

Predict Mature Forest Biomass from Environmental Predictors

Ana Avila

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Optim

```
data <- read.csv("data/mature_biomass_climate_categ.csv")
# the data comes with yearly columns of seasonality and precipitation. Since for the
# mature forest prediction we only want yearly values, we will calculate the mean of each cl
patterns <- c("si_", "prec_")
means <- sapply(patterns, function(pat) rowMeans(data[, grep(pat, names(data))], na.rm = TRUE)
colnames(means) <- c("mean_si", "mean_prec")
data <- cbind(data, means)

# remove unnecessary columns
data <- data[, -grep("prec_|si_|biome|geo|system.index", names(data))]

# turn categorical variables into dummy variables
categorical <- c("ecoreg", "soil")
data[categorical] <- lapply(data[categorical], as.factor)
data <- createDummyFeatures(data, cols = categorical)
data <- data %>%
```

```

    rename(agbd = b1, cwd = b1_1)

# Normalize numeric columns (0-1)
# Store max and min values to transform back the predictions
min_agbd <- min(data$agbd, na.rm = TRUE)
max_agbd <- max(data$agbd, na.rm = TRUE)
# transform all numeric columns
numeric_cols <- c("mean_si", "mean_prec", "cwd", "agbd")
data[numeric_cols] <- lapply(data[numeric_cols], function(x) {
  (x - min(x, na.rm = TRUE)) / (max(x, na.rm = TRUE) - min(x, na.rm = TRUE))
})

pars_chosen <- c("cwd", "protec", "mean_si", "mean_prec", "indig")
pars <- setNames(rep(0.1, length(pars_chosen)), pars_chosen)

mat_biomass_function <- function(pars, data, pars_chosen) {
  pred_agbd <- data[[1]] * 0
  for (i in seq_along(pars_chosen)) {
    pred_agbd <- pred_agbd + pars[[pars_chosen[i]]] * data[[pars_chosen[i]]]
  }
  return(pred_agbd)
}

likelihood <- function(pars, data, pars_chosen) {
  return(sum((mat_biomass_function(pars, data, pars_chosen) - data$agbd)^2))
}

o <- optim(pars,
  likelihood,
  data = data,
  pars_chosen = pars_chosen
)
o$value

```

```
[1] 1035.765
```

```
o$par
```

```

      cwd      protec    mean_si mean_prec      indig
0.4724562 0.1190372 0.1376150 0.3019738 0.1052000

```

```
# Calculate R-squared
calc_r_squared <- function(observed, predicted) {
  mean_observed <- mean(observed, na.rm = TRUE)
  TSS <- sum((observed - mean_observed)^2, na.rm = TRUE)
  RSS <- sum((observed - predicted)^2, na.rm = TRUE)
  R_squared <- 1 - (RSS / TSS)
  return(R_squared)
}

calc_r_squared(data$agbd, mat_biomass_function(o$par, data, pars_chosen))
```

```
[1] 0.3006736
```

If, however, we run it with all parameters, we get a worse fit:

```
pars_chosen <- names(data)[!names(data) %in% "agbd"]
pars <- setNames(rep(0.1, length(pars_chosen)), pars_chosen)

o <- optim(pars,
  likelihood,
  data = data,
  pars_chosen = pars_chosen
)
o$value
```

```
[1] 2879.161
```

```
o$par
```

	cwd	indig	protec	mean_si	mean_prec	ecoreg.439	ecoreg.440
	0.11	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.441	ecoreg.442	ecoreg.443	ecoreg.444	ecoreg.445	ecoreg.446	ecoreg.447	
	0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.448	ecoreg.449	ecoreg.450	ecoreg.451	ecoreg.453	ecoreg.454	ecoreg.455	
	0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.456	ecoreg.457	ecoreg.458	ecoreg.459	ecoreg.460	ecoreg.461	ecoreg.462	
	0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.463	ecoreg.464	ecoreg.465	ecoreg.466	ecoreg.467	ecoreg.468	ecoreg.469	
	0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.470	ecoreg.471	ecoreg.472	ecoreg.473	ecoreg.474	ecoreg.475	ecoreg.476	

