Invasive Weed Management Planning (WePlan) User Manual – v.1.0

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1. Code download and system requirements

This software is written in java code. For the most recent version of the code and supporting materials please contact the authors.

The latest version of java must be installed on the computer. Once installed simply click on the xspread icon to open the software.

Use the supplied demo data to follow all steps in this manual (supplied in demodata.zip).

2. Generalized model approach

We use a spatially explicit individual based simulation approach which links the spread, growth and management of invasive weed species into a single dynamic simulation model (with three management strategies available: containment core, boundary and ground control). Our model can handle multiple species with species specific spread, growth and management parameters (see section 3 for input of species specific parameters). The simulation algorithm is presented in Figure 1. The simulation steps for infested cells are presented in the order in which they occur for each annual time step. For each step we indicate eligibility requirements for each step and also specifications for each step. For example, only cells that are infested and in no control or containment core management zones can spread. Spread is influenced by both the species (sets distance and rate) as well as age (species specific age eligibility for spread).

Figure 1. Simulation steps, eligibility and specification attributes for each step.

Simulation steps	Eligibility	Specification attributes
Monitor	All	Density
Set management zones and manage	Control, Containment or newly detected in no control	Size (<=8 cells control, >8 cells contain), species
Cost accounting	All	Management zone
Growth	No control or containment core	Age, species
Spread (seeds dispersed)	No control or containment core	Age, species
Update cell status (decreased density for controlled sites, newly infested sites become low density)	All	Management zone, year of management

The model dynamically applies two management zones to infestations: containment and control (for general rules see Table 1).

Contain – containment involves delineating containment boundaries and searching and treating any new plants within the boundary to prevent spread outside of the containment zone but allowing further growth and spread within the containment core. We assume that control within the containment boundary is 100% effective and that all new infestations within the boundary are detected and locally eradicated on an annual basis.

Control –on-ground chemical control of infestations until local eradication is achieved. The duration of the control program depends upon the initial density of the infestation (see costs section for details). The duration of treatment depends on the initial density class and treatment ranges from 5-7 years. The density class (d) of an infestation given its treatment year (t) and initial density (i) is:

$$d_{t|i=1} = \begin{cases} 1 \ for \ t \le 5 \\ 0 \ for \ t > 5 \end{cases}$$

$$d_{t|i=2} = \begin{cases} 2 \ for \ t \le 2 \\ 1 \ for \ 2 < t \le 5 \\ 0 \ for \ t > 5 \end{cases}$$

$$d_{t|i=3} = \begin{cases} 3 \ for \ t \le 2 \\ 2 \ for \ 2 < t \le 4 \\ 1 \ for \ 4 < t \le 7 \\ 0 \ for \ t > 7 \end{cases}$$

Where density class 0 is absent, 1 is scattered (percentage cover <10%), 2 is medium (percentage cover 10-50%) and 3 is dense (percentage cover >50%).
We assume that control is 100% effective and at the end of the treatment the infestation is locally eradicated.

Table 1. General zone rules.

	Clean	Containment boundary	Containment core	Control
Can Grow	Y	N	Y	N
Can Spread	Y	N	Y	N
Management impacts	None	Maintain clean boundary	None	Decrease in density through time until local eradication is achieved
Monitoring	If detect infestation, place in Control, If undetected grow/spread	If detected remove with annual boundary patrol	Record new status of infestations	Record new status of infestations

We assume that co-management occurs when a cell is co-occupied by multiple species and each species is placed underground control. The cost of management is assumed to be the maximum cost across the species. Co-management does not occur if a cell is under containment for species 1 and under ground control for species 2. In that case the cost is the sum of containment and ground control costs.

3. Introduction to the input parameters

Below is a list of parameters that can be specified by the user within the properties file of the java code. The parameter name and a description of the parameter are provided below.

Parameter Name	Description
Species	Species names used to label all outputs per species [species1, species2,….speciesN]
Presence_File	Initial distribution - this should be a presence absence map. [filepath_SpeciesPresence1, filepath_SpeciesPresence2,…]
Age_File	Age of infestations in initial distribution. In the spread module this is used to calculate whether an infestation can spread based on wait time. In the growth module this is used to determine density. In the management module this is used to determine the cost and duration of treatment. [filepath_SpeciesAge1, filepath_SpeciesAge2,…]
Habitat_File	HSM - this is used to calculate establishment - if the user does not have an HSM then they may specify 'ALL' such that all grids are suitable. [filepath_SpeciesHabitat1, filepath_SpeciesHabitat2,…]
Reference_File	Final distribution map for calculating statistical measures - this should be a presence absence map. [filepath_SpeciesReference1, filepath_SpeciesReference2,…]
Output_Folder	Directory path for run outputs
Output_File	Name of file for statistics output (should have .csv extension)
Replicates	Number of replicates to run each parameter pair (we recommend at least 25 runs but users should explore run number to ensure calibration is providing stable results).
Start_Time	Initial time step (default is 0)
End_Time	Final time step. Total run duration is end_time-start_time
Step_Interval	Time step interval.
Distances	The distance values. There are three ways of specifying parameter values for runs. {start, end, number} to indicate the first and last parameter values and number of parameter values to select from equal steps within that interval. (start, step, number) to indicate the first parameter value, the interval step between parameter values and the number of parameter values. [param1, param2, param3, ..., paramN] to specify exact parameter values. So a user can specify the distance values 2, 4, 6, 8, 10 with the following inputs: {0,10,5}, (2,2,5), [2,4,6,8,10]. Distances for each species should be entered separated by ';'.
Rates	The rate values. There are three ways of specifying parameter values for runs. {start, end, number} to indicate the first and last parameter values and number of parameter values to select from equal steps within that interval. (start, step, number) to indicate the first parameter value, the interval step between parameter values and the number of parameter values.

