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Multi-species Sward Selector App

This document provides further information about the experimental literature that was used for the scoring of species traits in the app.

Species traits are scored using a 'thumbs' system in the app, where 'thumbs up' indicates the highest performance, 'thumbs horizontal' indicates intermediate performance and 'thumbs down' indicates lowest performance, compared to the other species in the functional group. Trait scores are based only on differences within the functional groups (legumes, forbs and grasses); they do not capture differences between functional groups. Traits were scored in this way because it corresponds to how suites of species were analysed in the experimental literature.

Each species trait score in the app is accompanied by a 'pop-up' box, listing the number of studies that the trait score is based on. Further details about these studies are found below. Virtually all studies were experimental articles published in indexed, peer-reviewed international journals between 1960 and 2020. Virtually all studies used replicated trials in a field environment in the methodological design and inferential statistics for data analysis.

Protein

Definition: the crude protein content of plant tissue dry matter, which was harvested at the optimal grazing/ensiling time in most studies

LEGUME species	Score	Studies with evidence supporting this score	Studies with partial evidence for this score	Studies with evidence contrary to this score
Alsike clover		Lang & Vejražka (2013) reported a similar crude protein for alsike clover compared to lucerne, red clover and birds-foot-trefoil (but with no statistical analysis). Experts from *Rothamsted Research* and *Cotswold Seeds* favoured this score (pers. comm. 2020).		Kuusela (2004) found a lower crude protein content for this species, compared to red and white clovers.
Birds-foot-trefoil			Low protein content in 4 studies (Chapman et al., 2008; Kleen, Taube & Gierus, 2011; Lang & Vejražka, 2013;	

			Scharenberg et al., 2007), intermediate in 3 studies (Adjesiwor et al. 2017; Elgersma, Søegaard & Jensen, 2014; Fraser, Fychan & Jones, 2000) and high in 3 studies (Da Silva et al., 2013; Da Silva et al., 2014; Molle et al., 2008). Taken together, the results suggest that an intermediate score should be allocated.	
Lucerne			Low protein content in 4 studies (Da Silva et al., 2013; Da Silva et al., 2014; Elgersma & Søegaard, 2016; Molle et al., 2008), intermediate in 6 studies (Albayrak et al., 2011; Adjesiwor et al. 2017; Elgersma, Søegaard & Jensen, 2014; Fraser et al. 2004, Fraser, Fychan & Jones, 2000; Lang & Vejražka, 2013) and high in 2 studies (Chapman et al. 2008; Kleen, Taube & Gierus, 2011).Taken together, the results suggest that an intermediate score should be allocated.	
Red clover		Intermediate protein content in 7 studies (Elgersma & Søegaard, 2016; Eriksen, Askegaard, & Søegaard, 2014; Fraser et al., 2004; Fraser & Jones, 2000; Kuusela, 2004; Lang & Vejražka, 2013; Søegaard and Nielsen, 2012)		High protein content in 2 studies *(*Kleen & Gierus, 2011; Molle et al., 2008)
Sainfoin		Low protein content in 4 studies (Adjesiwor et al., 2017; Albayrak et al., 2011; Aufre`re et al., 2008; Fraser, Fychan & Jones, 2000).		Intermediate protein content in 2 studies (Molle et al., 2008; Scharenberg et al, 2007a)

		Scharenberg (2007b) identified that the high condensed tannin content in sainfoin inhibited protein absorption, providing additional justification for allocating a low score for protein to this species.		
White clover		High protein content in 5 studies (Da Silva et al., 2013; Elgersma & Søegaard, 2016; Eriksen, Askegaard, & Søegaard, 2014; Kuusela, 2004; Lang & Vejražka, 2013).		Intermediate protein content in 2 studies (Kleen and Gierus, 2011; Molle et al., 2008).

FORB species	**Score**	**Studies with evidence supporting this score**	**Studies with partial evidence for this score**	**Studies with evidence contrary to this score**
Chicory		Harrington, Thatcher, & Kemp (2006) found that chicory was higher in crude protein than a perennial ryegrass control. Whilst we are not comparing across functional groups, this result does suggest chicory has a very high protein level for a forb. Jung et al. (1996) and Burke, Waghorn and Chaves (2002) found that chicory had a protein content comparable to some legumes.		
Plantain		Elgersma, Søegaard and Jensen (2014) and Warner et al. (2010), found that plantain had higher crude protein content than chicory, which suggests plantain also warrants a high score.		
Sheep's burnet			Elgersma, Søegaard and Jensen (2014) found sheep's burnet to be higher in protein than chicory whilst Stewart et al. (2019) found the	

			crude protein content to be very low. Taken together, these results suggest that an intermediate score should be allocated.	
Sheep's parsley	?	no data		
Yarrow	?	no data		

