

# Package ‘gridHR’

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**Title** Grid-Based Home-Range Analysis and Radial Space-Use Profiles

**Version** 1.0.0

## Description

Tools for estimating and exploring animal home ranges from geographical locations using regular spatial grids of square or hexagonal cells; see Ford and Krumme (1979) <[doi:10.1016/0022-5193\(79\)90366-7](https://doi.org/10.1016/0022-5193(79)90366-7)>. The package includes grid-based home-range estimation across different cell sizes, analyses of the relationship between grid-cell size and home-range area and spatial connectivity, and rarefaction analyses to evaluate how home-range estimates change with increasing numbers of locations. It also introduces a novel radial approach for characterizing the internal organization of space use by quantifying how space-use intensity changes with increasing distance from the centre toward the periphery of the home range.

**License** MIT + file LICENSE

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| <i>gibbons</i> | <i>Gibbon movement locations from Khao Yai National Park</i> |
|----------------|--------------------------------------------------------------|

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**Description**

Movement locations recorded at approximately 5-m intervals throughout 2003 for a group of white-handed gibbons (*Hylobates lar*) in Khao Yai National Park, Thailand.

**Usage**

*gibbons*

**Format**

An sf object containing 18,098 point locations.

**Details**

The dataset contains 18,098 spatial locations represented as an sf point object. Coordinates are provided in UTM zone 47N (EPSG:32647).

The dataset was originally used to examine short-term core-area use in white-handed gibbons.

**References**

Asensio, N., Brockelman, W. Y., Malaivijitnond, S. & Reichard, U. H. (2014). White-handed Gibbon (*Hylobates lar*) Core Area Use Over a Short-Time Scale. *Biotropica*, 46, 461-469.

**Examples**

```
data(gibbons)

grid_hr(
  gibbons,
  cell_area = 5000,
  fill_by = "radial",
  show_legend = FALSE,
  title = "Radial space-use intensity of a gibbon group
(1 hex = 0.5 ha)"
)
```

grid\_hr

*Grid-based home-range estimation***Description**

Estimates home-range size by overlaying animal locations with a regular spatial grid and identifying the occupied cells. The function supports both hexagonal and square cells and can display spatial variation in space-use intensity using either the number of locations recorded in each cell or a radial space-use profile.

**Usage**

```
grid_hr(
  points,
  cell_area = 5000,
  title = "",
  cell_shape = "hex",
  show_locations = FALSE,
  location_fill = "black",
  location_outline = "white",
  location_size = 1.2,
  location_alpha = 0.6,
  show_gradient = TRUE,
  fill_by = "locations",
  low_colour = "lightblue",
  high_colour = "darkblue",
  cell_fill = "lightblue",
  cell_outline = NA,
  linewidth = 0.4,
  show_centroid = TRUE,
  centroid_colour = "red",
  centroid_size = 5,
  show_legend = FALSE,
  text_size = 13
)
```

**Arguments**

|                |                                                                                                                                       |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------|
| points         | An sf object containing animal locations as point geometries. The coordinate reference system must be projected and use metric units. |
| cell_area      | Numeric. Area of each grid cell in square metres. Default is 5000 m <sup>2</sup> (0.5 ha).                                            |
| title          | Character. Title of the home-range plot.                                                                                              |
| cell_shape     | Character. Shape of the grid cells. Either "hex" or "square". Default is "hex".                                                       |
| show_locations | Logical. Should the individual locations be displayed on top of the home-range cells? Default is FALSE.                               |

|                  |                                                                                                                                                                                                                                                                 |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| location_fill    | Colour used to fill individual locations.                                                                                                                                                                                                                       |
| location_outline | Colour used for the outline of individual locations.                                                                                                                                                                                                            |
| location_size    | Size of individual location points.                                                                                                                                                                                                                             |
| location_alpha   | Transparency of individual location points.                                                                                                                                                                                                                     |
| show_gradient    | Logical. Should a colour gradient be used to represent space-use intensity? Default is TRUE.                                                                                                                                                                    |
| fill_by          | Character. Determines how space-use intensity is represented. "locations" colours each cell according to its number of recorded locations. "radial" colours cells according to the normalized space-use intensity of their radial ring. Default is "locations". |
| low_colour       | Colour representing low space-use intensity.                                                                                                                                                                                                                    |
| high_colour      | Colour representing high space-use intensity.                                                                                                                                                                                                                   |
| cell_fill        | Fill colour when show_gradient = FALSE.                                                                                                                                                                                                                         |
| cell_outline     | Colour of cell outlines. Default is NA, producing no cell outlines.                                                                                                                                                                                             |
| linewidth        | Line width of cell outlines.                                                                                                                                                                                                                                    |
| show_centroid    | Logical. Should the centre of the central home-range cell be displayed? Default is TRUE.                                                                                                                                                                        |
| centroid_colour  | Colour of the central-cell marker.                                                                                                                                                                                                                              |
| centroid_size    | Size of the central-cell marker.                                                                                                                                                                                                                                |
| show_legend      | Logical. Should the gradient legend be displayed? Default is FALSE.                                                                                                                                                                                             |
| text_size        | Base font size for the plot.                                                                                                                                                                                                                                    |

