PREVENTATIVE CONSERVATION REPORT

An assessment of one of Svendborg Museum's stores

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1. Introduction

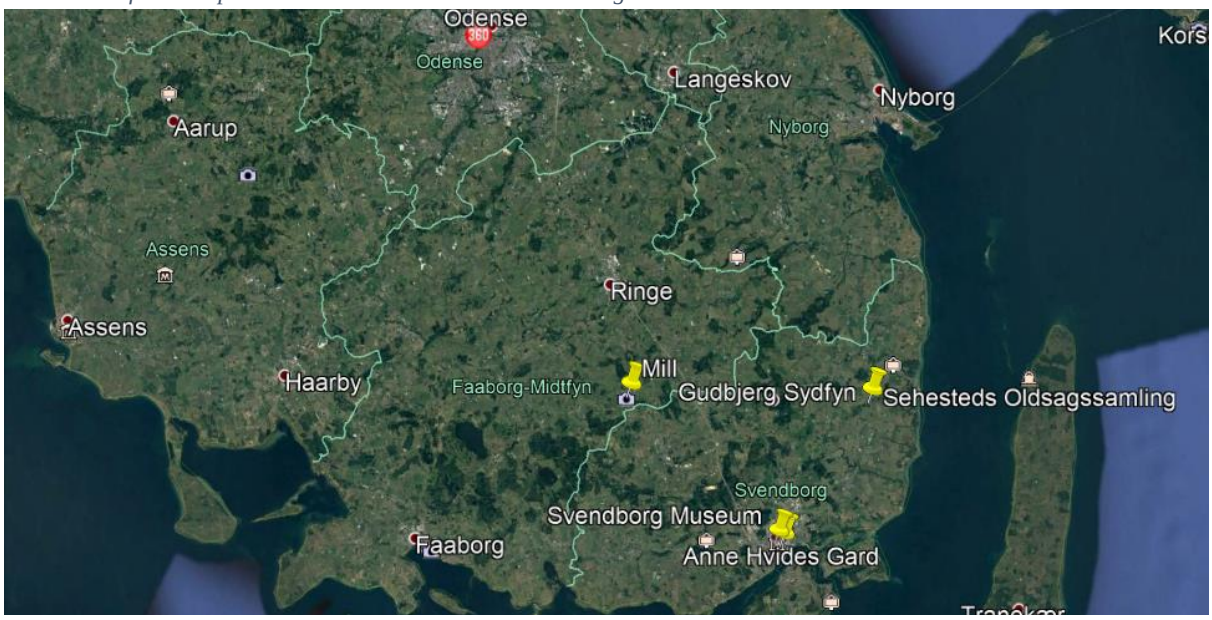
Preventative conservation is increasingly becoming a large part of the conservation discipline and practice (Ashley-Smith, 2018). Its aim is to keep objects in their ideal conditions, thereby 'preventing' damage and decay, by detection and responding to the agents of decay (Caple, 2000: 37). By keeping environmental conditions (Relative Humidity (RH), temperature and light) within appropriate ranges (dictated by material), the risk of damage is minimised (Thompson, 1981; Cassar, 2011). Although environmental control is one of the predominant elements, any effort made to avoid, and block mechanisms of decay can be considered preventative conservation (Caple, 2011: 1-16).

This project will focus on the conditions in one of Svendborg Museum's (SOM) store rooms, though the wider problems associated with the building will be discussed. The aim is to understand why the store has had problems with insects and fungi, and the measures that have been undertaken as a response to outbreaks and prevention of future cases, while also providing suggestions for other improvements that could be made to minimise the risk further.

2. Background and Layout

SOM is the main museum for the Svendborg region on south Funen. It comprises of several components spread across the region (Fig. 1) (Svendborgmuseum.dk, 2018).

Figure 1: Location of the buildings (the Danish Forsorgsmuseum (Social History Museum), Sehesteds Oldsagssamling (Archaeological artefacts collection) at Broholm, Anne Hvides Gård (oldest private house from 1560), Egeskov Mølle (a mill outside the city), Svendborg City History Archives, Svendborg Maritime Archives and 7 ships) under the remit of Svendborg Museum (map generated with Google Earth Pro, 2018 by author). Most of the archives are located with the museum itself. The ships are moored at the marina in Svendborg.



The storage facility holds objects from all parts and is located on the outskirts of Svendborg, (Fig. 2). It makes up most of the first floor of the building, with other businesses located on the floors above and below. The building was originally an apple processing and storage plant (date unknown) (Fig. 3) (Schölch & Hovmand, pers. comm., 2017), and much of the original features (Fig. 4) from this time remains in the building.

Figure 2: Location of the store building in relation to the sea and harbour. The store is located on an industrial estate towards the outskirts of Svendborg. (map generated with Google Earth Pro, 2018 by author)

Figure 3: Exterior of the building (photo of Google Streetview using Google Maps, 2018). There are clear loading bays spaced around the building, and the remains (circled) of a sign indicating that the building originally housed SAF Frugt

Figure 4: Original timber beam in the store room (photo by Simon Schölch). Original features like this may be a problem in the store due to the presence of mould spores that can lie dormant in materials for years (Sterflinger, 2010: 48)

The floor for the store has undergone changes to make it more suitable for museum storage. Much of the floor has been subdivided into smaller rooms to house different parts of the collection, and shelves have been installed in every room. Windows have been blocked off with plywood sheets as they were not water or air-tight. They were later insulated further with drywall (Schölch, pers. comms., 2018).

