

A Phenological Detectability Calendar for Invasive Plant Species

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INTRODUCTION

The SFAN I&M Invasive Species Early Detection Program (ISED) conducts protocol surveys to map recent invasions in network parks. The detectability of target species varies throughout the year with changes in the phenological phases of the species – morphological changes corresponding to life cycle events. Annual changes in plant phenology are strongly tied to seasonal changes in daylight hours and temperature, and thereby can be plotted on a calendar. Since 2012, ISED has been gathering data on phenology and detectability to train field staff on seasonal survey targets. We present here a phenology and detectability calendar based on the results of surveys in Golden Gate National Recreation Area (GGNRA).

METHODS

For each species encountered during surveys, detectability and phenology were estimated for the majority of individuals observed on a given day. Detectability was defined as the ability to distinguish a plant from the surrounding vegetation at a distance of 5, 20, or 100 meters, and was ranked on a scale of 0 – 4 (Figure 1). We recorded all phenological stages present on the majority of individuals observed. Phenological stages included: new growth, flowering, fruiting, senescence, and dead (leaves/stems). For trees, shrubs and perennial herbs, scores were based only on reproductively mature individuals. For short-statured annuals and bulbs, detectability was estimated for a dense 1 m² patch, and phenology was scored for all life cycle stages. Correlations between monthly detectability scores and occurrence data from ISED surveys were used to calibrate the final detectability scores in the calendar. (Figure 2).

