A base-line study of a tufa (petrifying) spring site at Glinsk, Camcor valley, Kinnitty, Co. Offaly. 2010

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Summary

Base-line ecological information has been collected from a half-hectare site on which two good quality tufa-forming (petrifying) springs occur. The site is part of the project area for LIFE05 NAT/IRL/000182. The site had been clear felled of Norway spruce in 2006 and was therefore expected to change rapidly. A comprehensive list of bryophytes has been made. A full list of vascular plant species has also been made and they have been recorded from four 2m x 2m set in each of two permanently marked 8m x 8m quadrats. A GPS based contour map with the positions of the spring mounds and other features has been produced. A set of photographs is presented that compares the site in 2007 and 2010. Some of these are from permanently fixed points so they can be faithfully replicated in the future to assess change. Photographic evidence shows significant growth of moss/tufa and two locations are identified where total growth of moss/tufa can be measured in the future. Devices are in place to measure both the upward growth and lateral spread of one of the tufa mounds. The report, including GPS data, jpg photographs and text are presented on a CD. It is hoped that the report will facilitate future monitoring and encourage further research work on the site in order to enhance knowledge, understanding and conservation of tufa forming (petrifying) springs.

Contents

The CD contains the following files and folders:
Folder: Mapping Glinsk
Folder: Photographic record Glinsk
File: IJH Tufa Monitoring project Glinsk.doc
File: Final text Glinsk 2010.doc
pdf: Final text Glinsk 2010.pdf
pdf: Final Campbell Glinsk bryophyte report.pdf
pdf:final_camcor.pdf
Excel: Final 2X2 quadrats Glinsk July 2010

1. Introduction

1.1. Location of site

The site is just over 0.5ha in area and is situated about 3 kms east of Kinnitty, Co. Offaly in the foothills of Slieve Bloom mountains in the Camcor River valley. Access is from the R440 Kinnitty to Mountrath road. The Grid Reference for the site is N218 045 (Fig. 1). The site is owned by Coillte, and it forms part of the Camcor Wood SAC 889. The geology of the site has not been examined in this report. In general, the Slieve Bloom mountains comprise Old Red Sandstone lying unconformably upon Silurian strata. Limestone-derived glacial drift lines the valley sides.

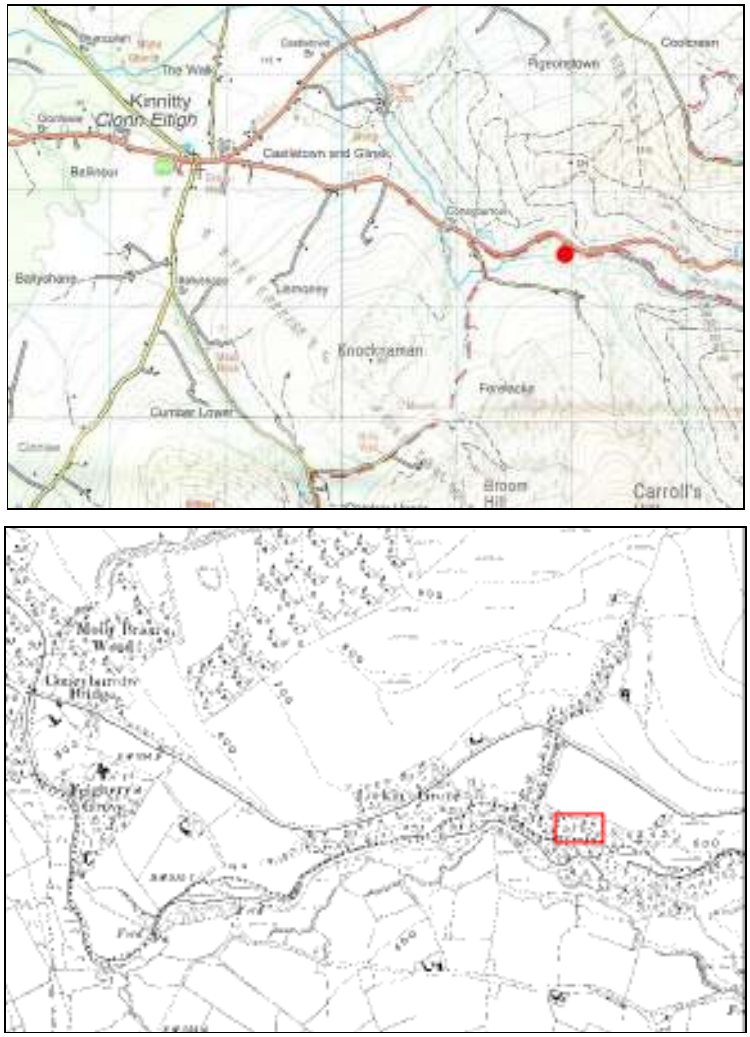


Fig. 1. Location of the study site

1.2. Petrifying springs

The habitat of interest at this site is Petrifying Springs with tufa formation (*Cratoneurion*) 7220 (Interpretation Manual of European Habitats, 2003). It is a priority habitat listed in the E.U. Habitats Directive, where it is defined as "*Hard water springs with active formation of travertine or tufa. These formations are found in such diverse habitats as forests or open countryside. They are generally small (point or linear) formations and dominated by bryophytes (Cratoneuron commutati).*"

Put simply, tufa, or travertine, is calcium carbonate (which is insoluble) that precipitates out of water that is saturated with calcium (in the form of soluble calcium bicarbonate) after it has passed through lime rich sediment. In the vicinity of the spring, the calcium bicarbonate loses carbon dioxide and reverts to insoluble calcium carbonate, deposited as tufa – a white to fawn coloured deposit.

The accumulation of tufa or travertine comes in various forms with various complex biological and non-biological means of deposition, described in detail by Pentecost (2005). Foss (2007) indicates, "the vegetation of such areas, and especially the mosses, may be coated in a thick crust of lime. Larger petrifying springs may form tufa cones that constitute a singular habitat".

The main habitat at Glinsk conforms to the latter. Setting aside terminology issues, these are accumulations of tufa/travertine of some thickness, variation and relief, formed from a low flow of water on a relatively low gradient, and on which a classic suite of bryophytes (mosses and liverworts), especially *Palustriella commutata*, grows while tufa continues to accumulate. These will be termed 'tufa spring mounds' in this report. There are two main tufa spring mounds on the site, a small number of minor ones, areas of calcareous seepage and a number of small streams or drainage lines (Map 1).

There are at least 20 such petrifying springs in the Slieve Bloom, described by Heery (2007). This site is Site 2 in that report. A wide range of morphologies were found in that study: waterfalls ('cascades') of high flow: 'spray' and 'drip' tufa, 'curtains' and columns of calcified moss, dams, a small travertine cave and a short keeled structure as well as the commoner 'tufa spring mounds' on low gradients such as at this study site.

1.3. Rationale for the project

The site was clearfelled in 2006 as part of a Coillte LIFE project to restore Alluvial Woodland (which occurs adjacent to the study site). A map of LIFE project area is given on the CD as *pdf final_camcor*. The spring mounds were well protected during clear felling but were not part of the project subsequently. However, the AfterLIFE monitoring programme does include the tufa spring mounds (Coillte, 2010).

The growth of bryophytes is clearly one of the main mechanisms for the growth of these mounds (Pentecost, 2005) and the growth of the bryophytes might be expected to accelerate after the removal of shade. Consequently, it is expected that these tufa mounds might visibly expand in the years after clear felling. Furthermore, much of the area between the springs are expected to progress to wet scrub and woodland of a particular type. This situation - a tufa spring mound suddenly exposed to light after many years of shade - is unique in the Slieve Bloom (and probably rare elsewhere).

1.4. Aim of the project

There are two main aims to the project:

Aim 1: to provide a base-line record of the site in order to facilitate the monitoring any changes into the future. This conforms to one of the aims of AfterLIFE monitoring (Coillte, 2010).

Aim 2: to encourage further ecological work on this classic petrifying spring site.

The three objectives to these aims are as set out in the proposal:

1. To produce a photographic record.
2. To make a full species list, including bryophytes, and record permanent quadrats.
3. To set up a basis for monitoring change in the dimensions of the tufa spring mound.

Early on the project, a fourth objective was devised:

4. To produce a GIS compatible contour map of the site and its features.

2. History of the site

2.1. Pre-1965 (i.e. pre Coillte forest cover)

The Coillte woodland history database for the site indicates Long-established Plantation. This means that the site has not been under continuous woodland cover. It was shown as open ground on the first (c. 1830s) editions but by the time the second edition of the 1:10,560 map was produced (in this case it was 1912), there were already trees on the site. The symbols on the 1912 map (Fig. 1) show a mixed forest of conifer and broad-leaved trees interspersed with scrub and furze. The same map shows broad-leaved woodland with scrub and furze along the valley floor (this is still good quality alluvial woodland in private ownership) and most of the mountain slopes above and around the site as unforested at this time.

