



M9 - Conceptual prioritisation framework for listed IAS developed

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**Author(s): Joana Vicente, Renato Henriques,
Cândida G. Vale, Eva Malta-Pinto, João F.
Gonçalves**



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Table of contents

| | |
|--|----|
| 1. Introduction..... | 9 |
| 1.1. Background and Motivation | 9 |
| 1.1. Project Objectives | 9 |
| 1.2. Scientific Framework | 9 |
| 2. Technology Stack..... | 10 |
| 2.1. Overview..... | 10 |
| 2.2. Core Technologies..... | 10 |
| 2.3. Architecture Decisions | 10 |
| 2.3.1. No External Charting Libraries..... | 10 |
| 2.3.2. State Management..... | 11 |
| 2.3.3. Computation Architecture | 11 |
| 2.4. Build Configuration | 11 |
| 2.5. Dependencies..... | 11 |
| 2.6. Data Flow Architecture | 11 |
| 2.7. Browser Compatibility | 12 |
| 3. Project Structure..... | 12 |
| 3.1. Directory Overview | 12 |
| 3.2. Source Code Organization..... | 13 |
| 3.2.1. Components Directory | 13 |
| 3.2.2. Engine Directory | 14 |
| 3.2.3. Utils Directory..... | 14 |
| 3.3. File Statistics..... | 14 |
| 3.4. Module Dependencies | 15 |
| 4. File Descriptions..... | 15 |
| 4.1. Application Entry Points..... | 15 |
| 4.1.1. main.jsx | 15 |
| 4.1.2. App.jsx | 16 |
| 4.2. Engine Modules | 16 |
| 4.2.1. isiEngine.js..... | 16 |
| 4.2.2. calculations.js..... | 18 |
| 4.3. Utility Modules | 18 |
| 4.3.1. constants.js | 18 |
| 4.3.2. helpers.js..... | 19 |
| 4.3.3. icons.jsx | 19 |
| 4.4. Tab Components (Main Views)..... | 19 |
| 5.4.1. DashboardTab.jsx..... | 20 |
| 4.4.1. WeightedISITab.jsx..... | 20 |





M9 - Conceptual prioritisation framework

| | | |
|---------|-----------------------------------|----|
| 4.4.3. | TemporalTab.jsx | 21 |
| 4.4.4. | TemporalVisualization.jsx | 21 |
| 4.4.5. | PrioritiesTab.jsx | 22 |
| 4.4.6. | SnapshotComparison.jsx | 22 |
| 4.5. | Layout Components | 23 |
| 4.5.1. | Header.jsx..... | 23 |
| 4.5.2. | Footer.jsx | 24 |
| 4.5.3. | TabNavigation.jsx | 24 |
| 4.5.4. | EditModeBar.jsx..... | 25 |
| 4.5.5. | ProjectIndicator.jsx | 25 |
| 4.6. | Editor Components | 25 |
| 4.6.1. | FaceGrid.jsx..... | 25 |
| 4.6.2. | FillInput.jsx..... | 26 |
| 4.6.3. | SnapshotCard.jsx | 26 |
| 4.7. | Components | 27 |
| 4.7.1. | ISISlider.jsx | 27 |
| 4.7.2. | LoadingSpinner.jsx | 27 |
| 4.7.3. | ProjectManager.jsx | 28 |
| 5. | Screen Descriptions | 28 |
| 5.1. | Editor & Snapshots | 28 |
| 5.1.1. | Screen Overview..... | 29 |
| 5.1.2. | Header Bar..... | 29 |
| 5.1.3. | Project Status Indicator..... | 30 |
| 5.1.4. | Tab Navigation..... | 30 |
| 5.1.5. | Species List Panel | 30 |
| 5.1.6. | Species Configuration Bar | 30 |
| 5.1.7. | Six-Face Grid Editor..... | 31 |
| 5.1.8. | Capture Snapshot Panel..... | 31 |
| 5.1.9. | Saved Snapshots Panel..... | 32 |
| 5.1.10. | Footer..... | 32 |
| 5.1.11. | Workflow Summary..... | 32 |
| 5.2. | Snapshot Comparison | 33 |
| 5.2.1. | Screen Overview..... | 34 |
| 5.2.2. | Compare Snapshots Panel..... | 34 |
| 5.2.3. | Summary Statistics Cards..... | 34 |
| 5.2.4. | Species Comparison Table..... | 35 |
| 5.2.5. | Change Matrix Heatmap | 35 |
| 5.2.6. | Species Evolution Bar Chart | 36 |
| 5.2.7. | Analytical Capabilities | 36 |





- 5.3. Dashboard Summary 37
 - 5.3.1. Screen Overview..... 39
 - 5.3.2. Key Performance Indicators..... 39
 - 5.3.3. Active Alerts Panel..... 39
 - 5.3.4. Top 5 Priorities Panel..... 40
 - 5.3.5. Risk Matrix by Species..... 40
 - 5.3.6. Recent Trends Charts..... 41
 - 5.3.7. Action Buttons..... 41
 - 5.3.8. Use Cases 41
- 5.4. Weighted ISI 42
 - 5.4.1. Screen Overview..... 43
 - 5.4.2. Parameter Configuration Panel..... 43
 - 5.4.3. Uncertainty Quantification..... 44
 - 5.4.4. ISI Evolution & Breakdown Section 44
 - 5.4.5. Species Turnover Dynamics Chart 45
 - 5.4.6. Scientific Applications 46
- 5.5. Temporal Analysis 46
 - 5.5.1. Screen Overview..... 48
 - 5.5.2. Aggregate ISI Evolution Chart 48
 - 5.5.3. Species Selection Controls 48
 - 5.5.4. ISI Evolution Chart (Species-Specific) 49
 - 5.5.5. Parameter Evolution Chart..... 49
 - 5.5.6. Analytical Capabilities 50
 - 5.5.7. Data Requirements 50
- 5.6. Prioritisation 50
 - 5.6.1. Screen Overview..... 50
 - 5.6.2. Common Interface Elements 50
 - 5.6.3. ISI Global Analysis Mode..... 52
 - 5.6.4. ISI by Species Mode 53
 - 5.6.5. Impact Priority Mode 55
 - 5.6.6. Traits Priority Mode..... 57
 - 5.6.7. Spread Priority Mode 59
 - 5.6.8. Management Priority Mode..... 61
 - 5.6.9. Drivers Priority Mode 63
 - 5.6.10. Detectability Priority Mode 65
 - 5.6.11. Common Features Across Face-Specific Modes..... 66
 - 5.6.12. Analytical Applications 67
- 6. Conclusion..... 67
 - 6.1. Current Capabilities 67





M9 - Conceptual prioritisation framework

| | | |
|------|--------------------------------------|----|
| 6.2. | Technical Achievement..... | 68 |
| 6.3. | Extensibility and Customization..... | 68 |
| 6.4. | Document Scope..... | 68 |
| 7. | Acknowledgements..... | 69 |
| 8. | References..... | 69 |





Summary

Invaders Toolbox is a comprehensive web-based scientific application designed for invasive species analysis, monitoring, and management decision support. The system serves a dual purpose: as a **research platform** for ecological studies and as an **operational tool** for invasion dynamics tracking and evidence-based decision-making.

The application implements the **Invasive Species Index (ISI)**, a multi-component metric that quantifies invasion pressure through six taxonomic dimensions: Impact, Invasiveness Traits, Geographic Spread, Management Effort, Drivers/Pathways, and Detectability.

As a **Research Platform**, Invaders Toolbox provides ecological researchers with:

- Real-time ISI calculation with 14 configurable parameters
- Bootstrap uncertainty quantification (95% confidence intervals)
- Interactive data visualization with native SVG charts
- Cross-platform compatibility via Progressive Web App architecture

As a **Monitoring and Registry System**, the application enables:

- Temporal snapshot management for longitudinal tracking of invasion dynamics
- Species portfolio evolution analysis across multiple time points
- Change detection and trend identification through comparative visualization
- Standardized data collection ensuring consistency across monitoring campaigns

As a **Decision Support Tool**, Invaders Toolbox empowers managers and policymakers with:

- Multi-criteria species prioritization across eight analysis modes
- Configurable risk thresholds adaptable to regional management objectives
- Component contribution analysis identifying key intervention targets
- Executive dashboards with alerts and actionable recommendations

This document presents the technical architecture, file structure, and functional overview of the Invaders Toolbox Web v3.0 implementation.





List of abbreviations

| | |
|------|----------------------------|
| EU | European Union |
| ISI | Invasive Species Index |
| SPA | Single Page Application |
| JSON | JavaScript Object Notation |
| SVG | Scalable Vector Graphics |
| DOM | Document Object Model |
| sm | Small screen |





1. Introduction

1.1. Background and Motivation

Invasive species represent one of the most significant threats to global biodiversity, ecosystem services, and economic stability. Effective monitoring and management therefore require standardized assessment frameworks capable of integrating multiple data dimensions across spatial and temporal scales, while capturing both the magnitude and dynamics of species impacts.

The **Invasive Species Index (ISI)** is an integrated framework for the prioritisation of invasive alien species in the European Union, developed to address this need. The ISI is designed as a weighted, composite metric that synthesises key components of invasion pressure and risk, including:

Severity Score - aggregate impact considering ecological damage, geographic extent, management costs, and detection difficulty

Dynamic Sensitivity - temporal changes in species pressure between monitoring periods

Invasiveness Traits - biological characteristics that facilitate establishment and spread

Drivers/Pathways - introduction vectors and environmental facilitators

Species Turnover - net flux of species entering and exiting the monitored area.

Together, these components enable consistent comparison and prioritisation of invasive alien species across regions and monitoring periods.

The ISI is operationalised through a multiple-dimensional data structure, adopting a data cube approach, described by Oldoni *et al.* 2020. The design of the integrated prioritisation framework considers flexibility and scalability, ensuring applicability across taxa, spatial scales, and policy needs.

This integrated approach enhances the effectiveness of IAS prioritisation by linking a robust composite index with a structured and interoperable data representation. The resulting ISI framework supports public awareness activities, effective management planning, and the provision of evidence-based inputs for policy briefs, aligning with contemporary data management practices for complex ecological assessments.

1.1. Project Objectives

The Invaders Toolbox Web application was developed to:

- Provide an accessible, browser-based interface for ISI calculations
- Enable temporal tracking through snapshot-based data management
- Support scientific rigor through configurable parameters and uncertainty quantification
- Facilitate data exchange via JSON import/export compatible with Python implementations
- Deliver professional-grade visualizations for research publications and reports

1.2. Scientific Framework

The ISI calculation follows the mathematical framework:





$$ISI = w_S \cdot \bar{S}_{port} + w_{Dy} \cdot f_g + w_T \cdot T_{port} + w_D \cdot D_{port} + w_E \cdot \tau \quad (1)$$

Where:

- \bar{S}_{port} = Portfolio-weighted severity score
- f_g = Growth dynamics function (logistic transformation)
- T_{port} = Aggregated invasiveness traits
- D_{port} = Drivers and pathways component
- τ = Species turnover signal
- w_* = Configurable component weights (normalized)

2. Technology Stack

2.1. Overview

The Invaders Toolbox Web v3.0 is built as a modern Single Page Application (SPA) using a lightweight, dependency-minimal architecture. This design decision prioritizes:

- **Performance** - Minimal bundle size with no heavy external charting libraries
- **Portability** - Easy deployment across different hosting environments
- **Maintainability** - Clear separation of concerns with modular components
- **Scientific Accuracy** - Native implementation of ISI calculations without third-party abstraction

2.2. Core Technologies

Table 1: Primary technology stack

| Technology | Version | Purpose |
|-----------------|-----------|-------------------------------------|
| React | 18.2.0 | UI component framework |
| Vite | 5.4.0 | Build tool and development server |
| Tailwind CSS | (via CDN) | Utility-first styling |
| Native SVG | - | Data visualization (charts, graphs) |
| JavaScript ES6+ | - | Application logic |

2.3. Architecture Decisions

2.3.1. No External Charting Libraries

Unlike typical data visualization applications that rely on libraries such as Chart.js, D3.js, or Recharts, the Invaders Toolbox implements all charts using native SVG elements. This approach provides:

- Complete control over rendering and styling
- Reduced bundle size (no additional dependencies)
- Consistent visual language across all visualizations
- Easier customization for scientific publication requirements





2.3.2. State Management

The application uses React's built-in state management through `useState` and `useEffect` hooks, avoiding external state libraries. State is centralized in the main `App.jsx` component and passed down via props to child components.

2.3.3. Computation Architecture

Scientific calculations are isolated in dedicated engine modules:

- `isiEngine.js` - Core ISI computation with temporal dynamics
- `calculations.js` - Severity scoring and portfolio weighting
- `helpers.js` - Mathematical utilities (clamping, normalization, logistic functions)

2.4. Build Configuration

The project uses Vite as the build tool with the following configuration:

```
// vite.config.js
import { defineConfig } from 'vite'
import react from '@vitejs/plugin-react'

export default defineConfig ({
  plugins: [ react ()],
  base: './', build : {
    outDir: 'dist'
  }
})
```

2.5. Dependencies

Table 2: Project dependencies (package.json)

| Package | Type | Description |
|----------------------|-------------|-------------------------------|
| react | Production | Core React library |
| react-dom | Production | React DOM rendering |
| @vitejs/plugin-react | Development | Vite plugin for React support |
| vite | Development | Next generation build tool |

2.6. Data Flow Architecture

The application follows a unidirectional data flow pattern:

1. **User Input** - Species data entry via grid editor or file import
2. **State Update** - React state management in `App.jsx`
3. **Computation** - ISI engine processes current and historical data
4. **Visualization** - Components render SVG charts and tables
5. **Persistence** - JSON export for data storage and interoperability



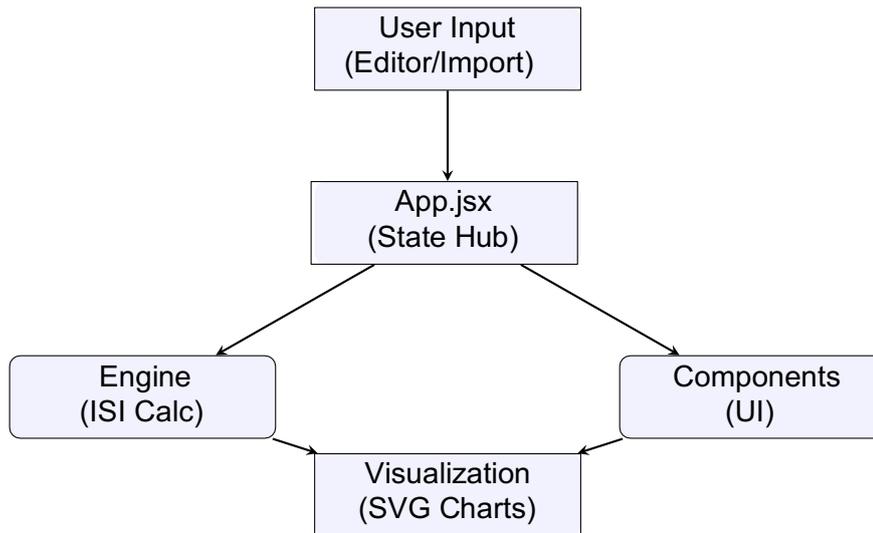


Figure 1: Application data flow architecture

2.7. Browser Compatibility

The application targets modern browsers with ES6+ support (Browser/Version):

- Google Chrome 90+
- Mozilla Firefox 88+
- Microsoft Edge 90+
- Safari 14+

3. Project Structure

3.1. Directory Overview

The project follows a modular architecture with clear separation between UI components, computation engine, and utility functions.

