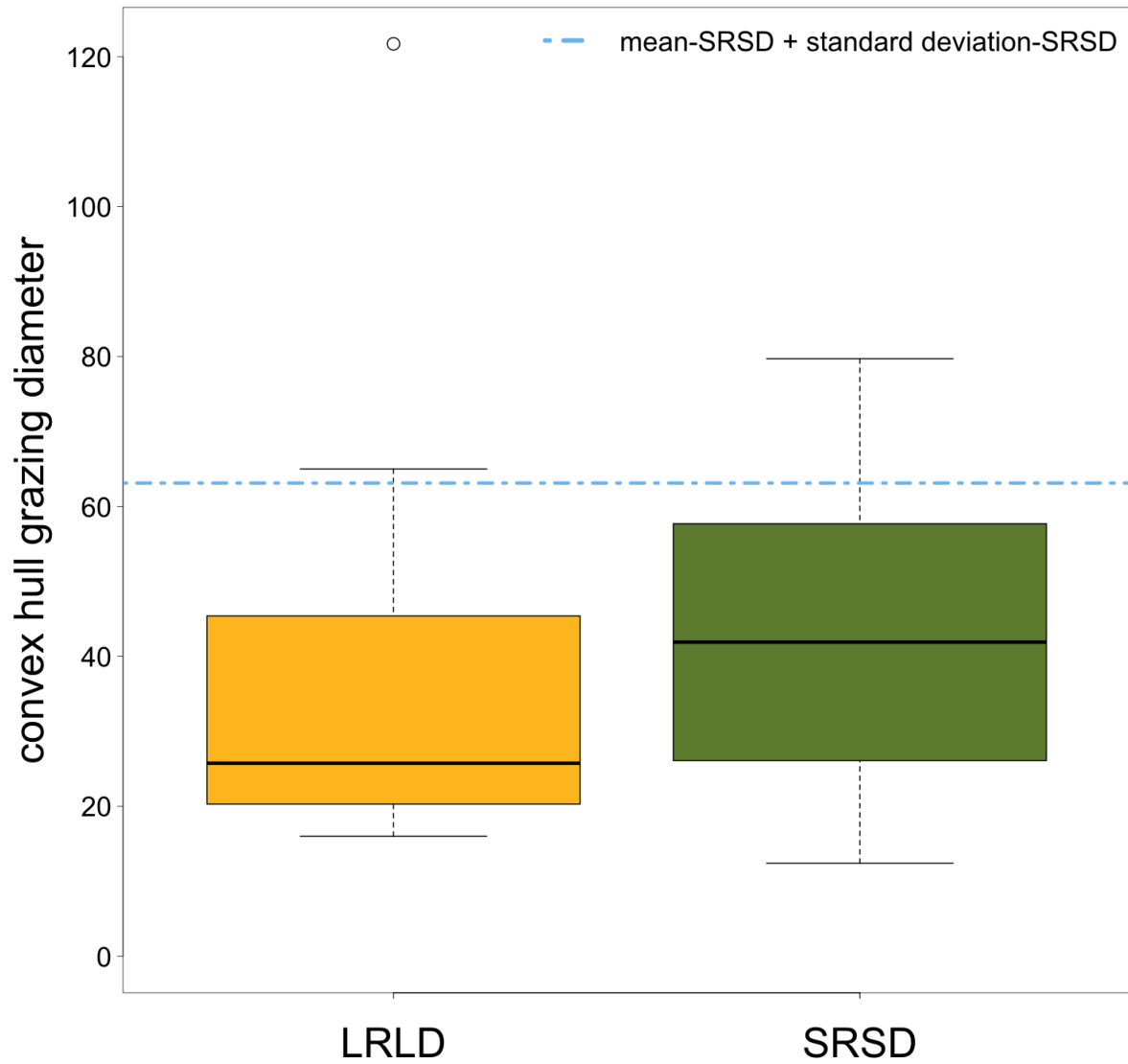


Figure A.2.1: Distribution of convex hull diameters across the LRLD and SRSD. To bound neighborhoods for inverse distance weighting we apply the mean diameter from the SRSD plus one standard deviation from the SRSD, which comes to 63 kilometers. (Author's calculations using GPS livestock collar data from Clark et al. 2006).

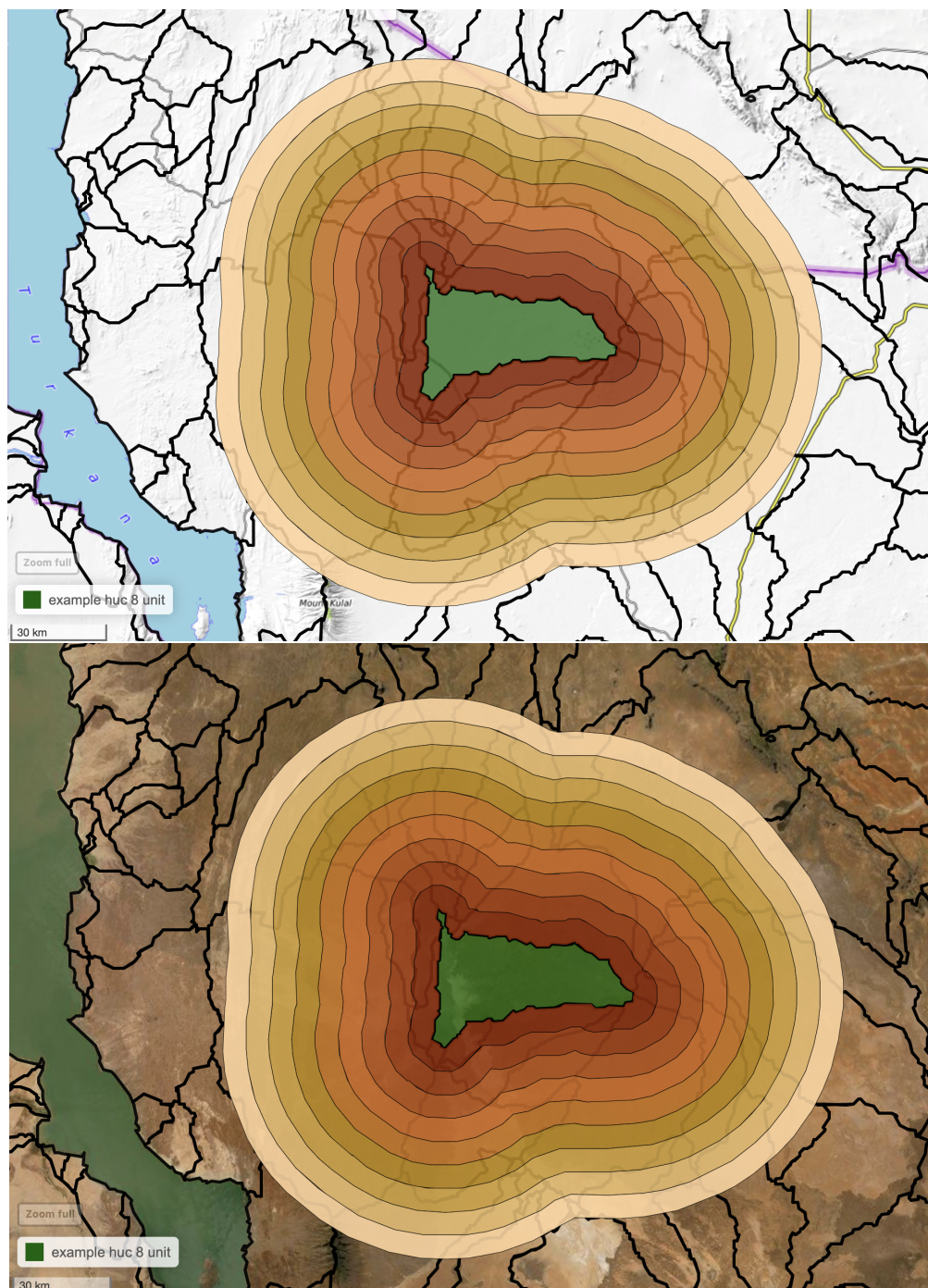


Figure A.2.2: Example neighborhood and concentric buffers for a HUC-8 watershed unit east of Lake Turkana.

2009 -- Long Rain Long Dry (LRLD)

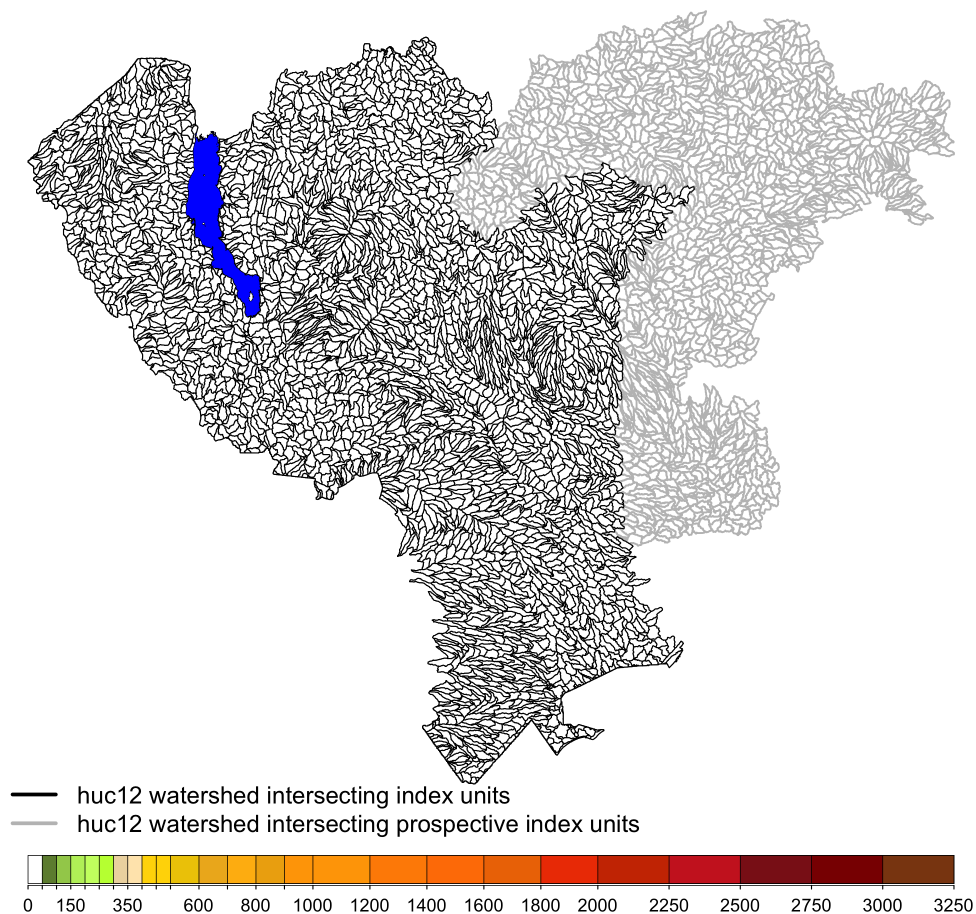


Figure A.2.3: Animation of inverse distance weighted *contemporaneous* (i.e., non-cumulative) TLUs insured by HUC-12 unit, year, and season. This figure shows the results of applying equation (A.2.1) using index-unit level IBLI sales data and the ‘all’ rangeland mask (see Section 3.3). Note that Adobe acrobat reader may be required to view the full animation as intended.

2009 -- Long Rain Long Dry (LRLD)

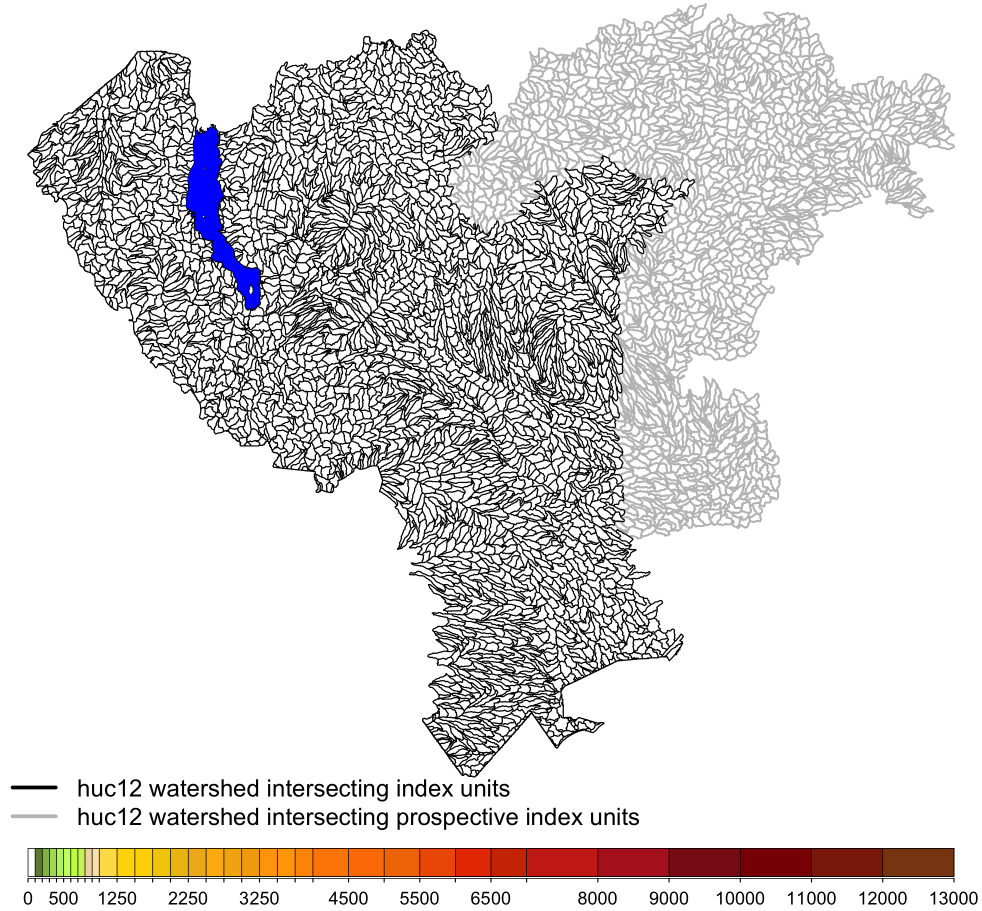


Figure A.2.4: Animation of inverse distance weighted *cumulative* TLUs insured by HUC-12, year, and season. This figure shows the results of applying equation (A.2.1) using index-unit level IBLI sales data and the ‘all’ rangeland mask (see Section 3). Note that Adobe acrobat reader may be required to view the full animation as intended.

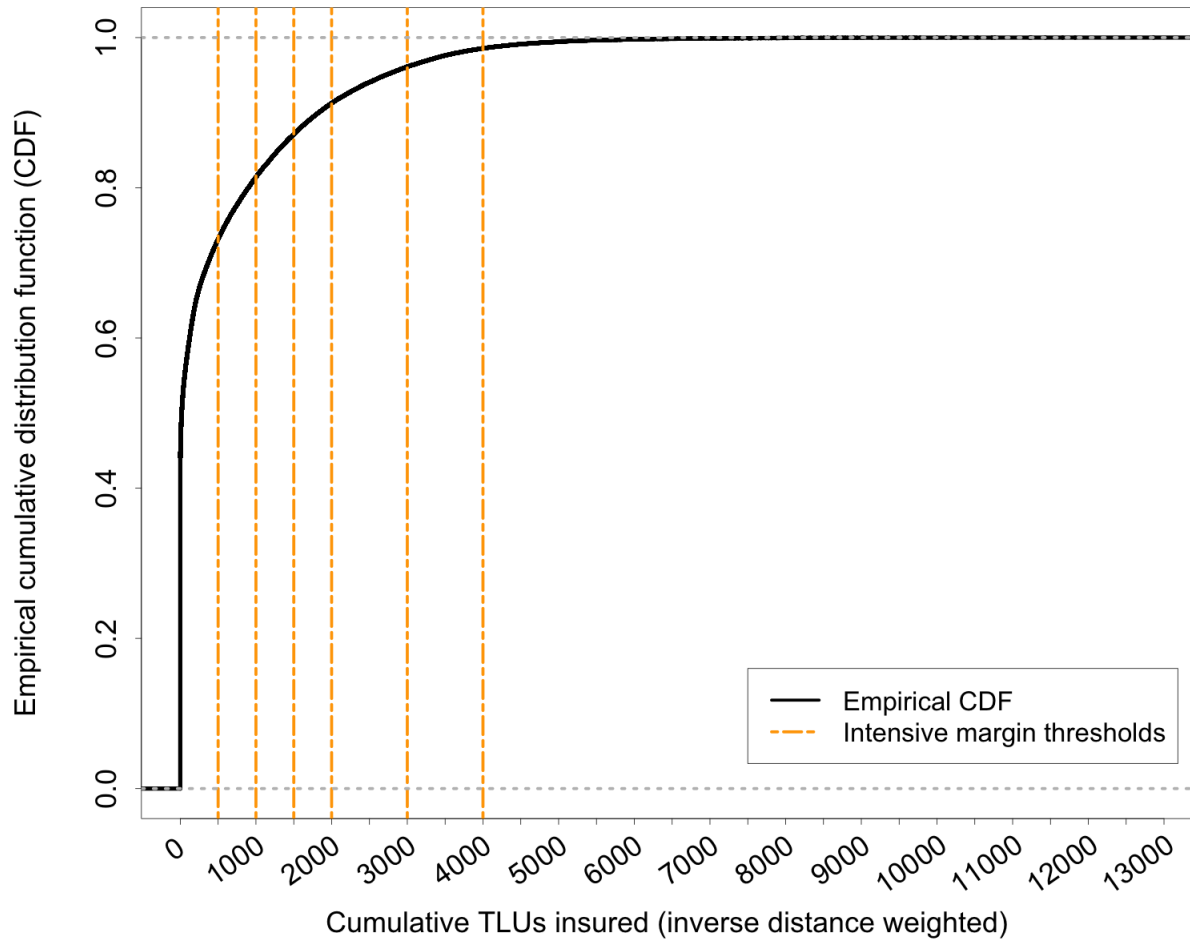


Figure A.2.5: Cumulative distribution function of inverse distance weighted cumulative IBLI exposure in TLUs insured over 2010 - 2020.

Table A.2.1: Summary statistics for tropical livestock units (TLUs) insured at each level of aggregation over 2010-2020 by differing exposure definitions.

Variable	Index Unit	HUC-8	HUC-9	HUC-12
TLUs insured	352.36 (650.07) [2860]	52.55 (165.78) [19140]	19.55 (56.49) [51458]	9.62 (23.6) [104566]
TLUs insured (IDW)	596.64 (921.37) [2860]	155.78 (331.39) [19140]	102.98 (194.29) [51458]	85.98 (147.9) [104566]
Cumulative TLUs insured	2133.33 (4384.54) [2860]	318.17 (1092.54) [19140]	118.35 (366.98) [51458]	58.24 (151.88) [104566]
Cumulative TLUs insured (IDW)	3587.36 (6276.66) [2860]	945.74 (2219.14) [19140]	625.29 (1298.73) [51458]	521.33 (990.92) [104566]

Note: Each column presents the mean, standard deviation (parenthesis), and sample size (square brackets) for each measure of IBLI exposure. Variables denoted with ‘(IDW)’ reflect inverse distance weighted exposure as described in Section 3.2 and Appendix A.2. The first year with semi-annual IBLI coverage was 2010 (see Section 2 for further details). Variable names reflect the following specific definitions of IBLI coverage/exposure: contemporaneous without IDW (‘TLUs insured’); contemporaneous with IDW (‘TLUs insured (IDW)’); cumulative without IDW (‘Cumulative TLUs insured’); and cumulative with IDW (‘Cumulative TLUs insured (IDW)’).

B Supplementary Figures and Tables: Rangeland Health Measures and Covariates

B.1 Rangeland condition measures within the rangeland health framework, summary statistics, and rangeland masks.

Table B.1.1: Remotely sensed (RS) indicators of rangeland health (RH) used in this study arranged by their relationship to the RH framework detailed by Pellant et al. (2020).

RH Attributes	RH Assessment Indicators (RHAI)	RS-based Estimates of RHAI	Sources & Methods
Biotic Integrity	dead or dying plants	non-photosynthetic vegetation	30m fractional cover Soto et al. (2024)
	functional / structural group canopy cover	photosynthetic vegetation	30m fractional cover Soto et al. (2024)
	functional/ structural groups, plant mortality and vigor	vegetation indices (e.g., EVI) ⁺⁺	250m MODIS vegetation indices Didan et al. (2021)
Hydrologic Function	bare ground	bare ground	30m fractional cover Soto et al. (2024)
Soil / Site Stability			

⁺⁺Denotes indirect estimates of RHAI. Ground-based measurement protocols outlined by Pellant et al. (2020) recommend a variety of RHAI to capture each RH attribute. We rely on RS-based estimates of RHAI that are either direct or indirect estimates of standard ground-based measures of RHAI.

Table B.1.2: Summary statistics for rangeland health attribute indicator measures at HUC-12 level over 2000-2020.

Variable	All	High	Low	CCW	SS	SV
BG share	0.28 (0.24) [99510]	0.13 (0.14) [98532]	0.33 (0.25) [99444]	0.04 (0.11) [72094]	0.28 (0.32) [20570]	0.59 (0.28) [85615]
PV share	0.21 (0.14) [99510]	0.26 (0.12) [98532]	0.21 (0.15) [99444]	0.45 (0.16) [72094]	0.19 (0.15) [20570]	0.11 (0.11) [85615]
NPV share	0.51 (0.19) [99510]	0.6 (0.15) [98532]	0.47 (0.19) [99444]	0.51 (0.15) [72094]	0.53 (0.24) [20570]	0.3 (0.21) [85615]
EVI	0.18 (0.07) [199584]	0.18 (0.07) [196642]	0.17 (0.07) [199448]	0.22 (0.08) [134850]	0.21 (0.06) [35855]	0.15 (0.05) [167792]

Note: Each column presents the mean, standard deviation (parenthesis), and sample size (square brackets) for each rangeland health measure at the HUC-12 level. Acronyms in this table are as follows: BG = bare ground; PV = photosynthetic vegetation; NPV = non-photosynthetic vegetation; and EVI = enhance vegetation index; all = all rangeland types; high = high forage quality rangeland types (including open canopy woodland (OCW), grassland (GR), sparse scrubland (SS), and cultivated land (CL)); low = low forage quality rangeland types (including sparse vegetation (SV), bushland (BU), dense scrubland (DS), and close canopy woodland (CCW)).