A former forestry worker (P.Lowry) remembers mature oak and larch being felled on the site at some date prior to the Coillte planting of 1965, and relicts of this forest are still extant on the site. There, in fact, are several old stumps (over 1m in diameter at the cut height of about 80cm) on the site and a number of soft deadwood fallen trunks are in evidence, particularly in the vicinity of the eastern tufa spring mound (**Photo 1**). These have good potential as a source of important invertebrate biodiversity. A number of oaks, with a dbh of c 60-80cm, are still standing around the perimeter of site (see Map 1), and probably date to this former mixed forest.

So, for the first half of the 20th century the site was probably under mixed oak/larch forest. This would be expected to have a scrubby under storey.

2.2. 1965 – 2006 (the Coillte plantation)

There is likely to have been a period (of unknown length) of rush and scrub regeneration, which may well have been similar to the present day, before the site was planted with Norway spruce in 1965 (the site occupies about one third of Coillte sub compartment 75001G 1). The 1974 black & white aerial photo appears to show much open ground, when the plantation was probably still at pre-thicket stage. Importantly, *no thinning was ever undertaken at the location of the site* because the land was too wet, sloping, of difficult access etc. The latest inventory visit was in 1993 and showed a yield class of 18 with stems 2022/ha, but when a forester looked at the site in 2010 he thought that the

density was much exaggerated for this part of the sub compartment (see below) and probably referred only to drier harvestable parts (which were indeed thinned).
In the absence of photographic evidence prior to clear felling, the amount of shade under which the tufa springs existed in the final years of the plantation may be inferred by the following:

Mapping of stumps
See Figs.2- 4 Appendix. The mapping of stumps (generally over 25cm in diameter), in the permanent 8mx8m quadrats and around the tufa spring mounds, gives a density of about 700-800/ha (**Photo 2**).

Photograph during clear felling.
This photo clearly shows that were many more Norway spruce trees of much smaller diameter (one of over 25cm can be seen in the bottom right of the photo), and some substantial shrubs (**Photo 3**).

Photograph in March 2007
This photo essentially shows the bare ground to be expected under the shade of conifers (**Photo 4**).

To summarise on the evidence above, at least in the final years before felling, the cover on the site comprised relatively widely spaced mature Norway spruce at a density of c 700-800 stems/ha, interspersed with a few young mature broad-leaves, very many stunted spruce and several well-developed shrub species. Shade was probably very significant and ground cover negligible, although the areas of the existing spring mounds themselves may have been only partly shaded. This conforms to the recollections of the forestry workers who were present at the felling.

The site was felled in September 2006.

2.3. 2006 – 2010 (evidence of change post Coillte felling)

Intermittent visits to the site during this period gave the impression that at least the moss cover on the spring mounds, especially on the eastern one, was visibly expanding: photographic evidence confirms this (see Section 4.2 Photographic record).

2.3.1 Evidence of total growth since clear felling.

Similarly, in two places on the eastern spring mound (**Photos 21-23,26,27** Fig.3 Appendix), it can be seen that a substantial growth of *Palustriella* has taken place *from bare ground* since March 2007 (see Section 4.2). These two places can be used in the future to measure amount of moss growth *and* its associated tufa formation at some time in the future (see Section 5).

3. The site in 2010

The site in 2010 was described in three ways.

1. A full bryophyte survey; and vascular plant species list.
2. Two permanent 8x8quadrats with four 2x2m each.
3. Topographical map; plan of tufa spring mounds; maps of stumps over 25cm.
4. Photographic record.

3.1. Species list

3.1.1. Vascular plants

One day (21st May 2010, two ecologists SH, MMcC) was spent recording vascular plants on the site. Some species were added during subsequent fieldwork and the final list is shown in Appendix.

3.1.2. Bryophytes

Bryophytes were listed by Christina Campbell, assisted by Neil Lockhart.

Results

The full report (*pdf: Final Campbell Glinsk bryophyte report*), containing many photographs to aid identification, and GPS positions to facilitate future comparisons, is reproduced on CD and hard copy. Her annotated list of species is reproduced in Appendix to this present report. In her report, Tufa Mound 1 is the western mound; Tufa Mound 2 is the eastern mound.

From Discussion in Campbell's report

At the petrifying spring site at Glinsk/Camcor the dominant tufa mound species was *Palustriella commutata* (formerly known as *Cratoneuron commutatum* - SH), along with *Cratoneuron filicinum*. These formed dense orange-red mats at the springheads and were actively accreting tufa at their bases (see Photo 10). *Eucladium verticillatum* (see Photo 11) is also regarded as one of the most important tufa-forming mosses as the lower parts of the tufts become hard and petrified with calcium salts (Atherton *et al*., 2010). This was evident at the Glinsk/Camcor site as it occurred on compact calcified substrate, with *Didymodon tophaceus*, another species associated with tufa deposits. *Pellia endiviifolia*, *Bryum pseudotriquetrum*, *Aneura pinguis* and *Calliergonella cuspidata* were also found growing in amongst the *P. commutata* in the tufa mounds and, while these species are not necessarily tufa-forming, they are usually found in base-rich habitats.

E. verticillatum can withstand some shading and was observed growing in light shade under *Juncus inflexus* and *J. effusus*. Tufa was also observed under old dead *Juncus* tussocks, with nothing actively growing on it, so presumably the bryophyte species here became completely shaded out. Indeed, another of the tufa mound species *Scorpidium cossonii,* requires open conditions so shading from *Juncus* and other vegetation would not be ideal.

Many of the other species found at the edges and around the mounds had tufa deposits at the bases of their stems, for example *Plagiomnium rostratum* and *Fissidens taxifolius* var. *taxifolius*.

An interesting feature of the site was that *Palustriella commutata* occurred nearly throughout the whole site, especially where there was the influence of calcium-rich water.

The tufa springs at this site appear to be good representative examples of the priority habitat despite having been covered by forestry up until quite recently.

Conclusion (by SH)

Several hours were spent by two expert bryologists searching for bryophytes so it can be considered to be a fairly exhaustive species list. Those mentioned above show a good diversity of specialist tufa forming and tufa associated species. Unfortunately, we don't know which species were present immediately prior to felling almost four years ago, and which have colonised since.

3.2. Permanent quadrats

Methods

See Appendix for a fuller account of methods, *which must be referred to for the purpose of replicating these data*.

Two permanent 8m x 8m quadrats were set up (see Map 1). The corner posts are permanent. At each corner, a 2m x 2m quadrat was situated. In each 2x2, vascular plant species were recorded on an estimated Domin scale. Species recording took place on 12 July 2010 by S. Heery and M. McCorry (see Table 1 and Fig. 2 Appendix).

Juncus effusus/*Juncus inflexus*, *Equisetum telmateia* and woody plants were evidently key elements of the vegetation, whose relative abundances might be expected to change in the future. Woody plants were *Salix cinerea/Salix aurita*, *Alnus glutinosa* and *Fraxinus excelsior*.

1. Further to this, in each 8x8, the % cover of *Juncus* spp was estimated, the number of *Equisetum* stems were counted and the number of willow stems was counted.
2. In addition, a line transect from corner to corner of each 8x8 was set up and a plumb line lowered every 20cm. Hits of the three elements (*Juncus, Equisetum* and woody plants) were recorded on the 217 points, thus giving more replicable data on the relative occurrence of these elements of the vegetation.

A (wide angle) photograph of each 2x2 was taken (*folder: Quadrats*). The camera was resting on each corner post and was pointing to the centre of the quadrat. They are therefore replicable at some time in the future.

Results

Table 1, in Appendix and in a separate Excel *file: Final 2x2 Glinsk*, shows the results of the 2x2 quadrat vascular species recording; % cover estimation in the 8mx8m quadrats; and the line transect results.

Juncus species are abundant, as is expected in highly disturbed, clear felled wet and damp land, and *Juncus inflexus* is prominent here. *Juncus inflexus* replaces *J. effusus* on base-rich, heavy and calcareous soils. In Table 1, those species that might be expected to form the basis of the predicted wet calcareous woodland on the site are shown in blue. The western 8x8 quadrat is the wetter of the two, evidenced by the following:

- It has more of these blue species than the eastern one (a crude measure is the total the Domin scores of the blue species – 135 for the western 8x8; 78 for the eastern 8x8.).
- *Mentha aquatica* and *Carex flacca* are unique to the western 8x8 and *Carex remota* is commoner and more abundant there also.
- *Equisetum telmateia* has greater cover with seven times more stems counted, and six times more hits counted than in the eastern 8x8.

