

Isoscapes of remnant and restored Hawaiian montane forests reveal differences in biological nitrogen fixation and carbon inputs

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Supporting Information

Supplemental figures

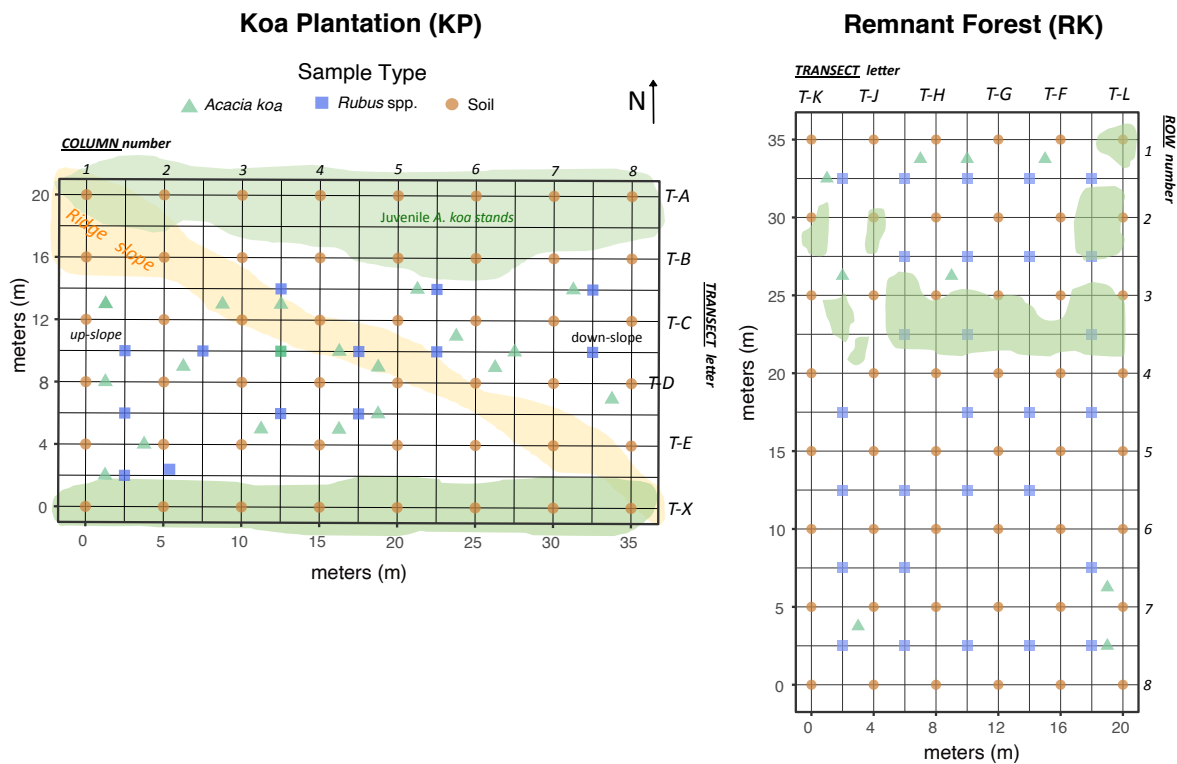


Figure S1. Forest plots (20 × 35 m) in the koa plantation (KP) and the remnant forest (RK) showing locations of sample collection (*Acacia koa* and *Rubus* spp. leaves, soil samples), slopes within the Koa Plantation, and patches of juvenile *A. koa* where samples were not collected.

