

Package ‘crownmetrics’

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Title Tree Crown Shape and Morphometric Parameters

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Description Provides functions to compute tree crown volume and projected area using geometric solid approximations (ellipsoid, cone, cylinder, paraboloid, and fan shapes), and to calculate morphometric indices commonly used in forest inventory and silviculture, including crown ratio, crown form factor, slenderness, salience index, and scope index. Methods are based on peer-reviewed literature in forest science.

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crown_area	<i>Crown Profile Area by Shape</i>
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Description

A unified interface to the four lateral profile area functions. The shape is selected via the shape argument:

shape	Model	Formula
"ellipse"	Ellipse	$\pi * (CL/2)(CW/2)$
"triangle"	Triangle (cone)	$CW * CL / 2$
"rectangle"	Rectangle (cylinder)	$CW * CL$
"fan"	Fan / umbrella	$\pi * CL / 4$

Usage

```
crown_area(crown_width = NULL, crown_length, shape = "ellipse")
```

Arguments

crown_width	Numeric. Crown width (mean diameter) in meters . Not used for shape = "fan".
crown_length	Numeric. Crown length in meters .
shape	Character. One of "ellipse", "triangle", "rectangle", or "fan". Default: "ellipse".

Value

A numeric vector of crown profile areas in square meters (m²).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35.

See Also

[crown_area_ellipse\(\)](#), [crown_area_triangle\(\)](#), [crown_area_rectangle\(\)](#), [crown_area_fan\(\)](#), [crown_projection_area\(\)](#)

Examples

```
crown_area(crown_width = 3.0, crown_length = 4.5)
crown_area(crown_width = 2.0, crown_length = 5.0, shape = "triangle")
crown_area(crown_length = 4.0, shape = "fan")
```

crown_area_ellipse	<i>Crown Profile Area — Ellipse</i>
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Description

Estimates the **lateral profile area** of a crown approximated as an ellipse. This is the cross-sectional area seen from the side (not the horizontal projection).

$$A_{ellipse} = \pi \left(\frac{CL}{2} \right) \left(\frac{CW}{2} \right)$$

Usage

```
crown_area_ellipse(crown_width, crown_length)
```

Arguments

crown_width	Numeric. Crown width (mean diameter) in meters .
crown_length	Numeric. Crown length in meters .

Value

A numeric vector of crown profile areas in square meters (m²).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35.

Examples

```
crown_area_ellipse(crown_width = 3.0, crown_length = 4.5)
```

crown_area_fan *Crown Profile Area — Fan (Umbrella) Shape*

Description

Estimates the **lateral profile area** for a fan or umbrella-shaped crown. The formula is based on a quarter-circle sector approximation using the crown length as the characteristic dimension.

$$A_{fan} = \frac{\pi \cdot CL}{4}$$

Usage

crown_area_fan(crown_length)

Arguments

crown_length Numeric. Crown length in **meters**.

Value

A numeric vector of crown profile areas in square meters (m²).

References

Lanner, R. M. (1989). An observation on apical dominance and the umbrella-crown of Italian stone pine (*Pinus pinea*, Pinaceae). *Economic Botany*, 43(1), 128–130.

Examples

crown_area_fan(crown_length = 4.0)

crown_area_rectangle *Crown Profile Area — Rectangle (Cylinder)*

Description

Estimates the **lateral profile area** of a crown approximated as a rectangle, corresponding to a cylindrical crown shape.

$$A_{rectangle} = CW \cdot CL$$

Usage

crown_area_rectangle(crown_width, crown_length)

Arguments

crown_width Numeric. Crown width (mean diameter) in **meters**.
 crown_length Numeric. Crown length in **meters**.

Value

A numeric vector of crown profile areas in square meters (m²).

References

Hecht, R., Meinel, G., & Buchroithner, M. F. (2008). Estimation of urban green volume based on single-pulse LiDAR data. *IEEE Transactions on Geoscience and Remote Sensing*, 46(11), 3832–3840.

