ForSysR: Quick Start User Guide

ForSys Overview

ForSys is a multi-objective spatial prioritization system that was designed to explore a range of management options at different scales, from national forests and regions, to nationwide. This Quick Start Guide is designed to get users up to speed with the program's basic functionality, introduce inputs and results using a simple example ForSys run, and provide data descriptions and preparation recommendations for users who wish to leverage their own local datasets within the program. More detailed information can be obtained from the full ForSys manual.

ForSys is a core component of the Forest Service scenario planning effort. Scenario planning considers a set of potential futures that include many of the important uncertainties in the modeled system rather than to focus on the accurate prediction of a single outcome. It is a process that guides planners, community members, and other stakeholders through considerations of various futures. This helps planners and stakeholders consider how various elements of their planning might respond to these different scenarios, and eventually build a strategic plan that reflects diverse input, quantitative realities, and qualitative goals. Scenario planning combines data-driven decision-making with an inclusive, participatory approach to guide the development of better management plans, which are more likely to be implemented than plans created without stakeholder involvement.

ForSys currently exists in three formats: 1) as an executable C++ stand-alone executable program (ForSysX), 2) as R packages (ForSysR with patchmax) described below, and 3) a ShinyApp web-based version (forsys.app) currently under development.

This manual is designed for a user to run ForSysR using the tutorial dataset as described at the end of this document (section 5), and use the manual text for reference to understand specific parameters and outputs.

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1. ForSysR Initial Configuration

ForSysR can be run via a configuration file or directly within an R script with parameters specified by the user for the given data set and scenario (Table 1). The primary input varies depending on the type of scenario. When spatial optimization with patchmax is needed, the input is a spatial dataset such as a shapefile or featureclass. When spatial optimization is not needed, ForSys can run with spatial data, or a CSV or DBF file that contains a table with all the stands within the study area. The input data must contain the required input parameters and basic information needed to run a scenario (Table 2). These data include field identification, information about objective metrics, treatment thresholds, treatment targets, constraints, and study area management subdivisions. The treatment selection process in ForSysR is conducted at the level of planning area units. Planning areas may then be combined into larger containers such as watersheds, firesheds, or National Forests.

Table 1. Basic inputs for the ForSysR configuration file. Required parameters indicated by **.

Category	Parameter	Description	Type	Default	Example
	config_file	Relative path to a config file that defines needed parameters	String	NULL	
	return_outputs	Flag to turn stand outputs on or off	Logical	FALSE	
	write_outputs	Write project and stand data to file.	Logical	TRUE	
	overwrite_outputs	Overwrites existing output of the same name	Logical	TRUE	
Basic	stand_data**	Input stand dataset	Data frame (required if loading stand from existing r object)	NULL	stand_dat
	stand_data_filename**	File path to the input dataset	String (required if loading stands from stand file)	""	c("data/ecoregion6_stands.csv")
	stand_id_field**	Field that contains the unique ID for each stand or treatment unit.	String (required)	""	"Stand_ID"
	stand_area_field**	Field that contains the area for each stand.	String (required)	NULL	"AREA_ACRE"
	stand_pcp_spm	Variables that must have the percent contribution to the problem (PCP) and the standardized	List of field names as string	NULL	c("priority1", "priority2")

		percent of the max (SPM) computed. Must include the priority variable(s). By default, `stand_pcp_spm` is set to NULL, in which case `forsys::run` calculates the PCP and SPM values for any fields set in `scenario_priorities`. `stand_pcp_spm` overwrites the default behavior if specified (typically it is not).			
	stand_threshold	Boolean statement passed as a string and used as threshold for whether stands are counted towards project objective	Boolean string	NULL	"hazard > 0.2"
	global_threshold	Boolean statement passed as a string used to define stands within the scenario. Excluded stands are not considered part of the problem so are not used to calculate PCP or ESum values.	Boolean string	NULL	"ownership == 2"
	normalize_values	Logical whether SPM fields should be normalized.	Logical	TRUE	
Project	proj_id_field proj_fixed_target**	Field that indicates which project or planning area a stand belongs to; Each stand belongs to one planning unit. Logical describing if project treatment target is fixed or relative.	String Logical (required when run_with_patchmax = FALSE)	"proj_id" TRUE	"POD_ID"

