easternwildturkeyForestHardDBH33.0cm model summary

Contents

Overview

This document summarizes the results of a global sensitivity and uncertainty analysis for the **easternwildturkeyForestHardDBH33.0cm** habitat suitability index (HSI) model for *Meleagris gallopavo sylvestris*. Metadata for the model is stored in the ecorest package in R.

The original documentation for this model can be found here[1].

Sub-model: **Forest and tree savanna cover (Deciduous Forested Wetland (DFW), Deciduous forest (DF), Evergeen Forest (EF), Evergreen Tree Savanna (ETS), and Deciduous Tree Savanna (DTS), hard mast producing trees with average DBH between 33.0cm and 35.6cm**

The easternwildturkeyForestHardDBH33.0cm model is comprised of **10** variables and **3** components.

Variables:

Table 1. SIV variables included in the easternwildturkeyForestHardDBH33.0cm model. Type indicates whether a variable is numeric or categorical and breakpoints indicates the number of distinct breakpoints in suitability graphs.

	Variable name	Type	Breakpoints
SIV1	herb.can.cov.SIV	numeric	5
SIV2	avg.h.herb.can.summer.SIV	numeric	5
SIV4	hard.mass.trees.SIV	numeric	3
SIV5	can.closure.soft.mass.SIV	numeric	3
SIV6	shrub.crown.cov.food.SIV	numeric	3
SIV7	shrub.crown.cov.behavior.SIV	numeric	4
SIV8	shrub.crown.cov.soft.mass.SIV	numeric	2
SIV11	tree.can.cov.SIV	numeric	4
SIV12	avg.dbh.overstory.trees.SIV	numeric	3
SIV13	evergreen.can.SIV	numeric	3

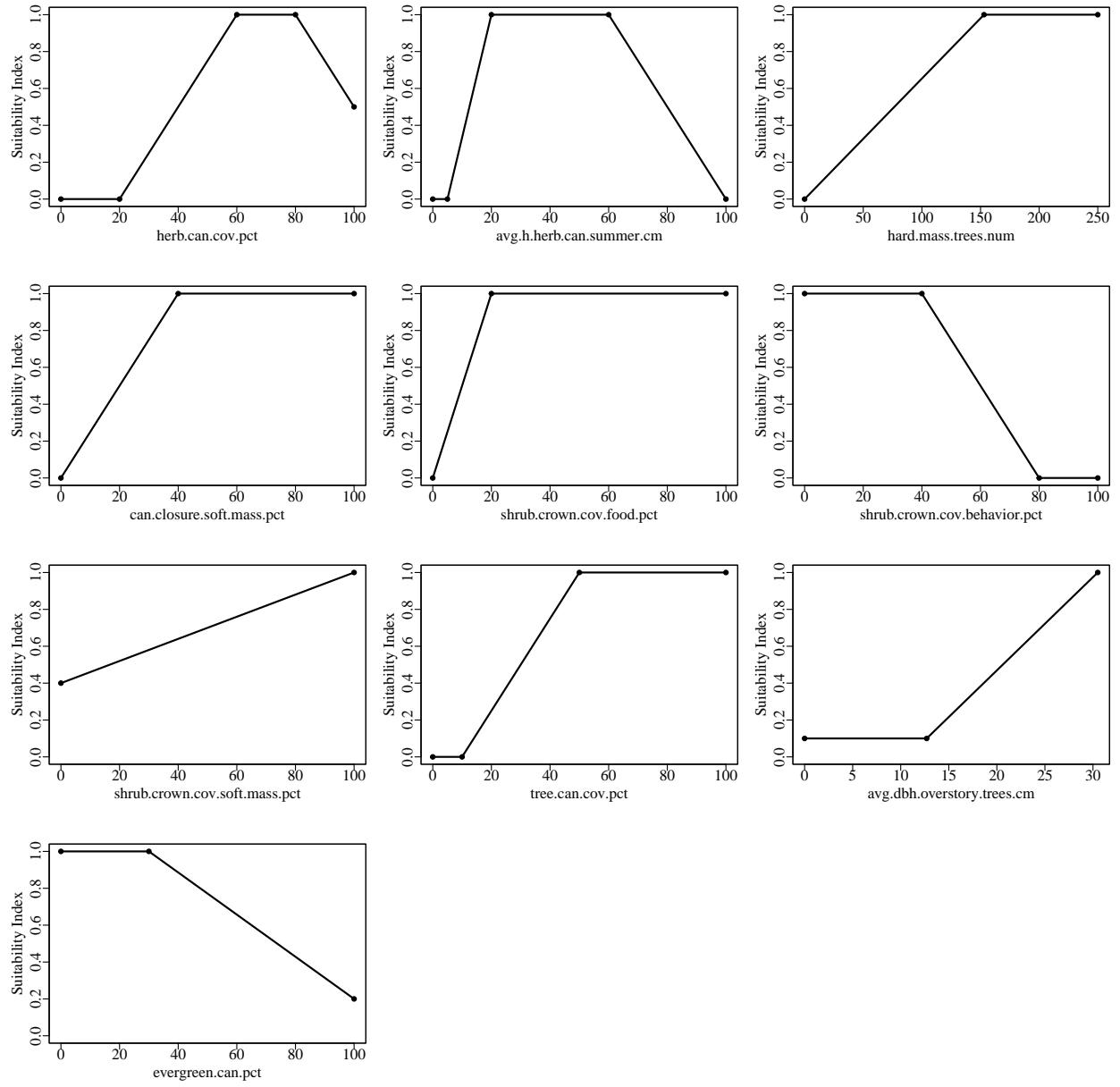[1]https://ecolibrary.sec.usace.army.mil/resource/721a717a-077e-49e9-9a5c-78ef818330b8

