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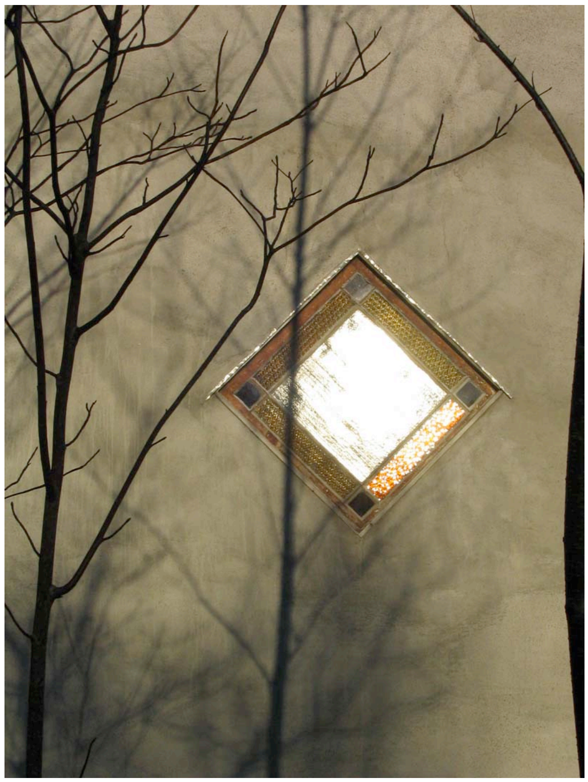

Straw Bale Construction in Atlantic Canada

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Abstract

In this report thirty-four straw bale buildings constructed between 1993 and 2006 in Atlantic Canada are profiled to show best practices, remediation strategies, and project highlights. It is also is also meant to serve as a general resource for people interested in building with bales, and to strengthen the network of people involved in natural building systems across Canada.

Acknowledgements

Voices of the thirty-four straw bale pioneers who participated in this survey resonate throughout the report. Sincere thanks go out to them for their patience and support while sharing their stories, and for their commitment to insuring that best building practices are documented in a public, and inclusive way.

Special thanks for the help, talents and gentle consciences of Heather McKibbon, Sarah Jene, Thea Wilson Hammond, Marley Parker, Zak Miller, Rod Malay, Geraline Blyleven, Mark Pierog, Kiersten Holden, Susanna Fuller, Youki Cropas, Ron Fritz, Steve Mannell, Don Fugler, Athena and Bill Steen, Canada Mortgage and Housing Corporation, Dalhousie University and the Ecology Action Center.

Preface

The research contained in this report paints a picture of the evolution of straw bale construction in Atlantic Canada between 1993 and 2006. It explores and documents the design and performance of bale buildings in the region and, to a degree, the decision making process that led to those designs, by profiling information about the owners, and the nature of the sites on which we find the buildings.

It is the intent of this research to capture some of the best practices that evolved during the first wave of straw bale construction in Atlantic Canada; to observe what worked, what didn't work, and to speculate as to why. It is also is also meant to serve as a general resource for people interested in building with bales, and to strengthen the network of people working in this field.

The information contained in the database provides a base line from which to continue to monitor the thirty-four profiled projects, as well as a means to compare their performance with buildings in other regions.

It is hoped that this report will be a valuable resource for homeowners, educational institutions, contractors and government to understand the viability of straw bale construction in Atlantic Canada. It is also hoped it will help inform a dynamic set of standards that effectively integrate and disseminate innovations and resources for creating healthier, safer, and more affordable shelter that minimally impacts the environment.

1.0 Executive Summary

This report examines the evolution of straw bale construction in Atlantic Canada between the years 1993 and 2006 with the intent of capturing the best straw bale building practices in the region. It is also is also meant to serve as a general resource for people interested in building with bales, and to strengthen the network of people involved in natural building systems across Canada.

Interviews with thirty-four straw bale owners from Nova Scotia, New Brunswick and Prince Edward Island explore the design and performance of their buildings. They also highlight the decision making processes, particularly those tied to site challenges, that led to their respective designs. Complementing the report is a large format map and a database of the profiled projects, as well as a video documentary of the first Straw Bale Builders Gathering in the region.

While only 34 buildings are documented in this report, more than fifty have been identified in the region (pop. 1,832,000) at the time of writing. As many as ten more will be added to the list in 2007 which underscores the significant concentration of bale building activity in the area, especially in relation to Canada wide statistics i.e. Ontario (population 12,500,000) has approximately 150 bale buildings at this time.