GRASS species	**Score**	**Studies with evidence supporting this score**	**Studies with partial evidence for this score**	**Studies with evidence contrary to this score**
Cocksfoot		High protein content in 3 studies (Jensen et al., 2016; King et al., 2012; Sayar et al., 2014)		
Meadow fescue		Intermediate protein content in 1 study (Schaefer, Albrecht & Schaefer, 2014).		
Meadow foxtail			Jensen (2016) found that meadow foxtail had lower crude protein content than cocksfoot, perennial ryegrass and timothy, whilst Rode (1986) and Waldie (1983) reported that meadow foxtail had a higher crude protein than timothy. Taken together, the results suggest that an intermediate score should be allocated.	
Perennial ryegrass		High protein content in 5 studies (Akdeniz et al., 2019; Fulkerson et al., 2007; Jensen et al., 2016; Sayar et al., 2014; Totty et al., 2013).		
Tall fescue		Intermediate protein content in 4 studies (Akdeniz et al., 2019; Bryant et al., 2017; Sayar et al., 2014; Schaefer, Albrecht & Schaefer, 2014).		Low protein content in 1 study Jensen et al. (2016).

Timothy			Jensen (2016) found that timothy had higher crude protein content than meadow foxtail and tall fescue, whilst Rode (1986) and Waldie (1983) reported that meadow foxtail had a higher crude protein than timothy. Taken together, the results suggest that an intermediate score should be allocated.	

Digestibility

Definition: the digestibility of plant tissue dry matter, which was harvested at optimal grazing/ensiling time in most studies and measured using IVTD, IVOMD, DOMD or NDFD.

LEGUME species	**Score**	**Studies with evidence supporting this score**	**Studies with partial evidence for this score**	**Studies with evidence contrary to this score**
Alsike clover		Intermediate digestibility in 2 studies (Kuusela, 2004; Huuskonen, Pesonen & Honkavaara, 2017).		Low digestibility in Paplauskienė & Dabkevičienė (2012).
Birds-foot-trefoil		Intermediate digestibility in 5 studies (Adjesiwor et al., 2017; Chapman et al., 2008; Da Silva et al., 2013; Elgersma, Søegaard & Jensen, 2014; Molle et al., 2008).		Higher digestibility than Lucerne in 3 studies, although still inferior to clovers (Christensen et al., 2015; Da Silva et al., 2014; Elgersma & Søegaard, 2016).
Lucerne		Intermediate digestibility in 6 studies (Adjesiwor et al., 2017; Brink, Sanderson & Casler, 2015; Chapman et al., 2008; Da Silva et al., 2013; Elgersma, Søegaard & Jensen, 2014; Fraser et al., 2004).		High digestibility in 2 studies (Fraser et al., 2004; Fraser, Fychan & Jones, 2000). Low digestibility in 1 study (Elgersma & Søegaard, 2016).

Red clover		High digestibility in 4 studies (Elgersma & Søegaard, 2016; Fraser, Fychan & Jones, 2000; Fraser et al., 2004; Johansen et al., 2017).		Intermediate digestibility in 2 studies (Huuskonen, Pesonen & Honkavaara, 2017; Kuusela, 2004).
Sainfoin			Molle et al., (2008) found no significant difference between lucerne and sainfoin digestibility. Wang et al., (2007) found that sainfoin had a higher digestibility than lucerne, whilst Adjesiwor et al. (2017) reported sainfoin as having a lower value compared to lucerne and birds-foot-trefoil. Taken together, the results suggest that an intermediate score should be allocated. Sainfoin is known to exhibit high genetic variability (e.g. Zarrabian et al. 2013), which may account for the contradictory results	
White clover		High digestibility in 4 studies (Brink, Sanderson & Casler, 2015; Da Silva et al., 2013; Elgersma & Søegaard, 2016; Johansen et al., 2017).		Intermediate digestibility in 2 studies (Huuskonen, Pesonen & Honkavaara, 2017; Kuusela, 2004).

FORB species	**Score**	**Studies with evidence supporting this score**	**Studies with partial evidence for this score**	**Studies with evidence contrary to this score**
Chicory		High digestibility in 4 studies (Burke, Waghorn & Chaves, 2002; Chapman et al., 2008; Hayes et al, 2010; Scales, Knight & Saville, 1995).		Low digestibility in 1 study (Bryant et al., 2007).
Plantain		Intermediate digestibility in 2 studies (Cheng et al., 2017; Minnee et al., 2017).		Low digestibility in 1 study (Bryant et al., 2007).
Sheep's	?	no data		

burnet				
Sheep's parsley	?	no data		
Yarrow	?	no data		

GRASS species	Score	Studies with evidence supporting this score	Studies with partial evidence for this score	Studies with evidence contrary to this score
Cocksfoot			Intermediate digestibility in 2 studies (Da Silva et al., 2013; Jensen et al., 2016), high in 1 study (Sayar et al., 2014), and low in 1 study (Bilman et al., 2017). Taken together, the results suggest that an intermediate score should be allocated.	
Meadow fescue			High digestibility in 2 studies (Bilman et al., 2017; Schaefer, Albrecht, & Schaefer, 2014), low digestibility in 2 studies (Da Silva et al. 2013; Elgersma & Søegaard, 2016). Taken together, the results suggest that an intermediate score should be allocated.	
Meadow foxtail			Waldie, Wright & Cohen (1983) reported meadow foxtail as having a higher digestibility than timothy, whilst Jensen et al. (2016) reported this species as having a lower digestibility than timothy, tall fescue but a similar value to cocksfoot. Taken together, the results suggest that an intermediate score should be allocated.	
Perennial ryegrass		High digestibility in 9 studies (Akdeniz et al., 2019; Frame, 1989; Frame, 1991; Jensen et al., 2016; Johansen et al., 2017; King et al., 2012; Lee et al., 2018; Sayar et al., 2014; Totty et al., 2013).		Intermediate digestibility in 1 study (Bilman, 2017).
Tall fescue			3 studies found that tall fescue had a lower digestibility than perennial ryegrass (Akdeniz et al., 2019; Johansen et al., 2017; Lee et al 2018). King et al. (2012) found it had	