Figure 1. Suitability index graphs for variables included in the easternwildturkeyForestHardDBH33.0cm model in ecorest.

Components:

Table 2. Components included in the easternwildturkeyForestHardDBH33.0cm model in ecorest.

	Component	Equation
CC	Cover component	(SIV11*SIV12*SIV13)
CFBS	Summer food-brood component	(SIV1*SIV2)^(1/2)
CFSWF	Fall-spring-winter food component	ifelse((SIV4+SIV5)>1,((1+(SIV6*SIV8))/2)*SIV7, (((SIV4+SIV5)+(SIV6*SIV8))/2)*SIV7)

Model equation:

The equation to calculate an overall HSI index for the easternwildturkeyForestHardDBH33.0cm model is:

min(CFBS,CFSWF,CC)

According to our classification, this model's format is: **author-specified**

Global sensitivity and uncertainty analysis:

We ran global sensitivity and uncertainty analyses on the easternwildturkeyForestHardDBH33.0cm model using the sensobol package in R (Puy et al. 2022). The following parameters were used for the sensobol analysis:

Table 3. Parameters and settings used for sensobol sensitivity and uncertainty analyses.

Parameter	Equation	Value
Number of input variables (M)	-	10
Base sample size (n)	-	10000
Number of model evaluations (N)	n*(M+2)	120000
First order estimator	See Puy et al. (2022)	Saltelli
Total order estimator	See Puy et al. (2022)	Jansen
Number of bootstrap replications	-	1000
Sampling scheme	-	Quasi-random
Matrices	-	A, B, AB

We ran a sensitivity and uncertainty analysis for the easternwildturkeyForestHardDBH33.0cm model using the original equation outlined in the documentation from Schroeder (1985) and using arithmetic mean, geometric mean, limiting factor, and multiplicative equations to contrast the results across different equation structures.