Throughout the report owners comment on remediation strategies, unusual features, and tips they would like to share with other builders. The systems described are typical to those constructed across Canada in recent years, with trends towards non-load bearing walls, less pinning and wiring, and a shift towards more earth and lime plasters and/or rain screens. There are a few examples of bales being used for floor or roof insulation. The majority of buildings in the report average 1,500 - 2,000 sq. ft. (139-185 sq. meters) in size.

Accurate observations on energy consumption were difficult to establish as the majority of the buildings use wood either as a primary or secondary heat source.

Information was gathered on the notorious gang of three: fire, rodents, and rot. None appeared problematic as long as precautions were taken to minimize fire risk, rule out access for critters, and build in excellent detailing to avoid moisture problems. There are a number of examples where all of the above precautions were not applied, and remediation strategies were employed to address problems that arose. Indicative of the resilience of straw bale building, these strategies have been remarkably successful.

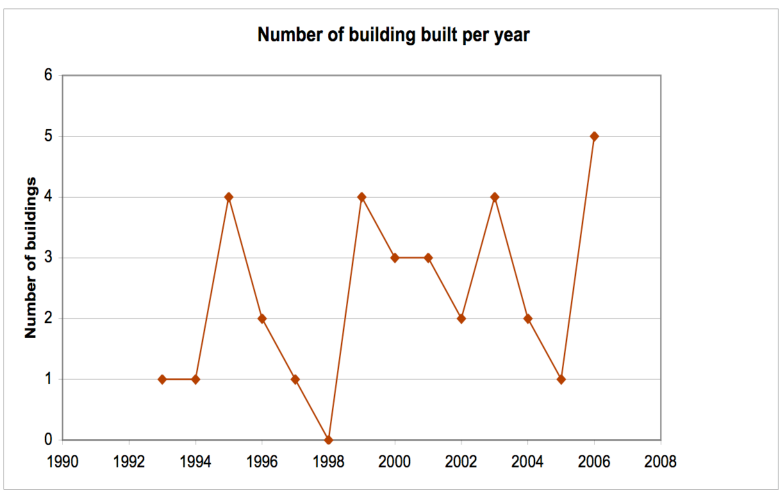
2.0 Introduction

Throughout this report references to specific projects, or comments by someone interviewed from a particular project, are noted by a single number in parenthesis. This number refers to the profile identification number in the database. Complete profiles are found in Appendix VII.
In addition to the report, a 3' x 3' map of the region surveyed, with the thirty-four projects located on it. and a 24 minute video documentary DVD on the first Atlantic Straw Bale Gathering are also attached.

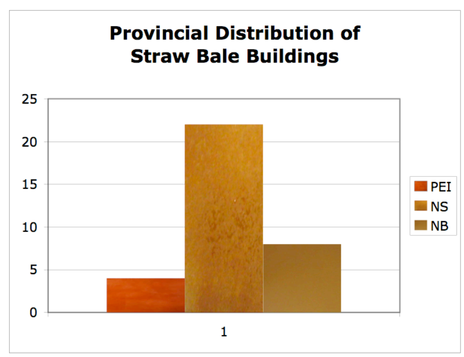
3.0 Background of Straw Bale Construction in Atlantic Canada

The first straw bale building in Atlantic Canada was constructed in 1993 in Ship Harbour, Nova Scotia. Over the next thirteen years another fifty-four buildings including large and small homes, sheds, studios, garages, a youth centre, and barns were built. While each of these projects was unique, design details and building strategies were often directly informed by learnings gleaned from earlier projects in the area.

Communication of these learnings, in the busy lives of owner/builders has often been sporadic, with information readily shared in "hot moments" of trouble shooting during the course of a build, but once the dust settles intentional conversations about what worked has often been missed. The network of people interested in straw bale, and natural building, is growing rapidly however, and it appears that a regional straw bale association will be in place sometime in 2007 to replace a Straw Bale Builders Association that was active from about 1994 – 1999.