Examples

```
crown_area_rectangle(crown_width = 3.0, crown_length = 4.0)
```

crown_area_triangle *Crown Profile Area — Triangle (Cone)*

Description

Estimates the **lateral profile area** of a crown approximated as a triangle, corresponding to a conical crown shape.

$$A_{triangle} = \frac{CW \cdot CL}{2}$$

Usage

```
crown_area_triangle(crown_width, crown_length)
```

Arguments

crown_width Numeric. Crown width (mean diameter) in **meters**.
 crown_length Numeric. Crown length in **meters**.

Value

A numeric vector of crown profile areas in square meters (m²).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35.

Examples

```
crown_area_triangle(crown_width = 2.0, crown_length = 5.0)
```

crown_form	<i>Crown Form Factor</i>
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Description

Computes the crown form factor, defined as the ratio between crown width and crown length. Values close to 1 indicate a hemispherical crown; values > 1 indicate a wide, flat crown; values < 1 indicate a narrow, elongated crown.

$$CF = \frac{CW}{CL}$$

Usage

```
crown_form(crown_width, crown_length)
```

Arguments

crown_width Numeric. Crown width (mean diameter) in **meters**.
crown_length Numeric. Crown length in **meters**.

Value

A numeric vector of crown form factor values (dimensionless).

References

Durlo, M. A., & Denardi, L. (1998). Morfometria de *Cabralea canjerana*, em mata secundária nativa do Rio Grande do Sul. *Ciência Florestal*, 8(1), 55–66.

Examples

```
crown_form(crown_width = 3.0, crown_length = 4.5)
```

crown_metrics	<i>Compute All Crown Metrics for a Data Frame</i>
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Description

Applies all crownmetrics calculations to a data.frame or tibble in a single step, returning the original data with additional columns for crown volume, crown profile area, crown projection area, and all six morphometric indices. Internally uses `dplyr::mutate()` for a tidy workflow.

The crown shape is specified per-row via a character or integer column, allowing mixed-shape inventories. Accepted values:

Integer	Character	Geometric solid
0	"ellipsoid"	Ellipsoid (default)
1	"cone"	Cone
2	"cylinder"	Cylinder
3	"paraboloid"	Paraboloid
4	"fan"	Fan / umbrella

Usage

```
crown_metrics(  
  data,  
  col_crown_width = "crown_width",  
  col_crown_length = "crown_length",  
  col_total_height = "total_height",  
  col_dbh = "dbh",  
  col_shape = NULL,  
  as_percentage = FALSE  
)
```

Arguments

data	A data.frame or tibble containing at least the columns specified by the col_* arguments.
col_crown_width	Character. Name of the column with crown width (meters). Default: "crown_width".
col_crown_length	Character. Name of the column with crown length (meters). Default: "crown_length".
col_total_height	Character. Name of the column with total tree height (meters). Default: "total_height".
col_dbh	Character. Name of the column with DBH (centimeters). Default: "dbh".
col_shape	Character. Name of the column with crown shape codes (integer 0–4 or character; see table above). If NULL, all trees are treated as ellipsoid. Default: NULL.
as_percentage	Logical. If TRUE, crown ratio is returned as a percentage. Default: FALSE.

Value

The input data with the following columns appended:

crown_volume_m3 Crown volume (m³).
 crown_area_m2 Crown profile area (m²).
 crown_projection_area_m2 Horizontal crown projection area (m²).
 crown_ratio Crown ratio (CR).
 crown_form Crown form factor (CF).
 slenderness Slenderness index (SLI).
 salience_index Salience index (SAI).
 scope_index Scope index (SCI).
 vital_space_index Vital space index (VSI).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35.

Durlo, M. A., & Denardi, L. (1998). Morfometria de *Cabralea canjerana*, em mata secundária nativa do Rio Grande do Sul. *Ciência Florestal*, 8(1), 55–66.