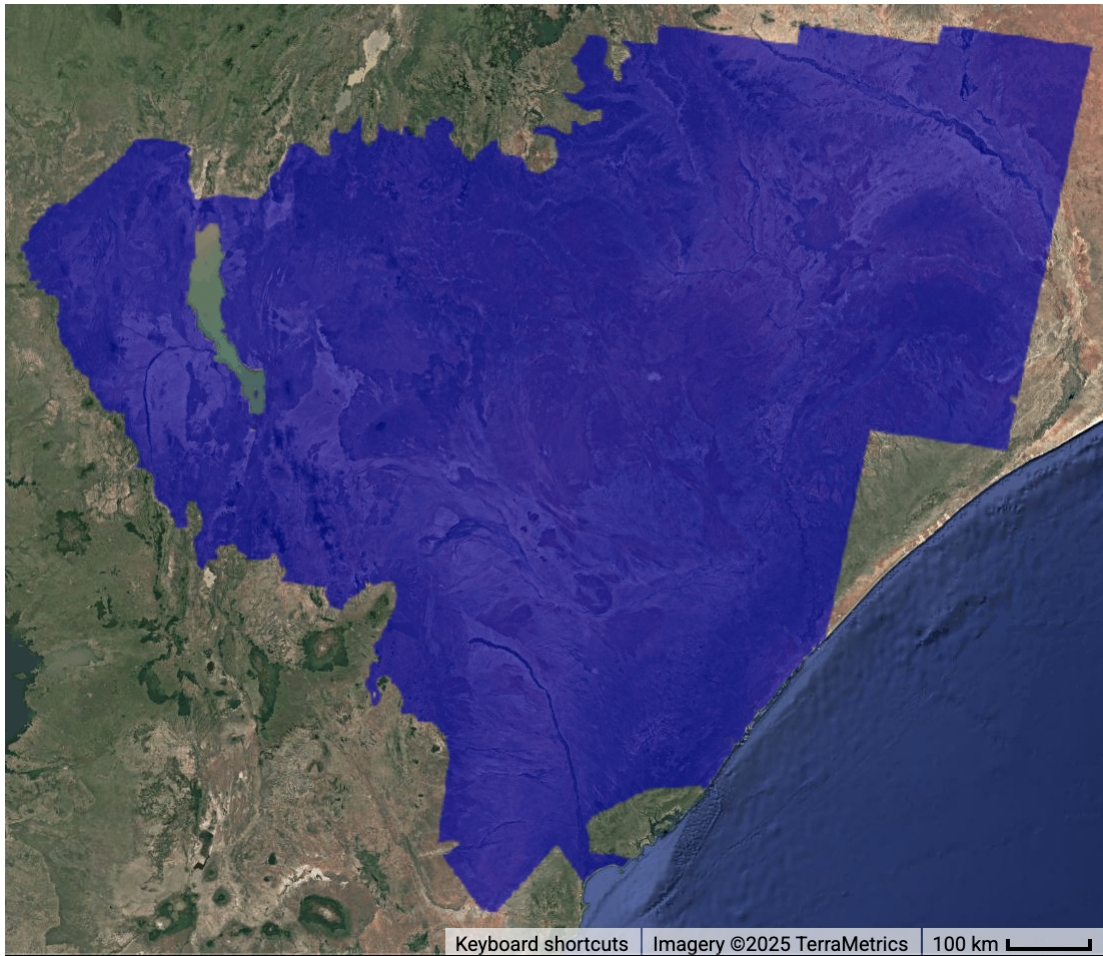


Figure B.1.1: Land cover mask for the ‘all’ rangelands over 2006-2010.

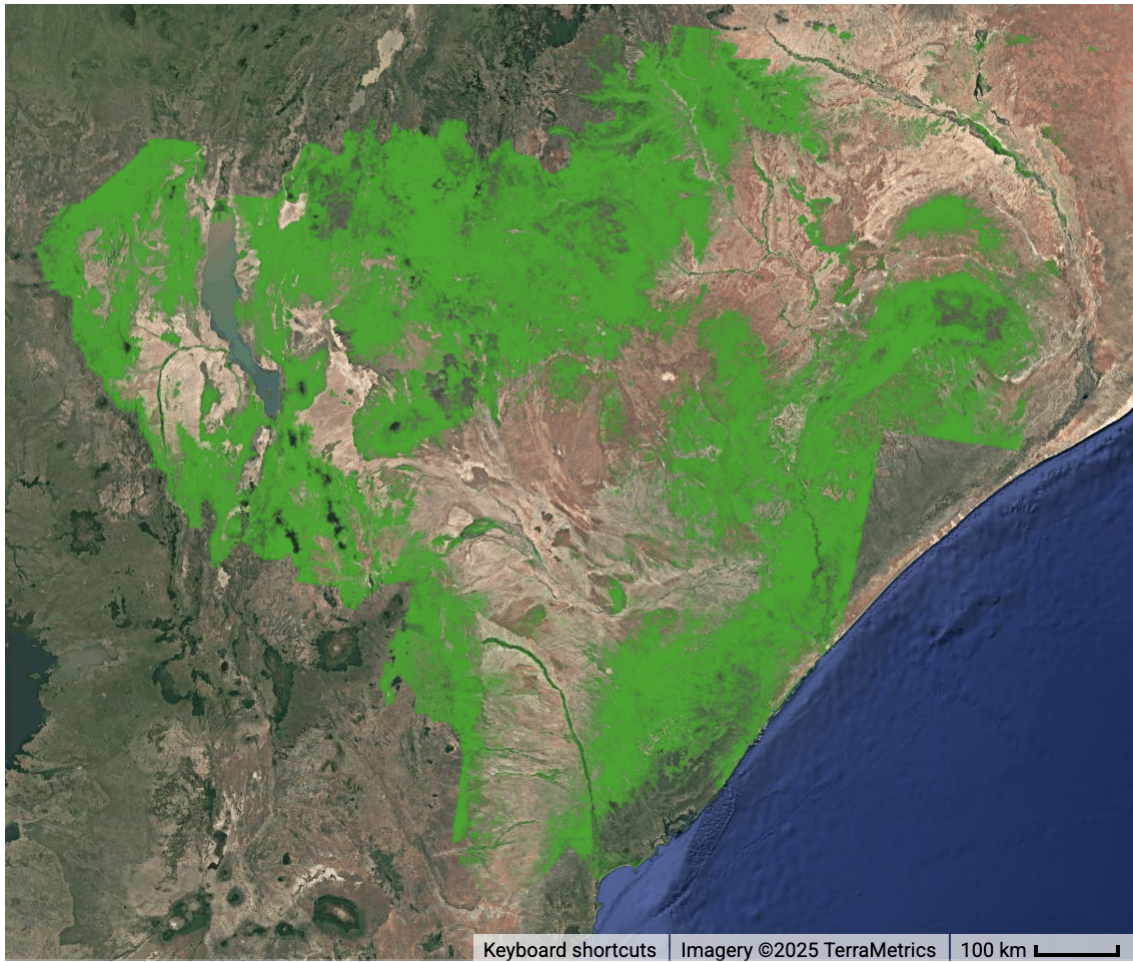


Figure B.1.2: Land cover mask for 'high' forage quality rangelands over 2006-2010.

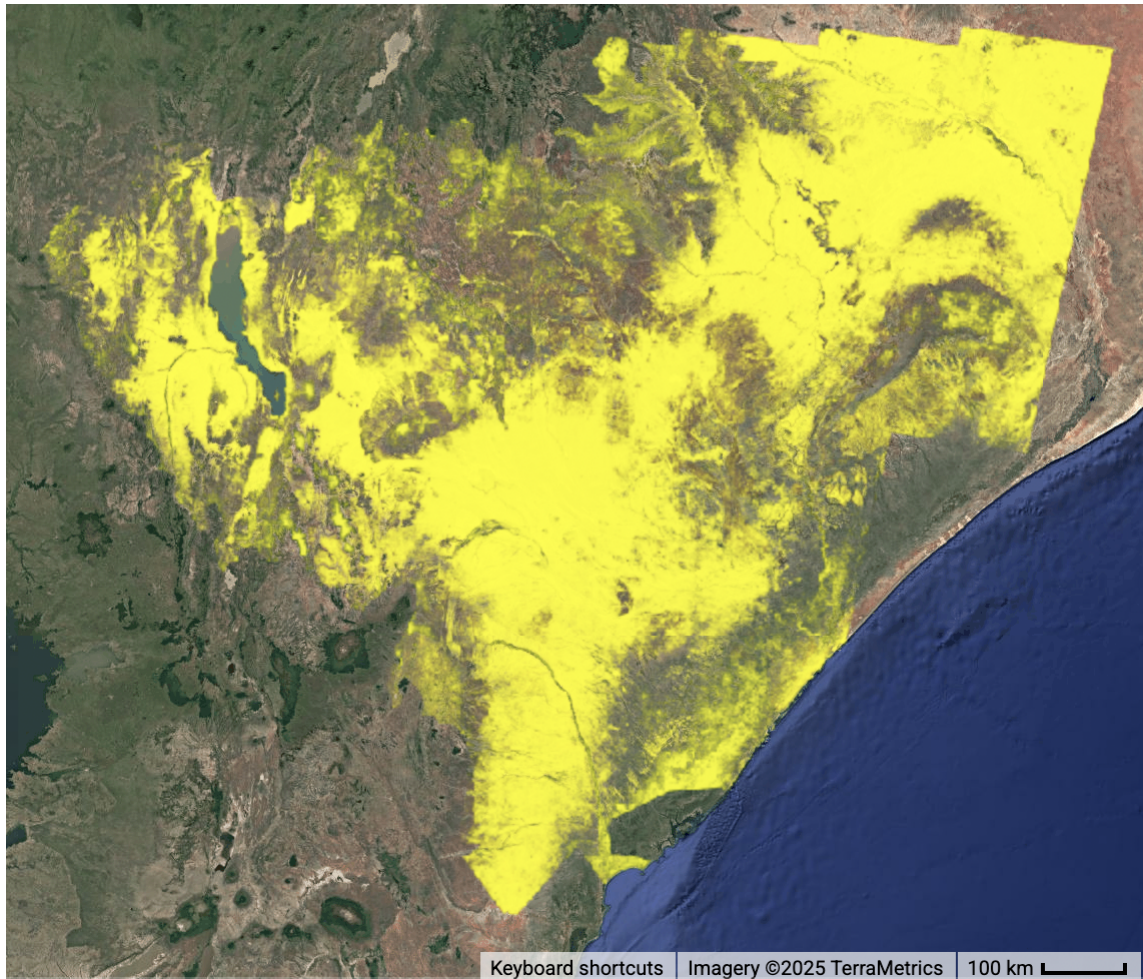


Figure B.1.3: Land cover mask for ‘low’ forage quality rangelands over 2006-2010.

Table B.1.3: Summary statistics for weather covariates at each level of aggregation over 2000-2020.

Variable	Index Unit	HUC-8	HUC-9	HUC-12
GDD 5-10 C	0.003 (0.04) [5460]	0.002 (0.05) [36540]	0.001 (0.03) [98238]	0.001 (0.05) [199626]
GDD 10-15 C	1.111 (4.18) [5460]	0.456 (3.11) [36540]	0.388 (2.77) [98238]	0.378 (2.91) [199626]
GDD 15-20 C	17.202 (28.35) [5460]	8.136 (19.53) [36540]	8.644 (20.51) [98238]	8.355 (20.25) [199626]
GDD 20-25 C	64.538 (22.29) [5460]	70.592 (20.75) [36540]	69.853 (20.44) [98238]	70.193 (20.49) [199626]
GDD 25-30 C	35.029 (20.75) [5460]	42.819 (19.46) [36540]	42.002 (19.62) [98238]	42.271 (19.88) [199626]
GDD 30-35 C	4.725 (5.4) [5460]	7.001 (6.93) [36540]	6.779 (6.89) [98238]	6.69 (6.96) [199626]
GDD 35-40 C	0.005 (0.05) [5460]	0.012 (0.09) [36540]	0.011 (0.09) [98238]	0.011 (0.09) [199626]
Precipitation mean (mm)	230.232 (143.24) [5460]	212.234 (136.8) [36498]	214.353 (136.02) [98196]	211.126 (136.03) [199542]
Precipitation standard deviation (mm)	42.786 (32.88) [5460]	28.073 (28.42) [36498]	21.049 (22.43) [98196]	17.471 (19.21) [199542]

Note: Each column presents the mean, standard deviation (parenthesis), and sample size (square brackets) for each measure. Temperature in degrees celsius (C) is captured by growing degree days (GDD) in 5 degree bins, defined as the average total number of hours in a unit divided by 24. Average precipitation is measured in millimeters (mm). No exposure to temperatures below 5° C or above 40° C was observed within the study area.

B.2 Unconditional and conditional trends in rangeland health measures.

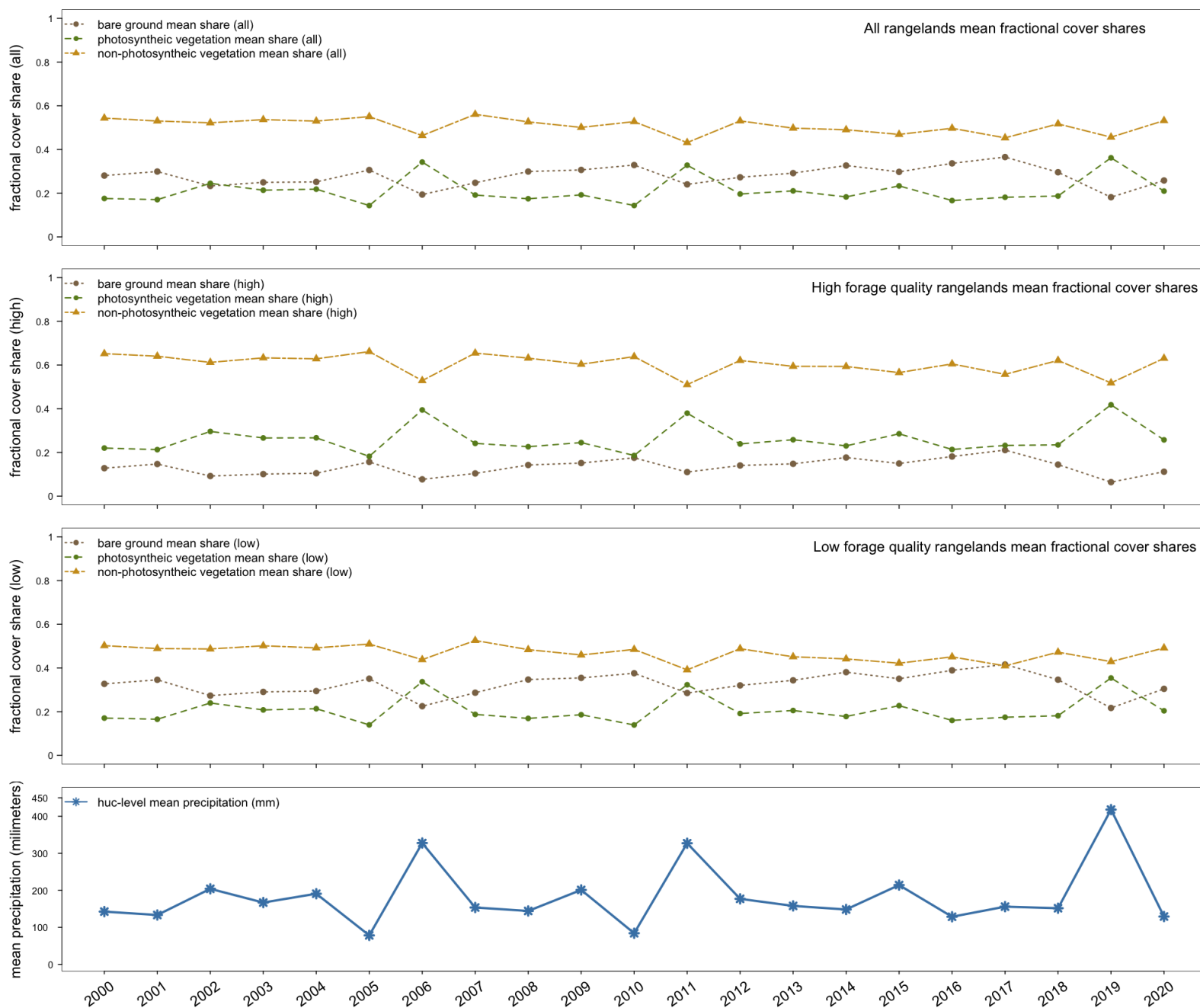


Figure B.2.1: Trends in the average fractional cover share of BG, PV, and NPV for all rangelands (top), high quality (second from top) and low quality (second from bottom) rangelands during the SRSD in each IBLI year, 2000-2020, with contemporaneous average precipitation at the HUC-12 level (bottom panel).

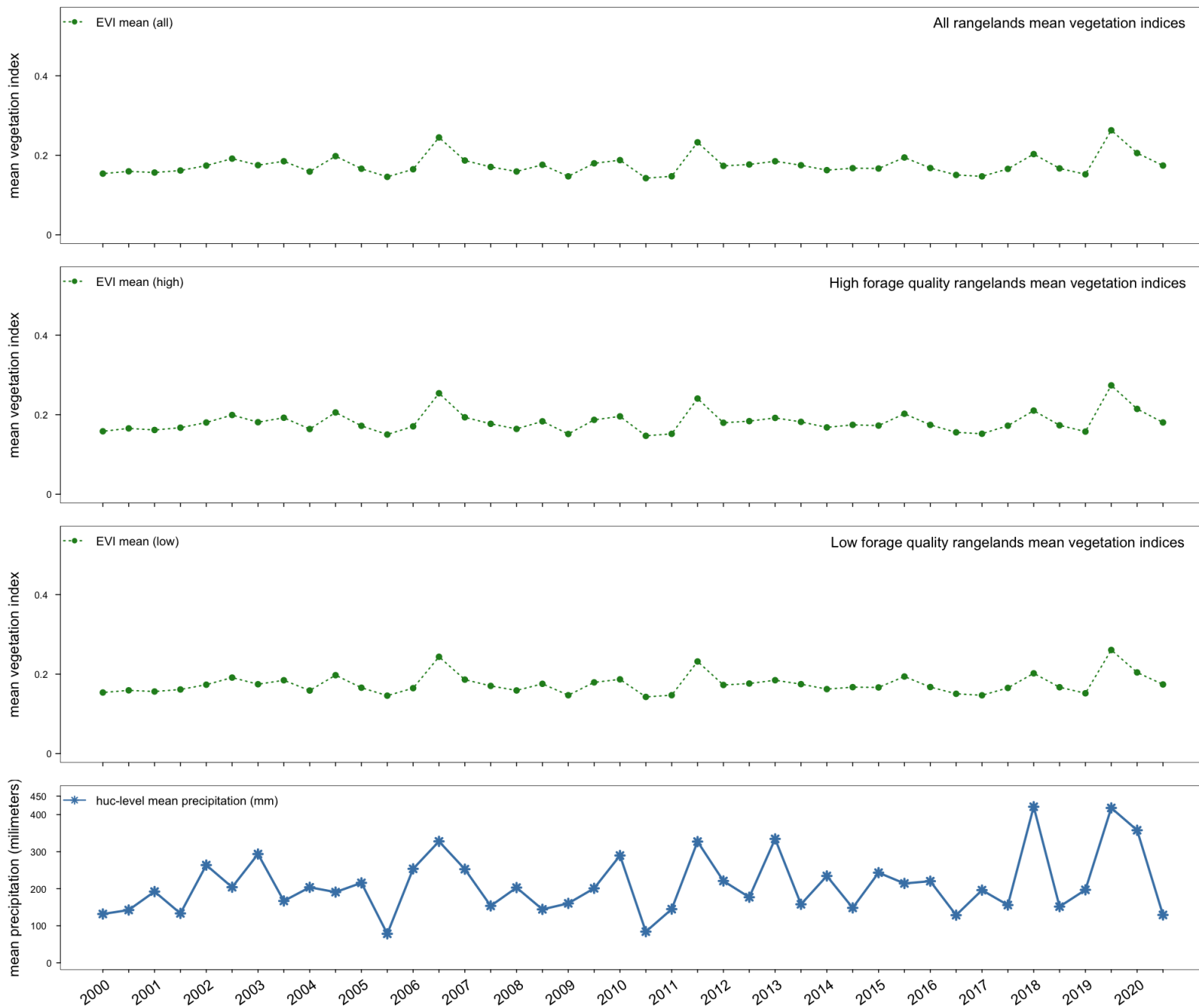


Figure B.2.2: Trends in seasonal mean EVI for all rangelands (top), high quality (second from top) and low quality (second from bottom) rangelands during the SRSD in each IBLI year, 2000-2020, with contemporaneous average precipitation at the HUC-12 level (bottom panel).

2000 -- SRSD

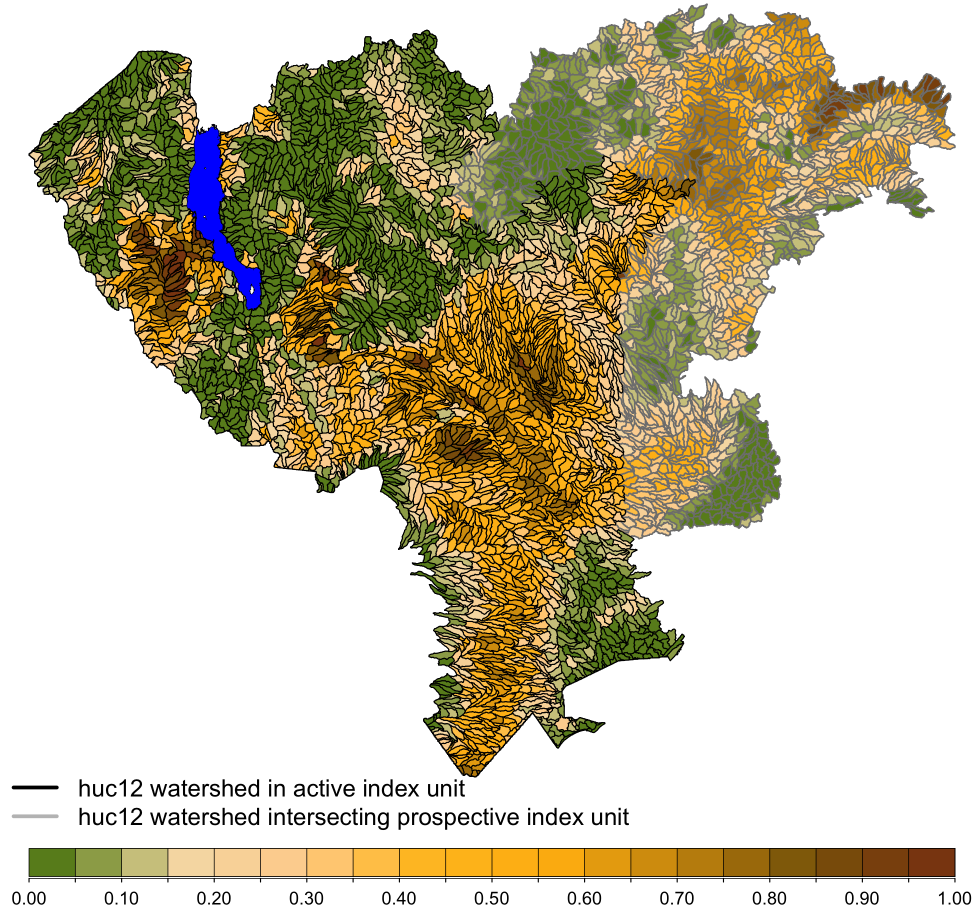


Figure B.2.3: Animation of the share of bare ground (BG) fractional cover at the HUC-12 level during the SRSD of each year for ‘all’ rangelands over 2000 - 2020. Note that Adobe acrobat reader may be required to view the full animation as intended.