Listing 1: Project directory tree

```

invaders-toolbox/
|-- dist/                # Production build output
|-- node_modules/       # Dependencies (auto-generated)
|-- public/             # Static assets
|-- src/                # Source code
|   |-- components/     # React UI components (17 files)
|   |-- engine/         # ISI calculation modules (2 files)
|   |-- utils/         # Constants, helpers, icons (3 files)
|   |-- App.jsx        # Main application component
|   |-- main.jsx       # Application entry point
|-- index.html          # HTML template
|-- package.json        # Project configuration
|-- package-lock.json   # Dependency lock file
|-- vite.config.js     # Vite build configuration
  
```





3.2. Source Code Organization

3.2.1. Components Directory

The src/components/ directory contains all React UI components, organized by functional responsibility:

Table 3: Components directory organization

| File | Responsibility |
|------------------------------------|---|
| <i>Tab Components (Main Views)</i> | |
| DashboardTab.jsx | KPIs, alerts, priorities, risk matrix, and trend charts |
| WeightedISITab.jsx | ISI parameter configuration and uncertainty analysis |
| TemporalTab.jsx | Temporal analysis container with visualization |
| PrioritiesTab.jsx | Species prioritization and management decision support |
| SnapshotComparison.jsx | Side-by-side snapshot comparison with change matrix |
| TemporalVisualization.jsx | Time series charts for species evolution |
| <i>Layout Components</i> | |
| Header.jsx | Application header with project management controls |
| Footer.jsx | Application footer with version information |
| TabNavigation.jsx | Tab switching navigation bar |
| EditModeBar.jsx | Snapshot editing mode indicator and controls |
| ProjectIndicator.jsx | Current project status display |
| <i>Editor Components</i> | |
| FaceGrid.jsx | Interactive 6-face grid editor for species data |
| FillInput.jsx | Numeric input with percentage/ratio/cell modes |
| SnapshotCard.jsx | Individual snapshot display with actions |
| <i>Utility Components</i> | |
| ISISlider.jsx | Parameter slider with visual feedback |
| LoadingSpinner.jsx | Loading state indicator |
| ProjectManager.jsx | Project file operations (new/open/save) |





3.2.2. Engine Directory

The src/engine/ directory contains the scientific computation modules:

Table 4: Engine directory organization

| File | Responsibility |
|-----------------|---|
| isiEngine.js | Core ISI computation with temporal dynamics, species turnover, and bootstrap uncertainty quantification |
| calculations.js | Severity scoring, portfolio weighting, and individual species ISI calculation |

3.2.3. Utils Directory

The src/Utils/ directory contains shared utilities and constants:

Table 5: Utils directory organization

| File | Responsibility |
|--------------|--|
| constants.js | Face configuration (colours, labels), face order, and emoji definitions |
| helpers.js | Mathematical utilities: clamp01, normalizeWeights, logistic, getExactRatio |
| icons.jsx | SVG icon components for UI elements |

3.3. File Statistics

Table 6: Project file statistics

| Category | Count |
|---------------------|-------|
| React Components | 17 |
| Engine Modules | 2 |
| Utility Modules | 3 |
| Configuration Files | 3 |
| Total Source Files | 25 |





3.4. Module Dependencies

The following diagram illustrates the import relationships between core modules:

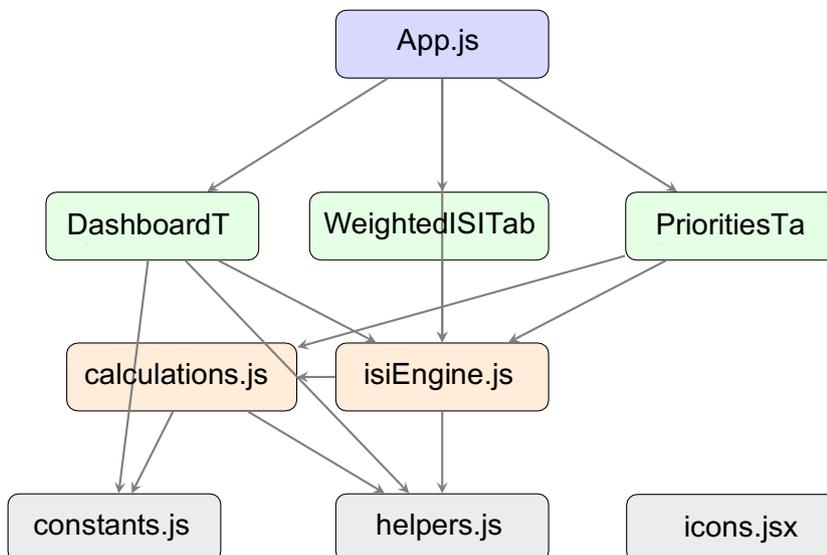


Figure 2: Core module dependency graph

4. File Descriptions

This section provides detailed documentation for each source file, including purpose, exports, and key implementation details.

4.1. Application Entry Points

4.1.1. main.jsx

| Property | Description |
|--------------|--|
| Location | src/main.jsx |
| Purpose | Application bootstrap and React DOM mounting |
| Dependencies | react, react-dom, App.jsx |

The entry point initializes the React application and mounts it to the DOM root element. Uses React 18’s createRoot API for concurrent rendering support.





4.1.2. App.jsx

| Property | Description |
|---------------|---|
| Location | src/App.jsx |
| Purpose | Main application component and state management hub |
| Lines of Code | ~850 |
| Dependencies | All components, engine modules, and utilities |

State Management:

The component manages 25+ state variables organized into functional groups:

- **Species Data:** species, activeIndex
- **Snapshots:** snapshots, snapshotDate, snapshotTime, snapshotNotes
- **UI State:** activeTab, inputMode, labelMode
- **Edit Mode:** editingSnapshotDate, loadedSnapshotDate
- **ISI Parameters:** isiParams (14 configurable parameters)
- **Uncertainty:** computeUncertainty, nBootstrap, uncertaintyData
- **Project Management:** projectName, projectFileName, projectModified

Key Functions:

- createEmptySpecies(name) - Factory function for new species objects
- handleCellClick(face, cellIndex) - Grid cell interaction handler
- updateFaceValue(face, value) - Numeric input handler with mode conversion
- captureSnapshot() - Creates temporal snapshot from current state
- editSnapshot(snapshot) - Loads snapshot into editor for modification
- handleNewProject() / handleOpenProject() / handleSaveProject() - Project file management

4.2. Engine Modules

4.2.1. isiEngine.js

| Property | Description |
|--------------|---|
| Location | src/engine/isiEngine.js |
| Purpose | Core ISI computation with temporal dynamics |
| Exports | computeISI, calculateBootstrapUncertainty |
| Dependencies | helpers.js, constants.js, calculations.js |





Function: computeISI (previousSnapshot, currentSnapshot, params)

Calculates the Invasive Species Index for a given snapshot with optional temporal context.

Parameters:

- previousSnapshot - Previous temporal snapshot (null for baseline)
- currentSnapshot - Current snapshot containing species array
- params - Configuration object with 14 ISI parameters

Returns: Object containing:

- S_bar_port - Portfolio-weighted severity score [0-1]
- f_g_core - Growth dynamics component [0-1]
- T_port - Invasiveness traits component [0-1]
- D_port - Drivers/pathways component [0-1]
- Turnover - Species turnover signal [0-1]
- ISI - Final weighted index [0-100]
- weights_global - Normalized component weights
- meta - Additional metadata (E_in, E_out)

Algorithm Highlights:

1. Calculate portfolio weights based on weighting mode (equal/geographic)
2. Compute severity scores for all species using inner weights
3. Calculate growth dynamics via logistic transformation of severity changes
4. Aggregate traits and drivers across portfolio
5. Compute turnover from species entries/exits with configurable credit
6. Apply normalized global weights and scale to 0-100

Function: calculateBootstrapUncertainty (snapshots, params, nBootstrap, onProgress)

Performs bootstrap resampling to estimate 95% confidence intervals for ISI values.

Parameters:

- snapshots - Array of temporal snapshots
- params - ISI parameter configuration
- nBootstrap - Number of bootstrap iterations (typically 100-1000)
- onProgress - Callback function for progress updates

Returns: Promise resolving to object with confidence intervals per snapshot:

```
{
  0: { isi: [ lower , upper], severity : [ lower , upper] },
  1: { isi: [ lower , upper], severity : [ lower , upper] },
  ...
}
```





4.2.2. calculations.js

| Property | Description |
|--------------|---|
| Location | src/engine/calculations.js |
| Purpose | Severity scoring and portfolio weight calculation |
| Exports | getSeverityScore, portfolioWeights, calculateISI |
| Dependencies | helpers.js, constants.js |

Function: getSeverityScore (species, params)

Calculates the aggregate severity score for a single species.

Implementation Details:

- Extracts ratios from four faces: red (impact), blue (geographic), yellow (management), orange (detectability)
- Applies detectability threshold (5%) to avoid artificial baseline inflation
- Inverts detectability: high detectability = low difficulty
- Applies normalized inner weights (u_imp, u_geo, u_mgmt, u_det)

Function: portfolioWeights (speciesList, mode)

Determines species weighting for portfolio aggregation.

Modes:

- "equal" — All species weighted equally (1/n)
- "geographic" — Weighted by geographic spread (blue face ratio)

Function: calculateISI (species, params)

Simplified ISI calculation for single species without temporal context.

4.3. Utility Modules

4.3.1. constants.js

| Property | Description |
|----------|--|
| Location | src/utills/constants.js |
| Purpose | Application-wide constants and configuration |
| Exports | EMOJIS, FACE_CONFIG, FACE_ORDER |

FACE_CONFIG - Defines the six-face taxonomy:



**Table 7: Face configuration mapping**

| Face | Colour | Label |
|--------|---------|------------------------|
| red | #ef5350 | Impact |
| green | #00e676 | Invasiveness |
| blue | #3d5afe | Geographic spread |
| yellow | #ffee33 | Management effort/cost |
| Grey | #CCCCCC | Drivers/pathways |
| orange | #ffb74d | Detectability |

FACE_ORDER - Canonical ordering: ["red", "green", "blue", "yellow", "Grey", "orange"]

EMOJIS - UI emoji constants for status indicators and organism types.

4.3.2. helpers.js

| Property | Description |
|----------|--|
| Location | src/utills/helpers.js |
| Purpose | Mathematical utility functions |
| Exports | clamp01, normalizeWeights, logistic, getExactRatio |

Exported Functions:

- clamp01(x) - Constrains value to [0, 1] range
- normalizeWeights(values) - Normalizes array to sum to 1.0, with fallback to equal weights if sum is zero
- logistic(x, k) - Logistic sigmoid function: $\frac{1}{1+e^{-kx}}$
- getExactRatio (faceData) - Extracts fill ratio from face data, preferring
- exact_ratio- field over calculated value

4.3.3. icons.jsx

| Property | Description |
|----------|---|
| Location | src/utills/icons.jsx |
| Purpose | SVG icon components for UI elements |
| Exports | icons object containing all icon components |

Provides a centralized collection of SVG icons used throughout the application, including navigation icons, action icons (save, edit, delete), chart icons, and status indicators. All icons are implemented as React functional components with consistent sizing and stroke properties.

4.4. Tab Components (Main Views)

These components represent the primary application views, accessible through the tab navigation system.





5.4.1. DashboardTab.jsx

| Property | Description |
|--------------|---|
| Location | src/components/DashboardTab.jsx |
| Purpose | Executive dashboard with KPIs, alerts, and risk visualization |
| Props | species, snapshots, isiParams |
| Dependencies | icons, EMOJIS, getExactRatio, computeISI |

Features:

- **Key Performance Indicators (KPIs):** Four summary cards displaying total species count, portfolio ISI (colour-coded by risk level), critical species count, and trend direction
- **Active Alerts Panel:** Dynamic alert generation based on threshold violations (critical ISI >75%, high impact >80%, high spread >70%, low detectability <30%)
- **Top 5 Priorities:** Ranked species list using composite score (50% weighted ISI + 20% impact)
- **Risk Matrix Table:** Heatmap visualization of all species across six face dimensions with viridis-like colour scale
- **Recent Trends:** Mini time-series charts for up to 6 species showing ISI evolution over last 5 snapshots

Visualization Implementation:

The risk matrix uses a custom getHeatmapColour(value) function implementing a five-zone gradient:

- 0-20%: Green zone (low risk)
- 20-40%: Yellow-green transition
- 40-60%: Yellow zone (moderate risk)
- 60-80%: Orange zone (high risk)
- 80-100%: Red zone (critical risk)

4.4.1. WeightedISITab.jsx

| Property | Description |
|--------------|---|
| Location | src/components/WeightedISITab.jsx |
| Purpose | ISI parameter configuration and temporal analysis |
| Props | snapshots, isiParams, setIISIParams, uncertainty-related states |
| Dependencies | icons, computeISI, calculateBootstrapUncertainty, ISISlider, LoadingSpinner |

Parameter Configuration Sections:

- **Global Component Weights:** wS (Severity), wDy (Dynamics), wT (Traits), wD (Drivers), wE (Turnover)
- **Inner Severity Weights:** uimp (Impact), ugeo (Geographic), umgmt (Management), udet (Difficulty)
- **Dynamics Parameters:** α (logistic slope), β (turnover gain), κ (exit credit), λT (entry mix), EMA half-life





Uncertainty Quantification:

- Configurable bootstrap iterations (50-1000)
- Progress bar with percentage indicator
- Asynchronous calculation with non-blocking UI
- Results displayed as 95% confidence intervals on charts

Visualizations:

- **ISI Gauge:** Large numeric display with optional confidence interval
- **ISI Time Series:** Line chart with gradient fill, optional EMA overlay, and CI band
- **Component Breakdown:** Bar chart showing current snapshot's five ISI components
- **Species Turnover Dynamics:** Triple-line chart showing turnover, entries score, and weighted exits score

4.4.3. TemporalTab.jsx

| Property | Description |
|--------------|---|
| Location | src/components/TemporalTab.jsx |
| Purpose | Container component for temporal evolution analysis |
| Props | snapshots |
| Dependencies | icons, TemporalVisualization |

Behavior:

- Displays placeholder message when fewer than 2 snapshots exist
- Renders TemporalVisualization component when sufficient data is available
- Provides consistent section header with icon

4.4.4. TemporalVisualization.jsx

| Property | Description |
|--------------|---|
| Location | src/components/TemporalVisualization.jsx |
| Purpose | Comprehensive temporal charts for species evolution |
| Props | snapshots |
| Dependencies | EMOJIS, FACE_ORDER, FACE_CONFIG, icons, getExactRatio, calculateISI |

State Management:

- selectedSpecies - Currently selected species for detailed view
- visibleFaces - Toggle state for each of the six face layers
- showISI - Toggle for ISI line visibility

Visualizations:

1. **Aggregate ISI Evolution:** Portfolio-wide average ISI over time with linear trend line and rate calculation (change per day)
2. **Species Selector:** Dropdown for individual species selection with layer toggle buttons
3. **Individual ISI Evolution:** Selected species ISI time series with gradient fill
4. **Parameter Evolution:** Multi-line chart showing all six face values over time with colour-coded lines
5. **Summary Cards:** Current values and delta changes for each face parameter





4.4.5. PrioritiesTab.jsx

| Property | Description |
|--------------|---|
| Location | src/components/PrioritiesTab.jsx |
| Purpose | Species prioritization and management decision support |
| Props | species, snapshots, isiParams, priorityMode, setPriorityMode, priorityThresholds, setPriorityThresholds |
| Dependencies | icons, getExactRatio, getSeverityScore, computeISI |

Priority Modes:

1. **ISI Global Analysis:** Portfolio-level ISI breakdown with component contribution analysis and actionable recommendations
2. **ISI by Species:** Ranked table of all species by individual ISI score with trend indicators
3. **Face-specific Priorities:** Six modes for Impact, Traits, Spread, Management, Drivers, and Detectability

Threshold Configuration:

Customizable five-tier classification system:

- Very Low: 0-10% (default)
- Low: 10-25%
- Medium: 25-50%
- High: 50-75%
- Very High: 75-100%

Special Handling:

Detectability mode uses inverted scale where low detectability values indicate higher priority (harder to detect species require more monitoring effort).

Output Features:

- Categorized species lists by risk level
- Visual progress bars with threshold-based colouring
- Configurable species limit selector (5-50 or all)
- Priority action recommendations based on component analysis

4.4.6. SnapshotComparison.jsx

| Property | Description |
|--------------|---|
| Location | src/components/SnapshotComparison.jsx |
| Purpose | Side-by-side comparison of two temporal snapshots |
| Props | snapshots |
| Dependencies | FACE_ORDER, FACE_CONFIG, getExactRatio, icons |

State Management:

- snapshot1, snapshot2 — Selected snapshots for comparison
- Auto-initializes to last two snapshots when data is available





Comparison Metrics:

- **Summary Statistics:** Added species, removed species, maintained species, global change percentage
- **Species Comparison Table:** Status (Added/Removed/Maintained), average fill values, delta changes for impact, spread, and management
- **Change Heatmap Matrix:** Colour-coded grid showing percentage changes per face per species
- **Bar Chart Comparison:** Visual side-by-side bars for each species

Change Heatmap Colour Scale:

- Green gradient: Negative changes (improvement, -50% to -5%)
- Grey: No significant change ($\pm 5\%$)
- Red gradient: Positive changes (concern, +5% to +50%)

4.5. Layout Components

These components provide the application's structural framework and navigation.