			a digestibility lower than both perennial ryegrass and timothy, whilst Sayar et al. (2014) found it was lower than perennial ryegrass and cocksfoot. Jensen et al. (2016) found its digestibility to be lower than 4 other species. In contrast, Bilman (2017) found its digestibility to be higher than perennial ryegrass and cocksfoot and Da Silva et al. (2013) found that its digestibility was higher than cocksfoot and meadow fescue. Taken together, the results suggest that an intermediate score should be allocated.	
Timothy			Digestibility for timothy was found to be high in Da Silva et al. (2013), intermediate in Jensen et al. (2016) and low in King et al. (2012). Taken together, the results suggest that an intermediate score should be allocated.	

Minerals

Definition: 'thumbs up' indicates species with a high content of one or more trace elements or macronutrients. Species are only scored as high in a particular mineral if the score is supported by two or more studies.

LEGUME species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Alsike clover	?	High in copper (Darch et al., 2020)	
Birds-foot-trefoil		High in zinc (Forbes & Gelman; 1981; Pirhofer-Walzl et al., 2011). Pirhofer-Walzl et al. also found birds-foot-trefoil to be high in molybdenum.	
Lucerne	?	1 study found Lucerne to be high in copper (Kunelius et al., 2006)	
Red clover		High in copper (Kunelius et al., 2006; Pirhofer-Walzl et al., 2011; Lindstrom et al., 2012). Lindstrom et al. also found red clover to be high in cobalt, zinc, molybdenum, iron.	
Sainfoin	?	1 study found sainfoin to be high in calcium and magnesium (Scharenberg at al., 2008)	

White clover		High in copper (Forbes & Gleman, 1981; Lindstrom et al., 2012). Lindstrom et al. also found white clover to be high in cobalt at, zinc, molybdenum, iron. Kuusela (2006) found white clover to be high in sodium and calcium.	

FORB species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Chicory		High in calcium, magnesium, zinc, copper, sulphur, iron and molybdenum (Forbes & Gleman, 1981; Harrington, Thatcher, & Kemp, 2006; Belesky et al., 2001; Jung et al., 1996; Pirhofer-Walzl et al., 2011; Scales, Knight & Saville, 1995; Darch et al., 2020).	
Plantain		High in sulphur and calcium (Harrington, Thatcher, & Kemp, 2006; Forbes & Gleman, 1981; Forbes and Gleman 1981; Darch et al., 2020); TOMS unpublished data).	
Sheep's burnet	?		
Sheep's parsley	?	Forbes and Gleman (1981) found sheep's parsley to be high in sodium, zinc	
Yarrow		High in potassium, copper and manganese (Alberski et al., 2009; Forbes & Gleman, 1981; Darch et al., 2020; TOMS unpublished data). 1 study also found yarrow to have high levels for each of magnesium, zinc, boron, iodine, calcium.	

GRASS species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Cocksfoot		High in manganese (Lindstrom et al., 2012; Darch et al., 2020; Forbes & Gleman, 1981). Forbes and Gleman also found cocksfoot to be high in copper.	
Meadow fescue	?	No data	
Meadow foxtail	?	1 study (Darch et al., 2020) found to be high in copper	
Perennial ryegrass	?	1 study (Darch et al., 2020) found to be high in colbat	
Tall fescue	?	No data	
Timothy	?	No data	

Relative yield – under cutting

Definition: dry matter yield under a 'cutting only' regime, when grown in a binary or multi-species sward.

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover		Low yielding in 2 studies (Frankow-Lindberg et al., 2009; Kunelius 2005)	
Birds-foot-trefoil		Low yielding in 6 studies (Adjesiwor et al., 2017; Gierus et al., 2012; Kleen, Taube & Gierus, 2011; Pirhofer-Walzl et al., 2011; Smit et al., 2008; Wiersma, Hoffman & Mlynarek, 1999).	Intermediate in 1 study (Elgersma & Søegaard, 2016).
Lucerne		High yielding in 6 studies (Adjesiwor et al., 2017; Elgersma & Søegaard, 2016; Gierus et al., 2012; Pirhofer-Walzl et al., 2011; Sanderson et al., 2013; Wiersma, Hoffman & Mlynarek, 1999).	Intermediate in 2 studies (Kleen et al., 2011; Smit et al., 2008).
Red clover		High yielding in 8 studies (Elgersma & Søegaard, 2016; Eriksen, Askegaard & Søegaard, 2014; Frame and Harkess, 1987; Gierus et al., 2012; Husse et al., 2016; Pirhofer-Walzl 2011; Smit et al., 2008; Wiersma et al., 1999).	Intermediate in 1 study (Frankow-Lindberg et al., 2009)
Sainfoin		Low yielding in 1 study (Adjesiwor et al., 2017).	
White clover		Intermediate yield in 6 studies (Elgersma & Søegaard, 2016; Eriksen, Askegaard & Søegaard, 2014; Husse et al., 2016; Pirhofer-Walzl et al., 2011; Sanderson et al., 2013; Smit et al., 2008).	High yielding in 3 studies (Frankow-Lindberg et al., 2009; Gierus et al., 2012; Kleen, Taube & Gierus, 2011).

