Australian Government
Department of Climate Change, Energy, the Environment and Water

The Australian Ecosystem Models Framework:

Mallee woodlands and shrublands

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CSIRO acknowledges the Traditional Owners of the land, sea, and waters, of the area that we live and work on across Australia. We acknowledge their continuing connection to their culture, and we pay our respects to their Elders past, present, and emerging.

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Cover image: *Triodia* mallee north of Kitchener, WA (Image: S. Prober).

Contents

The Australian Ecosystem Models Framework

This booklet of factsheets for '*Mallee woodlands and shrublands'* is part of a series that has been developed within the Australian Ecosystem Models (AusEcoModels) Framework. The AusEcoModels Framework is a collaborative project between CSIRO and the Department of Climate Change, Energy, the Environment and Water, and describes a nationally comprehensive set of conceptual models (termed 'archetypes') of ecosystem dynamics in Australia. These articulate an understanding of the dynamic expression of ecosystems under a set of endogenous or reference disturbance regimes. Endogenous disturbances are discrete events (in both space and time) that can disrupt ecosystem structure, or can change resources, substrate availability or the physical environment but maintain ecosystem integrity – they include both anthropogenic and non-anthropogenic-driven disturbances.

Each factsheet in this set describes an archetype model, i.e., a typical example. Boxes in the model diagram are ecosystem expressions, that describe manifestations of an ecosystem along a disturbance and biomass recovery pathway where ecosystem attributes (structure, function, composition, abiotic characteristics) are significantly different to other expressions. Some ecosystem expressions will link to expressions that are also described in another archetype model. These are denoted by a white box with a thick green border. Arrows in the model describe pathways between ecosystem expressions, and they represent endogenous disturbances or biomass recovery processes. Endogenous disturbances may also maintain an ecosystem in a particular expression, these are represented by circular arrows attached to a single box. Archetype models may also describe the reference landscape composition of ecosystem expressions (the proportion of a landscape, across space and time, that would be in a particular expression under reference conditions). See Figure 1 below for a description of the archetype model components.

Each archetype model has been developed with input from ecosystem science experts and scientific publications. Sets of archetype models have been grouped into Umbrella Classes to assist in dissemination, and to demonstrate links to published vegetation classification schemes. Umbrella Classes represent a consolidation of the National Vegetation Information System (NVIS) Major Vegetation Groups.

Archetype models in the AusEcoModels Framework describe the reference dynamics and ecosystem characteristics to which Australian ecosystems are adapted, and they provide a template to understand and predict how ecosystems respond to more recent, transformative disturbance processes. For example, the AusEcoModels Framework includes a methodology for the application of archetype models to the development of dynamic state and shift models. State and shift models include a reference state (informed by the archetype model) and a set of alternative expressions resulting from the introduction of recent and transformative anthropogenically-driven exogenous disturbances. Both the archetype models and their application to development of dynamic state and shift models inform forecasts of the likely direction and nature of change that ecosystems may experience in the future, and support contemporary ecosystem management, including approaches to maintain ecosystem resilience and adaptive capacity.

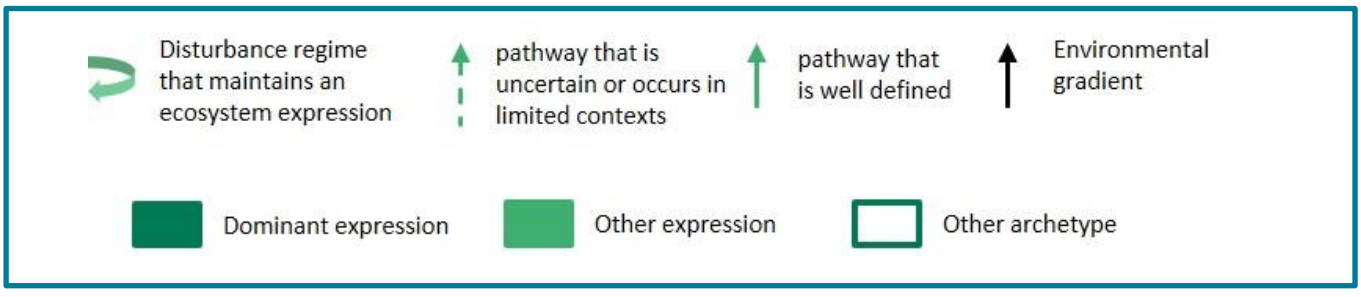

Figure 1: Key to diagrams in AusEcoModels Framework booklet.

Mallee woodlands and shrublands

Umbrella Class overview

The '*Mallee woodlands and shrublands'* Umbrella Class reflects the concepts of the NVIS (2018) Major Vegetation Groups MVG14 (Mallee woodlands and shrublands) and MVG 13 (Mallee open woodlands and sparse mallee shrublands). Mallee vegetation is typically dominated by eucalypts with multiple stems arising from an underground lignotuber. Consistent with Yates et al. (2017), this treatment also includes maalok communities (also known as marlock) which are dominated by short (<7 m), single-stemmed eucalypts with no lignotuber, as these typically occur in landscape mosaics with more extensive mallee communities of south-western Australia.

Four key mallee types with broadly differing disturbance dynamics can be identified within this Umbrella Class (Figure 1). The first major distinction is between the maalok non-resprouter, obligate-seeder eucalypts shrubland communities, characterised by a regime of infrequent intense fires ('maalok', Yates et al. 2017), and those dominated by the more common resprouter mallee eucalypts.