0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.477	ecoreg.478	ecoreg.479	ecoreg.480	ecoreg.481	ecoreg.482	ecoreg.483
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.484	ecoreg.485	ecoreg.486	ecoreg.487	ecoreg.488	ecoreg.489	ecoreg.490
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.491	ecoreg.492	ecoreg.493	ecoreg.494	ecoreg.495	ecoreg.496	ecoreg.497
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.498	ecoreg.499	ecoreg.500	ecoreg.501	ecoreg.502	ecoreg.503	ecoreg.504
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.505	ecoreg.506	ecoreg.507	ecoreg.508	ecoreg.509	ecoreg.510	ecoreg.511
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.512	ecoreg.513	ecoreg.514	ecoreg.515	ecoreg.516	ecoreg.517	ecoreg.518
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.519	ecoreg.520	ecoreg.521	ecoreg.522	ecoreg.523	ecoreg.524	ecoreg.525
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.526	ecoreg.527	ecoreg.528	ecoreg.529	ecoreg.530	ecoreg.531	ecoreg.532
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.533	ecoreg.534	ecoreg.535	ecoreg.536	ecoreg.537	ecoreg.538	ecoreg.539
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.540	ecoreg.541	ecoreg.542	ecoreg.543	ecoreg.544	ecoreg.545	ecoreg.546
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.547	ecoreg.548	ecoreg.549	ecoreg.550	ecoreg.551	ecoreg.552	ecoreg.553
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.554	ecoreg.555	ecoreg.556	ecoreg.557	ecoreg.558	ecoreg.559	ecoreg.560
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.561	ecoreg.562	ecoreg.563	ecoreg.564	ecoreg.565	ecoreg.566	ecoreg.567
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.568	ecoreg.569	ecoreg.570	ecoreg.571	ecoreg.572	ecoreg.574	ecoreg.575
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.577	ecoreg.578	ecoreg.579	ecoreg.580	ecoreg.581	ecoreg.582	ecoreg.583
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.584	ecoreg.585	ecoreg.587	ecoreg.588	ecoreg.589	ecoreg.591	ecoreg.593
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.597	ecoreg.600	ecoreg.602	ecoreg.605	ecoreg.606	ecoreg.608	ecoreg.609
0.10	0.10	0.10	0.10	0.10	0.10	0.10
ecoreg.610	ecoreg.611	ecoreg.616	soil.2	soil.3	soil.4	soil.5
0.10	0.10	0.10	0.10	0.10	0.10	0.10
soil.6	soil.7	soil.8	soil.9	soil.10	soil.11	soil.12
0.10	0.10	0.10	0.10	0.10	0.10	0.10
soil.13	soil.14	soil.15	soil.16	soil.17	soil.18	soil.19
0.10	0.10	0.10	0.10	0.10	0.10	0.10
soil.20	soil.21	soil.22	soil.23	soil.24	soil.25	soil.26
0.10	0.10	0.10	0.10	0.10	0.10	0.10

soil.27	soil.28	soil.29	soil.30	soil.31	soil.32	soil.33
0.10	0.10	0.10	0.10	0.10	0.10	0.10
soil.34						
0.10						

GAM

```
pars_categ <- names(data)[!names(data) %in% numeric_cols]

# Fit a GAM model
# Construct the formula dynamically
formula <- as.formula(paste("agbd ~ s(cwd) + s(mean_si) + s(mean_prec) +", paste(pars_categ,

# Fit the GAM model with the dynamically created formula
gam_model <- gam(formula, data = data)
summary(gam_model)
```