FORB species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Chicory		Intermediate yield in 1 study (Pirhofer-Walzl et al., 2011).	
Plantain		High yielding in 1 study (Pirhofer-Walzl et al., 2011).	
Sheep's burnet		Low yielding in 1 study (Pirhofer-Walzl et al., 2011).	
Sheep's parsley	?	No data	
Sainfoin	?	No data	
Yarrow	?	No data	

GRASS species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Cocksfoot		Intermediate yield in 1 study (Da Silva et al., 2013).	
Meadow fescue		Intermediate yield in 1 study (Frame and Harkess, 1987).	High yielding in 1 study (Da Silva et al., 2013).
Meadow foxtail		Low yielding in 1 study (Fairey, 1991).	
Perennial ryegrass		Intermediate yield in 1 study (Frame and Harkess, 1987).	
Tall fescue		High yielding in 1 study (Da Silva et al., 2013).	
Timothy		Intermediate yield in 2 studies (Frame and Harkess, 1987; Fairey, 1991).	High yielding in 1 study (Da Silva et al., 2013).

Relative yield – under grazing

Definition: dry matter yield under a 'grazing only' regime, when grown in a binary or multi-species sward.

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover	?	No data	
Birds-foot-trefoil		Low yielding in 3 studies (Barker et al., 1999; Deak et al., 2007; Kleen, Taube & Gierus, 2011).	
Lucerne		Intermediate yield in 2 studies (Barker et al., 1999; Deak et al., 2007; Kleen, Taube & Gierus, 2011).	
Red clover		High yielding in 3 studies (Eriksen, Askegaard & Søegaard, 2014; Deak et al., 2007; Kleen, Taube & Gierus, 2011).	
Sainfoin	?	No data	
White clover		High yielding in 2 studies (Deak et al., 2007; Kleen, Taube & Gierus, 2011).	

FORB species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Chicory		High yielding in 1 study (Somasiri, 2016).	
Plantain		High yielding in 1 study (Somasiri, 2016).	
Sheep's burnet	?	No data	
Sheep's parsley	?	No data	
Sainfoin	?	No data	

Yarrow	?	No data	

GRASS species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Cocksfoot		High yielding in 1 study (Scott, 2001).	
Meadow fescue		High yielding in 3 studies (Schaefer, Albrecht & Schaefer, 2014; Papadopoulos et al., 2012; Wilman & Gao, 1996).	
Meadow foxtail	?	No data	
Perennial ryegrass		High yielding in 3 studies (Bryant et al., 2017; Tharmaraj et al., 2014; Wilman & Gao, 1996).	
Tall fescue		High yielding in 4 studies (Lee et al 2018; Tharmaraj et al., 2014; Schaefer, Albrecht & Schaefer, 2014; Wilman & Gao, 1996).	
Timothy		Intermediate yield in 1 study (Papadopoulos et al., 2012).	

Persistence (grazing)

Definition: productivity of species over the life-time of a temporary ley (4- 5 years).

LEGUME species	Score	Studies with evidence supporting this score	Studies with partial evidence for this score	Studies with evidence contrary to this score
Alsike clover	?	No data		
Birds-foot-trefoil			2 studies found that this species has declined in the sward after two years' monitoring (Brummer & Moore, 2000; Douglas & Foote, 1993) whilst another study found that it did not decline until the fourth grazing season (Sheaffer et al., 1992). Taken together, these results suggest an intermediate score.	
Lucerne		Declined in the sward after two years' monitoring, in 2 studies		Persisted for more

		(Brummer & Moore, 2000; Douglas & Foote, 1993). Decreased steadily after the 5 years of monitoring, in 2 studies (Hayes et al., 2010; 2017).		than 4 years due to seedling recruitment Clark et al., 2013).
Red clover		Rapid decrease over first 2 grazing years and largely disappeared from sward by third year, in 3 studies (Sanderson, et al. 2005; Sanderson, 2010; Tracy & Faulkner, 2006). Scott (2006) found red clover increased over the first 3 years in the sward but then disappeared.		
Sainfoin		Declined over 2 grazing years in the sward (Mowrey & Matches, 1991).		
White clover		White clover was the dominant species in several mixtures at the end of 3 grazing years (Deak et al., 2007). There was no decline in abundance, after the 2 grazing years that were sampled (Brummer & Moore, 2000; Sanderson 2010).		