	proj_target_field**	Stand field used as target constraint.	String (required when run_with_patchmax = FALSE)	NULL	"AREA_ACRE"
	proj_target_value**	Numeric value for target constraint, either a fixed value if proj_fixed_target == TRUE or a value between 0 and 1.	Numeric (required when run_with_patchmax = FALSE)	NULL	2500 or 0.4
Scenario	scenario_name**	Unique scenario name. This will be used to save outputs.	String (required)	""	"test_scenario"
	scenario_priorities**	Priorities are named here. If only one priority exists, a weight of one will be used.	List of field names as string (required)	NULL	c("priority1", "priority2")
	scenario_weighting_values	Defines the weights and integer steps between weights. The values are for min, max, and step as a string of 3 integers separated by a space.	String of three integers	c(1, 1, 1)	c(0, 5, 1)
	scenario_output_fields**	A list of the desired fields summarized by project or planning area. Project ID, priority weights and treatment rank are added automatically. In addition, PCP and SPM are calculated for any fields listed here.	List of field names as strings (recommended to access desired outputs)	NULL	c("Priority1", "Priority2", "Hazard", "BiomassVol")
	scenario_output_grouping_fields	Any additional groupings of interest to summarize treatment nested below the project or planning area such as ownership or forest type.	List of field names as strings	NULL	c("ForestType")

	scenario_write_tags	Optional string appended to output filename used to describe scenario.	String	NULL	c("USFS_2022")
	overwrite_output	Logical whether to overwrite any existing output of the same name	Logical	TRUE	
Module	run_with_shiny	Logical whether run was called from within shiny	Logical	FALSE	
	run_with_patchmax	Logical whether Patchmax should be used for building projects	Logical	FALSE	
	run_with_fire	Logical whether to ForSys with Fire	Logical	FALSE	
Fire	fire_intersect_table	Data frame listing stands affected by fire by year.	Data frame (required when run_with_fire = TRUE)	NULL	
	fire_intersect_table_filename	File pathway to text file with list of stands affected by fire by year.	String (required when run_with_fire = TRUE)	NULL	'data/west_usfs_fsim19deciles5xfutures20xintersect.csv'
	fire_planning_years	The number of years to run ForSys and fire. This value cannot be greater than the number of years in the fire intersect table.	Integer	1	10
	fire_annual_target_field	Field name for field to use to calculate the annual planning area target. To be used when the annual target varies by planning area.	String (required when run_with_fire = TRUE)	NULL	'Area_HA'
	fire_annual_target	Numeric value for annual planning area target, when annual target is constant across all planning areas.	Integer (required when run_with_fire = TRUE)	NA	1000
	fire_dynamic_forsys	Logical whether to remove burnt stands from	Logical	FALSE	TRUE or FALSE

		available selection over time.			
	fire_random_projects	Logical whether to include random projects.	Logical	FALSE	TRUE or FALSE
Patchmax	patchmax_proj_number	Number of projects to be built.	Integer	1	5
	patchmax_proj_size	Target area for each project.	Integer	Inf	2500
	patchmax_proj_size_min	Minimum area viable for each project.	Integer	-Inf	100
	patchmax_sample_frac	Proportion of stands to search as best patch seed.	Integer	0.1	0.5
	patchmax_sample_seed	Random number generator used for random sampling.		NULL	
	patchmax_SDW	Stand distance weight parameter. At 1, the distance cost of adding the stand with the lowest priority score is penalized by 10x. Distances are unmodified when SPW = 0.	Numeric (0-1)	0.5	1
	patchmax_EPW	Stand exclusion weight parameter. At zero ForSys will jump over stands to find high objective stands; increase to 1 if the penalty of jumping over stands (e.g., a riparian area) is too costly to force patchmax to search around unavailable stands.	Numeric (0-1)	0.5	0
	patchmax_exclusion_limit	Maximum proportion of patch that can be excluded from treatments; et to 1 if patches can be as large as needed, with only a small	Numeric (0-1)	0.5	0.2

		proportion of stands actually treated			

1.A. Input stand data

ForSysR uses a stand table in which each row corresponds with a unique stand attributed with mandatory information, including a unique stand identification code, a planning unit identification code, and area metrics. The stand table also contains fields describing the characteristics of each stand with respect to the objectives, treatment thresholds, stand availability, investment or activity constraint, and other subdivisions, such as national forest (Table 2).

