7.2.8b Update to Machair Report

December 2018

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Background

Machair is a qualifying Interest of both Inis Mór and Inis Meáin SACs. An 'unfavourable-inadequate' conservation status was given to the machair habitat at Eararna (Trá Mór, Inis Mór) by the Coastal monitoring Project (CMP) (Ryle *et al*., 2009), owing to overgrazing, impact of rabbits and dominance of mosses and lichens. On Inis Méain the CMP noted that species diversity was low and moss cover was very high throughout the machair. These issues have to be addressed by the AranLIFE project in order to bring 29ha of machair habitat to favourable conservation status.

The AranLIFE project trialled the application of seaweed to machair sites to address issues such as over-dominance of bryophytes and reduction in species-diversity. The sandy soil lands that occur on particular parts of the islands such as the machair are free-draining and so have little capacity to retain nutrients for grass growth. The application of seaweed is necessary, both to supply some plant nutrients and improve organic matter of soil, and at the same time improving the water retaining capacity.

While bryophytes are an important component of machair vegetation, over-dominance of *Rhytidiadelphus squarrosus* in particular may have been the result of long term nutrient loss from the habitat. Moss over-dominance is having a deleterious impact on both the forage available to cattle as well as the species diversity of the habitat. This issue prevails at all the proposed trial sites. The application of seaweed on these habitats was part of the traditional farming system on the islands, according to the farmers who own these lands.

These issues have been discussed with NPWS as part of the AranLIFE project, and the trials are directly connected to improving understanding as to how to best manage the site.

Introduction

In Phase 1 of the seaweed trials, eight seaweed plots were set up in March/April 2015 when seaweed was applied to 20x10m plots. AranLIFE Machair Report (AranLIFE 2016) documents the results of phase 1 of the seaweed trials.
This update report documents the seaweed plots set up since 2016 and shows some impacts of one or two or three years of consecutive applications of seaweed as well as the impacts on different machair habitat of varying quality and condition.

The 8 plots vary in their habitat quality and structure.

From the initial machair report the following conclusions were made:

- Machair vegetation is highly variable owing to the dynamic nature of the habitat and this is shown in the variation between machair habitat between Inis Mór and Inis Meáin.

- The cover of bryophytes appears to be reduced in most of the seaweed treated plots. In particular *Rhytidiadelphus squarrosus* and *Scleropodium purum* are more abundant in the untreated areas.

- There is an apparent increase in sedge and grass cover in seaweed treated areas in 50% of the plots
- There is an apparent decrease in % broadleaf cover in seaweed treated areas in 60% of the plots
- *Vertigo angustior* is absent from the seaweed trial plot sites (Browne 2016).

- The dry matter yield is greater in 50% of the seaweed plots than in the corresponding untreated areas

- The machair soils have a high pH, and are very low in Phosphorous. Low potash is also a feature of these soils as are high magnesium levels.

- The application of seaweed increases the water holding capacity of the soil and the organic content of the soil, which facilitates the development of vegetation cover in previously bare areas.

This update to the report focuses on how the machair vegetation both within seaweed plots and control plots meets the national monitoring targets for favourable conservation status (Delaney *et al.* 2013).

Location of treatment plots

Machair sites on Inis Mór (Trá Mór) and Inis Méain have been selected for this action. The initial phase 1 trials consisted of 8 plots as documented in the machair report (2016). Subsequent phases consist of a further 6 plots. Phase 2 (2016) included 3 new plots at Kilmurvey, Inis Mór as well as new plots at Inis Meáin and Phase 3 (2017) included 1 new plot on Inis Meáin. Phase 2 also included reapplication of seaweed on most Phase 1 plots.

Table 1. Seaweed plots on Inis Mór and Inis Meáin. Phase 1 (2015), Phase 2 (2016), Phase 3 (2017)

Phase	Island	Townland	Ownership	No. of 20x10m^2 seaweed plots
1	**Inis Mór**	Trá Mór	Commonage (unwalled)	3 plots
1	**Inis Meáin**	Ceann Gainimh	Private (walled)	5 plots
2	**Inis Mór**	Kilmurvey	Private (walled)	3 plots
2	**Inis Meáin**	Ceann Gainimh	Private (walled)	3 plots
3	**Inis Meáin**	Ceann Gainimh	Private (walled)	1 plot

Plot locations were chosen for the most part in areas that were damaged or degraded or where forage from machair was considerably reduced. In many cases the areas where seaweed was spread was in a degraded state from the surrounding machair vegetation, as a result the control relevés were sited in machair that was in better condition than the vegetation in the seaweed plots.

Methodology

The first phase of seaweed application began in March/April 2015. As these machair sites are known lapwing nesting sites care was taken to avoid areas and times where and when lapwings were active. Each seaweed plot is approximately 20mx10m. Seaweed collected form the strandline was applied to plots by hand ensuring even coverage throughout.

The selection of plots for seaweed application was primarily based on the farmers input as to where the forage available for cattle was particularly low. Areas were also selected that showed obvious signs of damage through erosion where bare sand predominates.

Seaweed was applied by hand ensuring even coverage throughout the plot, however, it is not possible to ensure similar coverage between different plots as seaweed was spread by different landowners.

Permanent monitoring quadrats (4m^2) were set up within the 20mx10m plots by the AranLIFE team as well in adjacent untreated areas. These quadrats were surveyed for their floristic composition and monitored annually over the duration of the project and any changes in vegetation noted.

Monitoring followed national monitoring methodologies (Ryle *et al.* 2009; Delaney *et al*. 2013) (Appendix 1). A relevé size of 4m^2 is used for machair grassland monitoring.