FORB species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Chicory		Chicory substantially decreased over the 2 grazing years that were monitored (Deak et al., 2007; Soder et al., 2006; Skinner et al., 2006). Chicory decreased in the first 2 grazing years and had almost disappeared by the third (Sanderson et al., 2005). Chicory declined over four grazing years (Clark et al., 2013).	
Plantain		Plantain did not persist beyond 2 years in simple or complex mixtures (Sanderson et al., 2003).	
Sheep's burnet		Sheep’s burnet declined after 2 years under mob grazing (Douglas & Foote 1993).	
Sheep's parsley	?	No data	
Yarrow	?	No data	

GRASS species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Cocksfoot		The dominant species in several mixtures at the end of 3 grazing years (Deak et al., 2007; Sanderson et al., 2005; Soder 2006), 4 grazing years (Tracy & Faulkner, 2006) and 5 grazing years (Hayes et al., 2017; Scott & Pennell, 2006).	Brummer and Moore (2000) found that cocksfoot decreased over 2 grazing years.

Meadow fescue		Low persistence under all the experimental regimes and had decreased substantially after 3 grazing years (Gooding and Frame, 1997).	
Meadow foxtail	?		
Perennial ryegrass		Perennial ryegrass increased in abundance over 4 grazing years (Tracy & Faulkner, 2006), or remained stable, which was found to be due to seedling recruitment (Clark, 2013).	Nie et al. (2004b) found that this species failed to persist in many regions beyond 3–4 years after establishment. Deak et al. (2007) found that it accounted for a large proportion of the dry matter in the first 2 years but was short lived.
Tall fescue		Tall fescue increased in abundance over 2 grazing years (Brummer & Moore, 2000), 3 grazing years (Deak et al., 2007; Denison & Perry, 1990; Sanderson et al., 2005; Skinner et al.,2006), 4 grazing years (Clark, 2013; Tracy & Faulkner, 2006).	
Timothy		Timothy persisted over the three grazing seasons (Gooding & Frame, 1997).	

Tolerance to frequent cutting/grazing

Definition: productivity or persistence, as measured specifically under a cutting or grazing regime based on low residual height thresholds, continuous or high density stocking. Partially overlaps with the 'persistence' trait.

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover	?	No data	
Birds-foot-trefoil		This species did not persist under continuous, intensive grazing (Brummer & Moore, 2000).	
Lucerne		This species did not persist under continuous, intensive grazing (Brummer & Moore, 2000) or a high grazing frequency (Deak et al., 2007). Lucerne could only persist in stands with a long regrowth interval, of 40 days (Jung et al. 1996).	
Red clover		Red clover was suppressed by grazing regimes with continuous stocking with heifers and 5 cm residual height, whereas white clover was not (Eriksen, Askegaard & Søegaard, 2014).	
Sainfoin		Could only tolerate extensive grazing (Pecetti et al., 2009).	
White clover		This species persisted well under continuous, intensive grazing (Ter Heerdt, Bakker & De	

		Leeuw, 1991; Brummer & Moore, 2000; Pavlu et al., 2003). White clover increased in abundance under moderate- and hard-grazed set-stocked treatments (Scott, 2001). Red clover was suppressed by grazing regimes with continuous stocking with heifers and 5 cm residual height, whereas white clover was not (Eriksen, Askegaard & Søegaard, 2014). White clover did not thrive under a regime of three cuts per year, since its stoloniferous growth habit and continuous vegetative renewal is better suited to frequent harvesting (Frame & Harkess, 1987).	

FORB species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Chicory		This species did not cope with intensive grazing through damage to the tap root (Powell et al. 2007; Labreveux & Sanderson, 2004; Sanderson et al., 2003). The key principles to avoid tap root damage include not grazing to below 5 cm and maintaining a rotation length of 3–6 weeks to reduce the grazing pressure.	
Plantain		This species did not cope with intensive grazing through damage to the tap root (Pavlu et al., 2003; Powell et al. 2007; Labreveux & Sanderson, 2004; Sanderson et al., 2003). The key principles to avoid tap root damage include not grazing to below 5 cm and maintaining a rotation length of 3–6 weeks to reduce the grazing pressure.	
Sheep's burnet		Would be expected to exhibit poor tolerance due to having a taproot, as discussed by Kemp et al. (2010).	
Sheep's parsley		Would be expected to exhibit poor tolerance due to having a taproot, as discussed by Kemp et al. (2010).	
Yarrow		This species could not cope with continuous grazing, probably due to damage to the tap root (Pavlu et al., 2003).	

