**Benchmark standards workshop on the Preservation of Botanical Collections**

# These notes have been developed form a workshop comprised of a collection of experts in the field. The notes are for development and will be a living document covering best practice in the preservation of botanical materials and herbaria.

**1.0 Aims of workshop [[1]](#footnote-2)**

* To discuss best practice in the Preservation of Botanical Collections
* To agree standards in the care of collections
* To agree a syllabus for developing a standardised training program
* To review historic practice and discussed what is currently considered to be best practice in the field (where possible this will be backed up with researched evidence).
* Establish datasets being reserved as part of best practice

Best practice and standards ensure that collections are maintained to reduce levels of deterioration

**1.1 What is a herbarium?**

A herbarium is a collection of preserved plants stored, catalogued, and arranged systematically for scientific study by professionals and amateurs. Herbaria are a vital reference library to aid in current plant identification and future taxonomy.

The written data accompanying the specimen is as important as the specimen itself. A specimen with no data has no scientific value. The data provides evidence of where the specimen was found, who found it and when it was collected. Herbarium specimens are datasets, providing information relating to taxonomy, classification, chemistry, curatorial practice, flowering/fruiting times, morphology and physiology. Well preserved plant specimens can also be used to provide samples of DNA, other biological compounds and to validate scientific observations.

Also data on plant populations and distribution and habitat

Herbaria are used to aid plant identification, to help understand biodiversity and used in support of conservation, ecology and sustainable development.

The long-term preservation of this material is essential for future generations. Collections can date back hundreds of years and so conserving this material raises challenges that must be met as the collections are an essential resource for ecologists, scientists, geographers and historians.

A Herbarium may include some or all of the following;

* Herbarium sheets
* Cryptogams on sheets
* Packets – cryptogams
* Lichens, fungi, fruits, seeds and related economic material (boxes of bulky specimens)
* Materia medica (jars containing dried specimens)
* Diatoms (mounted in mica on herbarium sheets or slides) and in ethanol?
* Algae (floated onto mount paper)
* Fruits
* Seeds
* Fungi
* Bark
* Pith
* Timber (hand sections, planks, tree sections, microscopic sections)
* Pressed and bound collections
* Palm leaf materials
* Mounted slide collections
* Pollen
* Economic botany collections
	+ - * Anything used by man: food, shelter, clothing, seeds, pharmacological,
			* Preparation methods and packaging

**1.2 Use of Collections**

* Teaching aid, identification tool, conservation, ecology and sustainable management
* Arts and Humanities use of collection
* Research and Industry

**1.3 General statement on collections preservation**

* Do not microwave (or apply heat to an object) as this will cause degradation of DNA and associated proteins (enzymes) to degrade.
* (VP)Do not expose plant collections to high relative humidity or water , as this will encourage moulds and insect pests.
* Try to eliminate historic pesticide treatments and do not apply new chemical applications.

**2.0 Why does use of the collection affect preservation?**

Accessing and handling of collections is an essential part of a working herbarium. However this will lead to damage being caused to collections, e.g. through abrasion, movement to different environmental conditions, handling or changing light conditions. It is therefore essential that suitable policies and procedures are in place to ensure that best practice is maintained to reduce the risk of damage to the collections.

**2.1 How do we preserve collections and what data sets are we trying to maintain.**

Traditionally (DY) early herbaria were produced as books or bound volumes, the first being early Herbals and collections of plants. Linnaeus changed this approach to separated sheets to aid access and for ease of placing in taxonomic order. Scientific research was the driving force for this change and as a result, the collections are benefiting from a less structured preservation approach. With the change from high quality rag papers to cheaper and more readily available paper supports, however the specimen’s preservation has suffered.

The morphology and composition of plant specimens is also important and some specimens benefit from preserving in fluid rather than by being dried and pressed. Historically plant specimens were preserved in formalin e.g. Kew Cocktail[[2]](#footnote-3), analysis conducted on DNA extraction from historically stored plant material showed that nearly all attempts to amplify from specimens treated with 3.7% formaldehyde (at pH 3.0 and 7.0) failed (Prendini et. al 2002).

**2.2 What is it important to preserve**

The structure of the plant is important to preserve because of morphology for ID (DY) at microscopic and macroscopic levels. Important features to preserve include;

* DNA
* Chemistry
* Label data
* Associated organisms with specimens
* Substrate (mosses)
* Colour (although not a high priority for taxonomic work)
* Cell structure
* Historic mount papers/watermarks

Fungi (JY) colour is important for ID and there are standard colour guides to assess these against (Rayner 1970). There is little research knowledge on colour deterioration in fungi. Should we preserve the colour and do we understand the chemistry of the pigmentation enough, in particular the colour chemistry. Should we therefore preserve the colour in objects accurately? The working group suggested that it is preferrable to **maintain the chemistry (and material science) rather than accurate colour.** (Should we preserve the colour in lichens chemistry of pigments). This is potentially a research area on pigmentation and pigment deterioration. The profession needs to ensure that during handling and collection the colour is accurately recorded and that where possible well preserved colour is preferred (SD). Fungal and lichen specimens have a specific chemistry and this can be identified through chemical separation processes such as thin layer chromatography (TLC) a relatively simple approach. Specimens should be photographed with a digital standard colour card at the time of collection.

**2.3 What are the key data sets from a plant object?**

The herbarium sheet[[3]](#footnote-4) itself contains key documentation on the object and the plant sample should preserve the key stages in the life cycle of a plant. **Mounted specimens should preserve the specimen carefully whilst exposing to view all possible aspects (indicators) of a plant: the flowers — with all their petals; their fruit; seeds; the upper and lower surfaces of the leaf etc.** When a specimen is damaged, the loose pieces are placed in fragment capsules stuck to the data sheet, and this material should be dissected rather than removing flowers or fruits from the specimen. However it is recommended that samples for DNA analysis should not be taken from these fragments because the sample cannot be guaranteed to be from the original specimen and cross contamination with other specimens may have occurred.

Should an example of a leaf and a flower (if multiples available) not be added to capsule for research purposes?

The quality of DNA in preserved plant samples (pers com Tim Rich and from the review of plant species in Wales Barcoding of botanical species in Wales) depends on the quality of the sample and the time period the DNA sample is taken after collection of the sample.

It was asserted that 30 years is the maximum age where DNA can be easily sampled but expected DNA breakdown is between 20-30 years. When re-sampling specimens the quality of the data set is dependent on the quality of the sample and preservation of the plant.

RBGE always takes material for DNA from the capsules if available, before removing it from the mounted specimen. Is this not one of the reasons we are putting capsules on the specimen sheet?

This is also dependent on the quality of the specimen and the way in which specimens are collected. Green sections give better quality DNA, whereas brown do not give as good a quality. There are many plant species e.g. *Hypericum* that are difficult to extract DNA from because of the chemistry of the object (this needs to be explained a lot more). It is essential that the specimens are collected and dried quickly. The quicker the samples are preserved the less the breakdown of the DNA (Explain why this is the case). A list of plants which are awkward to mount is listed in Appendix 1.1.

See Sarkinen et al. (2012) for further information on optimising DNA extraction from herbarium specimens.

**2.5 Recording Data**

It is traditional to record specimen data taxonomic site, historic, treatment data, determinations etc. on the mounting paper. The mount will there for be a living document on the specimen, its history, scientific importance and treatment. It is essential that this data is recorded in an electronic collections management database so that it can be integrated with other sets of relevant data. However the mounting card becomes the original documentation source for the specimen. If a specimen needs to be remounted then it is important that this data follows the specimen, either in a linked folder, attached to the mount paper itself or with the specimen in a linked folder. Inks and paper used should follow recommendations as laid out in this document.