This report focuses on a single room of the facility (Figs. 5-6), which predominantly houses items from the social history collection, including furniture, tools, toys and work-related items for a variety of professions (a wide variety of materials are present).

Figure 5: Layout of the main store room. The shelves go from the floor to near the ceiling, with the number of shelves varying across the store

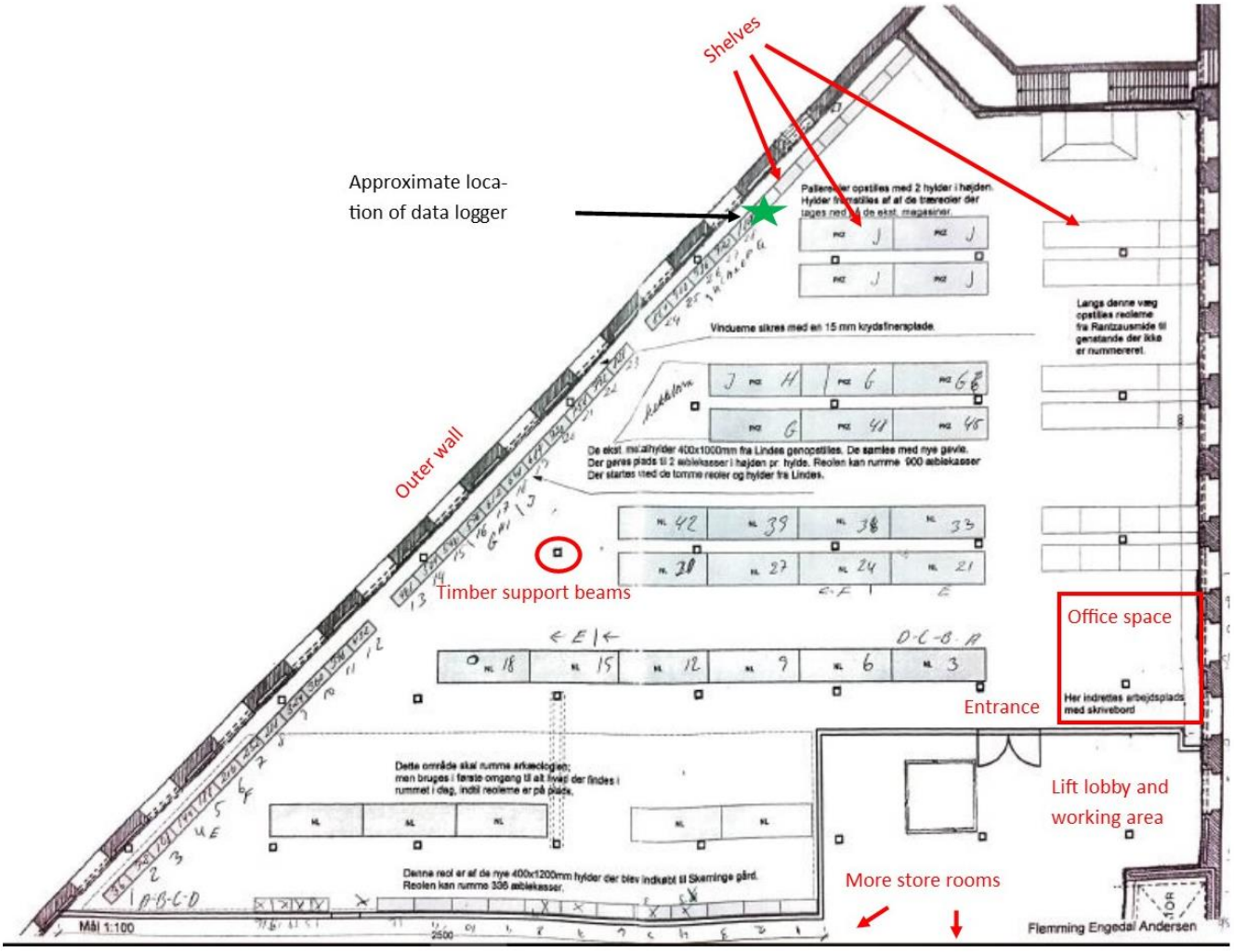


Figure 6: View down one of the aisles of shelves in the main store, showing how things are arranged, and the Tyvek sheets covering some of the objects. The back wall is entirely lined with boxes. Photo by author

3. The Environment

Environmental data is available for the past three years (Figs. 7-9), recorded by the data logger placed by the *Bevaringscenter Fyn* (See Fig. 5). Earlier data, taken by the museum and the *Bevaringscenter Fyn*, exists for odd periods (See Supplementary Data). Though the range varies throughout these periods, the RH appears to mostly sit around 60%, though in the past two years the RH has ranged above this point. The temperature varies considerably with seasonal variation but is typically on the cooler side. These conditions, while good for the processing and storing of fruit (Agric.wa.gov.au, 2016), are not the ideal conditions for storing museum objects (Mecklenburg, 2007). Wood can swell and warp with high humidity and becomes more susceptible to fungi and insects (*Ibid*.: 2), and metals are more susceptible to corrosion (Cronyn, 2005: 201).