Relevés were recorded in July and August 2015, 2016 and 2017 to analyse the impact of the seaweed applications on the grassland vegetation.

The percentage cover of all plant species within the relevé is estimated and a cover-abundance number from the Domin cover-abundance scale is assigned to each species identified (Table 2).

Table 2. The Domin cover/abundance scale

% cover/abundance	Domin scale
A single individual. No measurable cover	+
1 to 2 individuals. No measurable cover. Individuals with normal vigour	1
Several individuals but less than 1% cover	2
1-4% cover	3
5-10% cover	4
11-25% cover	5
26-33% cover	6
34-50% cover	7
51-75% cover	8
76-90% cover	9
91-100% cover	10

The following additional information is also recorded in each relevé: % cover of bare rock, % bare soil, % litter, % grass/sedge layer, % broadleaf layer, % bryophyte layer, median grass and herb height.

A series of fixed point photos are taken of each relevé and a close up photo of the relevé vegetation is taken.
These relevés are analysed as monitoring stops according to the criteria for assessing conservation status (Ryle *et al.* 2009; Delaney *et al*. 2013) (Appendix 1).

Four criteria and targets were used to assess vegetation at a relevé level (Table 3).

Table 3. Criteria and targets used to assess vegetation at relevé level.

Criteria	Targets
Positive Indicator Species	At least 3 species in every stop
Negative Indicator Species	Combined cover less than 5%
% cover of bryophytes	At least 1% in every stop
Sward height	At least 8cm in July and August

Results and Discussion

Machair vegetation

A total of 141 relevés were recorded in Machair vegetation over the 5 years of the Aran LIFE project (Appendix 2) and 67% (118 relevés) received an overall fail (Fig. 1), while 16% (23relevés) passed all four targets for favourable conservation assessment (Fig. 2). Sward height (Fig. 3), % negative species cover (Fig. 4) and insufficient positive indicator species (Fig. 5), were the targets which caused most relevés to fail the assessment process (Fig. 1.). This mirrors the national assessment in which sward height was the criterion which caused most sites to fail the assessment; this is followed by negative indicator species (Delaney *et al*. 2013).

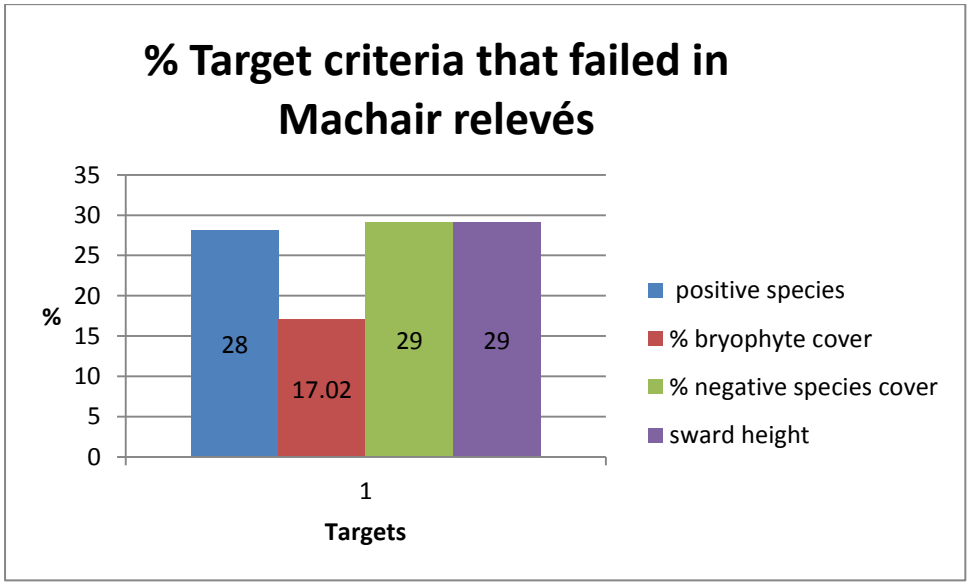

Fig. 1. Criteria targets for favourable conservation status that received a 'fail' in the 118 relevés that received an overall fail.

The criterion for positive indicator species also received a high level of 'fails' within the AranLIFE data (28%) (Fig. 1).

Fig. 2. Examples of relevés that passed all 4 targets for favourable conservation status.