Note 1. *Juncus inflexus*, though rarer in the eastern 8x8, is locally abundant where the tufa moss *Palustriella* is also present in 2x2 E,NW.

Note 2. *Juncus inflexus* has colonised the edges of the eastern moss/tufa mound, where no moss was growing but where water flowed around the edges (**Photo 5**). The substrate here is a tufa layer of unknown depth.

Note 3. *Equisetum telmateia* is rhizomatous and colony forming and dies back in the winter. The best time to record abundance therefore is at the end of the growing season (mid July would appear to suitable) when all the stems have emerged.

3.3. Mapping the site (*folder: Mapping Glinsk*).

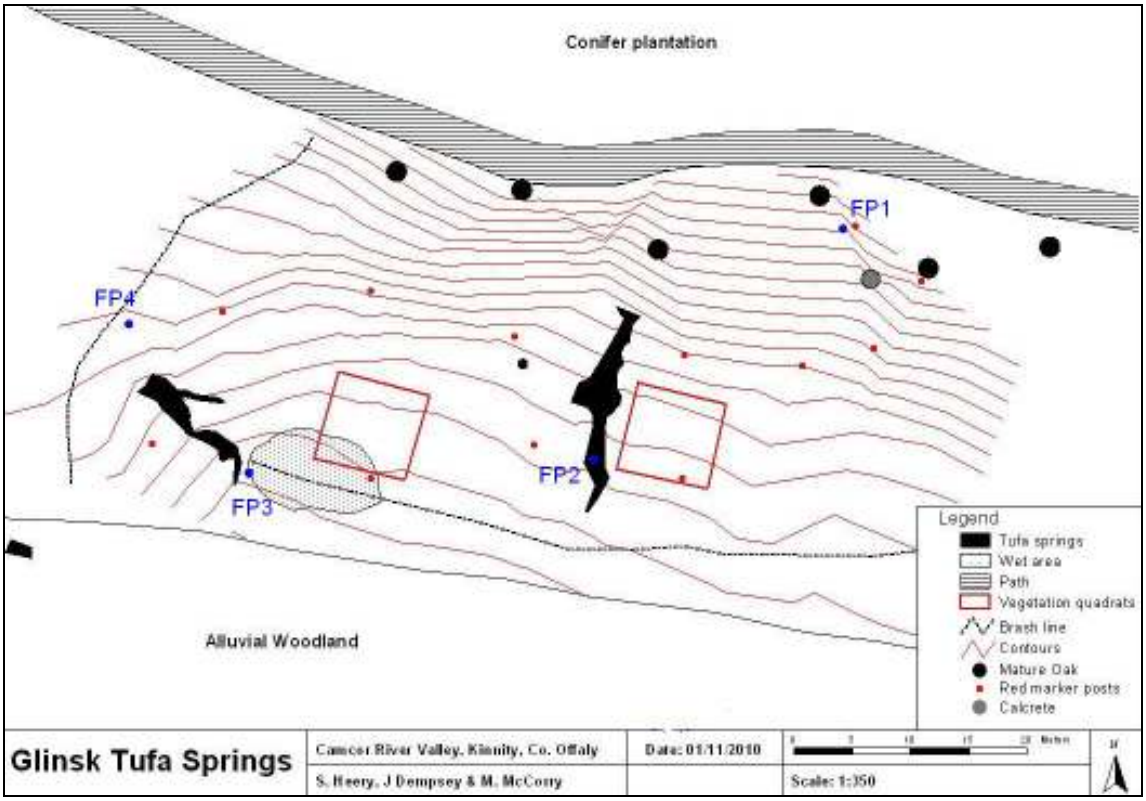
Three types of mapping were carried out on the site.

1. GPS based map
2. A plan of the tufa spring mounds
3. A map the conifer stumps.

1. GPS based map

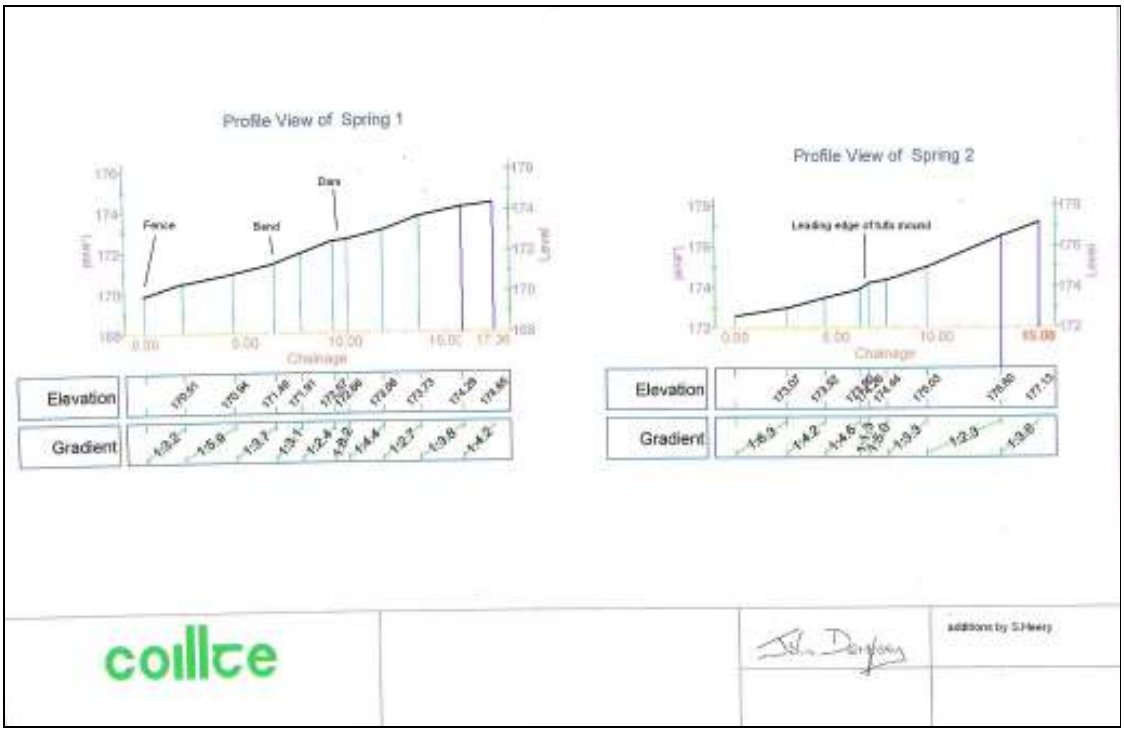
Two types of GPS based mapping were carried out on the site. Map 1. has used combined data. First, a map was prepared of various features of the site, using a Trimble GeoXT hand-held computer with GPS capability (21st July 2010, thanks to Mark McCorry). Later, a contour map, with profiles of the tufa spring mounds, was produced using Trimble 5600 Total Station (31st August 2010, thanks to John Dempsey of Coillte). The tufa mound profiles from Dempsey's data are reproduced below and are on the CD as *Dempsey profiles.jpg*.

M.McCorry has combined these two sources of GPS data and produced two *folders*: *Coillte_GIS* (Dempsey's data); and *Glinsk_final* (containing all the data used to make up Map 1 (see MMcC's explanation in Appendix).



Map 1. Topographical map of the site, with mapped features. Contours are at 1m intervals: the lowest point, along bottom fence line, is 170 m above sea level and the highest point 188 m. The Fixed Points (FP1 – 4) have been added to the map approximately: the posts themselves are permanent on the site. The wet part of the site extends upwards to about contour 175 m. The brash line parallel to the bottom fence had been pushed from alongside the fence: thus creating a long developing wet fen in which *Equisetum telmateia, Carex remota, Carex viridula* and *Juncus inflexus* are the most prominent constituents (**Photo 6**). The brash line to the west is on dry ground off the site and was mapped because it can be seen on GoogleEarth (2009).

Important note: the permanent post FP2 is situated 89cm to the west of the actual position of the photograph. This is because it was thought best not to position the post directly in the path of the spring.



On these profiles Spring 1 is the western spring mound; Spring 2 is the eastern spring mound.

2. Plan of tufa spring mounds

A plan of the dimensions of each tufa spring mound was made (SH). The definition of the tufa spring mound here is the area of *Palustriella* and associated water flow lines that are free from *Juncus* (see **Note 2.** on *Juncus inflexus* at the end of section 3.2 above and **Photo 2**). The resulting plans cannot be said to be completely accurate to the cm due to the method of measuring (see methods in Appendix) but they are readily assessable on the ground. The plans (Fig 3 and Fig 4) are reproduced in Appendix and each has a file on the Mapping folder.