GRASS species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Cocksfoot		Frequent and severe cutting reduced abundance of this species (Griffith and Teel, 1965), as did continuous grazing (Brummer & Moore, 2000; Pavlu et al., 2003) and a high stocking rate (Scott, 2001).	Species abundance was not influenced by grazing schedule (high intensity versus low intensity) but that could be due to the dry weather in both years of the experiment (Deak et al., 2007).
Meadow fescue		The annual dry matter yield was lower than tall fescue under all harvesting frequencies at 5 cm residual height, suggesting it has a low cutting and grazing tolerance (Brink, Sanderson & Casler, 2015). Schaefer,	

		Albrecht and Schaefer (2014) also found that meadow fescue could not tolerate the same defoliation frequency as tall fescue.	
Meadow foxtail	👎	This species could not cope with continuous grazing (Pavlu et al., 2003).	The yields of this species were virtually unaffected by 4 cuts a year, as compared to 1-2 cuts a year (Fairey, 1991).
Perennial ryegrass	👍	Perennial ryegrass was well suited to frequent grazing (20-day interval), coping with residual sward heights that were often less than 4 cm (Beleskey & Fedders, 1994). This species performed best under frequent cutting (Jung et al. 1996; Deak, Hall & Sanderson, 2009). Perennial ryegrass was found to be tolerant of frequent defoliation, compared to timothy (Hoglind et al., 2001).	
Tall fescue	👍	Tall fescue persisted well under continuous intensive grazing (Brummer & Moore, 2000). This species was found to be tolerant of frequent defoliation, compared to meadow fescue (Hoglind et al., 2001). Schaefer, Albrecht and Schaefer (2014).	
Timothy	👎	The yields of this species were reduced by 4 cuts a year, as compared to 1-2 cuts a year (Fairey, 1991). Timothy was most abundant under the low stocking-rate treatments, and under mob stocking as compared to set stocking (Scott, 2001). Timothy was less tolerant of frequent defoliation, than perennial ryegrass (Hoglind et al., 2001) and recovers slowly following defoliation (Gooding & Frame, 1997).	

Anthelminthic properties

Definition: consumption of this species was shown to reduce faecal egg count, egg hatchability or larval mortality of gastro-intestinal parasites, in sheep or cattle (excepting 2 studies based on results *in vitro* and 2 studies based on parasite incidence in other animal species).

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover	?	No data	
Birds-foot-trefoil	👍	Exhibited anthelminthic properties in 4 studies (Heckendorn et al., 2007; Niezen et al., 1998; Marley et al., 2003a; Ramirez-Restrepo 2005).	No antihelmintic properties exhibited in 1 study (Tzamaloukas et al., 2005).

Lucerne		No antihelmintic properties exhibited for 3 studies (Aufrere et al., 2013; Heckendorn et al., 2007; Marley et al., 2005).	Antihelmintic properties exhibited in 1 study (Scales et al., 1995).
Red clover	?	Exhibited anthelminthic properties in 1 study but only abomasal worms were reduced – was not effective for parasites in the small intestine (Marley et al., 2005).	
Sainfoin		Exhibited anthelminthic properties in 4 studies (Häring et al., 2008; Heckendorn et al., 2007; Ojeda-Robertos et al., 2010; Rios-de Alvarez et al., 2008).	
White clover		No anthelminthic properties exhibited in 2 studies (Tzamaloukas et al., 2005; Grace et al., 2019).	Antihelmintic properties exhibited in 1 study (Marley et al., 2005).

HERB species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Chicory		Exhibited anthelminthic properties in 9 studies (Heckendorn et al., 2007; Hoskin et al., 1999; Marley et al., 2003a; Marley et al., 2003b; Molan et al., 2003; Niezen et al., 1998; Pena-Espinoza et al., 2016; Scales et al., 1995; Tzamaloukas et al., 2005).	No anthelminthic properties exhibited in 1 study (Athanasiadou et al., 2005).
Plantain		Plantain displayed significant anthelmintic activity against pinworms, *Syphacia obvelata* and *Aspiculuris tetraptera*, in mice (Kozan, Küpeli & Yesilada, 2006).	
Sheep's burnet	?	No data	
Sheep's parsley	?	No data	
Yarrow		Exhibited anthelmintic properties in 1 study (Tariq et al., 2008). Yarrow is high in eugenol (Lourenco 1999), which showed potent anthelmintic activity *in vitro* (Asha 2001). Yarrow reduced incidence of the nematode parasite 'donkey strongyles' *in vitro* (Buza 2020).	

GRASS species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Cocksfoot		No anthelmint-ic properties exhibited for 1 study (Scales et al., 1995).	
Meadow fescue		Unlikely to have an anthelmintic effect as no record of sesquiterpene lactones, eugenol or condensed tannins for this species, the two plant secondary metabolites that are proven to exert an antihelmintic effect *in vitro/in vivo.*	

Meadow foxtail		See 'cocksfoot'	
Perennial ryegrass	👎	No anthelmintic properties exhibited for 4 studies (Grace et al., 2019; Heckendorn et al., 2007; Marley et al., 2005; Tzamaloukas et al., 2005).	
Tall fescue	👎	See 'cocksfoot'	
Timothy	👎	See 'cocksfoot'	

Bloat safe

Definition: Consumption of this species did not cause ruminal or abomasal bloat in sheep or cattle