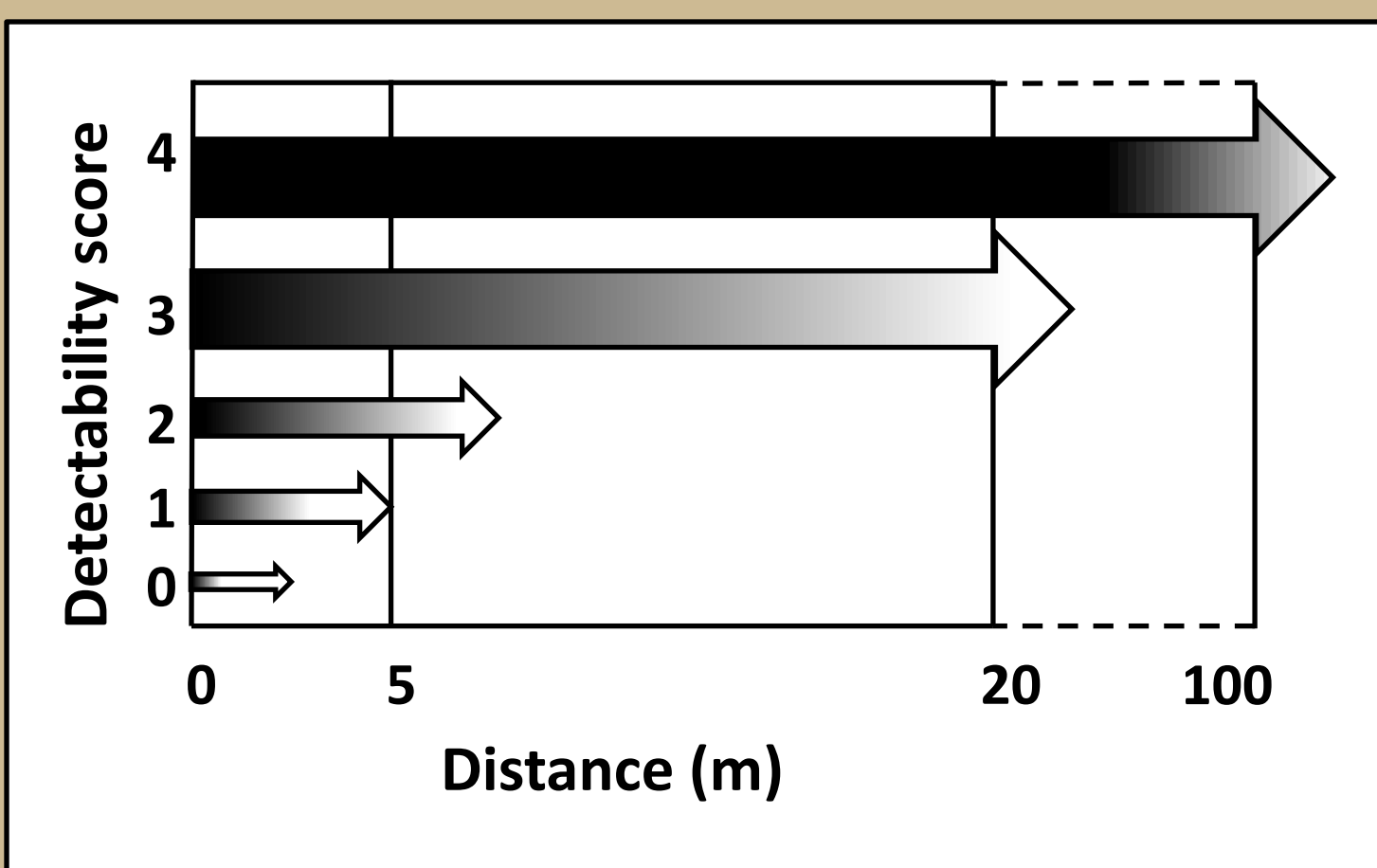


Figure 1. Detectability diagram

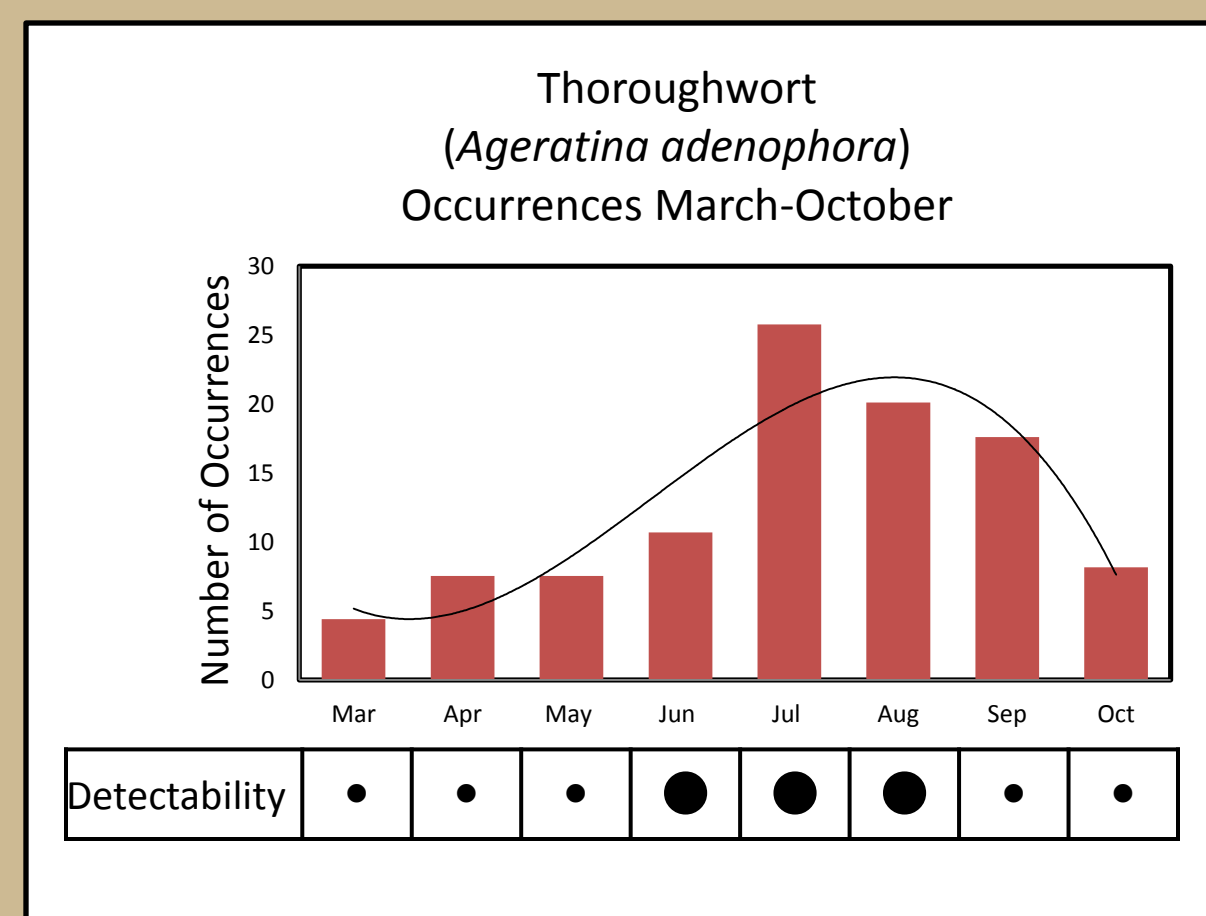


Figure 2. Detectability scores calibrated by monthly frequency of observations

RESULTS

The calendar symbolizes phenology by month using color codes, and the detectability by month using dots of increasing size (Figures 3 and 4). For annuals and biennials we present the phenological stages of one generation, followed by the initial germination of the next generation. Where data gaps existed for species that were rarely encountered during surveys, or for the winter months, when few ISED surveys were conducted survey data were supplemented by personal knowledge of the SFAN I&M Botanist, based on extensive year-round field experience in GGNRA. Information from the Calflora and Calphotos databases was also utilized for verification purposes.

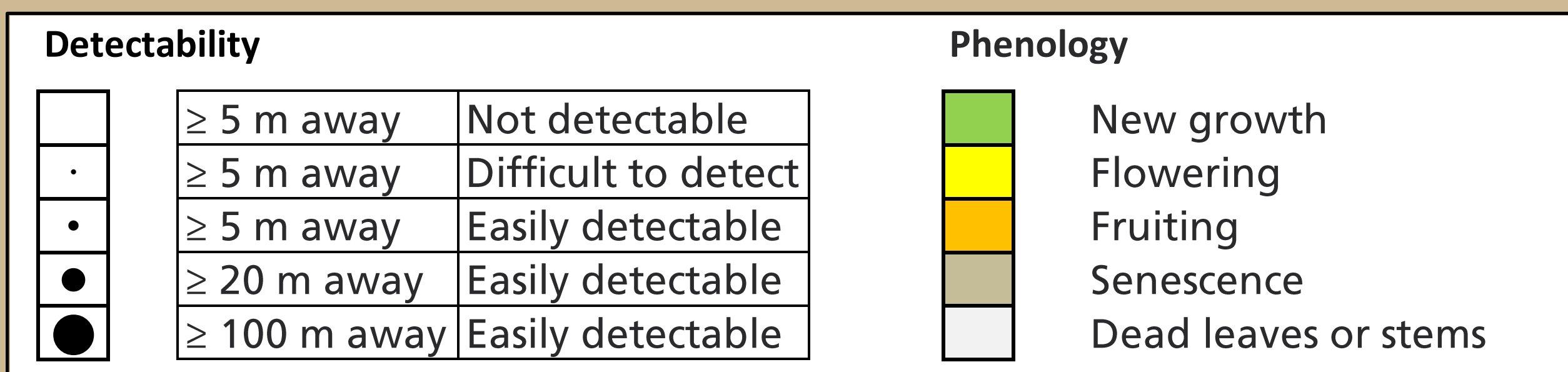


Figure 3. Detectability and phenology symbology.

DISCUSSION

Most species had the highest detectability at peak flowering, as is typically assumed. However, some species and life forms were more detectable in fruit, or were equally detectable in senescence. Phenophases often overlap temporally, e.g. fruiting and senescence often occur simultaneously. This calendar necessarily generalizes the predominant phenological stages by month. More detailed phenology charts can be constructed for each species, showing overlapping temporal ranges for each phenophase (Figure 5). Some species have a very small window of detectability before senescing and going dormant (e.g. *Oxalis pes-caprae*, *Rytidosperma* spp., *Sparaxis tricolor*). This calendar can be used to plan survey and control efforts efficiently, especially for those species with compressed phenological stages. For example, *Rytidosperma* spp. have a very narrow window of detectability before fruiting and senescing. However, the most effective treatment time is during active growth, before the plants set seed. This calendar allows managers to see that June is the best time to plan *Rytidosperma* treatments, for both detectability and phenology.