3. Map of conifer stumps

A map was made of the conifer stumps in and around the two tufa spring mounds (Figs 3 and 4) and inside the two permanent quadrats (Fig 2)(see methods in Appendix). The reason they were mapped was to gain an impression as to the amount of shade the site was subject to prior to clear felling (see also Section 2.2.).

4. Photographic record

A photograph record of the site has been compiled with the purpose of being able to assess changes into the future. The format is as follows:

Each photo is saved as jpg in the *folder: Photographic record Glinsk*, labelled appropriately. Some are reproduced in this text, below, and their relevance to the monitoring project is described. For greater clarity enlarge the page, if viewing electronically, or go to the folder and view the jpg versions. The photos are acknowledged as being by I.J.Herbert (IJH) or S. Heery (SH). There are four *folders*: *Fixed-point photographs* and *Other photographs*. Also in the *folder* are: *Permanent quadrat photographs* and *IJH Photographs*.

Other photographs of the spring mounds in 2010, which may of use in future monitoring, are with the author.

1. *Fixed-point photographs*.

Four fixed points (F1 to FP4) were marked with permanent metal posts similar to those used in the permanent quadrats (Map 1). Each fixed-point post was labelled with black paint. Photographs (except FP2) were taken with the tripod directly above the post. Fixed-points are marked on the map. Because the posts are permanent, *the photos can be replicated in to the future*. **Important Note**: with FP2 the permanent post is 89cms to the west of the actual position of the tripod. This is because it was thought best not to position the post directly in the path of the spring). Ian Herbert's report, with photographs, is on the CD (*File: IJHerbert Tufa Monitoring Project Glinsk*) and his photographs are also in the *folder IJH Photographs*.

4.1 From Fixed Points 1 and 4 - General view of site

See jpg or enlarge electronic text for more clarity

P7 Fixed Point 1. (July 2010) View west (270 deg)(IJH)

P8 Same view, in August 2007 (SH)

P9 Fixed Point 4. July 2010 View of site looking ENE (wide angle zoom 18mm). (IJH).

Points to note:

1. The view in August 2007 shows very little ground vegetation on the site, 11 months after clear felling, indicating the shade under which the site existed prior to felling. Note that the brash and forest debris was piled in the drier central and upper parts, leaving the more significant wetter areas free. Since the 2007 photo was taken the brash mat along the bottom of the site has been pushed upward (see Map1 and **Photo 6**).

2. The greening of the wet areas around the eastern spring (in the foreground) is caused by emerging *Juncus inflexus* seedlings at the end of the first growing season. Both *Juncus inflexus* and *J. effusus* were well established by 2008 and continue to dominate in 2010 along with their dead leaves, to the detriment of more diverse specialised vegetation suited to the site.

3. The broad-leaved woodland adjacent to the site is alluvial woodland comprising Alder *Alnus glutinosa* and Ash *Fraxinus excelsior* with some hazels and willows along the edge. This might be expected to be the source of colonisation onto the site. In 2010 alder and ash are rare on the site and woody regrowth comprises the willows *Salix cinerea* and *Salix aurita.* Hazel *Corylus avellana* is present but very rare.

4. As the willows and other woody species develop, shading will lessen the dominance of *Juncus* and allow species such as *Equisetum telmateia, Carex remota* and *Eupatorium cannabinum* to expand, at least in the wetter areas.

4.2 From Fixed Point 2 – Views eastern tufa mound

See jpg or enlarge electronic text for more clarity

P10 Fixed Point 2. Long view of eastern tufa spring mound looking up slope.
Taken 89cm east of FP Post and viewing NNE 20 deg (IJH).

Details from photo above:

P11 Wide angle view of mound

P12 Wet zone in front of 'leading edge' of spring

Points to note:

1. There are evident differences in growth of *Palustriella* to be seen, with the 'healthiest' moss on the left hand side and dried out moribund patches in the centre. This view can be replicated in the future and changes in these patterns determined. At present only a few shoots of *Equisetum telmateia* have colonised the *Palustriella* mound with some *Agrostis stolonifera* and *Cirsium* sp.

   The larger site is deer-fenced (as part of the LIFE project) but there have been signs that deer have visited the mound.

2. The wet zone (P12), where water flows from the leading edge of the mound, shows new colonisation by the liverwort *Pellia endiviifolia* (bright green flat leaves), *Palustriella commutata* and *Eucladium verticillatum* (small olive green amorphous); the herb *Veronica beccabunga* is also present. The three bryophyte species are all tufa forming (the *Pellia* can be seen to be noticeably tufa forming if the photograph is enlarged). Notably, *Pellia* has been observed at this location accumulating around the bases of the adjacent *Juncus*. As this view can be replicated in the future (*note the two white stones for replication*), the relative growth of the three newly colonised tufa forming bryophytes will be seen. In particular, the ability of, and the effect of, *Pellia endiviifolia* to accumulate around the bases of *Juncus* at this location can be followed.

4.3 From Fixed Point 3 – Views of the western tufa mound

See jpg or enlarge electronic text for more clarity

P13 Fixed Point 3. looking NW 315 degrees (IJH)

P14 Close-up detail of tufa mound from FP3 post

Points to note

1. As with the eastern mound, there are areas of dried out and degraded *Palustriella* and areas of more active *Palustriella* growth (e.g. bottom right corner of close-up). There are other more active areas of growth further up the mound, hidden from view in this photograph.

2. There is much greater colonisation of vascular plant species than has occurred at present on the eastern mound, including *Dechampsia cespitosa*, which is common.

3. The area of grass (light green) at the top centre of the close-up photo is the lip of the dam seen in **Photos 24, 25** below**.**

4. See also Campbell's bryophyte report for more photos of the western mound.

4.4.1 Other photographs See jpg or enlarge electronic text for more clarity

P15 Eastern tufa mound, looking north, August 2007 (SH)

P16 Same view, June 2008 (SH)

P17 Same view, June 2010 (SH)

Points to note

1. There are clear indications of growth of *Palustriella*, between 2007 and 2010, if the three photographs are examined carefully with regard to standard points (but **note:** there are slight differences in scale between the three photographs). Growth is clearly seen from the clipped photos of the leading edge, below.

Details of leading edge of mound, clipped from the above photos:

P18 August 2007

P19 June 2008

P20 June 2010

4.4.2 See jpg or enlarge electronic text for more clarity

P21 Eastern spring, March 2007 (IJH)

P22 Eastern spring, September 2010 with same features labelled (SH), see below.

P23 Continuing from the bottom of picture 2 (SH) (note label A, indicating an pre-Coillte fallen soft deadwood trunk).

Points to note

1. These photographs show *Palustriella* growth, which has clearly taken place from bare ground since March 2007. Note FP2 post for the location. This location can be used in the future to measure the rate of accumulation of moss and its associated tufa within. There is also *Eucladium verticillatum* at this location (but not in the photograph) which shows signs of probably having grown *since 2007*).

4.4.3. See jpg or enlarge text for more clarity

P24 A small dam on the western spring, (width of photo c. 1m), August, 2007 (SH).

P25 Same dam in July 2010 (SH).

Points to note

1. The dam consisted solely of tufa forming bryophytes (*Palustriella* etc) 11 months after, and presumably before, felling. In 2010 the dam has been colonised by *Agrostis stolonifera* and *Deschampsia cespitosa*. Standing water still remains within the dam.

5. Measuring growth

Objective 3 (see Section 1.2.2.) was to devise a method of measuring upward growth of the tufa mound (its moss and associated calcium deposits). The author had been in contact with Melinda Lyons, a Trinity College Dublin PhD student studying tufa springs throughout Ireland, who was simultaneously considering the same problem. The Glinsk site is one of five or six sites around the country where she has set up measuring devices. The author has assisted with this and the methods and results will be reported on in due course. The author has also set up a simple device to measure lateral spread at the same time. The positions of these devices are shown on Figs 3 and 4, Appendix and the methods are explained in Appendix.

There are at least two locations on the eastern spring where growth of moss/tufa has occurred from bare wet ground since September 2006 (**Photos 26** and **27**). P25 is the same location as P23 above. At some time in the future it can be decided to make measurements of the amount of accumulation of moss and its associated tufa. In this way a rate of growth can be determined.

6. Discussion

It is well known that after the clear felling of conifer plantation the vegetation undergoes rapid change with the removal of shade and other changes. This is the case in all types of ground from dry fertile loams to wet peat. Much of the ground uncovered by clear felling at this site is wet and calcareous and it contains two classic examples of tufa spring mounds, or petrifying springs. Although tufa mounds and larger deposits are well studied throughout the world, there is not a great deal of information on changes and succession (Pentecost, pers.com.). This site was first (briefly) described in 2007 (Heery, 2007) and visited intermittently between 2007 and 2010. Apart from the obvious rapid growth of vegetation to seen on the wider site, the intuitive feeling that the moss/tufa mounds might be expected to undergo a spurt of growth after exposure to light has proved correct. Photographic evidence, using photos from 2007, 2008 and 2010, has demonstrated this and can be used in the future to show further change. Photographs have also shown that at two identifiable locations the *Palustriella* moss and its associated tufa has grown from bare wet ground six months after clear fell. Thus the *total growth* can also be measured at some later date (to be selected after further consultations) to demonstrate the rate of growth.