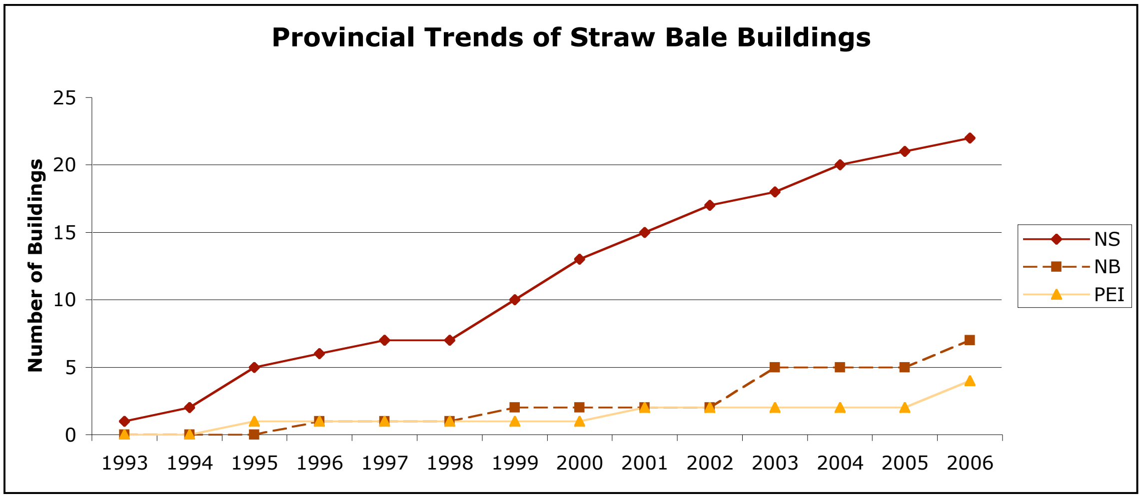
Graph 3.1



Graph 3.2

While the earliest bale buildings were constructed in Nova Scotia, in the last five years Prince Edward Island and New Brunswick have seen an increase both in the number of starts, and general interest in straw bale construction.

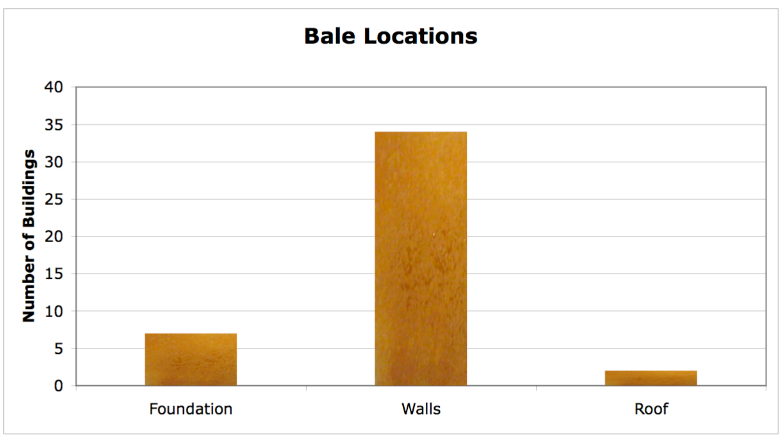
At the time of writing there were no known bale buildings in Newfoundland.



Graph 3.3

The range of methods for using straw bales in building systems in Atlantic Canada has varied according to budgets, site specific characteristics (particularly the intense climatic conditions of the region), and the experience each of the builders brought to their project. Straw bales are primarily found in wall systems, however seven of the buildings profiled also used bales to insulate foundations, and two used them as part of a green roof strategy.

See also Appendix VI for general information on straw bale construction and related resources.



Graph 3.4

System	# Projects
Timber frame	15
Stick frame	11
Load bearing	7
Honeycomb matrix	1
Total	34

3.1 Regional Climate Information

Weather in Atlantic Canada varies considerably depending on elevations and proximity to the ocean, with coldest temperatures found in north central New Brunswick and more moderate ones along the coasts. Intense freeze thaw cycles generate demanding building conditions, as do frequent big winds that bring driving, horizontal rain. Mean temperatures range from -7°C, in the winter, to +20° C, in the summer. Annual precipitation amounts vary from province to province averaging around 152 cm. (60 inches).

Detailed weather information is found in Appendix III, Climate Information for Atlantic Canada.

4.0 Methodology

4.1 Project Design

A preliminary investigation through letters of inquiry, telephone calls and conversations with builders in the natural building field identified approximately 30 sites where bale buildings had been constructed since 1993. Additional projects emerged once the study was underway. Letters of introduction were sent out to the home owners, and an interview arranged which consisted of a site visit to photograph, and examine the buildings, and complete the questionnaire.