**2.6 Destructive Sampling**

Any sampling should be controlled to reduce impact on objects and to preserve the object for the future. A full review of any destructive sampling proposal should be undertaken before any invasive sampling is undertaken. The sampling must consider the nature of the object, its potential to deliver the data, its historic and scientific specification e.g. type, figured etc. Institutional procedures must be followed and any datasets and samples should be returned to the institution from the whom the original specimens were acquired. Data should comply with the institutions ABS agreements and only be undertaken on specimen acquired under the agreement and policy of the owning institution. It is not recommended policy to sample types unless absolutely necessary. If destructive sampling is requested, then the label on the specimen must say sampled. Data sets from sampling should be returned to the institutions to reduce levels of repeat sampling.

See appendix 9 destructive sampling policy and forms

What is ABS agreements?

Destructive sampling requests should be recorded on Herbarium data base and linked to herbarium specimen or living collection or both. Specimens sampled from should be annotated with name of researcher, Herbaria, date of sampling and ref. num (from database) of the request (on herbarium sheet)

Material to be removed from herbarium specimen by a member of staff from the home Institute.

Herbarium specimens to be made if the material for DNA sampling has been taken from the living collections e.g. <http://www.rbge.org.uk/science/herbarium/destructive-sampling-requests>

**3.0 Remounting of objects [[4]](#footnote-5)**

NHM, AC-NMW, Liverpool and Kew will not remount specimens if the whole object (including mounting paper) is deemed to be of historical significance, however in most cases the original specimen and mount sheet can be mounted onto new herbarium sheets to reduce handling of the original or to provide strength to the specimen. The whole object includes the sample(s), labels and annotations, paper and any fragments/samples held in attached containers e.g. capsules, flimsy etc. Banks (DJ) collection prescribed the type of paper so this is an historic part of object as well. Handling insecticide-treated paper is a concern and balancing the safety of individuals and historic value of the object should be considered.

The remounting of an object is on a case by case decision. Considerations should be;

* Does it affect the preservation of the specimen
* Will it damage data in the object
* Health issues

If the specimen requires remounting then this should be onto modern conservation grade material unless there is a historic reason not to do so. Remounting should only be undertaken if the specimen has;

* Poor initial mounting (does not exhibit the relevant morphometric features)
* Original mount support is in such poor condition that the specimen (and associated data is not supported)
* When two or more species have been mounted originally together on one sheet and need separating onto new sheets for curation of specimen/ taxonomic purposes.

**4.0 Recommendation on Collecting**

On collection, specimens should be dried quickly and the DNA should be extracted as soon after collection as possible. However it is very difficult to predict how quickly DNA will degrade but the quicker they are dried in the field, the less breakdown of the DNA. Samples of fresh material should be collected into Silica Gel, for dry storage. Silica gel should be changed after one day and replaced with dry silica gel. Silica gel can be dried in the field using moderate heat, eg in a frying pan over a low flame.

Critical genes that are used for DNA Barcoding (TR) are ribulose-bisphosphate carboxylase gene (**rbcL**) (proteins) and rbcL+matK matk ( enzyme) are recommended as the twin loci for barcoding .

It should be noted that for differing materials, DNA extraction from different areas of the plant are appropriate, e.g. Hypericum (stem), Orchids apart from the leaves

Collectors should be aware of Cross-contamination across samples e.g. aquatic samples, diatoms and external pollen sources. The maintenance of a general herbarium sample is undertaken as one would in standard management of a general natural history collection.

Best practice states that the collector should

* Collect fertile material, with both flowers and fruits if possible.
* Small plants should be collected whole, including the roots. This is important in determining whether it is an annual or perennial plant.
* Reduce the material of densely leafy specimens by cutting off excess leaves or leaflets, but leaving the base of the petiole. Always include the complete tip of a pinnate leaf so that it is clear whether they are odd- or even-pinnate.
* If leaves vary on a plant then representative samples should be taken, eg umbels with large basal leaves.
* Use additional sheets for large specimens, making sure they are clearly numbered 1/3, 2/3, 3/3 etc
* Ensure that all data which may be lost in preservation, such as colours and smells, is recorded at the time of collection.
* Accurately note the location, preferably using a GPS. Always record lat long in degrees/minutes/seconds or decimal degrees. Never use degrees/decimal minutes as this introduces potential confusion.
* Describe the habitat, substrate, aspect and associated species.
* Number at the time of collection. Either write the number in permanent marker on the newspaper, or if alcohol is to be used in preservation write the number in pencil on a jeweller’s tag. The tag should be attached to a twig, not a petiole, as leaves may fall off.
* Press immediately in the field to cause the specimen to wilt. Later the same day rearrange the specimen as it is to be preserved. This is much better than collecting all material into a plastic bag and pressing at the end of the day.
* Add extra fertile material for dissection.
* If the flowers are large and tubular at least one should be cut down one side and pressed open to show the interior details. Protect these partial dissections with tissue paper which can be removed at time of mounting.
* Extra longitudinal and transverse sections of large, fleshy fruits should be included.
* If stems are fleshy consider splitting or making longitudinal cuts to aid drying.
* Dry a sample for DNA extraction in fresh silica gel or other water absorbent (conditioned to 0% RH
* Dry as quickly as possible without heat
* Lay out specimen to show details and see both sides of plant
* Use a plant press the same size as the herbarium sheet and collect a sample that is the same size of the herbarium sheet. Aim to almost fill the herbarium sheet, collecting several individuals if the plants are small.[[5]](#footnote-6)

Each specimen should be given a unique collectors number, always have this attached to the specimen. Collect extra material for capsule

It is essential that Field notes are connected directly with the specimens. Any techniques should be applicable to both Professional and amateurs.[[6]](#footnote-7)

Note discussion on use of varying drying agents e.g. Chinchila dust fast drying, Clay mineral that can be used for Orchids, fleshy specimens, cactus and the need to dry plants quickly and efficiently.

Wood sections can be preserved with glycerol and alcohol. Glycerol use should be monitored as there is an increased risk of mould growth associated with its use (ambient relative humidity around specimens stored in glycerol should be maintained well below 65% relative humidity).

Glycerol is used at RBGE for preservation of conifers . See: C. N. Page ‘The Herbarium Preservation of Conifer Specimens’, Taxon 28(4): 375-379, August 1979.

When pressing it is preferable that

* Corrugated papers are used to aid air circulation Plants are placed into blotting paper or newspaper
* Important to change the paper or card as it gets damp. Twice a day to start. Ensure that the sheets directly surrounding the specimens are not disturbed.
* Boards should be placed on either side
* Press should provide an even force on both sides

When drying in the tropics

* Dry as quickly as possible
* Press within paper and always ensure that there is a basic label
* When required treat with alcohol (or local derivative) to dry out and treat mould
* Practically, a plastic bag – soak newspaper with alcohol – is a solution

Effects of collecting techniques can damage or destroy potential DNA or change the morphology of the object so it is recommended that;

* Best practice would be to collect a sub sample with silica gel

Issues to be considered when processing materials in tropical conditions

* Material can come out black or dark and brittle
* Jewellers tags should be attached to the specimens so that the link between the specimen and collecting data is not lost
* Avoid coloured papers as they can leach colours into the sample
* Where possible Vacuum pressing could be considered however it can be damaging to an object and thorns or other woody specimens could pierce the bags.