Model uncertainty

We ran the easternwildturkeyForestHardDBH33.0cm model using 120000 combinations of its SIV variables, which were sampled from a uniform distribution spanning the range of possible values listed in the easternwildturkeyForestHardDBH33.0cm documentation. We limited the range of possible values for each parameter to the range in which the SIV values were greater than zero to prevent HSI score distributions with primarily zero values.
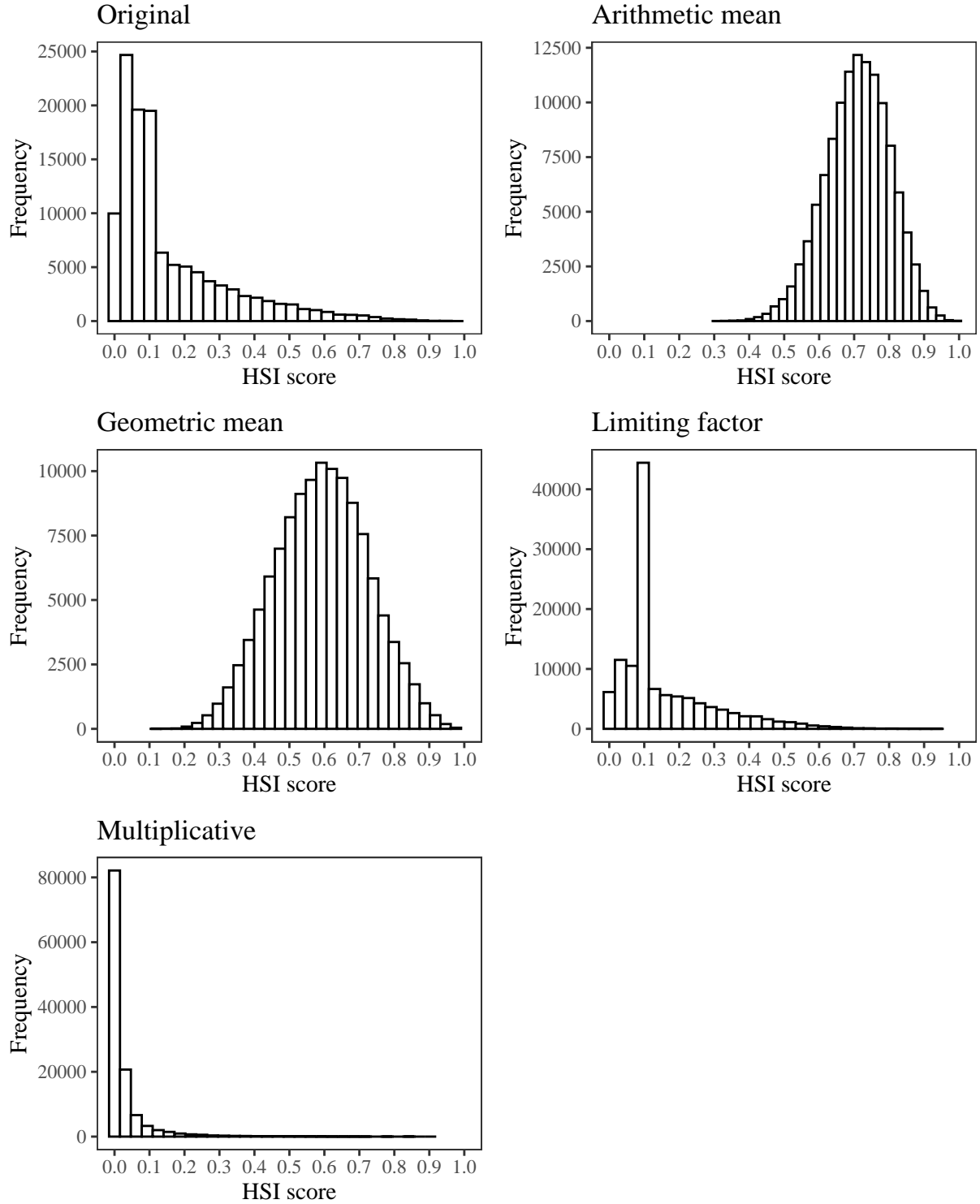
Figure 2. Empirical distributions of HSI scores for the easternwildturkeyForestHardDBH33.0cm model using the original author-specified model equation from Schroeder (1985), and an arithmetic mean, geometric mean, limiting factor, and multiplicative structure incorporating all SIV variables. Note differences in the y axis.

We assumed a uniform distribution for all parameters because we evaluated all ecorest models in batch. Should you decide to run your own sensitivity analysis, this assumption should be evaluated independently for each parameter in the model.

Table 4. Quantiles from the empirical distribution of HSI scores for the original easternwildturkey-ForestHardDBH33.0cm model structure, an arithmetic mean equation, a geometric mean equation, a limiting factor equation, and a multiplicative equation structure.

	1%	**2.5%**	**5%**	**25%**	**50%**	**75%**	**95%**	**97.5%**	**99%**	**100%**
Original	0.00	0.01	0.01	0.04	0.10	0.22	0.52	0.61	0.71	0.98
Arithmetic	0.48	0.52	0.55	0.65	0.71	0.78	0.86	0.88	0.91	0.99
Geometric	0.29	0.33	0.37	0.50	0.59	0.68	0.81	0.85	0.89	0.99
Limiting	0.00	0.01	0.02	0.09	0.10	0.21	0.45	0.52	0.60	0.94
Multiplicative	0.00	0.00	0.00	0.00	0.01	0.02	0.13	0.20	0.30	0.90

The empirical distribution of the original easternwildturkeyForestHardDBH33.0cm model has a coefficient of variation (CV) of **1.048**, while the arithmetic mean model has a CV of **0.13**, the geometric mean model has a CV of **0.225**, the limiting factor model has a CV of **0.85**, and the multiplicative model has a CV of **2.243**. Hence, the **Multiplicative** model is the most uncertain, while the **Arithmetic mean** model is the least uncertain.