### Details

When `fill_by = "locations"`, each occupied cell is coloured according to the number of recorded locations it contains. This represents the conventional grid-based spatial distribution of location density.

When `fill_by = "radial"`, the occupied cells are grouped into radial rings according to their distance from the centre of the home range. Cells belonging to the same ring are assigned the same colour, representing the normalized space-use intensity of that ring. Radial intensity is calculated as the number of locations recorded in a ring divided by the number of occupied cells in that ring. This provides a spatial representation of the radial space-use profile produced by `radial_plot()`.

The centre used for the radial representation is the centre of the grid cell containing the geometric centroid of all observed locations.

### Value

A list containing:

**hr\_size\_m2** Home-range area in square metres.

**hr\_size\_ha** Home-range area in hectares.

**n\_cells** Number of occupied grid cells.

**grid** An sf object containing the occupied home-range cells.  
**hr\_centroid** The geometric centroid of all locations.  
**central\_cell\_center** The centre of the grid cell containing the location centroid.  
**hr\_plot** The resulting ggplot2 home-range map.

### Examples

```
data(gibbons)

grid_hr(
  gibbons,
  cell_area = 5000,
  fill_by = "locations",
  show_legend = TRUE,
  title = "Grid-based space-use intensity of a gibbon group"
)

grid_hr(
  gibbons,
  cell_area = 5000,
  fill_by = "radial",
  show_legend = TRUE,
  title = "Radial space-use intensity of a gibbon group (0.5-ha hexagons)"
)
```

---

|              |                                               |
|--------------|-----------------------------------------------|
| hr_cell_size | <i>Home-range size across grid cell sizes</i> |
|--------------|-----------------------------------------------|

---

### Description

Calculates grid-based home-range size across a sequence of cell areas. For each cell size, the function overlays the animal locations with a regular grid, identifies occupied cells, and calculates home-range size as the number of occupied cells multiplied by the area of each cell.

### Usage

```
hr_cell_size(
  points,
  min = 100,
  max = 1000,
  interval = 100,
  cell_shape = "hex",
  show_plot = TRUE,
  line_colour = "#08519C",
  point_colour = "#08519C",
  linewidth = 1.2,
  point_size = 3,
```

```

    text_size = 13,
    title = ""
  )

```

### Arguments

|                           |                                                                                                                                       |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <code>points</code>       | An sf object containing animal locations as point geometries. The coordinate reference system must be projected and use metric units. |
| <code>min</code>          | Numeric. Minimum cell area to evaluate, in square metres. Default is 100 m2.                                                          |
| <code>max</code>          | Numeric. Maximum cell area to evaluate, in square metres. Default is 1000 m2.                                                         |
| <code>interval</code>     | Numeric. Increment between successive cell areas, in square metres. Default is 100 m2.                                                |
| <code>cell_shape</code>   | Character. Shape of the grid cells. Either "hex" or "square". Default is "hex".                                                       |
| <code>show_plot</code>    | Logical. Should the relationship between cell area and estimated home-range size be displayed? Default is TRUE.                       |
| <code>line_colour</code>  | Colour of the line connecting home-range estimates.                                                                                   |
| <code>point_colour</code> | Colour of the points representing individual cell-area estimates.                                                                     |
| <code>linewidth</code>    | Width of the line.                                                                                                                    |
| <code>point_size</code>   | Size of the points.                                                                                                                   |
| <code>text_size</code>    | Base font size for the plot.                                                                                                          |
| <code>title</code>        | Character. Title of the plot. Default is an empty character string.                                                                   |

### Details

This function can be used to examine how sensitive grid-based home-range estimates are to the spatial resolution of the grid. Both hexagonal and square cells are supported.

### Value

A list containing:

**results** A data frame containing the cell area, number of occupied cells, and estimated home-range size in square metres and hectares for each cell size.