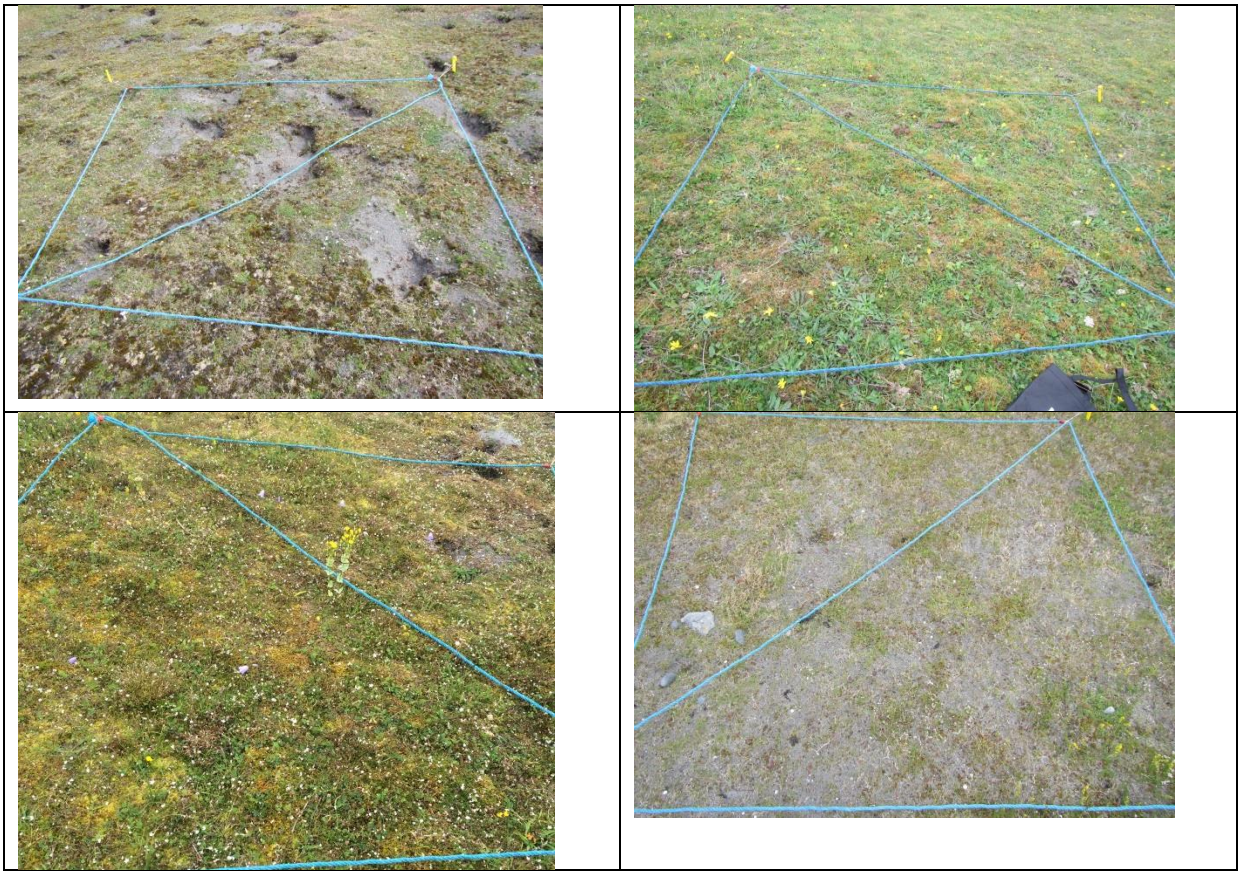

Fig.3. Examples of relevés that failed only because the sward height was less than 8cm

Fig. 4. Examples of relevés that failed only because of too high cover of negative indicator species

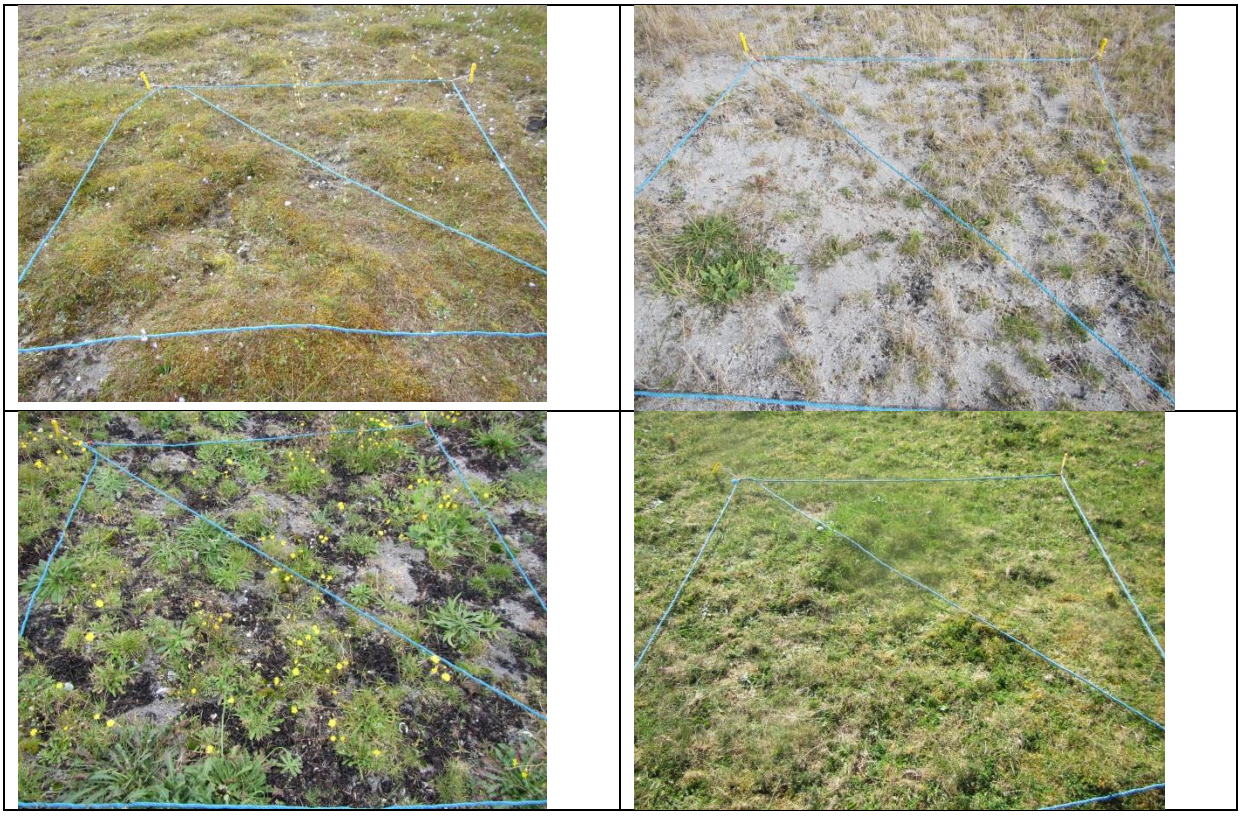

Fig. 5. Examples of relevés that failed only because of insufficient positive indicator species