Model sensitivity

Below are the results of the global sensitivity analysis for the easternwildturkeyForestHardDBH33.0cm model using the original equation, an arithmetic mean, a geometric mean, a limiting factor, and a multiplicative model structure. The sensobol package uses variance-based sensitivity metrics, so the model's sensitivity to a given parameter is a measure of how much variance in the HSI score decreases in response to that parameter being fixed (Puy et al. 2022). For each parameter, the observed changes in the variance of the HSI score can be described with a first order sensitivity index (S_i) that accounts for the influence of a single parameter of interest on variance in HSI, or with a total order index (T_i) that accounts for the influence of a single parameter on its own and in combination with all other parameters (*i.e.*, interactions) (Puy et al. 2022). We can compare the 95% confidence intervals for the first and total order indices to a dummy parameter, which represents a parameter that has no influence on the variance in a model's output. While an uninfluential variable should theoretically have an S_i and T_i of zero, small approximation errors can lead variables to have a non-zero influence on a model's output (Puy et al. 2022). If the confidence interval of the S_i and T_i index for a given parameter overlaps the confidence interval of the dummy parameter, we can deduce that the parameter has a negligible effect on variance in HSI scores, both on its own and in combination with all other variables.
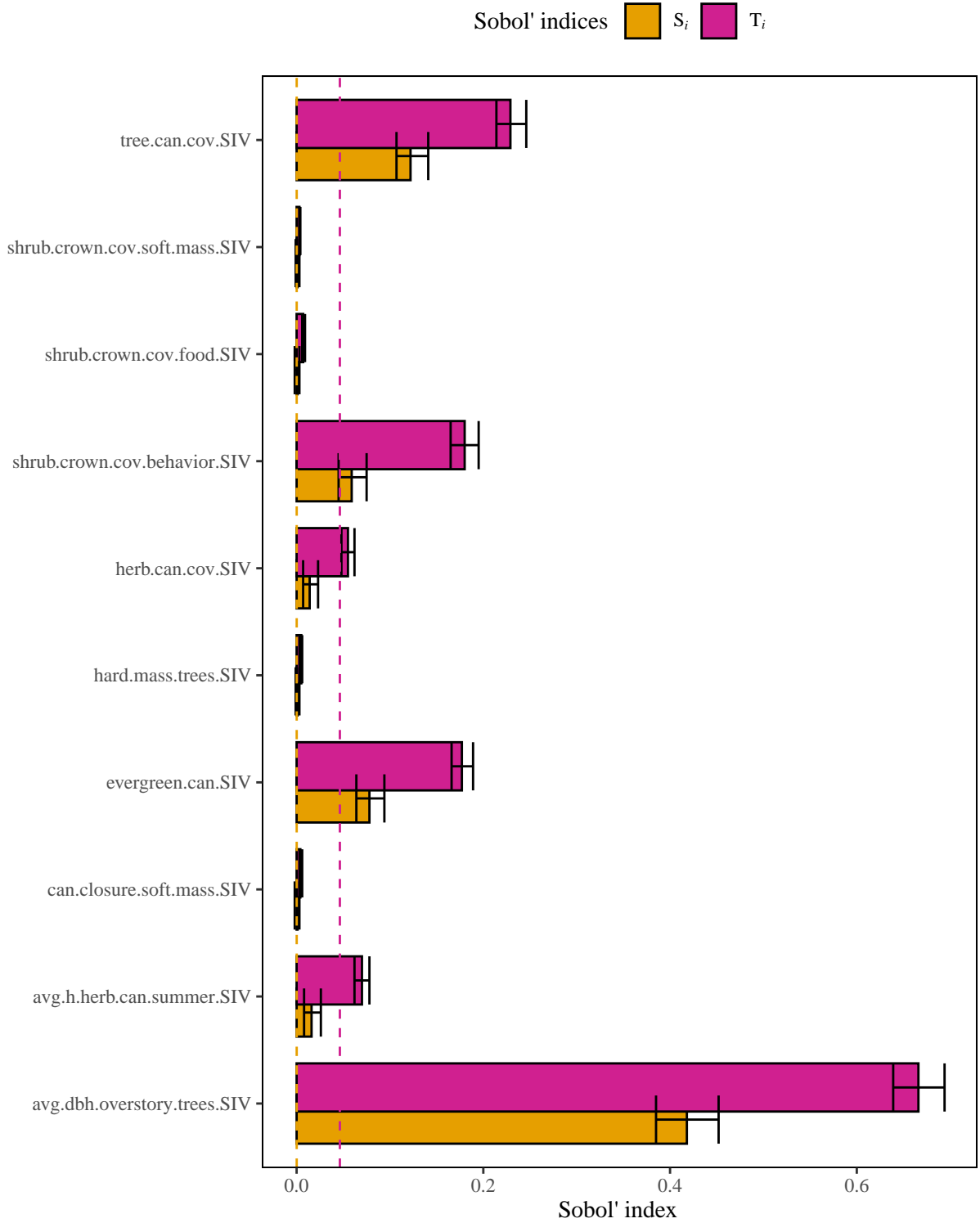
Original model

