

Package ‘FoRDM’

December 3, 2025

Type Package

Title Forest Many-Objective Robust Decision Making ('FoRDM')

Version 1.0.0

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Description Forest Many-Objective Robust Decision Making ('FoRDM') is a R toolkit for supporting robust forest management under deep uncertainty.

It provides a forestry-focused application of Many-Objective Robust Decision Making ('MORDM') to forest simulation outputs, enabling users to evaluate robustness using regret- and 'satisficing'-based measures. 'FoRDM' identifies robust solutions, generates Pareto fronts, and offers interactive 2D, 3D, and parallel-coordinate visualizations.

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Encoding UTF-8

Imports dplyr (>= 1.0.0), ggplot2 (>= 3.3.0), magrittr (>= 2.0.0), tidyr (>= 1.1.0), rlang (>= 0.4.0), tibble (>= 3.0.0), plotly (>= 4.10.0), emoa (>= 0.5.0), stats

Suggests testthat (>= 3.0.0)

RoxygenNote 7.3.3

Config/testthat/edition 3

NeedsCompilation no

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Repository CRAN

Date/Publication 2025-12-03 20:50:11 UTC

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build_fordm_table	<i>Build FoRDM Table</i>
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Description

Transfers the provided data table into the format for FoRDM analysis. The columns that represent management, sow (state-of-the-world, scenarios), and time have to be defined. All other columns are treated as objectives.

Usage

```
build_fordm_table(data, management, sow, time, time_unit = "years")
```

Arguments

data	A data.frame containing the input data.
management	The name of the management column.
sow	The name of the state-of-the-worlds (SOW) column.
time	The name of the time column.
time_unit	The unit of time used in the time column. Options are "years" (default) or "decades".

Value

A list with the processed data for further use in the FoRDM analysis, including the input data, mapping for identification of columns and objective columns.

build_objectives_regret

Build Objectives Data Frame for Regret Analysis

Description

Specify for which objectives regret-based FoRDM analysis should be applied. For each objective, define its name, direction, weight, time aggregation method (mean, sum, min or max), and discount rate.

Usage

```
build_objectives_regret(  
  names,  
  direction = rep("maximize", length(names)),  
  weights = rep(1/length(names), length(names)),  
  time_aggregation = rep("mean", length(names)),  
  discount_rate = rep(0, length(names))  
)
```

Arguments

names	Names of objectives as the column names in the provided data.
direction	Direction of objective function: 'maximize' or 'minimize'.
weights	Relative weights (0-1) for each objective, must sum to 1.
time_aggregation	Time aggregation across objectives: 'mean', 'sum', 'min' or 'max'.
discount_rate	Annual discount rates for each objective (e.g., 0.02 means 2% per year), applied during time aggregation.

Value

A data frame specifying objectives, directions, weights, time aggregation methods, and discount rates for use in FoRDM analysis.

build_objectives_satisficing

Build Objectives Data Frame for Satisficing Analysis

Description

Specify information for satisficing-based FoRDM analysis. For each objective, define its name, time aggregation method (mean, sum, min or max), discount rate, threshold and direction.

Usage

```
build_objectives_satisficing(
  names,
  time_aggregation = rep("mean", length(names)),
  discount_rate = rep(0, length(names)),
  threshold,
  direction = rep("above", length(names))
)
```

Arguments

<code>names</code>	Names of objectives as the column names in the provided data.
<code>time_aggregation</code>	Time aggregation across objectives: 'mean', 'sum', 'min' or 'max'.
<code>discount_rate</code>	Discount rates for each objective (e.g., 0.02 means 2% per time step), applied during time aggregation.
<code>threshold</code>	Numeric value(s) defining the satisficing level for each objective.
<code>direction</code>	'above' if values should meet or exceed the threshold, 'below' if they should be lower.

Value

A data frame specifying objectives name, time aggregation method, discount rate, threshold and direction for use in satisficing FoRDM analysis.

Description

This package provides a toolkit for supporting robust forest management under deep uncertainty. It provides a forestry-focused application of Many-Objective Robust Decision Making (MORDM) to forest simulation outputs, enabling users to evaluate robustness using regret- and satisficing-based measures. FoRDM identifies robust solutions, generates Pareto fronts, and offers interactive 2D, 3D, and parallel-coordinate visualizations.

Details

Main features:

- Create FoRDM input tables from forest simulation outputs.
- Calculate robustness measures based on Regret and Satisficing approaches.
- Visualize results using 2D, 3D, or parallel-coordinate plots.
- Explore trade-offs between robustness and performance.

Author(s)

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See Also

`browseVignettes(package = "FoRDM")`

`fordm_analysis_regret` *FoRDM Regret-Based many-objective Robust Decision-Making Analysis*

Description

Performs a regret-based (Type II or cVaR) many-objective robustness analysis for the provided data and objectives, providing a optimal robust management and the Pareto front.