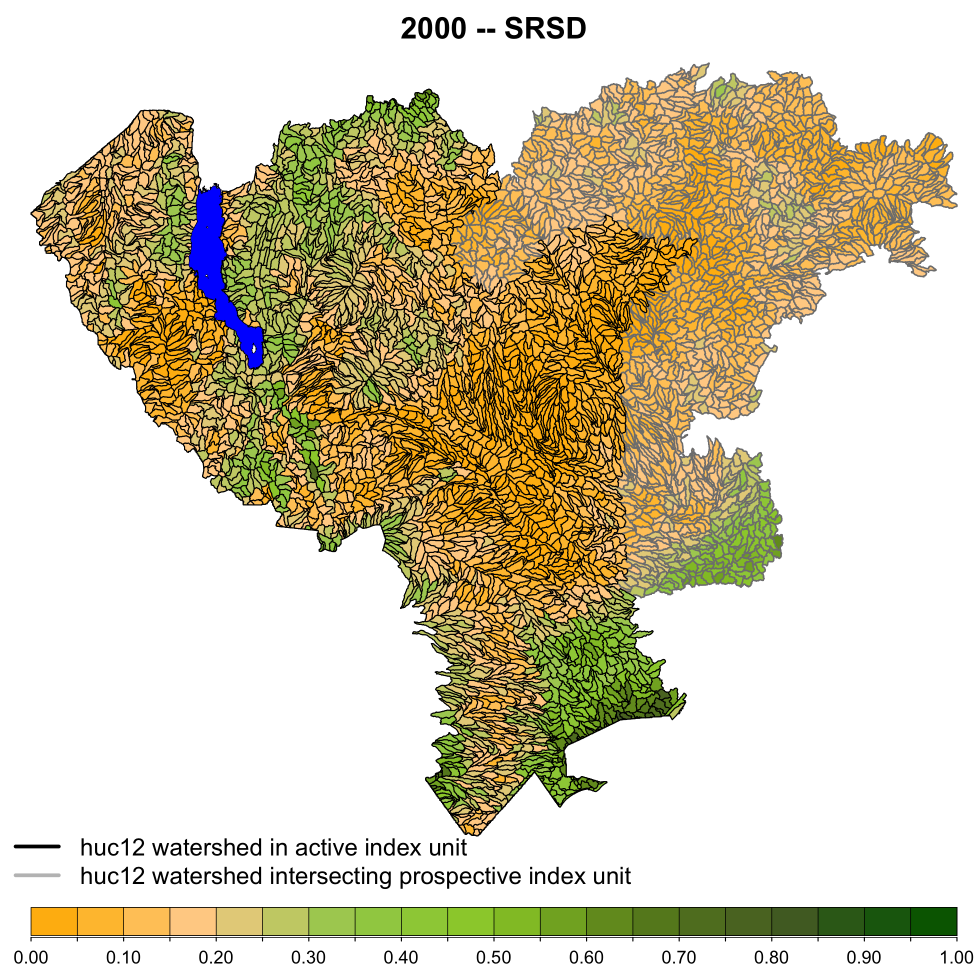


Figure B.2.4: Animation of the share of photosynthetic vegetation (PV) fractional cover at the HUC-12 level during the SRSD of each year for ‘all’ rangelands over 2000 - 2020. Note that Adobe acrobat reader may be required to view the full animation as intended.

2000 -- LRLD

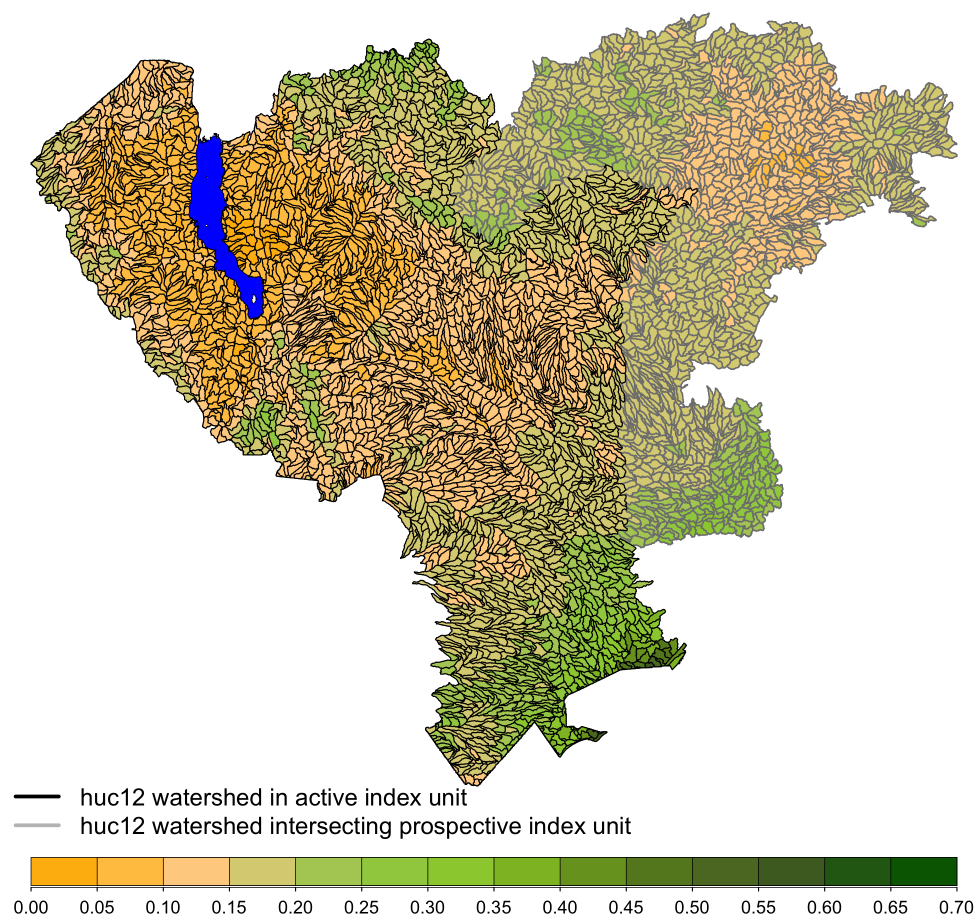


Figure B.2.5: Animation of average enhanced vegetation index (EVI) at the HUC-12 level by season and year for ‘all’ rangelands over 2000 - 2020. Note that Adobe acrobat reader may be required to view the full animation as intended.

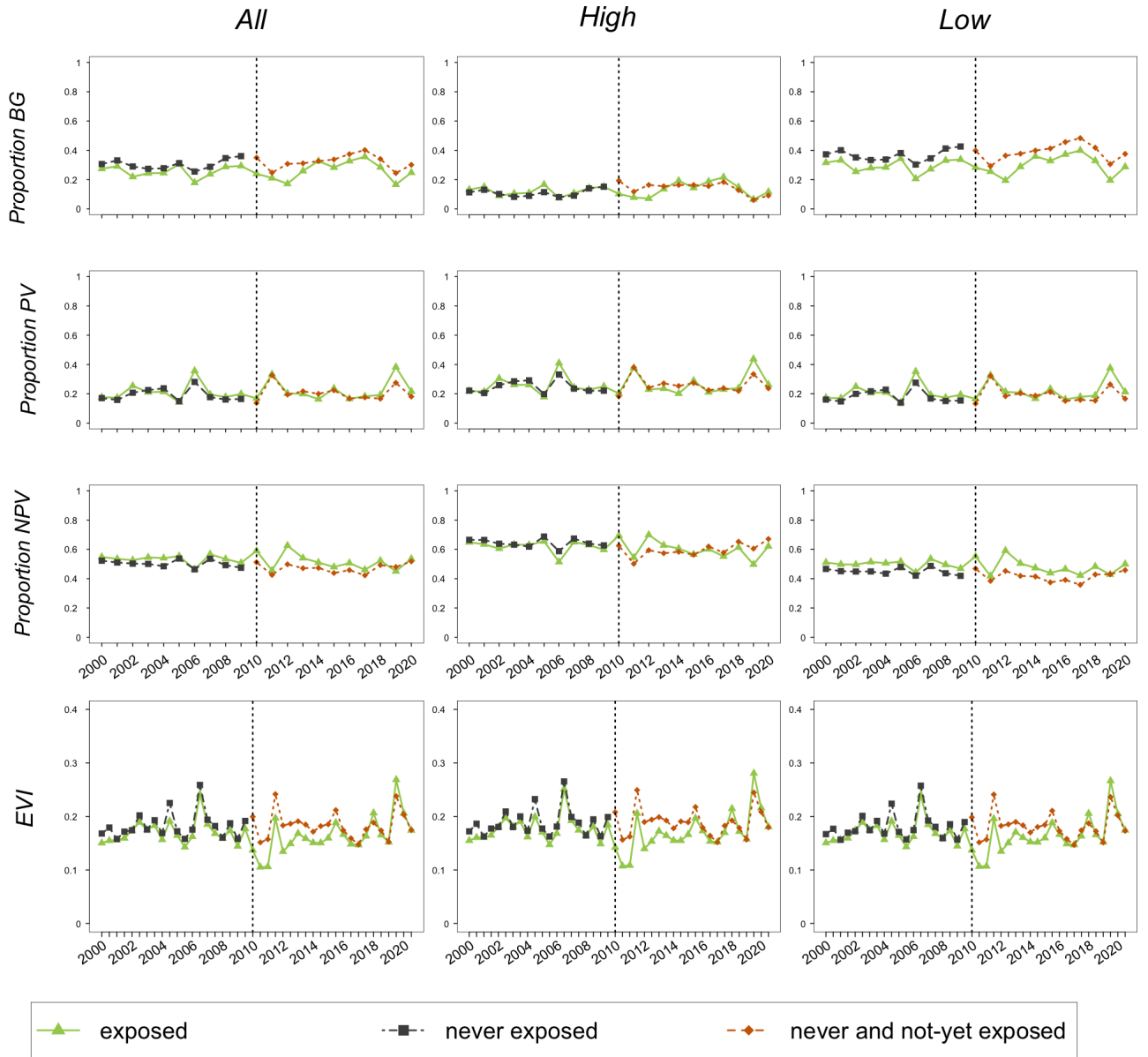


Figure B.2.6: Extensive margin conditional trends in RH indicator measures at the HUC-12 level; exposure is defined as having ≥ 1 cumulative TLU insured. Vertical dashed lines indicate when IBLI launched in 2010. RH indicators and values are captured on the vertical axes and time and variation by rangeland mask are featured along the horizontal axes (BG = bare ground, PV = photosynthetic vegetation, NPV = non-photosynthetic vegetation, EVI = enhanced vegetation index). Prior to exposure, comparison groups are fixed: the ‘exposed’ group includes any unit that is ever exposed; the ‘never exposed’ group includes never treated units only. For time periods including and following the vertical line, comparison groups vary each period per staggered exposure: the ‘exposed’ group is updated each period; and the ‘never and not-yet exposed’ group includes units in the ‘never exposed’ group and units that aren’t yet exposed.

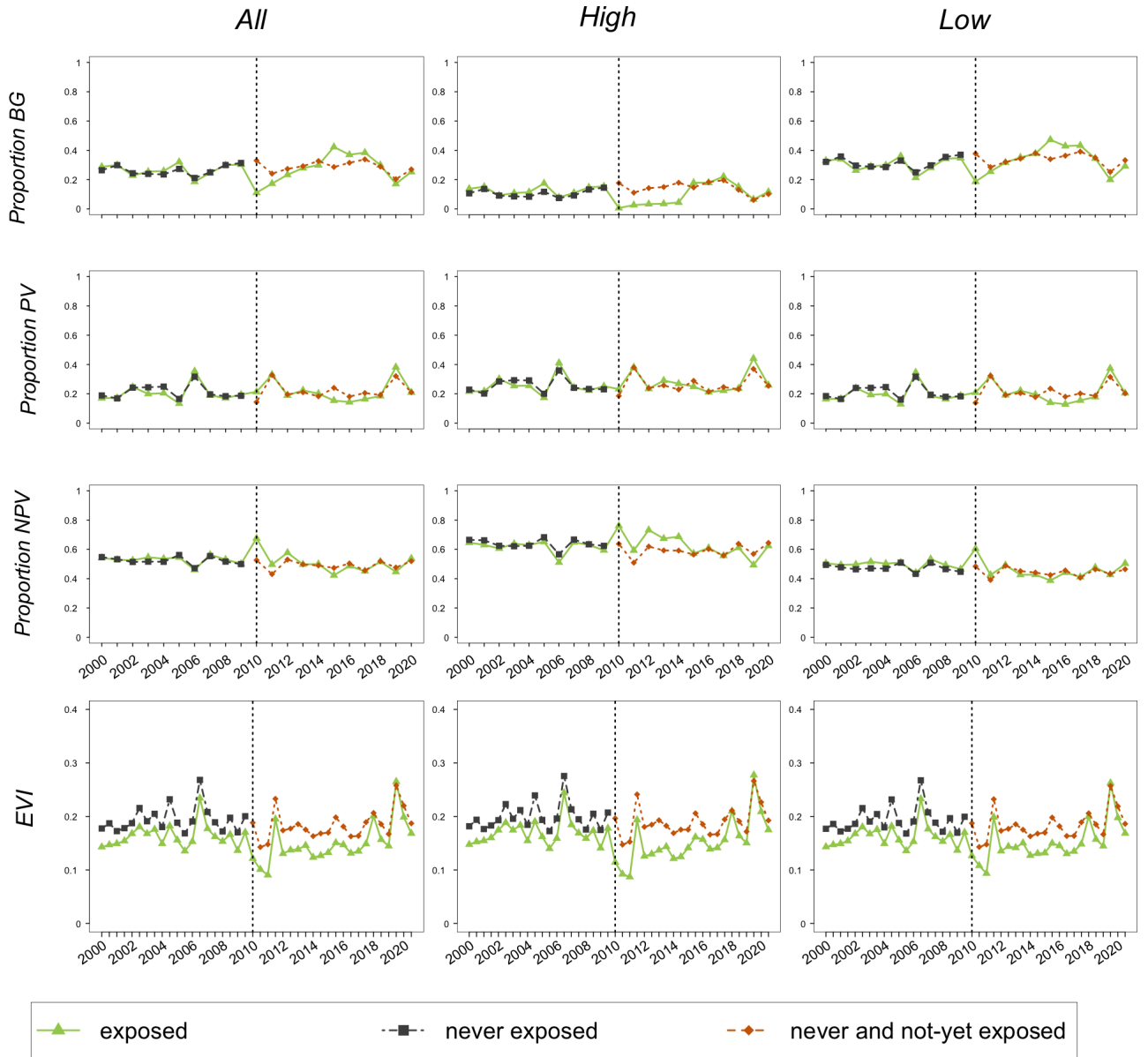


Figure B.2.7: Intensive margin conditional trends in RH indicator measures at the HUC-12 level; exposure is defined as having ≥ 500 cumulative TLU insured. Vertical dashed lines indicate when the first HUC-12 units were exposed to ≥ 500 cumulative TLUs insured in 2010. RH indicators and values are captured on the vertical axes and time and variation by rangeland mask are featured along the horizontal axes (BG = bare ground, PV = photosynthetic vegetation, NPV = non-photosynthetic vegetation, EVI = enhanced vegetation index). Prior to exposure, comparison groups are fixed: the ‘exposed’ group includes any unit that is ever exposed; the ‘never exposed’ group includes never treated units only. For time periods including and following the vertical line, comparison groups vary each period per staggered exposure: the ‘exposed’ group is updated each period; and the ‘never and not-yet exposed’ group includes units in the ‘never exposed’ group and units that aren’t yet exposed.

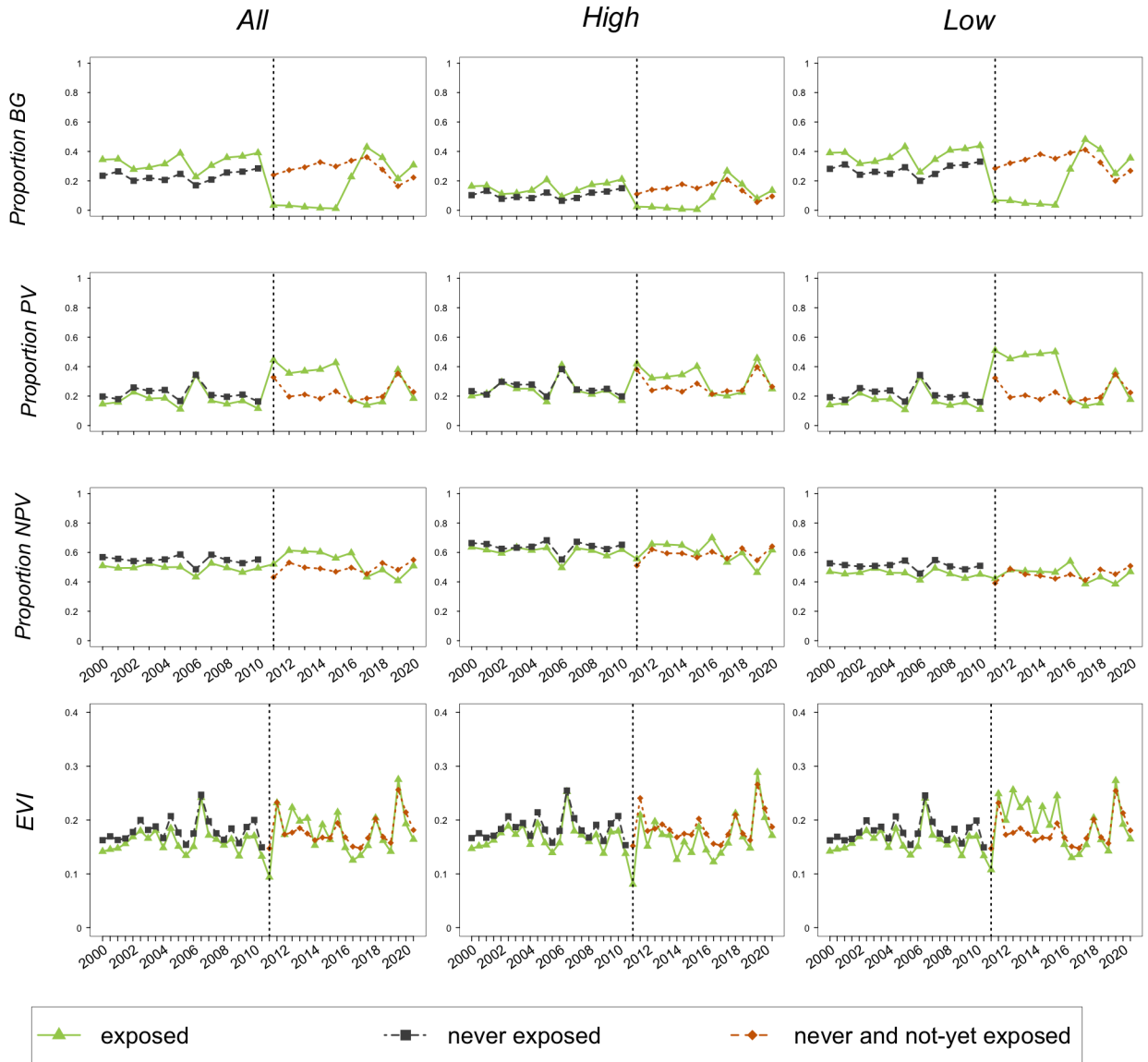


Figure B.2.8: Intensive margin conditional trends in RH indicator measures at the HUC-12 level; exposure is defined as having ≥ 2000 cumulative TLU insured. Vertical dashed lines indicate when the first HUC-12 units were exposed to ≥ 2000 cumulative TLUs insured in 2011. RH indicators and values are captured on the vertical axes and time and variation by rangeland mask are featured along the horizontal axes (BG = bare ground, PV = photosynthetic vegetation, NPV = non-photosynthetic vegetation, EVI = enhanced vegetation index). Prior to exposure, comparison groups are fixed: the ‘exposed’ group includes any unit that is ever exposed; the ‘never exposed’ group includes never treated units only. For time periods including and following the vertical line, comparison groups vary each period per staggered exposure: the ‘exposed’ group is updated each period; and the ‘never and not-yet exposed’ group includes units in the ‘never exposed’ group and units that aren’t yet exposed.

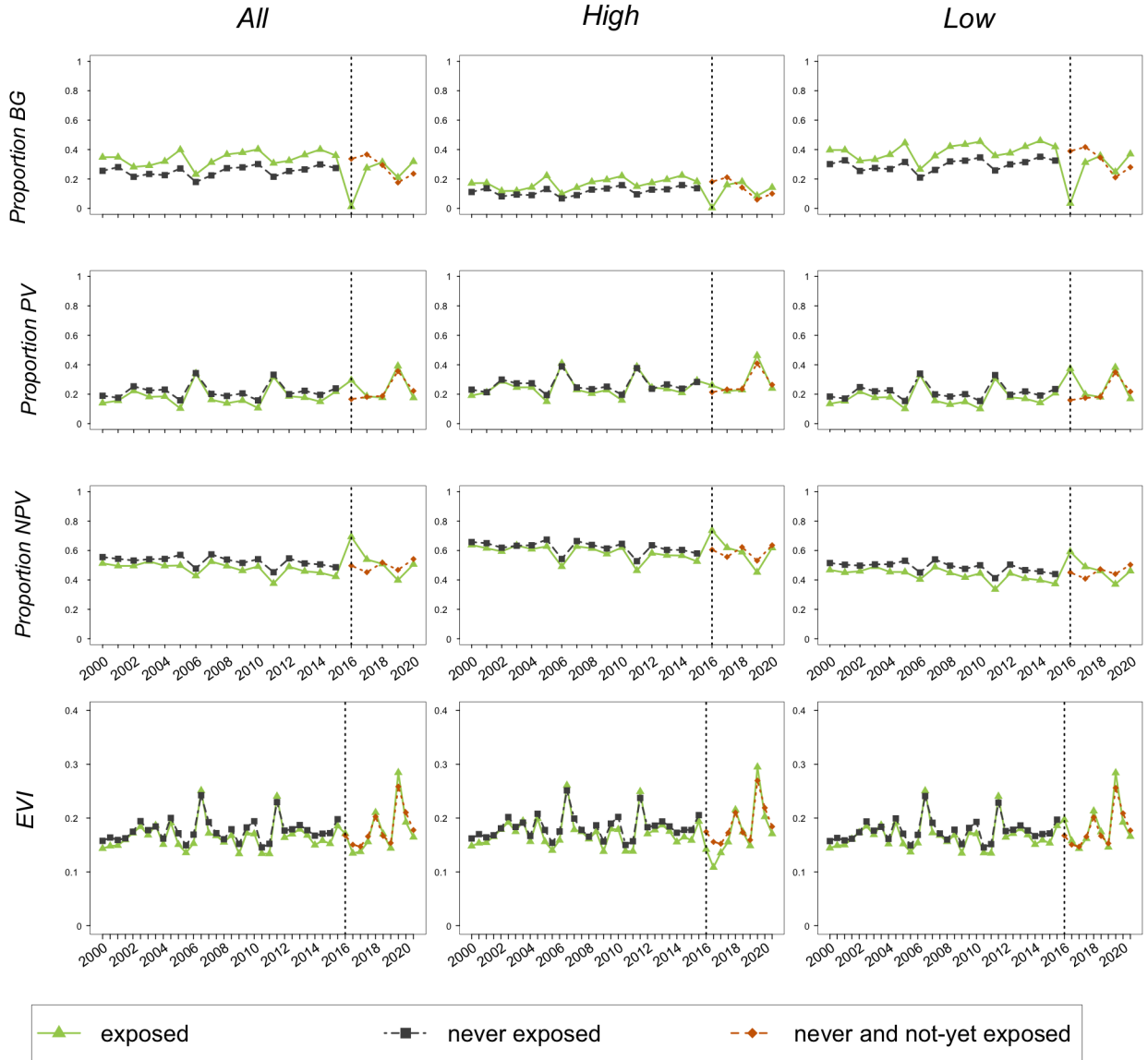


Figure B.2.9: Intensive margin conditional trends in RH indicator measures at the HUC-12 level; exposure is defined as having ≥ 3000 cumulative TLU insured. Vertical dashed lines indicate when the first HUC-12 units were exposed to ≥ 3000 cumulative TLUs insured in 2016. RH indicators and values are captured on the vertical axes and time and variation by rangeland mask are featured along the horizontal axes (BG = bare ground, PV = photosynthetic vegetation, NPV = non-photosynthetic vegetation, EVI = enhanced vegetation index). Prior to exposure, comparison groups are fixed: the ‘exposed’ group includes any unit that is ever exposed; the ‘never exposed’ group includes never treated units only. For time periods including and following the vertical line, comparison groups vary each period per staggered exposure: the ‘exposed’ group is updated each period; and the ‘never and not-yet exposed’ group includes units in the ‘never exposed’ group and units that aren’t yet exposed.