To normalize objective metrics among stands of varying size or create a standardized reporting metric to compare objectives of varying units, ForSysR contains a function to normalize values for each objective metric with the **calculate_spm** and **calculate_pcp** functions. The latter function calculates the percent contribution to the problem (PCP) for each selected metric such that the stand is assigned the percentage value it contributes to the entire landscape. The **calculate_spm** function calculates the standardized percent of the maximum (SPM) for each selected metric such that the stand is assigned the percentage value of the maximum across the landscape. Weighting priorities based on the SPM value will reduce the potential bias of large stands, and allow users to weight multiple objectives and ensure the same scale. Both the PCP and SPM calculations can be set to be calculated on a user defined land base. For example, if a user were interested in limiting the analysis to exclude wilderness areas, this would be defined here and those areas would not contribute to PCP or SPM calculations. The SPM metric is used to account for varying stand sizes when weighting objectives. These calculations are made outside the ForSys run function.

```
forsys::calculate_spm(fields = c("priority1", "priority2"), availability_txt = 'Wilderness == 0')
forsys::calculate_pcp(fields = c("priority1", " priority2", "biomass"), availability_txt = 'Wilderness == 0')
```

Table 2. Basic content of the stand table. Treatment thresholds may include expected wildfire behavior, timber volume, or other operational constraints that must be met for specific treatments to be considered within a stand. Simple treatment restrictions can also be integrated as a treatment availability flag (e.g. a field in which manageable = 1, non-manageable = 0 could be used to include only manageable areas). The user can employ stand-level "percent contribution to the problem" (PCP) objective metrics to homogenize units among the different objectives and facilitate output analysis and interpretation (see section 1.A).

Attribute	Parameter	Description	Data type
Stand ID	stand_id_field	Unique stand identification	integer
Predefined planning area ID	proj_id_field	Unique planning area identification	integer
Area	stand_area_field	Area of the stand	numeric
Objective$_n$	scenario_priorities	Objective metric$_n$, stand value, and/or standardized percentage of the maximum (SPM), for objective n	numeric
Threshold	stand_threshold	Treatment threshold	numeric
Availability	global_threshold	Availability flag	character
Outputs$_n$	scenario_output_fields	Stand values or effects to be summarized and/or percentage contribution to the problem (PCP) for output or objective variable n	numeric

1.B. Objective priorities and weights

ForSysR allows the user to consider multiple priorities when selecting stands for treatment in the **scenario_priorities** parameter in the configuration file or run function. In multiple-objective scenarios, the user must specify the Min Weight, Max Weight and Step as integer values in the **scenario_weighting_values** parameter, or it will be set to the default (c(1,1,1)). The steps represent the intervals between the maximum and minimum weights that determine the objective weight combinations. These values are filtered to exclude repetitive weights (e.g. weights 1-1 will provide the same results as weights 2-2 or 3-3 for a set of two-priority scenarios). For two objectives if a user selects weights between 0 and 3, ForSysR will run nine scenarios. Each scenario represents one combination of weights. For example, if objective1 is weighted 0 and objective2 is weighted 3, ForSysR will prioritize stands with high values of objective2 and will not consider objective1. If both objective1 and objective2 are weighted 1, ForSysR will prioritize stands that contribute to both objectives.