Figure 7: Graph showing relative humidity and temperature for 2015 in the main store room in the store

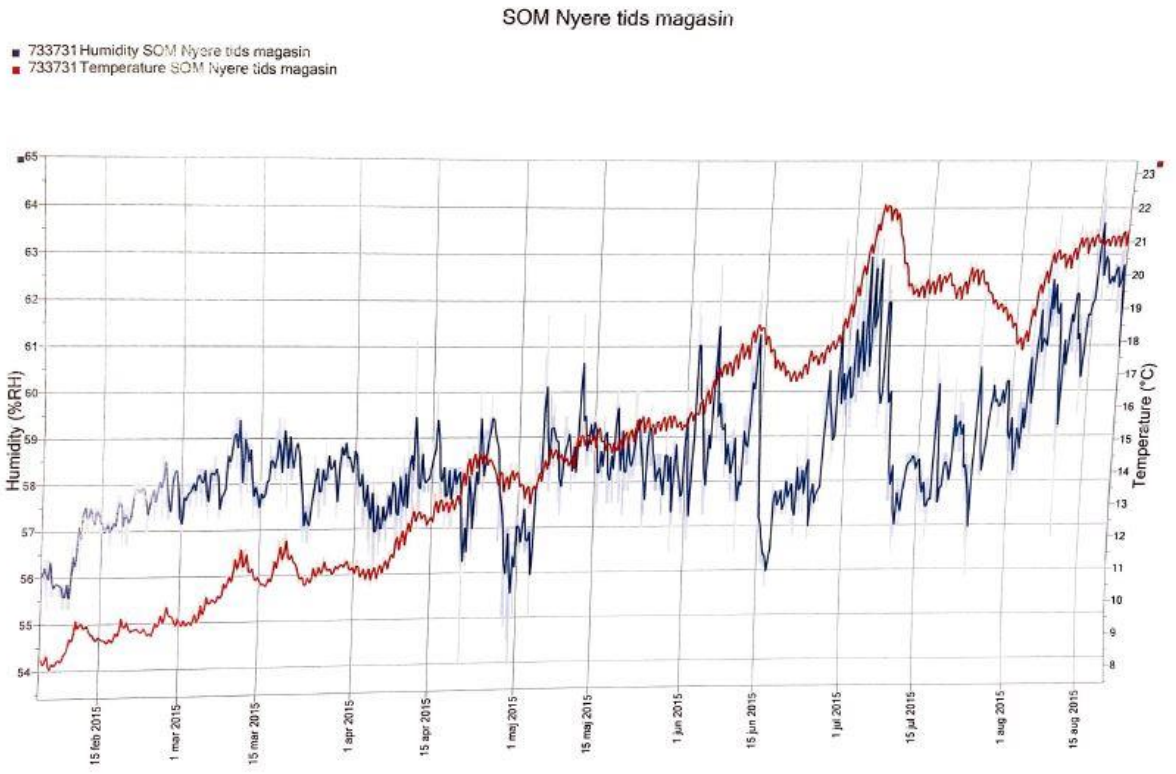


Figure 8: Graph showing relative humidity and temperature for 2016 in the main store room in the store. Note the higher RH compared to the previous year. As the RH sat above 60% for the entirety of the data collection period, it is possible that the later mould problems found in the store developed because of this.