Seaweed plots

Plot 1	**Trá Mór, Inis Mór**	**Moss-rich , short sward, heavily grazed by rabbits, small patches of eroded machair adjacent to plot.(August 2015). This plot received three annual applications of seaweed**

2015

2017

		Seaweed				Control		
		2015	**2016**	**2017**		**2015**	**2016**	**2017**
R41IMR	**Pos sp.**	Pass	Pass	Pass	**R43IMR**	Pass	Pass	Pass
	% bryos	Pass	Pass	Pass		Pass	Pass	Pass
	Neg sp.	Pass	Pass	Pass		Pass	Pass	Pass
	Sward ht	Fail	Fail	Fail		Fail	Fail	Fail
R42IMR	**Pos sp.**	Pass	Pass	Pass	**R44IMR**	Pass	Fail	Pass
	% bryos	Pass	Pass	Fail		Pass	Pass	Pass
	Neg sp.	Pass	Pass	Pass		Pass	Pass	Pass
	Sward ht	Fail	Fail	Fail		Fail	Fail	Fail

Conclusions

Despite being sited in heavily rabbit grazed machair vegetation with an over dominance of the bryophyte *Rhytidiadelphus squarrosus*, the vegetation passes targets for positive indicator species, percentage cover of bryophytes and percentage cover of negative indicator species for the most part, however, all relevés fail the sward height target. Seaweed has little impact on sward quality owing to the impact of grazing rabbits.

Plot 2	**Trá Mór, Inis Mór**	**Moss-rich , short sward, Over grazing by rabbits not as evident here as elsewhere at this site. One application of seaweed applied to this plot.**

2015

2016

		Seaweed			Control	
		2015	**2016**		**2015**	**2016**
R34MR	**Pos sp.**	Pass	Fail	**R33IMR**	Pass	Pass
	% bryos	Pass	Pass		Pass	Pass
	Neg sp.	Fail	Pass		Pass	Pass
	Sward ht	Pass	Pass		Pass	Pass
R35IMR	**Pos sp.**	Fail	Pass	**R36IMR**	Pass	Pass
	% bryos	Pass	Pass		Pass	Pass
	Neg sp.	Pass	Pass		Pass	Pass
	Sward ht	Pass	Pass		Pass	Pass

Conclusion

Sward growth in this part of the machair is not as degraded as elsewhere at this site. So seaweed application did not have as positive impact as it does on eroded and degraded sites as long as overgrazing is not occurring.

Plot 3	**Trá Mór, Inis Mór**	**Very eroded part of the machair, Erosion caused by a combination of sand removal, disturbance and wind. Rabbits also active in this area (July 2015). Two years of seaweed applications was applied to this plot.**

2015	**2016**
	

		Seaweed			Control	
		2015	**2016**		**2015**	**2016**
R37MR	**Pos sp.**	Pass	Pass	**R38IMR**	Pass	Pass
	% bryos	Pass	Fail		Pass	Pass
	Neg sp.	Pass	Pass		Pass	Pass
	Sward ht	Fail	Fail		Fail	Fail
R40IMR	**Pos sp.**	Pass	Fail	**R39IMR**	Pass	Pass
	% bryos	Fail	Fail		Pass	Fail
	Neg sp.	Pass	Pass		Pass	Pass
	Sward ht	Fail	Fail		Fail	Fail

Conclusion

Despite obvious visual improvement in vegetation cover, the quality of the vegetation does not meet the targets for favourable conservation status. The impact of grazing rabbits is likely to be having a deleterious effect.

Plot 4	**Inis Meáin**	**Thick sward of vegetation, rich in grasses and mosses (May 2015). One application of seaweed applied.**

		Seaweed		**Control**
		2015		**2015**
R91IMN	**Pos sp.**	Pass	**R90IMN**	Pass
	% bryos	Pass		Pass
	Neg sp.	Fail		Fail
	Sward ht	Pass		Pass

Conclusion

Both the control relevé and the relevé in the seaweed plot fail the target for negative indicator species. The high percentage cover of *Arrhenatherum elatius* is responsible for the failure of this target.

Plot 5	**Inis Meáin**	**Short sward of vegetation, rich in mosses. Bare unvegetated patches present (May 2015). Seaweed applied two years in a row.**

2015

2016

		Seaweed			**Control**	
R33/67 IMN		**2015**	**2016**	**R32/68 IMN**	**2015**	**2016**
	Pos sp.	Pass	Pass		Pass	Pass
	% bryos	Pass	Pass		Pass	Pass
	Neg sp.	Pass	Pass		Pass	Pass
	Sward ht	Pass	Pass		Pass	Fail
R66IMN	**Pos sp.**		Pass	**R69IMN**		Pass
	% bryos		Pass			Pass
	Neg sp.		Pass			Pass
	Sward ht		Pass			Fail

Conclusion

Vegetation outside the seaweed plot fails because of insufficient sward height. The application of seaweed assists vegetation growth without impacting on species composition.