4.5.1. Header.jsx

| Property | Description |
|--------------|--|
| Location | src/components/Header.jsx |
| Purpose | Application header with branding and project management |
| Props | snapshots, setSnapshots, setSpecies, setLabelMode, setInputMode, setActiveIndex, projectName, projectModified, onNewProject, onOpenProject, onSaveProject, onSaveProjectAs |
| Dependencies | EMOJIS, icons |

Layout Structure:

- **Left Section:** Application logo (Invader icon), title "Invaders Toolbox", version badge, and subtitle
- **Right Section:** Project management buttons and import/export controls

Project Management Actions:

- **New Project:** Creates empty project with user-defined name
- **Open Project:** File picker for JSON project files
- **Save Project:** Exports current state with modification indicator (yellow pulse dot)
- **Save As:** Optional duplicates save with new filename

Import/Export Functionality:

The component handles bidirectional format conversion:

- **Import:** Detects and converts Python format (with cubes key) to Web format, or loads native Web format directly
- **Export:** Generates Python-compatible JSON with cubes structure, filled_cells, exact_ratio, and metadata fields





4.5.2. Footer.jsx

| Property | Description |
|--------------|--|
| Location | src/components/Footer.jsx |
| Purpose | Application footer with version info and feature summary |
| Props | None (static component) |
| Dependencies | None |

Content Sections:

1. **About:** Version number (3.0), brief description of ISI engine capabilities
2. **Scientific Framework:** List of core features (ISI Engine, Bootstrap CI, Survey effort, 6-face taxonomy)
3. **Features:** Checkmark list of application capabilities
4. **Technology Bar:** Build information (React 18, Tailwind CSS, Native SVG Charts)

4.5.3. TabNavigation.jsx

| Property | Description |
|--------------|---|
| Location | src/components/TabNavigation.jsx |
| Purpose | Horizontal tab bar for main view navigation |
| Props | activeTab, setActiveTab |
| Dependencies | icons |

Tab Definitions:

Table 8: Tab navigation configuration

| ID | Label | Icon | View |
|--------------|---------------------|---------------|---------------------|
| editor | Editor & Snapshots | Editor Camera | Species data entry |
| compare | Snapshot Comparison | BarChart3 | Temporal comparison |
| dashboard | Dashboard Summary | BarChart3 | KPIs and alerts |
| weighted-isi | Weighted ISI | Sliders | Parameter config |
| temporal | Temporal Analysis | TrendingUp | Evolution charts |
| priorities | Prioritisation | Podium | Management support |

Responsive Design:

- Uses CSS clamp() for fluid font sizing (0.55rem to 1rem)
- Full labels on screens $\geq 640\text{px}$ (sm breakpoint)
- Abbreviated labels (first word only) on smaller screens
- Fluid padding and icon scaling





4.5.4. EditModeBar.jsx

| Property | Description |
|--------------|---|
| Location | src/components/EditModeBar.jsx |
| Purpose | Visual indicator and controls for snapshot editing mode |
| Props | editingSnapshotDate, saveToSnapshot, setEditingSnapshotDate, setSnapshotNotes |
| Dependencies | icons |

Behavior:

- Renders only when editingSnapshotDate is truthy (conditional rendering)
- Displays purple banner below header indicating edit mode is active
- Provides Save and Cancel action buttons
- Cancel action clears editing state and resets snapshot notes

4.5.5. ProjectIndicator.jsx

| Property | Description |
|--------------|--|
| Location | src/components/ProjectIndicator.jsx |
| Purpose | Displays current project status and modification state |
| Props | projectName, projectModified |
| Dependencies | None |

Display States:

1. **No Project:** Amber warning bar indicating changes won't be saved automatically
2. **Project Open (Saved):** Blue info bar with project name and "All changes saved" status
3. **Project Open (Modified):** Blue bar with pulsing "Modified" badge and "Unsaved changes" warning

4.6. Editor Components

These components provide the data entry interface for species information.

4.6.1. FaceGrid.jsx

| Property | Description |
|--------------|--|
| Location | src/components/FaceGrid.jsx |
| Purpose | Interactive grid editor for individual face data entry |
| Props | face, data, onCellClick |
| Dependencies | FACE_CONFIG |

Visual Structure:

- Header row with colour indicator dot, face label, and fill percentage
- Square grid container using CSS aspect-ratio trick (padding-bottom: 100%)
- Dynamic grid layout based on data.subdivisions value





Grid Rendering:

- Creates $n \times n$ cells where n = subdivisions (typically 6)
- Cells 0 to data.filled - 1 are coloured with face colour
- Remaining cells are white (unfilled)
- Each cell is clickable, triggering onCellClick(face, cellIndex)

Fill Percentage Calculation:

Prioritizes exact_ratio field when available, otherwise calculates from filled / totalCells.

4.6.2. FillInput.jsx

| Property | Description |
|--------------|--|
| Location | src/components/FillInput.jsx |
| Purpose | Numeric input with mode-aware value conversion |
| Props | face, data, inputMode, onChange |
| Dependencies | None |

Input Modes:

Table 9: Input mode configurations

| Mode | Range | Step | Display Format |
|------------|--------------|------|--------------------------------|
| percentage | 0-100 | 0.1 | (exact_ratio * 100).toFixed(1) |
| ratio | 0-1 | 0.01 | exact_ratio.toFixed(3) |
| cell | 0-totalCells | 1 | filled.toString() |

Local State Management:

Uses local useState for input value to prevent cursor jumping during typing. Value is only propagated to parent on blur or Enter key press.

4.6.3. SnapshotCard.jsx

| Property | Description |
|--------------|---|
| Location | src/components/SnapshotCard.jsx |
| Purpose | Individual snapshot display with action buttons |
| Props | snapshot, onLoad, onEdit, onDelete, isActive, isEditing |
| Dependencies | icons |

Display Information:

- Formatted date/time (Portuguese locale: dd/mm/yyyy HH:mm)
- Species count
- Truncated notes preview (2 lines maximum)

Visual States:

- **Default:** White background with subtle border





- **Active (Loaded):** Blue background tint with thick blue border
- **Editing:** Purple background tint with thick purple border

Action Buttons:

- **Load:** Blue button - loads snapshot data into editor (view only)
- **Edit:** Purple button - enters edit mode for the snapshot
- **Delete:** Red button - removes snapshot (with confirmation)

4.7. Components

Reusable components providing common UI functionality.

4.7.1. ISISlider.jsx

| Property | Description |
|--------------|---|
| Location | src/components/ISISlider.jsx |
| Purpose | Styled range slider for ISI parameter adjustment |
| Props | label, value, min, max, step, onChange, colour, tooltip |
| Dependencies | None |

Visual Features:

- Label with optional tooltip on hover
- Current value display with configurable colour
- Custom-styled range input with dynamic fill gradient
- Fill colour reflects current position: coloured portion from left to thumb, Grey from thumb to right

Gradient Calculation:

Returns: Promise resolving to object with confidence intervals per snapshot:

```
background : linear - gradient(
  to right ,
  ${ colour} 0% ,
  ${ colour} $ {(( value - min ) / ( max - min )) * 100}% ,
  # e5e7eb $ {(( value - min ) / ( max - min )) * 100}% ,
  # e5e7eb 100%
)
```

4.7.2. LoadingSpinner.jsx

| Property | Description |
|--------------|-----------------------------------|
| Location | src/components/LoadingSpinner.jsx |
| Purpose | Animated loading indicator |
| Props | size (default: 20), className |
| Dependencies | None |





Implementation:

Pure SVG spinner with CSS animation. Consists of:

- Background circle with 25% opacity
- Foreground arc (quarter circle) with full opacity
- Tailwind animate-spin class for rotation

4.7.3. ProjectManager.jsx

| Property | Description |
|--------------|--|
| Location | src/components/ProjectManager.jsx |
| Purpose | Compact project management button group |
| Props | projectName, projectModified, onNewProject, onOpenProject, onSaveProject |
| Dependencies | icons |

Note: This component provides an alternative, more compact layout for project management controls. The primary implementation is in Header.jsx; this component can be used for alternative layouts or mobile views.

Buttons:

- New Project (Grey)
- Open Project (Grey, file input)
- Save Project (blue, with modification indicator)

5. Screen Descriptions

This section provides detailed documentation of each application screen, including visual layout, functionality, and user interaction patterns.

5.1. Editor & Snapshots

The Editor & Snapshots screen serves as the primary data entry interface, where researchers input and manage species assessment data across the six taxonomic dimensions.



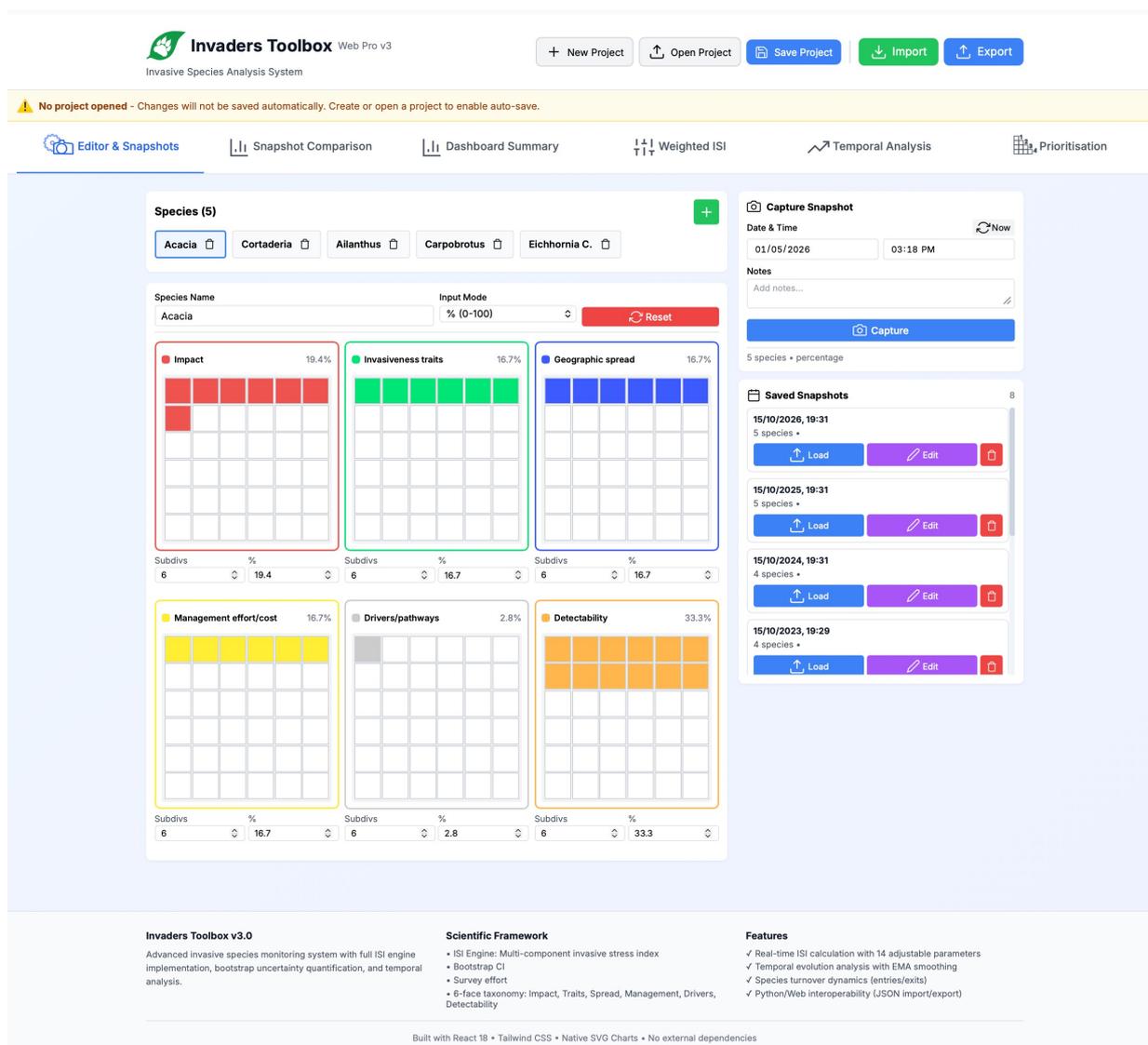


Figure 3: Editor & Snapshots screen — Main data entry interface

5.1.1. Screen Overview

The Editor & Snapshots view is organized into a responsive two-column layout optimized for efficient data entry workflows. The left column (8/12 grid units) contains the species editor with interactive face grids, while the right column (4/12 grid units) provides snapshot management controls.

5.1.2. Header Bar

The application header appears consistently across all screens and provides:

- **Branding:** Application logo (alien invader icon), title "Invaders Toolbox", version badge "Web Pro v3", and subtitle "Invasive Species Analysis System"
- **Project Management:**
 - New Project* (Grey) - Creates a new empty project with user-defined name





Open Project (Grey) - Opens file picker for loading JSON project files

Save Project (blue) - Exports current project state to JSON file

- **Data Exchange:**

Import (green) — Loads species data from JSON, with automatic Python format detection and conversion

Export (blue) — Saves data in Python-compatible format for cross-platform interoperability

5.1.3. Project Status Indicator

Immediately below the header, a status bar indicates the current project state. In Figure 3, the amber warning banner displays: *"No project opened - Changes will not be saved automatically. Create or open a project to enable auto-save."*

When a project is active, this bar changes to blue and displays the project name along with a modification indicator.

5.1.4. Tab Navigation

The horizontal tab bar provides access to six main application views:

1. **Editor & Snapshots** (currently active, indicated by blue underline)
2. Snapshot Comparison
3. Dashboard Summary
4. Weighted ISI
5. Temporal Analysis
6. Prioritisation

Each tab displays an icon and label, with responsive text truncation on smaller screens.

5.1.5. Species List Panel

The species list panel displays all species in the current working set:

- **Header:** Shows total count ("Species (5)") with green "+" button for adding new species
- **Species Chips:** Horizontal scrollable list of species names, each with a delete icon
- **Active Selection:** The currently selected species ("Acacia" in this example) is highlighted with a blue border and background tint
- **Quick Actions:** Each chip allows one-click selection or deletion

5.1.6. Species Configuration Bar

Below the species list, a configuration bar provides:

- **Species Name:** Editable text field for renaming the selected species
- **Input Mode:** Dropdown selector with three options:
 - % (0-100) - Percentage mode (default)
 - Ratio (0-1) - Decimal ratio mode
 - Cells - Direct cell count mode
- **Reset Button:** Red button that clears all face values for the selected species to zero





5.1.7. Six-Face Grid Editor

The core data entry interface consists of six interactive grid panels arranged in a 3×2 layout. Each panel represents one dimension of the ISI taxonomy:

Table 10: Six-face taxonomy dimensions

| Face | Colour | Label |
|------------------------|------------------|---|
| Impact | Red (#ef5350) | Realized ecological, economic, and social impacts |
| Invasiveness traits | Green (#00e676) | Biological characteristics facilitating invasion |
| Geographic spread | Blue (#3d5afe) | Spatial extent and distribution patterns |
| Management effort/cost | Yellow (#ffee33) | Resources required for control and eradication |
| Drivers/pathways | Grey (#CCCCCC) | Introduction vectors and facilitating factors |
| Detectability | Orange (#ffb74d) | Ease of detection and monitoring |

Grid Panel Structure:

Each face panel contains:

- 1. Header Row:**
 - Colour indicator dot (matching face colour)
 - Face label (e.g., "Impact", "Invasiveness traits")
 - Current fill percentage (e.g., "19.4%")
- 2. Interactive Grid:**
 - Square grid with configurable subdivisions (default: 6×6 = 36 cells)
 - Filled cells display the face colour; empty cells are white
 - Click interaction: clicking a cell fills all cells from the first cell up to and including the clicked cell
 - Visual feedback on hover for improved usability
- 3. Input Controls:**
 - *Subdivs* - Numeric input for grid resolution (1-20)
 - % (or Ratio/Cells) - Direct numeric input for precise value entry

Example Values (Figure 3):

The species "Acacia" displays the following assessment values:

- Impact: 19.4% (7 cells filled)
- Invasiveness traits: 16.7% (6 cells filled)
- Geographic spread: 16.7% (6 cells filled)
- Management effort/cost: 16.7% (6 cells filled)
- Drivers/pathways: 2.8% (1 cell filled)
- Detectability: 33.3% (12 cells filled)

5.1.8. Capture Snapshot Panel

The right sidebar's upper section provides snapshot creation controls:

- **Date & Time:** Two input fields for snapshot timestamp
Date picker (showing "01/05/2026")





Time picker (showing "03:18 PM")
 "Now" button to auto-fill with current date/time

- **Notes:** Text area for optional snapshot annotations and observations
- **Capture Button:** Blue button that creates a new temporal snapshot from the current editor state
- **Status Line:** Shows current context ("5 species • percentage")

5.1.9. Saved Snapshots Panel

The lower section of the right sidebar displays the snapshot timeline:

- **Header:** "Saved Snapshots" with total count badge ("8" in this example)
- **Snapshot List:** Scrollable list of captured snapshots, sorted by date (newest first)
- **Snapshot Card:** Each entry displays:
 - Date and time (e.g., "15/10/2026, 19:31")
 - Species count (e.g., "5 species •")
 - Optional notes preview (truncated to 2 lines)
- **Action Buttons:**
 - Load* (blue) - Loads snapshot data into editor for viewing
 - Edit* (purple) - Enters edit mode, allowing modification of the snapshot
 - Delete* (red) - Removes snapshot after confirmation

The visible snapshots in Figure 3 span multiple years (2023-2026), demonstrating the application's capability for long-term temporal monitoring studies.