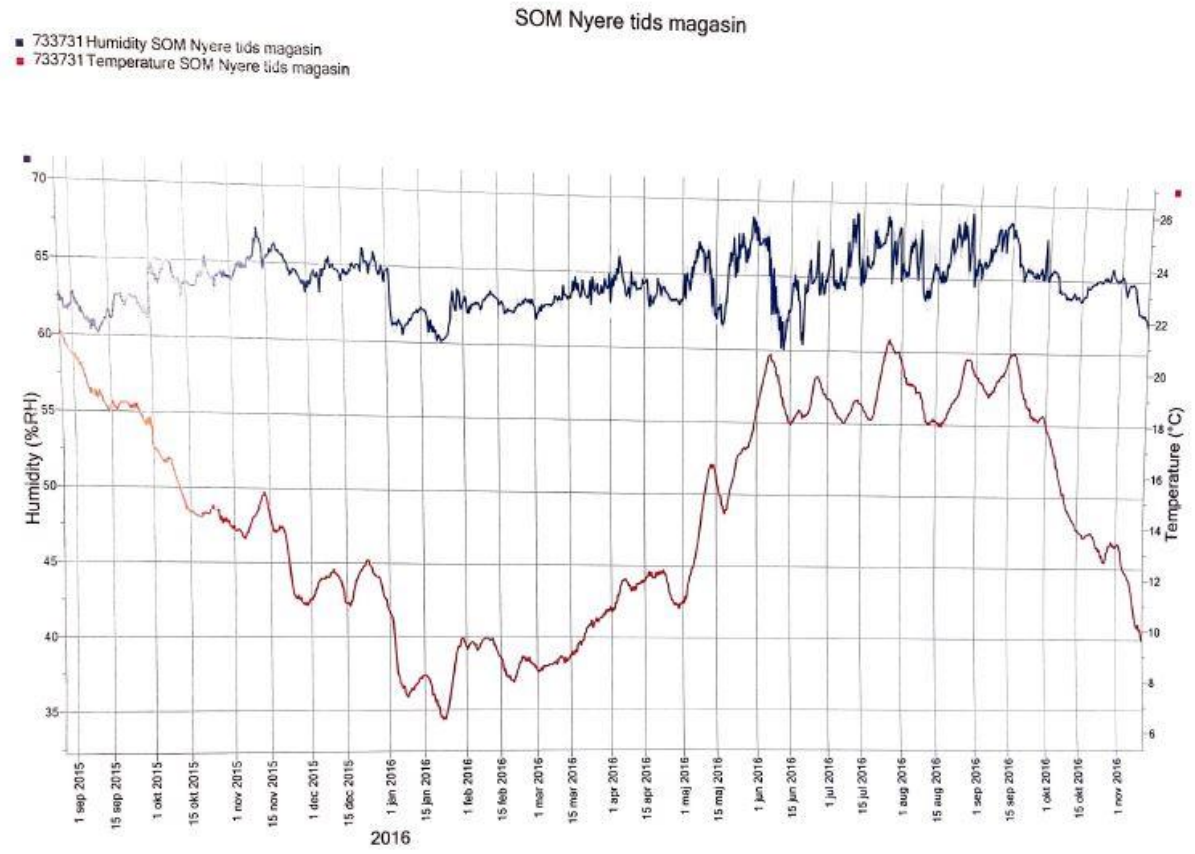
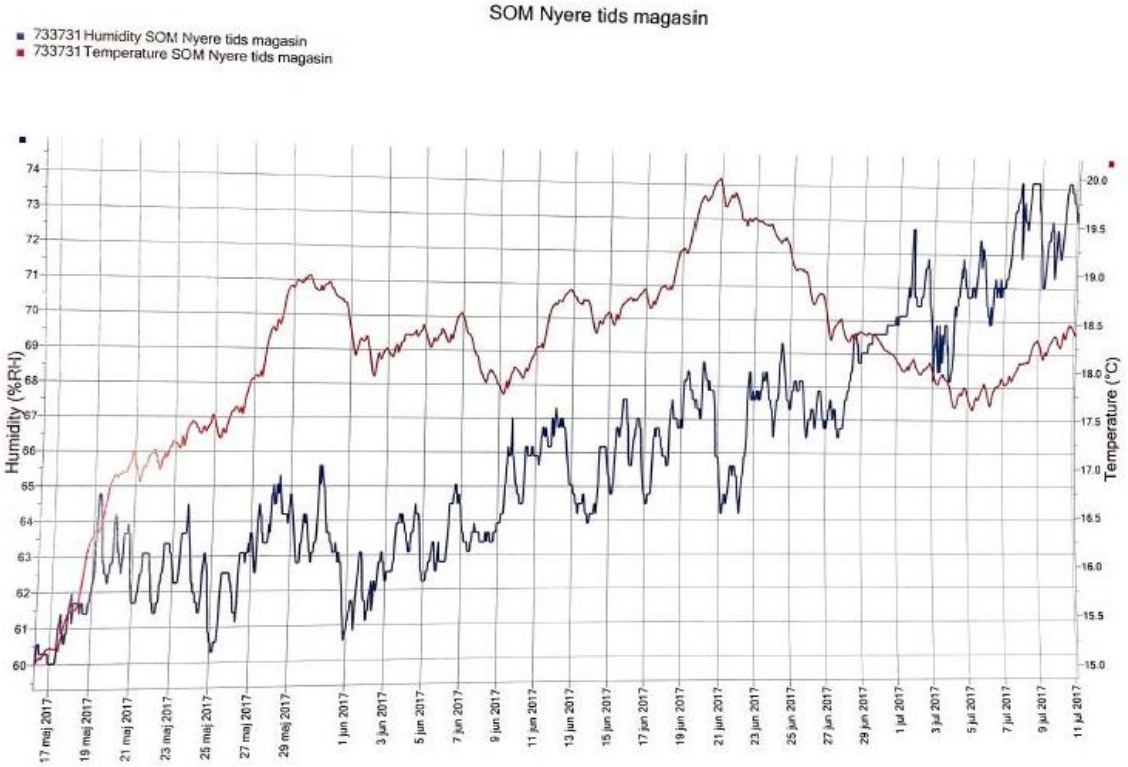


Figure 9: Graph showing relative humidity and temperature for a short period in 2017 in the main store room in the store. The RH continues to be high like the previous year and continues to rise. Though only spanning a few months, the rather steep rise in RH is rather concerning for such a short space of time.



4. Previous problems and outbreaks

The store has had several previous problems with pests. Woodworm (i.e. *Anobium punctatum*) have been noted in the building both in wooden europallets and the original timber beams in 2012 (Schölch, pers. comm., 2018). An infestation of clothes moths (*Tineloa pelionella* and *Tineola bisselliella*) occurred in the main room (on the upholstered furniture) and the textile room in 2011 (*Ibid.*). The textile room had a short-lived issue with silverfish in 2016 (*Ibid.*). There have been several mould outbreaks in the store (*Ibid.*). In the main room, an outbreak along the back (outer) wall occurred in 2012/13 (See Fig. 5), and another, more widespread case occurred in 2017, which took several months to address (*Ibid.*). Another outbreak was noted recently in the archaeology store room, which has yet to be addressed (*Ibid.*). Clearly, the mould problem is widespread, and infected a variety of materials throughout the main room (Figs. 10-14), including several metal objects.