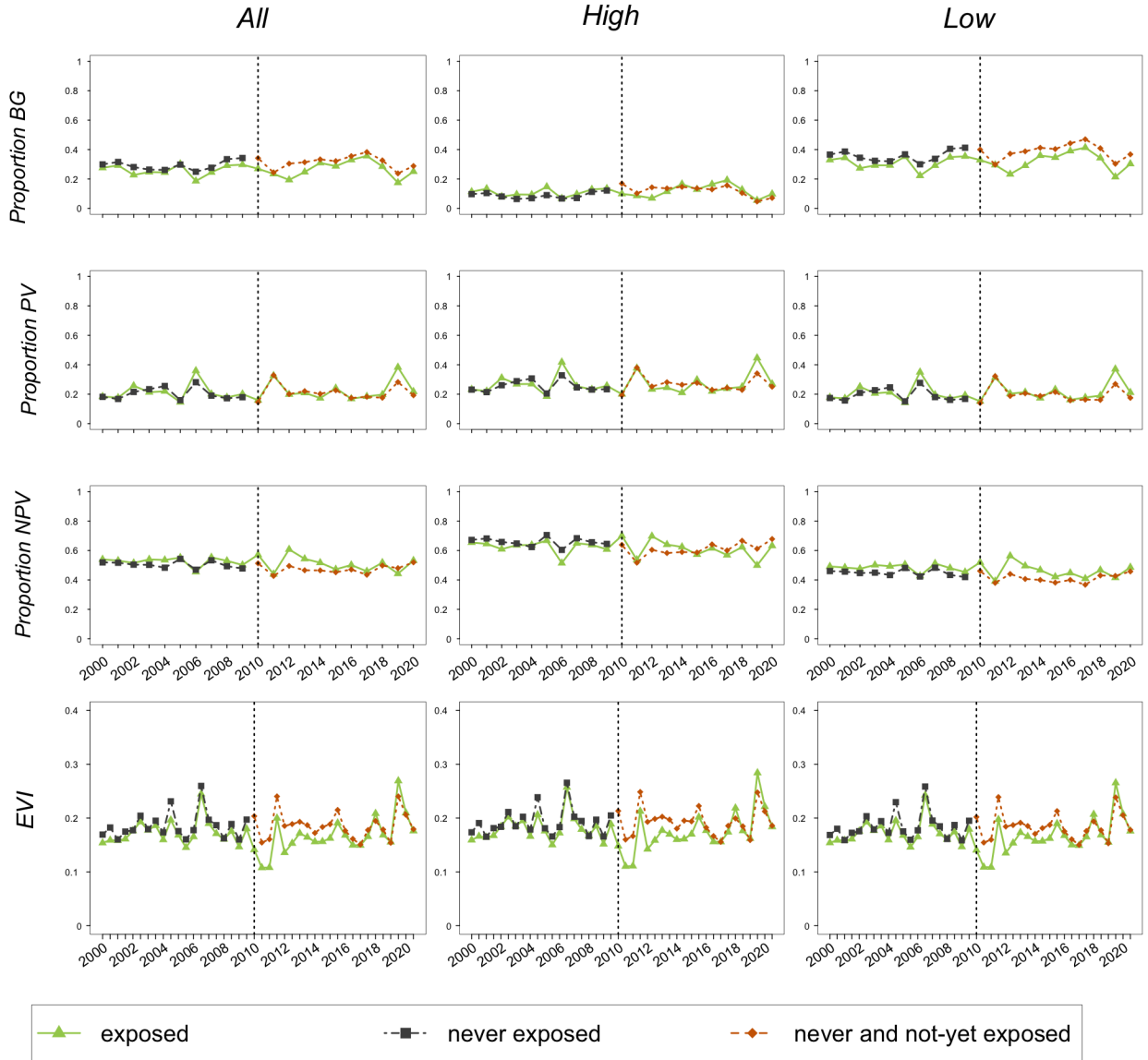


Figure B.2.10: Extensive margin conditional trends in RH indicator measures at the HUC-8 level; exposure is defined as having ≥ 1 cumulative TLU insured. Vertical dashed lines indicate when IBLI launched in 2010. RH indicators and values are captured on the vertical axes and time and variation by rangeland mask are featured along the horizontal axes (BG = bare ground, PV = photosynthetic vegetation, NPV = non-photosynthetic vegetation, EVI = enhanced vegetation index). Prior to exposure, comparison groups are fixed: the ‘exposed’ group includes any unit that is ever exposed; the ‘never exposed’ group includes never treated units only. For time periods including and following the vertical line, comparison groups vary each period per staggered exposure: the ‘exposed’ group is updated each period; and the ‘never and not-yet exposed’ group includes units in the ‘never exposed’ group and units that aren’t yet exposed.

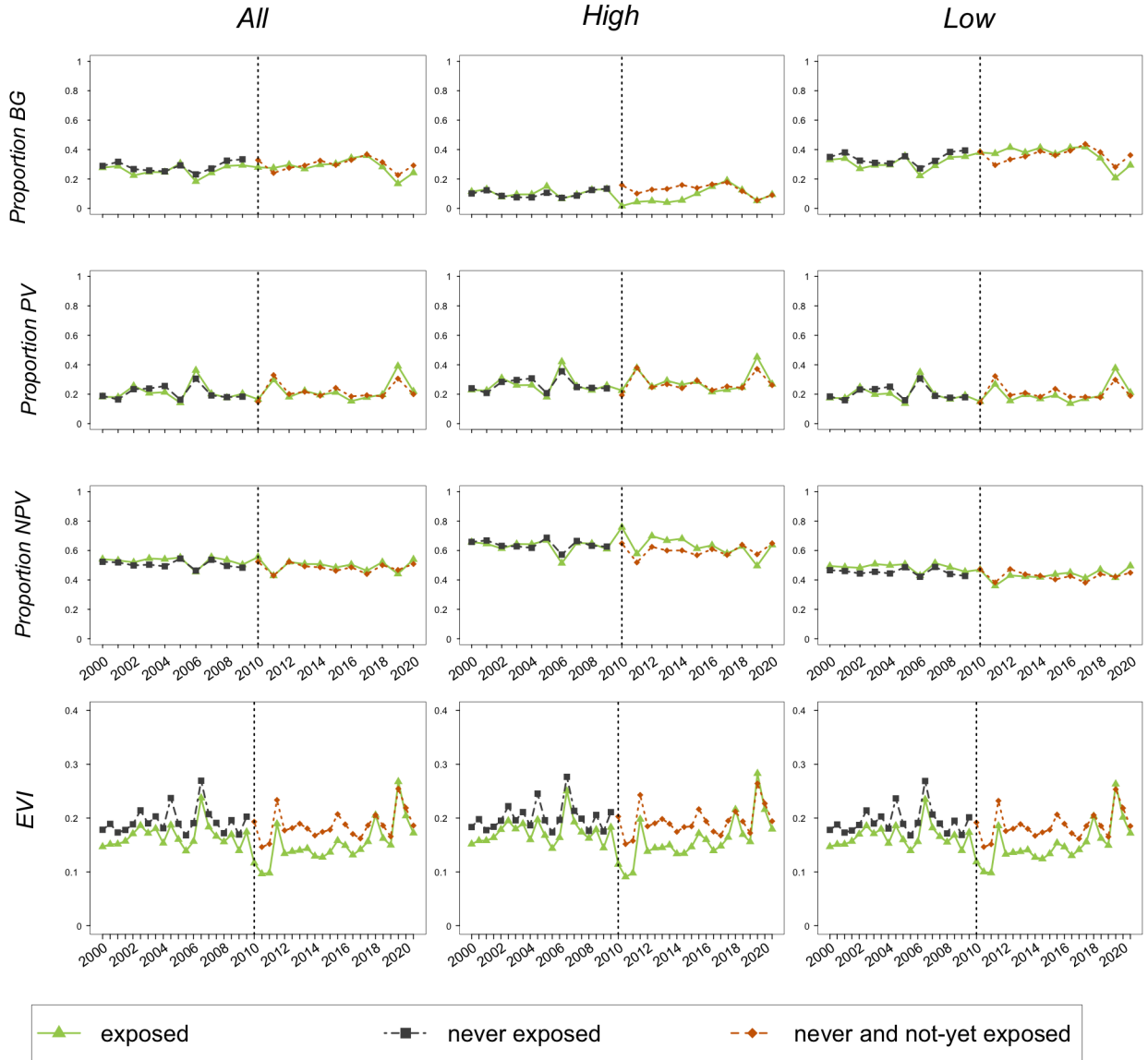


Figure B.2.11: Intensive margin conditional trends in RH indicator measures at the HUC-8 level; exposure is defined as having ≥ 500 cumulative TLU insured. Vertical dashed lines indicate when the first HUC-8 units were exposed to ≥ 500 cumulative TLUs insured in 2010. RH indicators and values are captured on the vertical axes and time and variation by rangeland mask are featured along the horizontal axes (BG = bare ground, PV = photosynthetic vegetation, NPV = non-photosynthetic vegetation, EVI = enhanced vegetation index). Prior to exposure, comparison groups are fixed: the ‘exposed’ group includes any unit that is ever exposed; the ‘never exposed’ group includes never treated units only. For time periods including and following the vertical line, comparison groups vary each period per staggered exposure: the ‘exposed’ group is updated each period; and the ‘never and not-yet exposed’ group includes units in the ‘never exposed’ group and units that aren’t yet exposed.

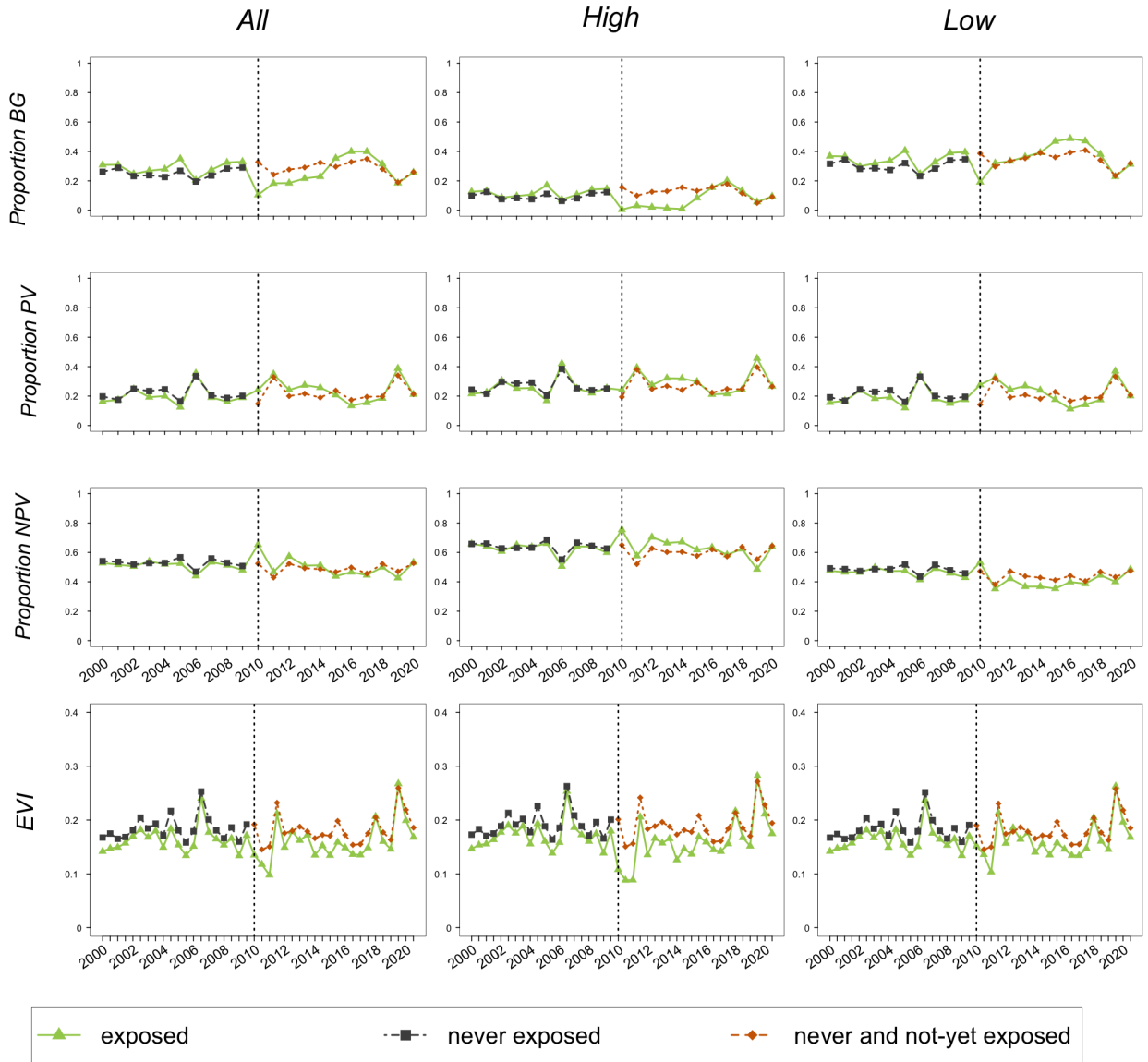


Figure B.2.12: Intensive margin conditional trends in RH indicator measures at the HUC-8 level; exposure is defined as having ≥ 2000 cumulative TLU insured. Vertical dashed lines indicate when the first HUC-8 units were exposed to ≥ 2000 cumulative TLUs insured in 2010. RH indicators and values are captured on the vertical axes and time and variation by rangeland mask are featured along the horizontal axes (BG = bare ground, PV = photosynthetic vegetation, NPV = non-photosynthetic vegetation, EVI = enhanced vegetation index). Prior to exposure, comparison groups are fixed: the ‘exposed’ group includes any unit that is ever exposed; the ‘never exposed’ group includes never treated units only. For time periods including and following the vertical line, comparison groups vary each period per staggered exposure: the ‘exposed’ group is updated each period; and the ‘never and not-yet exposed’ group includes units in the ‘never exposed’ group and units that aren’t yet exposed.

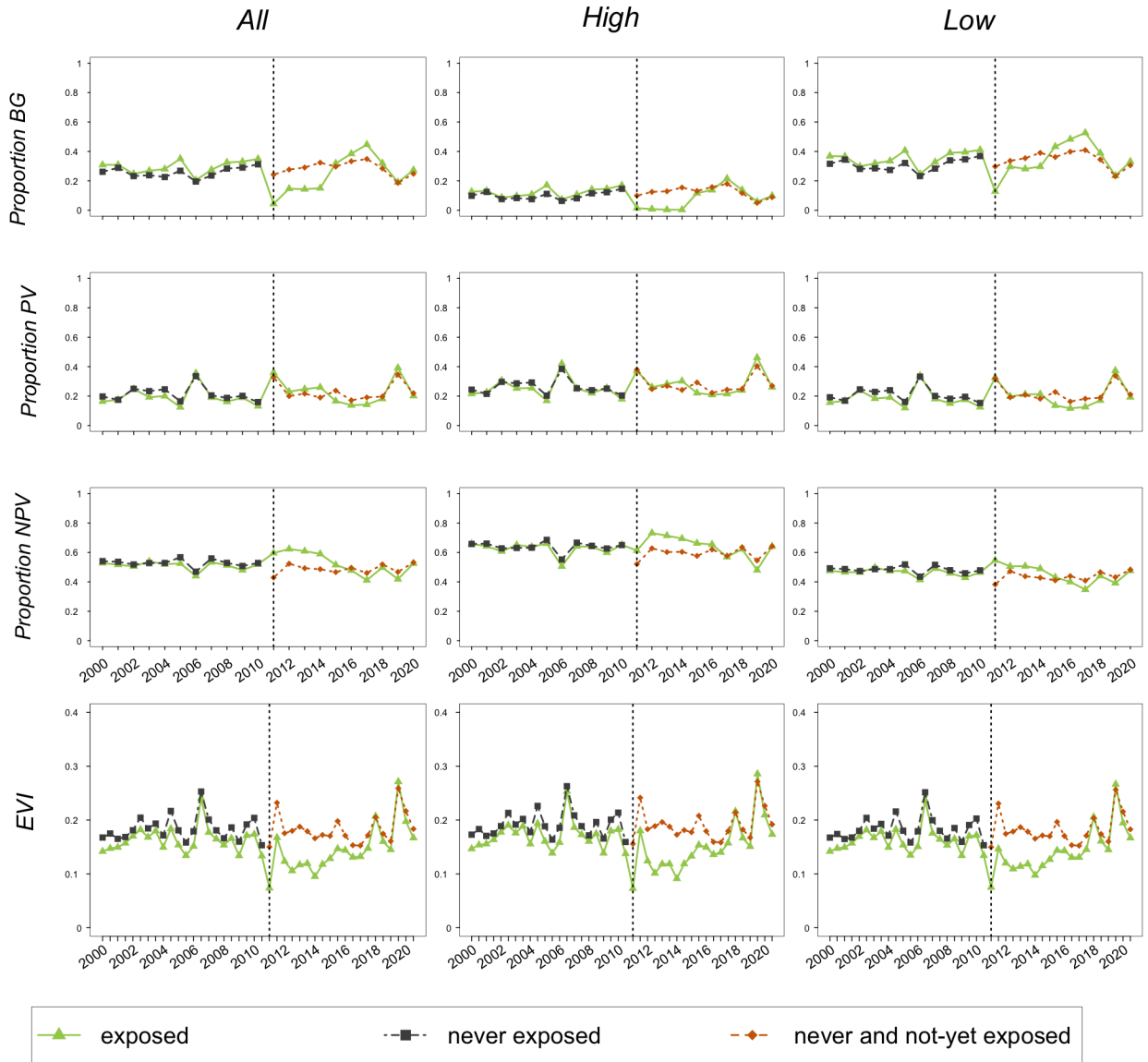


Figure B.2.13: Intensive margin conditional trends in RH indicator measures at the HUC-8 level; exposure is defined as having ≥ 3000 cumulative TLU insured. Vertical dashed lines indicate when the first HUC-8 units were exposed to ≥ 3000 cumulative TLUs insured in 2011. RH indicators and values are captured on the vertical axes and time and variation by rangeland mask are featured along the horizontal axes (BG = bare ground, PV = photosynthetic vegetation, NPV = non-photosynthetic vegetation, EVI = enhanced vegetation index). Prior to exposure, comparison groups are fixed: the ‘exposed’ group includes any unit that is ever exposed; the ‘never exposed’ group includes never treated units only. For time periods including and following the vertical line, comparison groups vary each period per staggered exposure: the ‘exposed’ group is updated each period; and the ‘never and not-yet exposed’ group includes units in the ‘never exposed’ group and units that aren’t yet exposed.

C Two-Way Fixed Effects DiD and DiD Diagnostics

Although we will ultimately use more sophisticated staggered DiD estimators, we illustrate the problem initially with a standard two-way fixed effects (TWFE) specification:

$$Y_{i,r,s,t} = D_{ist}\delta + \mathbf{X}'_{i,s,t}\alpha + \gamma_i + \sigma_t + \nu_{i,r,s,t} \quad (\text{C.1})$$

where δ captures the average effect of the IBLI exposure dummy variable D_{ist} for areal unit i in rangeland type r in season s and IBLI-year t on RH indicator Y .² The vector $\mathbf{X}'$ includes measures of average precipitation or precipitation variability and binned hours of temperature exposure, and γ_i and σ_t represent unit and time fixed effects, respectively. Our construction of D_{ist} assumes regular movement of herders across rangeland types such that once a spatial unit is exposed to IBLI, all rangeland types within that unit are exposed. Construction of D_{ist} also assumes herders' movements across unit boundaries as modeled using IDW (see Section 2.3 and Appendix 2). Since weather processes are more smooth over space than rangeland type variation r we rely on weather realizations summarized across the entirety of each unit i in periods s and t .

We implement two sets of tests for the appropriateness of TWFE for DiD estimation suggested by Jakiela (2021). First, we residualize D_{ist} by regressing it on time and location fixed effects. We then study the distributions of residualized D_{ist} by exposed and comparison (not-yet or never exposed) groups, to check for negative weights among the exposed group. Second, we employ optimal binscatter methods from Cattaneo et al. (2024b) to semi-parametrically regress residualized outcomes Y against residualized D and apply formal tests of the null hypothesis for treatment effect homogeneity, which implies a linear relationship between residualized Y and D .

A set of example TWFE results using equation (C.1) are provided in Table C.1 below. These results should be interpreted cautiously because the aforementioned tests suggest TWFE is in appropriate in this setting. Specifically, Figures C.1 and C.2 present evidence for the presence of negative weights and the aforementioned optimal binscatter tests reject the assumption of treatment effect homogeneity (see Figures C.3 - C.5 and Table C.2). For these reasons, we rely on the staggered DiD estimator from Gardner et al. (2025).

²An 'IBLI-year' begins March 1. Thus our year 2010 reflects the first year of IBLI exposure, from March 1, 2010, through February 28, 2011.

Table C.1: Example two-way fixed effects DiD specifications studying variation from all rangelands at the HUC-12 level and extensive margin IBLI exposure.

<u>Dependent variable: Bare ground (BG) share all rangelands</u>					
Post-IBLI extensive margin (dummy)	−0.024*** (0.002)	0.020*** (0.001)	0.004*** (0.001)	0.016*** (0.001)	0.016*** (0.003)
Adjusted R ²	0.167	0.923	0.933	0.943	0.943
<u>Dependent variable: Photosynthetic vegetation (PV) share all rangelands</u>					
Post-IBLI extensive margin (dummy)	−0.006*** (0.001)	−0.005*** (0.001)	−0.002*** (0.001)	−0.016*** (0.001)	−0.016*** (0.003)
Adjusted R ²	0.422	0.810	0.827	0.833	0.833
<u>Dependent variable: Non-photosynthetic vegetation (NPV) share all rangelands</u>					
Post-IBLI extensive margin (dummy)	0.030*** (0.002)	−0.015*** (0.001)	−0.002*** (0.001)	0.0002 (0.001)	0.0002 (0.004)
Adjusted R ²	0.149	0.883	0.893	0.901	0.901
<u>Fractional cover model parameters:</u>					
Unit FEs	N	Y	Y	Y	Y
Year FEs	N	N	Y	Y	Y
Unit specific linear trends	N	N	N	Y	Y
Standard errors	HW	HW	HUC	HUC	IU
Observations	99,426	99,426	99,426	99,426	99,426
<u>Dependent variable: Mean enhanced vegetation index (EVI) all rangelands</u>					
Post-IBLI extensive margin (dummy)	−0.017*** (0.0003)	−0.002*** (0.0002)	0.002*** (0.0003)	−0.003*** (0.0003)	−0.003*** (0.001)
Adjusted R ²	0.570	0.852	0.884	0.891	0.891
<u>Vegetation index model parameters:</u>					
Unit FEs	N	Y	Y	Y	Y
Period FEs	N	N	Y	Y	Y
Unit specific linear trends	N	N	N	Y	Y
Standard errors	HW	HW	HUC	HUC	IU
Observations	199,416	199,416	199,416	199,416	199,416

Note: Extensive margin exposure is defined as ≥ 1 cumulative TLU insured. Fractional cover models have SRSD variation and EVI models have semi-annual variation in the LRLD and SRSD seasons. All models include average precipitation, the standard deviation of precipitation, and 5° temperature bins, with the exception of 10° bins at the upper and lower ends due to limited exposure at the lowest and highest 5 degree bins (i.e., 5 -15° C, and 35-45° C). Standard errors vary from robust Huber-White to clustered at the HUC-level or index unit (IU) level. *p<0.1; **p<0.05; ***p<0.01.