Examples

```
trees <- data.frame(
  tree_id      = 1:4,
  crown_width  = c(3.0, 2.0, 3.5, 4.0),
  crown_length = c(4.5, 5.0, 4.0, 3.0),
  total_height = c(15, 18, 12, 10),
  dbh          = c(18.5, 15.0, 22.0, 25.0),
  shape_code   = c(0L, 1L, 2L, 3L)
)

crown_metrics(trees, col_shape = "shape_code")

# Without a shape column - all trees treated as ellipsoid
crown_metrics(trees)
```

crown_morphometrics *All Crown Morphometric Indices*

Description

Computes all five standard crown morphometric indices in a single call, returning a named list (for scalar inputs) or a tibble / data.frame (for vector inputs):

Symbol	Name	Formula
CR	Crown Ratio	CL / H
CF	Crown Form	CW / CL
SLI	Slenderness	$H / (DBH / 100)$
SAI	Salience Index	$CW / (DBH / 100)$
SCI	Scope Index	CW / H
VSI	Vital Space Index	$(CW/2)^2 / (DBH/200)^2$

Usage

```
crown_morphometrics(
  crown_width,
  crown_length,
  total_height,
  dbh,
  as_percentage = FALSE
)
```

Arguments

crown_width	Numeric. Crown width (mean diameter) in meters .
crown_length	Numeric. Crown length in meters .
total_height	Numeric. Total tree height in meters .
dbh	Numeric. Diameter at breast height in centimeters .
as_percentage	Logical. If TRUE, crown ratio (PC) is returned as a percentage (0–100 %). Default: FALSE.

Value

A `data.frame` with columns `crown_ratio` (CR), `crown_form` (CF), `slenderness` (SLI), `salience_index` (SAI), `scope_index` (SCI), and `vital_space_index` (VSI).

References

Durlo, M. A., & Denardi, L. (1998). Morfometria de *Cabralea canjerana*, em mata secundária nativa do Rio Grande do Sul. *Ciência Florestal*, 8(1), 55–66.

Burger, H. (1939). Baumkrone und Zuwachs in zwei hiebsreifen Fichtenbeständen. *Mitteilungen der Schweizerischen Anstalt für das Forstliche Versuchswesen*, 21, 147–176.

Examples

```
crown_morphometrics(
  crown_width = 3.5,
  crown_length = 4.5,
  total_height = 15.0,
  dbh = 18.5
)
```

```
# With a data frame
trees <- data.frame(
  cw = c(3.0, 3.5, 4.0),
  cl = c(4.0, 4.5, 5.0),
  h  = c(12, 15, 18),
  d  = c(15, 18, 22)
)
crown_morphometrics(trees$cw, trees$cl, trees$h, trees$d)
```

crown_projection_area *Crown Projection Area (Horizontal)*

Description

Computes the **crown projection area** (CPA) — the area of the crown's shadow on a horizontal plane, assuming a circular crown outline.

$$CPA = \pi \left(\frac{CW}{2} \right)^2$$

Usage

```
crown_projection_area(crown_width)
```

Arguments

crown_width Numeric. Crown width (mean diameter) in **meters**.

Value

A numeric vector of crown projection areas in square meters (m²).

References

Sayn-Wittgenstein, L., & Aldred, A. H. (1972). Tree size from large-scale photos. *Photogrammetric Engineering*, 38, 971–973.

Durlo, M. A., & Denardi, L. (1998). Morfometria de *Cabralea canjerana*, em mata secundária nativa do Rio Grande do Sul. *Ciência Florestal*, 8(1), 55–66.

Examples

```
crown_projection_area(crown_width = 3.5)

# Compare multiple trees
crown_projection_area(c(2.0, 3.0, 4.5))
```

crown_ratio

*Crown Ratio***Description**

Computes the crown ratio, defined as the ratio between crown length and total tree height. It represents the proportion of the tree height occupied by the living crown and is an indicator of crown vitality and light-use efficiency.

$$CR = \frac{CL}{H_{tot}}$$

Usage

```
crown_ratio(crown_length, total_height, as_percentage = FALSE)
```

Arguments

crown_length	Numeric. Crown length in meters — the vertical distance from the base of the live crown to the crown top.
total_height	Numeric. Total tree height in meters .
as_percentage	Logical. If TRUE, the result is multiplied by 100 and returned as a percentage (0–100 %). Default: FALSE.

