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fireexposuR: An R package for computing and visualizing wildfire exposure

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Software

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Summary

`fireexposuR` (v1.2.0) is an R package that automates wildfire exposure methodologies presented in several scientific publications (Beverly et al., 2010, 2021; Beverly & Forbes, 2023), providing an accessible and adaptable platform to a broad user base. Wildfire exposure is a numeric rating of potential wildfire transmission to, or from, a location based on the composition and configuration of the surrounding wildland fuels (i.e., flammable vegetation). Exposure assessments can be applied at multiple spatial scales (e.g., neighbourhood, region, country) to inform a wide range of management objectives and decisions (e.g., fuel management priorities, evacuation planning, land-use planning, habitat conservation, firefighting resource optimization); and are particularly well-suited for scenario and contingency planning. `fireexposuR` has functions for computational analysis and generating visualizations of results in summary tables, plots, and maps.

Background

Wildfire exposure assessments were originally introduced to assess fire entry points to the built environment (Beverly et al., 2010). The method is promoted nationally by FireSmart Canada as a tool for community protection planning (Firesmart Canada, 2018). The approach was later adapted for landscape scale assessments by Beverly et al. (2021), which included a performance validation confirming real wildfires burn preferentially in high exposure areas. Exposure assessments are omnidirectional but can be summarized locally to assess the directional vulnerability of a given location to potential fire encroachment using radial graphs developed by Beverly & Forbes (2023). Outputs of wildfire exposure and directional vulnerability assessments are typically well received and easily understood by diverse audiences due to the intuitive visualizations. The methods and data requirements are also comparatively simpler than alternative wildfire risk models, making them an ideal option when constrained by budget or time. These methods were developed in Alberta, Canada; but have since been adapted successfully to other geographic areas. Schmidt et al. (2024) customized exposure assessments for use in Alaska, USA, Khan et al. (2025) have applied them in Portugal, and a publication is currently in preparation that applies and validates the exposure metric across the entire Canadian land base (Beverly & Mahler, 2025). Research is also underway to adapt the methods for use in the United Kingdom. The exposure metric has been used as an input to evacuation planning (Kim et al., 2024), fuel treatment planning (Karimi et al., 2024), and to assess telecommunication vulnerability (Kuiper & Beverly, 2025).

Statement of need

Broad distribution and uptake of exposure and directional vulnerability assessments has been constrained by the technical nature of the original documentation within scientific publications,

some with access fees; and the need for proficiency in, and access to, geographic information system (GIS) software. The published methods were described in relation to Esri Inc. ArcGIS software and geoprocessing tools which has a subscription-based model that can be financially prohibitive to some users.

Conceptually, the methodologies are relatively simple, but they involve a detailed sequence of data processing steps that can intimidate new users, especially those lacking foundational knowledge in GIS and spatial analysis. New users may introduce unintentional errors, by misinterpreting processing steps or input data requirements and can lack confidence in their understanding of the methods and their process for executing the analysis independently. The objectives of `fireexposuR` are to reduce barriers to access and give users structured support to independently apply the methods with confidence. The analysis functions were developed and vetted in collaboration with the primary author of the wildfire exposure publications upon which `fireexposuR` is based. Custom parameterization options have been designed and described for adaptability within the suggested scope. In addition, a validation function has been included to confirm any custom decisions in alternative use cases or geographic areas. The package was developed in the R environment (R Core Team, 2024), an open-source platform with no financial fees. Package documentation is presented in plain language to ensure access to a non-technical audience. Access to the package requires basic proficiency in the R environment, which could present a barrier to some users; however, abundant online resources and tutorials are available to anyone willing to learn.

State of the field

At the time of writing, `fireexposuR` is the only fully open-source software option for computing and visualizing wildfire exposure. A custom Python toolbox has also been developed to replicate the wildfire exposure methods in Schmidt et al. (2024), and is freely available on GitHub (v1.0.5; GINA/ISER (2024)) but requires an ArcGIS license. The toolbox guides users through the steps of defining a hazardous fuel raster, computing ember exposure for fixed distances, and other additional steps specific to the methods presented in Schmidt et al. (2024). In comparison, `fireexposuR` includes transmission distance customization, directional vulnerability assessments, and rapid visualization of results with sensible defaults.