	[param1, param2, param3, ..., paramN] to specify exact parameter values. So a user can specify the rate values 2, 4, 6, 8, 10 with the following inputs: {0,10,5}, (2,2,5), [2,4,6,8,10]. Rates for each species should be entered separated by ';'.
Direction_kernel	This is the direction kernel where the first value given is the east direction and values are entered moving counter clockwise around the cardinal directions: [E,NE,N,NW,W,SW,S,SE]. Values can be any user specified weighting. Direction kernels for each species should be entered separated by ';'.
Run_type	'Calibration' specifies calibration mode and all possible combinations of the Distance and Rate values will be run for the specified replicates. The best parameter pairs from the analysis will be saved in calibration.csv in the output folder. 'Paired' specifies paired parameter pair mode and users should input parameter pair values using [ ]. Each parameter pair will run for the specified replicate numbers.
Wait_Time	time to wait before an infestation can spread - if user does not specify assumption should be set to 0. [Wait_Time1, Wait_Time2,…]
Age_Stage	Age at which an infestation is considered Medium and age at which an infestation is considered Dense (for age <Medium_age infestations are assumed to be Scattered). [AgeMedium1, AgeDense1];[AgeMedium2, AgeDense2];…
p_Detection	Probability of detection during survey conditioned on density. [pDetectionScattered1, pDetectionMedium1, pDetectionDense1]; [pDetectionScattered2, pDetectionMedium2, pDetectionDense2];…
Containment_Cutoff	The number of cells at which new infestations are no longer eligible for ground control. Adjoining cells are determined based on adjacency including diagonal adjacency.
Core_Buffer_Size	The size of containment boundary in meters.
Containment_Cost	The cost of managing a single containment unit.
Containment_Labour	The labour (in total hours) associated with managing a single containment unit.
Ground_Control_Cost	The cost of ground control of a single unit conditioned on density. Parameter input is the file path to the ground control cost file. Within the .txt file enter: [CostScattered1, CostMedium1, CostDense1];[CostScattered2, CostMedium2, CostDense2];….
Ground_Control_Labour	The labour associated with control of a single unit conditioned on density. Parameter input is the file path to the ground control labour file. Within the .txt file enter: [LabourScattered1, LabourMedium1, LabourDense1];[LabourScattered2, LabourMedium2, LabourDense2];….

|	
	Exempts listed species from containment. If containment does not apply to all species, use ALL.
Containment_Ignore	[species1, species2,….speciesN]
	Exempts listed species from ground control. If ground control does not apply to all species, use ALL.
Ground_Control_Ignore	[species1, species2,….speciesN]
	Species which are expempt from the rules for containment core (i.e. they can be controlled within core zones).
Core_Control	[species1, species2,….speciesN]
	This is the frequency with which the model undertakes monitoring and updates management zones based on detection of new infestations (monitoring applies to units in 'no control' zone, we assume complete knowledge of units already in containment or ground control given annual visits to each unit
Management_Frequency	for management activities).
	True = can overwrite existing files in the output destination. False = do not overwrite existing files in output folder. If files
Overwrite_output	already exist the user will receive an error.
	True = a text file in the output folder will be saved with the properties specified for that run, False = a file will not be
Save_Properties_File	generated.
	True = the occupation frequency file will be written to the output folder. False = the occupation frequency file will not be
Write_Frequency_Map	written.
	True = saves cover maps for each replicate run at each time step for each species. False = cover maps are not saved for each
Write_Each_Time_Step	time step.
	True = saves monitored management zone maps for each replicate run at each time step for each species. False = monitored management zone maps are not saved for each time
Write_Each_Mgt_Step	step.
Write_Raster_Header	True = include raster header in the map outputs for easy import into GIS. False = raster header is not included.
	True = writes summary outputs for each run at each time step for each species including number of units in each zone, infested, undetected and costs and labour associated with
Write_Trace_Files	management. False = file is not written.
Trace_Base_Name	Name of file for trace output (should have .csv extension)

3.1 Opening the software

Double click on the .jar file xspread_gui.jar. This will open the software. The default mode is to open in calibration mode. Click the prompt appropriately to proceed.
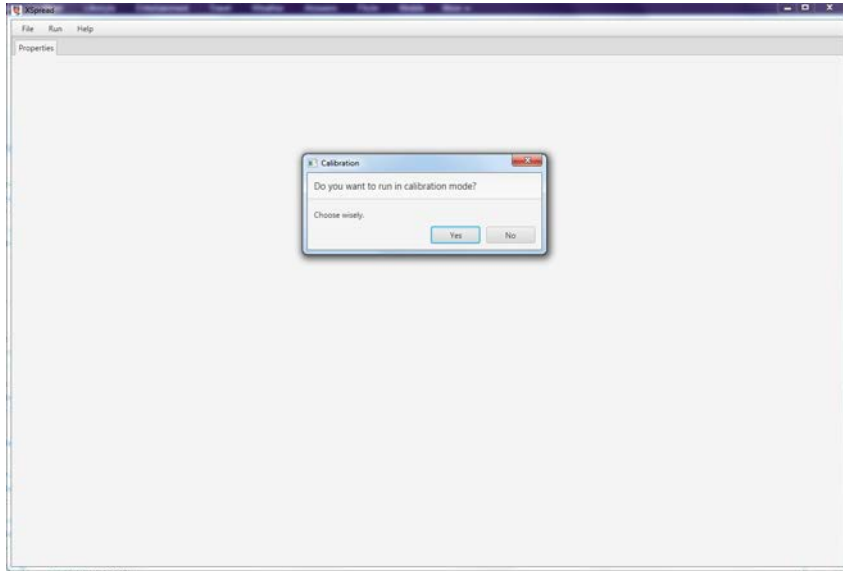
3.2 Opening a properties file