Value

A numeric vector of crown ratio values (dimensionless, or % when as_percentage = TRUE).

References

Durlo, M. A., & Denardi, L. (1998). Morfometria de *Cabralea canjerana*, em mata secundária nativa do Rio Grande do Sul. *Ciência Florestal*, 8(1), 55–66.

Burger, H. (1939). Baumkrone und Zuwachs in zwei hiebsreifen Fichtenbeständen. *Mitteilungen der Schweizerischen Anstalt für das Forstliche Versuchswesen*, 21, 147–176.

Examples

```
crown_ratio(crown_length = 4.5, total_height = 15.0)
crown_ratio(crown_length = 4.5, total_height = 15.0, as_percentage = TRUE)

# Vectorised use
crown_ratio(crown_length = c(3, 4.5, 6), total_height = c(12, 15, 18))
```

crown_volume	<i>Crown Volume by Shape</i>
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Description

A unified interface to the five geometric solid volume functions. The crown shape is selected via the shape argument:

shape	Model	Typical species / use
"ellipsoid"	Ellipsoid (default)	Broadleaf, urban trees
"cone"	Cone	Conifers with pointed crowns
"cylinder"	Cylinder	Dense, columnar crowns
"paraboloid"	Paraboloid	Broadleaf trees
"fan"	Fan / umbrella	Flat-crowned species

Usage

```
crown_volume(crown_width = NULL, crown_length, dbh = NULL, shape = "ellipsoid")
```

Arguments

crown_width	Numeric. Crown width (mean diameter) in meters . Not used for shape = "fan".
crown_length	Numeric. Crown length in meters .
dbh	Numeric. Diameter at breast height in centimeters . Required only for shape = "fan".
shape	Character. One of "ellipsoid", "cone", "cylinder", "paraboloid", or "fan". Default: "ellipsoid".

Value

A numeric vector of crown volumes in cubic meters (m³).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35. [doi:10.1093/forestry/cpaa037](https://doi.org/10.1093/forestry/cpaa037)

See Also

```
crown_volume_ellipsoid(), crown_volume_cone(), crown_volume_cylinder(), crown_volume_paraboloid(), crown_volume_fan()
```

Examples

```
crown_volume(crown_width = 3.0, crown_length = 4.5)
crown_volume(crown_width = 2.0, crown_length = 5.0, shape = "cone")
crown_volume(crown_length = 4.0, dbh = 25.0, shape = "fan")

# Compare all shapes for the same tree
shapes <- c("ellipsoid", "cone", "cylinder", "paraboloid")
sapply(shapes, function(s) {
  crown_volume(crown_width = 3.0, crown_length = 4.5, shape = s)
})
```

crown_volume_cone	<i>Crown Volume — Cone</i>
-------------------	----------------------------

Description

Estimates crown volume by approximating the crown shape as a **cone**. Suitable for coniferous species with narrow, pointed crowns (e.g., *Pinus* spp., young *Picea* spp.).

$$V_{cone} = \frac{1}{3}\pi \left(\frac{CW}{2}\right)^2 CL$$

Usage

```
crown_volume_cone(crown_width, crown_length)
```

Arguments

crown_width Numeric. Crown width (mean diameter) in **meters**.
crown_length Numeric. Crown length in **meters**.

Value

A numeric vector of crown volumes in cubic meters (m³).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35. doi:10.1093/forestry/cpaa037

McPherson, E. G., & Rowntree, R. A. (1988). Geometric solids for simulation of tree crowns. *Landscape and Urban Planning*, 15(3–4), 79–83.

Examples

```
crown_volume_cone(crown_width = 2.0, crown_length = 5.0)
```

crown_volume_cylinder *Crown Volume — Cylinder*

Description

Estimates crown volume by approximating the crown shape as a **cylinder**. Represents trees with uniform crown width from base to top.

$$V_{cylinder} = \pi \left(\frac{CW}{2} \right)^2 CL$$

Usage

```
crown_volume_cylinder(crown_width, crown_length)
```

Arguments

`crown_width` Numeric. Crown width (mean diameter) in **meters**.
`crown_length` Numeric. Crown length in **meters**.