**4.0 Mounting Techniques** (Appendix 5.)

It is essential that adequate training is provided for plant mounters and that they are exposed to the range of techniques and the range of requirements of the groups of plants and needs of the specimen. Specimens are mounted on a supporting (archival quality) card. The card should be pH neutral paper, lignin free, cotton/rag paper and of an adequate weight to support a sample. RBGE use two thicknesses: 550 microns for most specimens; 1100 microns for very bulky or particularly brittle material.

For protection, 15 gms protection paper (smooth and light) should be used to protect fragile and delicate specimens.

Specimens are attached using a number of techniques;

**4.1 Adhesives and Glues**

A wide range of adhesives have been used to attach specimens to a mount sheet/card;

* PVAc/PVAl (PVA) emulsions and dispersions (Poly vinyl acetate/polyvinyl alcohol – commonly called PVA)
* EVOH (ethylene vinyl alcohol)
* Gelatin
* Wheat starch Paste
* Methyl Cellulose
* Sodium methyl cellulose
* EVA (Ethylene vinyl acetate)
* Arrowroot

Dependent on the application and plant it is recommended that a natural adhesive is used. This should be applied following recommended procedures. Any of the artificial polymers may tend to be more acidic leading to acid hydrolysis of the paper and potentially the plant.

Many institutions use different techniques to mount objects.

* Stitching
* Total Adhesion
* Point Adhesion
* Linen tape strapping
* Strapping and adhesion

No particular approach is agreed as best practice[[7]](#footnote-8) however the specimen should be attached so as to prevent loss or flexing of the plant and associated features. The attachment method should be reversible and cause no loss of data or damage to the object (especially during transportation, freezing and handling). No treatment or process applied to the object should contaminate it or cause loss of data to the object. It is possible that a pancake (methyl cellulose ) method of long term adhesion [explain?]would be advantageous as a film attachment as this would not penetrate the specimen.

Strapping is found to be best undertaken with a linen tape and a gelatine or Methyl Cellulose adhesive. RBGE use a water-activated gummed paper tape with pH neutral starch based adhesive, Klug Conservation 067.

**4.2 Considerations**

Methyl Cellulose could splinter as a film leading to detachment and loss of the object .

Wheat Paste has stronger penetration and attachment which may cause disruption of the object.

Various families of plants could be penetrated by wheat starch paste (to be defined). This is due to the hydroscopic nature of wheat paste (and methyl cellulose) and could lead to contamination of the object and disruption of cell structure[[8]](#footnote-9).

Sewing is a possible mounting technique which with time can give good results. However, the potential structural damage from sewing could reduce the length of the life of the mount and lead to damage of the plant. It is not considered best[[9]](#footnote-10) practice.

However, transport and handling of specimens prior to mounting may often mean that loose material will already have been lost, and stitching can be a good method of securing very bulky specimens; a stitch at the stem base may withstand flexing of the sheet better than a tape. RBGE use cotton polyester thread. Should there be further research into whether damage from stitching (and other types of damage) actually impacts on use of specimen for research?

**Other considerations for use and future research**

There are a number of materials that could be considered as adhesives.

* Textile arrowroot (sodium alginate) could be considered as it has good adhesion and reversibility
* Isinglass can be used but may have ethical problems [explain?]
* Frankenstein twist of mulberry paper with wheat starch paste can be used to attach specimens
* Are there adhesives used in textile conservation for eg cotton and linen?

Synthetics and ethics of use should be considered before a final decision on the use of an appropriate adhesive (despite fact that most institutions use synthetic adhesives) is made.

**5.0 Material science of plant materials**

**5.1 Degradation Processes[[10]](#footnote-11)**

Acid migration leads to brown staining above and below an object

* Foxing shadow
* Oxalic, Formic, Tannic acid production will cause acid hydrolysis and cellulose degradation
* Waxes from barks – cherry bark forms a powdery efflorescence (loose powder)
* Increase friability – due to acid hydrolysis and dehydration
* Cellulose: little degradation except from embrittlement and loss of structural integrity
* Darkening of object due to dehydration or oxidation

Yellowing is a key character in an object after it is pressed. This is due to a:

* Natural Deterioration process
* Glands become darker

As part of the degradation process specimens will off-gas decay products. These can be indicative of the plant type.

Family level groups[[11]](#footnote-12) may be good predictors of deterioration (to be defined)

**5.2 Structural and Mechanical Deterioration**

Flexure on the mount will lead to fracture and cracking of the object and potential loss of material. Collecting and mounting techniques will cause damage if inappropriate materials and handling are used.

Other causes of deterioration

* Incorrect use of adhesives,
* Incorrect processing,
* Packaging and transportation into the herbarium is damaging to the collection
* If alkaline adhesives are used on pith paper especially wheat starch paste this will cause cell structure degradation (ref)

**5.3 Biocides and pest treatments**

Unless in the tropics where mould growth may quickly cause damage to the object, it **is not recommended that a biocide, fungicide or pest treatment is undertaken on an object**. It is recommended that an IPM programme is put in place to monitor any pest presence and that cabinetry is built to a high standard ensuring a reduction in pest migration. In the tropics **Neem** - azadir***achta indica*** is often used but the antiseptic leaves can leave staining as can similar plants including bayleaves, laurel , bog myrtle. These are used as a pesticide in various countries

**5.4 Damage due to Pest Treatments (Appendix 4)**

Freezing is the most common method of pest control within institutions housing natural history collections. Ensuring that the collections are properly packaged and sealed before treating and that they have enough time to acclimatise before being reintroduced into the collections is vitally important, otherwise condensation can form introducing moisture and attracting pests and leading to an environment where mould can form. If moisture is incorporated into the freezing process the cell structure can be damaged and if not dried appropriately the mould can form.

Thermolignum or controlled heat treatments are also used to control pests. When using Thermolignum or related heat treating process, DDT, lindane and / or mystox migration to the surface occurs when the specimens have been treated with them previously concentrating the chemical at the surface during the thermolignum process.

Mercuric chloride can form a coating of crystals and can break down the structure of the plant cuticle. The reduction of mercury II to mercury accelerates damage to the wax cuticle. Mercuric sulphide on specimens will form a grey/black compound. This will affect the ability to extract DNA samples[[12]](#footnote-13). The process was used up until the 1980s and large numbers of samples held in museums are still contaminated with mercuric chloride (sulphide). Repeated applications of mercuric chloride in alcohol can dissolve the plants waxy surface causing the plant surface to be more vulnerable to environmental fluctuations and also more friable.

Naphthalene crystals on specimens can cause damage to the surface. Naphthalene can accelerate the reduction of mercuric salts (I and II) to mercury (0) causing increased acid hydrolysis of cellulose.

Pollution in the original collection environment e.g. water contaminants or collection from sea water can lead to an accumulation of chemicals leading to increased risk of salt efflorescence in materials.

Camphor, Pesticides and adhesives can mix increasing the potential for pollutant concentration increasing potential damage to the specimen and an increased health and safety risk.