Figure 10: Mould growing on the metal pedal of a knife sharpening machine (converted from a sewing machine). Attached to a bike that belonged to a homeless man from Svendborg who went around sharpening knives for people all over town during the 1960s and 1970s. The storage containers (covered in stickers) contained all his worldly possessions. He was such an important part of town life at this time, that his bike was given to the museum to preserve his memory. It is likely that the mould was growing on some sort of coating that was on the metal Photos by author

Figure 11: Mould growing on a wooden object. Note the amount of dirt and dust build up in the area around the mould. It is likely that the mould began growing on that. Photo by author

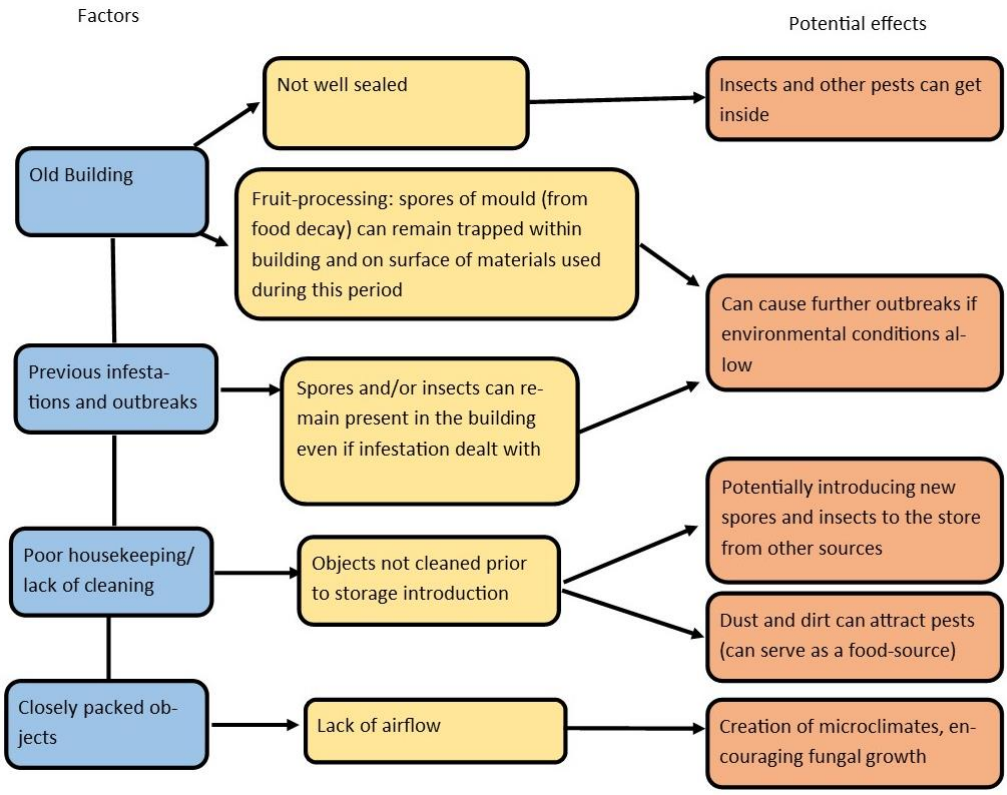
Figure 12: Mould growing on life jackets (textile) in the store. Photo by author

Figure 13: Mould growing on a basketry bowl. Photo by author

Figure 14: Mould growing between metal (iron) panels which assemble to form a stove. Photo by author

Though such outbreaks and infestations may be caused by multiple factors at once, not all of which can be identified, there are several clear influences in this case:

Figure 15: Diagram of the factors behind the store's problems, as well as how they might affect the collection



5. Responses

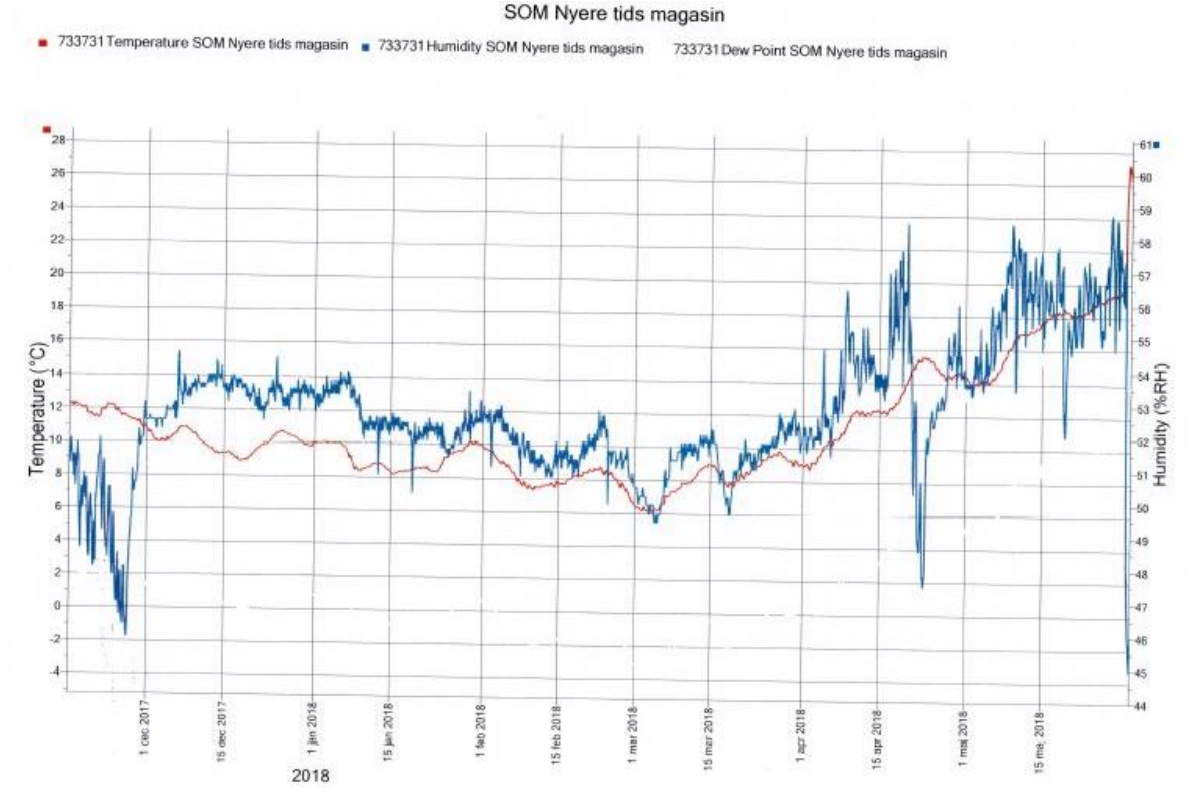
The approach to the moth infestation varied with the room. The textiles and their boxes from the textile store were freeze-disinfected, and the room's fixtures sprayed with K-Othrine SC 25, a deltamethrine, in the hopes that it would kill any of the remaining insects, larvae or eggs (MSDS sheet, Schölch, pers. comm., 2018). Smaller items from the main room were frozen, but the upholstered furniture was too large for the freezer (*Ibid*.). All the pieces were carefully vacuumed, and pheromone traps set out (*Ibid.*). A species of parasitic wasp (*Trichogramma evanescens*) was introduced to the space repeatedly over the course of a year in the hopes of eradicating the remaining eggs (*Ibid.*). These minute wasps, which are harmless to humans and do not damage the material on which they are deposited, lay their eggs into the moths' eggs, and their larvae consume the eggs (Amwnuetzlinge.de, 2014: Nuetzlinge.de, 2018). The wasp larvae will develop and repeat the cycle until no moths' eggs remain (*Ibid.*). The wasps will then die, and their remains can be removed with conventional cleaning methods (*Ibid*.). Though a wonderful idea with minimal health risks involved, this method was