The format and questions were developed by:

1. Examining surveys of similar nature, particularly ones which had been created by Sustainable Sources [1]and the Ontario Straw Bale Builders Association[2].
2. Reviewing drafts of the proposed questions with participants, to see if they reflected the kind of information they might have sought out for their projects
3. Consulting with building professionals in the straw bale world, to determine what information would be most relevant to them.

Some of the many challenges inherent in a project of this nature, where data is acquired through personal interviews, include:

1. Memory: relying on the participants' recollection of events, which are sometimes many years past; or in some cases interviewing someone who had not been involved with all aspects of the build.
2. Time: the intent of this research was to connect with as many straw bale projects as possible, and the time required of the participants, and the interviewer, for data collection was much greater than anticipated.
3. Interpretation: of both soft and hard data. Because the range of building experience amoung those interviewed there were occasionally misunderstandings of the terminology and systems used.
4. Logistics: given the distances between projects, it was not possible, in every case, to coordinate site interviews. Phone and email were reasonable alternatives to fall back on, but details were not as flushed out as they might have been in person.

Comments: In response to these challenges, data collected was reviewed with the participants during a follow up phone interview to confirm that original data was as accurate as possible. Efforts were made to insure that language used to describe the projects was simple and not jargon heavy. While it was not possible to associate a site visit with every interview, wherever possible regional visits were clustered together to further local building networks.

4.2 Database Design

File Maker Pro 7 [3]is the software program used to catalogue the survey material. About half of the interviews were also tape recorded and subsequently transcribed. File Maker Pro is a simple program to learn, and provides a very effective way to catalogue and search many kinds of data.

One of the biggest challenges of creating the database was that the framework of the survey continued to evolve as the project unfolded. During the course of the interviews, gaps in information, and better ways of structuring the questions revealed themselves, which meant returning to participants to confirm information, in some instances, more than once.

[1] www.greenbuilder.com
[2] Ontario Straw Bale Builders Association: http://www.strawbalebuilding.ca
[3] File Maker Pro 7: www.filemaker.com

All thirty-four profiles in the database appear in Appendix VII. The database was designed in such a way that it could be easily:

1. Updated to include new projects in Atlantic Canada
2. Transferable, and easily replicable in other regions, with purchase of File Maker Pro. How layouts will be shared is still to be determined, but it is hoped that they will be put to further use wherever there is someone willing to collect the information.

The database was designed to contain a certain amount of “soft data” which, while much of this information could not be included this report, none the less it remains available for other types of research. This is where the stories, and the deeper history of straw bale construction is recorded – it is here that one may find clues to many of the “why” questions.

4.3 Site Visits

Site visits to projects generally included an examination of: foundation, walls and roof, as well as window and door details. In addition to data collection the one-on-one visits with owners served to strengthen the straw bale network by validating, and supporting the experimental nature of the projects. They also connected owners with up to date resources, techniques and remediation strategies that they may not have been aware of.

Due to the personal nature and length of the interviews, use of a tape recorder helped capture valuable information that could get missed through note taking. Site visits lasted between 1.5 and 3 hours, while phone interviews were completed in 45 -90 minutes. Unfortunately phone conversations could not be recorded.

> ***“People that have no experience building are sometimes able to understand the principals and opportunities of working with straw more freely than those whose daily work it is. “*** **(101)**

4.4 Moisture Meter Readings

It was the intention of this project to test bale walls during site visits for moisture content. A digital Protimeter[4] was available for this purpose. However of the thirty-four homes profiled, only seven agreed to drilling the holes necessary to make the readings.

Most often owners were reluctant to drill into the plaster out of concern for how the walls would look after. Others thought the test was redundant as they were not experiencing any straw smells, nor evidence of any moisture problems.

As it became apparent that the bulk of the participants were hesitant to have moisture readings taken, I came to be of the opinion that in order to collect accurate moisture data it would need to be done as a separate study. The time needed to drill, measure, discuss and repair each hole would have easily added another hour or more to interviews which were already feeling long, for some people.

I believe that the ground work has been laid, and the majority of owners would be receptive to having moisture readings made on another occasion, given sufficient time to prepare for the task, and with some good strategies in place to repair the holes.