**plot** The resulting ggplot2 plot.

**cell\_shape** The shape of the grid cells used.

**min\_cell** The minimum cell area evaluated.

**max\_cell** The maximum cell area evaluated.

**interval** The increment between successive cell areas.

## Examples

```
hr_cell_size(
  spider_monkeys,
  min = 10000,
  max = 50000,
  interval = 10000,
  cell_shape = "hex",
  title = "Grid-based home-range size according to cell area"
)
```

hr\_rare

*Grid-based home-range rarefaction*

## Description

Evaluates how grid-based home-range size changes with increasing numbers of animal locations. Random permutations of the locations are used to generate accumulated samples, and home-range size is calculated at successive sample sizes as the number of occupied grid cells multiplied by the area of each cell.

## Usage

```
hr_rare(
  points,
  cell_area = 5000,
  cell_shape = "hex",
  n_reps = 1000,
  step = 1,
  seed = NULL,
  show_plot = TRUE,
  ribbon_colour = "#08519C",
  line_colour = "#08519C",
  linewidth = 1.1,
  text_size = 13
)
```

## Arguments

|            |                                                                                                                                                               |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| points     | An sf object containing animal locations as point geometries. The coordinate reference system must be projected and use metric units.                         |
| cell_area  | Numeric. Area of each grid cell in square metres. Default is 5000 m <sup>2</sup> (0.5 ha).                                                                    |
| cell_shape | Character. Shape of the grid cells. Either "hex" or "square". Default is "hex".                                                                               |
| n_reps     | Integer. Number of random rarefaction replicates. Default is 1000.                                                                                            |
| step       | Integer. Interval between sample sizes evaluated in the rarefaction curve. For example, step = 25 evaluates home-range size every 25 locations. Default is 1. |

|               |                                                                                                |
|---------------|------------------------------------------------------------------------------------------------|
| seed          | Optional integer used to make the random rarefaction replicates reproducible. Default is NULL. |
| show_plot     | Logical. Should the rarefaction plot be displayed? Default is TRUE.                            |
| ribbon_colour | Character. Colour used for the variability ribbon.                                             |
| line_colour   | Character. Colour used for the mean rarefaction curve.                                         |
| linewidth     | Numeric. Width of the rarefaction curve.                                                       |
| text_size     | Numeric. Base font size for the plot.                                                          |

## Details

Repeated random permutations of the locations are used to estimate the mean and variability of home-range size at each sample size. The resulting rarefaction curve can be used to assess how home-range estimates change with sampling effort and whether they approach an asymptotic value as the number of locations increases.

The step argument controls the resolution of the rarefaction curve. For example, step = 25 evaluates home-range size every 25 locations. Smaller values provide a more detailed curve but require more computation, particularly for large datasets.

The home range is defined as the set of grid cells containing at least one sampled location. Consequently, estimated home-range area depends on the specified cell size and cell shape.

For each rarefaction replicate, the locations are randomly reordered and progressively accumulated. At each selected sample size, the number of unique occupied grid cells is recorded and multiplied by the cell area to obtain the grid-based home-range estimate.

Sampling is performed without replacement within each replicate. The variability among replicates therefore represents the effect of the order in which locations are accumulated rather than uncertainty arising from different spatial locations being sampled independently.

Because grid-based home-range area is based on occupied cells, rarefaction results depend on both sampling effort and the chosen grid resolution. The curve can therefore be used to examine whether additional locations continue to increase the estimated home-range area under a specified grid configuration.

## Value

A list containing:

**rarefaction\_df** A data frame containing the number of locations evaluated, mean home-range size, and standard deviation across rarefaction replicates, expressed in square metres and hectares.

**rarefaction\_plot** The resulting ggplot2 rarefaction plot.

**grid** An sf object containing the grid used for the analysis.

**n\_total** Number of locations included in the analysis.

**cell\_area** Area of each grid cell in square metres.

**cell\_shape** Shape of the grid cells used in the analysis.

**Examples**

```
data(spider_monkeys)

# A reduced number of replicates is used here to keep the example
# computationally light. Larger values are recommended for analysis.
hr_rare(
  spider_monkeys,
  cell_area = 10000,
  cell_shape = "hex",
  n_reps = 99,
  step = 25,
  seed = 123
)
```

macaques

*Macaque group locations***Description**

Spatial locations of a macaque group (*Macaca leonina*) recorded at Khao Yai National Park, Thailand, from July 2012 to June 2013. The group was followed for five to eight full days per month, from sleeping site to sleeping site, using a handheld GPS. Locations were recorded at approximately 30-minute intervals.

**Format**

An sf object containing 16,478 macaque group locations.

**Details**

Coordinates are provided in UTM zone 47N using the WGS84 datum.