Once the software is open the user may manually input each properties field by typing directly in the field and hitting enter to save the input. Alternatively, a properties .txt or .prm file may be opened by navigating to the File>Load Parameters menu option. This will populate all property file entries. The user can check that entries are correct by clicking on each dropdown arrow to expand the property options.
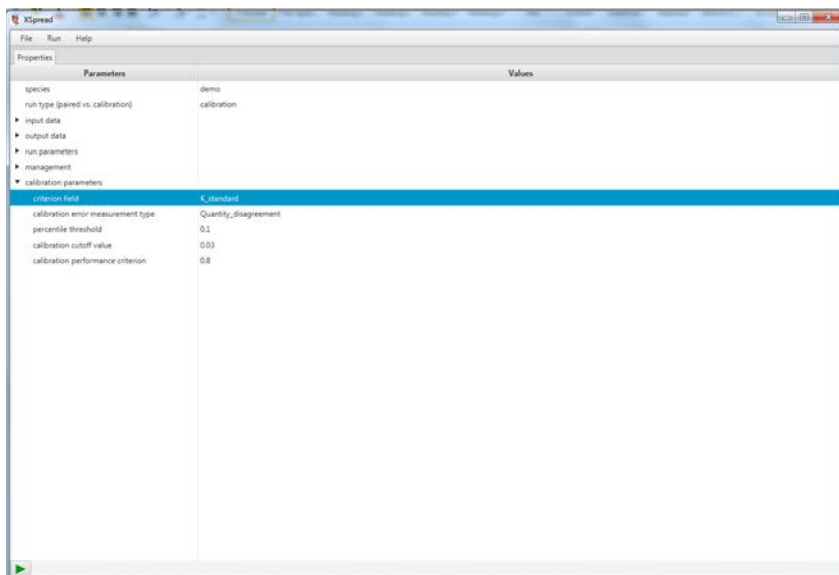
3.3 Saving a properties file

A properties .prm file can be created from the current run properties shown in the properties tab by navigating to the File>Save Parameters menu option.

3.4 Running

Once the properties have been entered manually or loaded from a .prm file the user can run the software in two ways: 1) by pressing the play arrow in the bottom left hand corner of the software or by selecting the menu option Run>Start.

3.5 Navigating software tabs

Once the software has run several output tabs will appear. For calibration mode there will be three additional tabs: Calibration Results, Image Gallery, Plots. For paired mode there will be two additional tabs: Image Gallery, Plots.

3.5.1 Calibration Results

This tab provides a calibration plot to assist users in exploring the selected parameter pairs, ensuring that the envelope of good solutions is captured in the selected parameter pair range that the user specified, exploring the associated kappa values and saving the final parameter pairs for running in paired mode. The initial output screen shows the plot on the left hand side with parameter Rates increasing on the horizontal axis (from left to right) and parameter Distances increasing on the vertical axis (from top to bottom). The grid color is shaded based on average Kappa standard values (grey to red color scale). In the right hand panel the final selected parameter pairs and their associated counts and average kappa values are shown in a table.

The selected parameter pairs are initially selected in the graph and their corresponding values are shown in the right hand text fields. Users should visually inspect the graph to ensure that there is a clear envelope of high kappa values (red) encapsulated within cooler color tones (blue-grey). This demonstrates that the parameter pair range fully captures the suitable range of parameter pairs.

The user can then click on any parameter pair in the graph and this will toggle the values on and off with the text fields in the right hand panel updating. This allows the user to explore kappa values of all parameter pairs.

Lastly, those parameter pairs that are toggled on in the graph (and have corresponding values displayed in the right hand panel text fields) can be saved in the properties tab. We recommend that users refer to the table of selected parameter pairs (stationary table in right hand panel) and ensure that toggled values match these parameter pairs. This can be done manually or the user can press 'Clear' and then 'Reset' and the values will be returned to the selected parameter pairs. However, users may manually select any parameter pairs they wish at this stage. Once the user

has selected their preferred parameter pairs they may press 'Save' and this will update the properties tab with the saved parameter pairs and switch the run mode to paired. At this stage we recommend that the user save the parameter pair file in a new .prm file by navigating to the menu File>Save Parameters.

3.5.2 Image Gallery

This tab displays user input maps and any saved output maps specified in the property file. On the right hand side thumbnails of all maps are available for browsing. To display a map in full size the user should click on the thumbnail and a full sized image will be displayed in the left hand panel. A large number of maps can be produced in a single run. To help users navigate to the desired map the thumbnails can be filtered by species and image type (available map outputs include cover (presence, absence), monitored (management stage and detected infestations when monitored), frequency (frequency of occupancy across runs)).

3.5.3 Plots

This tab displays the outputs from the runs saved in the trace files. The user can create graphs of the data by specifying the species, x-axis values, y-axis values and how to partition the data (e.g. by Rate or Distance will allow users to explore how sensitive the results are to parameter pair values, by replicate will allow users to explore how sensitive values are across runs). A user may save a plot as a .png file by clicking 'Save Image'.