[4] Protimeter, Balemaster. Protimeter Inc., 500 Research Dr, Wilmington MA 01887

4.5 List Serve

There was considerable interest in creating a local straw bale list serve amount participants in the study to enable ease of information and resource sharing. While participants were given information on how to connect to the SB-R–Us[5] and the REPP-Crest [6]straw bale list serves, one of the participants also created an Atlantic Canada forum which, while very quiet at the moment, for lack of a tech savvy “list mom”, promises to pick up once that person is in place. For more information contact Tegan Wong-Daughterty at email: tegan@fallsbrookcentre.ca

Two recently formed natural building groups are: *Valley Greens* in Quispamsis, New Brunswick which meets once a month. Contact Kara Stonehouse at email: kwiggins@unbsj.ca and the Built Environment Committee at the Ecology Action Centre in Halifax, which also meets monthly contact: builtenvironment@ecologyaction.ca.

5.0 Locator Information

One of the primary objectives of this project was to identify where bale buildings exist in Atlantic Canada. The clustering seen on the map that follows is fairly predictable given the interconnectedness of communities in the Maritimes. All of the buildings to date are in rural settings, though not necessarily remote. Two are in residential developments near small towns.

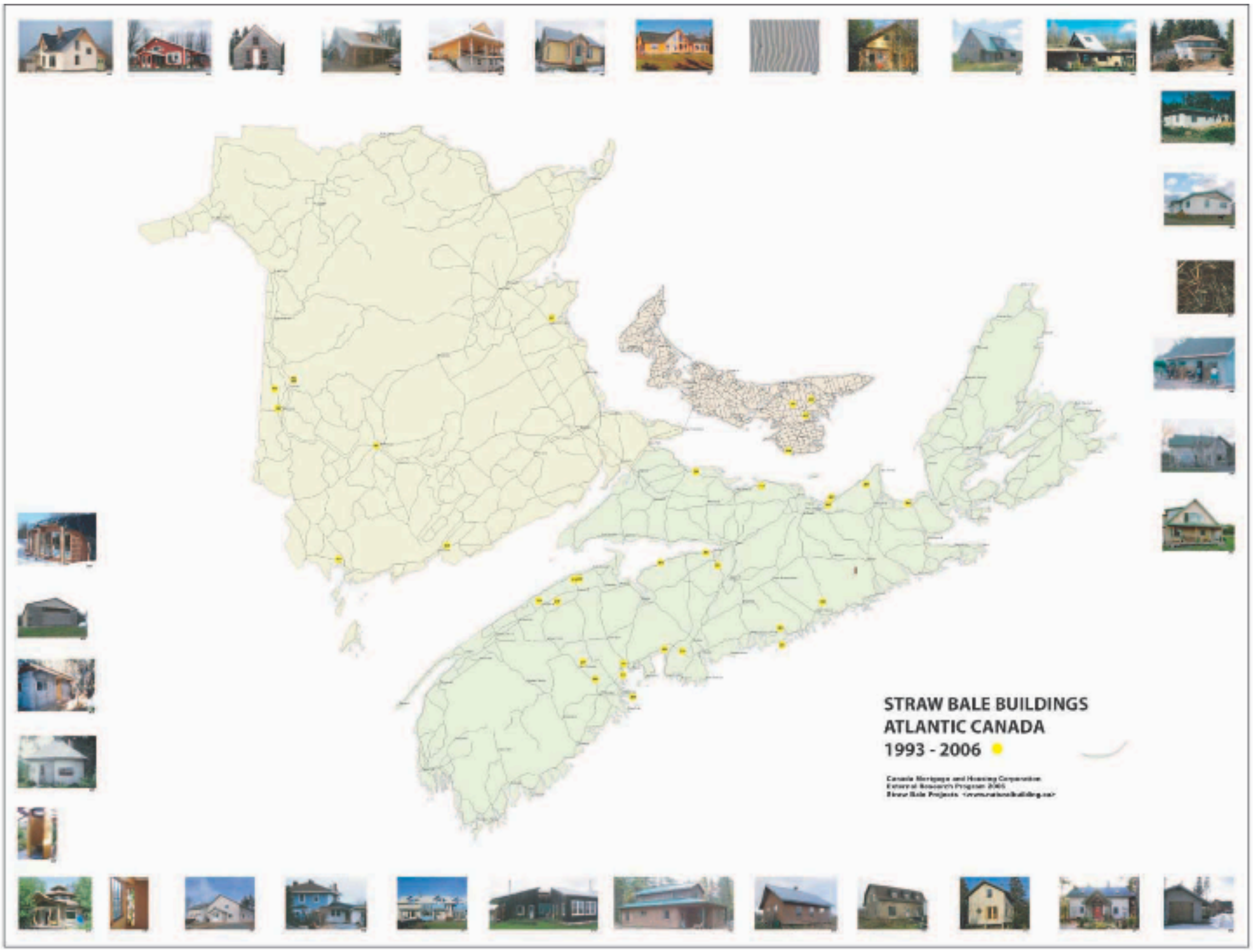
5.1 Distribution of Straw Bale Buildings in Atlantic Canada