The maalok dynamics are similar to the *Obligate-seeder eucalypt woodland* dynamics under the '*Eucalypt woodlands'* Umbrella Class.

Three distinct dynamics across five mallee floristic communities are recognised within the resprouter mallee group, aligned with previous, floristic classifications of '*Mallee woodlands and shrublands'* as summarised in Table 1. First, *Mesic heathy mallee*, comprising higher rainfall mallee with dense heathy understorey, is distinguished for its relatively frequent fire regimes regulated by fuel accumulation with time since fire. The second dynamic recognises a grade from arid shrubby to *Triodia*-dominated mallee along a gradient of increasing soil sand content (*Shrubby/Triodia mallee*), characterised by moderate frequency fires and regulated by high grass growth during above average rainfall years. The third dynamic reflects mallee with mixed chenopod-tussock grass understoreys (*Tussock grass/Chenopod mallee*), characterised by infrequent canopy fire and moderated by fire-retardant chenopods and seasonal grass growth.

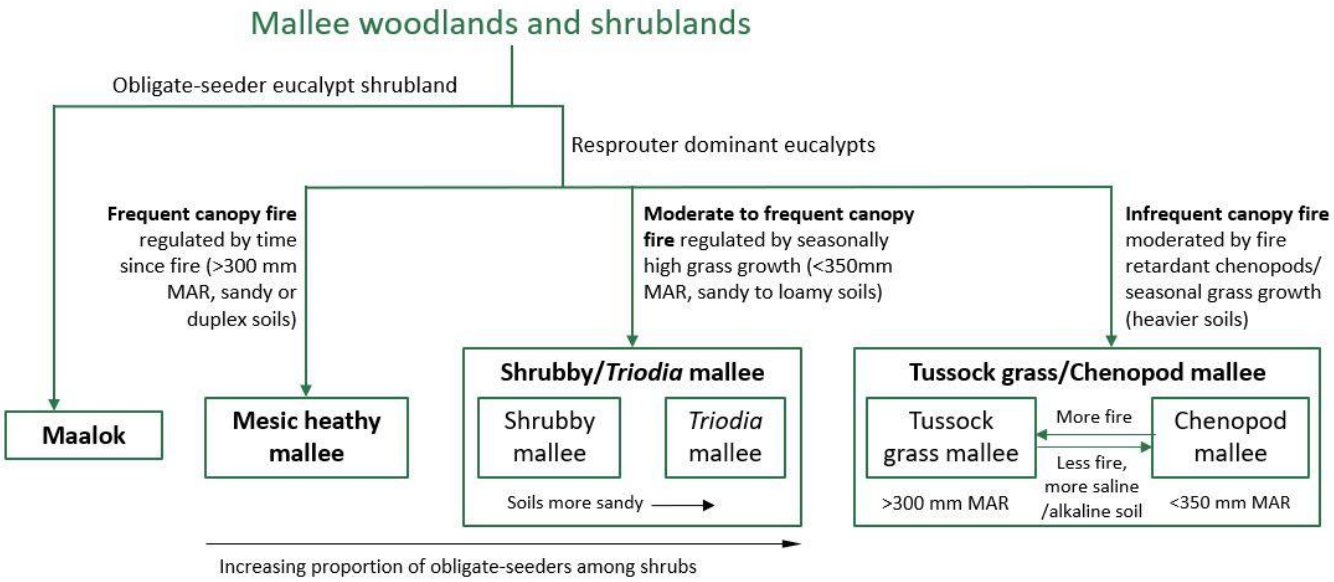

Figure 2: '*Mallee woodlands and shrublands*' Umbrella Class and ecosystem dynamics.

Table 1. Synthesis of prior floristic classifications of maalok and resprouter mallee woodland and shrubland communities (White 2006, Haslem et al. 2010, Yates et al. 2017), indicating alignment with dynamic models in this treatment.

FLORISTIC TYPE	UNDERSTOREY CHARACTERISTICS	RAINFALL (MM)	SOILS	FIRE
Maalok (obligate-seeder)	sparse or absent with dense litter	>300	heavy clays or calcareous sands	infrequent, stand-replacing
Mesic heathy mallee	dense sclerophyll shrubs from temperate genera	>300	duplex with sandy topsoil, coarse sands	frequent, fire-age dependent
Shrubby mallee	dominated by shrubs from arid plant genera	<350	loams	moderate, ephemeral driven
Triodia mallee	*Triodia* dominant with shrubs from arid plant genera	<350	light sands to sandy loams	moderate, ephemeral driven
Tussock grass mallee	tussock grasses dominant, with semi-succulent chenopods	>300	heavier soils	infrequent crown fire, poorly known
Chenopod mallee	semi-succulent chenopods dominant, with tussock grasses	<350	heavier, alkaline/ saline soils	infrequent, ephemeral driven

Maalok

Obligate-seeding taxa are generally uncommon among the eucalypts but are more common in dry to semi-arid (200 -700 mm mean annual rainfall) south-western Australia. Most can grow to moderate-sized trees (forming *Obligate-seeder eucalypt woodlands*), but a minority, particularly moorts such as *Eucalyptus platypus*, *E. cernua* and *E. utilis*, are short-statured and are commonly encountered as dense eucalypt shrublands or low forests known as maalok (or marlock). Maalok communities tend to occur on heavy clay soils in mid- to lower-slope depressions within extensive mallee landscapes of southern Western Australia. They are also known from calcareous sands on coastal dunes and islands (Yates et al. 2017).