Figure 3. Results of a sensitivity analysis for the easternwildturkeyForestHardDBH33.0cm model based on the original author-specified model outlined in Schroeder (1985). Dashed lines represent baseline numerical approximation error for S_i and T_i (*i.e.*, dummy variables).
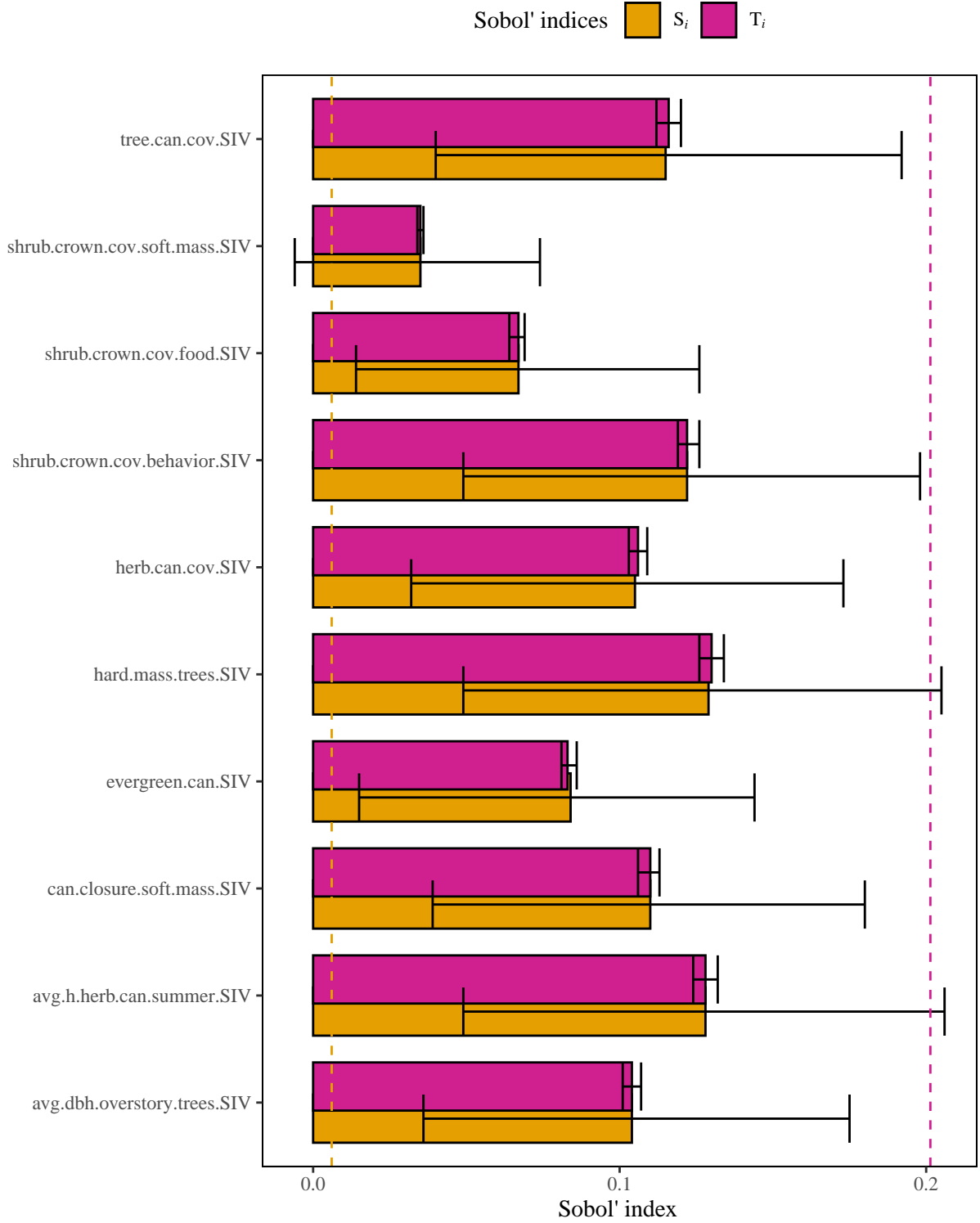
Arithmetic mean model

