Electronic Appendix

Algorithms for simulation follow the sequence of events outlined in a flowchart (Figure A1). For each time step these events simulate: (1) ageing, (2) age dependent succession, (3) new infestations, (4) expansion of existing infestations, (5) treatment of infestations, and (6) output.

Ageing is the process of incrementing the effective time since invasion for every polygon that has crested wheatgrass. After ageing, the model determines, for each polygon, whether there should be an age dependent transition (e.g. from the initial to the established state).

To simulate long distance dispersal, the model loops over potential target polygons at random. Potential target polygons include all polygons that are not already invaded by crested wheatgrass. While the number of new polygons invaded remains lower than the target number of new infestations drawn from the Poisson distribution for that time step, the model determines the relative probability of invasion of each polygon and uses a random draw to determine if the polygon will be invaded or not. The relative probability of invasion for a polygon is based on its vegetation community (see relative susceptibilities in the methods section). Once the number of infestations from outside of the landscape has been reached for a time step, the model simulates long-distance dispersal within the landscape by drawing a random source polygon for each target polygon. If the source polygon contains crested wheatgrass, the model draws a random spread distance from the Pareto spread distance distribution (equation [1]). If this random

Pareto variable is greater than the polygon-to-polygon distance, then the model checks the relative invasion probability and determines whether a new infestation will occur at the target. This process continues until all potential target polygons have been examined, thus making non-neighbour, long-distance dispersal within the landscape a function of the proportion of the landscape currently infested.

Our decision analysis considered two alternative hypotheses for spread rates by varying the shape parameter (alpha) for the Pareto distribution between the values of 2.01 and 3 (Table 1). Spread distributions were reduced for initial infestations. Seed production and successful establishment vary with the vegetation type, so spread distributions were also modified to reflect the relative competitiveness and success of crested wheatgrass across habitat classes (see below).

The potential distance is determined by taking a draw from the Pareto spread distance distribution (equation [1]) for each time step that the source has been contagious. A draw is taken for each time step to capture the gradual spread of propagules along the centroid-to-centroid polygon vector. The sum of these distances is then multiplied by the source strength variable that is dependent on the state of the source (Initial=0.05 or 0.1, Established=1.0) and by the relative susceptibility of the target polygon vegetation community. Simulated spread from established polygons is greater than from initial polygons and spread into the most vulnerable vegetation communities (like valley grasslands) is greater than spread into the least vulnerable communities (like eroded communities). If the spread distance is greater than the centroid-to-centroid distance between source and target polygons, the target polygon is invaded.

$$P(Spread < x) = 1 - \left(\frac{0.5}{x}\right)^{a}; x > 0.5 - meters \qquad [1]$$

The final step in the model algorithm is the simulation of management actions on vegetation transitions. The model first loops over all infestations in order of size. Depending on the scenario, we prioritized either the largest or smallest infestations for management. For each infestation the model first applies treatment to the polygons on the infestation edge and then moves toward the infestation center. In scenarios that prioritized large infestations we applied treatment only to the infestation edges. The model manages infected polygons in this order until either a management area ceiling for the time-step is reached or all infested polygons have been managed. Each time a management action is applied, there are three outcomes possible: control, setback, or failure (Figure 2).

Our five management strategies and three uncertainty components resulted in 36 possible permutations of the model (Electronic Appendix). Each permutation was replicated twice for a total of 72 model runs.