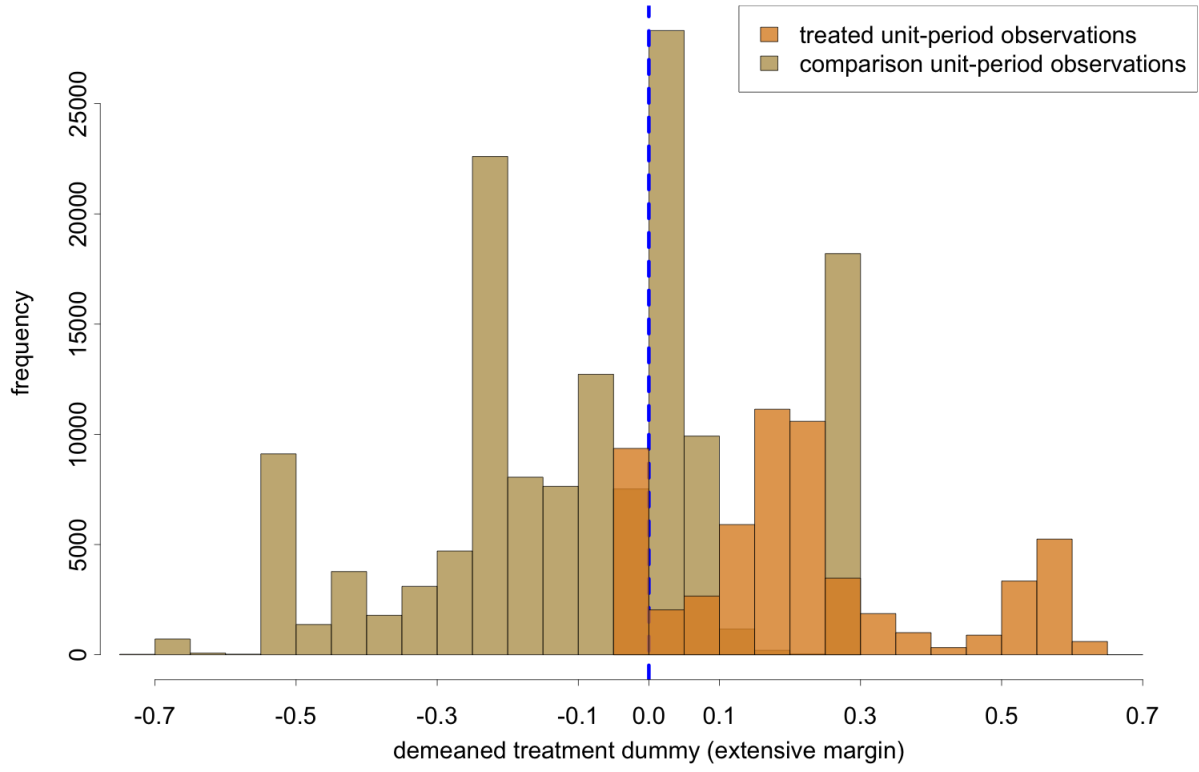


Figure C.1: Distribution of residualized treatment dummy D at the HUC-12 level from two-way fixed effects estimation focused on extensive margin exposure following Jakiela (2021). Extensive margin exposure is defined as ≥ 1 cumulative TLU insured by IBLI.

Extensive margin: negative weights are present from 2016-2020

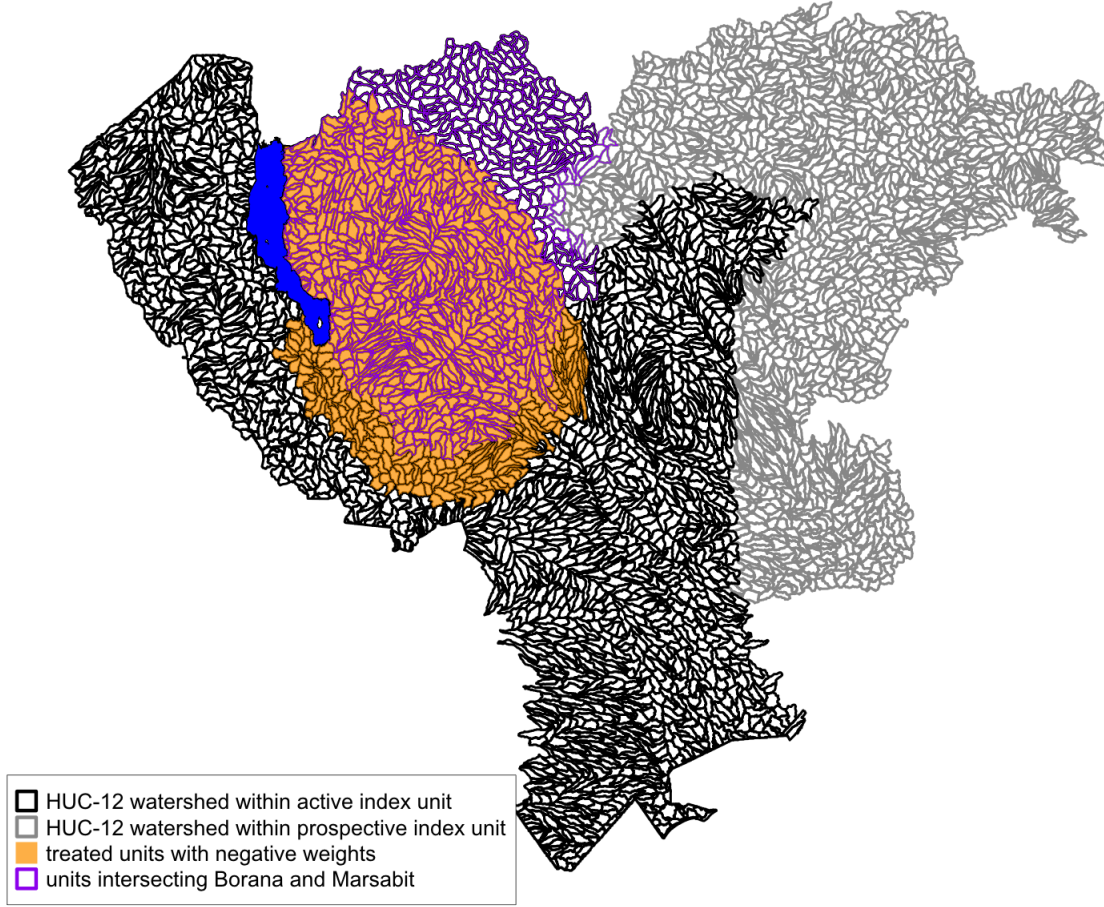


Figure C.2: Spatial distribution of negative weights present in later periods (2016-2020) at the HUC-12 level. Negative weights are identified from studying the distribution of residualized treatment dummy D at the HUC-12 level from two-way fixed effects estimation focused on extensive margin exposure following Jakiel [\(2021\)](#). Extensive margin exposure is defined as ≥ 1 cumulative TLU insured by IBLI.

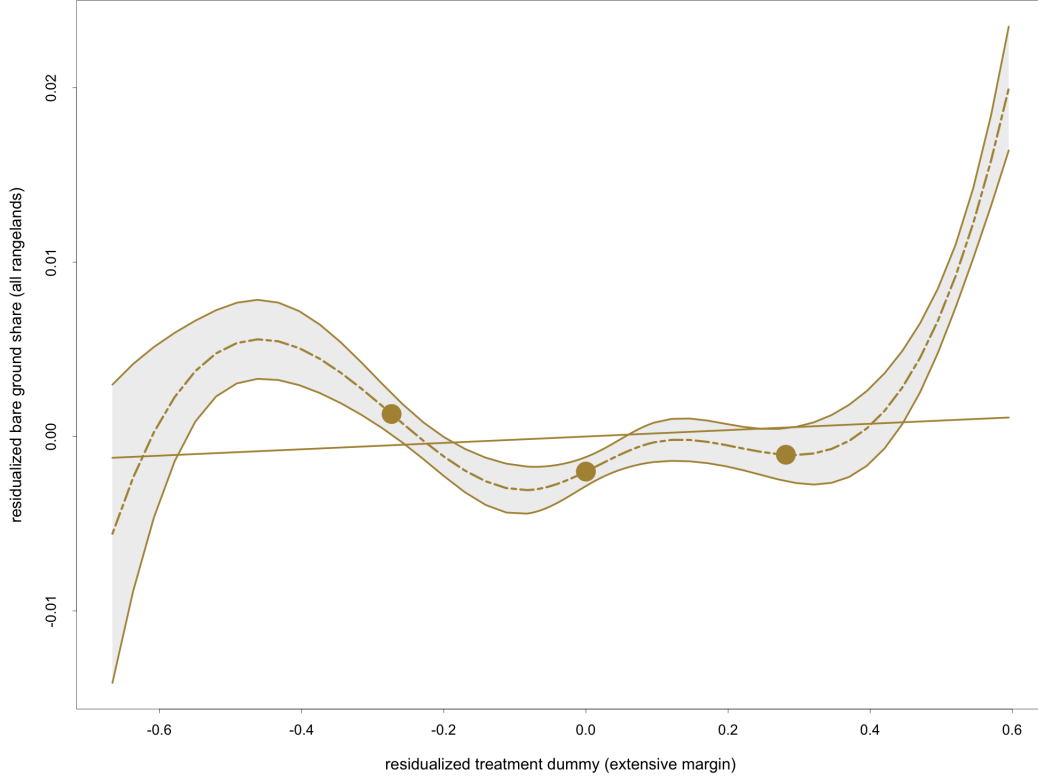


Figure C.3: Optimal binscatter of residualized bare ground (BG) share on the semi-parametric function $\mu(D)$, where D is a residualized treatment dummy reflecting extensive margin exposure defined as ≥ 1 cumulative TLU insured, with a contrasting linear fit. Estimation is motivated by tests suggested by Jakiela (2021) for the linearity of the treatment effect. Estimations employ the integrated mean squared error (IMSE)-optimal direct plug-in rule for bin selection and cubic B-splines within and between bins. Points reflect the mean within bins for unexposed and exposed units, which are quantile-spaced. Confidence bands are clustered at the index unit level. See Cattaneo et al. 2024b for details on optimal binscatter estimation.

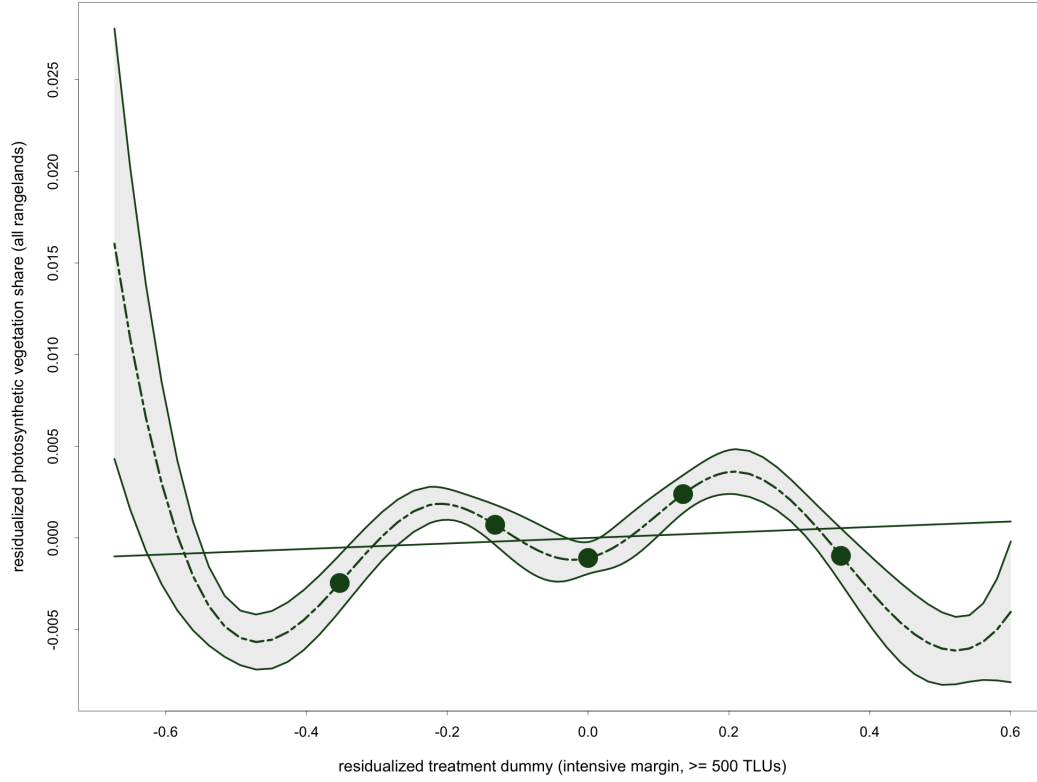


Figure C.4: Optimal binscatter of residualized photosynthetic vegetation (PV) share on the semi-parametric function $\mu(D)$, where D is a residualized treatment dummy reflecting extensive margin exposure defined as ≥ 1 cumulative TLU insured, with a contrasting linear fit. Estimation is motivated by tests suggested by Jakiela (2021) for the linearity of the treatment effect. Estimations employ the integrated mean squared error (IMSE)-optimal direct plug-in rule for bin selection and cubic B-splines within and between bins. Points reflect the mean within bins for unexposed and exposed units, which are quantile-spaced. Confidence bands are clustered at the index unit level. See Cattaneo et al. 2024b for details on optimal binscatter estimation.

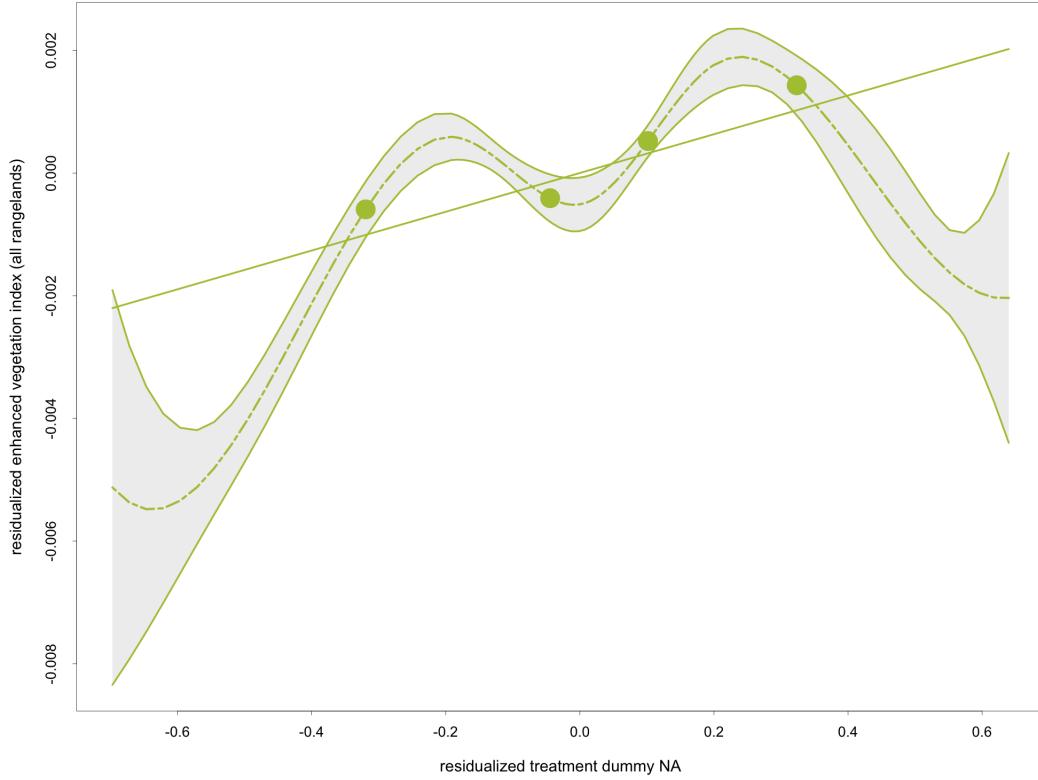


Figure C.5: Optimal binscatter of residualized average enhanced vegetation index (EVI) on the semi-parametric function $\mu(D)$, where D is a residualized treatment dummy reflecting extensive margin exposure defined as ≥ 1 cumulative TLU insured, with a contrasting linear fit. Estimation is motivated by tests suggested by Jakiela (2021) for the linearity of the treatment effect. Estimations employ the integrated mean squared error (IMSE)-optimal direct plug-in rule for bin selection and cubic B-splines within and between bins. Points reflect the mean within bins for unexposed and exposed units, which are quantile-spaced. Confidence bands are clustered at the index unit level. See Cattaneo et al. 2024b for details on optimal binscatter estimation.

Table C.2: Optimal binscatter pair-wise tests of the plausibility of the assumption of treatment effect homogeneity at the HUC-12 level following Cattaneo et al. (2024b).

	Dependent variables:		
	BG share	PV share	EVI
t-statistic from H0: $\mu(D)_{exposed} = \mu(D)_{un-exposed}$	3.302 (0.014)	3.544 (0.004)	3.239 (0.007)
J-unexposed	4	4	4
J-exposed	6	5	4
N clusters - unexposed	130	130	130
N clusters - exposed	126	126	126
N observations - unexposed	69718	69718	141065
N observations - exposed	29750	29750	58435

Note: This test determines if $\mu(D)$ for a treated group is the same as $\mu(D)$ for a control group. Respective tests stem from optimal binscatter estimations between residualized dependent variables listed above and residualized extensive margin exposed dummy D defined as ≥ 1 cumulative TLU insured following Jakiela (2021) for exposed and un-exposed subsets. P-values are in parentheses below t-statistics. J is the number of bins. N clusters is the total number of clusters, and observations for exposed and unexposed groups. Standard errors are clustered at the index unit level. Tests are implemented using the *binspwc* function in the *binsreg* R package Cattaneo et al. (2024a). *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

D Staggered Differences-in-Differences

D.1 Extensive Margin Results

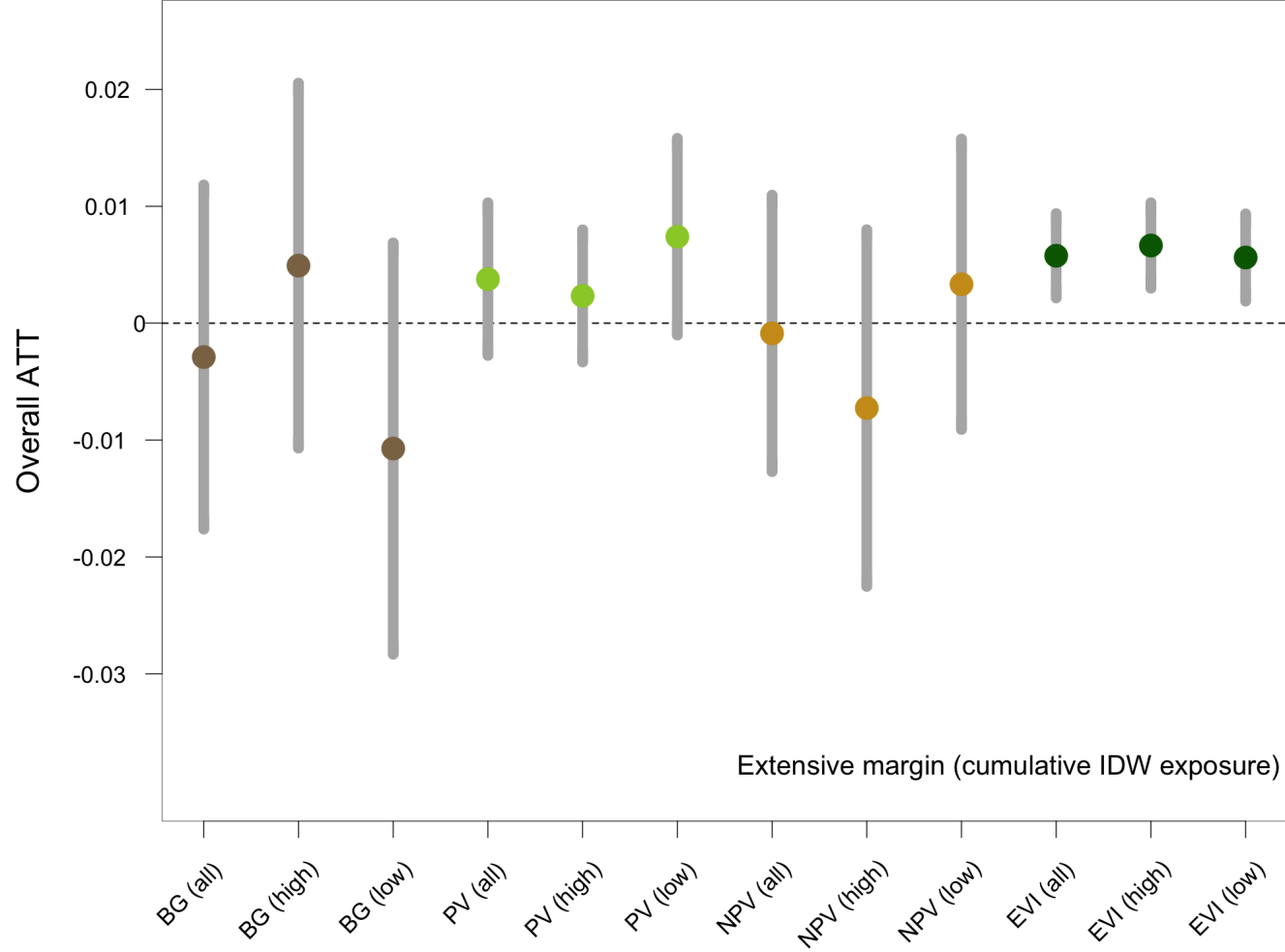


Figure D.1.1: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-12 level from IBLI exposure at the extensive margin based on the sum of IDW exposure (≥ 1 TLU insured). ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 99,426$; fractional cover high mask, $n = 98,373$; fractional cover low mask, $n = 99,361$; EVI all mask, $n = 199,416$; EVI high mask, $n = 196,474$; EVI low mask, $n = 199,280$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{-}10^\circ$ C and $30\text{-}45^\circ$ C due to limited exposure from $5\text{-}10^\circ$ C and $35\text{-}40^\circ$ C. Each model includes unit and period fixed effects.

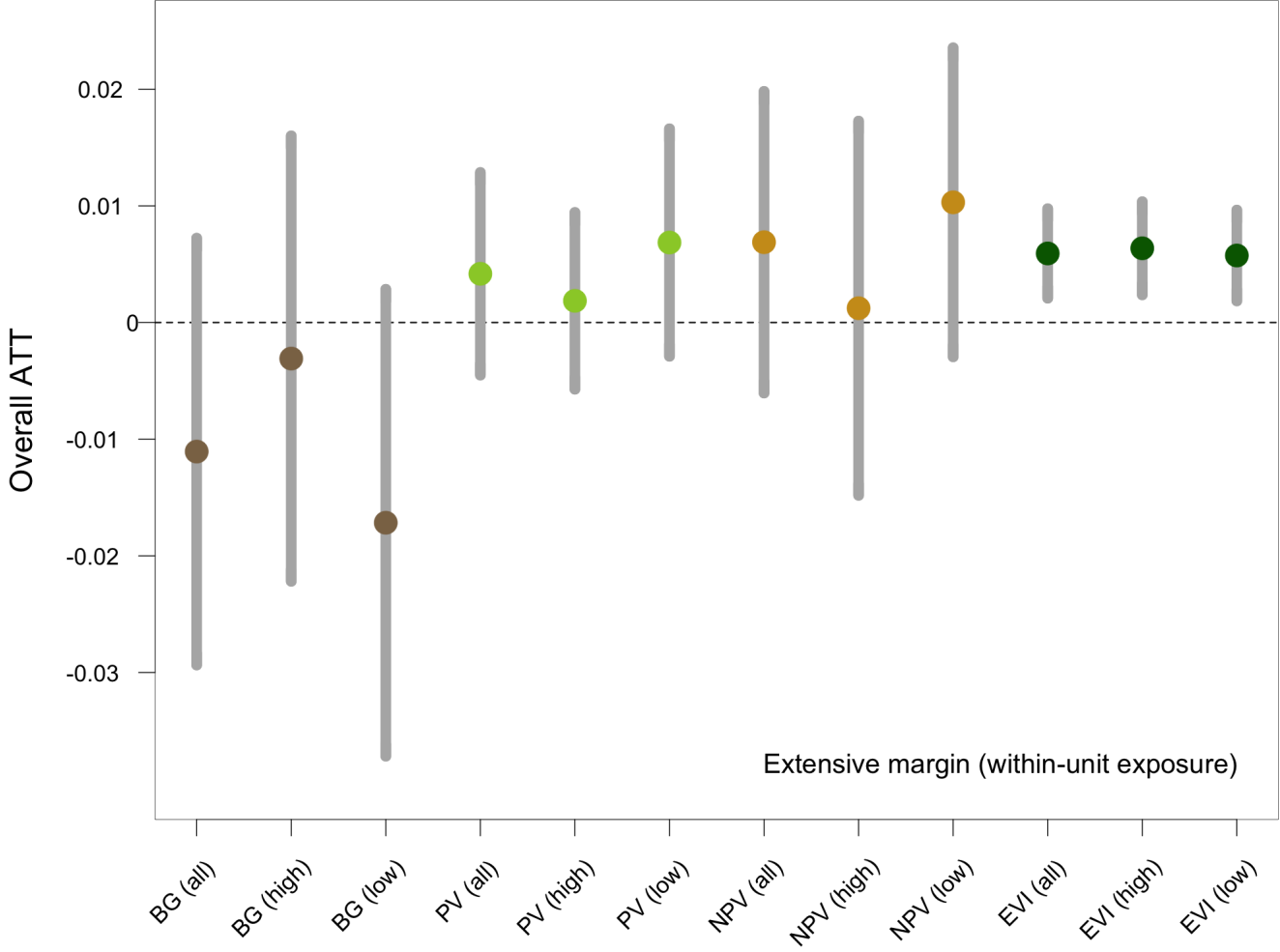


Figure D.1.2: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-12 level from IBLI exposure at the extensive margin based on the sum of within unit exposure without inverse distance weighting (≥ 1 TLU insured). ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 99,426$; fractional cover high mask, $n = 98,373$; fractional cover low mask, $n = 99,361$; EVI all mask, $n = 199,416$; EVI high mask, $n = 196,474$; EVI low mask, $n = 199,280$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{-}10^\circ$ C and $30\text{-}45^\circ$ C due to limited exposure from $5\text{-}10^\circ$ C and $35\text{-}40^\circ$ C. Each model includes unit and period fixed effects.