Family: gaussian

Link function: identity

Formula:

```
agbd ~ s(cwd) + s(mean_si) + s(mean_prec) + indig + protec +
  ecoreg.439 + ecoreg.440 + ecoreg.441 + ecoreg.442 + ecoreg.443 +
  ecoreg.444 + ecoreg.445 + ecoreg.446 + ecoreg.447 + ecoreg.448 +
  ecoreg.449 + ecoreg.450 + ecoreg.451 + ecoreg.453 + ecoreg.454 +
  ecoreg.455 + ecoreg.456 + ecoreg.457 + ecoreg.458 + ecoreg.459 +
  ecoreg.460 + ecoreg.461 + ecoreg.462 + ecoreg.463 + ecoreg.464 +
  ecoreg.465 + ecoreg.466 + ecoreg.467 + ecoreg.468 + ecoreg.469 +
  ecoreg.470 + ecoreg.471 + ecoreg.472 + ecoreg.473 + ecoreg.474 +
  ecoreg.475 + ecoreg.476 + ecoreg.477 + ecoreg.478 + ecoreg.479 +
  ecoreg.480 + ecoreg.481 + ecoreg.482 + ecoreg.483 + ecoreg.484 +
  ecoreg.485 + ecoreg.486 + ecoreg.487 + ecoreg.488 + ecoreg.489 +
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  ecoreg.500 + ecoreg.501 + ecoreg.502 + ecoreg.503 + ecoreg.504 +
  ecoreg.505 + ecoreg.506 + ecoreg.507 + ecoreg.508 + ecoreg.509 +
  ecoreg.510 + ecoreg.511 + ecoreg.512 + ecoreg.513 + ecoreg.514 +
  ecoreg.515 + ecoreg.516 + ecoreg.517 + ecoreg.518 + ecoreg.519 +
  ecoreg.520 + ecoreg.521 + ecoreg.522 + ecoreg.523 + ecoreg.524 +
```

ecoreg.525 + ecoreg.526 + ecoreg.527 + ecoreg.528 + ecoreg.529 +
 ecoreg.530 + ecoreg.531 + ecoreg.532 + ecoreg.533 + ecoreg.534 +
 ecoreg.535 + ecoreg.536 + ecoreg.537 + ecoreg.538 + ecoreg.539 +
 ecoreg.540 + ecoreg.541 + ecoreg.542 + ecoreg.543 + ecoreg.544 +
 ecoreg.545 + ecoreg.546 + ecoreg.547 + ecoreg.548 + ecoreg.549 +
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 ecoreg.570 + ecoreg.571 + ecoreg.572 + ecoreg.574 + ecoreg.575 +
 ecoreg.577 + ecoreg.578 + ecoreg.579 + ecoreg.580 + ecoreg.581 +
 ecoreg.582 + ecoreg.583 + ecoreg.584 + ecoreg.585 + ecoreg.587 +
 ecoreg.588 + ecoreg.589 + ecoreg.591 + ecoreg.593 + ecoreg.597 +
 ecoreg.600 + ecoreg.602 + ecoreg.605 + ecoreg.606 + ecoreg.608 +
 ecoreg.609 + ecoreg.610 + ecoreg.611 + ecoreg.616 + soil.2 +
 soil.3 + soil.4 + soil.5 + soil.6 + soil.7 + soil.8 + soil.9 +
 soil.10 + soil.11 + soil.12 + soil.13 + soil.14 + soil.15 +
 soil.16 + soil.17 + soil.18 + soil.19 + soil.20 + soil.21 +
 soil.22 + soil.23 + soil.24 + soil.25 + soil.26 + soil.27 +
 soil.28 + soil.29 + soil.30 + soil.31 + soil.32 + soil.33 +
 soil.34

Parametric coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.4307997	0.0063254	68.106	< 2e-16 ***
indig	0.0777038	0.0016692	46.552	< 2e-16 ***
protec	0.0634781	0.0017043	37.247	< 2e-16 ***
ecoreg.439	-0.0742534	0.0118441	-6.269	3.67e-10 ***
ecoreg.440	-0.0665299	0.0089177	-7.460	8.82e-14 ***
ecoreg.441	0.0335574	0.0353750	0.949	0.342822
ecoreg.442	-0.0060503	0.0100755	-0.600	0.548177
ecoreg.443	-0.0120278	0.0118465	-1.015	0.309967
ecoreg.444	-0.0177077	0.0891683	-0.199	0.842587
ecoreg.445	-0.0780848	0.0404046	-1.933	0.053297 .
ecoreg.446	0.1397366	0.0135887	10.283	< 2e-16 ***
ecoreg.447	0.0665990	0.0383025	1.739	0.082085 .
ecoreg.448	-0.0736584	0.0891111	-0.827	0.408475
ecoreg.449	0.1644319	0.0516851	3.181	0.001467 **
ecoreg.450	-0.0420301	0.0564334	-0.745	0.456414
ecoreg.451	0.0567971	0.0565842	1.004	0.315500
ecoreg.453	-0.0190900	0.0630847	-0.303	0.762190
ecoreg.454	0.0961750	0.0565284	1.701	0.088885 .
ecoreg.455	-0.0070661	0.0516361	-0.137	0.891155