As for *Obligate-seeder eucalypt woodlands* (Gosper et al. 2018), maalok eucalypts are killed by fire and large-scale fires initiate stand replacement, with post-disturbance vegetation typically comprising a single-aged cohort. The understorey is commonly sparse to absent but can include shrubs of more temperate genera including the families Fabaceae, Myrtaceae, Proteaceae, Ericaceae and Rutaceae. The archetype model for maalok (Figure 3) was developed from the related *Obligate-seeder eucalypt woodland* model (adjusted from Gosper et al. 2018), as there are no published investigations of disturbance dynamics in maalok.

Ecosystem dynamics

Dense seedling maalok

Fire kills stands of mature maalok eucalypts leading to dense stands of recruiting eucalypts (Image 1). There is some observational evidence to suggest an increase in above-ground diversity and cover of understorey species in the early post-fire period (<10 years), potentially due to recruitment from persistent

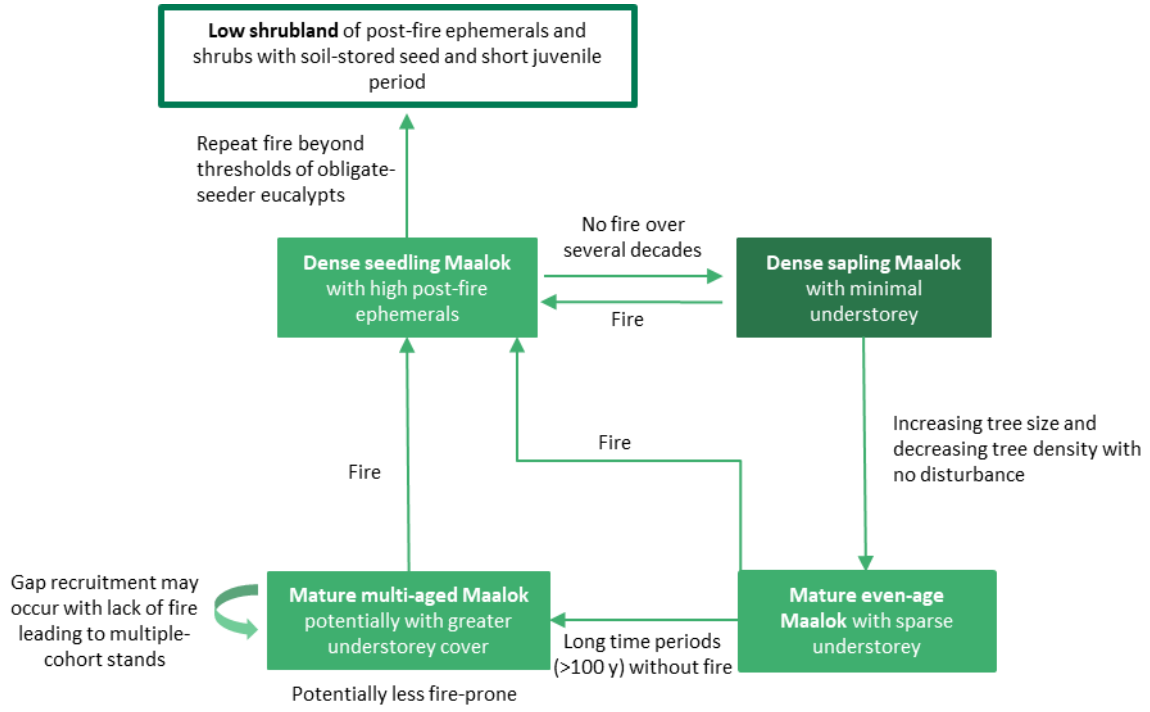

Figure 3: *Maalok* archetype model.

seedbanks (e.g., legumes), although no published data are available. Without fire over several decades, this state will shift to a *Dense sapling maalok* stand.

Image 1: Dense seedling maalok, Lake Magenta, WA (Image: C. Gosper).

Dense sapling maalok

Growth of dense seedling eucalypts leads to intense intra-specific competition, resulting in a dense sapling stand with reduced individual growth rates and no ongoing eucalypt recruitment. Understorey diversity and cover is increasingly suppressed, eventually resulting in stands with minimal understorey and high litter cover (Image 2).

Image 2: Dense sapling maalok, Ongerup, WA (Image: S. Prober).

Observations suggest seed set can begin as early as seven years since fire but time frames to development of a canopy seedbank adequate to ensure replacement are unknown for maalok. A fire during this stage would cause a shift to *Dense seedling maalok*, assuming adequate canopy seed-store (or if not, to an alternative Umbrella Class). Without further disturbance, the dense sapling stand would shift over long (unknown, but >50 years) timeframes to *Mature even-aged maalok*.

Mature even-aged maalok

With no major or localised fires or other disturbances, the community develops to a stand of tall shrubs to small trees of a single cohort. Tree density is lower than in *Dense sapling maalok* but still relatively high compared with *Obligate-seeder woodlands*, maintaining a dense canopy and sparse understorey with high litter cover. An extensive canopy seedbank is maintained. Fire would cause a rapid shift to a recruiting *Dense seedling maalok* woodland, while localised disturbances could cause the gradual development of a *Mature multi-aged maalok* stand.