5.1.10. Footer

The application footer provides reference information in three columns:

1. **About:** Version information and brief description
2. **Scientific Framework:** Core methodology features (ISI Engine, Bootstrap CI, Survey effort, 6-face taxonomy)
3. **Features:** Key capabilities checklist

A bottom bar displays the technology stack: *"Built with React 18 • Tailwind CSS • Native SVG Charts • No external dependencies"*

5.1.11. Workflow Summary

The typical user workflow on this screen follows these steps:

1. **Species Setup:** Add species using the "+" button and name them appropriately
2. **Data Entry:** For each species, fill the six face grids either by clicking cells or entering numeric values
3. **Snapshot Capture:** Set the appropriate date/time, add notes, and click "Capture" to save the temporal state
4. **Iteration:** Repeat the process at different time points to build a temporal dataset
5. **Analysis:** Navigate to other tabs (Dashboard, Temporal Analysis, Priorities) to analyse the captured data





5.2. Snapshot Comparison

The Snapshot Comparison screen enables side-by-side analysis of two temporal snapshots, providing detailed insights into species changes over time through multiple visualization formats.

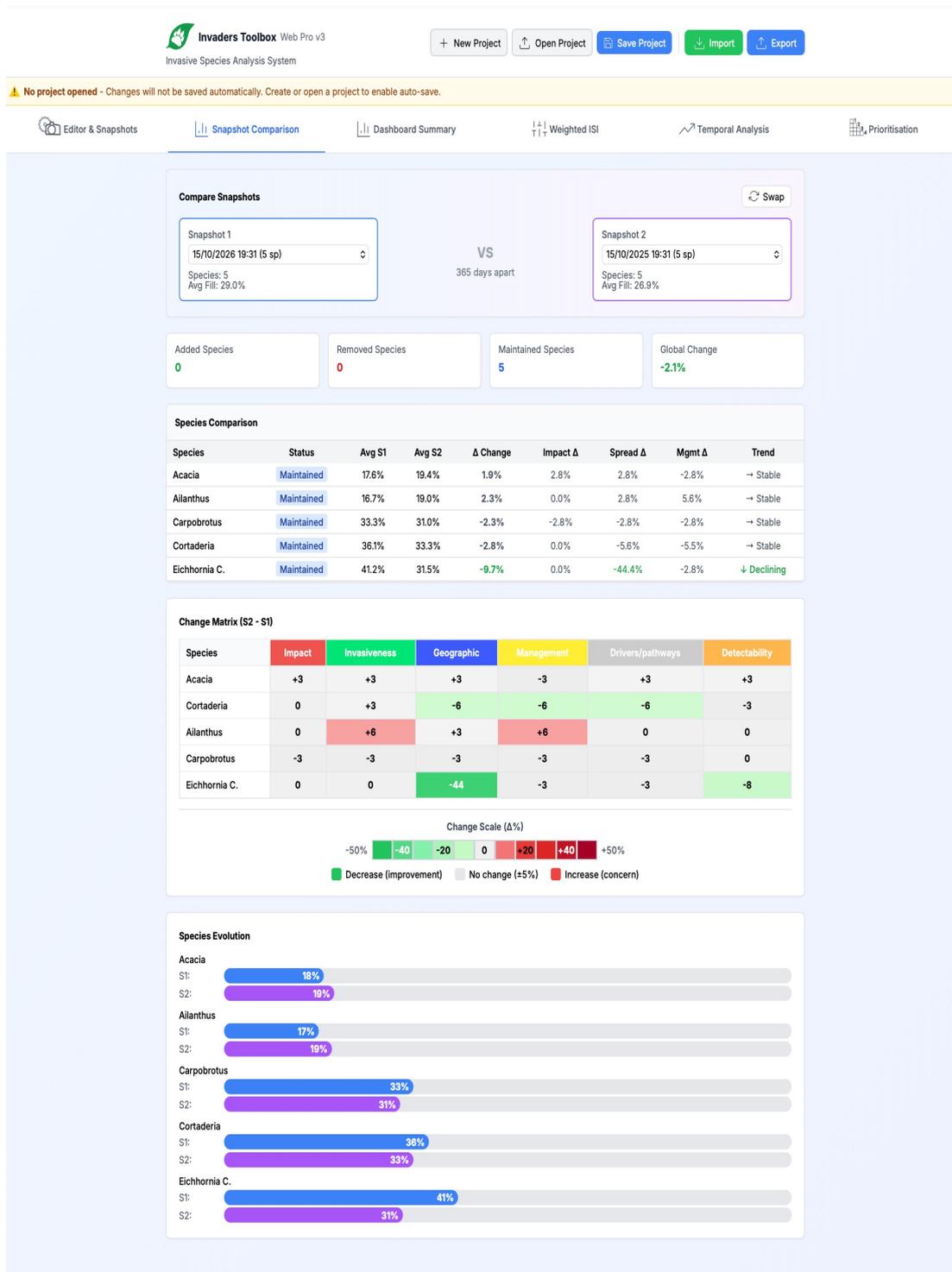


Figure 4: Snapshot Comparison screen - Temporal change analysis between two snapshots





5.2.1. Screen Overview

The Snapshot Comparison view provides a comprehensive toolkit for analysing temporal changes in invasive species data. The screen is organized vertically into five distinct sections: snapshot selection, summary statistics, detailed comparison table, change heatmap matrix, and visual evolution bars.

5.2.2. Compare Snapshots Panel

The top panel provides snapshot selection controls within a gradient background (blue to purple tint):

- **Snapshot 1 Selector (Left):** Dropdown menu with blue border displaying:
Date and time: "15/10/2026 19:31 (5 sp)"
Species count: "Species: 5"
Average fill percentage: "Avg Fill: 29.0%"
- **Central Indicator:** Large "VS" label with temporal distance calculation ("365 days apart")
- **Snapshot 2 Selector (Right):** Dropdown menu with purple border displaying:
Date and time: "15/10/2025 19:31 (5 sp)"
Species count: "Species: 5"
Average fill percentage: "Avg Fill: 26.9%"
- **Swap Button:** Located in the top-right corner, allows quick reversal of comparison direction

The dropdown menus list all available snapshots with their timestamps, species counts and can be freely combined for any pairwise comparison.

5.2.3. Summary Statistics Cards

Four summary cards provide an immediate overview of changes between snapshots:

Table 11: Summary statistics interpretation

| Metric | Value | Description |
|--------------------|---------------|---|
| Added Species | 0 (green) | Species present in S2 but absent in S1 |
| Removed Species | 0 (red) | Species present in S1 but absent in S2 |
| Maintained Species | 5 (blue) | Species present in both snapshots |
| Global change | -2.1% (green) | Overall change in average fill percentage |

The Global Change metric uses colour coding: green for negative values (indicating improvement/reduction in invasion pressure), red for positive values (indicating deterioration), and grey for negligible changes.





5.2.4. Species Comparison Table

The detailed comparison table presents per-species metrics with the following columns:

Table 12: Species comparison table columns

| Column | Description |
|-----------------|---|
| Species | Species name identifier |
| Status | Classification: "Maintained", "Added", or "Removed" (colour-coded badges) |
| Avg S1 | Average fill percentage across all faces in Snapshot 1 |
| Avg S2 | Average fill percentage across all faces in Snapshot 2 |
| Δ Change | Percentage point difference (S2 – S1) |
| Impact Δ | Change in Impact face (red dimension) |
| Spread Δ | Change in Geographic Spread face (blue dimension) |
| Mgmt Δ | Change in Management Effort face (yellow dimension) |
| Trend | Directional indicator: "→ Stable", "↑ Growing", or "↓ Declining" |

Example Data (Figure 4):

The table reveals that all five species were maintained between snapshots. Notable observations include:

- **Eichhornia C.** shows the most significant change with -9.7% overall and -44.4% in Geographic Spread, classified as "Declining"
- **Acacia** and **Ailanthus** show slight increases (1.9% and 2.3%), classified as "Stable"
- **Carpobrotus** and **Cortaderia** show minor decreases (-2.3% and -2.8%), classified as "Stable"

Change values are colour-coded: red text for increases (concern), green text for decreases (improvement), and black for minimal changes.

5.2.5. Change Matrix Heatmap

The Change Matrix provides a dense visualization of changes across all species and all six taxonomic dimensions:

Structure:

- **Rows:** One row per species (5 rows in this example)
- **Columns:** Six face dimensions with colour-coded headers:
 - Impact (red header)
 - Invasiveness (green header)
 - Geographic (blue header)
 - Management (yellow header)
 - Drivers/pathways (Grey header)
 - Detectability (orange header)
- **Cell Values:** Percentage point change (S2 – S1), displayed as integers





Colour Scale:

The heatmap uses a diverging colour scale centred on zero:

- **Green gradient** (–50% to –5%): Indicates decrease/improvement - darker green represents larger reductions
- **Grey** (±5%): Indicates no significant change
- **Red gradient** (+5% to +50%): Indicates increase/concern — darker red represents larger increases

Notable Patterns (Figure 4):

- **Eichhornia C.** displays a striking –44 value in Geographic spread (dark red cell), indicating a dramatic reduction in spatial extent
- **Ailanthus** shows increases in Invasiveness (+6) and Management (+6), highlighted in red
- **Cortaderia** shows consistent decreases across Geographic (–6), Management (–6), and Drivers (–6)

Legend:

Below the matrix, a visual legend displays:

- Continuous colour scale from –50% to +50% with labelled tick marks
- Three category descriptions: "Decrease (improvement)", "No change (±5%)", "Increase (concern)"

5.2.6. Species Evolution Bar Chart

The bottom section presents a visual bar chart comparison for intuitive assessment of changes:

Structure:

For each species, two horizontal bars are displayed:

- **S1 bar** (blue/top): Average fill percentage in Snapshot 1
- **S2 bar** (purple/bottom): Average fill percentage in Snapshot 2

Each bar displays its percentage value as an embedded label (e.g., "18%", "19%").

Visual Interpretation (Figure 4):

- **Acacia:** S1 = 18%, S2 = 19% (slight increase)
- **Ailanthus:** S1 = 17%, S2 = 19% (slight increase)
- **Carpobrotus:** S1 = 33%, S2 = 31% (slight decrease)
- **Cortaderia:** S1 = 36%, S2 = 33% (slight decrease)
- **Eichhornia C.:** S1 = 41%, S2 = 31% (significant decrease)

The bar lengths provide immediate visual feedback on relative magnitudes, while the side-by-side arrangement facilitates quick identification of species with notable changes.

5.2.7. Analytical Capabilities

The Snapshot Comparison screen supports several analytical workflows:

1. **Temporal Change Assessment:** Quantify changes in invasion pressure between any two time points





2. **Species-Level Analysis:** Identify which species are improving, stable, or deteriorating
3. **Dimension-Specific Tracking:** Determine which taxonomic dimensions show the greatest change
4. **Management Effectiveness:** Evaluate intervention outcomes by comparing pre- and post-treatment snapshots
5. **Pattern Recognition:** Use the heatmap to identify systematic patterns across species or dimensions

5.3. Dashboard Summary

The Dashboard Summary screen provides an executive overview of the invasive species portfolio, consolidating key performance indicators, alerts, priorities, risk assessment, and temporal trends into a single comprehensive view.



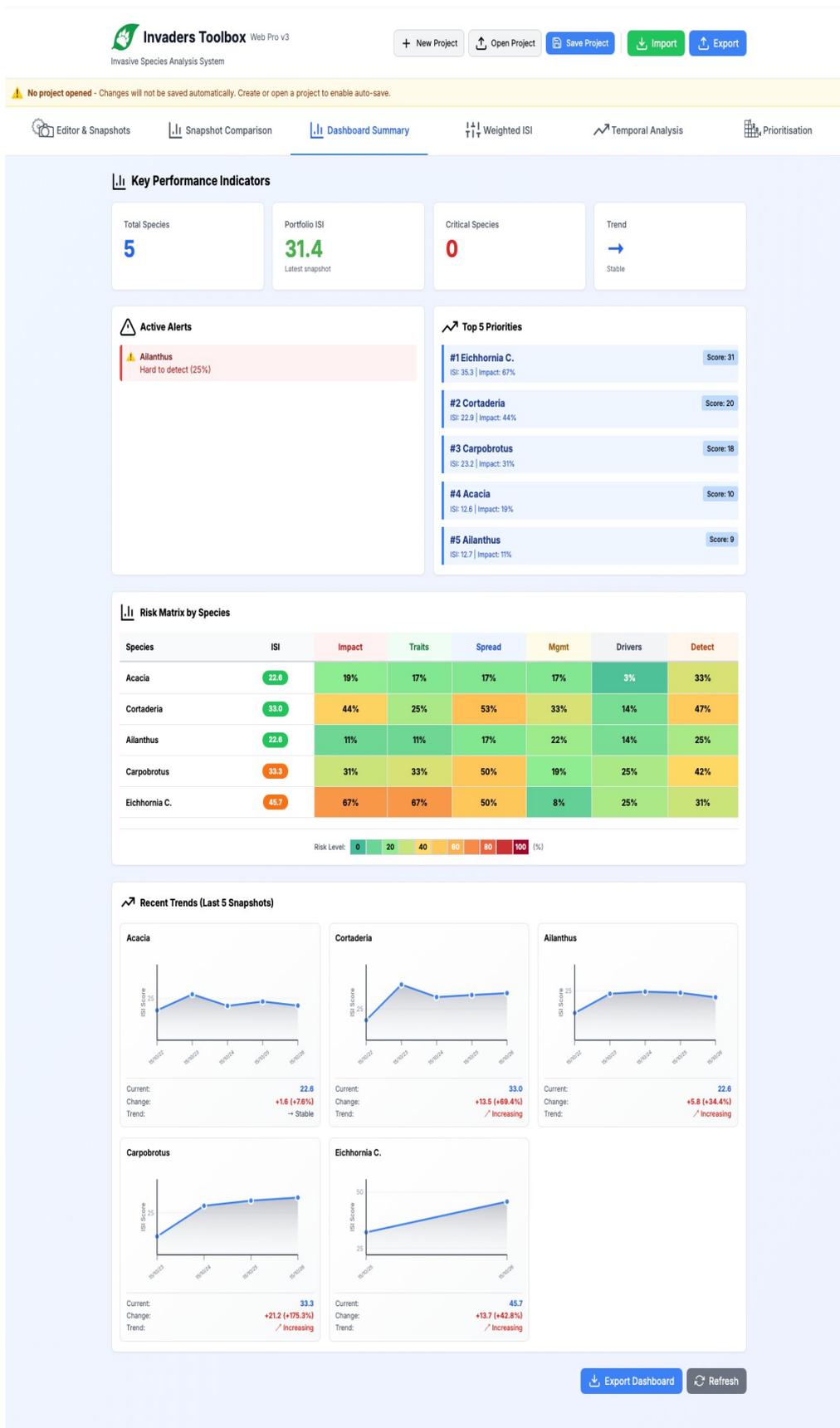


Figure 5: Dashboard Summary screen — Executive overview with KPIs, alerts, and risk matrix





5.3.1. Screen Overview

The Dashboard Summary serves as the central monitoring interface, designed for rapid situational awareness. The layout follows a top-to-bottom information hierarchy: summary metrics at the top, actionable insights in the middle, detailed analysis at the bottom.