Plot 6	Inis Meáin	Low grass cover and sward height and high moss cover. One and Two years of seaweed treatment. In 2016 plot area was extended

2015

2016

1YR OF seaweed	Seaweed			Control	
	R28IMN	R29IMN		R30IMN	R31IMN
	2015	2015		2015	2015
Pos sp.	Pass	Pass		Pass	Fail
% bryos	Pass	Pass		Pass	Pass
Neg sp.	Fail	Pass		Pass	Fail
Sward ht	Pass	Pass		Pass	Pass

	1yr of seaweed		2yrs of seaweed		Control	
	R72IMN	R73IMN	R70IMN	R71IMN	R74IMN	R75IMN
Pos sp.	Pass	Fail	Fail	Pass	Fail	Pass
% bryos	Pass	Pass	Pass	Pass	Pass	Pass
Neg sp.	Pass	Fail	Fail	Pass	Fail	Fail
Sward ht	Pass	Pass	Pass	Pass	Pass	Pass

Conclusions

Most of the releves (both control and seaweed plot) fail the negative species target, owing to the presence of *Arrhenatherum elatius.* The sward height target is attained in all relevés indicating that the sward may not have been as impoverished at this site as in other sites and therefore not as in need of nutrient input as more degraded sites. This series of fields is cultivated for potatoes and vegetables and rye in rotation so would have received some nutrient input intermittingly in the past. The seaweed applications do not seem to have had an impact on the presence of positive indicator species as both control and seaweed plot relevés pass and fail this target.

Plot 7	Inis Meáin	Very impoverished and degraded machair site. Area disturbed in the past with low sward cover. This area received 3 years of seaweed applications in 2015, 2016 and 2017.

2015	2016	2017
		

	1 yr seaweed	Control
	R35IMN	R34IMN
Pos sp.	Fail	Fail
% bryos	Fail	Pass
Neg sp.	Pass	Pass
Sward ht	Pass	Fail

	2yrs seaweed			Control	
	R60IMN	R61IMN		R62IMN	R63IMN
Pos sp.	Pass	Pass		Fail	Pass
% bryos	Fail	Fail		Pass	Pass
Neg sp.	Pass	Pass		PAss	Pass
Sward ht	Fail	Pass		Fail	Pass

	3yrs seaweed	Control
	R61IMNR	R62IMNR
Pos sp.	Pass	Pass
% bryos	Pass	Pass
Neg sp.	Pass	Pass
Sward ht	Pass	Pass

Conclusions

The absence of positive indicator species and too low a sward height are the main targets that are failed in this plot. After 3 consecutive years of seaweed applications, on this very impoverished and degraded site, all targets for assessing favourable conservation status have been passed. The seaweed applications adds both organic matter to the soil as well as improving the water retention capacity of the substrate.

Plot 8	Inis Meáin	Disturbed area of machair owing to sand removal. Seaweed plot covers entire disturbed area. Vegetation cover is low in 2015. Seaweed applied in 3 consecutive years 2015, 2016 and 2017.

2014 (before seaweed)	2016	2018
		

	before seaweed	Control
2014	**R14IMN**	**R59IMN**
Pos sp.	Fail	Pass
% bryos	Pass	Pass
Neg sp.	Pass	Pass
Sward ht	Pass	Pass

	2015	2016	2017
	Seaweed	**Seaweed**	**Seaweed**
	R54IMN	**R86IMN**	**R14IMNRRR**
Pos sp.	Fail	Fail	Fail
% bryos	Pass	Pass	Pass
Neg sp.	Pass	Pass	Fail
Sward ht	Pass	Pass	Pass

Conclusions

For this trial plot, the control relevé was recorded from undamaged machair. Before the seaweed application the obviously damaged and degraded machair passes all targets except for the positive indicator species target. On damaged machair the application of seaweed adds organic matter to the sandy substrate and improves the water retention capacity which enables vegetation to colonise the bare ground. After the three years of seaweed application the vegetation cover has visibly improved, however, the cover of *Arrhenatherum elatius* has increased which causes the plot to fail the negative indicator species target.

Plot 9	**Inis Mór**	**Disturbed area of machair owing to sand removal. Vegetation cover is low in 2015. Seaweed applied in 1 year (2016)**

2015 (before seaweed)

2016

	2015
	Before Seaweed
	R56IMR
Pos sp.	Pass
% bryos	Fail
Neg sp.	Pass
Sward ht	Pass

	2016	**2016**	**2016**	**2016**
	Seaweed	**Seaweed**	**Control**	**Control**
	R57IMR	**R58IMR**	**R59IMR**	**R60IMR**
Pos sp.	Pass	Pass	Fail	Fail
% bryos	Fail	Fail	Fail	Fail
Neg sp.	Pass	Pass	Pass	Pass
Sward ht	Pass	Pass	Pass	Pass

Conclusions

The relevé recorded before seaweed applications passed all targets except for the percentage cover of bryophytes, despite being obviously degraded and poor quality. Applications of seaweed helped increase vegetation cover by adding organic matter and increasing the water retention capacity of the substrate. Positive indicator species also increased in diversity following seaweed applications.

Plot 10	**Inis Mór**	**Area of machair with decreased forage potential owing to the high cover of *Rhytidiadelphus squarrosus*. Vegetation cover is low in 2015. Seaweed applied in 1 year (2016)**

2015 (before seaweed & after grazing)	**2016**
	

	2015
	Before Seaweed (after grazing)
	R54IMR
Pos sp.	Fail
% bryos	Pass
Neg sp.	Pass
Sward ht	Pass

	2016	**2016**	**2016**	**2016**
	Seaweed	**Seaweed**	**Control**	**Control**
	R61IMR	**R62IMR**	**R63IMR**	**R64IMR**
Pos sp.	Pass	Pass	Fail	Pass
% bryos	Pass	Pass	Pass	Pass
Neg sp.	Fail	Fail	Pass	Pass
Sward ht	Pass	Pass	Pass	Pass

Conclusions

Seaweed application increases the cover of *Arrhenatherum elatius* which causes the relevés to fail the negative indicator species target. Positive indicator species abundance in the seaweed plot has increased. Over abundance of *Rhytididadelphus squarrosus* was cited as an issue by the landowner at this site as it was a consequence of the reduction in available forage at this site. Over dominance of mosses is not recognised as a target threshold in the national monitoring criteria, but impact of moss cover may be picked up by reduction in positive indicator species and a fail for this target before seaweed application.