Value

A numeric vector of crown volumes in cubic meters (m³).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35. doi:[10.1093/forestry/cpaa037](https://doi.org/10.1093/forestry/cpaa037)

Hecht, R., Meinel, G., & Buchroithner, M. F. (2008). Estimation of urban green volume based on single-pulse LiDAR data. *IEEE Transactions on Geoscience and Remote Sensing*, 46(11), 3832–3840. doi:[10.1109/TGRS.2008.2001771](https://doi.org/10.1109/TGRS.2008.2001771)

Examples

```
crown_volume_cylinder(crown_width = 3.0, crown_length = 4.0)
```

crown_volume_ellipsoid

Crown Volume — Ellipsoid (or Sphere)

Description

Estimates crown volume by approximating the crown shape as a **half-ellipsoid** (prolate or oblate spheroid). This is one of the most widely used geometric approximations in forest inventory and urban tree assessment.

$$V_{ellipsoid} = \frac{4}{3}\pi \left(\frac{CL}{2}\right) \left(\frac{CW}{2}\right)^2$$

When crown_width == crown_length, the formula reduces to a sphere.

Usage

```
crown_volume_ellipsoid(crown_width, crown_length)
```

Arguments

crown_width Numeric. Crown width (mean diameter) in **meters**.
crown_length Numeric. Crown length in **meters**.

Value

A numeric vector of crown volumes in cubic meters (m³).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35. [doi:10.1093/forestry/cpaa037](https://doi.org/10.1093/forestry/cpaa037)

McPherson, E. G., & Rowntree, R. A. (1988). Geometric solids for simulation of tree crowns. *Landscape and Urban Planning*, 15(3–4), 79–83.

Examples

```
crown_volume_ellipsoid(crown_width = 3.0, crown_length = 4.5)

# Sphere (equal axes)
crown_volume_ellipsoid(crown_width = 3.0, crown_length = 3.0)
```

crown_volume_fan	<i>Crown Volume — Fan (Umbrella) Shape</i>
------------------	--

Description

Estimates crown volume for trees with a wide, flat **fan or umbrella-shaped** crown (e.g., *Pinus pinea*, some tropical species). The model treats the crown as a disc-like solid whose vertical extent is approximated by the trunk diameter at breast height (DBH), and whose horizontal extent is characterised by the crown length.

$$V_{fan} = \frac{\pi \cdot CL^2}{4} \cdot \frac{DBH}{100}$$

Usage

```
crown_volume_fan(crown_length, dbh)
```

Arguments

crown_length	Numeric. Crown length in meters .
dbh	Numeric. Diameter at breast height in centimeters .

Value

A numeric vector of crown volumes in cubic meters (m³).

References

Lanner, R. M. (1989). An observation on apical dominance and the umbrella-crown of Italian stone pine (*Pinus pinea*, Pinaceae). *Economic Botany*, 43(1), 128–130. doi:10.1007/BF02858917

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35. doi:10.1093/forestry/cpaa037

Examples

```
crown_volume_fan(crown_length = 4.0, dbh = 25.0)
```

crown_volume_paraboloid

Crown Volume — Paraboloid

Description

Estimates crown volume by approximating the crown shape as a **paraboloid** of revolution. This shape is intermediate between a cone and a cylinder and is often considered a good approximation for broadleaf trees.

$$V_{paraboloid} = \frac{1}{2}\pi \left(\frac{CW}{2}\right)^2 CL$$

Usage

```
crown_volume_paraboloid(crown_width, crown_length)
```

Arguments

crown_width Numeric. Crown width (mean diameter) in **meters**.

crown_length Numeric. Crown length in **meters**.

Value

A numeric vector of crown volumes in cubic meters (m³).