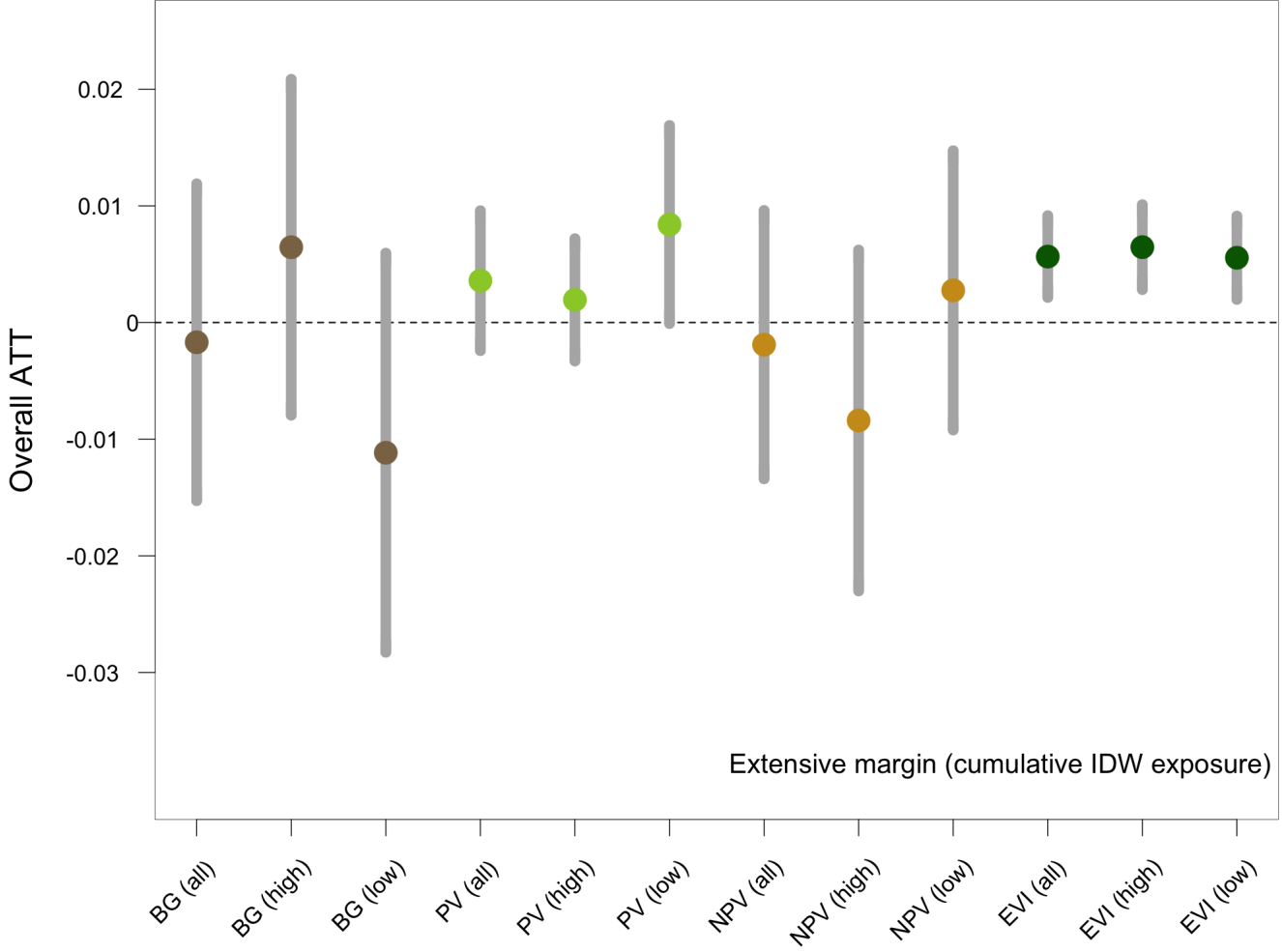


Figure D.1.3: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-9 level from IBLI exposure at the extensive margin based on the sum of IDW exposure (≥ 1 TLU insured). ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 48,953$; fractional cover high mask, $n = 48,520$; fractional cover low mask, $n = 48,922$; EVI all mask, $n = 98,154$; EVI high mask, $n = 97,012$; EVI low mask, $n = 98,102$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{--}10^\circ$ C and $30\text{--}45^\circ$ C due to limited exposure from $5\text{--}10^\circ$ C and $35\text{--}40^\circ$ C. Each model includes unit and period fixed effects.

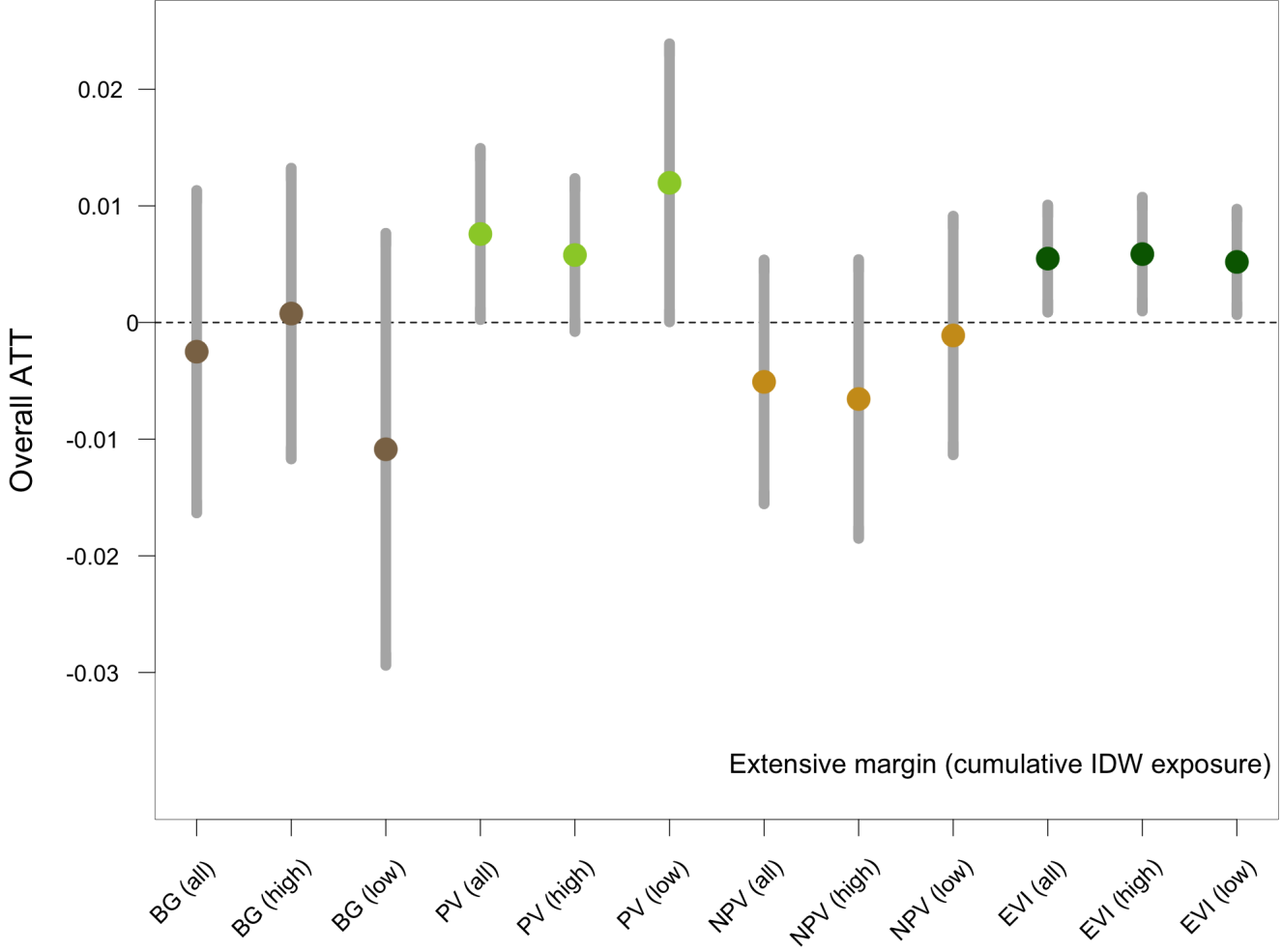


Figure D.1.4: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-8 level from IBLI exposure at the extensive margin based on the sum of IDW exposure (≥ 1 TLU insured). ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 18,221$; fractional cover high mask, $n = 18,095$; fractional cover low mask, $n = 18,215$; EVI all mask, $n = 36,498$; EVI high mask, $n = 36,246$; EVI low mask, $n = 36,488$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{-}10^\circ$ C and $30\text{-}45^\circ$ C due to limited exposure from $5\text{-}10^\circ$ C and $35\text{-}40^\circ$ C. Each model includes unit and period fixed effects.

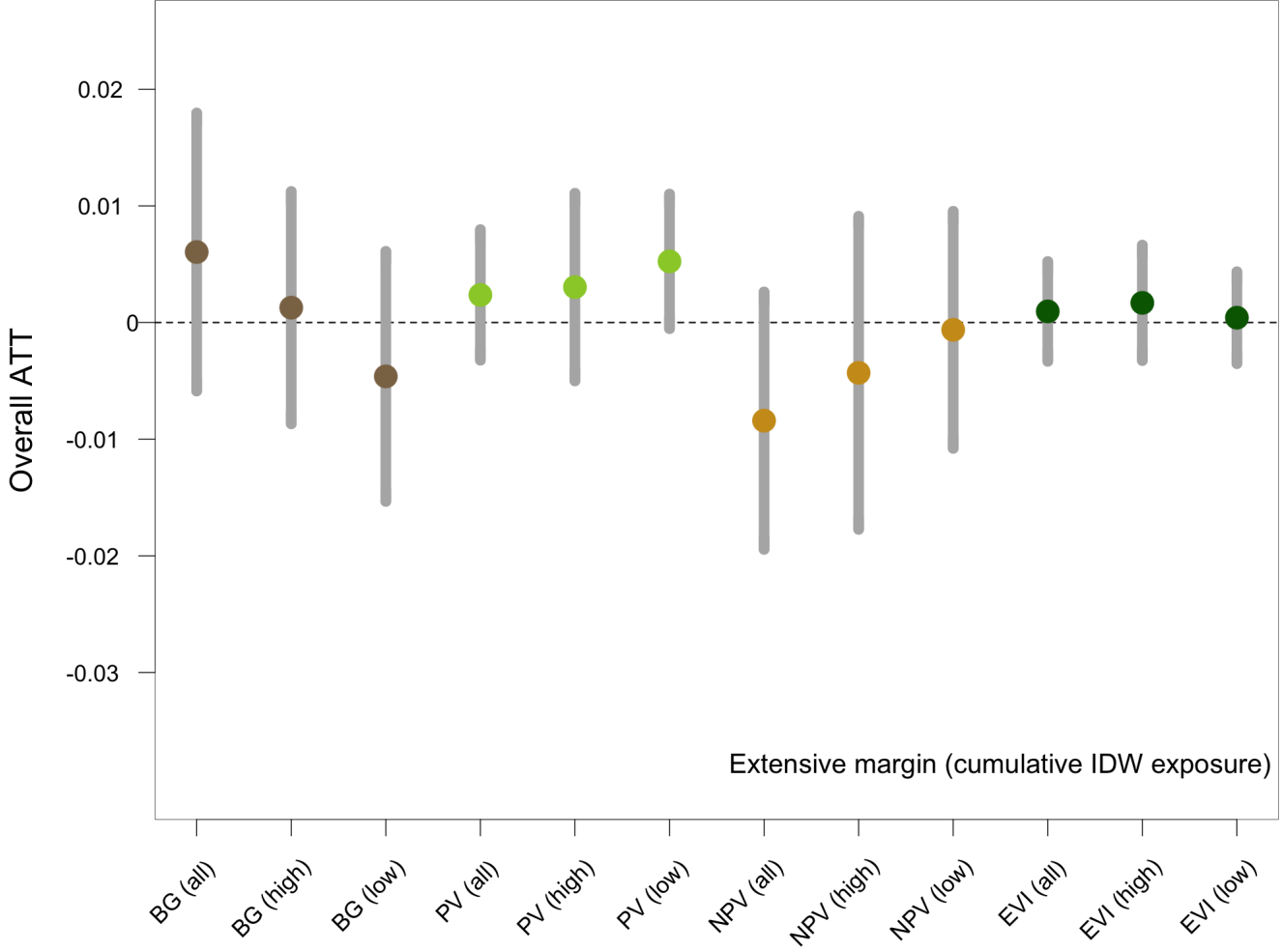


Figure D.1.5: Overall ATTs with 95% confidence intervals for tests of impacts at IU and CA level from IBLI exposure at the extensive margin based on the sum of IDW exposure (≥ 1 TLU insured). ATTs reflect point estimates of β in equation (2) using from Gardner et al. (2025). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 2,730$; fractional cover high mask, $n = 2,730$; fractional cover low mask, $n = 2,730$; EVI all mask, $n = 5,460$; EVI high mask, $n = 5,460$; EVI low mask, $n = 5,460$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5-10^\circ$ C and $30-45^\circ$ C due to limited exposure from $5-10^\circ$ C and $35-40^\circ$ C. Each model includes unit and period fixed effects.

D.2 Intensive Margin Results

Table D.2.1: First stage results for the share of bare ground (BG) in all rangelands at the HUC-12 level (see corresponding second stage results in Table 1 of main text).

Dependent variable: Bare ground (BG) share all rangelands				
Precipitation mean (mm)	-0.00026*** (0.00007)	-0.00022*** (0.00003)	-0.00024*** (0.00004)	-0.00026*** (0.00004)
Precipitation stn. dev. (mm)	-0.00178*** (0.00068)	0.00025* (0.00013)	0.00012 (0.00013)	0.00037** (0.00015)
GDD 5-15 C	0.00514*** (0.00194)	-0.01179*** (0.00250)	-0.01089*** (0.00412)	-0.01103** (0.00466)
GDD 15-20 C	-0.00082 (0.00098)	-0.01161*** (0.00238)	-0.01014** (0.00410)	-0.01010** (0.00464)
GDD 20-25 C	0.00072 (0.00100)	-0.01340*** (0.00258)	-0.01285*** (0.00437)	-0.01289*** (0.00483)
GDD 25-30 C	-0.00088 (0.00077)	-0.01241*** (0.00253)	-0.01118*** (0.00409)	-0.01207** (0.00464)
GDD 30-35 C	0.00627*** (0.00137)	-0.00999*** (0.00277)	-0.01037** (0.00467)	-0.01054** (0.00500)
GDD 35-45 C	-0.00208 (0.00274)	-0.00723** (0.00304)	-0.00884** (0.00423)	-0.01006** (0.00496)
Constant	0.15815*** (0.02912)			
Unit FE	No	Yes	Yes	Yes
Period FE	No	No	Yes	Yes
Unit-specific linear trends	No	No	No	Yes
Observations	69,691	69,691	69,691	69,691
RMSE	0.219	0.062	0.058	0.053
R ²	0.171	0.934	0.941	0.951
AIC	-14,052.3	-180,589.0	-188,562.8	-191,979.2
BIC	-13,969.9	-137,063.0	-144,853.7	-104,817.2
Adjusted R ²	0.171	0.929	0.937	0.943

Note: Standard errors are clustered at the level of index unit level. *p<0.1; **p<0.05; ***p<0.01.

Table D.2.2: First stage results for the share of photosynthetic vegetation (PV) in all rangelands at the HUC-12 level (see corresponding second stage results in Table 1 of main text).

Dependent variable: Photosynthetic vegetation (PV) share all rangelands				
Precipitation mean (mm)	0.00059*** (0.00004)	0.00056*** (0.00004)	0.00046*** (0.00004)	0.00047*** (0.00004)
Precipitation stn. dev. (mm)	0.00118*** (0.00022)	0.00009 (0.00018)	0.00001 (0.00018)	-0.00010 (0.00020)
GDD 5-15 C	0.00313*** (0.00076)	0.00635** (0.00256)	-0.04691*** (0.01419)	-0.04566*** (0.01483)
GDD 15-20 C	-0.00262*** (0.00054)	0.00233 (0.00278)	-0.05137*** (0.01426)	-0.05079*** (0.01487)
GDD 20-25 C	-0.00351*** (0.00053)	0.00164 (0.00262)	-0.05192*** (0.01422)	-0.05160*** (0.01484)
GDD 25-30 C	0.00121** (0.00046)	-0.00027 (0.00255)	-0.05366*** (0.01421)	-0.05290*** (0.01482)
GDD 30-35 C	-0.00457*** (0.00077)	-0.00060 (0.00254)	-0.05306*** (0.01420)	-0.05294*** (0.01480)
GDD 35-45 C	-0.00327*** (0.00104)	-0.00121 (0.00266)	-0.05608*** (0.01418)	-0.05543*** (0.01489)
Constant	0.37920*** (0.05603)			
Unit FEs	No	Yes	Yes	Yes
Period FEs	No	No	Yes	Yes
Unit-specific linear trends	No	No	No	Yes
Observations	69,691	69,691	69,691	69,691
RMSE	0.100	0.057	0.054	0.052
R ²	0.434	0.814	0.835	0.849
AIC	-122,655.6	-190,906.1	-198,913.6	-195,606.0
BIC	-122,573.2	-147,380.0	-155,204.5	-108,444.0
Adjusted R ²	0.434	0.801	0.822	0.825

Note: Standard errors are clustered at the level of index unit level. *p<0.1; **p<0.05; ***p<0.01.

Table D.2.3: First stage results for the share of non-photosynthetic vegetation (NPV) in all rangelands at the HUC-12 level (see corresponding second stage results in Table 1 of main text).

Dependent variable: Non-photosynthetic vegetation (NPV) share all rangelands				
Precipitation mean (mm)	-0.00033*** (0.00007)	-0.00034*** (0.00003)	-0.00022*** (0.00003)	-0.00022*** (0.00003)
Precipitation stn. dev. (mm)	0.00060 (0.00056)	-0.00034* (0.00018)	-0.00013 (0.00018)	-0.00027 (0.00021)
GDD 5-15 C	-0.00827*** (0.00174)	0.00544** (0.00256)	0.05780*** (0.01451)	0.05669*** (0.01429)
GDD 15-20 C	0.00344*** (0.00086)	0.00928*** (0.00241)	0.06151*** (0.01448)	0.06090*** (0.01427)
GDD 20-25 C	0.00279*** (0.00088)	0.01175*** (0.00251)	0.06477*** (0.01448)	0.06449*** (0.01426)
GDD 25-30 C	-0.00032 (0.00058)	0.01269*** (0.00256)	0.06484*** (0.01448)	0.06497*** (0.01426)
GDD 30-35 C	-0.00171 (0.00118)	0.01059*** (0.00251)	0.06343*** (0.01444)	0.06348*** (0.01418)
GDD 35-45 C	0.00535** (0.00213)	0.00843** (0.00341)	0.06492*** (0.01432)	0.06548*** (0.01415)
Constant	0.46265*** (0.04373)			
Unit FEs	No	Yes	Yes	Yes
Period FEs	No	No	Yes	Yes
Unit-specific linear trends	No	No	No	Yes
Observations	69,691	69,691	69,691	69,691
RMSE	0.177	0.062	0.058	0.055
R ²	0.148	0.896	0.908	0.919
AIC	-43,718.0	-180,585.5	-189,227.6	-188,395.2
BIC	-43,635.6	-137,059.4	-145,518.5	-101,233.2
Adjusted R ²	0.148	0.888	0.901	0.906

Note: Standard errors are clustered at the level of index unit level. *p<0.1; **p<0.05; ***p<0.01.

Table D.2.4: First stage results for mean enhanced vegetation index (EVI) in all rangelands at the HUC-12 level (see corresponding second stage results in Table 1 of main text).

Dependent variable: Mean enhanced vegetation index (EVI) in all rangelands				
Precipitation mean (mm)	0.00032*** (0.00002)	0.00021*** (0.00001)	0.00014*** (0.00001)	0.00014*** (0.00001)
Precipitation stn. dev. (mm)	-0.00025** (0.00010)	0.00007 (0.00005)	0.00011*** (0.00004)	0.00011** (0.00004)
GDD 5-15 C	0.00205*** (0.00030)	0.00023 (0.00021)	0.00074*** (0.00021)	0.00078** (0.00031)
GDD 15-20 C	-0.00101*** (0.00011)	-0.00068*** (0.00011)	-0.00028*** (0.00010)	-0.00024* (0.00012)
GDD 20-25 C	-0.00067*** (0.00025)	-0.00021** (0.00010)	0.00005 (0.00011)	-0.000002 (0.00013)
GDD 25-30 C	0.00040 (0.00028)	-0.00049*** (0.00009)	-0.00033*** (0.00010)	-0.00029*** (0.00010)
GDD 30-35 C	-0.00209*** (0.00038)	-0.00061*** (0.00016)	-0.00007 (0.00013)	-0.00005 (0.00014)
GDD 35-45 C	-0.00005 (0.00036)	-0.00036* (0.00019)	0.00019 (0.00025)	0.00028 (0.00026)
Constant	0.22038*** (0.01532)			
Unit FE	No	Yes	Yes	Yes
Period FE	No	No	Yes	Yes
Unit-specific linear trends	No	No	No	Yes
Observations	141,010	141,010	141,010	141,010
RMSE	0.044	0.024	0.022	0.021
R ²	0.565	0.865	0.893	0.903
AIC	-481,678.9	-637,261.5	-670,386.5	-673,837.4
BIC	-481,590.2	-590,383.5	-623,104.5	-579,756.3
Adjusted R ²	0.565	0.860	0.890	0.896

Note: Standard errors are clustered at the level of index unit level. *p<0.1; **p<0.05; ***p<0.01.

D.3 Robustness Checks

Table D.3.1: Intensive margin tests (overall ATTs) for the effect of IBLI on rangelands using inverse distance weighted (IDW) continuous measures of the total cumulative TLUs insured at the HUC-9 level (see Gardner et al. (2025) pg. 17-18).