Campbell's detailed report on the bryophyte flora of the tufa mounds and surrounds, with photographs and GPS reading is an especially useful account of the situation in 2010. It is unfortunate that we do not know if any of the species have arrived since the clear fell but the report is detailed enough to assess changes into the future. The occurrence of a stonewort (*Chara vulgaris* var. *longibracteata*) on the site is of interest.

During felling operations, most of the brash and forest debris was piled in the central dry 'ridge' leaving the significant wetter areas free from debris: and the tufa spring mounds untouched by machinery. The line of debris parallel to the bottom fence was pushed up to facilitate the erection of the fence and thus there is a wide wet zone at the bottom of the site that is free from debris and is developing into a wet fen, fed by calcareous streams from the springs, and well characterised by *Equisetum telmateia*, *Carex remota* *Carex viridula* and *Juncus inflexus*.

Juncus effusus, especially, is characteristic of the initial stages of vegetation change after most clear fell. At this site, *Juncus inflexus*, a species of base-rich sites, is also prominent. Around the tufa mounds this species, along with *Juncus effusus,* has colonised moss-free tufa deposits on the perimeters that were flowing with calcium rich water but it has not colonised (up to now) the moss covered mound or the open flowing water below the mounds where *Palustriella* and other tufa forming bryophytes are developing well. The rank and overhanging *Juncus inflexus* leaves are somewhat of a hindrance to observing the edges of the tufa mound but at at least one location such *Juncus* (in this case *J. effusus*) has active *Palustriella* growing rapidly up and around the leaves (**Photo 28**). It remains to be seen whether the lateral growth of the tufa mound can overwhelm the *Juncus.*

On the wider site, as seen in the permanent quadrats, the *Juncus* plants and their dead leaves matted on the ground are an obvious hindrance to the development of a more diverse and interesting ground flora. In the future, the shade exerted by developing scrub, or possibly competition from the colony forming *Equisetum telmateia*, should eventually allow the site to realise its full diversity.

Further research

The potential value of the site lies not only in following succession in the vegetation on the site as a whole, and the future growth and changes in the tufa spring mounds, but also in studying the complex biological and non-biological processes that are known to be involved in tufa formation. Work in other disciplines, including invertebrate ecology, geology and hydrogeology are also needed to gain an fuller understanding of the site and its processes. The Slieve Bloom survey found an important diversity of molluscs associated with the moss/tufa deposits with *Vertigo geyeri* found in a basal fen at one site (Moorkens in Heery, 2007). Unfortunately, this site was not sampled in that survey. *Pirata latitans*, a spider of wetlands, was found on the western tufa mound by during a brief visit this year (Myles Nolan pers. com.).

The geology of the site has been paramount in the formation the tufa mounds and the nature and palaeontology of the tufa deposits are part of the recent geology. Observations on the site have shown that tufa deposits undoubtedly occur over a wider area than is visible in the mounds. The thickness and character of the glacial drift interspersed with calcrete deposits (a calcareous ‘hardpan’), seen in **Photo 2**, and the

solid geology of Silurian and Old Red Sandstone with its unconformity, folds, joints and faults have a role to play in the character and formation of the site. Feehan (1982) forms a basis for this but the site lends itself to a unique detailed investigation.

The hydrology (and chemistry) of the springs is known to be equally formative. Observations at the site showed that flow can vary from 'almost no flow' to a much greater flow when water could be heard falling under the *Palustriella* about a metre from the top of the eastern spring mound (on 9th September 2010).

It is hoped that the base-line work described in this report will be used to monitor changes into the future and, importantly, to encourage further research on the site in order to enhance knowledge, understanding and conservation of tufa forming (petrifying) springs.

7. References

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SH is very grateful to Mark McCorry for many discussions regarding the site, for assisting with the vascular plant species recording: and also for the GPS mapping and subsequent preparation of the map and organisation the GIS data.

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Appendix

Sections in Appendix are numbered as in the main text.

3.1.1. Vascular plants list (for the whole site)

*Species that were recorded rooted in *Palustriella* on the tufa spring mounds.

Agrostis stolonifera*
Ajuga reptans
Alnus glutinosa sapling
A.glutinosa re-growing
Anthoxanthum odoratum
Arum maculatum
Brachypodium sylvaticum
Cardamine flexuosa*
Cardamine pratensis
Carex echinata
Carex flacca*
Carex nigra
Carex sylvatica
Carex remota
Carex viridula
Chryso. oppositifolium
Cirsium palustre
Cirsium arvense
Corylus avellana
Deschampsia cespitosa*
Digitalis purpurea
Dryopteris dilatata
Epilobium angustifolium
Epilobium parviflorum
Epilobium hirsutum
Epilobium obscurum
Equisetum telmateia*
Eupatorium cannabinum
Filipendula ulmaria
Fragaria vesca
Fraxinus excelsior seedling*
Galium palustre
Geranium robertianum*
Glechoma hederacea*
Hedera helix
Hypericum androsaemum
Hypericum tetrapterum
Holcus lanatus*
Endymion non-scriptus
Juncus effusus
Juncus inflexus
Lychnis flos-cuculi
Lysimachia nemorum
Mentha aquatica
Molinia careulea
Phyllitis scolopendrium*
Plantago lanceolata
Poa pratensis*
Polystichum setiferum
Primula veris
Quercus. sp re-growing
Ranunculus acris
Ranunculus flammula
Rubus fruticosus
Ribes uva-crispa
Rumex acetosa
Rumex sp
Salix cinerea
Salix aurita
Scrophularia nodosa
Stellaria sp
Taraxicum agg.
Tussilago farfara*
Ulmus glabra
Urtica dioica
Veronica beccabunga*
Veronica officinalis

*In addition, *Cirsium* sp and *Epilobium* sp were found growing on the mounds.

3.1.2. Bryophyte list

See Campbell's main report for full explanation.

On tufa spring mounds 1(west) and 2(east)	**Edge of mounds, shaded among rushes**	**Around mounds, on banks and stumps**
Palustriella commutata	Fissidens taxifolius var. taxifolius	Conocephalum conicum
Cratoneuron filicinum	Plagiomnium rostratum	Mnium hornum
Scorpidium cossonii	Eucladium verticillatum	Thuidium tamariscinum
Eucladium verticillatum	Pellia endiviifolia	Kindbergia praelonga
Didymodon tophaceus	Conocephalum conicum	Plagiochila porelloides
Pellia endiviifolia*		Isothecium myosuroides
Bryum pseudotriquetrum		Palustriella commutata
Aneura pinguis		
Calliergonella cuspidata		
Stream runnels at bases of tufa mounds and second runnel	**Wet area at base of slope, dominated by Equisetum telmateia**	
Brachythecium rivulare	Scorpidium cossonii	
Calliergonella cuspidata	Brachythecium rivulare	
Thuidium tamariscinum	Pellia endiviifolia	
Kindbergia praelonga	Palustriella commutata	
Lophocolea bidentata	Cratoneuron filicinum	
Plagiomnium undulatum	Bryum pseudotriquetrum	
Rhytidiadelphus triquetrus	Dicranella varia	
Pellia endiviifolia	Dicranella schreberiana	
Fissidens taxifolius var. taxifolius	Atrichum undulatum	
Plagiomnium rostratum	Calliergonella cuspidata	

3.2. Permanent quadrats

Methods

Two permanent 8m x 8m quadrats were set up. The corners of the quadrats are marked with galvanised steel tubes of the same type and dimensions as was used previously during the LIFE Project (i.e.76mm x 1320mm with plastic caps). 8x8 was used instead of 10x10 because of the difficulty in finding uniform vegetation relatively free from brash and felling debris. These posts are permanent.

At each corner, a 2m x 2m quadrat was situated. These quadrats were carefully marked on the day of recording by non-permanent bamboo poles. Corner positions were selected for the 2x2 so that they could be recorded from outside the 8x8. Thus, care was taken, and should be taken in the future, not to trample within 8x8s. The two 8x8s were named W and E respectively; and the 2x2s were named by their 8x8 quadrat and their position within it, for instance W-SW, E-SW etc (see Fig.2, below). In each 2x2, vascular plant species were recorded on an estimated Domin scale:

+ solitary, insignificant cover; 1 seldom, insignificant cover; 2 very scattered, small cover; 3 scattered, cover <5%, 4 cover 5-10%, 5 cover 10-25%; 6 cover 25-33%; 7 cover 33-50%, 8 cover 50-75%, 9 cover >75%; 10 100% complete cover (see Table 1.).