Target audience

The target audience for `fireexposuR` includes researchers, agencies, practitioners, and individuals who are interested in conducting wildfire exposure assessments. Package functions are highly customizable, for ease of application in new geographic areas or use cases.

Typical workflow

The workflow for conducting wildfire exposure assessments using the functions within the `fireexposuR` package is demonstrated in Figure 1. Input data requirements are detailed in the function documentation.

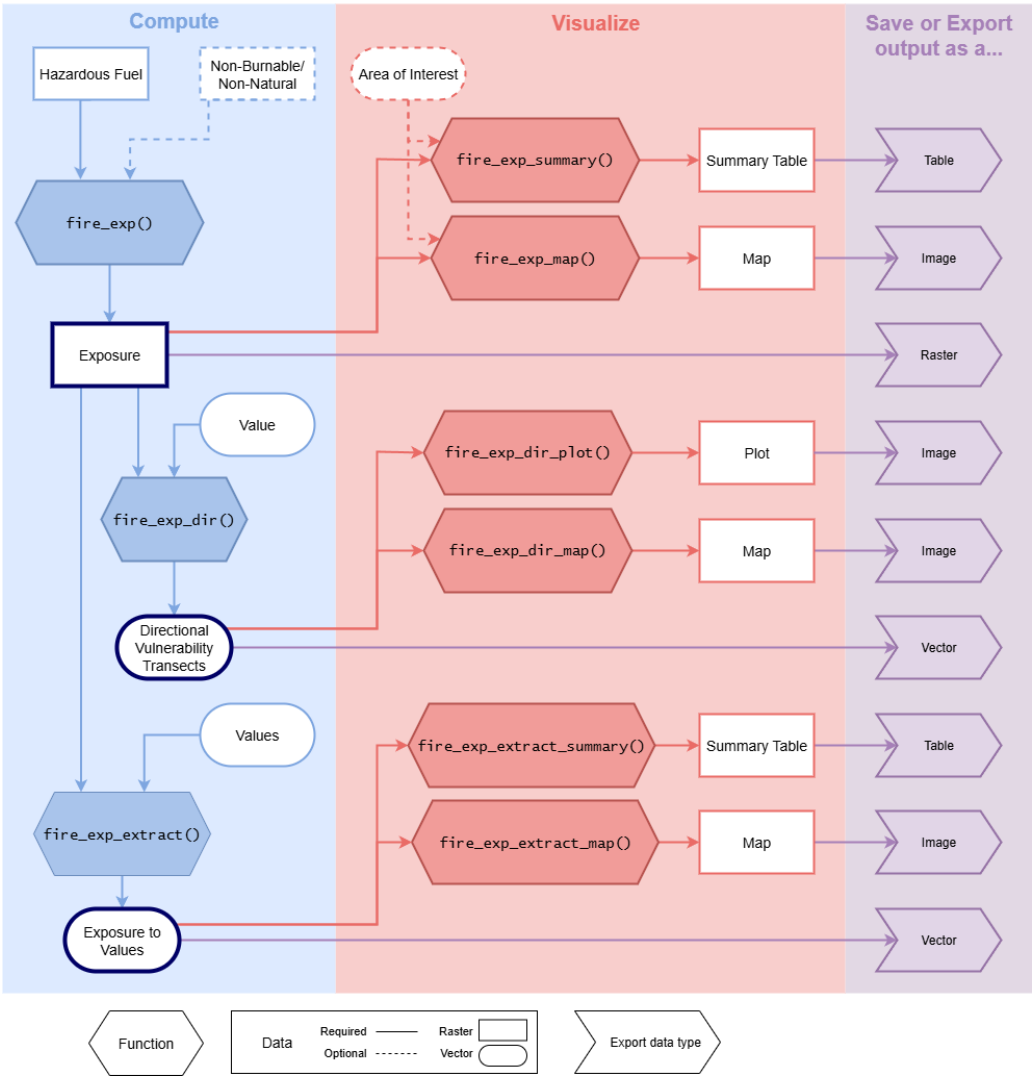

Figure 1: Figure 1. Suggested workflow of core `fireexposuR` functionality. Computational outputs, outlined in navy, can be further manipulated in R, visualized with `fireexposuR` functions, or exported. Images and tables can be exported with base R and spatial data can be exported with `{terra}`.

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