Plot 11	**Inis Mór**	**Area of machair with decreased forage potential owing to the high cover of *Rhytidiadelphus squarrosus*. Vegetation cover is low in 2015. Seaweed applied in 1 year (2016)**

2015 (before seaweed & after grazing)

2016

	2015
	Before Seaweed (after grazing)
	R55IMR
Pos sp.	Fail
% bryos	Pass
Neg sp.	Pass
Sward ht	Pass

	2016	2016	2016	2016
	Seaweed	**Seaweed**	**Control**	**Control**
	R66IMR	**R67IMR**	**R65IMR**	**R68IMR**
Pos sp.	Pass	Pass	Pass	Pass
% bryos	Pass	Pass	Pass	Pass
Neg sp.	Fail	Fail	Pass	Fail
Sward ht	Pass	Pass	Pass	Pass

Conclusions

The overdominance of *Rhytididadelphus squarrosus* may be seen in the before seaweed application by the fail for the positive indicator target. The application of seaweed seems to promote growth of *Arrhenatherum elatius*, and hence a fail in the negative indicator species target. The increase in *Arrhenatherum elatius* has not effected the positive indicator species diversity, however, as this target is passed.

Plot 12	**Inis Meáin**	**Area of machair with decreased forage potential and poor vegetation growth. Seaweed applied in 1 year (2016)**
		

	2016	**2016**
	Seaweed	**Control**
	R84IMN	**R85IMN**
Pos sp.	Pass	Pass
% bryos	Pass	Pass
Neg sp.	Fail	Pass
Sward ht	Pass	Pass

Conclusions

Addition of seaweed causes in an increase in grass species such as *Arrhenatherum elatius* and *Phleum pratense* which are negative indicator species. This increase in negative species is not correlated with a decrease in positive indicator species and this target is passed.

Plot 13	**Inis Meáin**	**Area of machair with bare ground, decreased forage potential and poor vegetation growth. Seaweed applied for 2 years (2016 & 2017)**

2016	**2017**
	

	2016 Seaweed R82IMN	**2016 Control R83IMN**
Pos sp.	Pass	Fail
% bryos	Pass	Fail
Neg sp.	Fail	Pass
Sward ht	Pass	Fail

Conclusion

The untreated areas fail all targets owing to degraded nature of the machair. Seaweed treated area fails negative indicator species target owing to the increase in cover of *Arrhenatherum elatius*.

Plot 14	**Inis Meáin**	**Area of machair with bare ground, decreased forage potential and poor vegetation growth. Seaweed applied for 1 year (2016)**

2016

	2016	**2016**
	Seaweed	**Control**
	R78IMN	**R79IMN**
Pos sp.	Pass	Fail
% bryos	Fail	Pass
Neg sp.	Pass	Pass
Sward ht	Pass	Fail

Conclusion

The application of seaweed at this site reduced the cover of bryophytes, but increased the diversity of positive indicator species and sward height.

Conclusions

From analysis of the relevés recorded in Machair habitat using the national monitoring assessment methods (Delaney *et al*.2013), only 16% passed the four conservation criteria for assessment: positive indicator species, percentage cover of negative indicator species, sward height and percentage bryophyte targets. Most of the relevé sites were selected so as to highlight the areas of machair on the islands that required some intervention to improve the conservation status. Issues such as over dominance of bryophytes and overgrazing by rabbits have contributed to this low pass rate. The over grazing of machair by rabbits is discussed further in the report 'Rabbit exclusion trials report' (AranLIFE 2017).

Most of the relevés failed owing to too low sward height, insufficient positive indicator species or to high percentage cover of negative indicator species.

Seaweed treatment was highly effective for improving the conservation status of degraded areas of machair with limited vegetation cover. Seaweed applications helps to add some organic matter and improve the water retention capacity of the substrate. These factors aid the colonisation of bare, damaged areas.

Following seaweed application, an increase in *Arrhenatherum elatius* cover was noted and was responsible for some relevés failing to reach the target for cover of negative indicator species. The threshold used was combined cover of 5% or less in each relevé. Following seaweed treatment, careful management of grazing must be implemented so as to prevent grass species from out-competing the herbaceous and sedge species characteristic of machair.

Grazing times on machair should be left as late as possible (September) to allow flowers to set seed free from grazing during the summer months. Machair that is overgrazed by rabbits suffers from reduced species diversity because of the all year round grazing by rabbits

Over dominance of *Rhytidiadelphus squarosus* was noted as an issue of concern in a significant area of the Aran Islands machair and usually was indicative of degraded machair that had limited nutrients and insufficient forage potential resulting in abandonment. The national monitoring target for percentage bryophyte cover has a lower threshold that must exceed 1% per relevé, however there is no maximum threshold of bryophyte cover. Perhaps other targets would be failed as a consequence of this, e.g. relevés with excessive bryophyte cover would have failed owing to insufficient positive indicator species.