A regional map of Nova Scotia, Prince Edward Island and New Brunswick was used on which to place the buildings profiled in the database. Newfoundland was not included as no projects have been identified there.

An identification number on the locator button corresponds to a photograph contained in the perimeter of the map. It also refers to the ID number by which to reference the project in the database.

[5] SB-R-US http://groups.yahoo.com/group/SB-r-us/

[6] REPP-Crest http://listserv.repp.org/mailman/listinfo/strawbale_listserv.repp.org



5.2 Thumbnail Profiles

See Appendix I for summary information and project images.

6.0 Summary of Current Building Practices in the Field

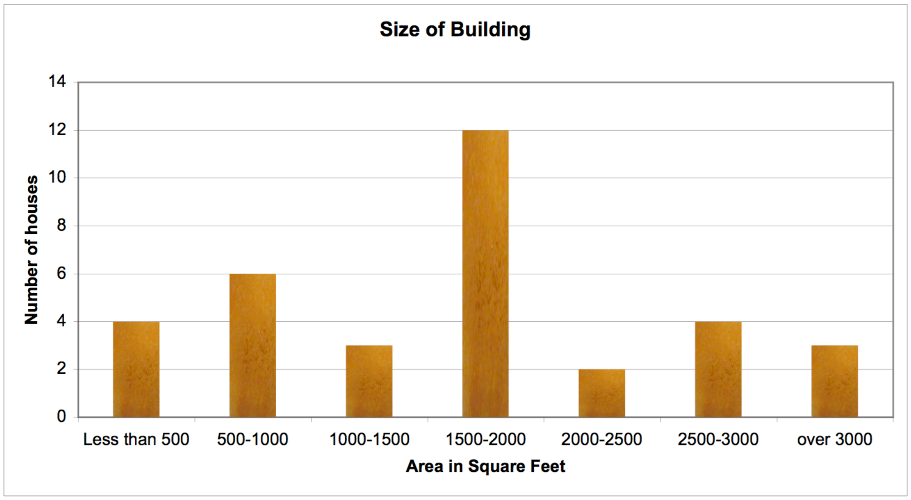
The following notes are based on comments from the straw bale owners interviewed for this study. Some observations may appear so obvious as to not warrant mention, but given that we don't always do the obvious, especially in the throes of a building project, even apparently simple tips have been included.

There is sometimes a fine line between the Notes on Best Practices, and the Tips and Recommendations section which follows. Observations that were common to more than one project, and resulted in a successful long-term strategy were included in the Notes on Best Practices.

6.1 *Observations Relating to Best Practices*

6.1A Bales

1. Search out high quality bales. If at all possible check the batch out yourself. (all)
2. “Know your farmer - be sure they understand the type of bale you are looking for, where possible before they begin their harvest. When this is not possible ask that they pay special attention to quality when they are selecting bales for building i.e. that they are tight, dry and evenly tensioned.” (211)
3. Pre order your bales, ideally in the spring, making them available in August, at harvest time, for wall installation. About two thirds (21/34) of builders in the study purchased bales the fall before their builds began, over wintering them in order to be able to begin (theoretically) much earlier in the building season. This has become a recommended practice, when possible, given the short building season in this part of the world.
4. The down sides of over wintering are that: 1. the bales often end up being handled more, which, when done carelessly can compromise their integrity 2. if there are rodents in the storage facility, they have been known to nip bale strings, which makes for extra work retying before they can be used. (218, 212, 215)
5. “Shelter your bales. Insure that they are up off the ground on pallets or stickers (even if they are sheltered under a roof and up on a slab). Construct a shelter if needed to protect them, and/or wrap them twice as well as you think you will need. If they are going to be stored under tarps only, stack them in such a way that they create a peak, so that water will not pool in the centre of the pile.” (222, 201)
6. “Choose the most local straw obtainable. If available, flax is very tough and rodent resistant, it doesn’t easily decompose on field.” (303)
7. “Avoid using bales that have been rebaled i.e. round bales that have been opened and rebaled square, as the more irregular straw orientation makes for irregular flakes and less “compliant” bales.” (215, 201)
8. “Respect your bales. Take care not to throw them around, and generally use both strings to carry them, in order to not compromise their integrity.” (201)
9. While hay has been used for three projects in the region (216, 303, unprofiled building) it is not recommended, at this time. Hay, in all three cases, was purchased only because there was a shortage of straw in the area. These owners commented that they found hay tough i.e. difficult to use bale needle on.
10. Have lots of extra tarps available and think through how the bales are going to be protected, before they arrive. (all)