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover	👎	Caused bloat in 2 studies (Jones and Lyttleton, 1971; Wang, Majak & McAllister et al., 2012).	
Birds-foot-trefoil	👍	Did not cause bloat in 4 studies (Berard et al., 2011; Fay et al., 1990; Jones and Lyttleton, 1971; Li, Tanner & Larkin, 1996).	
Lucerne	👎	Caused bloat in 4 studies (Hancock et al., 2014; Majak et al., 1983; Majak, Garland & Lysyk, 2003; McMahon et al., 1999).	
Red clover	👎	Caused bloat in 4 studies (Agnew, Morris & Cullen, 2000; Carruthers et al., 1992; Majak et al., 1983; Li, Tanner & Larkin, 1995).	
Sainfoin	👍	Did not cause bloat in 3 studies (McMahon et al., 1999; Waghorn and McNabb, 2003; Wang et al., 2006).	
White clover	👎	Caused bloat in 5 studies (Agnew, Morris & Cullen, 2000; Hancock et al., 2014; Li, Tanner & Larkin, 1996; Majak et al., 1983; Schils et al., 2000).	

Drought tolerant

Definition: species was shown to survive, and/or be productive, under periods of prolonged moisture deficit.

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover	👎	Poor drought tolerance in 3 studies (Davis, 1991; Fairey, 1991; Lang & Vejražka, 2013).	
Birds-foot-trefoil	👍	Good drought tolerance in 5 studies (Fairey, 1991; Davis, 1991; Douglas & Foote, 1993; Hopkins et al., 1996; Lang & Vejražka, 2013).	Poor drought tolerance in 1 study (Langworthy et al., 2018).
Lucerne		Good drought tolerance in 9 studies (Fairey,	

		1991; Goh & Bruce, 2005; Hayes et al., 2010; Hayes et al., 2016; Lang & Vejražka, 2013; Langworthy et al., 2018; Neal et al., 2009; Peel et al., 2004; Skinner et al., 2006).	
Red clover		Poor drought tolerance in 5 studies (Davis, 1991; Elgersma & Søegaard, 2016; Lang & Vejražka, 2013; Langworthy et al., 2018; Skinner, Gustine & Sanderson, 2004).	Good drought tolerance in 1 study (Hoekstra et al., 2018).
Sainfoin		Good drought tolerance in 2 studies (Carbonero et al., 2011; Peel et al., 2004).	
White clover		Poor drought tolerance in 7 studies (Goh & Bruce, 2005; Hoekstra et al., 2018; Knowles, Fraser & Daly, 2003; Lang & Vejražka, 2013; Neal et al., 2009; Schaefer, Albrecht & Schaefer, 2014; Skinner et al., 2006).	

HERB species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Chicory		Good drought tolerance in 7 studies (Cranston et al., 2016; Goh & Bruce, 2005; Hoekstra et al., 2018; Langworthy et al., 2018; Perera, Cullen & Eckard, 2019; Skinner, Gustine & Sanderson, 2004; Skinner, 2008).	Poor tolerance in Hayes et al. (2016) was not included as results were based on severe drought.
Plantain		Good drought tolerance in 2 studies (Cranston et al., 2016; Langworthy et al., 2018).	Poor drought tolerance in 1 study (Goh & Bruce, 2005). Poor tolerance in Hayes et al. (2016) was not included as results were based on severe drought.
Sheep's burnet		Good drought tolerance in 3 studies (Douglas & Foote, 1993; Douglas et al., 1990; Douglas, Robertson & Chu, 1991).	
Sheep's parsley	?	No data	
Yarrow	?	No data	

GRASS species	**Score**	**Studies with evidence supporting this score**	**Studies with evidence contrary to this score**
Cocksfoot		Good drought tolerance in 3 studies (Hayes et al., 2017; Hayes et al., 2010; Volaire, Conéjero & Lelièvre, 2001; Volaire & Lelièvre, 2001; Sheaffer et al., 1992).	Poor drought tolerance in 3 studies (Perera, Cullen & Eckard, 2019; Langworthy et al., 2018; Suleiman et al., 1999). Poor tolerance in Hayes et al. (2016) was not included as results were based on severe drought.
Meadow fescue		Poor drought tolerance in 4 studies (Elgersma & Søegaard, 2016; Schaefer, Albrecht & Schaefer, 2014; Wilman, Gao &	

		Leitch, 1998; Zimmermann & Nösberger, 1999).	
Meadow foxtail	👎	Poor drought tolerance in 1 study (Fairey, 1991).	
Perennial ryegrass	👎	Poor drought tolerance in 8 studies (Anderson et al., 1999; Hoekstra et al., 2018; Langworthy et al., 2018; MacFarlane, 1990; Nie et al., 2004; Perera, Cullen & Eckard, 2019; Reed, 1974; Waller et al., 2001). Poor tolerance in Wilman, Gao & Leitch, (1998) was not included as results were based on severe drought.	
Tall fescue	👍	Good drought tolerance in 6 studies (Cougnon et al., 2014; Langworthy et al., 2018; Schaefer, Albrecht & Schaefer, 2014; Skinner et al., 2006; Volaire & Lelièvre, 2001; Wilman, Gao & Leitch, 1998).	Poor drought tolerance in 2 studies (Hayes et al., 2010; Perera, Cullen & Eckard, 2019). Poor tolerance in Hayes et al. (2016) was not included as results were based on severe drought.
Timothy	👍	Good drought tolerance in 1 study (Elgersma & Søegaard, 2016).	Poor drought tolerance in 1 study (Sheaffer et al., 1992).