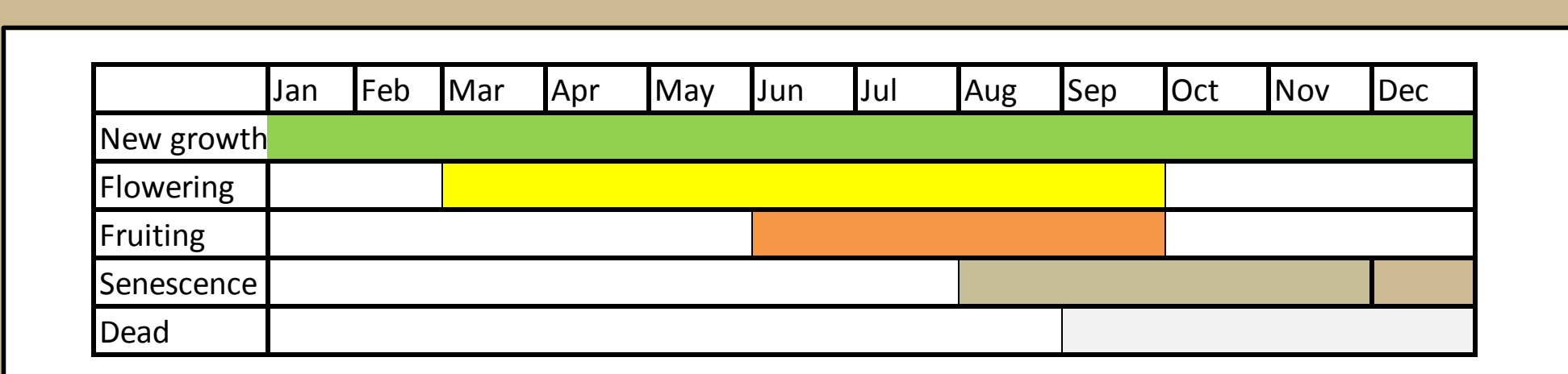


Figure 5. Annual phenological stages of thoroughwort. Because it is an evergreen perennial, some degree of new growth is present throughout the year.