The *Juncus effusus*/*Juncus inflexus*, *Equisetum telmateia* and woody plants were evidently key elements of the vegetation and their relative abundances might be expected to change in the future. Woody plants were *Salix cinerea/Salix aurita*, *Alnus glutinosa* and *Fraxinus excelsior*. Further to this, in each 8x8 the % cover of *Juncus* spp was estimated, the number of *Equisetum* was counted and the number of willow stems was counted.

In addition, a line transect from corner to corner of each 8x8 was set up and a plumb line lowered every 20cm. Hits of these three elements were recorded on the 217 points, thus giving more replicable data on their occurrence. The plumb line (improvised by rolling a 4cm length of roofing lead and attaching it to a string) was c 0.5 cm in diameter and was lowered until it hit the ground. For the sake of replication, a 'hit' was taken to be when the plum line rested on the ground *vertically under* the leaves of any of the three elements (*Juncus* spp*, Equisetum telmateia, Salix* spp and *Alnus*). Thus, under the overhanging leaves of a *Juncus* tussock, under the spreading branches of an *Equisetum* stem and under the general cover of a *Salix* sapling were taken to be 'hits'.

This definition is rather loose but it is considered that any significant changes in abundance in these three elements in the future will be registered by this method.

A (wide angle) photograph was taken of each 2x2. Each photograph was taken with the camera resting on the top of the respective corner post and pointing towards the centre of the quadrat. They are therefore replicable at some time in the future.

Fig 2 Plan of quadrats showing numbering and lettering; also showing positions of conifer stumps over 25cm in diameter.

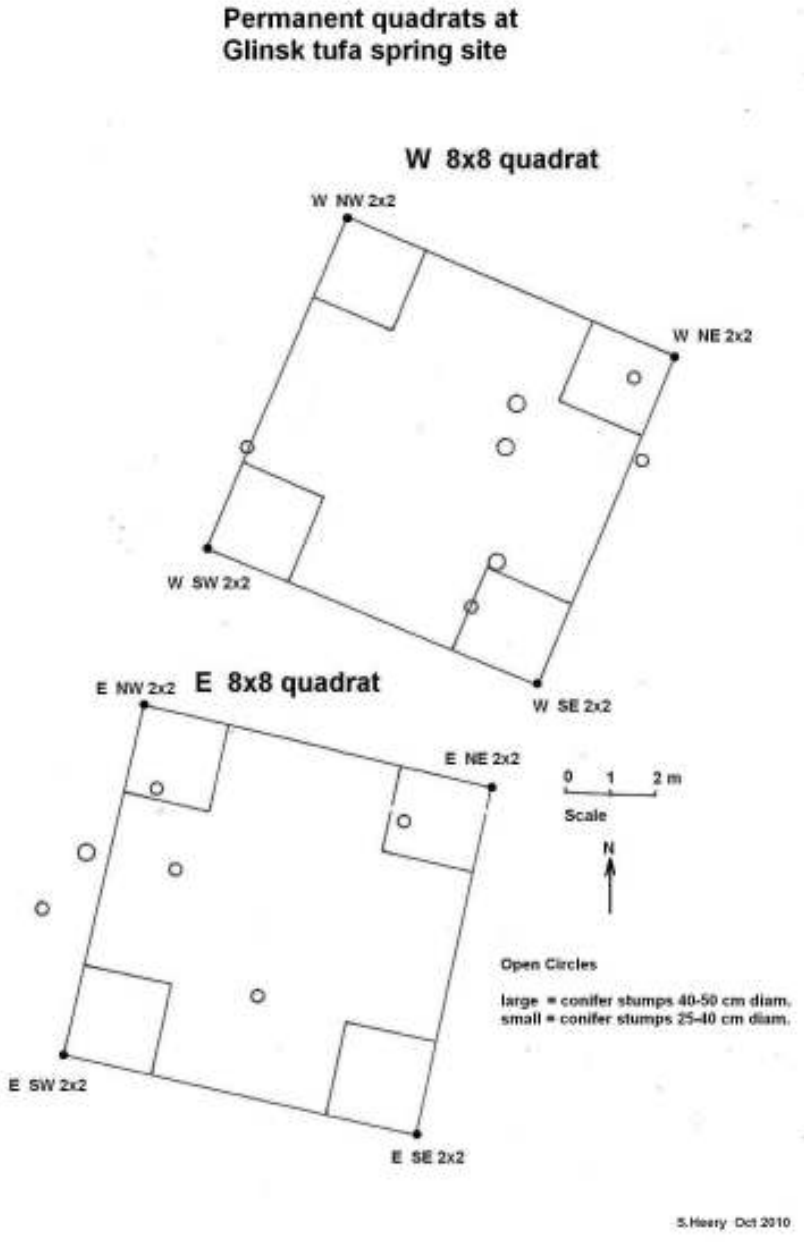

Table 1

Permanent 8m x 8m quadrats*

	Vascular plants (Domin scale)									Line transects			
	W, SW	W, NW	W, NE	W, SE	E, NW	E, SW	E, SE	E, NE	interval	W 8x8		E 8x8	
										SW->NE	NW->SE	SW->NE	NW->SE
Juncus effusus	5	3	4	3	4	6	3	3	1	E	J	J	E, J
Juncus inflexus	5	4		4	7	1		1	2	E	J	J	J
Agrostis stolonifera	6	2	2	2	2	2	3		3	E	J	J	J
Ranunculus repens	4	2	2		2	3	2	4	4	J	E	J	J
Salix aurita/Sal cinerea	3	1	3	3	4	3	3		5	J	E, J	J	J
Carex remota	5	3	4	5	2	3			6	J	J	J	J, S
Equisetum telmateia	4	2	3		2	1	1		7	J	J	J	J
Lysimachia nemorum	2	2	2	1		2	3		8	E	J	J	J
Juncus conglomeratus	1		1	2		2	4	3	9	E	J	J	J
Rubus fruticosus		2	4		2	4	3	5	10	E, J	J	J	J
Carex sylvatica			2			2	4	3	11	E, J	J	J	E, J
Carex flacca	2	1	3	2					12	E, J	J	J	E, S
Cirsium arvense	2		4	3	1	1		3	13	E, J	J	J	E, J
Carex viridula	2			2			4		14	E, J	J	J	J
Hypericum tetrapterum	2	2		3	3	1			15	E, J	J	J	J
Scrophularia nodosa			3	3	2	1		3	16	NONE	J	J	J, S
Holcus lanatus	1	3	1			2			17	E, J	J	J	J
Urtica dioica		1	1	2			1		18	E	J	J	J, S
Fraxinus excelsior seedl			3	1			1	1	19	J	E, J	J	J
Lonicera periclymenum			2	2			1	1	20	E	J	J	J
Mentha aquatica	4	4		3					21	E	J	J	J, S
Epilobium obscurum			2				1	1	22	E, J	J	J	J
Juncus articulatus	4	1				1			23	J	J	J	J
Poa trivialis			1	2		3			24	J	E	NONE	J
Chryso. oppositifolium				2			1	2	25	J	NONE	J	J
Stachys sylvatica				3	2		2		26	J	E	J, S	J
Epilobium parviflorum	1		1					1	27	J	NONE	J	J
Trifolium repens	1			1					28	NONE	E	J	J
Cirsium palustre			1			4			29	J	NONE	J	J
Glechoma hederacea				3	p				30	J	NONE	J	J
Ajuga repens	2			2					31	J	NONE	J	J
Taraxicum agg.			1				1		32	J	E	J	J
Geranium robertianum						2		1	33	E, J	E, J	J	J
Carex echinata				1					34	J	J	J	J
Anthoxanthum odoratum	1								35	J	J	J	J
Eupatorium cannabinum		1							36	J	J	J, S	J
Carex hirta		1							37	J, S	J, S	J, S	J, S
Alnus glutinosa sapling			2						38	J	J	J	J
Hypericum androsaemum			1						39	J	J	J, S	J
Lathyrus pratensis				3					40	NONE	J, S	J	NONE
Veronica chamaedryas				2					41	A	E, J, S	J	J
Carex ovalis							3		42	E	NONE	J	J
Epilobium hirsutum									43	E	NONE	J	J
Fragaria vesca						1			44	J	NONE	J	NONE
Cerastium fontanum						1			45	E, J	NONE	NONE	J
Senecio jacobaea						1			46	E	NONE	NONE	NONE
Digitalis purpurea						1			47	E	J	J	J
Palustriella commutata	5				5				48	NONE	J	J	E, J
									49	J	J	J	NONE
No.of Equ tel stems in W 8x8 = 207					No.of Equ tel stems in E 8x8 = 28				50	NONE	NONE	J	NONE
Cover of *Juncus* sp = 33%					Cover of *Juncus* sp = 60%				51	NONE	NONE	J	NONE
Salix plants = c 5% cover, c 20 plants					Salix plants = c 5% cover, c 14 plants				52	NONE	J	J	J
Alder = 1 plant					Alder = 1 plant				53	NONE	J	NONE	J
									54	J	J	J	J
Other species within W 8x8									55			J	
Deschampsia cespitosa, Filipendula ulmaria, Galium palustre										n=108		n=109	
other species present in 2x2									E.tel	31 (28.7%)		5(4.6%)	
E SW = Dryopteris dilatata, Hyacinthoides non-scripta									Juncus spp	70(64.8%)		98(89.9%)	
E SE = Dryopteris affinis, Hya. non-s, Ranunculus acris									Salix spp	4(3.7%)		10(9.2%)	
Agrostis capillaris, Pteridium aquilinum, Rumex obtusiflius									Alder	1(<1%)		0(0%)	
E NE = Epilobium angustifolium, Polystichum setifreum									NONE	20(18.5)		10(9.3%)	