Figure 4. Results of a sensitivity analysis for the easternwildturkeyForestHardDBH33.0cm model based on an arithmetic mean structure. Dashed lines represent baseline numerical approximation error for S_i and T_i (*i.e.*, dummy variables).
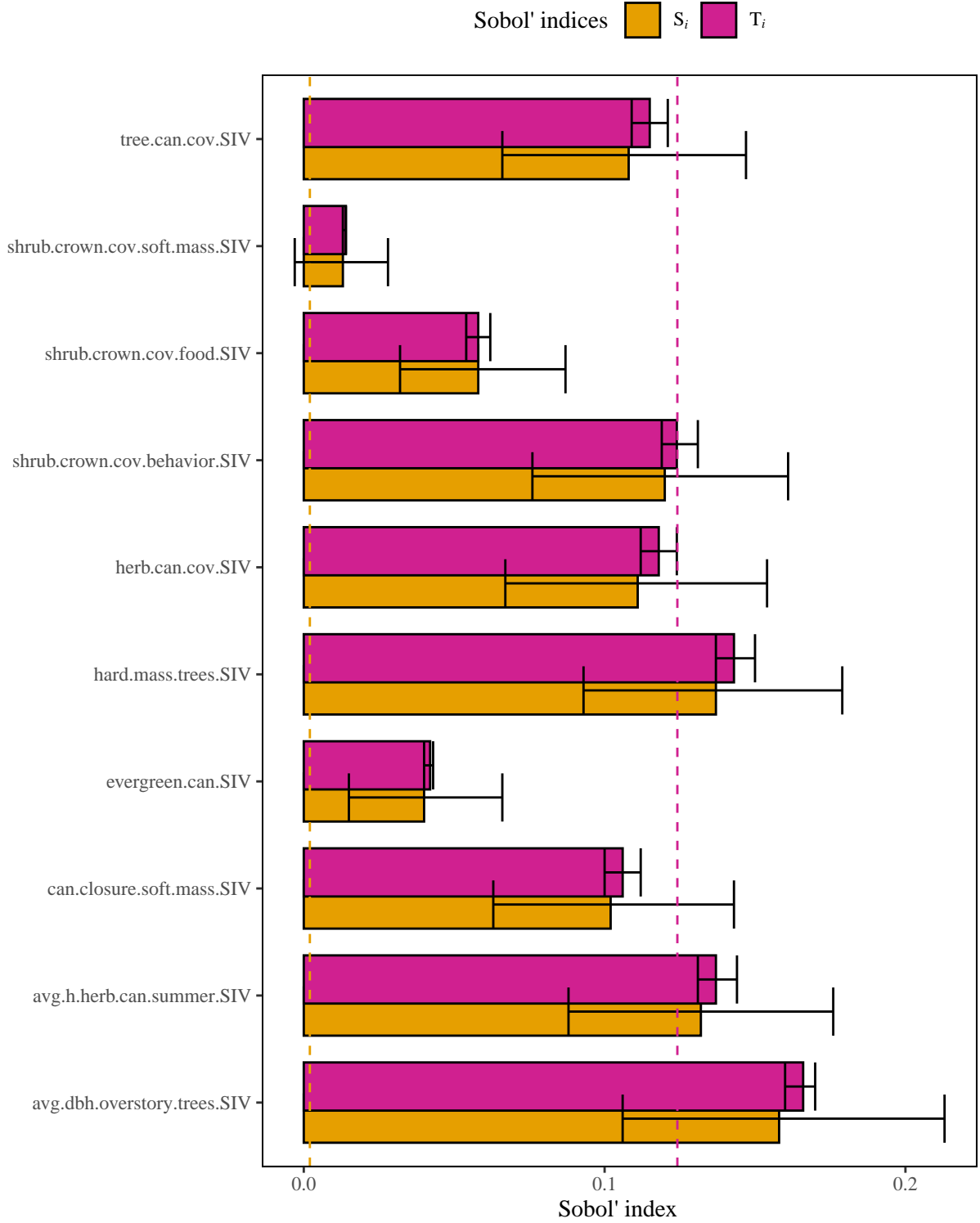
Geometric mean model