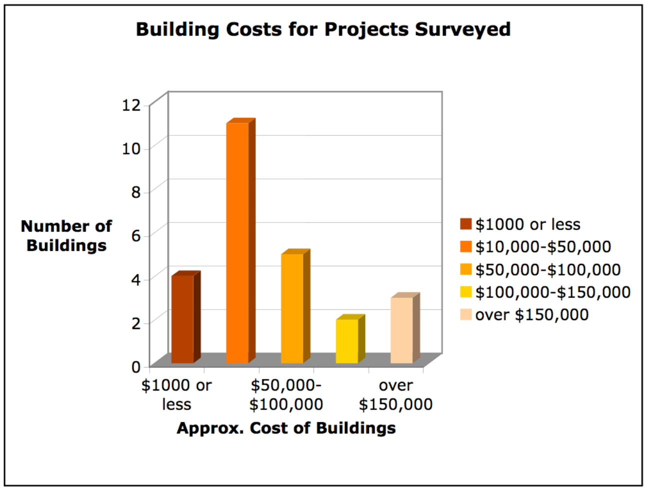
Graph 6.1A

6.1B Design

A few familiar refrains came up in almost every conversation around design, the first three listed below in particular came up many times.

1. Simple designs are most likely to succeed.
2. Do your research, and once a design is roughed out, run it by a designer who has experience in straw bale construction to get their feedback on feasibility and efficiency of the ideas.
3. Keep up to date on best practices. Be critical about information in books, and on the web.
4. "Evaluate which approaches keep you in the sustainable context and pay attention to details that can add unexpected costs onto the project." (106)
5. "Think long term." (203)
6. "Design allowing the availability of local materials to inform material choices."(205)
7. "The most successful projects were those where owners had been able to spend time on the site – connecting with its shape and its relationship to the sun and the local weather patterns. While this is not always possible in the scheme of every construction project, it is possible also to tap into the local wisdom about these characteristics… this applies to both rural and urban builds." (201)
8. For non load bearing buildings, make sure project is roof tight before bales go in. Many builders commented on this, and at least four (106,104, 209, 219, 101) had stories of weather issues that ensued because that kind of detail had not been observed.
9. "Take into account bale dimensions when calculating spaces to be efficient with time and resources." (105, 303)
10. "Include heat sinks/thermal mass wherever possible to maximize solar gain." (204)
11. "Good passive solar design, and building in open areas, where the building can dry out contributes to the overall heath of any structure. (203). On the other hand, some owners selected sites which were much more sheltered by trees or geographical features in order to protect their building from wind driven rain and snow. These buildings did not necessarily have strong passive solar design, but may have been able to tap into wind generation as an energy source." (104, 201, 210)
12. A combination of sheltered site, and great passive solar orientation is optimal. (304, 212, 106, 220)
13. "Rooms can have unusual or round shapes under rectilinear roofs and on standard rectilinear foundations - this can save $$ and make for interesting and functional outdoor spaces. (203)
14. Round exterior shapes contribute to stability of structures." (301, 203)

"The simple design meant that the building went up quickly, and was not difficult to detail."(212)