Air pollution and soot on specimens or surface dirt will cause acidic damage to the surface of plants

**5.5 Other Deterioration Mechanisms**

Plants can deteriorate due to a number of processes

* Embrittlement of e.g. rushes due to salt contact as against fresh water (do salt water plants deteriorate more quickly? And are they more brittle?)
* Rotting on rushes due to iron corrosion
* High Nitrous Oxide content can lead to increased oxidation
* Blackening – some plant fibres more susceptible to oxidation
* Family *Scrophulariaceae* will go black
* Fleshy plants difficult to press
* Mosses and Lichens will tend to go mouldy if not dried properly
* Timber specimens suffer at too low an RH for prolonged periods of time– 50% too low – 55% - 80%
* Plants 18-20oC
* High protein and sugar species will be more sensitive to pests
* Lighting – changes natural colours and can raise oxidation rates
* Phylostachys – leopard bamboo - bamboo fresh green strip ? [Clarify?]

**5.6 Plants affected by Insect Attack (Appendix 2.)**

|  |  |
| --- | --- |
| *Stegobium* sp. Trogoderma sp.(Herbarium Beetle) |  freeze dried fungi, and plants with high sugar, high protein content are particularly susceptible. Economic materials, grains etc.  |
|  | Beans, lentils, high protein (compositae, flower heads) do get eaten |
|  | silica rich plants do not get eaten –  |
| *Psocids* (Book lice) |  main food source is microscopic fungi, therefore all fungi and lichens are vulnerable |

**6.0 Environmental Standards and materials for Herbarium Collections**

**6.1 Relative Humidity**

RH 40-50% for general herbarium (above will lead to hydrolysis and mould growth, below shrinkage and acid hydrolysis)

50% - 60% for wood collections

**6.2 Packaging and Storage Systems**

Packaging – the designs of fragment capsules should be considered carefully as opening mechanisms – envelope – make accessing specimens difficult (See appendix 3)

Poor materials – Do not use acidic or highly alkaline papers. Do not use paper clips. A guideline to a suitable archival paper is in appendix10 (to follow). Which British and International standards should be followed for herbarium sheets, folders?[[13]](#footnote-14)

**6.3 Herbarium Sheet**

The herbarium sheet which supports the plant should be of adequate weight to support a specimen. The paper should be [[14]](#footnote-15)

The paper should be cut at source with the grain and not across the grain as this provides better strength and support when holding a specimen. Although ideally the specimen should be supported by a board if moving from one area to the next.

If a specimen is too large and more than one sheet is required. The sheets should not be adhered to each other and each sheet should remain separate but should be labelled appropriately so that if they should become separated it will be easy to marry them back up. Ideally the original specimen label can be photocopied to provide an exact replica of the data e.g Sheet 1 of 2; sheet 2 of 2

**6.4 Folders and capture enclosures [see 6.2 above: ‘capture holder’. Is this a fragment capsule or something different?]**

The genus folder in which the Herbarium sheet is stored should be a double or triple spine folder. The size should encompass the standard herbarium sheet used. A weight of c. 300gsm is recommended for the folders.

* Folder with spines should be stored in low stacks.
* A stack height in an enclosed cabinet of no more than 30 is recommended
* Single fold spines should be avoided as specimens get squashed and damaged
* Wet coloured papers (sugar paper) should be avoided as they can lead to colour migration
* Papers should be standardized as using a range of size of papers – range of sizes leads to damage
* Field tags (once recorded elsewhere) should be removed prior to final storage
* Labels where specimen goes through the specimen what does this mean?

Is this species covers or is this back to mounting board? Recommended weight 220 gsm for paper recommended. The paper should be appropriate to support the specimen. They should be self-supporting so that the specimen does not flop. The maximum heights of stacks should be considered appropriate to the weight and size of the object.[[15]](#footnote-16)

[[16]](#footnote-17)Bulky specimens can become damaged and should not be stacked, where bulky specimens have to be stored in stacks they should be stored in boxes or each folder containing a bulky specimen should be raised to the level of the specimens so that the specimen does not get stacked. E.g. a frame of folded card to raise sheet flat should be used (or a frame of plastazote™). In particular type specimens should be adequately protected to stop them from being crushed.[[17]](#footnote-18)

Spines always side out so that they can be pulled and handled. They can also be clearly identified. For loans this should be alternate to general storage so that the load is distributed.

**6.5 Pest Control and IPM**

**Freezing**

All inward arriving specimens should be frozen ,including when loans are returned,.and when moved into new premises This should be undertaken as part of an institutions IPM procedures (see appendix 11 (to follow?))

**Recommendation - When received freeze**

**Plants should be frozen at -20oC for a minimum of 72 hours sealed in a box or plastic bag**

 **A day either side of this should be given to acclimatising the specimens**

Prints and drawings should be visually inspected as freezing can cause degradation to the item and may not be deemed appropriate

Take care when freezing algae or Lichens (can have delicate reds pigments) or use anoxic pest control methodology if unsure about the stability of the materials.

All objects should be returned in their original packaging or wrapped using methodology defined by loaning institution

**7.0 MOUNTING TECHNIQUES – HOW TO MOUNT**

Considerations (Plant groups that have special or awkward requirements (See appendix 1.1))

The users of the herbarium sheet should make the decisions on how the sheet should be laid out e.g. What are research needs and what are the key features of the object?

How are you going to lay out the object before you mount the specimen?

Ensure Opportunity to really mount the object properly – displaying key features of specimen

* Layout of Upper and Lower sides of Leaves, Petals, Flowers,
* Label should be in a consistent place, that is easily accessible
* Duplicate sheets – distribution to other herbaria and should be identical to the original
* Sequential sheet carries on to next sheet but avoid where possible

It is recommended that a standardised template should be developed for herbarium sheets

If the specimen is a unique or rare specimen then only glue one flower or put in the capture package. Do you mean capsule? Don’t understand this – do you mean that all the other flowers should be loose?

Even if adhered the petals can come off (a list of awkward plants can be found in appendix 1.1.)

Group and how the collection of species represented in herbaria. [Clarify?]

 If represented well then glue the key elements of the specimen down

Any mount should have a border for handling around the edge , the width of e.g. thumb joint. However to prevent bowing of specimens when stacked the specimen should not always be mounted centrally on the sheet.

As long as key features are easily observable, and it is not covering the data or too close to the edges of the mount, the specimen can be placed anywhere on the sheet. This practice helps to keep stacks of specimens flat.

Take into account where fragment packets are placed as these too can help to keep sheets flat if not always mounted in the same place.

This is very difficult to do if you are dealing with mixed boxes of specimens from collectors. With a large collection it is not practical to check on the other specimens already mounted in the cabinets to ensure the best placement.

Bryophyte Storage (appendix 3.)

* Stored in archival storage system
* 3D flapped structure composed of a paper of suitable weight
* Upright archival cotton packets, (100gsm) pre-printed with data before forming packets

Large 3d (bulky) Objects

* Paper to hold specimen down [clarify?]
* Flap cover – 15 gms Japanese toshiushi
* Acid Free tissue
* Upright archival cotton packets, (100gsm) A4 pre-printed with data before forming packets can incorporate bulky specimens.

3D objects should be stored in archival trays with either an archival or polyester lid to prevent contamination. The tray should be adequate to support the object and protect it from physical damage.

Standardised size of paper

* If different size then do not have resources to (text missing?)
* Are there standard sheet sizes we should recommend?
* AC-NMW paper sizes are 260 x 415mm. RBGE 265 x 420

**8.0 Health and Safety (appendix 1.2 and 4)**

(All specimens should be labelled with the appropriate Health and safety and handling information ( [http://mic-ro.com/plants/)](http://mic-ro.com/plants/%29)) Impossible to label all specimens, but H&S recommendations can be displayed where herbarium users can consult them.