**Source**

José-Domínguez, J. M., Huynen, M.-C., García, C. J., Albert-Daviaud, A., Savini, T., & Asensio, N. (2015). Non-territorial Macaques Can Range Like Territorial Gibbons When Partially Provisioned With Food. *Biotropica*, 47, 733–744. doi:10.1111/btp.12256

**Examples**

```
grid_hr(
  macaques,
  cell_area = 25000,
  fill_by = "locations",
  title = "Macaque home range with radial space-use pattern",
  low_colour = "grey90",
  high_colour = "grey10"
)
```

min\_cell

*Minimum grid-cell size based on home-range connectivity***Description**

Evaluates the topological connectivity of a grid-based home range across a sequence of grid-cell sizes. Animal locations are overlaid on grids of increasing cell area, occupied cells are identified, and their connectivity is evaluated based on shared cell edges.

**Usage**

```
min_cell(
  points,
  min = 100,
  max = 1000,
  interval = 100,
  cell_shape = "hex",
  show_plot = TRUE,
  line_colour = "#08519C",
  point_colour = "#08519C",
  linewidth = 1.2,
  point_size = 3,
  text_size = 13
)
```

**Arguments**

|              |                                                                                                                                       |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------|
| points       | An sf object containing animal locations as point geometries. The coordinate reference system must be projected and use metric units. |
| min          | Numeric. Minimum cell area to test, in square metres. Default is 100 m2.                                                              |
| max          | Numeric. Maximum cell area to test, in square metres. Default is 1000 m2.                                                             |
| interval     | Numeric. Increment between successive cell areas, in square metres. Default is 100 m2.                                                |
| cell_shape   | Character. Shape of the grid cells. Either "hex" or "square". Default is "hex".                                                       |
| show_plot    | Logical. Should the connectivity plot be displayed? Default is TRUE.                                                                  |
| line_colour  | Character. Colour of the connectivity line.                                                                                           |
| point_colour | Character. Colour of the connectivity points.                                                                                         |
| linewidth    | Numeric. Width of the connectivity line.                                                                                              |
| point_size   | Numeric. Size of the connectivity points.                                                                                             |
| text_size    | Numeric. Base font size for the plot.                                                                                                 |

## Details

Connectivity is expressed as the proportion of occupied cells belonging to the largest topologically connected component. Cells that touch only at a corner are not considered connected. The function also identifies the smallest *tested* cell size at which all occupied cells form a single connected component.

Because the grid is recreated independently at each cell size, connectivity is not necessarily monotonic with increasing cell size. The complete connectivity profile is therefore returned rather than assuming that connectivity, once achieved, is maintained at larger cell sizes.

For each cell size, the function counts the number of locations in each grid cell and retains occupied cells as the grid-based home range. Topological connectivity is then evaluated using shared cell edges. The resulting connectivity value is the proportion of occupied cells belonging to the largest connected component.

A connectivity value of 1 indicates that all occupied cells belong to a single connected component. The corresponding `fully_connected` value is `TRUE`.

The analysis is useful for evaluating whether a particular grid resolution produces a spatially compact representation of the observed home range and for identifying the smallest tested cell size at which the occupied grid becomes fully connected.

## Value

A list containing:

**results** A data frame containing the connectivity results for every tested cell size.

**plot** The resulting ggplot2 connectivity plot.

**cell\_shape** The grid-cell shape used in the analysis.

**minimum\_connected** The smallest tested cell area at which all occupied cells form a single connected component. Returns NA if no tested cell size is fully connected.

**min\_cell** The minimum cell area specified for the analysis.

**max\_cell** The maximum cell area specified for the analysis.

**interval** The increment between tested cell areas.

## Examples

```
min_cell(  
  macaques,  
  min = 5000,  
  max = 40000,  
  interval = 10000,  
  cell_shape = "hex"  
)
```

radial\_plot

*Radial space-use profile of a grid-based home range***Description**

Calculates and plots the relationship between space-use intensity and distance from the centre to the periphery of a grid-based home range.