5.3.2. Key Performance Indicators

The KPI section displays four summary cards providing immediate insight into portfolio status:

Table 13: Key Performance Indicators

| KPI | Description |
|------------------|--|
| Total Species | Count of species in the current working set |
| Portfolio ISI | Aggregate Invasive Species Index calculated from the latest snapshot, colour-coded by risk level (green <33, orange 33– 66, red >66) |
| Critical Species | Count of species with ISI >75%, indicating immediate intervention priority |
| Trend | Directional indicator comparing recent snapshots: "→ Stable", "↑ Increasing", or "↓ Decreasing" |

In Figure 5, the Portfolio ISI of 31.4 is displayed in orange, indicating moderate risk level, with the annotation "Latest snapshot" confirming the data source.

5.3.3. Active Alerts Panel

The Active Alerts panel provides automated threshold-based notifications requiring attention:

Alert Generation Rules:

- **Critical ISI:** Species with aggregate ISI >75%
- **High Impact:** Species with Impact face >80%
- **High Spread:** Species with Geographic Spread >70%
- **Low Detectability:** Species with Detectability <30%

Each alert displays the species name, alert type, and relevant metric value. Alerts are styled with red background and left border for visual prominence. In the example shown, "Ailanthus" triggers a detectability alert at 25%.

When no threshold violations exist, the panel displays a green checkmark with "No active alerts" message.





5.3.4. Top 5 Priorities Panel

The priorities panel ranks species by a composite priority score, helping managers focus resources on the most pressing concerns:

Priority Score Calculation:

$$\text{Score} = 0.5 \times \frac{\text{ISI}}{100} + 0.2 \times \text{Impact Ratio} \quad (2)$$

Display Format:

Each priority entry shows:

- Rank position (#1 through #5)
- Species name in bold
- ISI value and Impact percentage
- Composite score badge (e.g., "Score: 31")

Entries are styled with a blue left border, providing visual hierarchy through the ranking structure.

5.3.5. Risk Matrix by Species

The Risk Matrix provides a comprehensive heatmap visualization of all species across the six taxonomic dimensions:

Table Structure:

- **Rows:** One row per species
- **Columns:** ISI (aggregate), Impact, Traits, Spread, Mgmt, Drivers, Detect
- **ISI Column:** Displayed as coloured badge (green/orange/red based on value)
- **Face Columns:** Percentage values with heatmap background colouring

Heatmap Colour Scale:

The matrix uses a five-zone viridis-inspired gradient:

- 0–20%: Green (low risk)
- 20–40%: Yellow-green
- 40–60%: Yellow (moderate risk)
- 60–80%: Orange (high risk)
- 80–100%: Red (critical risk)

A visual legend below the table displays the continuous colour scale with percentage markers (0, 20, 40, 60, 80, 100).

Interpretation Example:

In Figure 5, *Eichhornia C.* shows the highest ISI (45.7, orange badge) with elevated Impact (67%) and Traits (67%) values displayed in orange/red cells, while Drivers remains low (25%, green cell).





5.3.6. Recent Trends Charts

The Recent Trends section displays mini time-series charts for up to six species, showing ISI evolution over the last five snapshots:

Chart Components:

- **Line Graph:** ISI values connected by line with circular data points
- **Gradient Fill:** Light blue/Grey gradient beneath the line for visual weight
- **X-Axis:** Snapshot dates
- **Y-Axis:** ISI Score scale

Statistics Panel:

Below each chart, three metrics are displayed:

- **Current:** Latest ISI value
- **Change:** Absolute and percentage change from first to last snapshot (colour-coded: red for increase, green for decrease)
- **Trend:** Classification with directional icon ("→ Stable", "↗ Increasing", "↘ Decreasing")

The 3-column grid layout allows efficient comparison across species, with each chart maintaining consistent scaling for visual comparability.

5.3.7. Action Buttons

The bottom of the dashboard provides two action buttons:

- **Export Dashboard** (blue): Exports dashboard data for reporting purposes
- **Refresh** (Grey): Reloads the dashboard with current data

5.3.8. Use Cases

The Dashboard Summary supports several key workflows:

1. **Daily Monitoring:** Quick assessment of portfolio status and emerging concerns
2. **Alert Response:** Identification of species requiring immediate attention
3. **Resource Allocation:** Priority ranking for management intervention planning
4. **Reporting:** Executive-level overview for stakeholder communications
5. **Trend Analysis:** Early detection of deteriorating or improving species





5.4. Weighted ISI

The Weighted ISI screen provides full control over the 14 configurable parameters of the Invasive Species Index calculation, along with temporal visualizations and uncertainty quantification options.

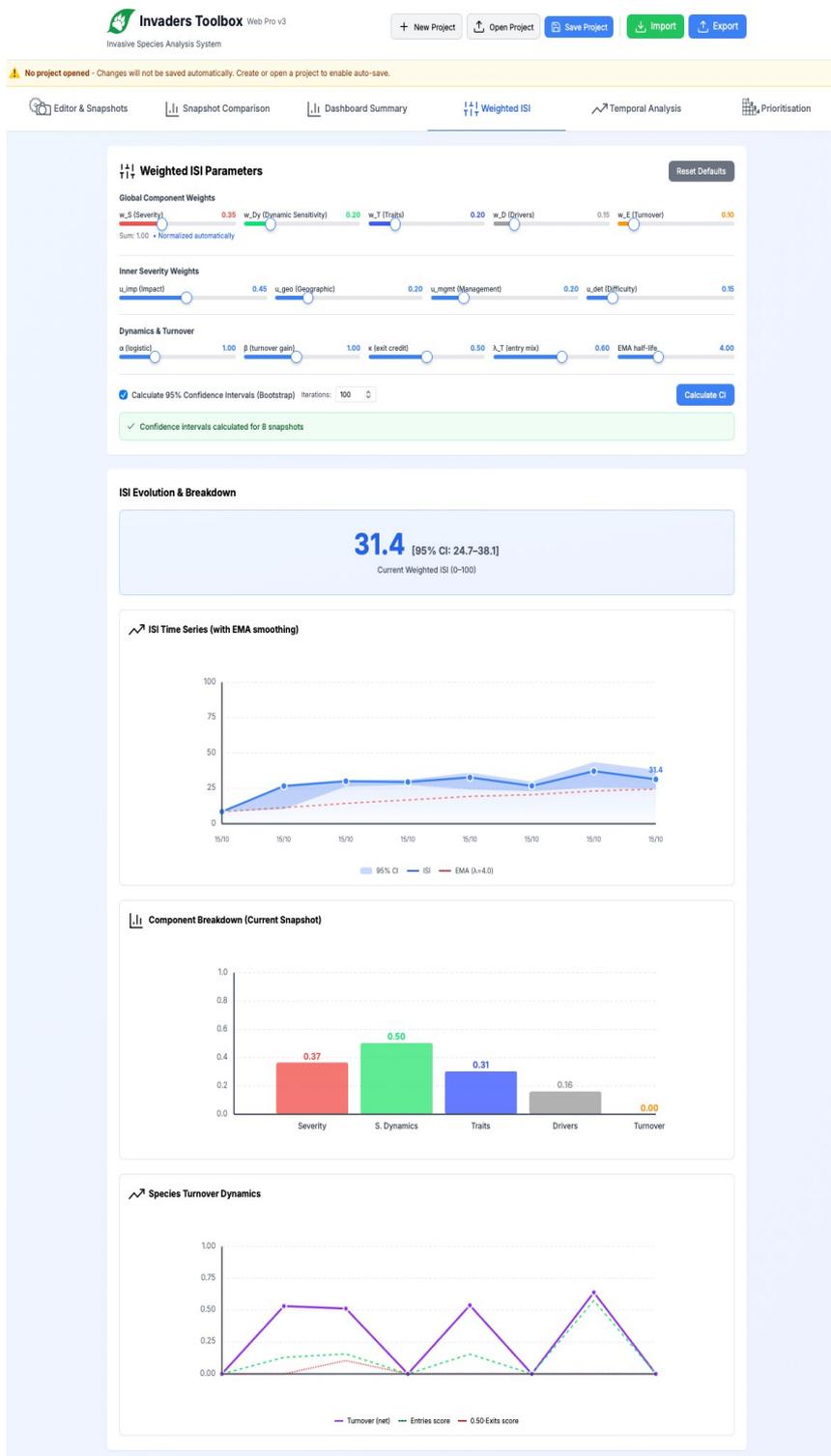


Figure 6: Weighted ISI screen — Parameter configuration with bootstrap confidence intervals





5.4.1. Screen Overview

The Weighted ISI screen is designed for advanced users and researchers who need fine-grained control over the ISI calculation methodology. The interface is divided into two main sections: parameter configuration (top) and visualization/analysis (bottom).

5.4.2. Parameter Configuration Panel

The configuration panel provides interactive sliders for all 14 ISI parameters, organized into three logical groups:

Global Component Weights:

These weights determine the relative contribution of each ISI component to the final index:

Table 14: Global component weights

| Parameter | Default | Description |
|--------------------------------|---------|---------------------------------------|
| w_S (Severity) | 0.35 | Weight for aggregate severity score |
| w_{Dy} (Dynamic Sensitivity) | 0.20 | Weight for temporal severity dynamics |
| w_T (Traits) | 0.20 | Weight for invasiveness traits |
| w_D (Drivers) | 0.15 | Weight for drivers and pathways |
| w_E (Turnover) | 0.10 | Weight for species turnover signal |

A status line below the sliders displays the current sum (e.g., "Sum: 1.00") with a note that weights are "Normalized automatically", ensuring they always sum to 1.0 regardless of individual slider positions.

Inner Severity Weights:

These weights control the composition of the severity score from four face dimensions:

Table 15: Inner severity weights

| Parameter | Default | Description |
|-------------------------|---------|--|
| u_{imp} (Impact) | 0.45 | Weight for realized impacts (red face) |
| u_{geo} (Geographic) | 0.20 | Weight for geographic spread (blue face) |
| u_{mgmt} (Management) | 0.20 | Weight for management effort (yellow face) |
| u_{det} (Difficulty) | 0.15 | Weight for detection difficulty (inverted orange face) |

Dynamics & Turnover Parameters:

These parameters control the mathematical behaviour of temporal dynamics and species turnover calculations:



**Table 16: Dynamics and turnover parameters**

| Parameter | Range | Default | Description |
|-------------------------|----------|---------|---|
| α (logistic) | 0.2–3.0 | 1.00 | Logistic function slope for growth mapping |
| β (turnover gain) | 0.2–2.0 | 1.00 | Gain factor for turnover signal amplification |
| κ (exit credit) | 0.0–1.0 | 0.50 | Credit given to species exits (0=none, 1=full)) |
| λ_T (entry mix) | 0.0–1.0 | 0.60 | Blend ratio for new entries (traits vs. severity) |
| EMA half-life | 0.0–12.0 | 4.00 | Exponential moving average smoothing period |

Slider Interface:

Each parameter slider features:

- Parameter label with tooltip on hover explaining its function
- Current value display (colour-coded where applicable)
- Interactive slider track with dynamic fill gradient
- Continuous value adjustment with configurable step size

Reset Defaults Button:

Located in the top-right corner, this button restores all 14 parameters to their scientifically-validated default values.

5.4.3. Uncertainty Quantification

Below the parameter sliders, a dedicated section enables bootstrap uncertainty analysis:

Configuration Controls:

- **Checkbox:** "Calculate 95% Confidence Intervals (Bootstrap)" — when checked (as shown in Figure 6), enables uncertainty quantification
- **Iterations Input:** Numeric field for bootstrap iterations (default: 100, range: 50–1000)
- **Calculate CI Button:** Blue button that triggers asynchronous bootstrap computation

Progress and Results:

During calculation, a progress bar displays completion percentage. Upon completion, a green confirmation banner appears: "✓ Confidence intervals calculated for 8 snapshots", indicating successful computation across all available temporal data points.

Bootstrap Methodology:

The bootstrap procedure performs species-level resampling with replacement for each snapshot, recalculating ISI values across n iterations to estimate the sampling distribution. The 2.5th and 97.5th percentiles define the 95% confidence interval bounds.

5.4.4. ISI Evolution & Breakdown Section

The visualization section presents the results of ISI calculations across temporal snapshots:





Current ISI Gauge:

A prominent display panel shows:

- Large numeric value (e.g., “31.4”) in blue
- **Confidence Interval:** When bootstrap is enabled, displays the 95% CI in brackets (e.g., “[95% CI: 24.7–38.1]”)
- Label: “Current Weighted ISI (0–100)”
- Gradient background (blue to indigo tint) for visual emphasis

ISI Time Series Chart:

The time series visualization includes:

- **Confidence Band** (light blue shaded area): 95% CI envelope surrounding the ISI line, visualizing uncertainty across all snapshots
- **Primary Line** (blue, solid): Raw ISI values across snapshots
- **EMA Line** (red, dashed): Exponential moving average smoothed values (when EMA half-life > 0)
- **Data Points:** Circular markers at each snapshot
- **Grid Lines:** Horizontal reference lines at 0, 25, 50, 75, 100
- **X-Axis:** Snapshot dates
- **Y-Axis:** ISI scale (0–100)
- **Current Value Label:** Final value annotated on the chart (e.g., “31.4”)

Chart Legend:

Below the chart, a legend identifies each visual element:

- “95% CI” — Confidence interval band
- “ISI” — Primary ISI line
- “EMA ($\lambda=4.0$)” — Smoothed trend line with current half-life parameter

The chart title indicates when EMA smoothing is active: “ISI Time Series (with EMA smoothing)”.

Component Breakdown Bar Chart:

A vertical bar chart displays the five ISI components for the current snapshot:

- **Severity** (red bar): Portfolio-weighted severity score
- **S. Dynamics** (green bar): Growth dynamics component
- **Traits** (blue bar): Invasiveness traits component
- **Drivers** (Grey bar): Drivers/pathways component
- **Turnover** (orange bar): Species turnover component

Each bar displays its numeric value (0.0–1.0 scale) above the bar. The Y-axis ranges from 0.0 to 1.0, and bar heights directly reflect component magnitudes before weight application.

5.4.5. Species Turnover Dynamics Chart

The bottom chart visualizes the temporal dynamics of species entries and exits:

Three-Line Display:

- **Turnover (net)** (purple, solid): Net turnover signal after combining entries and exits
- **Entries score** (green, dashed): Weighted score of species entering the portfolio





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- **κ -Exits score** (red, dotted): Weighted score of species exiting, multiplied by exit credit parameter

Interpretation:

The chart helps researchers understand:

- When new invasive species entered the monitored area
- When species were successfully removed or naturally declined
- The net balance between entries and exits over time
- How the κ parameter affects exit crediting

A legend below the chart identifies each line type.

5.4.6. Scientific Applications

The Weighted ISI screen enables several advanced analytical workflows:

1. **Sensitivity Analysis:** Adjust individual parameters to understand their influence on the final ISI value
2. **Uncertainty Assessment:** Quantify confidence in ISI estimates through bootstrap re-sampling
3. **Methodology Customization:** Adapt weights to reflect regional priorities or management objectives
4. **Temporal Smoothing:** Apply EMA filtering to reduce noise in longitudinal studies
5. **Turnover Analysis:** Evaluate the balance between species introductions and removals
6. **Publication-Ready Outputs:** Generate charts with confidence intervals suitable for scientific publications

5.5. Temporal Analysis

The Temporal Analysis screen provides comprehensive time-series visualization for tracking invasive species evolution across multiple snapshots, enabling both portfolio-level and species-specific trend analysis.