Risk assessments should be produced for use of scalpels and cutting of paper (Paper cuts), possible risks of contaminated collections re: inorganics lead, arsenic, mercury, organics; naphthalene, DDT, mystox, lindane, paradichlorobenzene, and possible risks from inherently toxic collections genetic/ environmental/agricultural.

**8.1 Risks to Personnel from handling:**

**8.11 Mechanical**

Sharp spines, hairs etc. are normally visible, for example, from prickles, thorns, trichomes e.g. nettle or barbs. Less visible but also purely mechanical are the sharp edges of certain grasses that can cause unpleasant cuts. Bamboo also belong to the botanical family of grasses, and some bamboo species bear thin bristles on the surface, which can penetrate the skin and cause itching or irritation. There are many mechanically active plants, and injuries of the skin can cause secondary infections when dirt enters the human body. Chemically treated specimens could inadvertently contaminate personnel through mechanical damage to the skin. Antiaris toxicaria (Upas Tree) can be lethal if the sap enters the blood stream through for example a minor skin injury.

**8.12 Chemical**.

These are poisons that can enter the skin without mechanical action. When the sap of some species gets onto the skin surface it can lead to painful skin irritation or irreversible damage. Some species can even cause temporary or permanent blindness if a person touches broken parts of the plant and then their own eyes. Throwing such plant material into a fire [!] can also be dangerous (Oleander sp., Senecio jacobaea) as the smoke can be inhaled into the lungs, irritate the skin and can lead to blindness. Typical representatives of this principle belong to the Euphorbiaceae family. There are many members of other botanical families, however, that act similarly.

Ragwort (Senecio jacobaea) contains Pyrrolizidine Alkaloids (PAs). These chemicals are not poisonous, but once absorbed they enter the blood stream terminating in the liver where natural metabolic processes convert them into lethal toxins which attack the liver and slowly kill it. All parts of the plant contain PA’s.

Chrysanthemum sp., Atropa sp., Chelidonium majus, Dracunculus sp., Echium sp.,Rhus sp., Prunus laurocerasus, (cherry laurel) leaves and fruit pips contain cyanolipids that cancyanide and benzaldehyde (what does this mean – is there a word missing?). (1.5% cyanogenic glycosides are present in the leaves. During maceration, i.e. chewing, this becomes glucose, hydrogen cyanide (prussic acid), and benzaldehyde. The poison in the leaves can be used by entymologists as a way of killing insect specimens without physical damage. They seal the live insects in a vessel containing the crushed leaves. What has this got to do with risks to personnel from handling?)

**8.13 Phototoxicity in Plants**

This occurs through contact with many plants. The best example is the Giant Hogweed (Heracleum mantegazzianum). Phototoxic poison acts chemically, but only if the skin is exposed to sunlight at the same time

(Mechanical-chemical Is this a new paragraph title?). Some Plants penetrate the skin mechanically and then introduce a poisonous chemical. The result is an immediate burning sensation of the skin. The best known representatives of this kind are the stinging nettles  and their close relatives in all parts of the world. Most mechanically-chemically acting plants belong to the botanical families Urticaceae and Euphorbiaceae, some of them being much more powerful than the Stinging Nettle. Under an electron microscope, fragile hollow needles are visible with nettle cells at the base filled with liquid poison. When touched, a needle breaks off, leaving an oblique tip, which can enter the human skin like a syringe and release the poison.

**8.14 Allergenic Plants.**

Mainly found in members of the botanical family called Anacardiaceae. E.g. Toxicodendron species  native to North America. Contact can sensitise the victim and subsequent contacts can cause progressively more severe skin irritations.

The majority of medicinal plants are toxic and should therefore be treated with extreme caution. Ideally these specimens should be kept separate from the pressed plants and stored in sealed glass jars (ideally ground-glass jars). A list of plants containing toxic substances can be found in appendix 1.2)

They should be accurately identified and appropriate Health and Safety documentation and PPE put in place. A Drug’s License available from the Home Office is necessary to hold or transport any scheduled material. A list is available for viewing here <https://www.gov.uk/controlled-drugs-licences-fees-and-returns>. Click on Controlled Drugs List.

**8.15 Handling toxic and sensitive plants**

Specimens should be handled in;

* Shallow trays
* Nitrile gloves or wash hands (Finger cots(?))
* Masks should always be worn when handling specimens of unknown origin or known to be contaminated with mercuric chloride on labels. The correct mask must be selected carefully; there are numerous choices available, none of which covers all inhalation issues. Some are specific to dusts or vapours and therefore one mask will not necessarily protect you from working on a range of materials. Those using masks should always have training for fitting the masks.
* Masks should be fit tested. Working with fume/dust extraction would be a better all-round precaution. This is necessary when re-mounting material especially if humidification is utilised and when new mounts are being cut.

**8.151 Precautions**

* Economic collections – PPE appropriate to the hazards must be provided
* Mark collections with appropriate H&S regulations (?)
* Assume that there is a hazard on historic collections, especially those predating 1986 and treat as a hazard
* Assume cocktail affect of different pest treatments and toxicity from plants

**9.0 Internal Movement**

* Internal movement policy and procedure should be in place with a relevant sign-off sheet.
* Ensure Correct handling i.e. the sheet, book or enclosure should be fully supported and never stacked more than 5 sheets high. (Not very practical – we often carry stacks of specimens containing many more than 5 sheets!)
* Training for working and moving herbarium sheets should always be provided to new staff or visitors

**9.1 Handling instructions and guidelines**  appendix to follow?

Guidelines governing the handling of specimens, minimise damage and encourage standardised examination practise. The following suggests some basic instructions. These should be read by all users of the collection and preferably remain displayed in the natural history store.

1. Always hold the specimen sheets and their folders by both sides in a horizontal position, keeping them flat and fully supported.
2. Always hold above a table or suitable trolley
3. When examining sheets never turn them as if they were the pages of a book, or invert them. Loose fragments may come loose when turned upside-down and fall into the spine of the folder.
4. To look through a folder, place flat on a work surface and stack the specimens to one side.
5. Never bend the sheet to examine part of it under a microscope. In instances where the parts to be examined are awkward, use a good hand-lens.
6. Do not place books or heavy objects on top of folders.
7. Any loose fragments found or parts of the specimen removed for examination should be placed into a fragment capsule attached to the sheet, but only when you are completely sure that the fragment came from that sheet.
8. Annotations to the specimen should be written in pencil or with permanent (water/light proof) ink(in this case ALWAYS on an additional label, not on the sheet itself). These should be signed and dated.
9. When placing the folders back into the cabinet, the open edge should contact the right-hand side of the pigeon-hole. This will give access to the spine of the folder when it needs to be removed again.
10. Bound volumes of herbaria should be stored horizontally unlike books to prevent fragments falling out.