To pass a specific set of weights to the ForSys run function, the combine_priorities function can be used. Here we equally weight priorities 1 and 3, but increase the weight of priority 5. The 'tri_priority' field that is created will the be called in the scenario_priorities parameter.

```
forsys::combine_priorities(
  fields = c('priority1','priority2', 'priority3'),
  weights = c(1,5,1),
```

new_field = 'tri_priority')

1.C. Treatment thresholds

Treatment thresholds are conditions that must be met in order for a stand to be considered for treatment. In ForSysR these thresholds are additive, meaning all conditions must be met in order for a stand to be included in the selection process. The **stand_threshold** parameter defines thresholds. A global stand filter can also be applied with the **global_threshold** parameter and is applied to all stands, for example that the area of the stand must be greater than 10 acres (c("standarea_acre >= 10")).

1.D. Constraints

The user must specify a planning unit-level treatment constraint when run_with_patchmax == FALSE that represents the total possible investment in management activities for a given planning unit. Typically, this is expressed in terms of area treated, a budget, or a target harvest volume. This can be a static value (e.g. treat 2000 acres) where **proj_fixed_target** is set to TRUE, or can vary by subunit (**proj_fixed_target** is set to FALSE). Constraints provide parameters for treatment solutions based on attributes within the input data. An area constraint, for example, specifies the total area that can be treated in a given planning area, and the field in the stand table that contains the area of each stand is set as the **pa_unit**. This is similar to subunit constraints in ForSysX. For variable targets, the target varies for each planning unit; here the **proj_fixed_target** is set to FALSE, the **proj_target_field** is set to the field containing the area within each planning area and the **proj_target_value** is set to the proportion of the planning area that should be treated. Thus the **proj_target_value** will be duplicated for each stand within the same planning area. The variable target is the equivalent to running ForSysX with Constraint by Subunit checked.

1.E. Output fields

The output fields are the data the user wants summarized by planning unit, which includes statistics about area treated and treatment effects. These are set in the **scenario_output_fields** parameter. The program sums the outputs for each planning unit and reports these values in the project output results file. If the user defines other grouping categories in the **scenario_output_grouping_fields** parameter, such as summarizing results by ownership group or forest type, these outputs will be available in the subset output file. The reported results include one field for the sum of all treated stands indicated with the ETrt prefix. ForSysR also outputs planning area solutions for planning areas that contain no treated stands; these are indicated with a treatment_rank = 0 in the output files.

1.F. Output files

Forsys always writes its outputs to csv files saved within the output folder (unless **write_outputs** == FALSE), but we can optionally set it to write that data out to a list which has three elements containing the outputs (**return_outputs** == TRUE): 1) project level output, 2) stand level output and 3) subset output which includes additional grouping levels if specified in **scenario_output_grouping_fields**. The proj_*.csv lists all the project areas with a summary of the treated areas (ETrt_x fields), the weighted priority for a given project area (weightedPriority), the weight assigned to each of the two priorities (Pr_1_x, Pr_2_x), and the final treatment rank for each project area (treatment_rank). The treatment rank designates the order in which planning areas should be treated, with the highest priority treatment rank equal to one. The subset_*.csv files break out the planning area information in the pa_all.csv by other grouping categories (as listed in the input **scenario_output_grouping_fields** and described in section 1.E). This may include categories within project areas such as ownership, forest type, or management designation. Detailed stand outputs are reported in the stnd_*.csv file. These files include a list of the stands that are treated for the given weighted scenario.

2. Saving Runs

The user must create a new configuration file or run function for each scenario or set of weighted scenarios.

3. Data preparation and structure

ForSysR input data are stored in a CSV or a DBF stand table, and in the case of spatial optimization using patchmax, a shapefile or featureclass is required. The variables described in this section are used to populate the fields described in section 1.A. There are five primary types of stand data included in the table for most ForSysR runs: 1) land base variables, 2) exclusion variables, 3) priority or objective variables, 4) contribution variables, and 5) target variables.

3.A. Land base variables

Most datasets used for scenario planning and prioritization will include location-descriptive land base attributes: a unique stand identifier (**stand_id_field** = "Cell_ID") and project area identifier (**proj_id_field** = "POD_ID"). Additional potential extent variables may include (but are not restricted to) national forests, districts, PODS, or ownership. These variables allow the user to define where stands should be selected. Typically stands are selected within project areas, then project areas are selected for treatment based on priority ranking within a larger extent (e.g. five project areas may be selected per national forest to meet a restoration treatment goal, or the number of project areas required to meet a regional timber target).