unfortunately not successful in this instance, but the other methods employed appear to be keeping the situation under control at present. The furniture in the main room was subsequently re-arranged to a more open arrangement to discourage the moths and facilitate later inspection, and pest traps were placed for monitoring (Schölch, pers. comms., 2018).

The previous mould outbreak was treated by museum staff and volunteers. The objects were cleaned with brushes, vacuum cleaners and paper towels, then wrapped in acid-free tissue, and packed into new boxes (Schölch, pers. comm., 2018). Those boxes without mould were kept. The complete set of shelves was moved away from the wall, creating an area for air flow. The continued use of boxes that had been close to the mouldy boxes may present a problem, as the spores may remain within the cardboard (Sterflinger, 2010: 48), though at the time of writing, no mould growth has been noted in this area, despite the recent outbreak in the rest of the room. This outbreak was more widespread than the previous (Fig. 16). For the period between 16 Oct. 2017 and 15 Dec. 2017, the author and Simon Schölch spent at least 2 days a week cleaning and treating the mouldy objects in the store (for treatment details see Experimental Report). The cleaning of objects continued well after this period, but occurred in the lab, as the remaining objects were small enough to be easily transported, allowing for more comfortable working conditions and better health and safety for those working. During this treatment period, a dehumidifier was installed in the store. Though only 6 months of data are available since the dehumidifier was installed, a noticeable difference can be seen (Figs. 17). The RH varies less drastically (except for odd spikes- there were some problems with the machine's sensor settings during the first few weeks) than before. In comparison to the beginning of October 2017, when work first began, the air feels noticeably drier and less fusty (as of May 2018).

Figure 16: Diagram showing the approximate spread of mouldy objects across the store, though this does not take into account which shelf the object is located upon. For the most part, one dot represents one object. Though the highest concentration can be found in the lower part (may indicate the origin of the outbreak), there are still mouldy objects throughout the room, indicating a severe outbreak.

Figure 17: Graph showing the relative humidity and temperature data collected between Dec 2017 and May 2018 in the main store room. Except for the beginning and end of the period, the RH appears to be more stable, and the range, rather than being above 60%, is between 45% and 58%, which is far more acceptable for the collection and more likely to inhibit mould outbreaks and insect infestations.



6. Suggestions for Future

With regards to fungal growth, there are three main elements that can be used to prevent an outbreak: climate control, cleaning and monitoring (Sterflinger, 2010: 52). Though the installation of the dehumidifier will help regulate the environment, there are further steps that should be taken to meet the other two elements, particularly given the number of previous problems in the building. Some basic, low-budget steps that could be done by volunteers are:

1. Remove all the boxes and pallets that have been in close contact with mould, and replace them with ones that have not been stored in the building
2. Implement a housekeeping regime with regular cleaning- i.e. vacuuming the room and horizontal surfaces once every few months with HEPA-fitted vacuum cleaners
3. Clean and check objects prior to putting them in the store
4. Rearrange the objects to prevent the formation of micro-climates, where the lack of air circulation may increase the likelihood of mould growth (Sequeira *et al*, 2012: 68). Taking off the Tyvek sheets (originally put on for dust protection) will also prevent the formation of microclimates underneath. Alternatively, fans can be put at strategic points in the store to encourage air circulation.

Some things that should be considered but require more time/effort and bigger expenditure are:

5. Introduction of a quarantine space or area to isolate objects that are showing signs of fungal growth or insect infestation to prevent further spread, and to check those objects being introduced to the collection. This can also be considered an important health and safety step for those working in the store (Pinniger & Winsor, 2004).
6. Introduction of a clear pest management scheme. This will promote the more active monitoring of the store and prevent problems from becoming so widespread before they are addressed, thereby minimising the health risks and the need for more drastic treatments (Florian, 1997: 115). Many of the steps described here, such as regular cleaning and quarantine are essential elements of such a scheme (Pinniger & Winsor, 2004). A sample policy can be seen in the Supplementary Data section.
7. Microbiological monitoring: measurement of fungal spores in the air (air sampling) and of fungal spores on objects and shelves (surface contacts) (Sequiera 2010: 52). The results of this can be used to inform the hygiene status of the store, and allow for the creation of better informed cleaning plans and pest management schemes (*Ibid*.)