4. Spread Mode: Running model with no management (calibration and runs)

The model can be run in Spread mode (no management allowed) by specifying the Containment_Ignore = True for all species and Ground_Control_Ignore = True for all species. In spread mode the user can determine appropriate spread parameters (Distance and Rate) in calibration mode (Run_type =Calibration) or assess potential losses in the absence of management in run mode (Run_type = Paired and include user specified Distance and Rate parameters). For full details of the spread model approach taken see Adams et al. (2015).
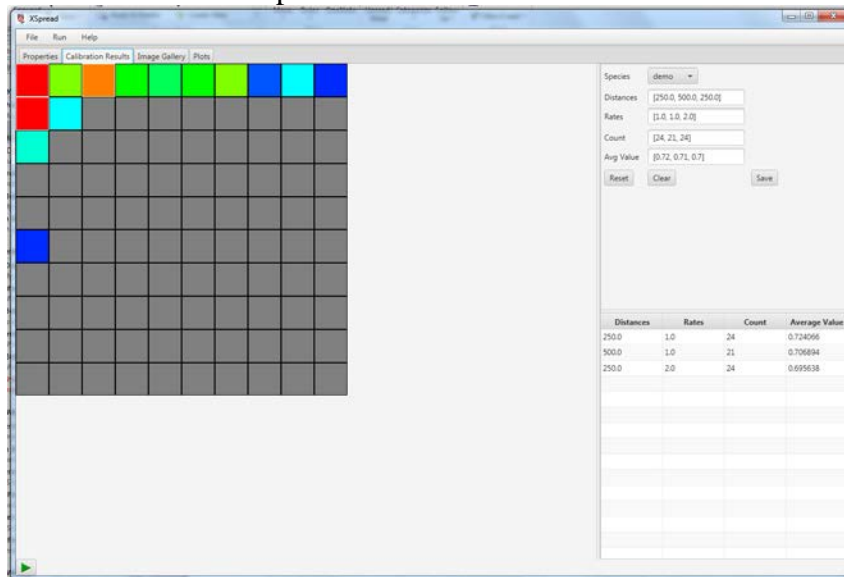
4.1 Calibration

4.1.1. Calibration run step 1: Specify parameter inputs in the properties file
For calibration, the Run_type should be set to CALIBRATION and Distances and Rates should be specified to reflect expected ranges for the species of interest.

4.1.2. Calibration run step 2: Run calibration
Once the calibration parameters have been specified the user should run the calibration runs. The output of the calibration analysis is displayed on the Calibration Results tab (and is saved in calibration.csv) which contains the final parameter pairs that meet the criteria of being in the top 10% of all runs (based on Kappa), having less than 3% quantity error and having greater than 80% of runs in the top 10%.

The user should visually inspect the calibration plot to ensure that a clear envelope of high kappa values (red) is captured in the selected parameter pair rang (shown above and corresponding to demo data package). If the range selected does not result in a stable calibration then the range should be extended until the calibration becomes stable. Due to the stochasticity of the model users may find that the parameter pair set selected based on calibration runs may vary slightly (1-2 parameter pairs). The user may explore the kappa values of parameter pairs by clicking on the calibration plot (values will toggle on in the right hand text fields).

Once the user has fully explored the results the final parameter pairs may be saved to the properties tab. To do this the user should either manually toggle on only the parameter pairs selected through calibration (displayed in the stationary table in the right hand panel) or by selecting 'Clear' and then 'Reset' in the interactive text fields to pull in the calibrated parameter pairs. The user can then select 'Save' to pull the parameter pairs into the properties tab and switch to paired mode. The user may save the new .prm file by navigating to File>Save Parameters.

4.2 Run initial time step runs

4.2.1. Run step 1: Specify parameter inputs in the properties file
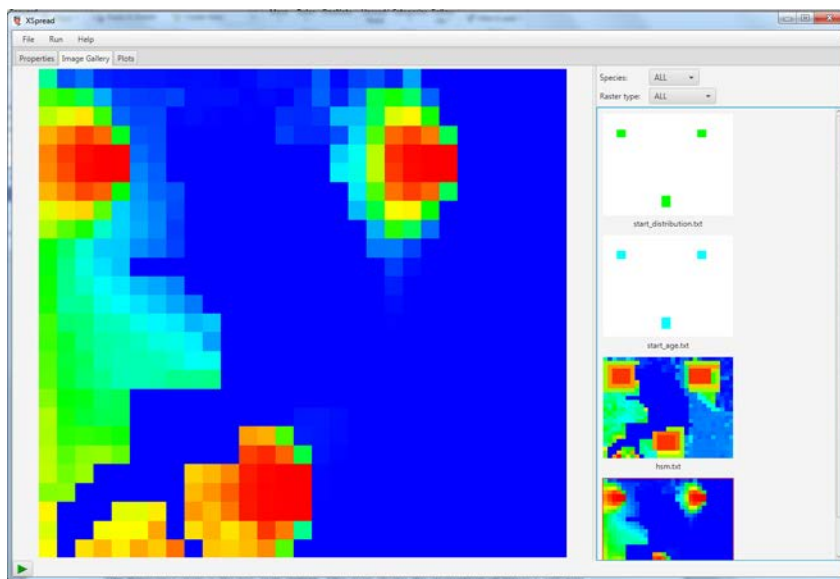
Once calibration is complete the user should return to the Properties tab, ensure that the appropriate parameter pairs have been imported from the Calibration Results tab and that run type has been switched to paired and save the .prm file.