3.B. Exclusion variables

ForSysR excludes stands that have been designated as non-treatable by the user, such as wilderness and other protected areas. These exclusions are managed through the **global_thresholds** parameter as described in section 1.C. In addition to treatment exclusions, stands may be excluded for treatment based on a threshold such as merchantable volume, a forest or cover type, ownership, or any local variables that would preclude entry into a stand using the treatment threshold options.

3.C. Priority/value variables

Priority variables describe values on the landscape that matter to managers and decision-makers and are quantitative links to management questions. These may include timber volume, building exposure from wildfire ignitions, wildfire hazard potential, wildfire risk to drinking water or biodiversity as examples. These are variables that ForSysR uses to meet treatment targets. ForSysR prioritizes stands based on these metrics, and in most cases it is important to normalize these metrics with the **calculate_SPM** function. This function normalizes a priority metric as a standardized percent of the maximum (SPM) value for each of these variables (described in section 1.A) to rank and select stands, subject to a constraint and thresholds. The SPM value is calculated as the percent of the maximum value for each priority. In addition, a percent contribution to the problem (PCP) value can be calculated for each variable within each stand. The PCP is calculated as the percent of the sum of all stand values for a given priority. In some cases the meaning of the PCP is clear, for example the total percent of building exposure that is treated for a given scenario or a given planning area. For priorities that are based on an index or non-market value, describing this output is more challenging. Treating X% of the wildfire hazard potential, for example, may be less meaningful than an analysis of the pre- and post-treatment expected flame length of treated stands. But the PCP values allow for the comparison of all metrics of varying units in output analysis.

3.D. Contribution variables

Stand contribution variables are the value each stand provides to meet a larger target. These variables may include anything that can be summed across stands, including timber volume, area, building exposure, and more, and may be the same as a priority or objective value variable. A common method is to set a treatment area target for planning areas and select stands based on their contribution to that target until the treatment target is met but not exceeded. These values are summed over planning subunits, and the summations can be used to meet targets at greater extents as well. For example, we can identify how many planning areas can be treated within a forest, while staying within a forest-level target.

3.E. Treatment target variables

Target variables are used to describe a treatment goal, such as total volume and area treated. Targets work in concert with stand contribution variables, which are more descriptively called the stand contribution to the target. Targets can be incorporated at the planning area level (e.g. treat 10% of each planning area), the forest (treat planning areas until a boardfoot target is met), or any other extent.

3.F. Determining suitability of data for use in ForSysR

The resolution and extent of spatial data must meet certain criteria for use in ForSysR. Data that are intended for use as priority variables must be at a higher resolution than the planning area scale, and ideally a higher resolution than the average stand size. Data intended for use as stand exclusion variables have no restrictions to their resolution, as they act as a filter. Past work has shown that very large variability in stand size can affect results, and as a rough guide stands ranging in size from 1 to 100 acres have functioned well in the program, although SPM values will correct for differences in most cases. *Data included in the model must align with management objectives and questions; and scenarios, including priorities, constraints and treatment thresholds, must be well developed prior to developing a final dataset for input into ForSysR.*

3.G. Preparing data for use in ForSysR

There are five steps to preparing data for inclusion in ForSysR scenarios recognizing that it is import to first identify key objectives and management questions and how to use quantitative metrics to address these questions: 1) determine what dataset will be used as a stand layer, 2) identify the type of data you are adding, 3) determine how to attribute the data to the stand layer depending on data type, 4) spatially link data with stands using tools such as the ArcGIS tool Zonal Stats as Table, and 5) join the zonal statistic output data to the stand attribute table. Stand layers can be forest-level stand layers, hexnets intersected with land base variables such as ownership or manageability, or fine-scale polygon-based vegetation spatial data. ForSysR requires certain variables to have specific data types (see Table 2) and none of the variables in the dataset can contain null values. Users need to examine maps of each priority variable and summary statistics prior to running scenarios to understand how the values are distributed across the landscape. For instance, two priorities that are highly spatially correlated will reveal the same answers and not identify tradeoffs.