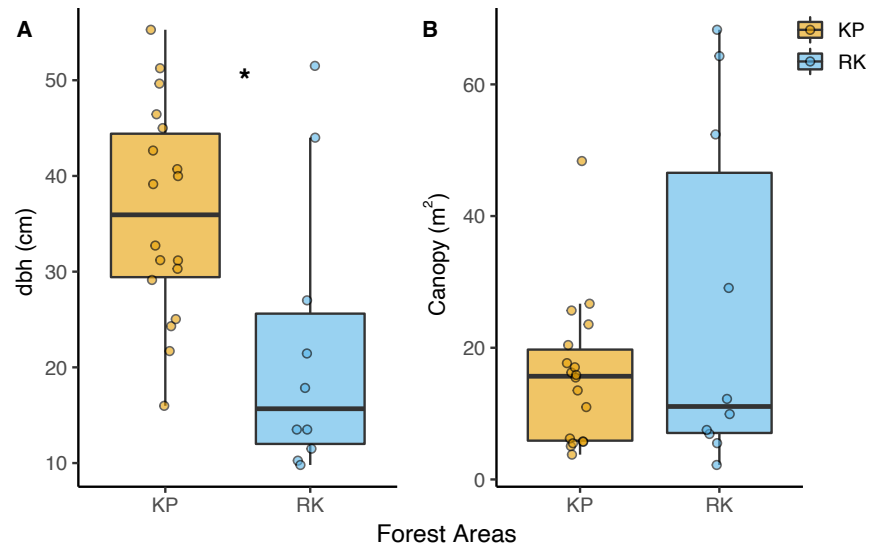


Figure S2. (A) Box plots of *Acacia koa* tree diameter at breast height (dbh), and (B) *Acacia koa* tree canopy area (m²) in the koa plantation (KP) and remnant (RK) Hakalau forest areas ($n = 18$ [KP] and 10 [RK]). Asterisks indicate significant plot effects ($p < 0.05$).

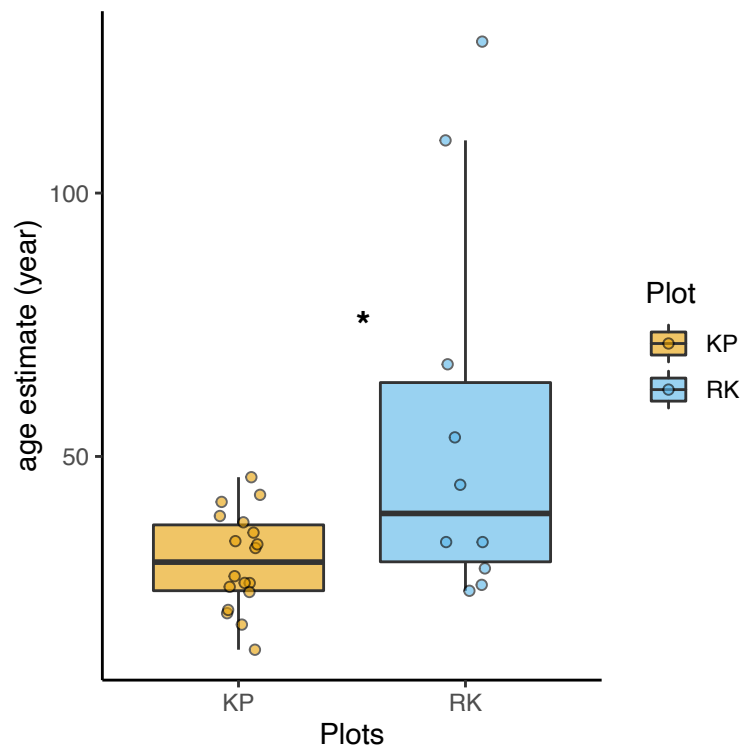


Figure S3. Box plot estimates of *Acacia koa* age in the koa plantation (KP) and remnant forest (RK) using diameter at breast height-based growth rates of 12 mm (KP) and 4 mm per year (RK). Asterisks indicate significant plot effects ($p < 0.05$).

Table S1. Nonparametric tests of forest type (koa plantation vs. remnant forest) effects on *Acacia koa* diameter at breast height, *A. koa* forest canopy area, and *A. koa* age estimates. Forest type effects on the distribution of interpolated values in nitrogen and carbon isoscapes generated from soil or foliar samples.