Figure 5. Results of a sensitivity analysis for the easternwildturkeyForestHardDBH33.0cm model based on a geometric mean structure. Dashed lines represent baseline numerical approximation error for S_i and T_i (*i.e.*, dummy variables).
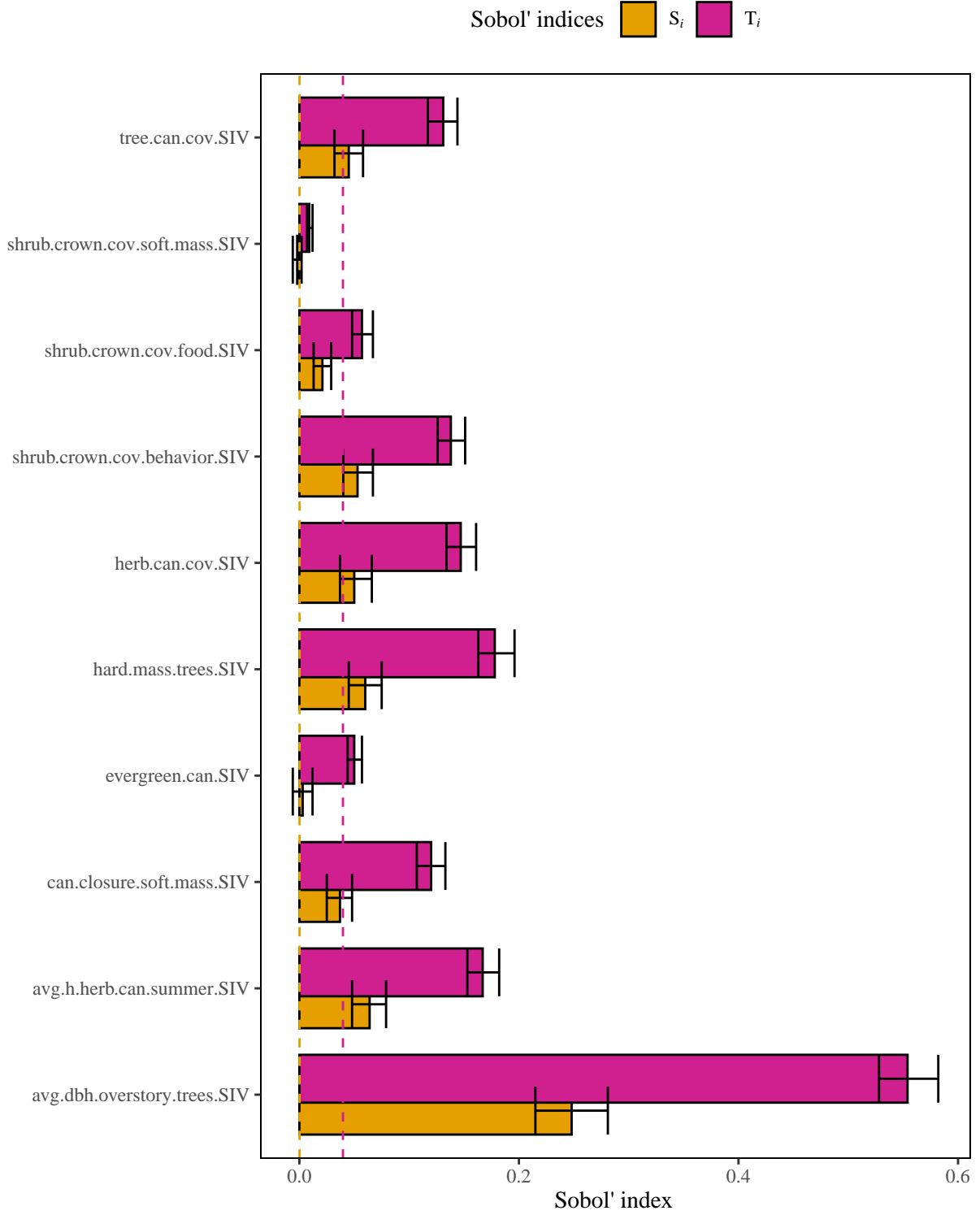
Limiting factor model

Figure 6. Results of a sensitivity analysis for the easternwildturkeyForestHardDBH33.0cm model based on a limiting factor structure. Dashed lines represent baseline numerical approximation error for S_i and T_i (*i.e.*, dummy variables).
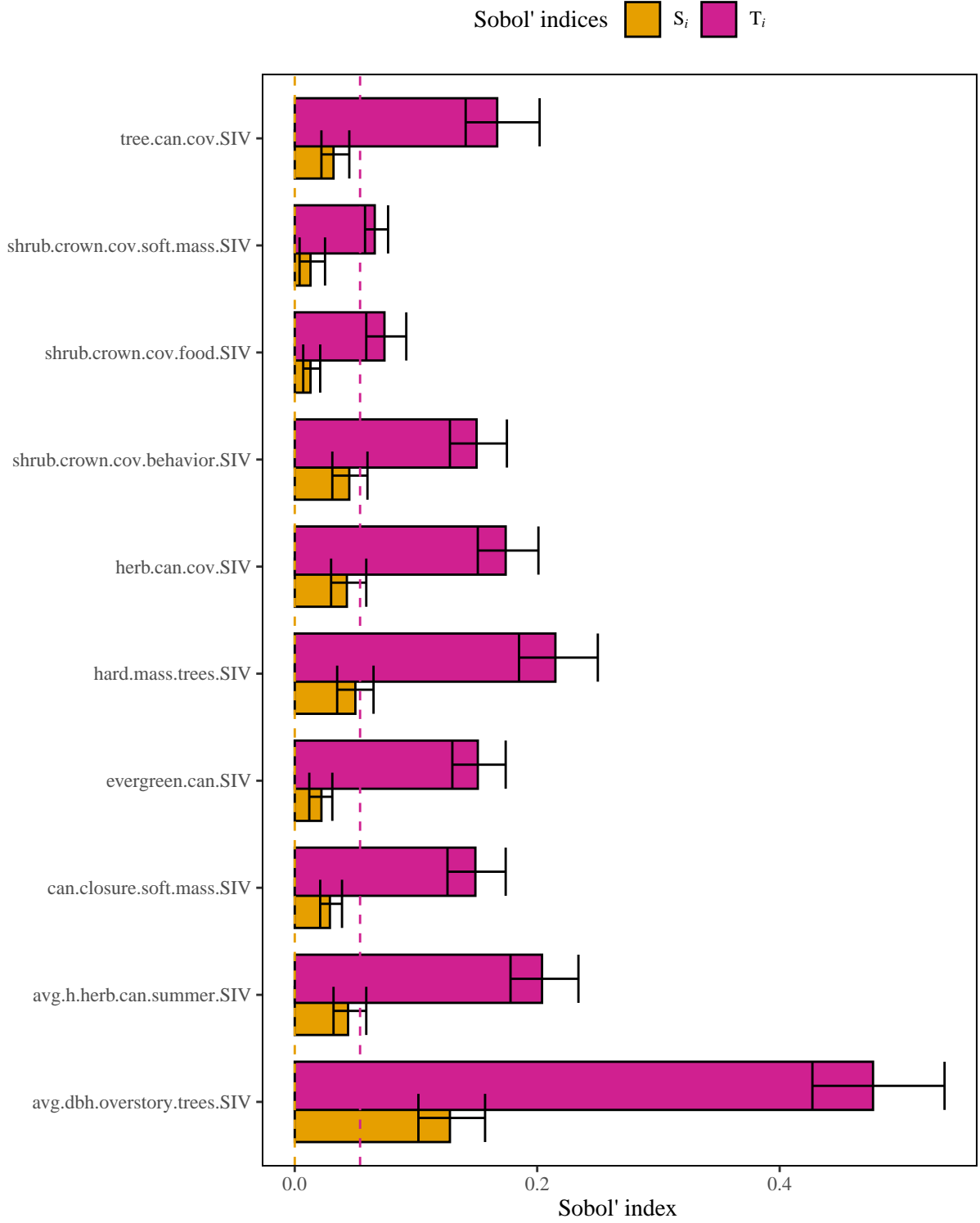
Multiplicative model