**10.0 Examination Guidelines**

* Specimens should be handled with great care and not bent, cut, folded or laid face down. Sheets should be always kept horizontal and fully supported. Never rest books, heavy objects or elbows on sheets.
* If small portions of the specimen become detached during examination, place the material in a fragment capsule and keep with the specimen. No repair should be attempted.
* Do not dissect, section, clean, stain or in any way alter, treat or sample specimens or their mounts without prior permission from a member of the staff responsible for the collection. Any portions removed should be replaced in a fragment capsule and kept along with the specimen (attached in a way that does not cause mechanical or chemical damage to the object and mount.
* An *Application for destructive sampling/analysis* form (appendix \*) must be filled in if any sampling is undertaken
* Please annotate material whenever possible using confirmavit, determinavit or project labels. Annotations, signature and dates should be hand written clearly using pencil or permanent (water/light proof) ink only.
* DO NOT use biro pens.
* Adhere new labels/slips onto mount by wetting one edge of the slip only (staff will provide water). Place with specimen on sheet.
* Original labels/slips should never be removed, obscured or defaced.
* No annotations should be made directly onto the mount sheets themselves, except to distinguish elements of ‘mixed’ sheets. Use pencil for this purpose.
* Request that a copy of any published research resulting from the study of material loaned should be sent to (insert herbarium code) and that due acknowledgement to (insert herbarium code, and also institution name if standard) are made in such publications.
* Determination Slips should always be put in with objects.
* Board supports should always be used to support Herbarium sheets or folders
* Board supports should fully support the specimen to prevent flexing
* Trolleys – smooth running, and material should be boxed on a trolley for movement from room to room

Instructions on loan of material to outline that that they use the same packing method and materials for return

**11.0 Documentation**

Will there be a separate document to cover digitization of herbarium specimens other than loans? Eg storage standards for digital images, photographs associated with specimens etc? All plant loans should be fully condition reviewed, documented and imaged (following an institutions standard policy and procedures

Recommended Imaging standards are:

* 600 Dpi GPI standards (gold standard)
* 300 DPI is still high standard, press quality, and requires less storage space
* No compression or lossless compression is recommended TIFF (Tagged Image File Format) or Jpeg- 2000 to prevent loss of image quality.

Slides of key characters up to 7 images should be recorded for each sample. Historic labelling can be an issue if written in iron gall ink. This will deteriorate and should be considered when reviewing the stabilisation of a plant sample and its associated documentation

**12.0 Storage furniture**

|  |  |
| --- | --- |
| Style | Compartmentalised storage system allowing storage of discrete supported stacks of herbarium sheets |
| Doors  | open to 180 degrees |
| Colour | White for inspection to aid cleaning and visible inspection |
| Structure  | Seal materials should be inert and not off-gas anything that could harm specimens (plastazote or tested silicon is recommended) |
| Height  | Cabinets should be accessible from a low step and be no more than 2 m high |

Size of cabinets should be standardised to accommodate the standardised sheets

Epoxy powder coated steel is the preferred material for carcasses and shelves[[18]](#footnote-19)

It is recommended that a minimum of 10% expansion space is maintained across the collection for future expansion and to prevent over stacking of shelves.

Pull out shelf to place sheet or box onto them – shelf should fit and support the specimens

Lip to put hands under the sheets

 It is important to have sufficient space to undertake work on specimens, and sorting benches

Kew boxes are fine for temporary storage and moving on trolley but not for long term storage

**12.1 Storage of Bulky 3d Objects**

Bulky 3D material should be stored in drawers, stored in boxes (Collins 2013) with suitable packaging materials ). Where possible these should have a non-static clear lid. RBGE use acid free, wire stitched, 1300 microns, grey/white archival box board.

Large samples of wood should be support on foam in a suitably sized container on racking that can support the weight of the object

Metal drawers with dividers are recommended

Ethnobotany collections can be stored in archival trays card with clear polyester lids which reduces risk of unnecessary exposure or contamination.

Wet samples should be stored in glass as per wet collection standards

Boxes with lids should be used at all times

Polythene polyester packets should be used form fragments or powders from specimens

Glass jars with ground grass lids or screw lids can be used for ethnobotany collections with clear markings

Polystyrene crystal boxes can develop static and contaminate the object. They have a short lifetime but could be used for storage

Poly propylene tubes or enclosures also provide effective enclosures.

**12.2 Species folders** (separates each specimen in storage, transportation and handling sections 6.3 and 6.4)

Flimsy An (Archival) form a folder for object that goes around it

Protective enclosure for objects are archival and pairs each specimen inside a flimsy

For materials that exceptionally are more brittle storage in Flimsies can lead to Deterioration of the specimens

There are various designs available for folders and protective (appendix 3) Capturing fragments that have become detached from the specimens. Genus Cover cotton Rag Folder is from CXD (Liverpool and Cardiff). These are bigger than herbarium sheet and with a spine of at least 1 cm (these folds are made by the individuals and can be made larger if needed.

Species Cover approx. 100 gms (AC-NMW folder is closer to 200 gsm is a 4 flap folder into which capsules are placed.[[19]](#footnote-20)

To add info on flimsies, species covers, genus covers, four flap white folders and grey boxes.

**12.3 Labelling methods**

Label structure should be standardised as there are differing methods. Users currently use an Atlantis Copy Spec Paper/Lineco Paper/pH neutral unbuffered cotton rag paper for:

* Newly processed data
* Never remove a label from the specimen
* Original Author generates a computer label –which would be text missing?
* NHM would place scraps of data in (Capture packet? – see 6 above) capsule orpacket
* Herbarium – lot of data linked to handwriting, type of paper etc. so important that this is preserved with the sheets – where there is not a lot of room then labels flapped Documentation should be written in pencil permanent (water/light proof) ink
* Original fragment capsules with historic data – put in modern fragment capsule with a photocopy of the older labels on front.

**Notes on Reattaching labels**

* Pencil labels should be reattached to the paper
* Any ink label should be tagged with Japanese tissue to the corner
* Double sided label – Japanese tissue hinge
* Labels on back – photocopied and put on front with Japanese tissue
* All remounting with wheat paste or Carboxy Methyl Cellullose (CMC)
* wheat starch paste is hygroscopic and pulls in water this can cause cockling in sheet and labels
* line of EVA (Evacon-R) either on the top or side of the label.
* Use gelatine size and fully reversible repair but beware of effects on Iron Gall[[20]](#footnote-21)
* Sympatex (cheaper) rather than gortex and does not have the pressing effects but can be used to humidify specimens or paper
* Non-tear brass paper clips can be used to clip sheets together but should never use paper clips. The whole folder should be an origami that lays flat

TAGs

Coloured Papers – which archival coloured papers are available?

Folding of type folders – provided flat

An inspection kit should be provided for users. This should include

* Fragments packets plus instructions on how to fold
* Ruler
* scale bar
* any process undertaken on the object should be recorded either in the electronic management system or directly on the herbarium sheet

**Appendix 1 Awkward Plants and Plants that present a Health and Safety Risk**

|  |  |
| --- | --- |
| **Genus (species if relevant)** | **Issue** |
| *Rubus* | Thorny (H&S), Bulky stems (buckling on sheets on top of each other) |
| *Rumex* | Flower detachment |
| *Eucalyptus* | Waxy cuticle (adhesive difficult to apply) |
| *Gentiana* | Long flower head and short body, important not to impede the flower when mounting but the length of the flower makes it more vulnerable to damage |
| *Pinaceae e.g. Pinus, larix, Cedrus* | Needle detachment, bulky |
| *Rosa* | See *Rubus –* spiny, thorny stems |
| *Cirsium* & *Carduus* | Spiny leaves and stems; bulky and fragile seed heads |
| Ferns e.g. *Dryopteris, Athyrium* | Large – often needing two or more sheets. Fronds often wider than sheet.Risk of cross-contamination of spores on brushes (if using adhesive) |
| *Asteraceae –* many genera esp. *Taraxacum, Hieracium* | Flowerheads often go to seed on pressing/drying of specimens. Taraxacum and Hieracium leaves are flimsy. |
| *Lemna* | Very small nature of plant makes it difficult to handle/separate out. |
| *Charophytes* | Fragile  |
| *Papaver* | Very thin petals |
| *Carex arenaria* | Sometimes long rhizome attached |
| Bracken | Re rhizomes see above – v.bulky, lots of spores, often very large and so several sheets needed |