**Usage**

```
radial_plot(
  points,
  cell_area = 5000,
  title = "",
  cell_shape = "hex",
  smooth = FALSE,
  loess_span = 0.8,
  show_points = FALSE,
  point_colour = "#08519C",
  point_size = 2,
  point_alpha = 0.8,
  line_colour = "#08519C",
  linewidth = 1.3,
  text_size = 13
)
```

**Arguments**

|              |                                                                                                                                                    |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| points       | An sf object containing the observed animal locations as point geometries. The coordinate reference system must be projected and use metric units. |
| cell_area    | Numeric. Area of each grid cell in square metres. Default is 5000 m <sup>2</sup> (0.5 ha).                                                         |
| title        | Character. Title of the plot. Default is "".                                                                                                       |
| cell_shape   | Character. Shape of the grid cells. Either "hex" or "square". Default is "hex".                                                                    |
| smooth       | Logical. If TRUE, fits a LOESS-smoothed curve to the radial space-use profile. Default is FALSE.                                                   |
| loess_span   | Numeric. Span parameter used for LOESS smoothing. Must be greater than 0 and less than or equal to 1. Default is 0.8.                              |
| show_points  | Logical. If TRUE, displays the observed radial values as points. Default is FALSE.                                                                 |
| point_colour | Character. Colour of the observed radial points. Default is "#08519C".                                                                             |
| point_size   | Numeric. Size of the observed radial points. Default is 2.                                                                                         |
| point_alpha  | Numeric. Transparency of the observed radial points. Default is 0.8.                                                                               |
| line_colour  | Character. Colour of the radial profile curve. Default is "#08519C".                                                                               |
| linewidth    | Numeric. Width of the radial profile curve. Default is 1.3.                                                                                        |
| text_size    | Numeric. Base text size of the plot. Default is 13.                                                                                                |

## Details

The function divides the occupied home-range cells into radial rings according to their distance from the centre. The centre is defined as the centre of the grid cell containing the geometric centroid of all observed locations. For each radial ring, space-use intensity is calculated as the total number of recorded locations divided by the number of occupied cells in that ring.

This approach provides a cell-based description of how space-use intensity is organized spatially from the centre toward the periphery, while accounting for differences in the number of occupied cells represented at different distances.

Both distance and space-use intensity are normalized from 0 to 1. Normalized distance represents the position of each radial ring between the centre and the outermost occupied ring, whereas normalized space-use intensity represents relative intensity, with the most intensively used ring assigned a value of 1.

The resulting profile describes how the intensity of space use changes with increasing distance from the centre of the home range. A decreasing profile indicates relatively greater use toward the centre, whereas an increasing profile indicates relatively greater use toward the periphery. The function can display either the observed radial profile or a LOESS-smoothed curve.

Space-use intensity is calculated separately for each radial ring as the total number of locations recorded in the ring divided by the number of occupied cells comprising that ring. This prevents rings containing more occupied cells from automatically having higher intensity simply because they cover a larger number of cells.

The grid is constructed using the specified cell area and shape. Only cells containing at least one recorded location are considered part of the home range. Radial distance is measured from the centre of the central grid cell to the centres of the occupied grid cells.

The radial profile is therefore based on the spatial organization of observed locations within the grid rather than on a kernel density estimate. No spatial smoothing is applied unless `smooth = TRUE` is specified.

## Value

A list containing:

**ring\_summary** A data frame containing the radial rings, number of locations, number of occupied cells, space-use intensity, distance from the centre, and normalized distance and intensity.

**central\_cell\_center** The centre of the grid cell containing the geometric centroid of the observed locations.

**radial\_plot** A ggplot object showing the radial space-use profile.

## Examples

```
radial_plot(
  gibbons,
  cell_area = 5000,
  cell_shape = "hex",
  title = "Radial space-use profile of a gibbon group (0.5-ha hexagons)"
)
```

---

|                |                                         |
|----------------|-----------------------------------------|
| spider_monkeys | <i>Spider monkey subgroup locations</i> |
|----------------|-----------------------------------------|

---

## Description

Spatial locations of spider monkey subgroups recorded at approximately 30-minute intervals from 2005 to 2008 in a regenerating tropical forest. Coordinates are provided in UTM zone 16N using the WGS84 datum (EPSG:32616).

## Usage

```
spider_monkeys
```

## Format

An sf object containing spider monkey subgroup locations.

## Details

The dataset was used to investigate the effects of roads on spider monkey home-range size and mobility in a heterogeneous regenerating forest.

## Source

Asensio, N., Murillo-Chacon, E., Schaffner, C. M. & Aureli, F. (2017). [doi:10.1111/btp.12441](https://doi.org/10.1111/btp.12441)

## References

Asensio, N., Murillo-Chacon, E., Schaffner, C. M. & Aureli, F. (2017). The effect of roads on spider monkeys' home range and mobility in a heterogeneous regenerating forest. *Biotropica*. [doi:10.1111/btp.12441](https://doi.org/10.1111/btp.12441)

## Examples

```
data(spider_monkeys)

grid_hr(
  spider_monkeys,
  cell_area = 10000,
  fill_by = "radial",
  title = "Radial space-use intensity of a spider monkey group (1 ha hexagons)"
)
```

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