Usage

```
fordm_analysis_regret(
  ford़_table,
  objectives,
  robustness = 0.9,
  method = "regretII"
)
```

Arguments

<code>fordm_table</code>	Output from <code>build_fordm_table()</code> .
<code>objectives</code>	Output from <code>build_objectives_regret()</code> .
<code>robustness</code>	Numeric (0-1) specifying the quantile of regret used to define robustness, e.g., 0.9 evaluates management performance that is at least as good as in 90% of SOWs.
<code>method</code>	the method used to evaluate robustness <ul style="list-style-type: none"> • "regretII": Regret type II (regret to best performing alternative) approach using the robustness quantile of scenario regrets. • "CVaR": Conditional Value at Risk, using the mean of the worst (1 - robustness) fraction of weighted regrets for risk-aware selection.

Value

A list containing the results of the FoRDM analysis:

- `optimal`: The management strategy identified as most robust given the regret metrics.
- `pareto_front`: The Pareto front of robust management strategies.

fordm_analysis_satisficing

FoRDM Satisficing-Based many-objective Robust Decision-Making Analysis

Description

Performs a satisficing-based many-objective robustness analysis for the provided data and objectives, providing a optimal robust management and the Pareto front.

Usage

```
fordm_analysis_satisficing(fordm_table, objectives, robustness = 0.9)
```

Arguments

fordm_table	Output from build_fordm_table().
objectives	Output from build_objectives_satisficing().
robustness	Numeric (0-1) specifying the robustness level across SOWs, e.g., 0.9 evaluates management performance that meets objectives in at least 90% of SOWs.

Value

A list containing the FoRDM analysis results:

- **optimal**: The management strategy that balances all objectives (Euclidean distance) while meeting the robustness threshold.
- **pareto_front**: The Pareto front of robust management strategies.

robustness_tradeoff_analysis

Robustness Trade-Off Analysis (Regret-based)

Description

Analyzes what happens when you sacrifice robustness for better performance. Shows marginal benefits and losses for each objective when switching between management strategies across different robustness levels.

Usage

```
robustness_tradeoff_analysis(fordm_table, objectives)
```

`visualize_fordm_2d`

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Arguments

- | | |
|--------------------------|--|
| <code>fordm_table</code> | Output from <code>build_FoRDM_table()</code> . |
| <code>objectives</code> | Output from <code>build_objectives_regret()</code> . |

Value

List containing the list of optimal managements at certain robustness levels, and a plot

`visualize_fordm_2d` *Visualize 2D Pareto Front*

Description

Plots a 2D plot of the Pareto front of management alternatives from FoRDM_analysis output.

Usage

```
visualize_fordm_2d(analysis_output, x, y, fordm_method)
```

Arguments

- | | |
|------------------------------|--|
| <code>analysis_output</code> | Output list from <code>FoRDM_analysis_regret()</code> or <code>FoRDM_analysis_satisficing()</code> . |
| <code>x</code> | Name of the objective for the x-axis (string). |
| <code>y</code> | Name of the objective for the y-axis (string). |
| <code>fordm_method</code> | Either "regret" or "satisficing". |

Value

A ggplot2 object showing the 2D Pareto front for the selected objectives.

`visualize_fordm_3d` *Visualize 3D Pareto Front*

Description

Plots a 3D plot of the Pareto front of management alternatives from FoRDM_analysis output.

Usage

```
visualize_fordm_3d(analysis_output, x, y, z, fordm_method)
```

Arguments

analysis_output	Output from FoRDM_analysis_regret or FoRDM_analysis_satisficing.
x	Name of the objective for the x-axis (string).
y	Name of the objective for the y-axis (string).
z	Name of the objective for the z-axis (string).
fordm_method	Either "regret" or "satisficing".

Value

A plotly object showing the 3D Pareto front for the selected objectives.

visualize_fordm_parcoord

Visualize a Parallel Coordinates plot of the Pareto Front for FoRDM Analysis Results

Description

Creates a parallel coordinates plot showing the Pareto front from FoRDM analysis.

Usage

```
visualize_fordm_parcoord(analysis_output, fordm_method)
```

Arguments

analysis_output	Output from fordm_analysis_regret() or fordm_analysis_satisficing().
fordm_method	Either "regret" or "satisficing".

Value

A parallel coordinates plot object.

visualize_fordm_parcoord_management

Visualize Parallel Coordinates Plot for a single selected management across all SOWs

Description

Creates a parallel coordinates plot showing SOW performance across objectives for a selected management strategy.

Usage

```
visualize_fordm_parcoord_management(  
  ford़_table,  
  objectives,  
  ford़_method,  
  management  
)
```

Arguments

ford़_table	Output from build_fordm_table().
objectives	Output from build_objectives_regret() or build_objectives_satisficing().
ford़_method	Either "regret" or "satisficing".
management	Character string specifying which management to visualize.

Value

A parallel coordinates plot object.

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