4.2.2. Run step 2: Run spread model

The user should run the model for the selected number of parameter pair replicates (at least the same number of replicates used in calibration).
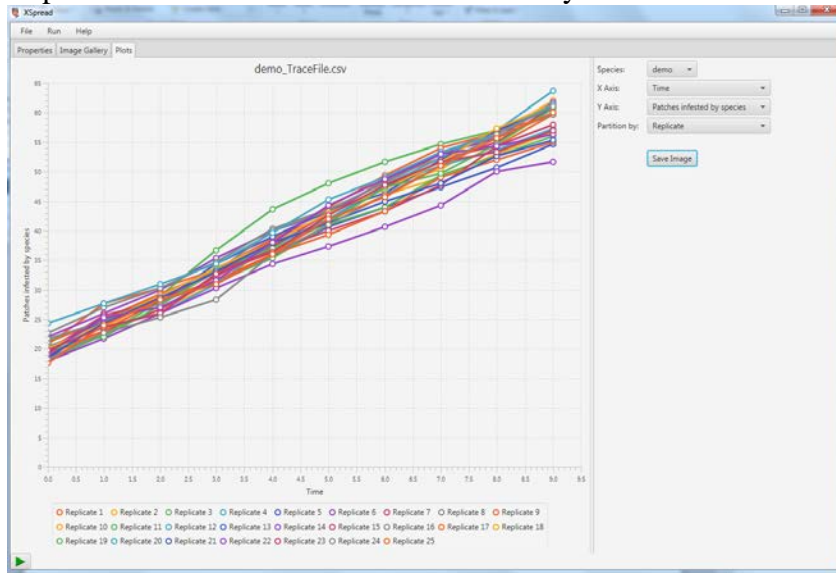
4.2.3. Run step 3: Explore outputs

The user may explore the map outputs in the Image Gallery and run outputs (such as number of patches infested) in the Plots tab. If the users wish to further explore the statistics or run outputs in another program the output file (saved as a .csv file) contains statistics comparing the predicted final distribution and the actual final distribution for each run. We use Kappa, quantity disagreement and allocation disagreement to explore our results; however a number of other statistics are provided (see Pontius for descriptions) that users may choose to explore.


The frequency map is the key map output (shown above in the Image Gallery tab). This map shows the proportion of times a cell was occupied across the runs and can be interpreted as a

probability of occurrence. Maps of final distributions for individual runs may also be used to explore differences in parameter pair performance and stochasticity.

The Plots tab can be used to further explore the run outputs. For example, by partitioning on Replicate the user can visualize stochasticity across runs.

Similarly, by partitioning on spread parameters (Distance and Rate) the user can visualize the difference in outputs across parameter pairs.
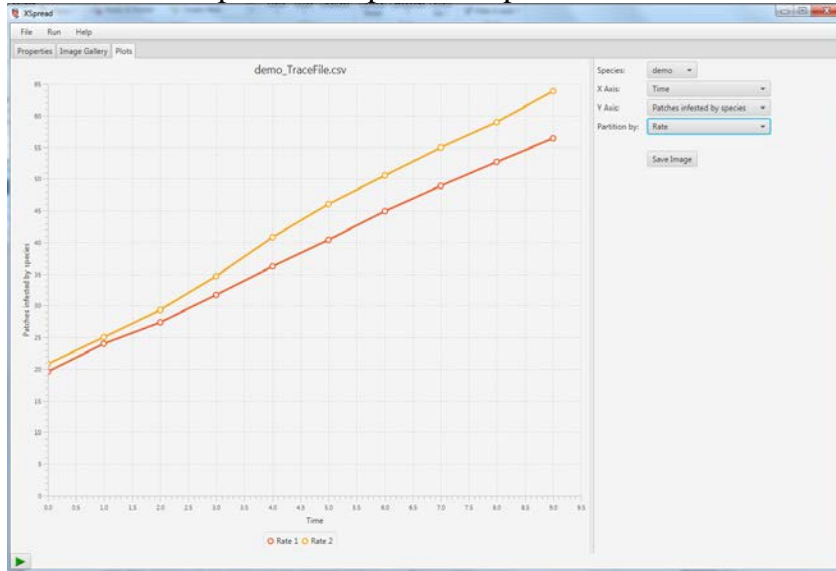
4.3 Run future spread runs

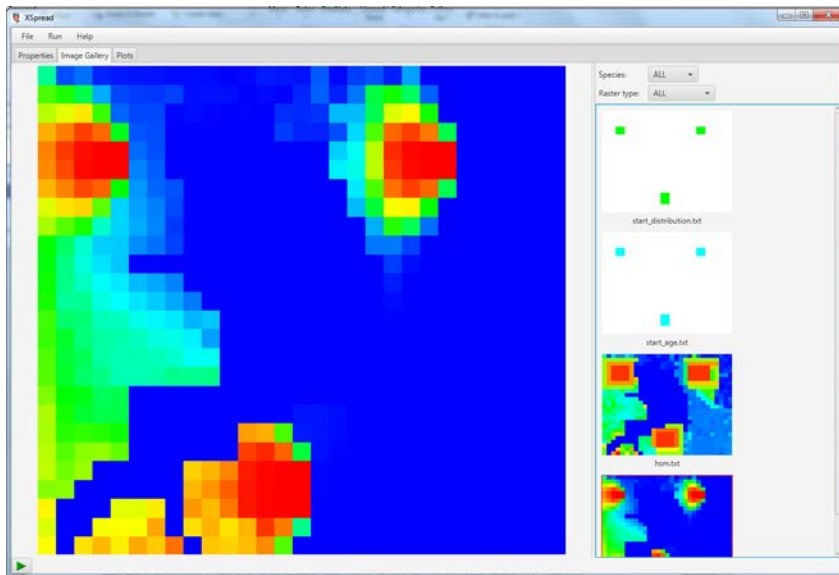### 4.3.1. Run step 1: Specify parameter inputs in the properties file

The user should update the initial and final distribution maps in the Properties tab and number of time steps to reflect a future time step. If the user has a second time step to use for measuring goodness of fit off the calibration based on a first time step then the statistical outputs can be used for this purpose. However, if the user is simply running the spread model for a future time frame then the map outputs in the Image Gallery should be used to explore potential future distributions.