ecoreg.456	0.0402188	0.0630755	0.638	0.523719	
ecoreg.457	0.0434391	0.0728165	0.597	0.550809	
ecoreg.458	0.0089493	0.0728619	0.123	0.902245	
ecoreg.459	-0.2539921	0.0890128	-2.853	0.004328	**
ecoreg.460	-0.0022460	0.0448580	-0.050	0.960068	
ecoreg.461	0.0606512	0.0565167	1.073	0.283209	
ecoreg.462	0.0905673	0.0565496	1.602	0.109263	
ecoreg.463	0.0619137	0.0631422	0.981	0.326825	
ecoreg.464	0.1561339	0.0105144	14.850	< 2e-16	***
ecoreg.465	0.2204134	0.0070029	31.474	< 2e-16	***
ecoreg.466	0.1020306	0.0068044	14.995	< 2e-16	***
ecoreg.467	0.0800077	0.0251343	3.183	0.001458	**
ecoreg.468	0.1284864	0.0318191	4.038	5.40e-05	***
ecoreg.469	0.1464230	0.0124861	11.727	< 2e-16	***
ecoreg.470	0.1198888	0.0209426	5.725	1.05e-08	***
ecoreg.471	0.1307861	0.0238346	5.487	4.11e-08	***
ecoreg.472	0.1533022	0.0285154	5.376	7.66e-08	***
ecoreg.473	0.0951876	0.0060754	15.668	< 2e-16	***
ecoreg.474	0.2137846	0.0058376	36.622	< 2e-16	***
ecoreg.475	0.1684999	0.0144482	11.662	< 2e-16	***
ecoreg.476	0.1571182	0.0052048	30.187	< 2e-16	***
ecoreg.477	0.0937981	0.0112265	8.355	< 2e-16	***
ecoreg.478	0.0721093	0.0123084	5.859	4.71e-09	***
ecoreg.479	0.1178488	0.0128203	9.192	< 2e-16	***
ecoreg.480	0.0161841	0.0081351	1.989	0.046664	*
ecoreg.481	0.0530817	0.0057474	9.236	< 2e-16	***
ecoreg.482	0.0748011	0.0089274	8.379	< 2e-16	***
ecoreg.483	0.0612014	0.0138348	4.424	9.73e-06	***
ecoreg.484	0.0626258	0.0081804	7.656	1.97e-14	***
ecoreg.485	0.0680732	0.0137465	4.952	7.38e-07	***
ecoreg.486	0.1050224	0.0149565	7.022	2.23e-12	***
ecoreg.487	0.0761704	0.0158723	4.799	1.60e-06	***
ecoreg.488	0.0489554	0.0160988	3.041	0.002360	**
ecoreg.489	0.1111797	0.0155622	7.144	9.23e-13	***
ecoreg.490	0.1040590	0.0129525	8.034	9.74e-16	***
ecoreg.491	0.0736794	0.0155788	4.729	2.26e-06	***
ecoreg.492	0.0847267	0.0146681	5.776	7.70e-09	***
ecoreg.493	0.1093376	0.0152914	7.150	8.83e-13	***
ecoreg.494	0.0870196	0.0149415	5.824	5.79e-09	***
ecoreg.495	0.1173265	0.0153133	7.662	1.88e-14	***
ecoreg.496	0.1294392	0.0068941	18.775	< 2e-16	***
ecoreg.497	0.1154154	0.0059640	19.352	< 2e-16	***
ecoreg.498	0.0388436	0.0086592	4.486	7.29e-06	***