Figure 1: Action sequence flow chart for TELSA simulations

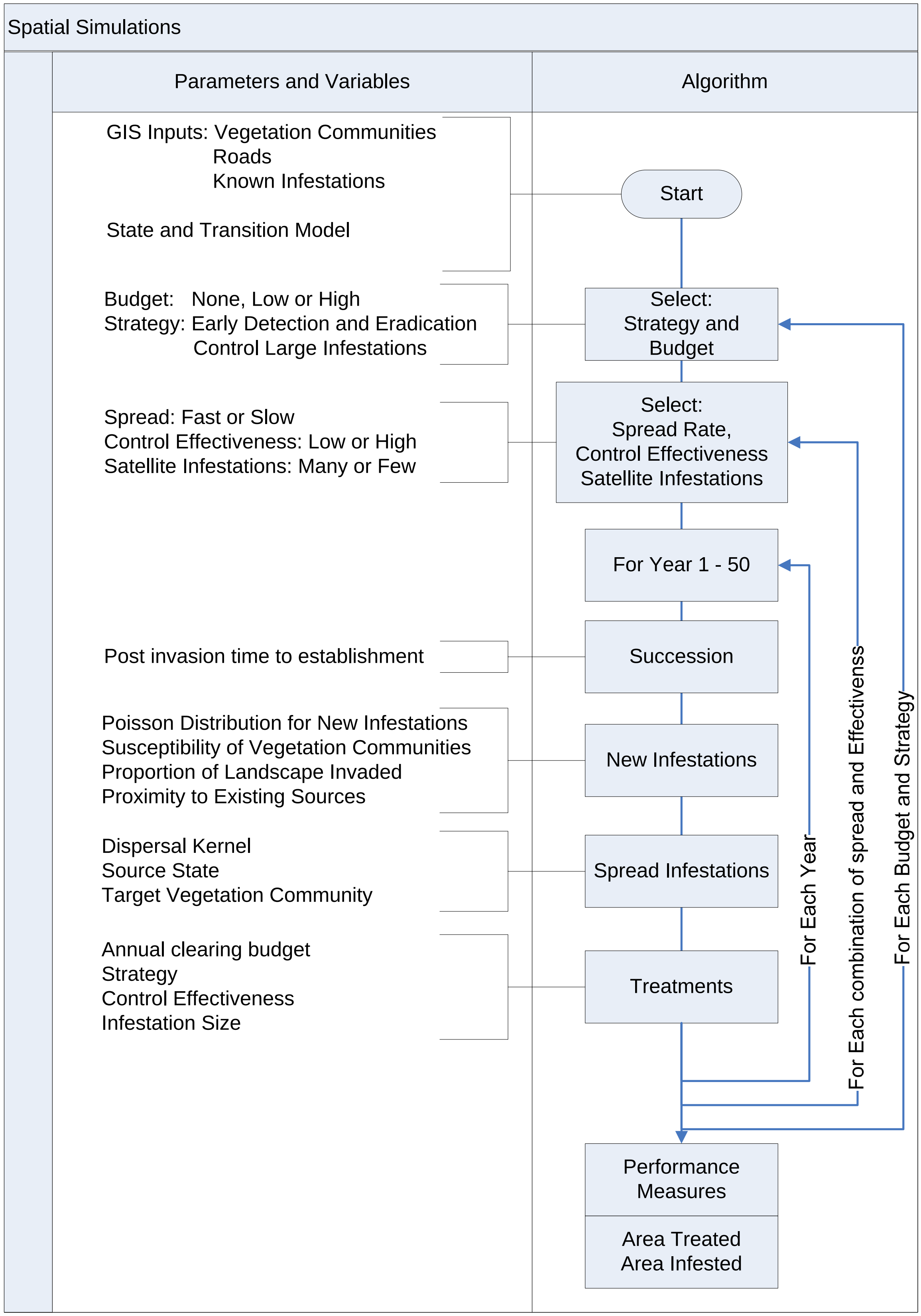

Table 1. Parameters used to simulate alternative hypotheses characterizing three components of crested wheatgrass spread and control dynamics: Control effectiveness, Patch Spread and Long Distance Spread.

Component	Hypothesis	Control Ratio Initial[1]: C:S:F	Control Ratio Established[2]: C:S:F	Setback Time[3]	Time to Establish[4]	Pareto Shape	Spread Ratio I:E[5]	Satellite Mean[6]
Control	**Effective**	75:20:05	50:40:10	5	-	-	-	-
Effectiveness	**Ineffective**	50:25:25	10:50:40	2	-	-	-	-
Patch	**Slow Spread**	-	-	-	15	3	0.05	-
Spread	**Fast Spread**	-	-	-	10	2.01	0.1	-
Long Dist.	**Few Satellites**	-	-	-	-	-	-	1
Spread	**Many Satellites**	-	-	-	-	-	-	2

[1] Control ratios in the initial state, where C represents the proportion of the time that there is a ‘control’ transition to the un-invaded state, S represents the proportion of the time that there is a ‘set-back’ transition that reduces the density of crested wheatgrass but the polygon remains in the initial state, and F represents the proportion of the time that the treatment ‘fails’ to have any effect.

[2] Control ratios in the established state, where C represents the proportion of the time that there is a ‘control’ transition to the un-invaded state, S represents the proportion of the time that there is a ‘set-back’ transition that reduces the density of crested wheatgrass and the polygon transitions to the initial state, and F represents the proportion of the time that the treatment ‘fails’ to have any effect.

[3] The number of years that crested wheatgrass is set back on its population growth curve when a set-back transition occurs.

[4] Number of years it takes for a polygon to transition into the established state after invasion.

[5] Relative spread distances from polygons that are in the initial state relative to those that are in the established state.

[6] Mean of the Poisson distribution used to determine the number of new patches appearing from outside the landscape each time-step.