* 1. **‘Awkward’** plants when mounting

|  |  |
| --- | --- |
| *Typhaceae* | Like *Asteraceae* above – flower heads can go to seed during or after mounting with change in humidity |
| *Poaceae* | Often large amount of material ‘intertwined’ – sometimes delicate to separate. ‘Bends’ made during pressing can be weak breaking points. |
| *Iridaceae* | Delicate flowers |
| *Cactaceae* | Bulky and spiny. Need to be well prepared during drying (flesh removed) |
| *Palmaceae* | Bulky. Need cutting for continuation sheets |
| *Chara, Nitella, Tolypella* | Fragile – break easily |

|  |  |
| --- | --- |
| Zingiberaceae | Bulky roots and fragile flowers |
| Epilobium; some Apocynaceae | Seed pods can expand and open after mounting |
| Gesneriaceae | Base of plant can be bulky, with fine stems and fragile flowers |
| Potamogeton; Utricularia | Very fine, friable stems |
| Rhododendron | Leaves can be brittle and curl if not well pressed, making them difficult to secure.  |
| Acacia | Very small leaves which detach easily |

1.2 List of Plants that present a health and safety risk to users? Eg Malus, Prunus, Sorghum especially?

|  |  |
| --- | --- |
| Genus/Species | Common Name |
| Antiaris toxicaria | Upas tree |
| Senecio jacobaea | Ragwort |
| Heracleum mantegazzianum | Hogweed |
| Conium maculatum | Hemlock |
| Aconitum napellus  | Monkshood |
| Actaea |  |
| Atropa |  |
| Daphne |  |
| Datura | Thornapple |
| Digitalis |  |
| Euphorbia |  |
| Hyoscyamus sp. | Henbane |
| Rhamnus |  |
| Rhus |  |
| Scilla |  |
| Solanum |  |
| Cyanogenic genus (Cyanide containing) |  |
| Malus |  |
| Pyrus  |  |
| Prunus  |  |
| Sambucus |  |
| Linum |  |
| Sorghum  |  |
| Alelanchier |  |
|  |  |
| Skin irritants |  |
| Aconitum sp.  | Monkshood |
| Actaea | Baneberry |
| Alstromeria |  |
| Atropa |  |
| Chrysanthemum | Marigold |
| Daphne |  |
| Datura | Thornapple |
| Euphorbia |  |
| Hedera | Ivy |
| Rhamnus |  |
| Rhus and other Anacardiaceae |  |
| Mucuna |  |
| Photosensitive |  |
| Hypericum perforatum | St. John’s Wort |
| Ruta sp. | Rue |
| Heracleum mantegazzianum | Hogweed |
| Asparagus sp. | Asparagus Fern |
| Ficus | Fig |
| Physical H and S |  |
|  |  |
| Rubus sp. |  |
| Urtica dioica |  |
| Rosa sp. |  |
| Cactaceae |  |
| Pteridophyta spores, esp. Pteridium aquilinum |  |
| Fungal spores |  |

**Appendix 2 Pest infestation indicators**

Genera that are particularly prone to pest attack

*Asteraceae*  - esp. *Taraxacum* & *Hierarium*

*Apiaceae*

All Fungi -

*Lichen*

*Lactuca sp*

*Brassicacea*

*Ranunculus*

*Rosa*

*Fruit woods*

*Sweet Chestnut*

*High pollen/protein*

*High sugar/nectar/sapwood.*

 **Appendix 3 stages in Design and folding a Bryophyte storage container**

 

**Appendix 4 Identification of Historic Aqueous Stains on Herbarium Sheets**

**(Purewal 2008)**

**Recommendations**

Suspect **all** organic material such as textiles, natural history and ethnographic collections dated 1986 and earlier as having been treated with a pesticide.

Speak with a member of staff from the Health and Safety Laboratories

<http://www.hsl.gov.uk/> hslinfo@hsl.gov.uk Tel No: (+44) 01298 218218

 They are able to provide the same service as an occupational hygienist. This includes:

* Visiting the area, monitoring for atmospheric pollutants and swab testing areas for contaminated surfaces and dusts
* Providing personal monitoring equipment which allows for measuring contamination within the breathing zone during normal working practice
* Arranging the necessary biological monitoring with relation to the type of contamination and the nearest medical centre
* Carrying out all of the analytical work and interpreting the results
* Advising on personal protection equipment (PPE) and the necessary fit testing

Unfortunately this is not a free service and so in the meantime immediate measures should be implemented such as:

* Applying a barrier cream such as Derma Shield, lasts for 5 hrs even after repeated hand washing.
* Wearing of nitrile gloves (powder free) an excellent barrier to the majority of historic pesticides. After use the glove should be removed by pulling inside out without contaminating the clean hands and thrown away
* Wearing of lab coats only in the contaminated zones
* Ensuring areas are well ventilated before commencing work
* Limiting time working on suspected contaminated collections
* Stopping close work such as working with a hand held lens and using a microscope.
* Carrying out as much work as possible within a filter fume cabinet
* Not consuming any food or drink within areas containing specimens
* Washing hands after handling material and before eating, drinking, smoking or applying make-up

**Appendix 5 Styles of Mounting Herbarium Specimens**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Style of Mount | Strap | Pinning | Point adhesion | Full Adhesion | Packets (archival) | strapping and Adhesion | Loose | gelatine capsules | (paper) strapping | Strapping plus point adhesion |
| Adhesive/Mount material |   |   |   |   |   |   |   |   |   |   |
| PVAc |  |   |   |   |   | [[21]](#footnote-22)NHM161515151515 RBGE |   | NHM |   |   |
| Gelatine(medical) |  |   |   |   |   |   |   |   |   |   |
| CMC |  |   |   |   |   | NML[[22]](#footnote-23) |   |   |   |  NML[[23]](#footnote-24) |
| wheat Paste |  |   |   |   | AC-NMW[[24]](#footnote-25) |   |   |   |   |   |
| pH Neutral adhesive |  |   |   |   |   | NML |   |   |   |   |
| Insinglass |  |   |   |   |   |   |   |   |   |   |
| Animal Glue |  |   |   |   |   |   |   |   |   |   |
| Gelatine coated paper |  |   |   |   |   |   |   |   | NMW |   |
| gummed paper |  |   |   |   |   |   |   |   |   |   |
| Brand Adhesive (name) |  |   |   |   |   |   |   |   |   |   |
| No adhesive (folded) |  |   |   |   | NHM, NML |   |   |   |   |   |
| Linen tape with gelatine adhesive |  |   |   |   |   |   |   |   |   | AC-NMW, NML |
| EVA |  |   |   |   | AC-NMW |   |   |   |   |   |

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**Appendix 7 Project workshop Team**

Chris Collins Conservator, Natural History Museum. Coordinator of Standards Projects

Jonathon Gregson Collections Manager, Flowering Plants

Jovita Yesilyurt Collections Manager, Algae, Lichens, Protists, NHM - Currently undertaking research on plant-mounting

Sherry Doyle Freelance Conservator organic artefacts conservation – botanic materials and basketry

David Jacobs Paper Conservator. Working on plant based materials, use of wheat start paste, EVA– NON-ADHERED attachments

Tim Rich AC-NMW Researcher. Currently working on Infraspecific flora of the British Isles, curation and documentation of the herbarium, and standardised botanical recording. Interests include;

* UK Plant taxonomy
* UK Plant ecology, UK Plant distribution
* Environmental impact assessment
* UK Rare plant conservation
* UK Vegetation and Monitoring

Dr Victoria Purewal Accredited conservator of botanical specimens and related material. Employed at AC-NMW since 1990, main areas of specialism include identification and quantification of historic residues on specimens, with expertise in this field, conducting condition surveys of botanical collections, re-mounting glued and sellotaped specimens, packaging and cleaning of large objects including Wallace Palms, conservation of bound herbaria, prints, drawings, timber, archive and wax models. Consultant for several key botanical institutions, and co-leading on the NatSCA Care of Botanical Collections workshops with Donna Young.