ecoreg.499	0.1267296	0.0154781	8.188	2.75e-16	***
ecoreg.500	-0.0043770	0.0081843	-0.535	0.592786	
ecoreg.501	0.1205419	0.0166705	7.231	4.90e-13	***
ecoreg.502	0.1315553	0.0145519	9.040	< 2e-16	***
ecoreg.503	0.1876272	0.0090745	20.676	< 2e-16	***
ecoreg.504	0.1453671	0.0163164	8.909	< 2e-16	***
ecoreg.505	0.2619506	0.0055350	47.326	< 2e-16	***
ecoreg.506	0.0783523	0.0242180	3.235	0.001216	**
ecoreg.507	0.1695657	0.0055409	30.603	< 2e-16	***
ecoreg.508	0.0197813	0.0072234	2.738	0.006175	**
ecoreg.509	0.0136373	0.0223935	0.609	0.542537	
ecoreg.510	0.0423928	0.0193171	2.195	0.028201	*
ecoreg.511	0.1686353	0.0054435	30.979	< 2e-16	***
ecoreg.512	0.0254269	0.0272346	0.934	0.350503	
ecoreg.513	0.0502136	0.0339329	1.480	0.138939	
ecoreg.514	0.0148075	0.0299966	0.494	0.621564	
ecoreg.515	-0.0141300	0.0352255	-0.401	0.688327	
ecoreg.516	0.0146273	0.0285082	0.513	0.607891	
ecoreg.517	-0.0028529	0.0251248	-0.114	0.909597	
ecoreg.518	0.1492285	0.0063361	23.552	< 2e-16	***
ecoreg.519	0.0674992	0.0515404	1.310	0.190327	
ecoreg.520	-0.1188407	0.0515587	-2.305	0.021175	*
ecoreg.521	0.0488701	0.0734704	0.665	0.505948	
ecoreg.522	0.0018267	0.0480759	0.038	0.969692	
ecoreg.523	0.0972232	0.0563909	1.724	0.084700	.
ecoreg.524	0.0027131	0.0227712	0.119	0.905161	
ecoreg.525	-0.0095078	0.0178329	-0.533	0.593925	
ecoreg.526	0.0943004	0.0480201	1.964	0.049565	*
ecoreg.527	0.0548492	0.0630336	0.870	0.384220	
ecoreg.528	-0.0186671	0.0515514	-0.362	0.717274	
ecoreg.529	-0.0354355	0.0116181	-3.050	0.002290	**
ecoreg.530	0.0555296	0.0480348	1.156	0.247677	
ecoreg.531	-0.0931387	0.0891263	-1.045	0.296021	
ecoreg.532	0.0087250	0.0515721	0.169	0.865655	
ecoreg.533	0.0257686	0.0401060	0.643	0.520545	
ecoreg.534	-0.1004629	0.0630938	-1.592	0.111331	
ecoreg.535	0.0795471	0.0564604	1.409	0.158873	
ecoreg.536	0.0143299	0.0422354	0.339	0.734395	
ecoreg.537	0.1248870	0.0515502	2.423	0.015414	*
ecoreg.538	-0.1300764	0.0515509	-2.523	0.011632	*
ecoreg.539	-0.0184970	0.0401982	-0.460	0.645415	
ecoreg.540	0.0262030	0.0111400	2.352	0.018670	*
ecoreg.541	-0.2192766	0.0726704	-3.017	0.002551	**