3.H. Utilizing raster data in ForSysR\

An ArcPro tool has been developed to convert raster data to a stand layer, and then attribute the stand layer with other raster or feature class data. This tool is available upon request.

4. Outputs

ForSysR generates a series of output files for each scenario, which are listed below.

4.A. Tabular outputs

1. **Main results. The pa_all.csv file is a planning-area or project-level dataset containing the summarized treatment variables for all treated stands within all planning areas for all weighted scenario combinations.**
    - For most analyses, this file will contain the most important results. As a result, ForSysR will always produce this file and there is no option to deselect this output.

2. **Stand-level treatments. Each csv file (one for each weighted scenario) contains stands that were selected for treatment within each planning or project area. These data are used to add information about treatments based on other attributes such as individual forest districts, and other spatial statistics that exist at the stand level but are lost at the level of the aggregated planning area data.**

- These outputs are most useful for identifying which stands were selected in a given weighted scenario and for comparing how those selections change as priority weights shift.

3. **Planning Area Results by Group. The pa_subset.csv file is a planning-area level dataset containing the summarized treatment variables for all treated stands within all planning areas for all weighted scenario combinations and by a grouping variable, for example ownership or forest type. Therefore, users can examine the contribution to the treated area by these groupings. For example, how many acres were treated on USFS lands, and how much volume or building exposure was treated on USFS lands.**

4.B. Post-processing ForSysR results

There are three primary figures used for interpreting ForSysR outputs: (1) cumulative attainment graphs, (2) production frontiers (PFs), and (3) maps. Each of these are built using the data stored in the pa_all_x.csv. These figures are created outside ForSysR using a combination of Excel, R or other graphing programs, and ArcGIS. See the Quick Start Guide for ForSysX for instructions on using the automated Excel graphing program. Below is a brief description of the primary means of interpreting ForSysR outputs.

4. **Cumulative attainment graphs. These graphs describe results in two ways: 1) how much of a total problem is treated (cumulative attainment of the PCP values), and 2) how much of something is produced (total timber volume, potential building exposure mitigated). Planning areas are ordered by treatment_rank for a specific weighted scenario and effects are summed as a successive number of planning areas are considered. Cumulative attainment graphs are shown for four scenarios where objectives are prioritized individually (Fig. 3). For instance, Fig. 3 shows attainment in reduction of building exposure when exposure is prioritized *and* when three other objective are each individually prioritized. In addition, these graphics can show attainment by ownership, forest, region, and other subcategories.**