8. Finding a way to better seal the building to prevent spores, insects and other pests from entering the building, though this may be made difficult since the store is only one floor of a building with other businesses.
9. An air filtration system to try and reduce the number of spores within the building.
10. Obtaining future Europallets from pharmaceutical company leftovers (are chemically heat treated to prevent insects and mould)
11. Instal transmitting thermohygrographs to monitor environmental conditions in real time.

These steps will also help with the insect problems. Clothes moths prefer higher humidity (Cranshaw, 2007), and woodworm only thrive above 60% (they infect wood with a higher water content) (Querner, 2015: 598-9). By lowering the RH, the likelihood of infestation will be reduced. The implementation of regular cleaning and monitoring as part of a pest management scheme will help with the prevention of a subsequent infestation (Pinniger, 2012; Querner, 2015).

Ultimately, the best thing would be to no longer use the building (Child, 2011, 3), as it is not suitable for the storage of museum objects given all its problems. The presence of other businesses in the building may also introduce factors that cannot be addressed by the museum. Discussions had been in place to have a purpose-built store for all the museums in Southern Denmark (Schölch & Hovmand, pers. comm., 2017). Though the initial outlay would have been large, the long-term running costs of such a building would have been significantly lower, as all museums in the region would have been contributing, and the likelihood of an outbreak would have been reduced (*Ibid.*). For unknown reasons, the plan was not carried out, and SOM continued to use the store it already had, with all its attendant problems. However, if the steps above are undertaken (particularly 1-6) along with the continued use of the dehumidifier, the SOM collection will be at less of a risk of the problems reoccurring.

7. Conclusions

As preventative conservation is becoming an increasingly larger part of the conservation discipline, the analysis of the appropriateness of buildings for museum storage is a task that will be important in future. By looking at the store holistically and the many factors that may present risks to the SOM collection, solutions were proposed to confront these factors within the limits presented by the building itself. The skillset that I have learned during the completion of this report will hopefully help in future preventative conservation projects.

8. Acknowledgements

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10. Supplementary Data

Sample Integrated Pest Management Policy

1. Objective

The objective of this document is to provide a sample Integrated Pest Management Policy for Svendborg Museum *magasin* (store). The policy will focus on the elements than can be performed by museum staff, of which a leader would have to be appointed, as some activities, such as food and plant restriction and building maintenance, cannot be done as the space is rented in a building with several other businesses from a local landlord. The aim of this is to give an overview of some of the methods that may be employed: in an actual policy, further documents with procedures for each element would also be provided.

2. Introduction

Fungi, insects and other pests can cause major problems in museum collections, and the damage is often irreversible. The historic use of chemicals as a method of pest prevention is becoming increasingly less attractive as the health hazards and potential damage to collections are being pointed out. The best method of treatment is to prevent infestations and outbreaks from occurring.

Integrated pest management (IPM) is an approach that takes a holistic view at the many factors that may contribute towards the development of fungal growth and other pest infestations to prevent and manage such events, while also providing a framework should such an event occur. It is preventative, long-term and a low-toxicity method of controlling pests.

3. Pest Management Programme for SOM Magasin

a. Climate Control

i. Temperature

Many pests thrive in temperatures between 20°C-30°C. The ideal temperature for storerooms is 18°C, but this can be too cold for staff working in these areas, though it should be noted that staff rarely work there full time. There is no means of temperature control in the building, however, so not much can be done at this stage in time.

Monitor the temperature of the storeroom on a yearly basis with an electronic thermohygrometer (i.e. TinyTag). Make a graph/chart of the readings of the previous year.

ii. Relative Humidity

Relative humidity (RH) is defined as the relationship between the amount of water in a given volume of air and maximum amount of water that the air can hold at a given temperature. Insects tend to proliferate between 60-80% RH, and mould growth can occur above 60%. The optimum RH range for a mixed material store room is between 40% and 60%, though ideally the RH should be kept constant around 50%. Below 45% could cause structural damage to some objects (i.e. those made of wood), though these conditions would be better for metals.

Monitor the RH of the storeroom on a yearly basis with an electronic thermohygrometer (i.e. TinyTag). Make a graph/chart of the readings of the previous year.

b. Housekeeping

- Regularly clean the collection store thoroughly: Every 6 months
- Check for pests once a month
- Check for mould once a month
- Ideally, clean objects once a year, if not, once every three years
- Regularly check objects for stains and signs of insects
- Check stores for dead insects and remove them (some insects may be attracted to the decaying bodies)
- Check for rodents and their droppings. If found, clean up droppings. Determine a potential point of entry and set traps. Track down nests and set traps.
- Used packaging material should be removed from the building as soon as possible (provides a haven for insects and rodents)

c. Storage Conditions

- Ensure storage areas are clean to prevent:
    a. Insects thriving in dark, quiet undisturbed places and on long undisturbed objects. Dead insects/debris can attract more insects so needs to be removed as soon as possible

b. Dust and dirt can attract pests so build up should be prevented
c. Spare packaging material lying around can make it difficult to detect pests and provide a haven for them, so should be stored correctly. The same goes for other clutter in the store room

d. Likely Pests

Mould/fungi, common clothes moths (*Tineola bisselliella*) and woodworm (several species possible, but *Anobium punctatum* common) are the most likely infestations to occur, as there have been previous outbreaks. The following table, taken from the IPM policy for the Natural Cultural History Museum in Pretoria gives a list of the common biological pests (not including fungi which can affect all materials) that can affect museums, as well as a list of the materials most at risk from them:

Insects	**What they eat in museums**
Cigarette beetle	A wide variety of plant and animal-based materials
Drugstore beetle	A wide variety of plant and animal-based materials
Spider beetle	A variety of plant and animal-based materials
Carpet beetle	Wool, fur, hair, feathers, silk, insect specimens, books and other products of animal origin, e.g. horn
Furniture beetle	The sapwood of softwoods; will infest some hardwoods
Common clothes moth	Wool, fur, hair, silk, dead insects, horn and feathers
Casemaking clothes moth	Wool, fur, hair, silk, dead insects, horn and feathers
Booklice	Feed mostly on mould growing on old books or dead insects, but they can also damage the surface of materials
Silverfish	Paper fabrics- starched or stained material especially-cotton, linen, photographs, book bindings and paste
Other Pests	
Birds	Bird droppings can damage collections; their nests can also lead to insect problems
Rodents	Can cause extensive damage to collections through feeding and stains from their droppings. Their nests also attract insects

e. Pest Control

i. Non-toxic control of common pests

Make the environment undesirable:

- Environmental control to discourage growth
- Physical exclusion
- Physical removal/Good housekeeping

ii. Building Maintenance

- Check all routes into the store area
- Ensure all doors and windows are tightly sealed
- Check water sources in the building at least once a month (insects attracted to damp)
- Wrap sweating pipes with insulation

- Close off unused drains and openings
- Regularly check for standing water on the roof and/or basement

iii. Monitoring

The building

- To ensure no leaks etc. are occurring
- No obvious cracks/access points are letting pests in
- Check dark corners and small nooks and crannies for pests regularly

Pest monitoring

- Place sticky traps to provide information about insect types, possible entry points, insect numbers, habitat and why they might be surviving. Date and number the traps, as well as their location on a floor plan
- Regularly inspect the traps (once a month), making note of the insects present, numbers, life stage, and whether or not the trap needs replacing
- More traps (i.e. every 10m) should be placed in areas where an infestation is suspected, and checked more regularly
- Objects should be checked regularly for mould
- Keep a detailed report of any other evidence of activity, such as live or dead insects, droppings, rodents and other pests

iv. Inspect incoming material

- Ideally, isolate incoming objects away from the rest of the collection until processing takes place
- Examine (and treat if necessary) incoming objects to prevent new pests from being introduced
- Remove all packaging and check for pests. Ideally, discard afterwards, but for environmental/cost reasons, regular treatment of packaging could be considered as an alternative.
- Clean objects with vacuum (may require a net if object is fragile) to remove any dirt and dust that may be on it. Regularly dispose of bag and filter of the vacuum.

v. If pest infestation found

Will depend on the object and the species of infestation, but regardless of these, the following steps must be undertaken:

- The object(s) should be isolated from the collection as soon as possible
- Contact conservators to determine the best method to proceed
- Growths/insects vacuumed with vacuum fitted with a HEPA filter to remove as much of the infestation as possible

- Non-chemical treatments

Controlled freezing, anoxic fumigation (gases or oxygen scavenger), heat treatment, introduction of parasitic wasps

- Chemical treatments

  Attractants (pheromones), fumigants, dry formulations. For mould, objects should be treated with one of the following solutions depending on material type after the growths have been removed

	Chemical Composition	**Applications**	**Application Methods**	**Materials used on***
Rodalon (10% in water or ethanol)	Aqueous solution of benzalkonium chloride (BZK), a cationic surfactant	Commercial cleaner/disinfectant, detergent. BZK in many pharmaceutical and personal care products	Sprayed and/or rubbed in with sponge cloth	Wood, plastics, leather
Preventol ON (1-2% in ethanol)	Ortho-phenylphenol sodium salts	Disinfectants (incl. food handling, commercial, industrial, residential etc.), material preservation, agriculture	Sprayed, brushed on	Metals
Ethanol (70%)	C_2H_6O. Ethyl alcohol	Disinfectant, solvent	Sprayed	Paper, basketry, textiles, leather

f. Summary

As fungi, insects and rodents can cause severe damage to museum collections, infestations should be avoided at all costs. The best method for this, which is also the least hazardous to the collection and staff is preventative measures and regular monitoring.

If an infestation does occur, treatment must be tailored for the specific pest and for the material infected.

Widespread chemical treatments should be avoided except as a last resort.

4. Documentation

Taken from the Integrated Pest Management Working Group Policy Document template:

“A list of the documentation that is linked to the policy may be included in this section of the policy along with 1) other relevant institutional policy documents relating to IPM, collection management, security, etc., 2) procedural documents that lay out the specifics of the policy’s

implementation and 3) other relevant documents external to the institution, e.g. relevant professional standards."

5. **Review**

The policy should be revised every 2 years by the manager of the store to ensure that it is up to date and revised to include any necessary changes that should have arisen during the previous period of implementation. Those involved in the implementation of the policy should be included in this review.

References

Museumpests.net A Product Of The Integrated Pest Management Working Group Policy Document Template https://museumpests.net/wp-content/uploads/2014/03/2-FINAL-Policy_Template.pdf

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Other Environmental Data Graphs & Images of Store