	<u>Dependent variable: Bare ground (BG) share all rangelands</u>			
Total cumulative TLUs insured (IDW)	0.000008*** (0.000003)	-0.000004*** (0.000001)	-0.000003 (0.000003)	0.0000008 (0.000002)
<i>BG second stage statistics</i>				
Observations	48,953	48,953	48,953	48,953
Adjusted R ²	0.001	0.004	0.002	0.0001
	<u>Dependent variable: Photosynthetic vegetation (PV) share all rangelands</u>			
Total cumulative TLUs insured (IDW)	-0.000005*** (0.000002)	0.000006*** (0.0000008)	0.000006*** (0.000001)	-0.000002 (0.000003)
<i>PV second stage statistics</i>				
Observations	48,953	48,953	48,953	48,953
Adjusted R ²	0.002	0.014	0.014	0.001
	<u>Dependent variable: Non-photosynthetic vegetation (NPV) share all rangelands</u>			
Total cumulative TLUs insured (IDW)	-0.000005* (0.000003)	-0.000002** (0.000001)	-0.000004 (0.000003)	0.000001 (0.000003)
<i>NPV second stage statistics</i>				
Observations	48,953	48,953	48,953	48,953
Adjusted R ²	0.0008	0.001	0.004	0.0005
	<u>Dependent variable: Mean enhanced vegetation index (EVI) all rangelands</u>			
Total cumulative TLUs insured (IDW)	-0.0000006 (0.0000009)	0.000001*** (0.0000004)	0.000004*** (0.0000008)	0.000002** (0.0000009)
<i>EVI second stage statistics</i>				
Observations	98,154	98,154	98,154	98,154
Adjusted R ²	0.00008	0.003	0.022	0.009
<i>First stage specifications (BG, PV, NPV, EVI)</i>				
Unit fixed effects	No	Yes	Yes	Yes
Period fixed effects	No	No	Yes	Yes
Unit-specific trends	No	No	No	Yes

Note: First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from 5-10° C and 30-45° C due to limited exposure from 5-10° C and 35-40° C. Standard errors are clustered at the level of index unit level. *p<0.1; **p<0.05; ***p<0.01.

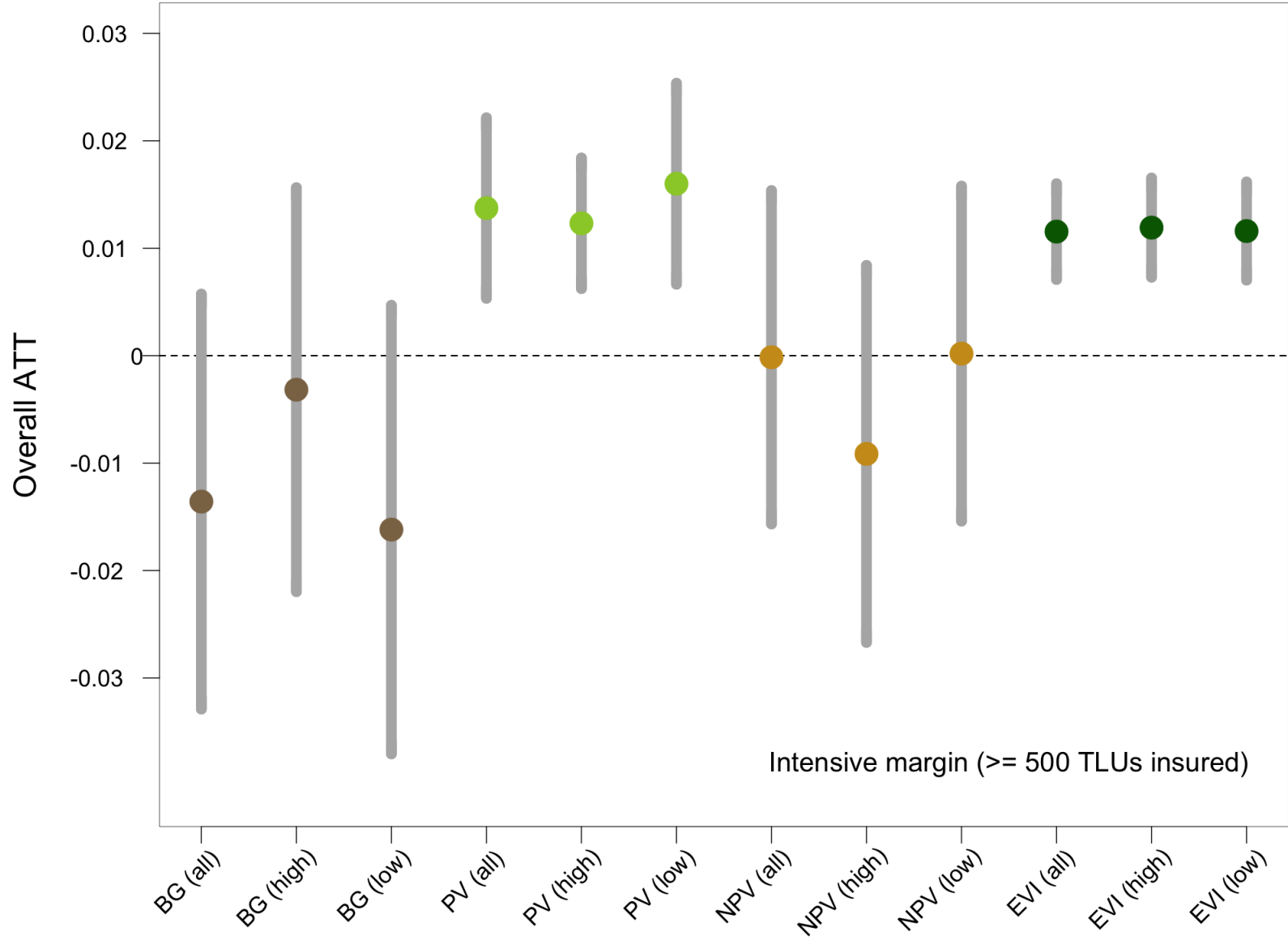


Figure D.3.1: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-12 level from IBLI exposure at the intensive margin of ≥ 500 cumulative IDW TLUs insured. ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025) (see Section 4). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 99,426$; fractional cover high mask, $n = 98,373$; fractional cover low mask, $n = 99,361$; EVI all mask, $n = 199,416$; EVI high mask, $n = 196,416$; EVI low mask, $n = 199,416$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{-}10^\circ$ C and $30\text{-}45^\circ$ C due to limited exposure from $5\text{-}10^\circ$ C and $35\text{-}40^\circ$ C. Each model includes unit and period fixed effects.

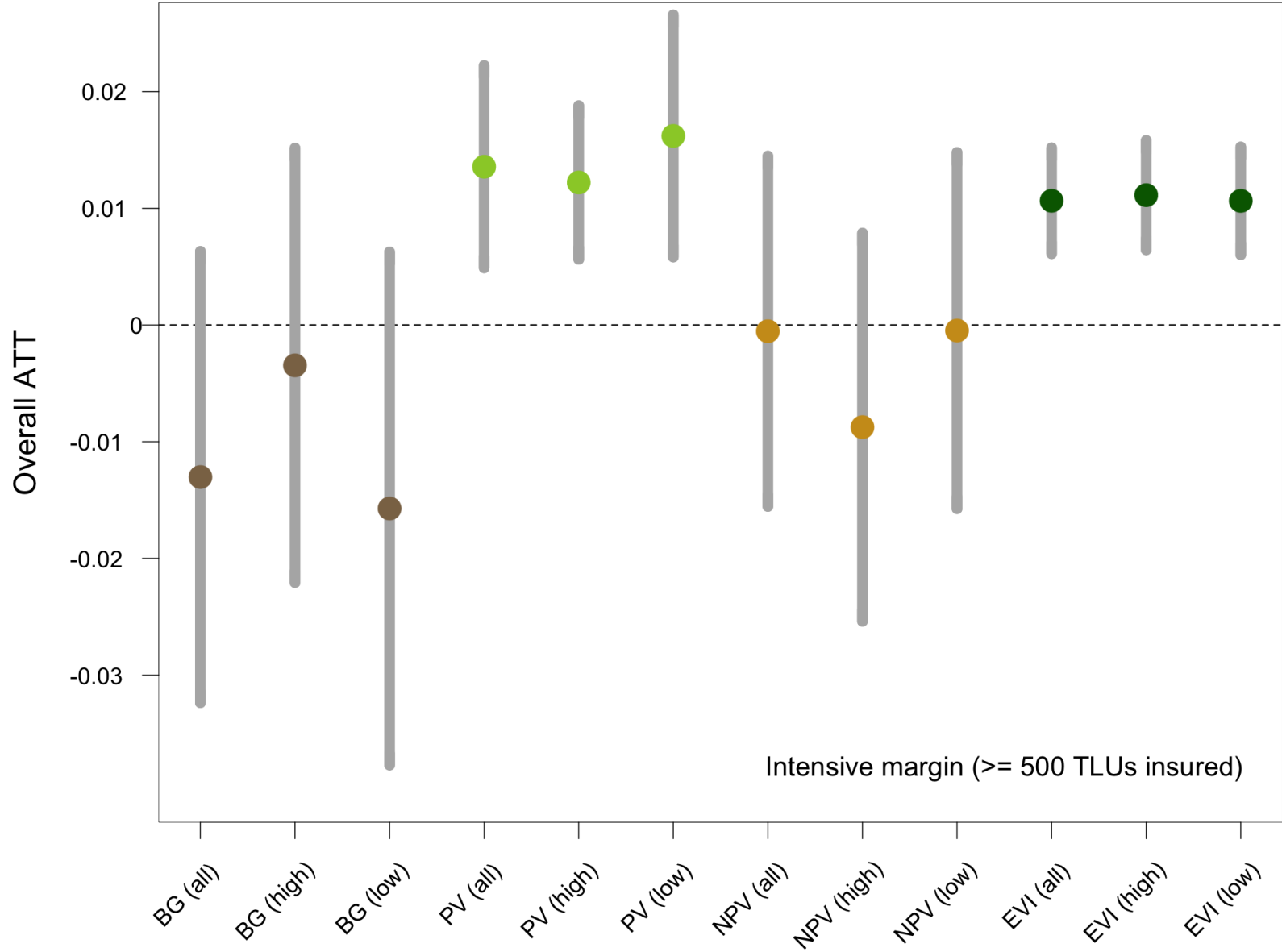


Figure D.3.2: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-9 level from IBLI exposure at the intensive margin of ≥ 500 cumulative IDW TLUs insured. ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025) (see Section 4). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 48,953$; fractional cover high mask, $n = 48,520$; fractional cover low mask, $n = 48,922$; EVI all mask, $n = 98,154$; EVI high mask, $n = 97,012$; EVI low mask, $n = 98,102$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5-10^\circ$ C and $30-45^\circ$ C due to limited exposure from $5-10^\circ$ C and $35-40^\circ$ C. Each model includes unit and period fixed effects.

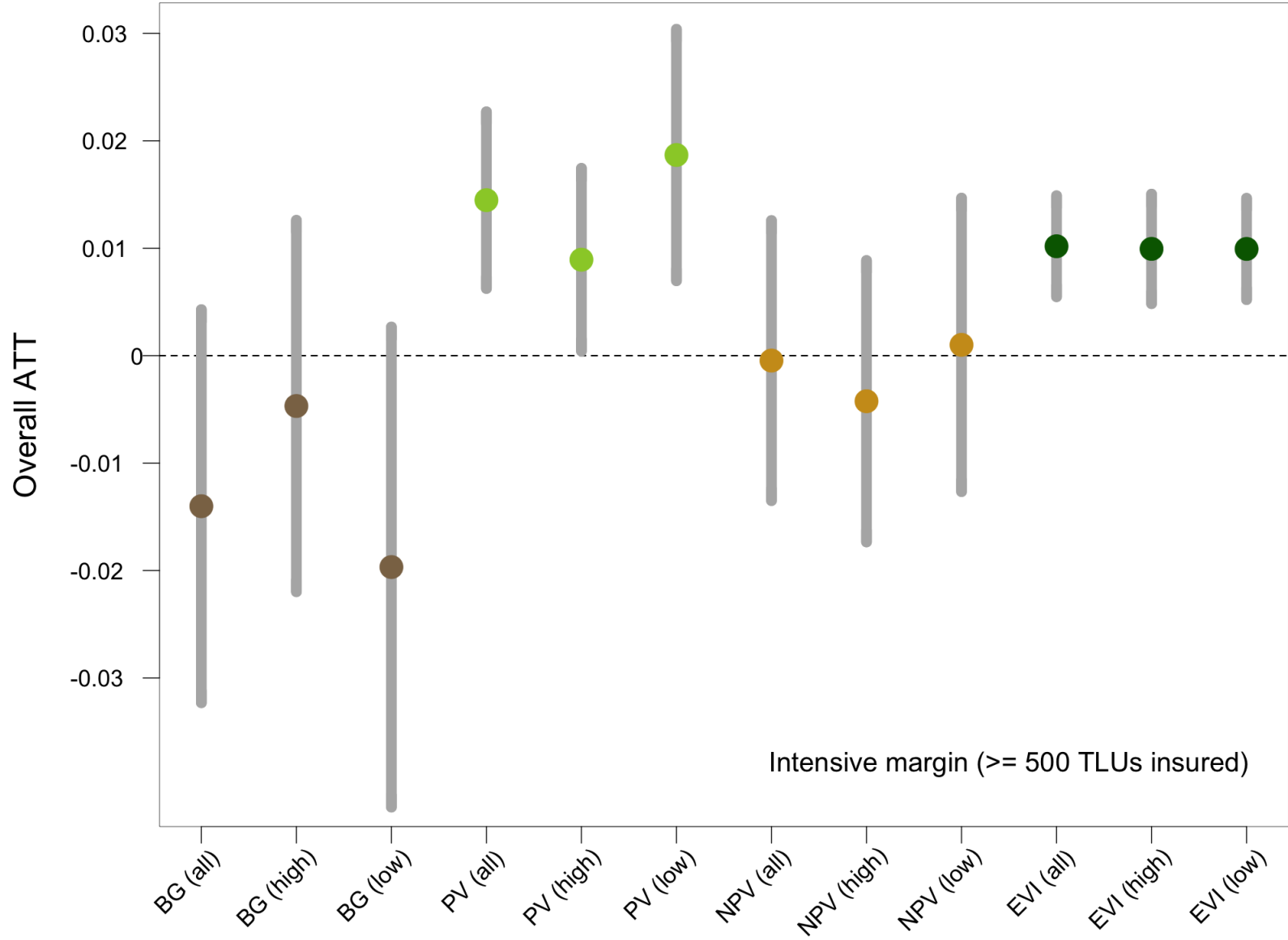


Figure D.3.3: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-8 level from IBLI exposure at the intensive margin of ≥ 500 cumulative IDW TLUs insured. ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025) (see Section 4). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 18,215$; fractional cover high mask, $n = 18,095$; fractional cover low mask, $n = 18,215$; EVI all mask, $n = 36,488$; EVI high mask, $n = 36,246$; EVI low mask, $n = 36,488$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{-}10^\circ$ C and $30\text{-}45^\circ$ C due to limited exposure from $5\text{-}10^\circ$ C and $35\text{-}40^\circ$ C. Each model includes unit and period fixed effects.

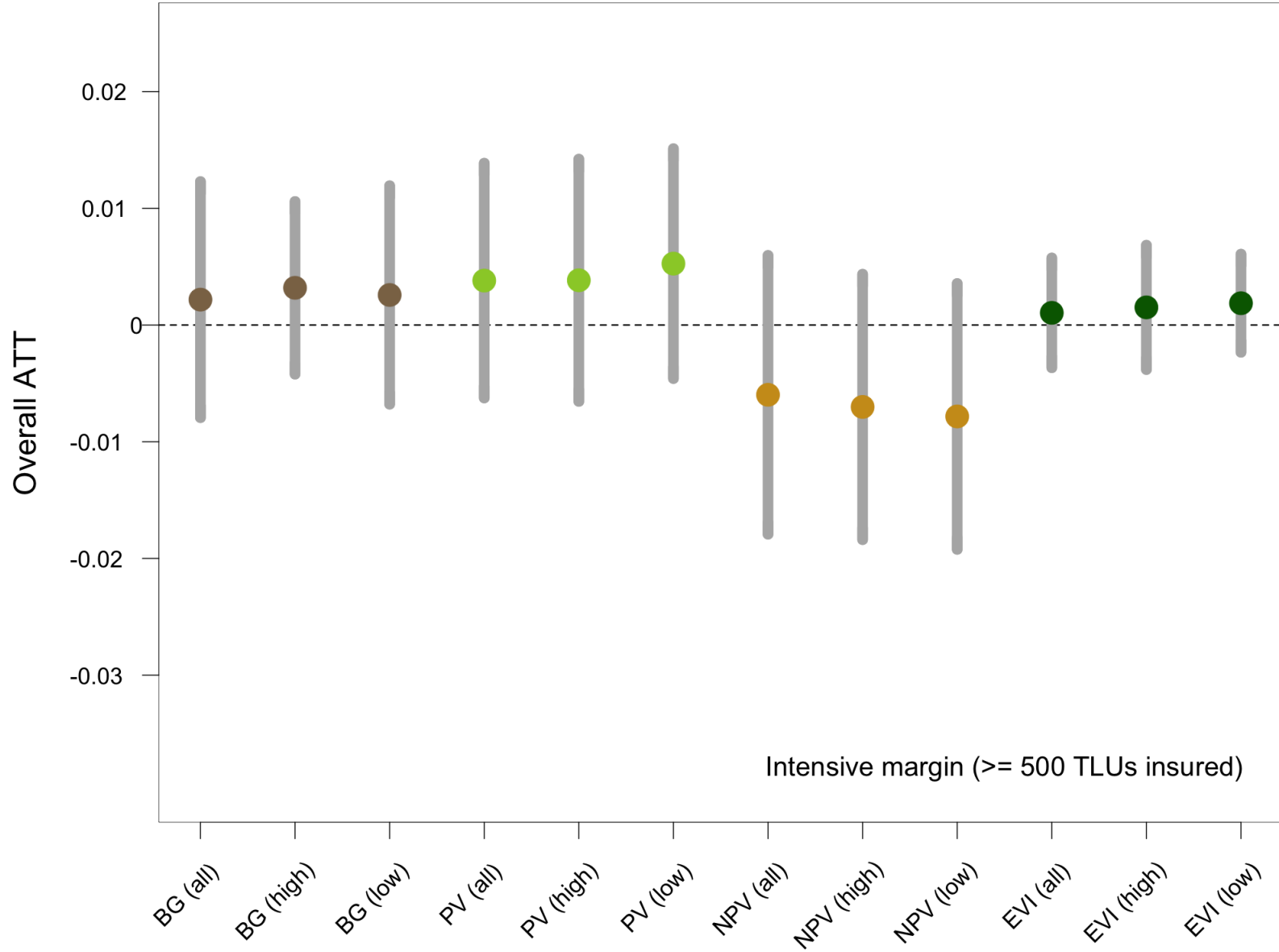


Figure D.3.4: Overall ATTs with 95% confidence intervals for tests of impacts at IU-CA level from IBLI exposure at the intensive margin of ≥ 500 cumulative IDW TLUs insured. ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025) (see Section 4). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 2,730$; fractional cover high mask, $n = 2,730$; fractional cover low mask, $n = 2,730$; EVI all mask, $n = 5,460$; EVI high mask, $n = 5,460$; EVI low mask, $n = 5,460$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{-}10^\circ$ C and $30\text{-}45^\circ$ C due to limited exposure from $5\text{-}10^\circ$ C and $35\text{-}40^\circ$ C. Each model includes unit and period fixed effects.

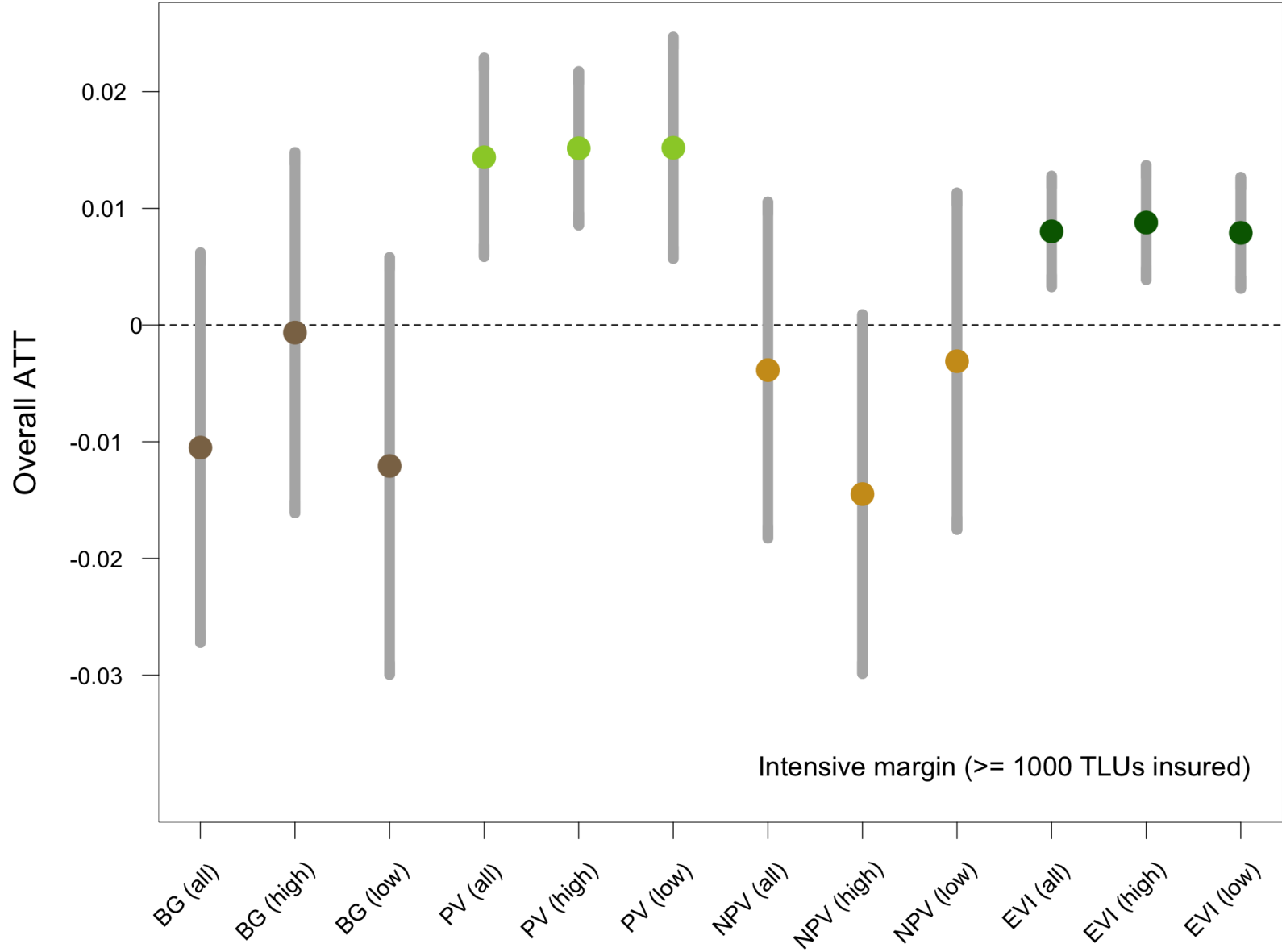


Figure D.3.5: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-12 level from IBLI exposure at the intensive margin of ≥ 1000 cumulative IDW TLUs insured. ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025) (see Section 4). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 99,426$; fractional cover high mask, $n = 98,373$; fractional cover low mask, $n = 99,361$; EVI all mask, $n = 199,500$; EVI high mask, $n = 196,558$; EVI low mask, $n = 199,364$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{-}10^\circ$ C and $30\text{-}45^\circ$ C due to limited exposure from $5\text{-}10^\circ$ C and $35\text{-}40^\circ$ C. Each model includes unit and period fixed effects.