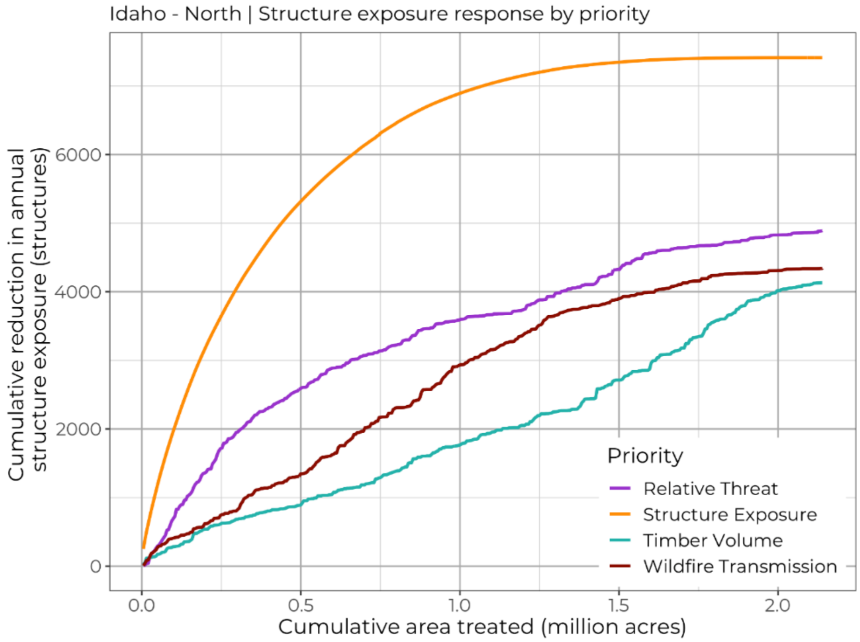

Figure 3: Cumulative attainment curves for building exposure for four different scenarios where each objective is individually prioritized. The rate of attainment under a building exposure priority is much higher than any other priority, suggesting a strong tradeoff exists between protecting buildings and efficient timber production, for example. This graph was created using pa_all_*.csv files for multiple scenario runs and cumulatively summing the output and area treated metrics for each scenario.

5. **Production Frontiers.** Production frontier (PF) curves are typically grouped at the predefined planning area level. Each curve graphs the total attainment of two priorities for a given range of weighted scenarios for each single planning area (Fig. 4). In most cases, producing more of one variable will necessarily mean producing less of the other variable. This allows a manager to identify two things: 1) planning areas where both values can be produced at high levels, and 2) solutions for a given planning area where one priority can be increased with a small opportunity cost relative to the other priority. For example, the PF curve for planning area 1439 in Fig. 4 has the highest attainment for both objectives, although skewed towards exposure reduction. It is important to understand that each point on a single curve is a different selection of stands within the planning area where one objective is weighted more, less, or equal to the other (as set in the **scenario_priorities** and **scenario_weighting_values** parameters). The shorter the curve the fewer combinations of stands are available to increase attainment for a given priority. The longer the curve, the more opportunities there are on the landscape to change a selection of treatment stands to emphasize one metric or another.

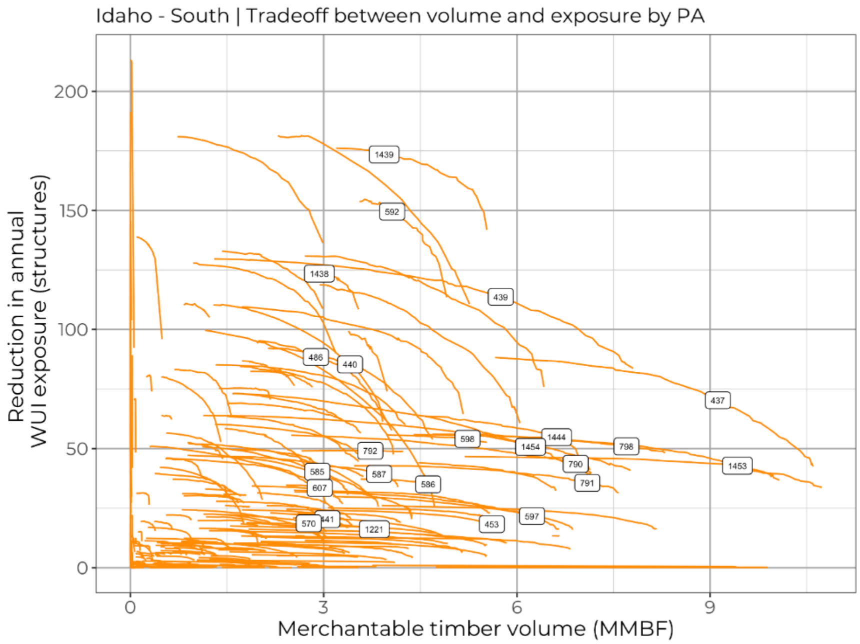

Figure 4: Production frontiers for a timber-building exposure tradeoff in the northern Idaho study area. This graph was created using the pa_allIdaho_test.csv file and graphing the two ETrt_* metrics shown above. Each line represents a single planning area with points along the line the different weight combinations (two *_SPM columns). Numbers reference the planning area ID.