Acknowledgements

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Scientific Name	Common Name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<i>Acacia melanoxylon</i>	blackwood acacia	●	●	●	●	●	●	●	●	●	●	●	●
<i>Ageratina adenophora</i>	thoroughwort	●	●	●	●	●	●	●	●	●	●	●	●
<i>Ailanthus altissima</i>	tree-of-heaven	●	●	●	●	●	●	●	●	●	●	●	●
<i>Albizia lophantha</i>	silk tree	●	●	●	●	●	●	●	●	●	●	●	●
<i>Arctotheca calendula</i>	fertile capeweed												
<i>Arctotheca prostrata</i>	creeping capeweed	●	●	●	●	●	●	●	●	●	●	●	●
<i>Brassica rapa</i>	field mustard												
<i>Bromus madritensis</i> ssp. <i>rubens</i>	red brome												
<i>Bromus tectorum</i>	cheat grass												
<i>Buddleja davidii</i>	butterfly bush	●	●	●	●	●	●	●	●	●	●	●	●
<i>Calendula arvensis</i>	field marigold												
<i>Carpobrotus chilensis</i>	sea fig	●	●	●	●	●	●	●	●	●	●	●	●
<i>Carpobrotus edulis</i>	iceplant	●	●	●	●	●	●	●	●	●	●	●	●
<i>Centaurea calcitrapa</i>	purple starthistle												
<i>Centaurea melitensis</i>	localote												
<i>Centaurea solstitialis</i>	yellow starthistle												
<i>Cestrum parqui</i>	orange jessamine	●	●	●	●	●	●	●	●	●	●	●	●
<i>Conicosia pugioniformis</i>	narrow-leaved iceplant	●	●	●	●	●	●	●	●	●	●	●	●
<i>Cortaderia jubata</i>	jubata grass	●	●	●	●	●	●	●	●	●	●	●	●
<i>Cortaderia selloana</i>	pampas grass	●	●	●	●	●	●	●	●	●	●	●	●
<i>Cotoneaster franchetii</i>	orange cotoneaster	●	●	●	●	●	●	●	●	●	●	●	●
<i>Cotoneaster lacteus</i>	milkflower cotoneaster	●	●	●	●	●	●	●	●	●	●	●	●
<i>Cotoneaster pannosus</i>	silverleaf cotoneaster	●	●	●	●	●	●	●	●	●	●	●	●
<i>Crataegus monogyna</i>	singleseed hawthorn												
<i>Cytisus scoparius</i>	Scotch broom	●	●	●	●	●	●	●	●	●	●	●	●
<i>Cytisus striatus</i>	Portuguese broom	●	●	●	●	●	●	●	●	●	●	●	●
<i>Dactylis glomerata</i>	orchard grass												
<i>Delairea odorata</i>	cape ivy	●	●	●	●	●	●	●	●	●	●	●	●
<i>Digitalis purpurea</i>	purple foxglove												
<i>Dipsacus fullonum</i>	Fuller's teasel												
<i>Ditrichia graveolens</i>	stinkweed	●	●	●	●	●	●	●	●	●	●	●	●
<i>Ehrharta erecta</i>	panic veldt grass												
<i>Erigeron karvinskianus</i>	Latin American fleabane												
<i>Eucalyptus globulus</i>	bluegum eucalyptus	●	●	●	●	●	●	●	●	●	●	●	●
<i>Euphorbia oblongata</i>	oblong spurge	●	●	●	●	●	●	●	●	●	●	●	●
<i>Festuca arundinacea</i>	tall fescue												
<i>Foeniculum vulgare</i>	sweet fennel	●	●	●	●	●	●	●	●	●	●	●	●
<i>Genista monspessulana</i>	French broom	●	●	●	●	●	●	●	●	●	●	●	●
<i>Geranium purpureum</i>	herb robert												
<i>Geranium robertianum</i>	Robert geranium												
<i>Hedera helix</i>	English ivy	●	●	●	●	●	●	●	●	●	●	●	●
<i>Helichrysum petiolare</i>	licorice plant	●	●	●	●	●	●	●	●	●	●	●	●
<i>Hypericum grandifolium</i>	largeleaf St. Johnswort												
<i>Hypericum perforatum</i>	Klamathweed												
<i>Ilex aquifolium</i>	English holly	●	●	●	●	●	●	●	●	●	●	●	●
<i>Iris pseudacorus</i>	yellow flag iris	●	●	●	●	●	●	●	●	●	●	●	●
<i>Lathyrus latifolius</i>	everlasting pea												
<i>Leptospermum laevigatum</i>	Australian teatree	●	●	●	●	●	●	●	●	●	●	●	●
<i>Leucanthemum vulgare</i>	oxeye daisy												
<i>Maytenus boaria</i>	Chilean mayten	●	●	●	●	●	●	●	●	●	●	●	●
<i>Mentha pulegium</i>	pennyroyal												
<i>Myriophyllum aquaticum</i>	parrot's-feather	●	●	●	●	●	●	●	●	●	●	●	●
<i>Oxalis pes-caprae</i>	Bermuda buttercup												
<i>Pennisetum clandestinum</i>	Kikuyu grass	●	●	●	●	●	●	●	●	●	●	●	●
<i>Phalaris aquatica</i>	Harding grass												
<i>Pitopsisporum crassifolium</i>	stiffleaf cheesewood	●	●	●	●	●	●	●	●	●	●	●	●
<i>Pyracantha angustifolia</i>	narrowleaf firethorn	●	●	●	●	●	●	●	●	●	●	●	●
<i>Rhamnus alaternus</i>	Italian buckthorn	●	●	●	●	●	●	●	●	●	●	●	●
<i>Romulea rosea</i> var. <i>australis</i>	rosy sandcrocus												
<i>Rosa rubiginosa</i>	sweetbriar rose	●	●	●	●	●	●	●	●	●	●	●	●
<i>Rubus armeniacus</i>	Himalayan blackberry	●	●	●	●	●	●	●	●	●	●	●	●
<i>Rytidosperma caespitosum</i>	common wallaby grass												
<i>Rytidosperma penicillatum</i>	hairy wallaby grass												
<i>Scabiosa atropurpurea</i>	mourningbride												
<i>Solanum aviculare</i>	New Zealand nightshade	●	●	●	●	●	●	●	●	●	●	●	●
<i>Sparaxis tricolor</i> hybrid	Harlequin flower												
<i>Spartium junceum</i>	Spanish broom	●	●	●	●	●	●	●	●	●	●	●	●
<i>Stipa purpurata</i>	Stipoid ricegrass												
<i>Stipa manicata</i>	Andean tussockgrass												
<i>Tradescantia fluminensis</i>	small-leaf spiderwort	●	●	●	●	●	●	●	●	●	●	●	●
<i>Trifolium angustifolium</i>	narrowleaf clover												
<i>Ulex europaeus</i>	gorse	●	●	●	●	●	●	●	●	●	●	●	●
<i>Vinca major</i>	periwinkle	●	●	●	●	●	●	●	●	●	●	●	●
<i>Xanthium spinosum</i>	spiny cocklebur	●	●	●	●	●	●	●	●	●	●	●	●
<i>Xanthium strumarium</i>	rough cocklebur	●	●	●	●	●	●	●	●	●	●	●	●

Figure 4. Phenological detectability calendar