Waterlogging tolerant

Definition: survival following a prolonged period of standing water in the rooting zone of the soil

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover	?	No data	
Birds-foot-trefoil	👍	Good survival in 2 studies (Dear, Reed & Craig, 2008; Heinrichs, 1970).	
Lucerne	👎	Poor survival in 3 studies (Berhongaray, Basanta & Jauregui, 2019; Finn et al., 1961; Thompson & Fick, 1981).	
Red clover	👎	Poor survival in 1 study (Frankow-Lindberg et al., 2009).	
Sainfoin	👎	Poor survival in 1 study (Heinrichs, 1970).	
White clover	👍	Good survival in 4 studies (Annicchiarico et al., 1995; Finn et al., 1961; Frankow-Lindberg et al., 2009; Heinrichs, 1970).	

HERB species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Chicory	?	No data	
Plantain	👍	Good survival in 1 study (Banach et al., 2009).	

Sheep's burnet	?	No data	
Sheep's parsley	?	No data	
Yarrow	👎	Poor survival in 1 study (Banach et al., 2009).	

GRASS species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Cocksfoot	👎	Poor survival in 1 study (Rogers & Davies, 1973).	
Meadow fescue	?	No data	
Meadow foxtail	👍	Good survival in 1 study (Wenick, Svejcar & Angell, 2008).	
Perennial ryegrass	?	No data	
Tall fescue	👍	Good survival in 1 study Rogers & Davies, 1973).	
Timothy	👍	Good survival in 3 studies (Banach et al., 2009; Jørgensen, Torp & Mølmann, 2020; Rogers & Davies, 1973).	

Tolerant of low fertility soils

Definition: productive under low soil phosphorus, low soil nitrogen or pH extremes.

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover	👍	Tolerant of acidic soil (pH 5.0) (1 study (Jo, Yoshida & Kayama, 1980).	
Birds-foot-trefoil	👍	Tolerant of acidic soil (Dear, Reed & Craig, 2008) and low soil phosphorus (Davis, 1991; Hopkins et al., 1996).	
Lucerne	👎	Requires pH 6.5 -7.5 (Jo, Yoshida & Kayama, 1980; Rice, 1982; Rice, Penney & Nyborg, 1977).	
Red clover	👎	Requires pH > 5 (Jo, Yoshida & Kayama, 1980; Rice, Penney & Nyborg, 1977).	
Sainfoin	👎	Requires alkaline soil (pH 7.0 – 8.0) (Cicek et al., 2020; Peel et al., 2004; Tufenkci, Erman & Sonmez, 2006).	
White clover	👎	Intolerant of low soil fertility (Davis, 1991; Hopkins, 1996).	

HERB species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Chicory	?	No data	
Plantain		Tolerant of low soil fertility (Hoveland et al., 1976; Olff & Bakker, 1991).	
Sheep's burnet	?	No data	
Sheep's parsley	?	No data	
Yarrow	?	No data	

GRASS species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Cocksfoot		Intolerant of low soil fertility (Reid, 1985; Scott, 2001).	
Meadow fescue	?	No data	
Meadow foxtail	?	No data	
Perennial ryegrass		Intolerant of low soil fertility (Lambert et al., 1986; Reid, 1985).	
Tall fescue	?	No data	
Timothy		Tolerant of low soil fertility (King et al., 2012; Scott, 2001).	

Tolerant to hard frosts

Definition: survival following a prolonged period of heavy freezing.

LEGUME species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Alsike clover		High tolerance (Caradus, 1995; Meyer & Badaruddin, 2001).	
Birds-foot-trefoil	?	No data	
Lucerne		Low tolerance (Meyer & Badaruddin, 2001).	
Red clover	?	Exhibited poor tolerance in Skinner & Gustine (2002) but omitted because results were based on temperatures that were considerably lower than UK.	
Sainfoin		High tolerance (Adjesiwor et al., 2017; Irani et al., 2015; Meyer & Badaruddin, 2001).	
White clover	?	No data	

HERB species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Chicory		High tolerance (Skinner & Gustine, 2002).	
Plantain	?	Exhibited poor tolerance in 3 studies but these were omitted because results were based on temperatures that were considerably lower than UK (Sanderson et al., 2003; Skinner & Gustine, 2002; Skinner & Stewart, 2014).	
Sheep's burnet	?	No data	
Sheep's parsley	?	No data	
Yarrow	?	No data	

GRASS species	Score	Studies with evidence supporting this score	Studies with evidence contrary to this score
Cocksfoot	?	No data	
Meadow fescue		High tolerance (Fjellheim et al., 2009).	
Meadow foxtail	?	No data	
Perennial ryegrass		Low tolerance (Höglind et al., 2010; Kunelius et al., 2006)	
Tall fescue		High tolerance (Niemeläinen, Jauhiainen & Miettinen, 2001).	
Timothy		High tolerance (Annicchiarico et al., 1995; Höglind, Schapendonk & Van Oijen, 2001; Hoglind et al., 2010).	

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