6. Maps. Maps are produced within ArcGIS or R and are typically most useful to identify and sequence planning areas. Mapping requires filtering the pa_all.csv data to a single priority weighting combination (say 0 for priority 1 and 1 for priority 2; or where Pr_2_*_SPM = 0 and Pr_1_*_SPM = 1) and joining the rows from that selection to the project areas shapefile using the **proj_id_field**. The treatment_rank indicates the planning area rank for that scenario ordered by the priority of interest or the weighted value. Maps similar to those shown in Fig. 5 could be created for each weighting combination or scenario. For a scenario where **scenario_weighting_values = c(0,1,0)**, there are 21 different weighted scenarios, which in turn could produce 21 different maps. Doing so would show how stand selection gradually shifts between the two extremes shown in Fig. 5 under different combinations of weighted priorities. Note also that in this kind of scenario, some planning areas might not meet the treatment target.

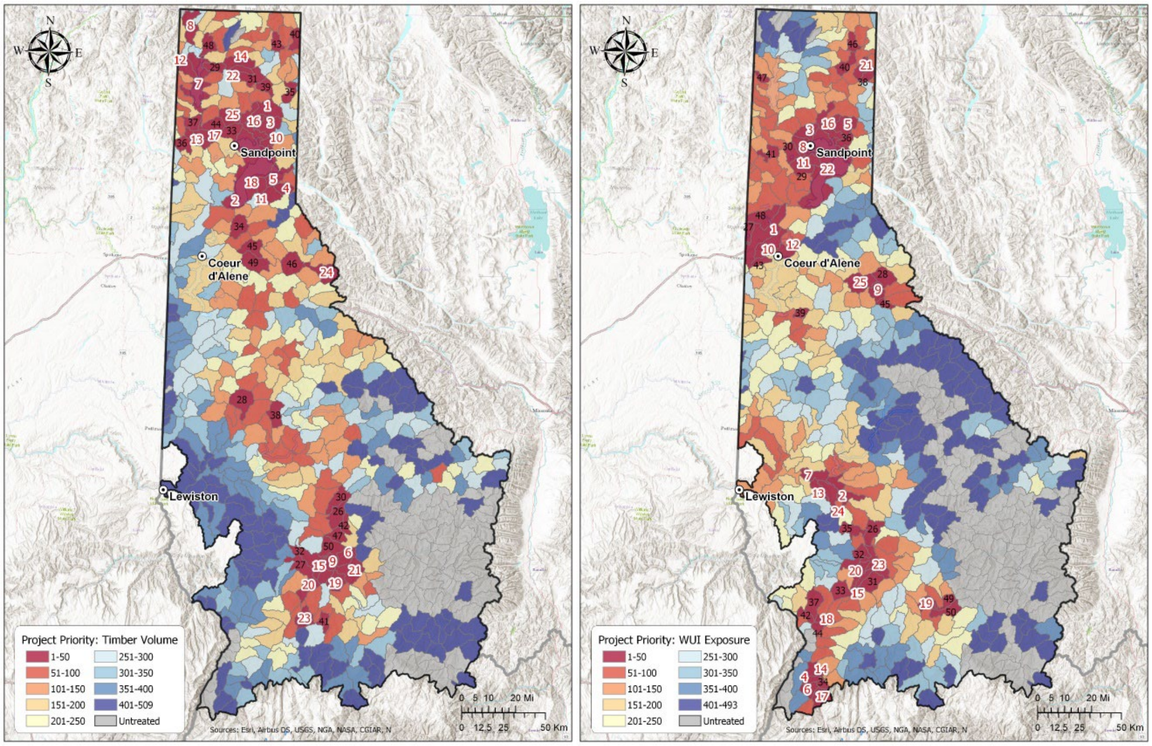

Figure 5: Planning area treatment ranking when prioritizing only A) timber volume or b) building exposure. The top 50 projects are labeled. Stands are available for treatment on any land tenure; 2500 ha of each planning area are treated.

Acknowledgments

This manual was written by Rachel Houtman and Michelle Day. Stu Brittain and Alan Ager designed version 1 of ForSysX (formerly the Landscape Treatment Designer), the executable version of ForSys. Rachel Houtman, Cody Evers, Pedro Belavenutti, Michelle Day and Alan Ager all contributed to ForSysR. Ken Bunzel has provided all updates and programming for version 2 of ForSysX.

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