4.3.2. Run step 2: Run spread model

The user should run the model for the selected number of replicate runs.
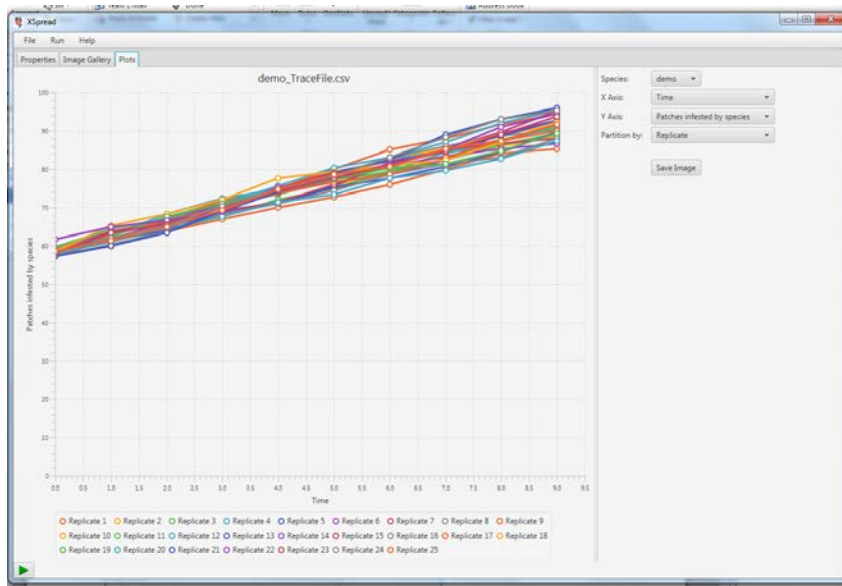
4.3.3. Run step 3: Explore outputs

The user may explore the map outputs in the Image Gallery and run outputs (such as number of patches infested) in the Plots tab. If the users wish to further explore the statistics or run outputs in another program the output file (saved as a .csv file) contains statistics comparing the predicted final distribution and the actual final distribution for each run. We use Kappa, quantity disagreement and allocation disagreement to explore our results; however a number of other statistics are provided (see Pontius for descriptions) that users may choose to explore.

The frequency map is the key map output (shown above in the Image Gallery tab). This map shows the proportion of times a cell was occupied across the runs and can be interpreted as a probability of occurrence. Maps of final distributions for individual runs may also be used to explore differences in parameter pair performance and stochasticity.

The Plots tab can be used to further explore the run outputs. For example, by partitioning on Replicate the user can visualize stochasticity across runs.

5. Management Mode

5.1. Run step 1: Specify parameter inputs in the properties file

To run in management mode additional user inputs are required including:

1) the management zone file (ascii file indicating placement of spatial management zones),
2) eligibility for containment zone, size of infestation at which the management strategy should switch from control to containment (specified in number of cells),
3) the depth of the containment boundary (specified in distance),
4) costs of control by density class and labour hours of control by density class
5) costs of containment (assumes uniform costs regardless of density) and labour hours of containment (assumes uniform effort regardless of density).

The management zones are:

	Clean	Control	Containment boundary*	Containment core
Zone code for software	0	1	2	3
Can Grow	Y	N	N	Y
Can Spread	Y	N	N	Y
Management impacts	None	Decrease in density through time until local eradication is achieved	Maintain clean boundary	None
Monitoring	If detect infestation, place in management zone***, If undetected grow/spread	Record new status of infestations	If detected remove with annual boundary patrol	Record new status of infestations

*We recommend that as a default the boundary be set to twice the average spread distance from the calibrated spread model or other available references to inform the size of the boundary.
**If a new infestation is detected it is placed into either control or containment based on the infestation size and species. The decision to place a new infestation into either containment or control is user specified but we suggest that this should be based on the relative economic costs of the two management options (Fletcher et al. 2015).

The management zones are user specified and initialized for the first time step based on the management zone map. For all future time steps management zones are dynamically placed based on monitoring and management zone rules presented in the above table. If the user wishes to allow the software to automatically assign management zones based on the zone rules then the initial management zone map can be set to all 0's ('clean') and in the software will then allocate zones based on the monitored map.

5.2. Run step 2: Run management model

The user should run the model for the selected number of replicate runs.

5.3. Run step 3: Explore outputs

The user may explore the outputs including the statistical outputs and map outputs. The output file contains statistics comparing the predicted final distribution and the actual final distribution for each run at all specified resample resolutions (for use to compare match of final distribution against an expected distribution, primarily under spread runs). The trace file for each species contains the number of cells infested, the number of cells under each zone as well as and total costs and labour time.

The frequency map is the key map output for exploring spread and mean occupancy. This map shows the proportion of times a cell was occupied across the runs and can be interpreted as a probability of occurrence. The cover and monitored maps are the key map output for exploring change in infestations over time and corresponding dynamic changes to management zones.

5.4. Post processing analysis of spatial features infested or managed.

We have provided a post-processing module (xtab.jar) which cross tabulates a specified zone map with a feature map. This can be used to tabulate the number of cells either infested (cover maps) or managed (monitor maps) that are in a specified value class. Xtab.jar requires a .csv file with three inputs: zonal ascii file (cover or management zone), values ascii file (for example, presence absence of species of interest) and the output file path. The output is a cross tabulation of values in each zone.

6. Kakadu Case Study

We present the design and evaluation of a two species (Olive hymenachne and para grass) management approach for the Kakadu floodplains. We first present the spread model parameters for each species and then discuss a management scenario and present methods of evaluating outputs from the runs. All files associated with the case study are provided in the reference folder.