ecoreg.542	-0.0096409	0.0447294	-0.216	0.829349	
ecoreg.543	-0.0261211	0.0477363	-0.547	0.584248	
ecoreg.544	0.0193718	0.0565382	0.343	0.731877	
ecoreg.545	-0.0892522	0.0630125	-1.416	0.156662	
ecoreg.546	-0.1949202	0.0515272	-3.783	0.000155	***
ecoreg.547	-0.1471373	0.0629834	-2.336	0.019490	*
ecoreg.548	-0.0406402	0.0732489	-0.555	0.579020	
ecoreg.549	-0.0469167	0.0421834	-1.112	0.266056	
ecoreg.550	0.1041851	0.0727180	1.433	0.151945	
ecoreg.551	-0.0382511	0.0515590	-0.742	0.458159	
ecoreg.552	0.0382207	0.0447048	0.855	0.392580	
ecoreg.553	0.0161438	0.0516099	0.313	0.754432	
ecoreg.554	0.0426617	0.0477321	0.894	0.371449	
ecoreg.555	-0.0292415	0.0421652	-0.693	0.488002	
ecoreg.556	-0.1081452	0.0515082	-2.100	0.035774	*
ecoreg.557	-0.1427208	0.0446881	-3.194	0.001406	**
ecoreg.558	-0.0437645	0.0516219	-0.848	0.396562	
ecoreg.559	-0.1457752	0.0516140	-2.824	0.004741	**
ecoreg.560	0.0225915	0.0447505	0.505	0.613680	
ecoreg.561	-0.0620270	0.0564184	-1.099	0.271596	
ecoreg.562	-0.2593282	0.0728415	-3.560	0.000371	***
ecoreg.563	-0.1023181	0.0564236	-1.813	0.069780	.
ecoreg.564	-0.0295571	0.0447526	-0.660	0.508966	
ecoreg.565	-0.0546933	0.0400779	-1.365	0.172364	
ecoreg.566	-0.0543414	0.0300938	-1.806	0.070969	.
ecoreg.567	-0.0453490	0.0071733	-6.322	2.61e-10	***
ecoreg.568	-0.0300690	0.0477951	-0.629	0.529272	
ecoreg.569	-0.0896340	0.0727165	-1.233	0.217715	
ecoreg.570	-0.0094037	0.0114981	-0.818	0.413453	
ecoreg.571	-0.1424411	0.0597711	-2.383	0.017172	*
ecoreg.572	-0.0205766	0.1260854	-0.163	0.870365	
ecoreg.574	-0.1252577	0.0303167	-4.132	3.61e-05	***
ecoreg.575	-0.0776654	0.0733224	-1.059	0.289501	
ecoreg.577	-0.1869087	0.1256886	-1.487	0.137003	
ecoreg.578	-0.1865966	0.0729277	-2.559	0.010512	*
ecoreg.579	-0.2259895	0.0631630	-3.578	0.000347	***
ecoreg.580	-0.2176242	0.1260839	-1.726	0.084351	.
ecoreg.581	-0.0727554	0.0729057	-0.998	0.318316	
ecoreg.582	-0.2465381	0.0893163	-2.760	0.005778	**
ecoreg.583	-0.1328021	0.0728147	-1.824	0.068185	.
ecoreg.584	-0.1116494	0.0182958	-6.102	1.06e-09	***
ecoreg.585	0.0649584	0.1259325	0.516	0.605984	
ecoreg.587	0.0189281	0.1261473	0.150	0.880728	