Figure 7. Results of a sensitivity analysis for the easternwildturkeyForestHardDBH33.0cm model based on a multiplicative mean structure. Dashed lines represent baseline numerical approximation error for S_i and T_i (*i.e.*, dummy variables).

Summary of influential variables

Original model In the **original easternwildturkeyForestHardDBH33.0cm** model, **6 of 10** variables are influential and **avg.dbh.overstory.trees.SIV** has the highest first order sensitivity. In addition, **avg.dbh.overstory.trees.SIV** has the highest total order sensitivity.

Un-influential variables in original model:

```
hard.mass.trees.SIV
can.closure.soft.mass.SIV
shrub.crown.cov.food.SIV
shrub.crown.cov.soft.mass.SIV
```

Arithmetic mean model In the **arithmetic mean easternwildturkeyForestHardDBH33.0cm** model, **9 of 10** variables are influential and **hard.mass.trees.SIV** has the highest first order sensitivity. In addition, **hard.mass.trees.SIV** has the highest total order sensitivity.

Un-influential variables in arithmetic mean model:

```
shrub.crown.cov.soft.mass.SIV
```

Geometric mean model In the **geometric mean easternwildturkeyForestHardDBH33.0cm** model, **9 of 10** variables are influential and **avg.dbh.overstory.trees.SIV** has the highest first order sensitivity. In addition, **avg.dbh.overstory.trees.SIV** has the highest total order sensitivity.

Un-influential variables in geometric mean model:

```
shrub.crown.cov.soft.mass.SIV
```

Limiting factor model In the **limiting factor easternwildturkeyForestHardDBH33.0cm** model, **9 of 10** variables are influential and **avg.dbh.overstory.trees.SIV** has the highest first order sensitivity. In addition, **avg.dbh.overstory.trees.SIV** has the highest total order sensitivity.

Un-influential variables in limiting factor mean model:

```
shrub.crown.cov.soft.mass.SIV
```

Multiplicative model In the **multiplicative mean easternwildturkeyForestHardDBH33.0cm** model, **10 of 10** variables are influential and **avg.dbh.overstory.trees.SIV** has the highest first order sensitivity. In addition, **avg.dbh.overstory.trees.SIV** has the highest total order sensitivity.

Un-influential variables in multiplicative model:

None

References

1. McKay S, D Hernandez-Abrams, and K Cushway. 2024. ecorest: conducts analyses informing ecosystem restoration decisions. R package version 2.0.0, https://CRAN.R-project.org/package=ecorest.
2. Puy, A, S Lo Piano, A Saltelli, and SA Levin. 2022. sensobol: an R package to compute variance based sensitivity indices. Journal of Statistical Software 102(5):1-37. doi: 10.18637/jss.v102.i05
3. Schroeder, RL. 1985. Habitat suitability index models: Eastern wild turkey. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.106). 33 pp.