Mature multi-aged maalok

It is feasible that eventual, sporadic mortality of mature eucalypts (e.g., due to windthrow or disease) in long-unburnt (e.g., >100 years) *Mature even-aged maalok* could promote occasional eucalypt recruits, leading to increasingly multiple-cohort stands (Image 3). These more open stands, with discontinuous litter cover, could begin to resemble *Obligate-seeder eucalypt woodlands*, and potentially promote a higher diversity of herbaceous and shrubby understorey species.

Given the localised position of many maalok communities within fire-prone mallee landscapes, this expression is expected to be rare, and there is currently no published evidence for it. Nevertheless, expert observations suggest it may occasionally occur, for example in coastal moort (*Eucalyptus utilis*) communities. The fate of maalok over extremely long timeframes without fire has not been documented, but a major fire followed by adequate rain would cause a rapid shift to *Dense seedling maalok*.

Image 3: Mature maalok with sporadic mortality of mature eucalypts and discontinuous litter (although no young recruits of maalok evident), Lake Magenta, WA (Image: C. Gosper).

Low shrubland or other non-maalok vegetation community

Given that maalok eucalypts are killed by fire and have no soil-stored seedbanks, their population dynamics are expected to be particularly sensitive to fire intervals. Theory predicts that a fire in *Dense seedling maalok* before adequate development of the canopy seedbank could result in a shift of the maalok community to a different vegetation Umbrella Class, such as a shrubland initially dominated by post-fire ephemerals and shrubs with soil-stored seed. Further information is required to confirm whether such shifts occur in nature.

Experts consulted

Keith Bradby, Malcolm French, Carl Gosper, Nathan McQuoid, Suzanne Prober, Colin Yates.

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Gosper CR, Yates CJ, Cook GD, Harvey JM, Liedloff A, McCaw WL, Thiele KR and Prober SM (2018) A conceptual model of vegetation dynamics for the unique obligate-seeder eucalypt woodlands of south-western Australia. *Austral Ecology* 43, pg. 681-695.

Mesic heathy mallee

Mesic heathy mallee communities are notable for their high diversity of both mallee eucalypts and understorey shrubs, particularly in Western Australia, with shrubs commonly from temperate plant genera in families such as Fabaceae, Proteaceae, Ericaceae and Rutaceae. They typically occur on duplex soils (sand over clay) or coarse sands, in the more mesic parts of the range of mallee communities (>300 mm mean annual rainfall) (White 2006, Yates et al. 2017). The dynamics of mesic heathy mallee are characterised by recurrent fire that kills mallee top growth, followed by resprouting from the lignotuber (Figure 4). Fire occurrence is regulated by the growth of woody shrub fuels with time since fire (Yates et al. 2017). A suite of characteristic serotinous obligate-seeder shrubs (e.g., Proteaceae) is vulnerable to short and long fire intervals (i.e., to high fire frequency and very low fire frequency).

Ecosystem dynamics

Diverse heathy mallee woodland

Mature forms of diverse heathy mallee comprise low woodlands of multi-stemmed mallee eucalypts above a dense, sclerophyllous understorey (Image 4). The larger crowns, loose bark, hollows and other parts of the mature mallee, and litter and shrubs in the understorey, form important fauna habitat. A typical scenario is for hot fire to pass through *Diverse heathy mallee woodland* after sufficient build-up of fuels in the shrub layer (increasing rapidly for up to 20-30 years), leading temporarily to a *Diverse heathland with resprouting mallee*. Alternatively, while there is no evidence for structural senescence in long-unburnt *Diverse heathy mallee woodland*, lack of fire for >100-200 years can lead to *Depauperate heathy mallee woodlands* through decline of serotinous obligate-seeders. Mean fire intervals for *Mesic heathy mallee* in south-western Australia are estimated to be 40-65 years (data not available for south-eastern Australia).