ecoreg.588	-0.0970350	0.1261976	-0.769	0.441950	
ecoreg.589	-0.1644150	0.0630084	-2.609	0.009074	**
ecoreg.591	-0.2332488	0.1257239	-1.855	0.063570	.
ecoreg.593	-0.2862042	0.1261224	-2.269	0.023259	*
ecoreg.597	-0.0881532	0.0727399	-1.212	0.225560	
ecoreg.600	-0.0383061	0.1264821	-0.303	0.762000	
ecoreg.602	-0.0804968	0.0728561	-1.105	0.269222	
ecoreg.605	-0.0659336	0.1263082	-0.522	0.601670	
ecoreg.606	-0.1053543	0.1263577	-0.834	0.404412	
ecoreg.608	-0.1131677	0.1262052	-0.897	0.369887	
ecoreg.609	-0.0928699	0.1264940	-0.734	0.462841	
ecoreg.610	-0.0609596	0.1262358	-0.483	0.629168	
ecoreg.611	-0.1272270	0.0358582	-3.548	0.000389	***
ecoreg.616	-0.3575479	0.0727743	-4.913	9.00e-07	***
soil.2	0.0398724	0.0335072	1.190	0.234068	
soil.3	0.0228070	0.0111450	2.046	0.040725	*
soil.4	0.0347386	0.0270824	1.283	0.199607	
soil.5	0.0023037	0.0239902	0.096	0.923500	
soil.6	0.0282675	0.0294320	0.960	0.336843	
soil.7	-0.0081140	0.0059773	-1.357	0.174637	
soil.8	0.0005319	0.0071855	0.074	0.940994	
soil.9	0.0612607	0.0049341	12.416	< 2e-16	***
soil.10	-0.0229421	0.0058113	-3.948	7.90e-05	***
soil.11	-0.0397036	0.0082400	-4.818	1.45e-06	***
soil.12	-0.0464289	0.0086815	-5.348	8.95e-08	***
soil.13	-0.0381901	0.0093415	-4.088	4.36e-05	***
soil.14	0.0719378	0.0060794	11.833	< 2e-16	***
soil.15	-0.0070193	0.0109447	-0.641	0.521306	
soil.16	-0.0017451	0.0117173	-0.149	0.881606	
soil.17	0.0522283	0.0118363	4.413	1.02e-05	***
soil.18	0.0325326	0.0087058	3.737	0.000187	***
soil.19	0.0223433	0.0111731	2.000	0.045535	*
soil.20	0.0533981	0.0120316	4.438	9.10e-06	***
soil.21	0.0369457	0.0124186	2.975	0.002932	**
soil.22	0.0263679	0.0123091	2.142	0.032189	*
soil.23	0.0297592	0.0115380	2.579	0.009906	**
soil.24	0.0505442	0.0095710	5.281	1.29e-07	***
soil.25	0.0846911	0.0049655	17.056	< 2e-16	***
soil.26	0.0363679	0.0078025	4.661	3.16e-06	***
soil.27	0.0333454	0.0104879	3.179	0.001477	**
soil.28	0.0216095	0.0083169	2.598	0.009374	**
soil.29	0.0307940	0.0087434	3.522	0.000429	***
soil.30	0.0298338	0.0094316	3.163	0.001562	**

```

soil.31      0.0277788  0.0054332   5.113 3.19e-07 ***
soil.32      0.0641746  0.0062191  10.319 < 2e-16 ***
soil.33     -0.1461932  0.0928157   -1.575 0.115244
soil.34     -0.1532979  0.0912967   -1.679 0.093138 .
---

```

```

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Approximate significance of smooth terms:

```

              edf Ref.df      F p-value
s(cwd)         8.201  8.838 18.57 <2e-16 ***
s(mean_si)     8.948  8.998 96.28 <2e-16 ***
s(mean_prec)  8.698  8.975 54.34 <2e-16 ***
---

```