Donna Young (DY) Curator of Herbarium; World Museum (LIV), Liverpool. Background in paper conservation - remounting of historic collection of plants from the late 18th/early 19th century. Particularly interested in the methods employed in the preparation and preservation of botanical collections, investigating the practice of different herbaria. Carried out consultancy work for various British institutions, as well as demonstrating and talking about herbarium techniques in the UK and overseas. Co-developed and deliver modules on the NatSCA training workshop 'Caring for Botanical Collections'.

**Appendix 8 Training Course and Syllabus**

Any training scheme should be a mix of theory and practice

- theory first and then practical PM

2-days with an optional third day for practical

What about on-line modules for some topics? See eg RBGE Propagate website offering blended learning courses: <http://www.rbge.org.uk/education/home>

Topics to be covered

1. What is a Herbaria
2. Collecting
3. Health and Safety
4. Material science of plants and papers
	1. Fibres, weights, grain, face, strength
5. Understanding importance of labels
6. Conservation Grade Materials
	1. Adhesives use and material
	2. Papers and Cards
7. Correct Handling techniques and procedure
8. Mounting Methods
9. Storage Furniture
10. Environmental Control and Conditions
11. Remounting and Cleaning
12. Principals of Paper Conservation
13. Best Practice
14. Pragmatic Approach
15. Bibliography and resources

Notes

**Is spirit collection section to follow ?**

**Spirit collection – will there be recommendations for a good fixative for botanical specimens which doesn’t contain formalin? Will there be up to date recommendations for containers, lids, seals which are available now and from suppliers in the UK?**

Appendix 9 Destructive Sampling Policies

Natural History Museum, London <http://www.nhm.ac.uk/resources-rx/files/nhm_destructive_sampling_terms_and_conditions_and_guidelines-32480.pdf>

National Museum of Natural History <http://www.mnh.si.edu/rc/> (Collection specific)

1. Project Team – Appendix 7 [↑](#footnote-ref-2)
2. Kew cocktail or Kew mixture (formalin, methanol, glycerol and water), now Copenhagen solution which dispenses with the formalin. [↑](#footnote-ref-3)
3. Standardize terminology for herbarium specimens/sheets/mounts etc? e.g. herbarium sheet = mount + plant specimen? [↑](#footnote-ref-4)
4. **Add section with similar recommendations about when repairs/cleaning of specimens are appropriate? And what levels and methods of documentation are appropriate for repaired /remounted specimens?** [↑](#footnote-ref-5)
5. See RBGE video Basic Plant Collecting and Pressing

<http://www.youtube.com/watch?v=2wFN9YmkBOQ> [↑](#footnote-ref-6)
6. (Richard Lester) Botanical Science of the British Isles Hints for Hard pressed collectors [↑](#footnote-ref-7)
7. The coordinating group felt that total adhesion and stitching were not approved methods of attachment. I felt that at the end of the discussion we had come more to agree on strapping and point adhesion with methyl cellulose only and that EVA or PVA were not to be used at all, due to the risk of acid hydrolysis. [↑](#footnote-ref-8)
8. Are there papers on this or is it related to cellulosic material and not necessarily plant specimens? [↑](#footnote-ref-9)
9. Sewing raises several issues, for example the inversion of the specimen to tie off the threads can cause loss of material it is also probable that the specimen will be worked on upside down, where pressure may be applied forcing more unseen damage to the specimen. The threads can also too strong for the specimen and cut into the stems. [↑](#footnote-ref-10)
10. Research area to look at the charophytes [↑](#footnote-ref-11)
11. Project to produce document on indicators of major features [↑](#footnote-ref-12)
12. DNA sampling JY to see if she extracted Hg CL [↑](#footnote-ref-13)
13. RBGE use Premier 4 flap folder, white, 120 gsm archival photokraft, acid free and lignin free (ASTM D1030/ISO302). PH 6.5-8.5 unbuffered [↑](#footnote-ref-14)
14. RBGE use Heritage Museum Board TG off white, 264x420 mm, medium weight 550 or heavy 1100 microns. [↑](#footnote-ref-15)
15. RBGE Species covers are goatskin, 120 gsm. [↑](#footnote-ref-16)
16. RBGE Type covers are 125 gsm, buffered, folded in 4 positions. [↑](#footnote-ref-17)
17. RBGE have trialled use of [Juris expansion folders](http://www.klug-conservation.com/index.php?site=produkte&id=228) (<http://www.klug-conservation.com/index.php?site=produkte&id=228>) for bulky specimens. Generally useful, but initial problems with users refolding incorrectly (so short side in contact with specimen) and lack of consistency in label info written on outer flap. Both solved by stamping boxes with ‘fold this flap first’ and mini form to fill in for label info. Staff have complained that boxes ‘take up too much space’ in overcrowded cabinets(!) . It can also be difficult to maintain strict taxonomic order without placing boxes on top of other specimens; folded card ‘frames’ might help, but would users replace them? [↑](#footnote-ref-18)
18. Wooden cabinets can buffer and protect from fire but steel framed cabinets are becoming the standard for storage [↑](#footnote-ref-19)
19. See CSIP environmental standards 2014 [↑](#footnote-ref-20)
20. Herbarium supply company – adhesive on back to glue fragment capsule down and then put the fragments into the capsule Template for fragment capsule [↑](#footnote-ref-21)
21. NHM: adheres and straps specimens. In the 1970s used a latex. Now use an unident PVAc and Evacon-R. Glue across a sheet of glass and then pull the plant . Paper comes from conservation by design. This is done for Speed and not dealing with the backlog [↑](#footnote-ref-22)
22. Liverpool: 50 a day with training and handling. Use Gelatine/Wheat Paste (animal., Methyl cellulose and strapping. Remounting collections use Lineco pH Neutral adhesive. [↑](#footnote-ref-23)
23. NML – Carboxy Methyl cellulose [↑](#footnote-ref-24)
24. Cardiff: strap a max of 50 a day using a Linen/gelatin tape. Use a Lignin free calcium carbonate buffered, Now 100% rag 220 gsm gelatine size

16 RBGE: adheres, straps and stitches specimens. PVAc applied diluted with tap water approx. 8:1 and applied with small pieces of household sponge. Water-activated pH neutral, gummed paper tape with starch based adhesive (Klug Conservation 067) used for strapping and to cover stitching knots on reverse. Polyester cotton thread used for stitching. Lineco methyl cellulose paste used for remounting. [↑](#footnote-ref-25)