References

Zhu, Z., Kleinn, C., & Nölke, N. (2021). Assessing tree crown volume — a review. *Forestry*, 94(1), 18–35. [doi:10.1093/forestry/cpaa037](https://doi.org/10.1093/forestry/cpaa037)

McPherson, E. G., & Rowntree, R. A. (1988). Geometric solids for simulation of tree crowns. *Landscape and Urban Planning*, 15(3–4), 79–83.

Examples

```
crown_volume_paraboloid(crown_width = 3.0, crown_length = 4.5)
```

salience_index

Salience Index

Description

Computes the salience index, defined as the ratio between crown width and DBH (both converted to the same unit). It expresses how many times wider the crown is compared to the trunk diameter, reflecting the tree's ability to occupy horizontal space relative to its stem size.

$$SAI = \frac{CW}{DBH/100}$$

Usage

```
salience_index(crown_width, dbh)
```

Arguments

crown_width Numeric. Crown width (mean diameter) in **meters**.
 dbh Numeric. Diameter at breast height in **centimeters**.

Value

A numeric vector of salience index values (dimensionless).

References

Durlo, M. A., & Denardi, L. (1998). Morfometria de *Cabralea canjerana*, em mata secundária nativa do Rio Grande do Sul. *Ciência Florestal*, 8(1), 55–66.

Examples

```
salience_index(crown_width = 3.5, dbh = 18.5)
```

scope_index

Scope Index

Description

Computes the scope index, defined as the ratio between crown width and total tree height. It describes the lateral reach of the crown relative to tree height and is used to characterise the crown's competitive influence on neighbouring trees.

$$SCI = \frac{CW}{H_{tot}}$$

Usage

```
scope_index(crown_width, total_height)
```

Arguments

`crown_width` Numeric. Crown width (mean diameter) in **meters**.
`total_height` Numeric. Total tree height in **meters**.

Value

A numeric vector of scope index values (dimensionless).

References

Durlo, M. A., & Denardi, L. (1998). Morfometria de *Cabralea canjerana*, em mata secundária nativa do Rio Grande do Sul. *Ciência Florestal*, 8(1), 55–66.

Examples

```
scope_index(crown_width = 3.5, total_height = 15.0)
```

slenderness	<i>Slenderness Index</i>
-------------	--------------------------

Description

Computes the slenderness index, defined as the ratio between total tree height and diameter at breast height (DBH). Higher values indicate more slender trees that are more susceptible to wind and snow damage.

$$SLI = \frac{H_{tot}}{DBH/100}$$

Usage

```
slenderness(total_height, dbh)
```

Arguments

`total_height` Numeric. Total tree height in **meters**.
`dbh` Numeric. Diameter at breast height in **centimeters**.

Value

A numeric vector of slenderness index values (dimensionless).

References

- Durlo, M. A., & Denardi, L. (1998). Morfometria de *Cabralea canjerana*, em mata secundária nativa do Rio Grande do Sul. *Ciência Florestal*, 8(1), 55–66.
- Sterba, H. (1991). Forstliche Wuchslehre. Universität für Bodenkultur, Wien.

Examples

```
slenderness(total_height = 15.0, dbh = 18.5)
```

vital_space_index	<i>Vital Space Index</i>
-------------------	--------------------------

Description

Computes the vital space index, defined as the ratio between the crown projection area (m²) and the basal area of the stem (m²). It quantifies how much ground area the crown occupies per unit of stem cross-sectional area, and is used as an indicator of competition and growing space efficiency.

$$VSI = \frac{CPA}{BA} = \frac{\pi(CW/2)^2}{\pi(DBH/200)^2}$$

Usage

```
vital_space_index(crown_width, dbh)
```

Arguments

crown_width	Numeric. Crown width (mean diameter) in meters .
dbh	Numeric. Diameter at breast height in centimeters .

Value

A numeric vector of vital space index values (dimensionless).

References

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- Wink, C., Monteiro, J. S., Reinert, D. J., & Liberalesso, E. (2012). Parâmetros da copa e a sua relação com o diâmetro e altura das árvores de eucalipto em diferentes idades. *Scientia Forestalis*, 40(93), 57–67.

Examples

```
vital_space_index(crown_width = 3.5, dbh = 18.5)
```

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