```

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Rank: 220/222

R-sq.(adj) = 0.62 Deviance explained = 62.3%

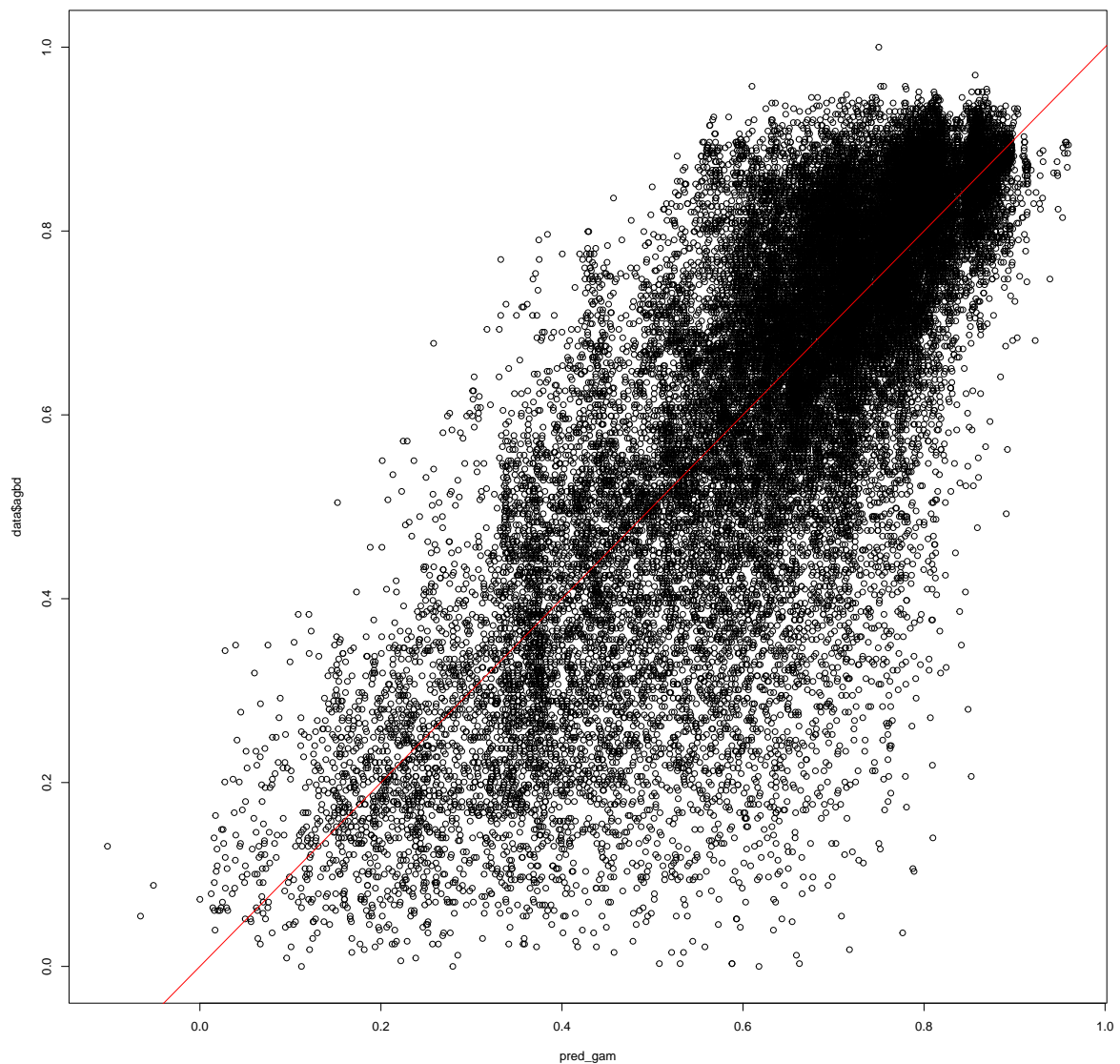
GCV = 0.016055 Scale est. = 0.015955 n = 35243

```

# Predict using the GAM model
pred_gam <- predict(gam_model, newdata = data)

# Plot predictions vs observed
plot(pred_gam, data$agbd)
abline(0, 1, col = "red")

```



Random Forest

```
# Split data into training and testing sets
set.seed(123)
train_indices <- sample(1:nrow(data), size = floor(0.7 * nrow(data)))
train_data <- data[train_indices, ]
```

```
test_data <- data[-train_indices, ]

# Fit a Random Forest model on the training data
rf_model <- randomForest(agbd ~ ., data = train_data, ntree = 500, mtry = sqrt(ncol(train_data)))

# Print model summary
print(rf_model)
```

Call:

```
randomForest(formula = agbd ~ ., data = train_data, ntree = 500, mtry = sqrt(ncol(train_data)))
Type of random forest: regression
Number of trees: 500
No. of variables tried at each split: 14
```

```
Mean of squared residuals: 0.01258224
% Var explained: 70.2
```

```
# Predict using the Random Forest model on the test data
pred_rf_test <- predict(rf_model, newdata = test_data)

calc_r_squared(test_data$agbd, pred_rf_test)
```

```
[1] 0.7056137
```

```
# Plot predictions vs observed for the test data
plot(pred_rf_test, test_data$agbd)
abline(0, 1, col = "red")
```