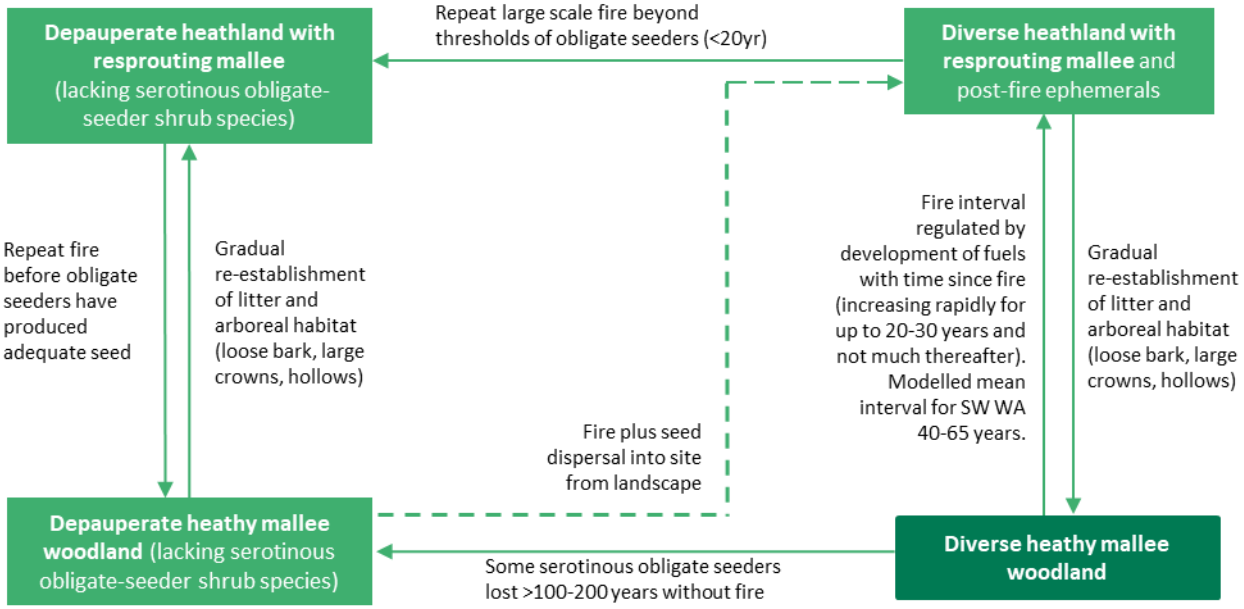

Figure 4: ***Mesic heathy mallee*** **archetype model.**

Image 4: Diverse heathy mallee, Lake Bryde, WA (Image: C. Gosper).

Image 5: Diverse heathland with resprouting mallee, Lake Magenta, WA (Image: S. Prober).

Diverse heathland with resprouting mallee

After fire, mature mallee stems die, young stems resprout from lignotubers, and shrubs resprout or recover from seed. Fire stimulates germination and provides less competitive environments for establishment in many species. In resprouters in particular (including mallee eucalypts), recruitment success is often low except in years of favourable rainfall. Nevertheless, with normal fire intervals, there is little expected loss of species after fire, and additionally, above ground plant diversity can increase due to emergence of short-lived post-fire ephemerals in the early stages after fire (Yates et al. 2017). Without further fire, mallee and shrubs mature to return to *Diverse heathy mallee woodland*, with parallel decline in post-fire ephemerals and development of fauna habitat (litter, leaves, hollows, flowers, trunks, bark, shrubs, and eucalypt crowns). If burnt too soon (e.g., <20 years), a *Depauperate heathland with resprouting mallee* may result owing to loss of serotinous obligate-seeders (Image 5).

Depauperate heathland with resprouting mallee

These communities appear similar and follow similar trajectories to *Diverse heathland with resprouting mallee*, except that key plant functional groups such as serotinous obligate-seeders may be sparse or absent (Yates et al. 2017). Loss of these species can occur through two pathways – short fire intervals exceeding the period required to develop sufficient canopy seedbanks, and long fire intervals exceeding the longevity of mature plants (although evidence is limited; Yates et al. 2017). Without fire, *Depauperate heathland with resprouting mallee* progresses to *Depauperate heathy mallee woodland*.

Depauperate heathy mallee woodland

Depauperate heathy mallee woodland lacking serotinous obligate-seeders can arise through maturation of *Depauperate heathland with resprouting mallee*, involving concurrent development of fauna habitat features such as large crowns, peeling bark, hollows, litter, and dense shrub layers. Alternatively, they may form through gradual senescence without replacement of serotinous obligate-seeders in *Diverse heathy mallee woodland*, although there is little published evidence for this. Fire events in appropriate landscape contexts may facilitate recruitment of serotinous obligate-seeders and other species dispersing to the site from elsewhere in the landscape, leading to *Diverse heathland with resprouting mallee*.

Experts consulted

Carl Gosper, Craig Gillespie, David Keith, Luke Kelly, Suzanne Prober, Allen Sundholm, Matt White, Colin Yates.

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Shrubby/*Triodia* mallee

The *Shrubby/Triodia mallee* model represents semi-arid mallee (<350 mm mean annual rainfall) with understoreys grading from sclerophyll shrub-dominated to *Triodia* (hummock grass)- dominated as soil sandiness increases from loams to light sands. In eastern Australia this soil gradient can involve a localised gradient from dunes (more *Triodia*) to swales (more shrubs). Shrubs are typically sclerophyllous species from arid plant genera, particularly *Eremophila* spp. (Yates et al. 2017, White 2006).

Vegetation dynamics in *Shrubby/Triodia mallee* are driven by moderate-frequency, crown-killing fires (Figure 5). In contrast to *Mesic heathy mallee*, shrub fuels in *Shrubby/Triodia mallee* remain discontinuous even when mature. Consequently, fire occurrence is less dependent on time since fire, rather, it is often associated with high rates of growth of grasses in years with above average rainfall (Enright et al. 2012, Yates et al. 2017). Ephemeral grass dynamic may be more important for regulating fire at the shrubby end of the spectrum. Mean fire intervals are poorly characterised but are likely to increase with aridity. Published models indicate the mean fire-interval for *Shrubby/Triodia mallee* in south-western Australia ranges from c. 40 to 65 yrs.

Ecosystem dynamics

Diverse shrubby/*Triodia* mallee woodland

This expression of *Shrubby/Triodia mallee* comprises low mallee woodlands above a discontinuous understorey of *Triodia* (hummock grass) species (often obligate-seeders) and/or shrubs from arid plant genera. Trees may include a range of species including *Eucalyptus dumosa, E. socialis* and *E. incrassata.* This more mature mallee (>35 years) is preferred by a range of animal species, particularly birds, due to development of habitat features such as larger crowns, fewer, thicker stems with peeling bark, stem hollows, litter, and large shrubs and