Figure 7: Temporal Analysis screen — Multi-level temporal evolution visualization





5.5.1. Screen Overview

The Temporal Analysis view is structured in four main sections: aggregate portfolio analysis, species selection controls, individual species ISI evolution, and multi-parameter temporal tracking. This hierarchical approach enables researchers to identify both portfolio-wide trends and species-specific patterns.

5.5.2. Aggregate ISI Evolution Chart

The top chart displays the portfolio-level ISI trend across all species:

Chart Elements:

- **Title:** "Aggregate ISI Evolution - All Species Average"
- **Primary Line (blue):** Average ISI across all species at each snapshot
- **Gradient Fill:** Light blue area beneath the line for visual emphasis
- **Data Points:** Circular markers with ISI values labelled above each point
- **X-Axis Labels:** Snapshot dates with species count annotations (e.g., "15/10/19 (1 sp)", "15/10/26 (5 sp)")
- **Y-Axis:** ISI scale from 0 to 100
- **Grid Lines:** Horizontal dashed lines at 25, 50, 75, and 100 for reference

Trend Analysis:

A linear regression trend line is calculated and displayed with the daily rate of change shown in red text at the top of the chart (e.g., "Trend: +0.01% per day"). This metric provides a quantitative measure of whether the overall invasion pressure is increasing, stable, or decreasing over the monitoring period.

Species Count Tracking:

The X-axis annotations showing species counts at each snapshot (e.g., "(1 sp)", "(3 sp)", "(5 sp)") allow researchers to contextualize ISI changes against portfolio composition changes.

5.5.3. Species Selection Controls

A control panel below the aggregate chart enables species-specific analysis:

Select Species Dropdown:

- Dropdown menu listing all species present across any snapshot
- Selection updates both the ISI Evolution and Parameter Evolution charts below
- In Figure 7, "Acacia" is selected

Toggle Layers:

A set of toggle buttons allows selective display of data layers:

- **ISI Line (blue button):** Toggles the ISI trend line visibility
- **Impact (red button):** Toggles Impact face data
- **Invasiveness (green button):** Toggles Invasiveness Traits face data
- **Geographic (blue button):** Toggles Geographic Spread face data
- **Management (dark grey button):** Toggles Management Effort face data





- **Drivers/pathways** (light grey button, dimmed): Toggles Drivers face data
- **Detectability** (orange button): Toggles Detectability face data

Active layers appear as solid-coloured buttons; inactive layers appear dimmed. This filtering capability enables focused analysis on specific dimensions of interest.

5.5.4. ISI Evolution Chart (Species-Specific)

The second chart displays the ISI trajectory for the selected species:

Chart Elements:

- **Title:** Dynamic title reflecting selection (e.g., "ISI Evolution - Acacia")
- **Primary Line** (purple): Species-specific ISI values over time
- **Gradient Fill:** Light purple area beneath the curve
- **Data Points:** Circular markers with values labelled (e.g., 25.0, 37.8, 41.0, 32.9, 25.0, 26.2, 25.4)
- **X-Axis:** Snapshot dates
- **Y-Axis:** ISI scale from 0 to 100

This chart reveals species-specific dynamics that may be masked in portfolio averages. For example, in Figure 7, Acacia shows a peak ISI of 41.0 in late 2022, followed by a decline and stabilization around 25–26 in subsequent years.

5.5.5. Parameter Evolution Chart

The bottom chart provides multi-dimensional temporal analysis across all six face parameters:

Chart Elements:

- **Title:** Dynamic title (e.g., "Parameter Evolution - Acacia")
- **Six Colour-Coded Lines:** One line per taxonomic dimension
 - Impact (red line)
 - Invasiveness traits (green line)
 - Geographic spread (blue line)
 - Management effort/cost (yellow/orange line)
 - Drivers/pathways (Grey line)
 - Detectability (orange line)
- **Data Points:** Circular markers at each snapshot for all visible layers
- **Y-Axis:** Percentage scale from 0% to 100%
- **X-Axis:** Snapshot dates aligned with other charts

Summary Legend:

Below the chart, a comprehensive legend displays current values and recent changes for each parameter in a 3×2 grid:

- Colour indicator square
- Parameter name
- Current value (e.g., "19.4%")
- Delta change with directional indicator (e.g., "↓ 2.8%" in green for decrease, "↑ 2.8%" in red for increase)





This summary provides at-a-glance assessment of which parameters are improving, stable, or deteriorating.

5.5.6. Analytical Capabilities

The Temporal Analysis screen supports several key research workflows:

1. **Long-term Monitoring:** Track invasion pressure across multi-year study periods
2. **Intervention Assessment:** Evaluate management effectiveness by comparing pre- and post-intervention trends
3. **Early Warning Detection:** Identify species showing increasing ISI trajectories before they reach critical levels
4. **Dimensional Analysis:** Determine which specific parameters are driving ISI changes
5. **Comparative Studies:** Switch between species to compare temporal patterns
6. **Seasonal Patterns:** Identify cyclical variations in invasion pressure (with sufficient temporal resolution)

5.5.7. Data Requirements

The Temporal Analysis screen requires a minimum of two snapshots to display meaningful visualizations. With fewer than two snapshots, an informational message is displayed prompting the user to create additional temporal data points.

5.6. Prioritisation

The Prioritisation screen provides comprehensive management decision support through multiple analysis modes, enabling researchers to identify intervention priorities based on aggregate ISI, individual species ranking, or specific taxonomic dimensions.

5.6.1. Screen Overview

The Prioritisation view offers eight distinct analysis modes, each providing a different perspective on species prioritization. The interface adapts dynamically based on the selected mode, presenting relevant metrics, categorization, and visualizations.

5.6.2. Common Interface Elements

All priority modes share a consistent header section:

View Mode Selector:

A horizontal button group allows switching between eight analysis modes:

- **ISI Global Analysis** - Portfolio-level ISI breakdown with component contributions
- **ISI by Species** - Species ranking by individual weighted ISI scores
- **Impact Priority** - Ranking by Impact face (red dimension)
- **Traits Priority** - Ranking by Invasiveness Traits face (green dimension)





- **Spread Priority** - Ranking by Geographic Spread face (blue dimension)
- **Management Priority** - Ranking by Management Effort face (yellow dimension)
- **Drivers Priority** - Ranking by Drivers/Pathways face (Grey dimension)
- **Detectability Priority** - Ranking by Detectability face (orange dimension, inverted scale)

The active mode is highlighted with a coloured background matching the dimension’s theme colour.

Threshold Configuration:

A configurable five-tier classification system allows customization of risk categories:

Table 17: Default threshold configuration (Standard Scale)

| Category | Default Range | Colour | Interpretation |
|-----------|---------------|--------|---------------------------|
| Very Low | 0-10% | Green | Minimal concern |
| Low | 10-25% | Lime | Low priority |
| Medium | 25-50% | Yellow | Moderate attention needed |
| High | 50-75% | Orange | Significant concern |
| Very High | 75-100% | Red | Critical priority |

Each threshold boundary can be adjusted via numeric inputs. The "Reset Thresholds" button restores default values.

Scale Types:

- **Standard Scale:** Used for Impact, Traits, Spread, Management, Drivers, and ISI modes. Higher values indicate greater concern.
- **Inverted Scale:** Used for Detectability mode. Lower detectability values indicate harder detection, thus higher monitoring priority. Category labels are inverted (e.g., "Critical (Hard to Detect)" for 0–10%).





5.6.3. ISI Global Analysis Mode

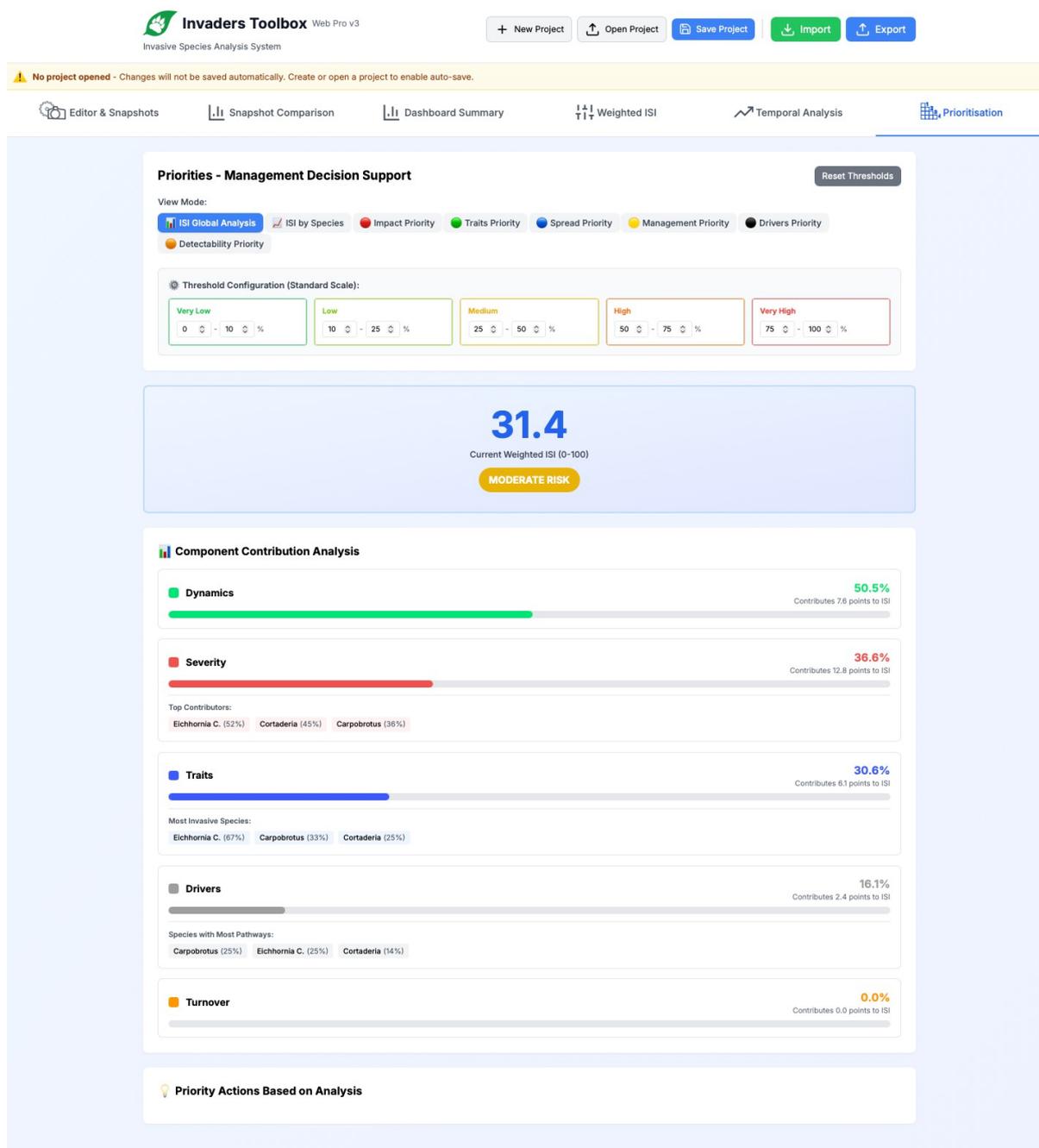


Figure 8: Prioritisation screen — ISI Global Analysis mode with component contribution break-down

This mode (Figure 8) provides portfolio-level analysis of the weighted ISI:

Current ISI Display:

- Large numeric value (e.g., "31.4") centered in gradient panel
- Label: "Current Weighted ISI (0-100)"
- Risk classification badge (e.g., "MODERATE RISK") colour-coded by threshold





Component Contribution Analysis:

Each of the five ISI components is displayed with:

- Component name with colour indicator (Dynamics, Severity, Traits, Drivers, Turnover)
- Percentage value and contribution to final ISI (e.g., "50.5% — Contributes 7.6 points to ISI")
- Horizontal progress bar showing relative magnitude
- Top contributing species listed for Severity, Traits, and Drivers components with individual percentages

Priority Actions Panel:

Context-sensitive recommendations based on component analysis, highlighting which areas require immediate attention based on the data patterns identified.

5.6.4. ISI by Species Mode

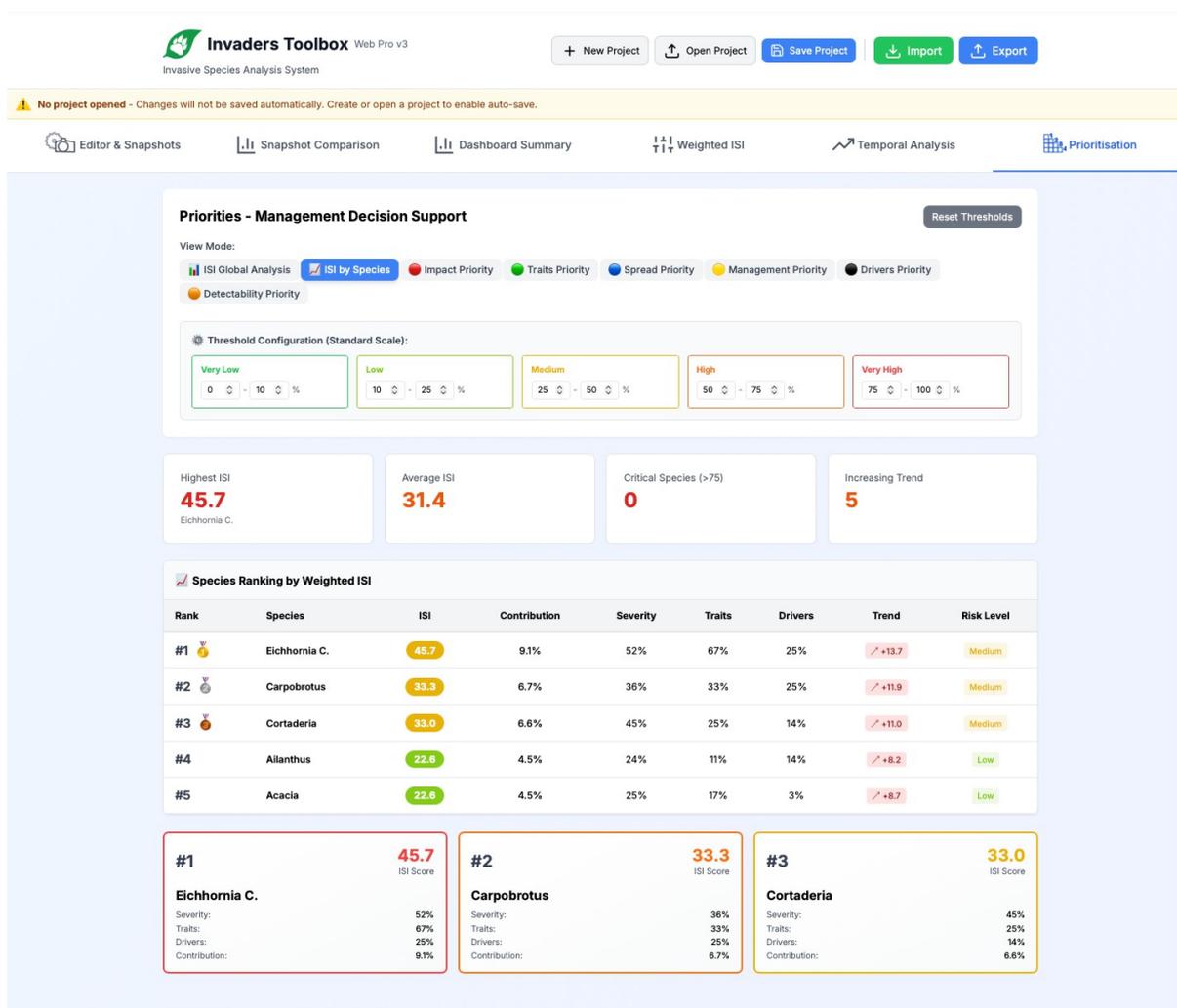


Figure 9: Prioritisation screen — ISI by Species mode with ranked species table





This mode (Figure 9) ranks all species by their individual weighted ISI scores:

Summary Statistics:

Four KPI cards display:

- **Highest ISI:** Maximum value with species name (e.g., "45.7 — Eichhornia C.")
- **Average ISI:** Mean across all species
- **Critical Species:** Count exceeding the configured high threshold
- **Increasing Trend:** Count of species showing upward ISI trajectory

Species Ranking Table:

Comprehensive table with columns:

- **Rank:** Position with medal icons for top 3
- **Species:** Species name
- **ISI:** Weighted ISI value as coloured badge (green/yellow/orange/red based on thresholds)
- **Contribution:** Percentage contribution to portfolio ISI
- **Severity, Traits, Drivers:** Component breakdown percentages
- **Trend:** Directional indicator with change value (e.g., "↗ +13.7")
- **Risk Level:** Category badge (Low, Medium, High, Critical)

Top 3 Species Cards:

Highlighted cards below the table for the three highest-priority species, each showing:

- Rank number and ISI score prominently displayed
- Species name
- Detailed breakdown: Severity, Traits, Drivers percentages
- Contribution to portfolio percentage
- Yellow/orange border indicating priority level





5.6.5. Impact Priority Mode

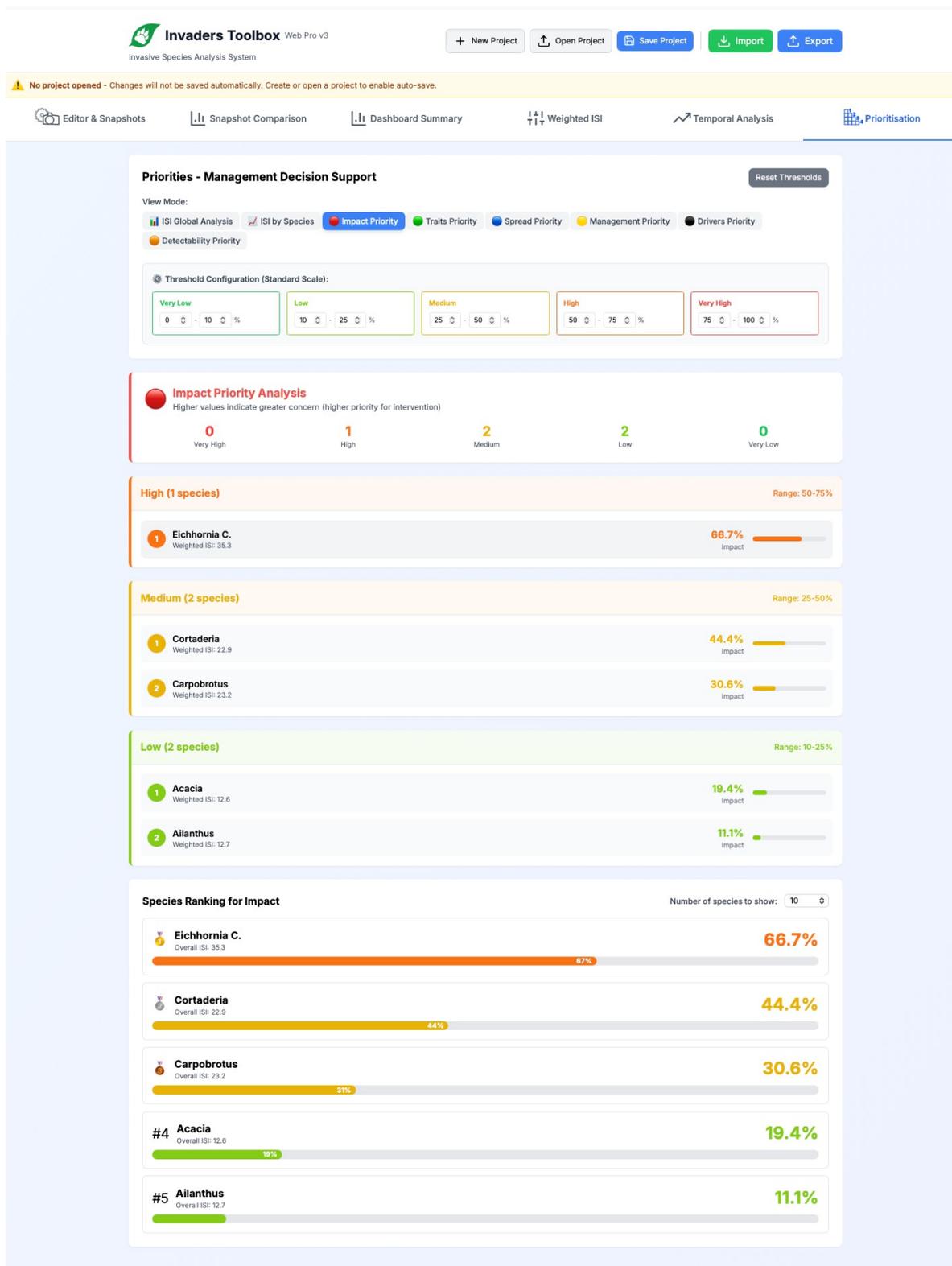


Figure 10: Prioritisation screen — Impact Priority mode showing ecological impact ranking





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The Impact Priority mode (Figure 10) ranks species by their realized ecological, economic, and social impacts (red face dimension):

Impact Priority Analysis Header:

- Red icon indicator with title "Impact Priority Analysis"
- Interpretation note: "Higher values indicate greater concern (higher priority for intervention)"
- Five-column distribution showing species count per category (Very High, High, Medium, Low, Very Low)

Categorized Species Groups:

Species are organized into collapsible sections by threshold category. Each section displays:

- Category header with species count and threshold range (e.g., "High (1 species) - Range: 50-75%")
- Red-tinted left border indicating severity level
- Individual species cards showing rank, name, weighted ISI, and impact percentage with progress bar

Species Ranking for Impact:

Full ranked list featuring:

- Medal icons for positions 1-3
- Species name with Overall ISI reference
- Large impact percentage with threshold-coloured progress bar
- Configurable display limit selector





5.6.6. Traits Priority Mode

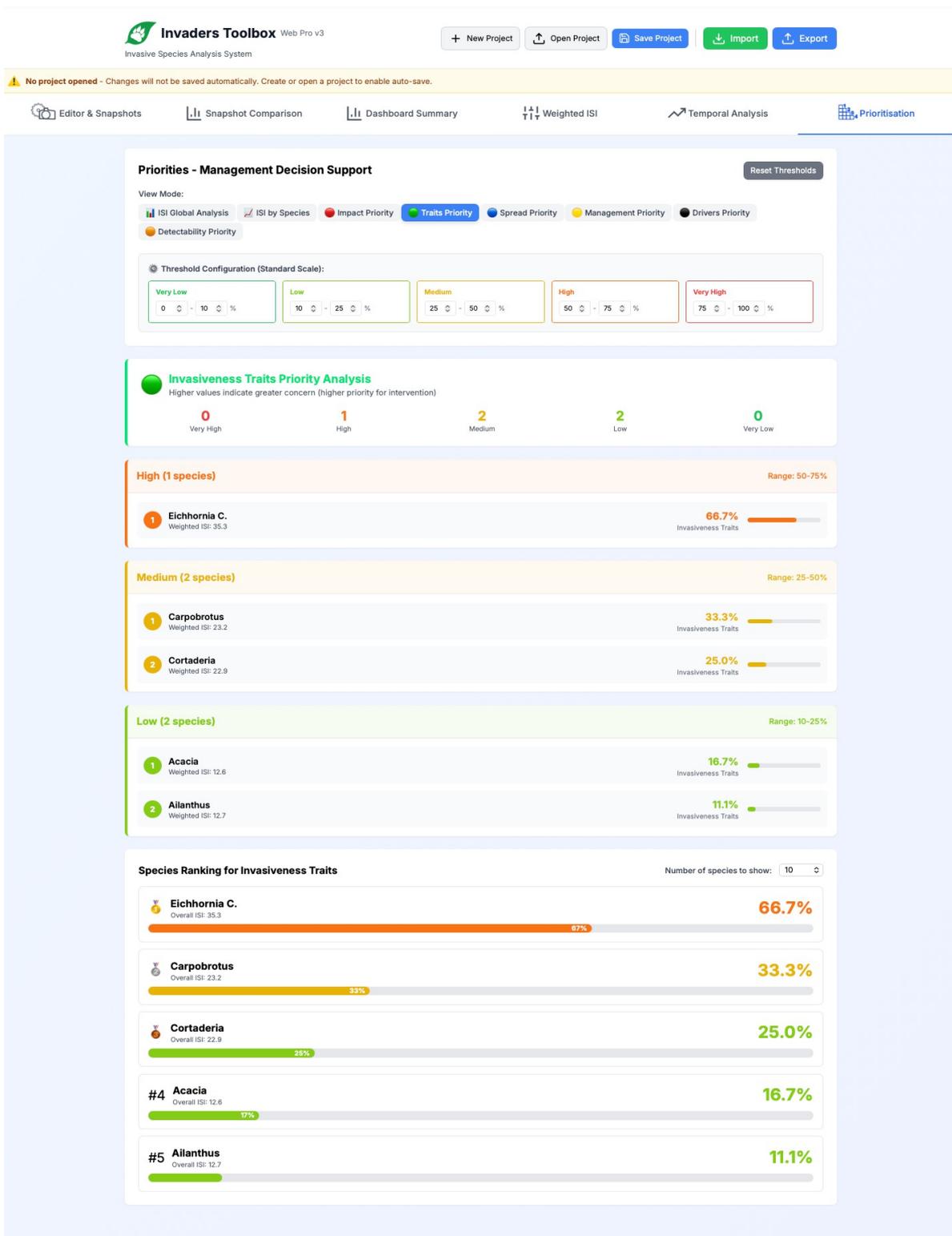


Figure 11: Prioritisation screen — Invasiveness Traits Priority mode



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The Traits Priority mode (Figure 11) ranks species by their biological invasiveness characteristics (green face dimension):

Invasiveness Traits Priority Analysis:

- Green icon indicator with analysis title
- Standard scale interpretation (higher = greater concern)
- Distribution summary across five categories

This mode helps identify species with high reproductive rates, dispersal capabilities, competitive advantages, or other biological traits that facilitate invasion success. Species with high trait scores may warrant prevention-focused strategies even if current impacts are limited.





5.6.7. Spread Priority Mode

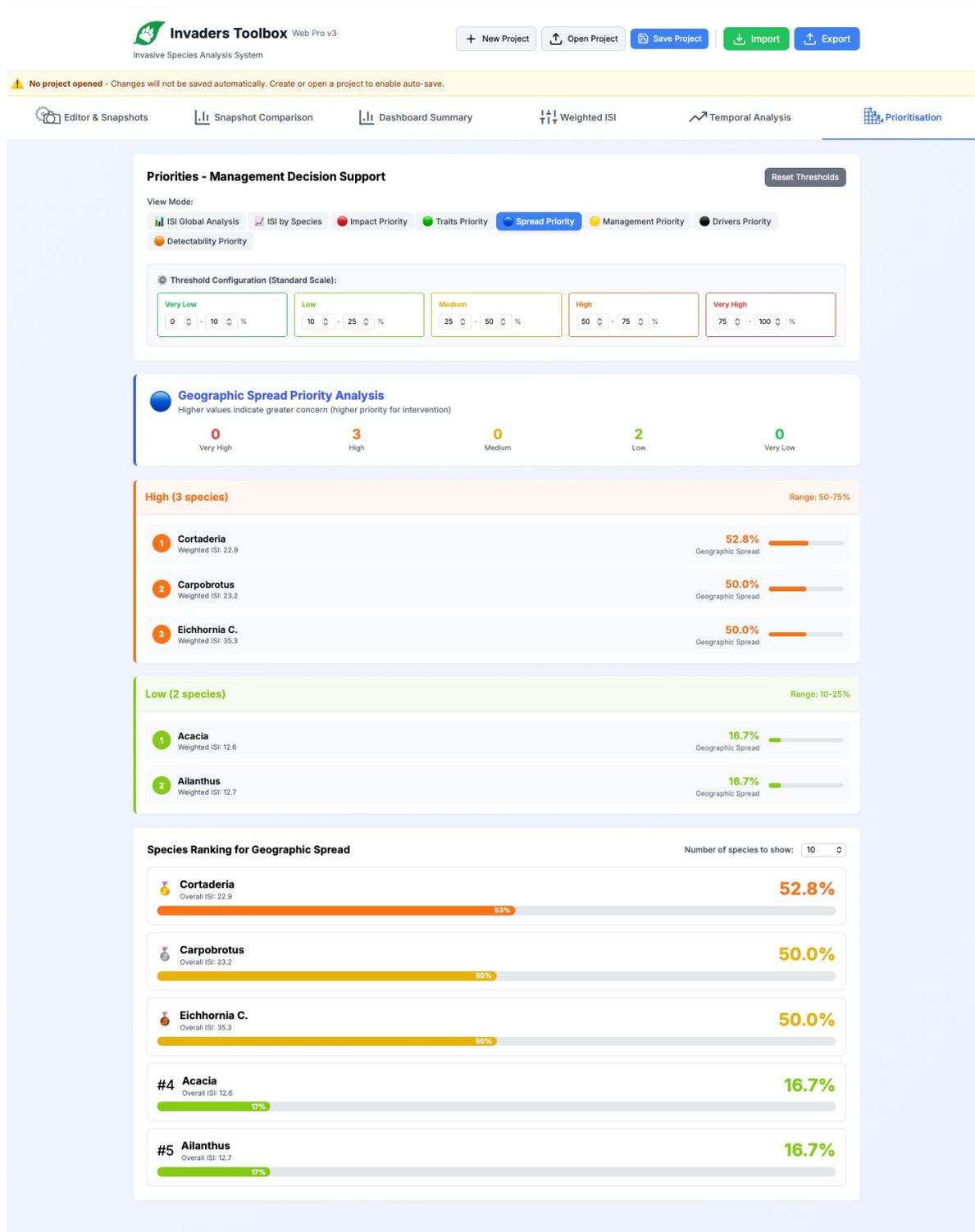


Figure 12: Prioritisation screen — Geographic Spread Priority mode





The Spread Priority mode (Figure 12) ranks species by their geographic distribution extent (blue face dimension):

Geographic Spread Priority Analysis:

- Blue icon indicator with analysis title
- Standard scale interpretation
- Species distribution across threshold categories

This mode identifies species with wide spatial distribution that may require coordinated regional management efforts. High spread values indicate species that have successfully established across large areas, potentially making eradication more challenging.