6.1 Para Spread Model

Parameter	Description	Value used and reference
Spread rate	The number of offspring produced by an individual cell	Internally calibrated as an Exponential random variable based on two time steps of the distribution records. Calibration range was 5-100 spread events. Final selected values ranged from 30-120.
Distance	The distance travelled by offspring to a neighbouring cell	Internally calibrated as a Poisson random variable based on two time steps of the distribution records. Calibration range was 250 - 5000 m. Final selected values ranged from 250-500m.
Direction	The direction of dispersal	Water flow direction kernel (Table 2).
Wait Time	Growth of species to reproductive age	Time period before reproduction occurs that was estimated using data or expert knowledge prior to model calibration. Wait time is estimated to be 5.
Establishment	Establishment of the offspring occurs if the cell that is reached is suitable	Habitat suitability modelled based on available environmental predictors.

Table 2. Percentage of vectors in each direction across Magela fluid flow model.

| Direction	Spread direction
N	51.5
NE	15.4
E	3.6
SE	0.9
S	2.0

SW	3.1
W	5.0
NW	18.4

6.2 Olive hymenachne Spread Model

Parameter	Description	Value used and reference
Spread rate	The number of offspring produced by an individual cell	Internally calibrated as an Exponential random variable based on two time steps of the distribution records. Calibration range was 1-10 spread events. Final selected value was 3.
Distance	The distance travelled by offspring to a neighbouring cell	Internally calibrated as a Poisson random variable based on two time steps of the distribution records. Calibration range was 250 - 2500 m. Final selected value was 500.
Direction	The direction of dispersal	Uniform direction.
Wait Time	Growth of species to reproductive age	Time period before reproduction occurs that was estimated using data or expert knowledge prior to model calibration. Wait time is estimated to be 1.
Establishment	Establishment of the offspring occurs if the cell that is reached is suitable	Habitat suitability modelled based on available environmental predictors.

6.3 Management parameters

All data can be found in the Reference folder. The scenario presented here reflects the Best Practice Management scenario (Figure 6) developed in collaboration with Kakadu park staff.

Figure 6. Best Practice Management scenario for Olive Hymenachne (OH) and Para Grass (para).
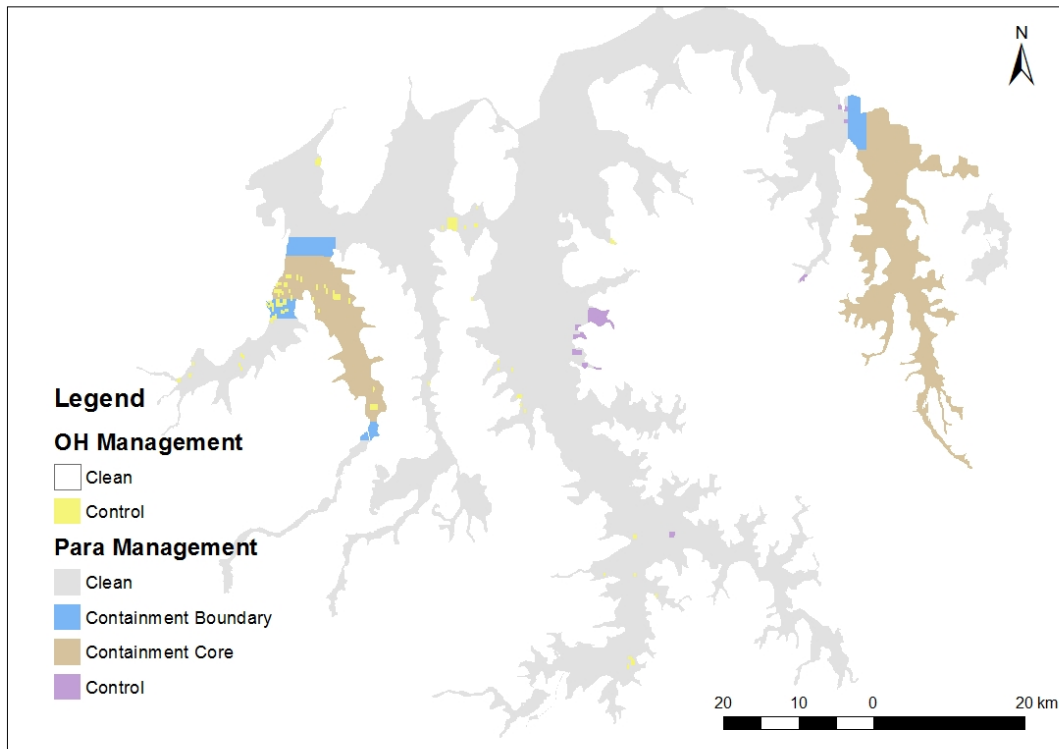
We assume that containment is not an effective strategy for Olive hymenachne (OH) and as such only allow ground control for OH (Containment Ignore = [OH]). We also assume that all infestations of OH will be treated regardless of whether they fall within a containment boundary or containment core for para grass (para) (Core_Control = [OH]). We assume that para grass can be contained effectively and we set the boundary to twice the average spread distance of 750m (Core_Buffer_Size =1500). We assume that containment boundaries are visited once a year and use the <1% cover class cost estimated by McMaster et al. (2014) (Containment_Cost=90, Containment_Labour=1) . For ground control we use the costs estimated by McMaster et al. (2014) and assume two control visits each year (Ground_Control_Cost ground_control_cost_2visit.txt, Ground_Control_Labour ground_control_labour_2visit.txt) . Lastly, based on costs we estimate that it is only cost efficient to control infestations that are less than or equal to 8 cells (Containment_Cutoff=8). Monitoring occurs on an annual basis and our probability of detection is based on detection rates from the Magela para grass aerial survey (p_Detection=[.69,.91,1]; [.69,.91,1]).