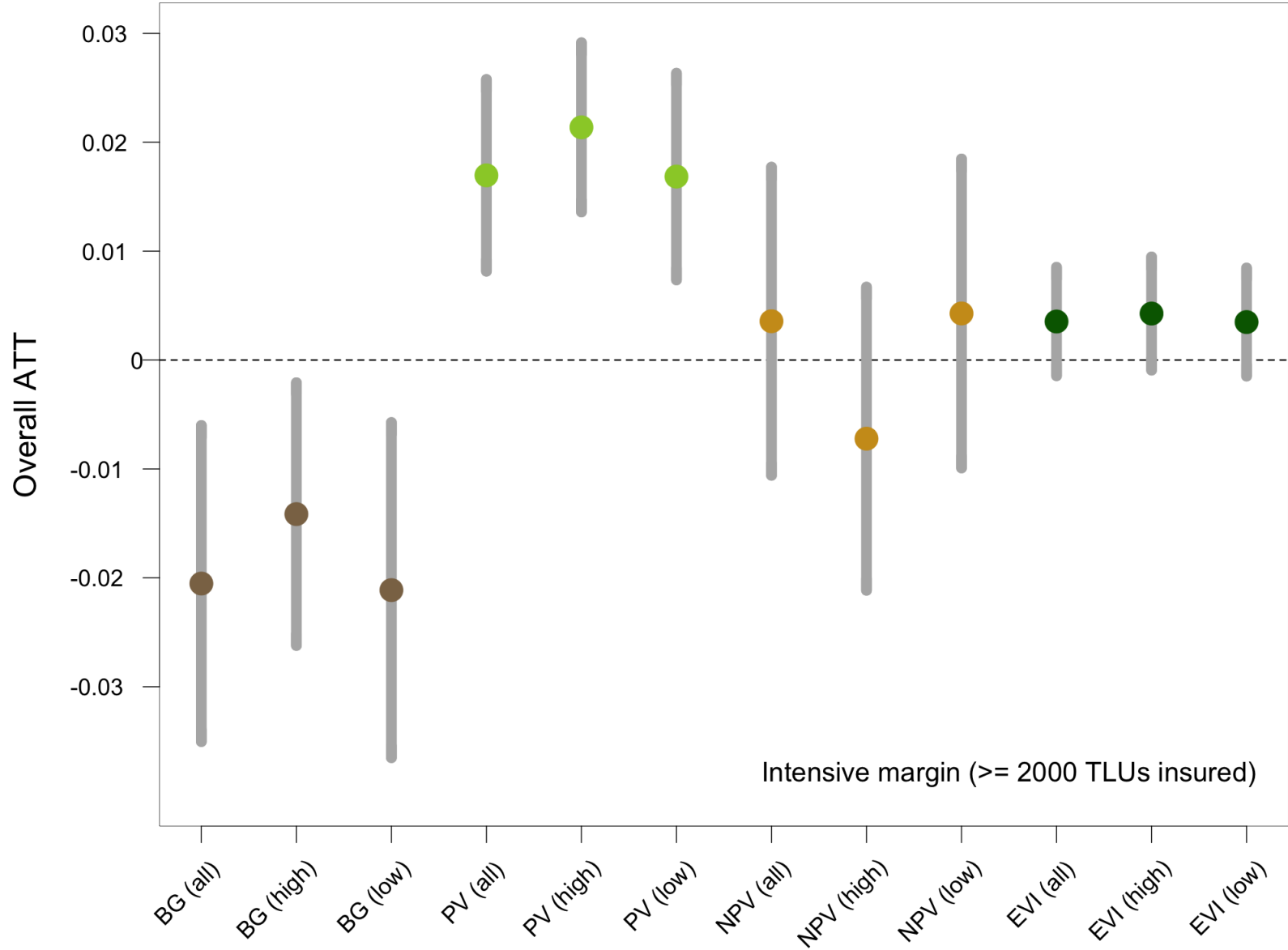


Figure D.3.6: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-12 level from IBLI exposure at the intensive margin of ≥ 2000 cumulative IDW TLUs insured. ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025) (see Section 4). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 99,426$; fractional cover high mask, $n = 98,373$; fractional cover low mask, $n = 99,361$; EVI all mask, $n = 199,500$; EVI high mask, $n = 196,558$; EVI low mask, $n = 199,364$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5\text{--}10^\circ$ C and $30\text{--}45^\circ$ C due to limited exposure from $5\text{--}10^\circ$ C and $35\text{--}40^\circ$ C. Each model includes unit and period fixed effects.

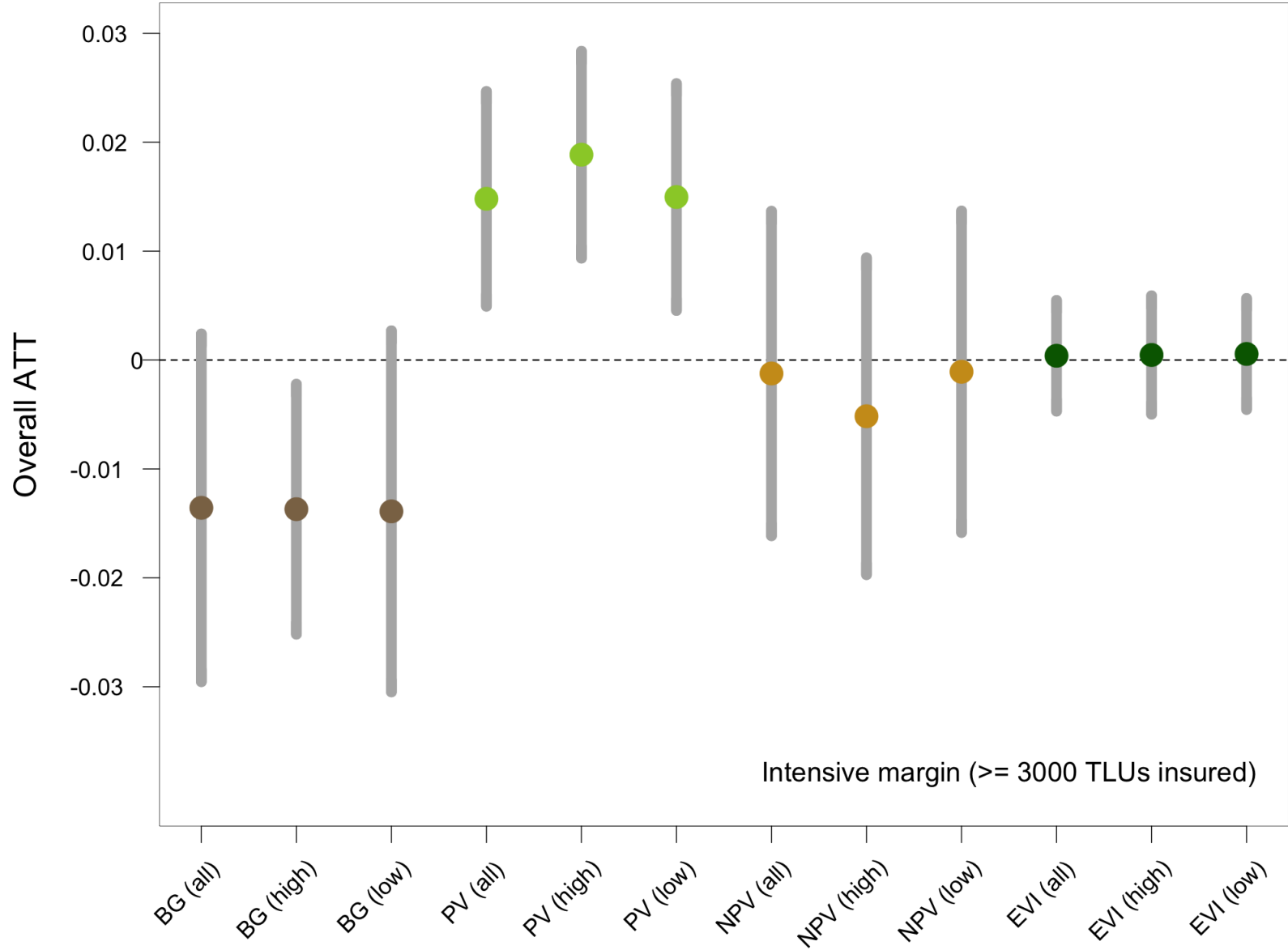


Figure D.3.7: Overall ATTs with 95% confidence intervals for tests of impacts at HUC-12 level from IBLI exposure at the intensive margin of ≥ 3000 cumulative IDW TLUs insured. ATTs reflect point estimates of β in equation (2) from Gardner et al. (2025) (see Section 4). Standard errors are clustered at the index unit level. From left to right, estimated coefficients reflect IBLI's impacts on BG, PV, NPV and EVI within all, high, and low rangelands (see Section 3.3). The number of observations for respective estimations are: fractional cover all mask, $n = 99,426$; fractional cover high mask, $n = 98,373$; fractional cover low mask, $n = 99,361$; EVI all mask, $n = 199,500$; EVI high mask, $n = 196,558$; EVI low mask, $n = 199,364$. First stage covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from $5-10^\circ$ C and $30-45^\circ$ C due to limited exposure from $5-10^\circ$ C and $35-40^\circ$ C. Each model includes unit and period fixed effects.

Table D.3.2: Overall ATT tests for seasonal differences in the effect of IBLI on average EVI.

Extensive margin test for different effects by season			
	EVI-all	EVI-high	EVI-low
Post-IBLI extensive margin (dummy)	0.00369** (0.00186)	0.00462** (0.00197)	0.00359* (0.00190)
Post-IBLI extensive margin (dummy) $\times$ LRLD season (dummy)	0.00423 (0.00279)	0.00412 (0.00281)	0.00414 (0.00274)
<i>Second stage statistics</i>			
Observations	199,416	196,474	199,280
Adjusted R ²	0.014	0.015	0.013
Intensive margin test for different effects by season (continuous exposure)			
	EVI-all	EVI-high	EVI-low
Total cumulative TLUs insured (IDW)	0.000005*** (0.000001)	0.000005*** (0.000001)	0.000005*** (0.000001)
Total cumulative TLUs insured (IDW) $\times$ LRLD season (dummy)	0.00000015 (0.000002)	0.0000003 (0.000002)	0.000000017 (0.000002)
<i>Second stage statistics</i>			
Observations	199,416	196,474	199,280
Adjusted R ²	0.024	0.026	0.023
<i>First stage specifications</i>			
Unit fixed effects	Y	Y	Y
Period fixed effects	Y	Y	Y
Weather covariates	Y	Y	Y

Note: Estimated effects are from extensive margin and continuous intensive margin versions of the two-stage estimator from Gardner et al. (2025) (see Section 4). Respective second stage equations are augmented with an interaction term between respective IBLI exposure variables and a dummy variable capturing the LRLD season. First stage weather covariates are the same across models and include: the mean and standard deviation of seasonal precipitation (mm), and mean GDD in 5° C bins with the exception of two 10° C bins from 5-10° C and 30-45° C due to limited exposure from 5-10° C and 35-40° C. Standard errors are clustered at the index unit level. *p < 0.1; **p < 0.05; ***p < 0.01.

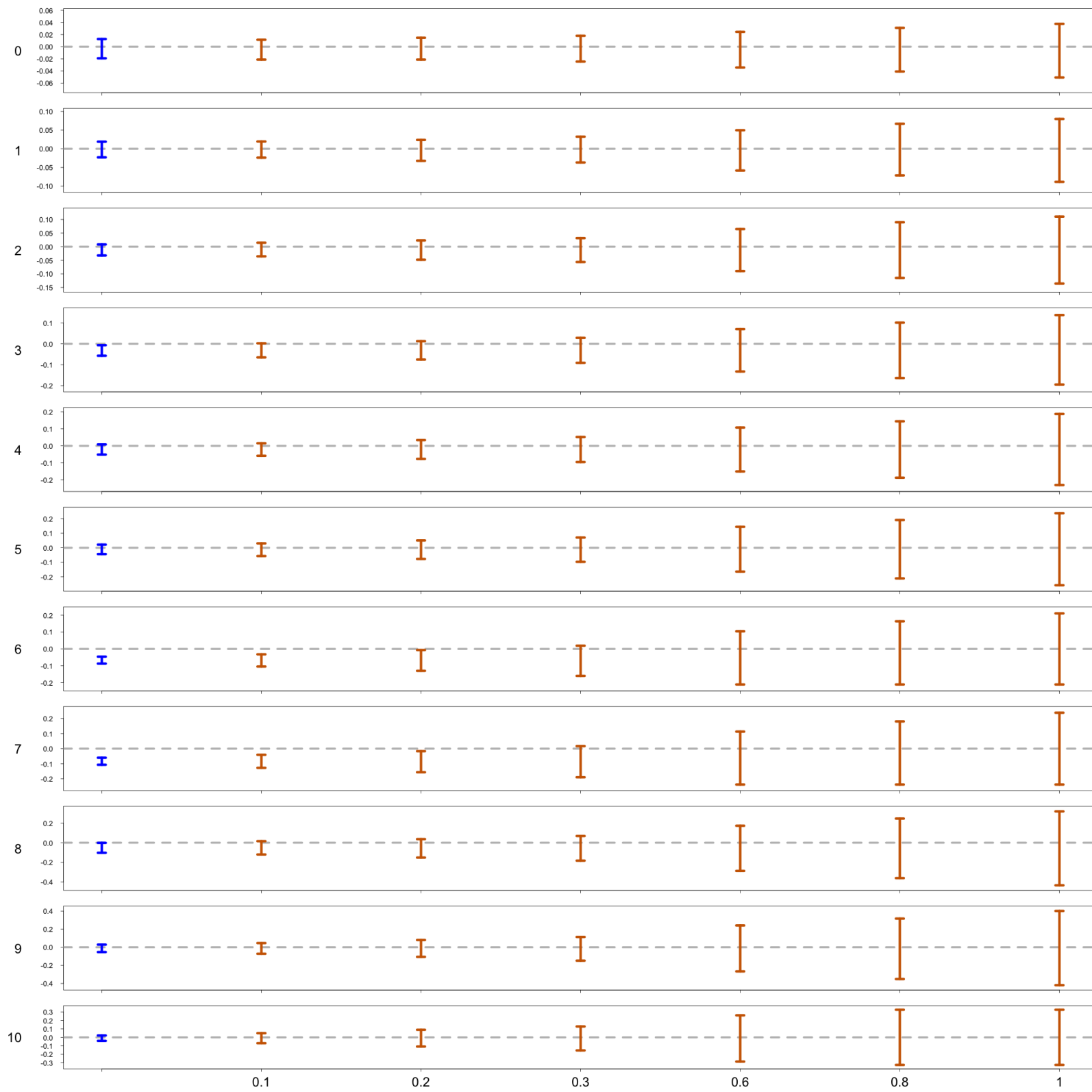


Figure D.3.8: 95% confidence intervals (CIs) following Rambachan and Roth (2023) for the effect of IBLI on the share of bare ground (BG) in all rangelands at the HUC-12 level and exposure to ≥ 500 cumulative IDW TLUs insured. The y-axis captures post-treatment event time period CIs. Blue CIs are original and orange CIs vary based on the proportion (x-axis) of the maximum M pre-treatment violation of parallel trends that is applied to bound maximum potential post-treatment violations of parallel trends between consecutive time periods.

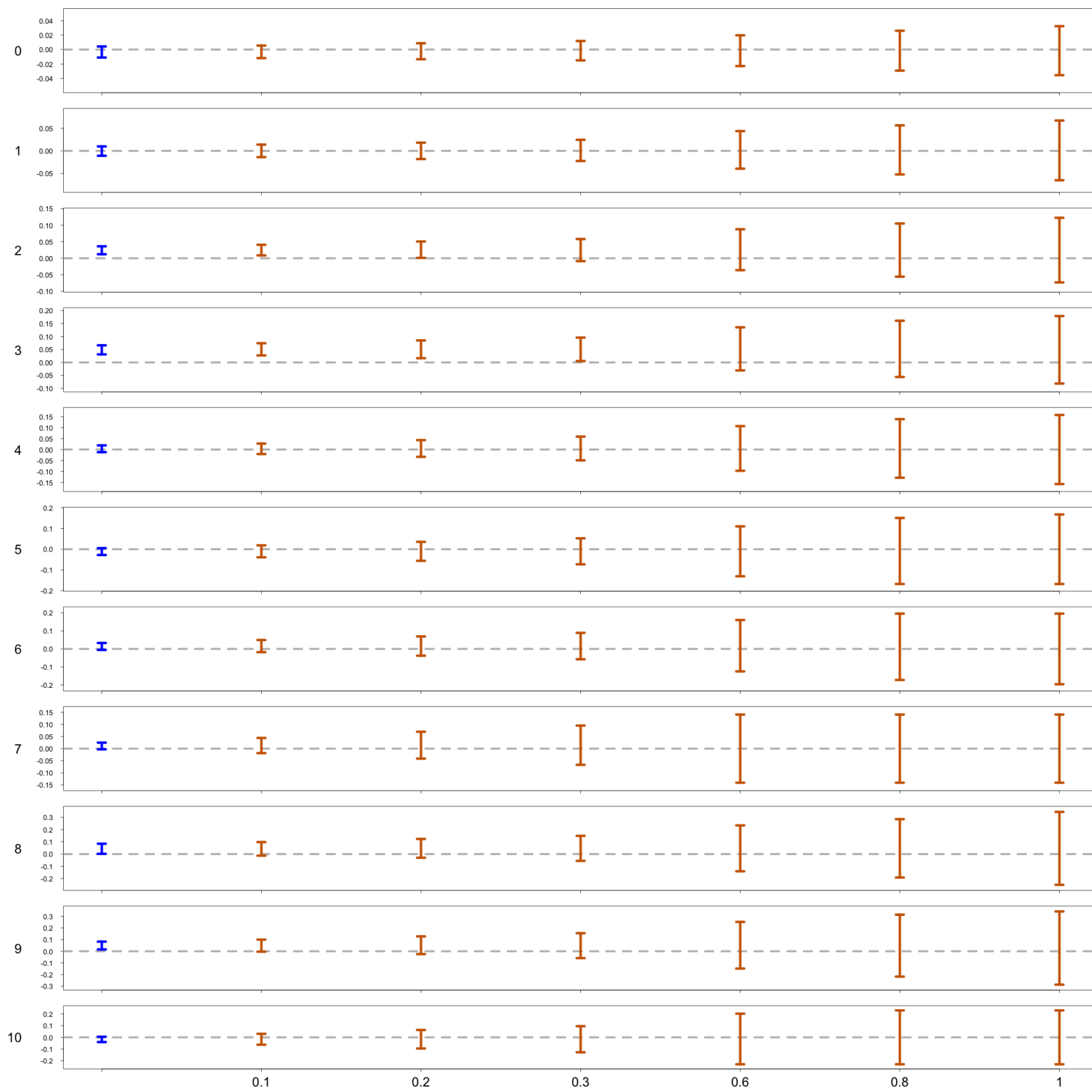


Figure D.3.9: 95% confidence intervals (CIs) following Rambachan and Roth (2023) for the effect of IBLI on the share of photosynthetic vegetation (PV) in all rangelands at the HUC-12 level and exposure to ≥ 500 cumulative IDW TLUs insured. The y-axis captures post-treatment event time period CIs. Blue CIs are original and orange CIs vary based on the proportion (x-axis) of the maximum M pre-treatment violation of parallel trends that is applied to bound maximum potential post-treatment violations of parallel trends between consecutive time periods.

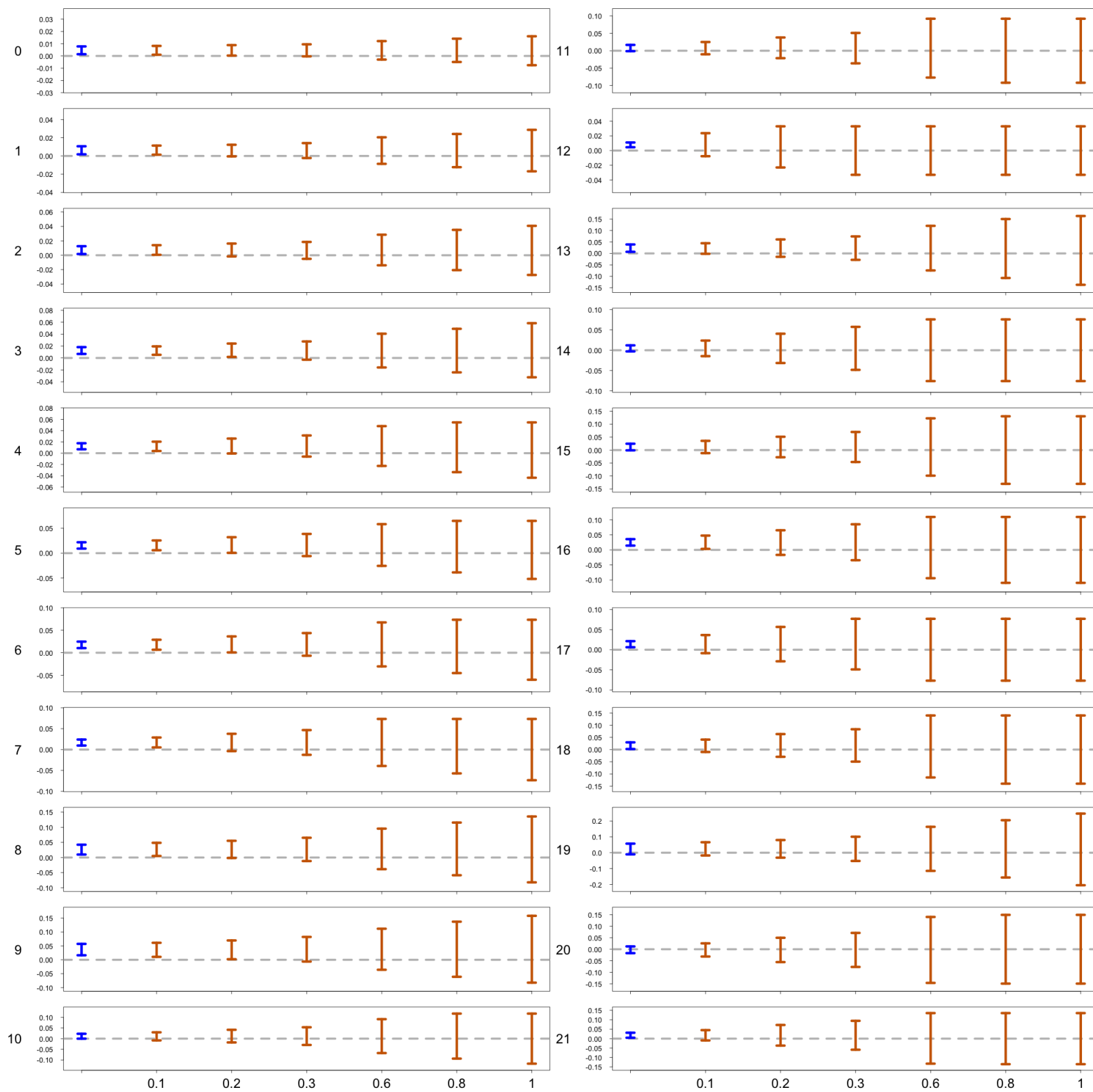


Figure D.3.10: 95% confidence intervals (CIs) following Rambachan and Roth (2023) for the effect of IBLI on mean enhanced vegetation index (EVI) in all rangelands at the HUC-12 level and exposure to ≥ 500 cumulative IDW TLUs insured. The y-axis captures post-treatment event time period CIs (periods 0 to 21). Blue CIs are original and orange CIs vary based on the proportion (x-axis) of the maximum M pre-treatment violation of parallel trends that is applied to bound maximum potential post-treatment violations of parallel trends between consecutive time periods.

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