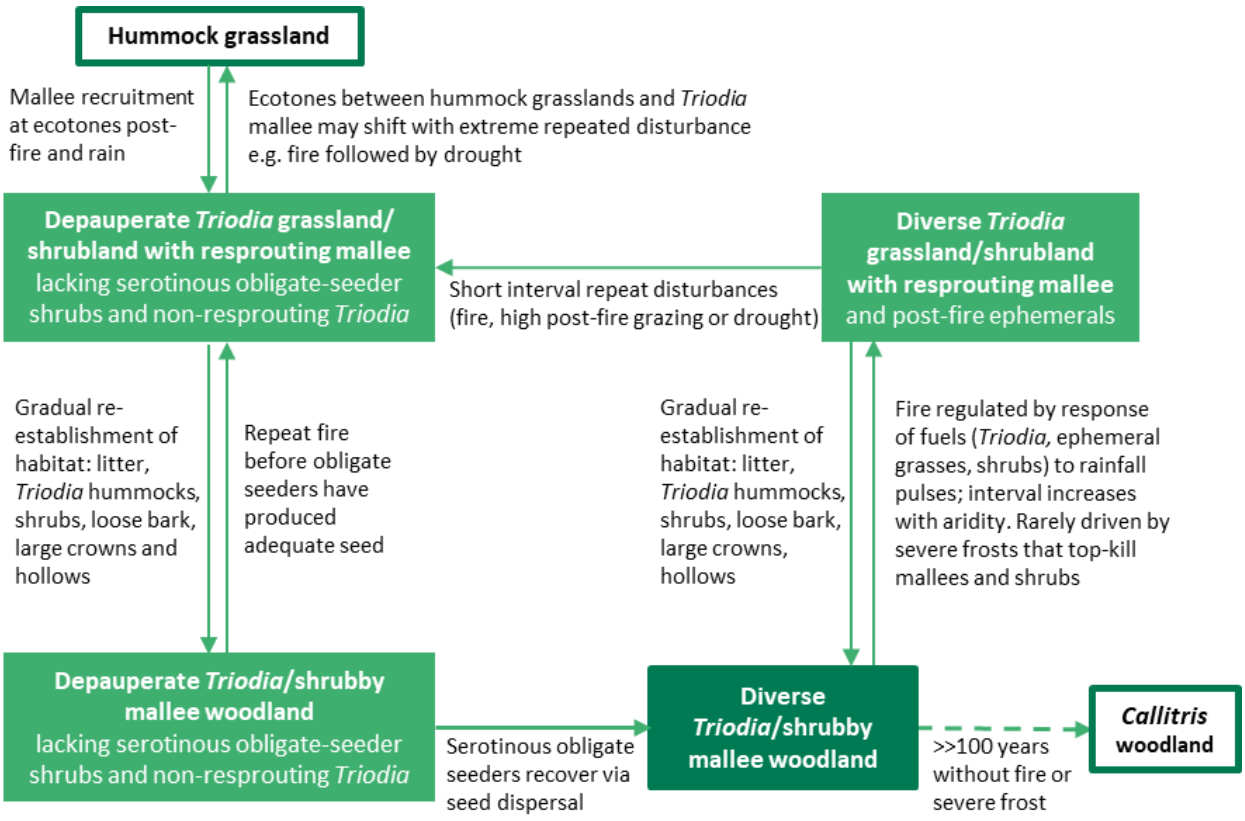

Figure 5: *Shrubby/Triodia mallee* archetype model.

Triodia hummocks. Research has shown that fuels may reach peak cover at 20-80 years since fire in *Triodia* mallee (Yates et al. 2017).

Large landscape fires, regulated by the response of fuels (*Triodia,* ephemeral grasses, shrubs) to rainfall pulses, lead to mortality of above ground stems and temporary shift to *Diverse Triodia grassland/shrubland with resprouting mallee.* A similar dynamic can be driven by severe frosts that top-kill mallee and shrubs, although such frosts are rare. Alternatively, in the absence of fire or severe frosts for long periods (>100 years), studies indicate few species are lost through senescence (Yates et al. 2017). However, anecdotal evidence suggests potential to shift from *Diverse shrubby/Triodia mallee woodland* to fire-retardant *Callitris* woodland as *Callitris* increases in abundance and competes for soil moisture.

Diverse *Triodia* grassland/shrubland with resprouting mallee

Image 6: Diverse *Triodia* grassland/shrubland with resprouting mallee and post-fire ephemerals, Kitchener, WA (Image: S. Prober).

Top-kill of mallee through fire or extreme frost leads temporarily to *Diverse Triodia grasslands or shrublands with resprouting mallee* (Image 6). A suite of obligate-seeders, including many *Triodia* species and shrubs in the genera *Senna, Santalum, Callitris, Eremophila* and *Alectryon* rely on recruitment from seed that is stimulated after fire and associated post-fire conditions for establishment. Without further fire, faunal habitat features, including litter, *Triodia* hummocks, shrubs (*Leptospermum*, *Melaleuca*), loose bark, large crowns and hollows redevelop gradually over time leading to *Diverse shrubby/Triodia mallee woodland*. Conversely, repeated disturbances at short intervals can result in *Depauperate Triodia grassland/shrubland with resprouting mallee*.

Depauperate *Triodia* grassland/shrubland with resprouting mallee

This expression of *shrubby/Triodia mallee* appears similar to *Diverse Triodia grassland/shrubland with resprouting mallee* but lacks specific functional groups of plants and fauna. Short fire intervals (<10-20 years), high post-fire macropod pressure or post-fire drought can eliminate serotinous obligate-seeding shrubs and non-resprouting *Triodia* species, and drive local declines in birds, mammals, and reptiles. In extreme cases of repeated disturbance, persistence of mallee may be compromised, leading to other Umbrella Classes such as hummock grassland. Without further disturbance (fire or severe frost), the system will progress to *Depauperate shrubby/Triodia mallee woodland*, with habitat development along a similar trajectory to *Diverse Triodia grassland/shrubland with resprouting mallee*.