<i>Variable</i>	<i>Effect</i>	<i>U</i>	<i>Z</i>	<i>Effect-size r</i>	<i>p-value</i>
Diameter at breast height (dbh, cm)	Forest type	315	2.589	0.489	0.010
Canopy area (m ²)	Forest type	252	-0.432	0.082	0.666
dbh-estimated age (years)	Forest type	220	-1.966	0.372	0.049
Isoscape: soil					
$\delta^{15}\text{N}$	Forest type	4.743×10^8	-66.868	0.281	<0.001
$\delta^{13}\text{C}$	Forest type	8.194×10^8	116.006	0.487	<0.001
Isoscape: foliar					
$\delta^{15}\text{N}$	Forest type	1.429×10^8	-129.769	0.637	<0.001

U = U-statistic; *Z* = Z-value. Significant effects ($p < 0.05$) are in bold.

Table S2. Linear models testing the effects of forest (remnant forest vs. koa plantation) and sample types (*Acacia koa* leaves, *Rubus* spp. leaves, soil) on response variables.

<i>Variable</i>	<i>Effect</i>	<i>SS</i>	<i>df</i>	<i>F</i>	<i>p-value</i>
$\delta^{15}\text{N}$	Sample type	670.48	2	336.862	<0.001
	Forest type	14.07	1	14.138	<0.001
	Sample \times Forest	3.64	2	1.828	0.164
	Residuals	159.23	160		
$\delta^{13}\text{C}$	Sample type	1075.09	2	635.030	<0.001
	Forest type	56.56	1	66.823	<0.001
	Sample \times Forest	2.24	2	1.322	0.269
	Residuals	135.44	160		
Total nitrogen (mmol/gdw)	Sample type	17.544	2	139.520	<0.001
	Forest type	0.165	1	2.621	0.107
	Sample \times Forest	0.188	2	1.492	0.228
	Residuals	10.060	160		
Total carbon (mmol/gdw)	Sample type	16428.6	2	763.903	<0.001
	Forest type	98.6	1	9.166	0.003
	Sample \times Forest	17.2	2	0.801	0.451
	Residuals	1720.5	160		
C:N	Sample type	929.10	2	107.344	<0.001
	Forest type	1.06	1	0.245	0.621
	Sample \times Forest	8.84	2	1.022	0.362
	Residuals	692.43	160		

SS = sum of squares; *df* = degrees of freedom. Significant effects ($p < 0.05$) are in bold.

Table S3. Model parameters used to perform automatic kriging and generation of variograms for spatial interpolation in the koa plantation (KP) and remnant forest (RK).

<i>isoscape</i>	<i>metric</i>	<i>site</i>	<i>model</i>	<i>nugget</i>	<i>sill</i>	<i>range (m)</i>	<i>sserr</i>	<i>kappa</i>
soil	$\delta^{15}\text{N}$	KP	Matern	0.00	1.44	3.43	0.01	10.00
soil	$\delta^{15}\text{N}$	RK	exponential	0.00	1.00	3.00	0.14	–
soil	$\delta^{13}\text{C}$	KP	Matern	0.24	1.17	5.09	0.35	10.00
soil	$\delta^{13}\text{C}$	RK	exponential	0.00	0.80	3.00	0.12	–
foliar	$\delta^{15}\text{N}$	KP	exponential	0.20	0.40	3.00	0.12	–
foliar	$\delta^{15}\text{N}$	RK	exponential	0.01	0.82	5.00	0.17	–

isoscape = input sample type used in the spatial interpolation; *metric* = input data type used in isoscapes; *model* = best fit model iteratively selected using R package automap (Hiemstra et al. 2009); *nugget* = minimum semivariance; *sill* = maximum semivariance; *range* = maximum distance, in meters for the current study; *sserr* = sum of squares between sample and fitted variogram; *kappa* = smoothing parameter in Matern (Ste) model.