3.3 Mapping the site

1. GPS based map (Map 1) Mark McCorry

The habitat map was created using GIS (Arcmap 9.2). The main data sources were several series of GPS data points collected by Mark McCorry and J. Dempsey (Coillte). GPS points collected by MMcC were collected using a using a Trimble GeoXT hand-held computer with GPS capability. This GPS normally has accuracy within 3 m. MMcC collected two series of data points and then created a composite map. This map contained features such as tufa springs, calcrete outcrop, red marker posts, fence-lines, brash-lines, position of escarpment, large trees, young trees and stumps. Background mapping such as OSI 2nd edition 6 inch maps and OSI ortho-rectified aerial-photos 2000 series also aided in the mapping. The positions of the tufa springs were mapped using GPS but the shape and dimensions of these springs were mapped by tape measure and subsequently transferred to digital format using the same dimensions.

Subsequently there was some additional survey work (including contours) carried out by JD who used a more accurate system (Trimble 5600 Total Station) with an accuracy of < 1 m. Points collected by JD were also overlain on the draft map and final habitat map was compiled. Where there was overlapping of points (e.g., positions of red marker points), the position recorded by JD was used as the final position.

The final habitat map (Map 1 in the text) marking the position of tufa springs, calcrete mounds, red marker posts, two permanent vegetation quadrats, brash-lines, contour lines, site boundary lines and mature Oak trees was created.

2. Plan of tufa spring mounds

Methods

The definition of the tufa spring mound here is the area of *Palustriella* and associated water flow lines that are free from *Juncus.* The dimensions of each tufa spring mound were measured using a temporary line stretched between two points so that the line ran parallel to mound. The distance from the line to *Juncus* free *Palustriella* was measured at 1m intervals. The length of the spring lines agree well with the length found by GIS mapping.

The positions of conifer stumps were measured using a tape measure and compass from a reference stump. This was the method used to map the stumps in the permanent quadrats.

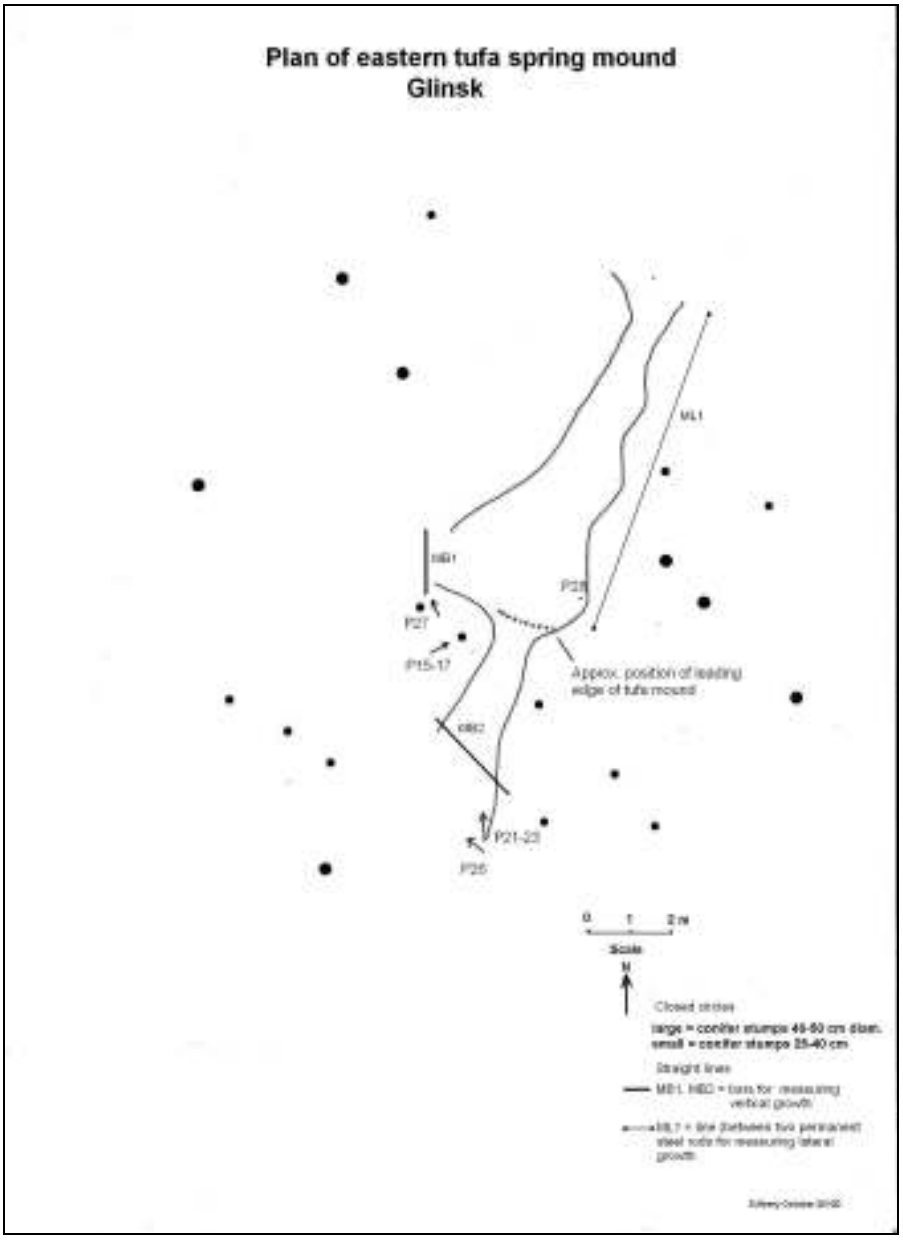

Fig. 3.