Depauperate shrubby/*Triodia* mallee woodland

This expression of *shrubby/Triodia mallee* is similar to *Diverse shrubby/Triodia mallee woodland* but is depauperate in serotinous obligate-seeder shrub species (e.g., *Callitris*) and non-resprouting *Triodia* (Yates et al. 2017). Over long-time frames, these species may re-colonise from elsewhere in the landscape (although it is not known whether fire is needed to promote such recruitment). Alternatively, repeat fire before recovery, and without adequate propagule supplies of these species, the system will temporarily return to *Depauperate Triodia grassland/shrubland with resprouting mallee.*

Callitris woodland or shrubland

Some components of *shrubby/Triodia* mallee, particularly *Callitris* species (e.g., *C. verrucosa*) are fire-retardant. These obligate-seeding species increase in biomass with time since fire, and over long-time frames result in negative feedbacks that can suppress fire spread and reduce fire occurrence in mallee. This may facilitate persistence of such species in patches within fire-prone mallee, and in extreme cases has been proposed to result in shift to *Callitris woodland or shrubland*. The latter would require mortality triggers for otherwise robust mallee individuals, potentially involving competition for moisture.

Hummock grassland

Mallee are expected to be robust to multiple repeat disturbances due their strong resprouting capacity from large lignotubers. Nevertheless, some circumstances may lead to decline of mallee individuals and shift to hummock grassland or other Umbrella vegetation classes. This is most likely to occur in the case of fire followed by drought in marginal mallee habitat, leading to a shift in ecotone between hummock grasslands and *Triodia* mallee.

Experts consulted

Carl Gosper, Hannah Fraser, Gary Howling, David Keith, Luke Kelly, Suzanne Prober, John Vranjic, Matt White (ARI), Colin Yates.

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Chenopod/tussock grass mallee

Chenopod/tussock grass mallee occurs on finer textured topsoils than other mallee communities, supporting understoreys dominated by tussock grasses and/or chenopods and other semi-succulent shrubs (e.g., *Cratystylis*). Mallee with tussock grass dominating the understorey has been widely cleared for agriculture, so interpretation of its original extent, structure, composition, and dynamics is challenged by lack of information. Nevertheless, it is thought to have predominated in moister mallee environments (>300 mm mean annual rainfall), grading to mallee with understoreys dominated by chenopods in more arid environments with greater soil alkalinity and/or salinity (<350 mm) (White 2006, Yates et al. 2017). The balance between chenopods and grasses in the understorey along this gradient is moderated by fire frequency. Chenopods are often killed by fire, recovering via (wind or animal-dispersed) seed, hence frequent fire is expected to favour grasses.

On the other hand, the semi-succulent nature of chenopods makes them relatively fire-retardant (fire-avoiders), with higher chenopod dominance promoting lower fire frequency (White 2006). The frequency of ground and crown fires is poorly studied in the context of this dynamic, but where fires crown, mallee stems are killed and resprout at ground-level. While fire is the key driver of *Chenopod/tussock grass mallee* dynamics, understoreys may also be influenced by waterlogging and drought (see Figure 6).

Ecosystem dynamics

Chenopod mallee woodland with tussock grasses

This expression forms open mallee woodlands of small trees such as *Eucalyptus oleosa* and *E. gracilis,* over tussock grasses and semi-succulent shrubs such as *Maireana, Atriplex, Enchylaena* and *Cratystylis* spp. The large mallee crowns, thick stems, loose