Many important species, such as *Vertigo angustior*, Lapwing and Chough is depend on the machair grassland. Lands that are poor for grazing due to lack of vegetation, land that farmers consider would benefit from improvement in fertility and vegetation growth response through seaweed application, would also not have the thatch and litter build up that most snail species require for food and shelter (Browne 2016). Lapwing nest at machair habitat on Inis Mór and Inis Meáin and nest sites are more prone to predation if sward height is not sufficient to camouflage nests.

Continued Improvements in the conservation status of Machair habitat on the islands requires multiple elements which must be constantly managed, such as:

- Balancing nutrient input so degraded and impoverished machair can improve its species diversity,
- Maintaining adequate forage so that low intensity grazing is maintained and abandonment is prevented and species diversity is maintained,
- Controlling overgrazing by rabbits.

The Actions of AranLIFE have initiated the conservation management of Machair on the islands and this must be continued and maintained in future schemes to further the conservation of this habitat.

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Appendix 1. National Monitoring Methods for assessing *21A0 Machairs

The following table shows the criteria used to assess the conservation status at a monitoring stop and site level (Delaney *et al.* 2013) (Table 3). A monitoring stop or relevé must support greater than 6 positive indicator species, a low percentage cover of negative indicator species and more than 1% cover of bryophytes as well as have a sward height greater than 8cm to pass and have favourable conservation status.

Table 3. Criteria to pass/fail monitoring stops in the assessment of conservation status

1a. Positive species indicators: At least six must be present in more than 20% stops to pass
Agrostis stolonifera
Aira praecox
Bellis perennis
Carex arenaria
Carex flacca
Carex nigra
Cerastium fontanum
Crepis capillaris
Euphrasia officinalis agg.
Festuca rubra
Galium verum
Hydrocotyle vulgaris
Linum catharticum
Lotus corniculatus
Orchid spp.
Plantago lanceolata
Potentilla anserina
Prunella vulgaris
Rhinanthus minor
Sedum acre
Thymus polytrichus
Trifolium repens
Viola canina
Viola riviniana
Viola tricolor

1b. Lowest number of positive indicator species in a monitoring stop: At least three species present in each stop

2. Cover of bryophytes: Always over 1%

3. Negative Indicator species: No species present in more than 40% of stops. *L. perenne* *and P. pratense* **not present in more than 20% of the stops. Combined cover of negative indicators 5% or less**
Arrenatherum elatius
Cirsium arvense
Cirsium vulgare
Senecio jacobaea
Urtica dioica
Lolium perenne
Phleum pratense

Pteridium aquilinum

4. Non-Native species: no species present in more than 20% of the stops

5. Flowering and fruiting of positive indicator species: present in more than 40% of stops

6. Sward Height: mean height should be at least 8cm in July and August

Appendix 2. Machair relevés and targets for conservation assessment

	ISGS 21A0 Pos (Pass/fail)	cover of bryos >1%	combined cover of neg species <5%	sward height >8cm
R1IMR	Pass	Pass	Pass	Fail
R2IMR	Fail	Pass	Pass	Pass
R21IMR	Pass	Pass	Pass	Pass
R22IMR	Pass	Pass	Pass	Pass
R9IMN	Pass	Fail	Fail	Pass
R10IMN	Fail	Pass	Pass	Pass
R14IMN	Fail	Pass	Pass	Pass
R54IMN(R14IMNR)	Fail	Pass	Pass	Pass
R86IMN (R14IMNRR)	Fail	Pass	Pass	Pass
R14IMNRRR	Fail	Pass	Fail	Pass
R15IMN	Pass	Pass	Fail	Pass
R15IMNR	Pass	Pass	Fail	Pass
R15IMNRR	Pass	Pass	Fail	Pass
R16IMN	Fail	Pass	Pass	Pass
R17IMN	Pass	Pass	Fail	Pass
R17IMNR	Pass	Pass	Pass	Fail
R17IMNRR	Fail	Pass	Pass	Pass
R19IMN	Fail	Fail	Fail	Pass
R20IMN	Pass	Pass	Fail	Pass
R21IMN	Pass	Pass	Fail	Pass
R22IMN	Pass	Pass	Fail	Pass
R23IMN	Fail	Pass	Fail	Pass
R28IMN	Pass	Pass	Fail	Pass
R28IMNR (R70IMN)	Fail	Pass	Fail	Pass
R29IMN	Pass	Pass	Pass	Pass
R71IMN (R29IMNR)	Pass	Pass	Pass	Pass
R30IMN	Pass	Pass	Pass	Pass
R74IMN (R30IMNR)	Fail	Pass	Fail	Pass
R31IMN	Fail	Pass	Fail	Pass
R75IMN (R31IMNR)	Pass	Pass	Fail	Pass
R32IMN	Pass	Pass	Pass	Pass
R68IMN (R32IMNR)	Pass	Pass	Pass	Pass
R33IMN	Pass	Pass	Pass	Pass
R67IMN (R33IMNR)	Pass	Pass	Pass	Pass
R34IMN	Fail	Pass	Pass	Fail
R63IMN (R34IMNR)	Pass	Pass	Pass	Fail
R35IMN	Fail	Fail	Pass	Pass
R60IMN (R35IMNR)	Pass	Fail	Pass	Fail
R56IMN	Pass	Pass	Fail	Pass
R57IMN	Fail	Fail	Pass	Pass
R58IMN	Pass	Pass	Pass	Pass