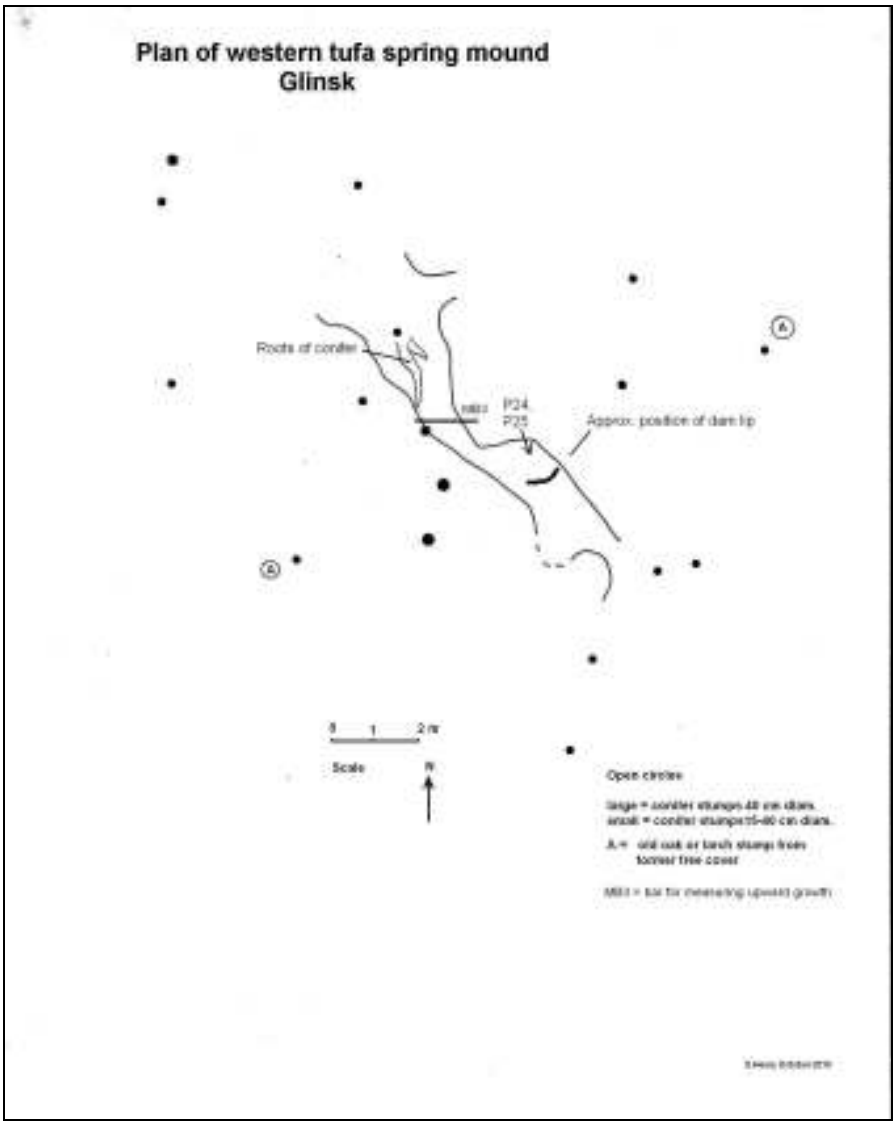

Fig. 4.

5. Measuring growth

Upward growth

The lines MB1, MB2 (Fig 3) and MB3 (Fig 4) show the approximate positions of the bars used for measuring the upward growth of the moss/tufa. Melinda Lyons, a PhD student, Trinity College Dublin (starting September 2011) will be measuring and reporting on the results over the next four years. The results, when complete, will be filed with this report. In general the measuring device comprises a hollow square horizontal bar, permanently fixed in position between two vertical angle iron posts. A metal rod of specific diameter and weight is lowered onto the tufa mound, vertically through aligned holes, situated at 5cm intervals along the bar. **Photo 29** shows bar MB1. Before repeating these measurements Melinda Lyons' data and methods must be consulted

Lateral growth

Fig 5, below, shows the approximate position of the line to measure lateral growth of the tufa mound. A tape measure is stretched between the two permanent rods and the distance from the tape to the first *Palustriella* is measured. This can be replicated in the future. Decisions as to exactly where the first *Palustriella* is located, and observer differences, mean that repeat measurements cannot be said to be significant in cms, but any macro change in the position of the eastern edge of the mound will certainly be determined.

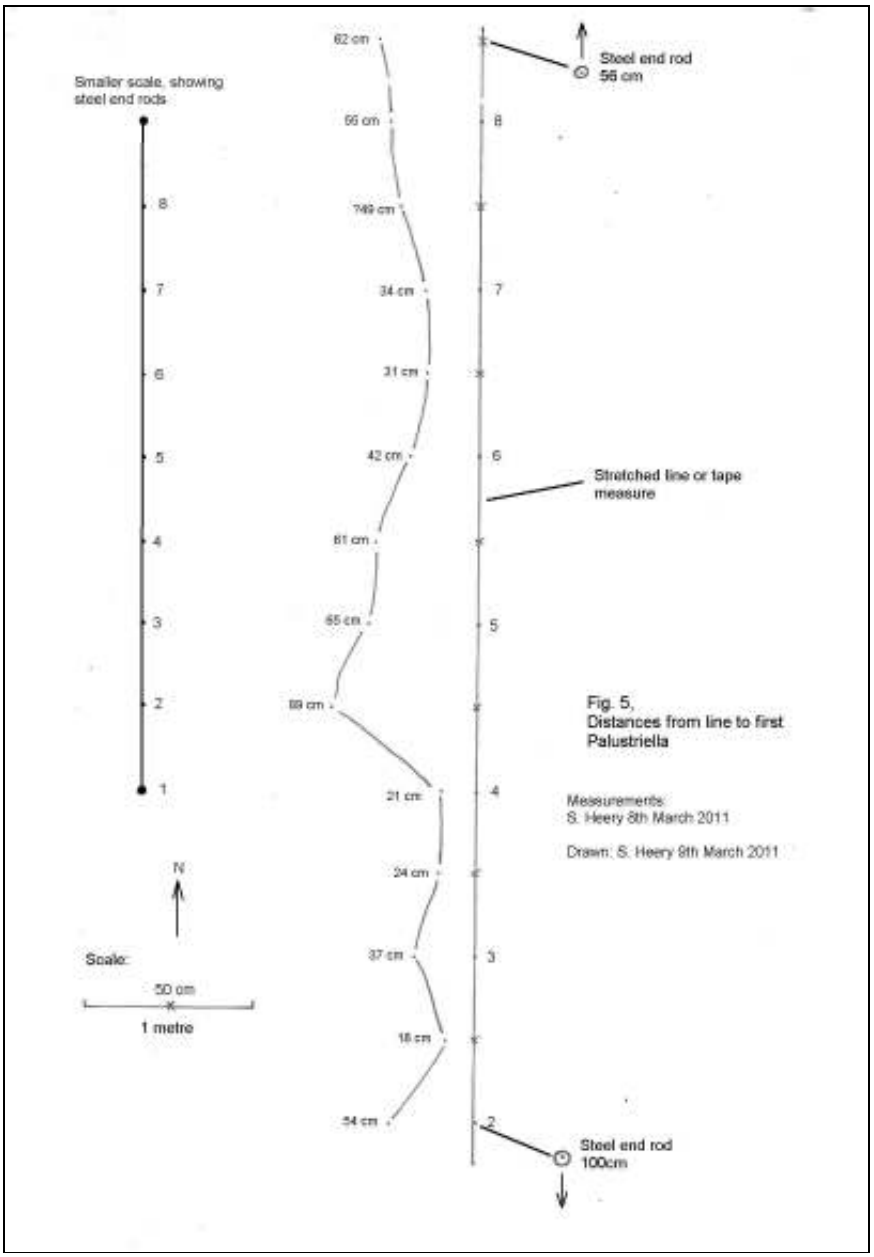

Fig. 5

Recommendations

The main aims of this report were to monitor change and to encourage further ecological work at the site. In this regard, three recommendations are made.

Recommendation 1.

- ***The study should well-flagged for further research and monitoring***

To this end:

1. An abstract of the project will be included in *A Bibliography of Ecological and Geological References to Co. Offaly* (available from Offaly Co. Co., and on their website). This will be written by S.Heery.

2. See also Recommendation 2, regarding Coillte's biodiversity programme.

Recommendation 2.

- ***The site should be monitored every six years***.

This project looked at the site in the fourth year after clear felling and change has been quite rapid. For a project such as this, with a long-term objective, measures should be taken to include this site in any programme of biodiversity monitoring undertaken by Coillte. Under the EU Habitats Directive, Ireland is required to report on the condition of habitats and species within SACs on a 6-yearly cycle (NPWS 2008) – the above recommendation is in line with this national commitment.

Attributes to monitor:

- Repeat the vascular plant species recording in each of the eight 2x2 quadrats.
- Repeat the photographs of each 2x2 quadrat from same angle as in the report.
- Repeat fixed-point photographs.
- Repeat the two diagonal line-transect measurements in each of the 8x8 quadrats.
- Make measurements of upward and lateral growth on the devices that are in situ (these have been put onto the site after the base-line report was completed).
- Write a brief summary of findings and changes observed.
- File the results in such a way that they are accessible with the original report.

This should take one day in the field for two ecologists; and one day in the office for one ecologist assessing change and writing up the results.

Recommendation 3.

- ***Further research should be encouraged on the site.***

The landowner, Coillte, must be consulted before any such work is done on the site. The site is considered an ideal location for further work to gain a more integrated understanding of this rare habitat, which is listed as a priority habitat in the E.U. Habitats Directive.

In this regard, the following is an incomplete list of suggested research topics for the site:

Geological

- ✓ The geological context of the springs' emergence
- ✓ Amount and distribution of tufa below ground
- ✓ Fossil flora and fauna encased within the tufa
- ✓ Evidence of pre-conifer deposition of tufa

Biological

- ✓ Micro flora (bacteria etc) involved in the tufa formation

- ✓ Macro invertebrate fauna (snails, beetles, spiders and other tufa specialists) within the various tufa-forming habitats
- ✓ Present day encasement of fauna and flora

Hydrological

- ✓ Seasonal flow of water from the springs
- ✓ Chemistry of water in terms of tufa formation
- ✓ Identification of the catchment of the water source

The results of any future work on the site should be filed in such a way that they are accessible with the original report.