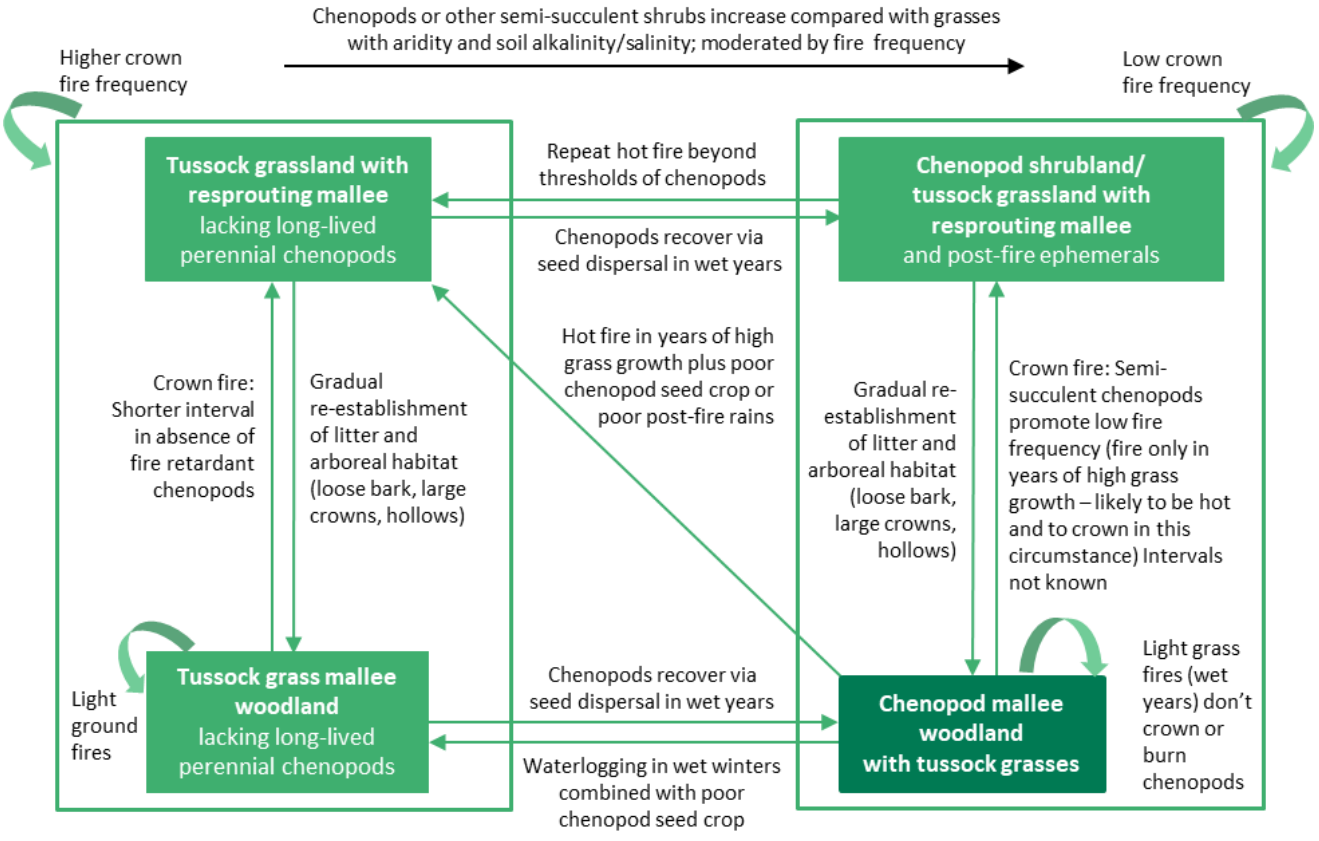

Figure 6: *Chenopod/tussock grass mallee* archetype model.

bark, hollows, and the ground cover of shrubs, grasses, litter, and humus, provide important fauna habitat (Image 7). Light, patchy ground fires may pass through in wetter years without burning tree crowns or chenopods, however the pre-homogonecene frequency of ground fires is not known.

Crown fires are infrequent in chenopod-dominated understoreys owing to their fire-retardant properties, expected only in unseasonably wet years with high tussock grass growth. They may be more frequent where grasses are a more prominent component of the ground layer; alternatively, Aboriginal fire management may have favoured regular ground fire in grassy mallee, potentially limiting crown fire occurrence. Where fires crown, the mallee woodland temporarily shifts to *Chenopod shrubland/tussock grassland with resprouting mallee.*

Image 7: Chenopod mallee with false bluebush (*Cratystylis conocephala*) understorey, Yalata, SA (Image: S. Prober).

In the absence of fire for long periods (>100 years), few species are known to be lost through senescence. However, waterlogging in wet winters can kill mature chenopods, and when this coincides with poor seed crops limiting chenopod recovery, *Tussock grass mallee woodland* lacking long-lived perennial chenopods can result.

Chenopod shrubland/tussock grassland with resprouting mallee

Top-kill of mallee through fire leads temporarily to *Chenopod shrubland/tussock grassland with resprouting mallee*. Without further fire, faunal habitat features, including litter, chenopods, grass tussocks, loose bark, large crowns, and hollows redevelop gradually over time. Conversely, repeated disturbances at short intervals can result in *Tussock grassland with resprouting mallee*.

Tussock grassland with resprouting mallee

This expression of *Chenopod/tussock grass mallee* appears similar to *Chenopod shrubland/tussock grassland with resprouting mallee* but lacks recovering chenopods and other succulent shrubs. This is expected after repeated hot fire beyond the thresholds for rapid chenopod recovery and may be prevalent after crown fire in moister regions that are naturally less favourable for chenopods. In appropriate environments (<350 mm rainfall, alkaline or saline soils) chenopods may gradually recover through seed dispersal from elsewhere in the landscape. Without further fire or recovery of chenopods, *Tussock grassland with resprouting mallee* will progress to *Tussock grass mallee woodland*, with habitat development along a similar trajectory to *Chenopod shrubland/tussock grassland with resprouting mallee*.

Tussock grass mallee woodland

Tussock grass mallee woodland is similar to *Chenopod mallee woodland with tussock grasses,* but without a prominent layer of semi-succulent shrubs (Image 8). This expression can either be favoured after waterlogging or repeat fire. This reduces dominance of chenopods in the latter, or in wetter, low salinity environments that favour grasses over chenopods. The grassy expression may be perpetuated by ongoing ground fire, potentially including Aboriginal lit fires (maintaining *Tussock grass mallee woodland*), or crown fire (killing above ground mallee stems and temporarily resulting in *Tussock grassland with resprouting mallee*). However, the pre-homogonecene frequency of ground or crown fires is not known. In the absence

of fire in drier environments or on alkaline/saline soils, chenopods may recover via seed dispersal in wet years, resulting in *Chenopod mallee woodland with tussock grasses.*

Image 8: Tussock grass mallee, NW Victoria (Image: M. White).

Experts consulted

Carl Gosper, Mark Bourne, David Cheal, David Duncan, David Keith, Luke Kelly, Suzanne Prober, Ian Sluiter, John Vranjic, Matt White (Arthur Rylah Institute), Nathan Wong, Colin Yates.

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