R59IMN	Pass	Pass	Pass	Pass
R87IMN (R59IMNR)	Pass	Pass	Fail	Pass
R59IMNRR	Pass	Pass	Pass	Pass
R33IMR	Pass	Pass	Pass	Pass
R100IMR (R33IMRR)	Pass	Pass	Pass	Pass
R34IMR	Pass	Pass	Fail	Pass
R101IMR (R34IMRR)	Fail	Pass	Pass	Pass
R35IMR	Fail	Pass	Pass	Pass
R102IMR (R35IMRR)	Pass	Pass	Pass	Pass
R36IMR	Pass	Pass	Pass	Pass
R103IMR (R36IMRR)	Pass	Pass	Pass	Pass
R37IMR	Pass	Pass	Pass	Fail
R104IMR (R37IMRR)	Pass	Fail	Pass	Fail
R38IMR	Pass	Pass	Pass	Fail
R105IMR (R38IMRR)	Pass	Pass	Pass	Fail
R39IMR	Pass	Pass	Pass	Fail
R106IMR (R39IMRR)	Pass	Fail	Pass	Fail
R40IMR	Pass	Fail	Pass	Fail
R107IMR (R40IMRR)	Fail	Fail	Pass	Fail
R41IMR	Pass	Pass	Pass	Fail
R112IMR (R41IMRR)	Pass	Pass	Pass	Fail
R124IMR (R41IMRRR)	Pass	Pass	Pass	Pass
R42IMR	Pass	Pass	Pass	Fail
R113IMR(R42IMRR)	Pass	Pass	Pass	Fail
R125IMR (R42IMRRR)	Pass	Fail	Pass	Fail
R43IMR	Pass	Pass	Pass	Fail
R114IMR (R43IMRR)	Pass	Pass	Pass	Fail
R126IMR(R431MRRR)	Pass	Pass	Pass	Fail
R44IMR	Pass	Pass	Pass	Fail
R115IMR (R44IMRR)	Fail	Pass	Pass	Fail
R127IMR(R44IMRRR)	Pass	Pass	Pass	Fail
R54IMR	Fail	Pass	Pass	Pass
R55IMR	Fail	Pass	Pass	Pass
R56IMR	Pass	Fail	Pass	Pass
R61IMN	Pass	Fail	Pass	Pass
R61IMNR	Pass	Pass	Pass	Pass
R62IMN	Fail	Pass	Pass	Fail
R62IMNR	Pass	Pass	Pass	Pass
R64IMN	Fail	Pass	Fail	Pass
R64IMNR	Fail	Pass	Fail	Pass
R64IMNRR	Fail	Pass	Fail	Pass
R65IMN	Fail	Pass	Fail	Pass
R65IMNR	Pass	Pass	Fail	Pass

R65IMNRR	Pass	Pass	Fail	Pass
R66IMN	Pass	Pass	Pass	Pass
R69IMN	Pass	Pass	Pass	Fail
R72IMN	Pass	Pass	Pass	Pass
R73IMN	Fail	Pass	Fail	Pass
R76IMN	Fail	Pass	Fail	Pass
R76IMNR	Pass	Pass	Fail	Pass
R76IMNRR	Pass	Pass	Fail	Fail
R77IMN	Pass	Pass	Fail	Pass
R77IMNR	Fail	Pass	Pass	Pass
R77IMNRR	Fail	Pass	Fail	Fail
R78IMN	Pass	Fail	Pass	Pass
R79IMN	Fail	Pass	Pass	Fail
R80IMN	Pass	Fail	Fail	Pass
R81IMN	Pass	Pass	Pass	Pass
R82IMN	Pass	Pass	Fail	Pass
R83IMN	Fail	Fail	Pass	Fail
R84IMN	Pass	Pass	Fail	Pass
R85IMN	Pass	Pass	Pass	Pass
R88IMN	Pass	Pass	Pass	Pass
R88IMNR	Pass	Pass	Pass	Pass
R89IMN	Pass	Pass	Pass	Pass
R89IMNR	Fail	Pass	Pass	Pass
R90IMN	Pass	Pass	Fail	Pass
R91IMN	Pass	Pass	Fail	Pass
RI04IMN	Pass	Fail	Pass	Pass
R105IMN	Pass	Pass	Pass	Pass
R112IMN	Fail	Fail	Pass	Pass
R113IMN	Pass	Fail	Pass	Pass
R57IMR	Pass	Fail	Fail	Pass
R58IMR	Pass	Fail	Pass	Pass
R59IMR	Fail	Fail	Pass	Pass
R60IMR	Fail	Fail	Pass	Pass
R61IMR	Pass	Pass	Fail	Pass
R62IMR	Pass	Pass	Fail	Pass
R63IMR	Fail	Pass	Pass	Pass
R64IMR	Pass	Pass	Pass	Pass
R65IMR	Pass	Pass	Pass	Pass
R66IMR	Pass	Pass	Fail	Pass
R67IMR	Pass	Pass	Fail	Pass
R68IMR	Pass	Pass	Fail	Pass
R108IMR	Pass	Pass	Pass	Fail
R109IMR	Pass	Pass	Pass	Fail
R110IMR	Pass	Pass	Pass	Fail

R111IMR	Pass	Pass	Pass	Fail
R116IMR	Fail	Pass	Pass	Fail
R116IMRR (R128IMR)	Pass	Pass	Pass	Fail
R117IMR	Pass	Pass	Pass	Pass
R117IMRR (R129IMR)	Pass	Fail	Pass	Fail
R118IMR	Pass	Pass	Pass	Fail
R119IMR	Fail	Pass	Pass	Fail
R120IMR	Pass	Pass	Pass	Fail
R121IMR	Fail	Pass	Pass	Pass
R122IMR	Fail	Fail	Pass	Pass
R116IMN	Pass	Pass	Pass	Pass
R117IMN	Pass	Pass	Pass	Pass
R118IMN	Pass	Pass	Pass	Fail