5.6.8. Management Priority Mode

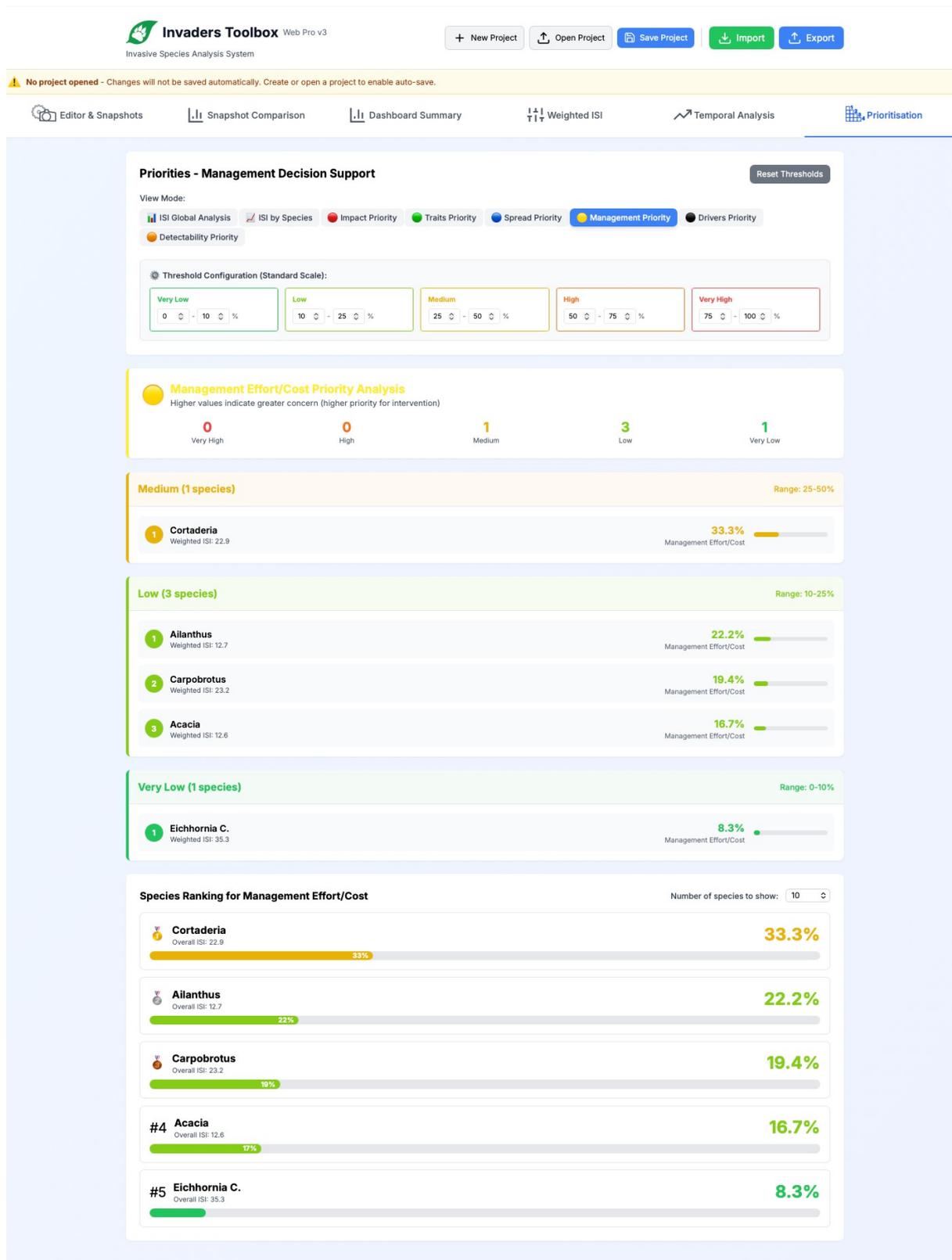


Figure 13: Prioritisation screen — Management Effort/Cost Priority mode





The Management Priority mode (Figure 13) ranks species by management effort and cost requirements (yellow face dimension):

Management Effort/Cost Priority Analysis:

- Yellow icon indicator with analysis title
- Standard scale interpretation (higher = more resources required)
- Category distribution summary

This mode helps resource allocation decisions by identifying species requiring significant management investment. High management scores indicate species that are costly or labour-intensive to control, informing budget planning and prioritization of cost-effective interventions.





5.6.9. Drivers Priority Mode

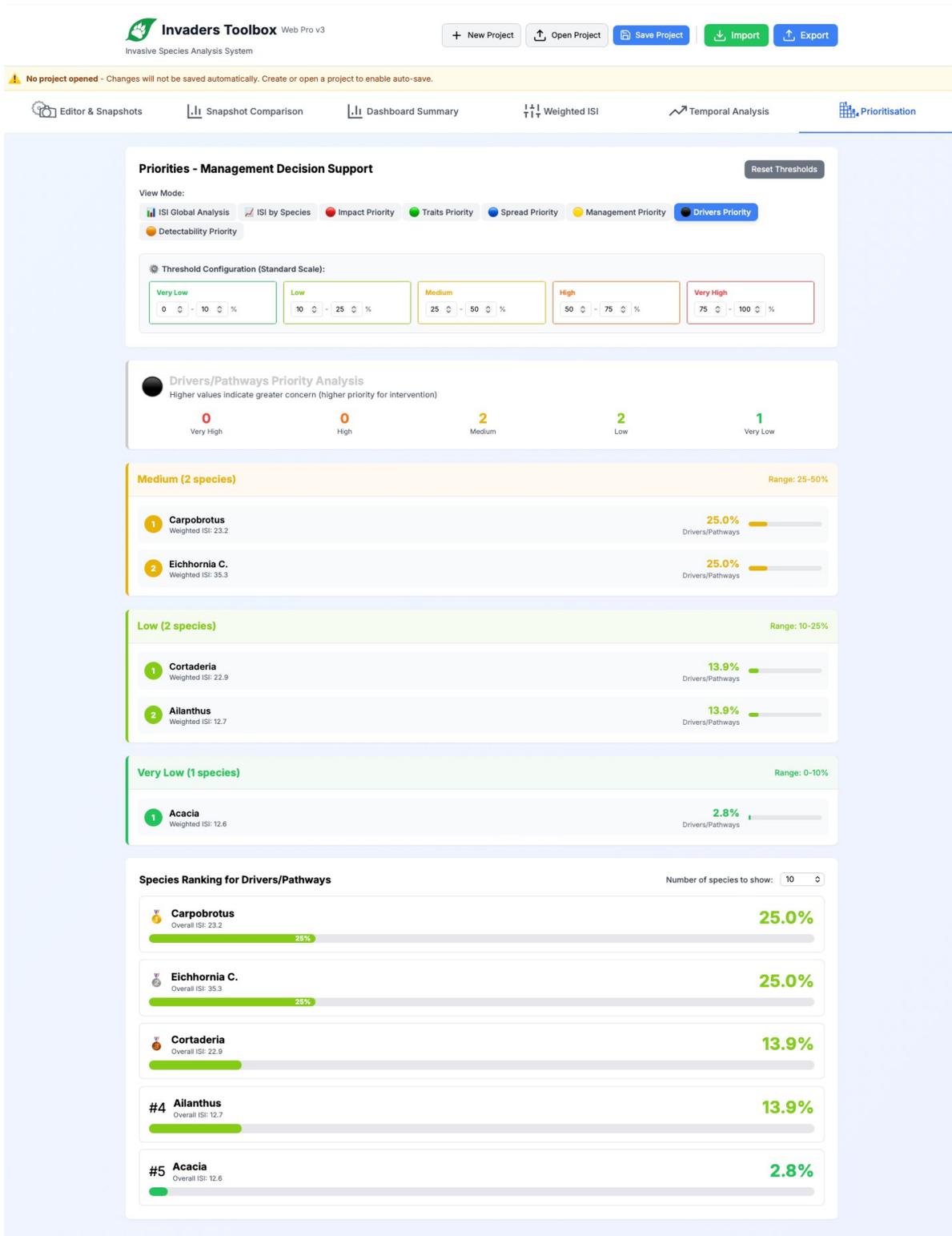


Figure 14: Prioritisation screen — Drivers/Pathways Priority mode





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The Drivers Priority mode (Figure 14) ranks species by introduction vectors and environmental facilitators (Grey face dimension):

Drivers/Pathways Priority Analysis:

- Grey icon indicator with analysis title
- Standard scale interpretation
- Five-category distribution display

This mode identifies species benefiting from multiple introduction pathways or environmental drivers. High driver scores suggest species that may continue to be introduced through active vectors (trade, transport, horticulture) or are facilitated by environmental changes (climate, land use), warranting pathway management interventions.





5.6.10. Detectability Priority Mode

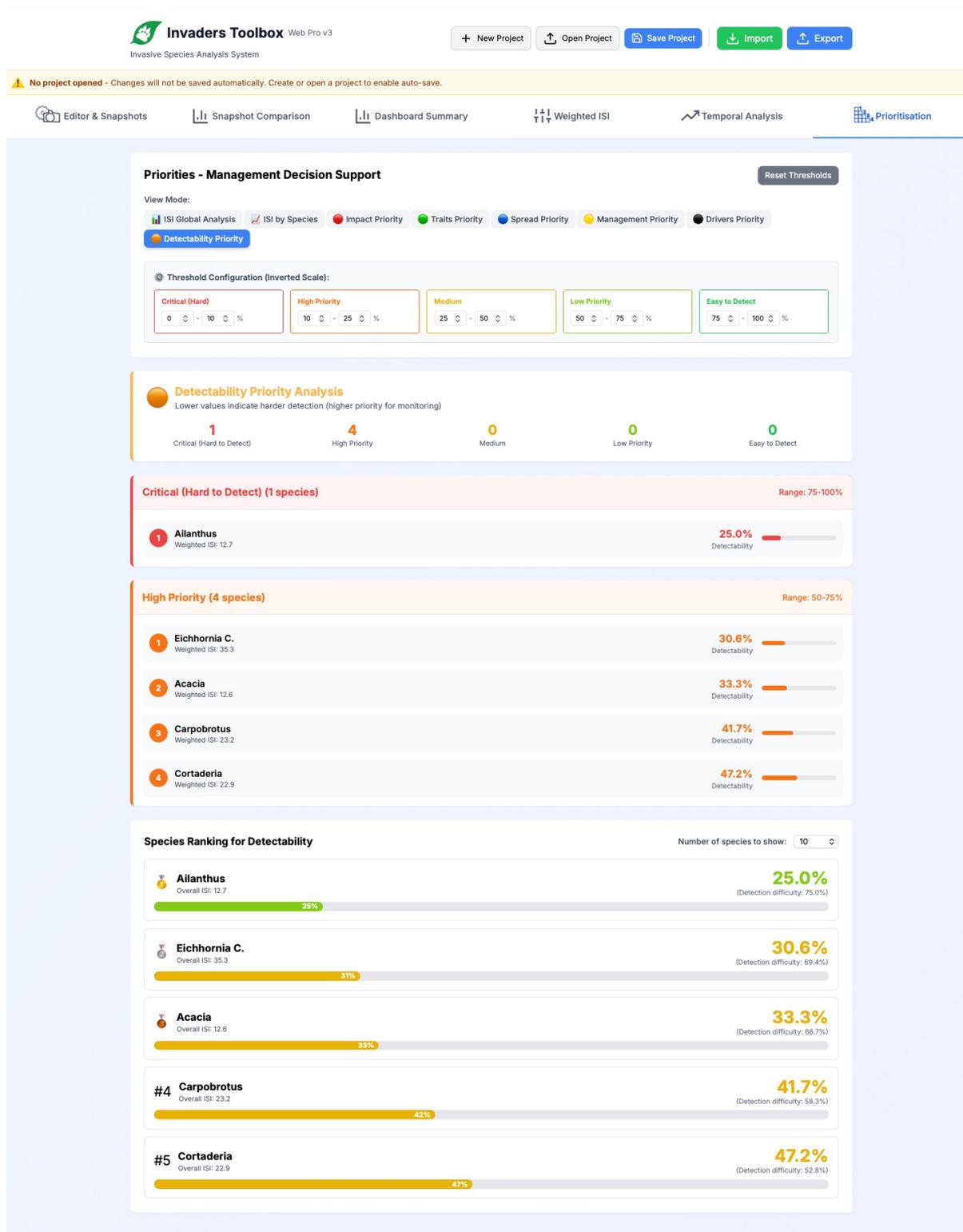


Figure 15: Prioritisation screen — Detectability Priority mode (inverted scale)





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The Detectability Priority mode (Figure 15) uses an inverted scale to rank species by detection difficulty (orange face dimension):

Detectability Priority Analysis:

- Orange icon indicator with analysis title
- Inverted scale note: “Lower values indicate harder detection (higher priority for monitoring)”
- Modified category labels reflecting inverted interpretation

Inverted Category Labels:

Table 18: Detectability mode inverted category mapping

| Default Range | Standard Label | Detectability Label |
|---------------|----------------|---------------------------|
| 0-10% | Very Low | Critical (Hard to Detect) |
| 10-25% | Low | High priority |
| 25-50% | Medium | Medium |
| 50-75% | High | Low priority |
| 75-100% | Very High | Easy to Detect |

Detection Difficulty Display:

In addition to the detectability percentage, each species entry shows the calculated "Detection difficulty" value (100% minus detectability), providing an intuitive measure of monitoring challenge.

This mode is critical for early detection programs, identifying cryptic or difficult-to-detect species that may establish unnoticed. Species with low detectability scores warrant enhanced surveillance efforts and specialized detection methods.

5.6.11. Common Features Across Face-Specific Modes

All six face-specific priority modes (Impact, Traits, Spread, Management, Drivers, Detectability) share consistent interface patterns:

Priority Analysis Summary:

- Dimension-specific icon and colour theme
- Scale interpretation guidance
- Five-column category distribution with species counts

Categorized Species Lists:

- Expandable sections per threshold category
- Colour-coded left borders matching severity
- Species cards with rank, name, weighted ISI, dimension value, and visual progress bar
- Threshold range displayed in section header

Species Ranking Section:

- Configurable display limit (5 to 50, or All species)





- Medal icons for top 3 positions
- Overall ISI shown as reference context
- Full-width progress bars with embedded percentage labels
- Threshold-based colour coding for immediate visual assessment

5.6.12. Analytical Applications

The Prioritisation screen supports diverse management decision workflows:

- **Resource Allocation:** Use ISI by Species mode to identify which species warrant the most management investment
- **Impact Mitigation:** Focus on Impact Priority to address species causing the greatest ecological or economic damage
- **Prevention Planning:** Use Traits Priority to identify high-risk species for prevention programs before impacts materialize
- **Containment Strategy:** Geographic Spread mode helps prioritize species for containment before further expansion
- **Budget Planning:** Management Priority informs cost projections and resource requirements
- **Pathway Management:** Drivers Priority identifies species requiring intervention at introduction vectors
- **Surveillance Programs:** Detectability Priority guides early detection monitoring efforts toward cryptic species
- **Integrated Assessment:** ISI Global Analysis provides holistic portfolio evaluation for strategic planning

6. Conclusion

Invaders Toolbox Web v3.0 represents a fully functional implementation of an integrated platform for invasive species analysis, monitoring, and management decision support. This milestone document has detailed the technical architecture, component structure, and user interface design of the application.

6.1. Current Capabilities

The application successfully delivers on its three core objectives:

Research Platform: The ISI engine provides a scientifically rigorous framework for quantifying invasion pressure, with 14 configurable parameters allowing researchers to adapt the methodology to specific study contexts. Bootstrap uncertainty quantification ensures statistical validity of results, while the native SVG visualization system enables publication-quality chart generation without external dependencies.

Monitoring and Registry System: The temporal snapshot architecture supports longitudinal tracking of invasion dynamics across unlimited time points. Researchers and field teams can systematically record species assessments, track portfolio evolution, and detect emerging trends through comparative analysis tools. The standardized six-face taxonomy ensures data consistency across monitoring campaigns and facilitates cross-study comparisons.





Decision Support Tool: The prioritization module delivers actionable intelligence for managers and policymakers through eight specialized analysis modes. Configurable risk thresholds accommodate diverse regional management objectives, while component contribution analysis identifies specific intervention targets. The executive dashboard consolidates key performance indicators, active alerts, and trend summaries for rapid situational awareness.

6.2. Technical Achievement

The React-based implementation achieves a balance between functionality and maintainability:

- 17 modular UI components with clear separation of concerns
- Isolated computation engine ensuring testability and scientific reproducibility
- Zero external charting dependencies through native SVG implementation
- Full Python/Web interoperability via bidirectional JSON format conversion
- Progressive Web App architecture enabling offline-capable deployment

6.3. Extensibility and Customization

The application architecture is designed to accommodate future extensibility, particularly regarding:

User Profiles: The system is prepared to support different user profiles, enabling role-based access and personalized configurations. Researchers, field technicians, and decision-makers may require different interface layouts, default parameters, or data access levels tailored to their specific workflows.

Customizable Taxonomy: While the current implementation uses a standardized six-face taxonomy (Impact, Invasiveness Traits, Geographic Spread, Management Effort, Drivers/Pathways, and Detectability), the modular architecture allows for future customization of assessment dimensions. This extensibility enables:

- Addition of domain-specific faces for specialized assessment contexts
- Removal or simplification of dimensions for rapid field assessments
- Regional adaptations reflecting local management priorities and data availability
- Alternative taxonomic frameworks as methodological standards evolve

This flexibility ensures the platform can adapt to diverse research contexts and management frameworks without requiring fundamental architectural changes.

6.4. Document Scope

This technical milestone document serves as a comprehensive reference for the Invaders Toolbox Web v3.0 codebase, providing:

- Complete file-by-file documentation of source code organization
- Detailed screen descriptions with annotated interface elements
- Parameter specifications for the ISI calculation engine
- Visual reference through captured application screenshots





The Invaders Toolbox platform is positioned to support both ongoing research activities and operational deployment in invasive species management contexts.

7. Acknowledgements

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8. References

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