The following are the inputs into the parameter file for the base management scenario (properties file spread_properties_scen1.txt).

Parameter	Value
Species	[para,OH]
Presence_File	[C:/Temp2/Rasters/parapresab.txt,C:/Temp2/Rasters/olivepresab.txt]
Age_File	[C:/Temp2/Rasters/paraage2.txt,C:/Temp2/Rasters/oliveage.txt]
Habitat_File	[C:/Temp2/Rasters/parahsm.txt,C:/Temp2/Rasters/olivehsm.txt]
Reference_File	[C:/Temp2/Rasters/parapresab.txt,C:/Temp2/Rasters/olivepresab.txt]
Management_File	[C:/Temp2/Rasters/paramgmt.txt,C:/Temp2/Rasters/olivemgmt.txt]
Output_Folder	C:/Temp2/Scenario1
Output_File	mycoolstats.csv
Replicates	9
Start_Time	0
End_Time	20
Step_Interval	1
Distances	[750,750,500,750,500,500,500,500,500,500,500]; [500,500,500,500,500,500,500,500,500,500,500]
Rates	[30,40,50,50,60,70,80,90,100,110,120];[3,3,3,3,3,3,3,3,3,3,3]
Direction_Kernel	[3.6,15.4,51.5,18.4,5.0,3.1,2.0,0.9];[1,1,1,1,1,1,1,1,1]
Age_Stage	[5,8];[5,8]
p_Detection	[.69,.91,1];[.69,.91,1]
Containment_Cutoff	8
Core_Buffer_Size	1500
Containment_Cost	90
Containment_Labour	1
Containment_Ignore	[OH]
Ground_Control_Ignore	
Core_Control	[OH]
Ground_Control_Cost	file:C:/Temp2/ground_control_cost_2visit.txt
Ground_Control_Labour	file:C:/Temp2/ground_control_labour_2visit.txt
Management_Frequency	1
Wait_Time	[5,1]
Run_Type	Paired
Overwrite_Output	TRUE
Save_Properties_File	FALSE
Write_Frequency_Map	TRUE
Write_Each_Time_Step	TRUE
Write_Each_Mgt_Step	FALSE
Write_Raster_Header	TRUE
Write_Trace_Files	TRUE
Trace_Base_Name	Trace

6.4 Management outputs

We chose to output cover and monitoring maps at each time step for 100 runs. This results in ~10GB of data. In order to summarize the costs and labour requirements of the management scenario we average the costs and labour at each time step across each run (found in Trace files) (Figure 7).

Figure 7. Average costs and standard deviation at each time step for management scenario. (a) Average costs and standard deviation at each time step for the two management scenarios (Scenario 2 – Strategic weed management, Scenario 3 – Strategic weed management + indigenous priorities for resource access). (b) Average team weeks and standard deviation at each time step (assuming a four person team and 37.5 work hour week) (Scenario 2 – Strategic weed management, Scenario 3 Strategic weed management + indigenous priorities for resource access).
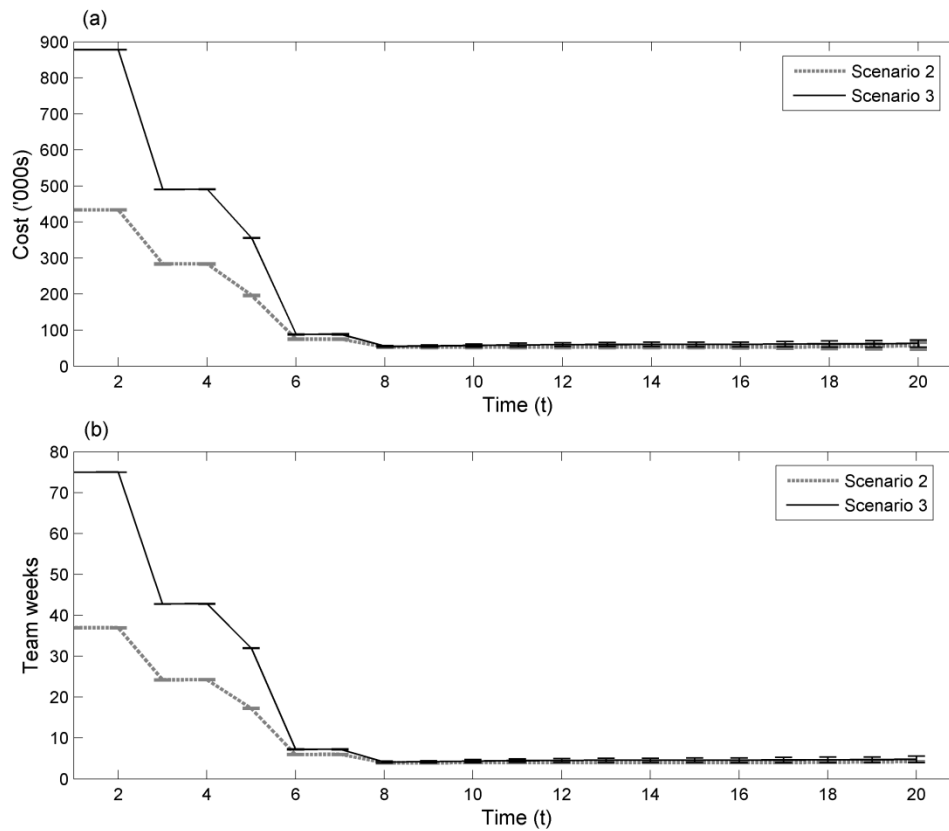
7. References

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