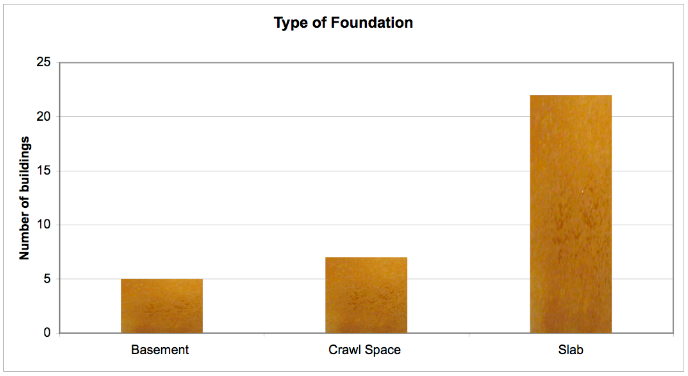
Graph 6.1B

6.1C Hybrids
As bale building design matures, there has been an increase in hybrid systems that use materials which respond to site specific needs. A movement has begun as well away from cement plasters towards cladding systems which contain less embodied energy. This results in buildings that often incorporate a combination of systems depending on the site, and the weather patterns it presents. For example, an exposed site might use wood cladding in the gable ends, and earth/lime plaster on the more protected lower walls (215); or for passive solar design, there might be a non load-bearing bale wall with a southern exposure and lots of glazing, with load bearing bale walls for the remainder of the building.

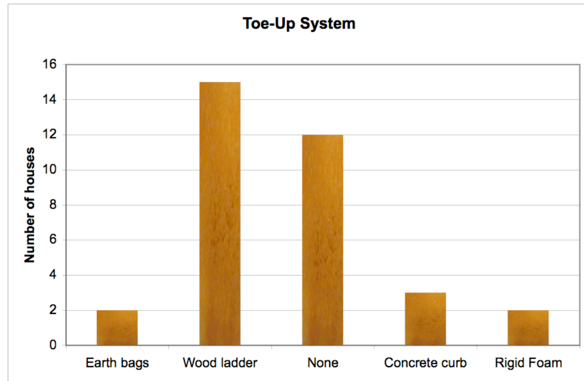

Earth plaster ground floor, board and baton second floor.


Lime plaster final coat (215)

6.1D Foundation
1. “Installation of an insulated curb/toe up is an essential part of any straw bale building even if built on piers.” (201)
2. Insure that the curb has drainage breaks to avoid pooling should there be moisture penetration i.e. several projects in-filled the rungs of the “toe-up ladder” with solid 2’ rigid foam between wood, or used rigid foam itself to create a toe up rather than detailing with drainage in mind.
3. “Placing bales below grade is not recommended without very serious consideration of how to keep water and damp away from them.” (222)
4. “Build the foundation 12” - 18” above grade, according to the site demands.” (222)
5. “Use foundations and floors as an opportunity for thermal massing i.e. a massive granite floor (3’ thick) was constructed using recycled wall facing to act as a heat sink.” (301)



Graph 6.1Da



Graph 6.1Db

"Plan for the unexpected where possible – like floods and fire. Our house had a flood not long ago. A dog knocked the tap open, we returned home to 1" of water in all rooms. The toe up saved us."(216)

6.1E Straw bale slab

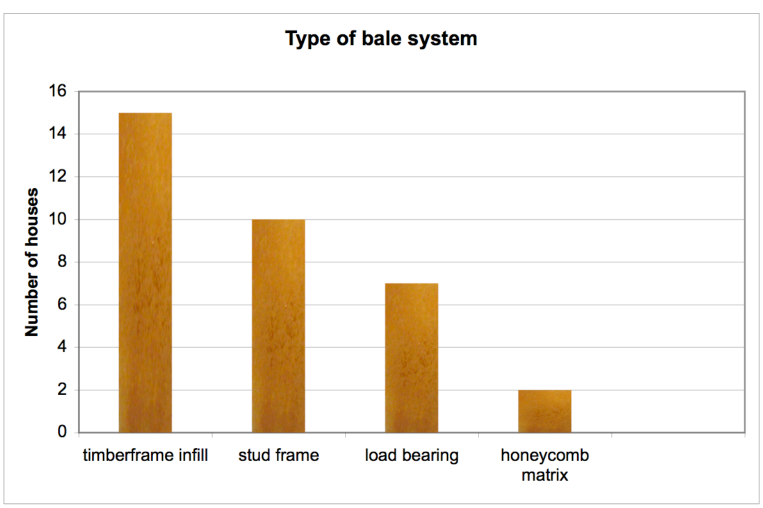
There was only one straw bale slab documented in the survey. The house in this instance sits on two levels where the main level is a straw bale slab and a standard stem wall construction extends the footprint. The slab design consists of a poured 3 inch slab with 180 bales laid in grid pattern on top. A second pour of concrete resulted in a matrix of concrete piers being formed between the bales, a second 3" slab was added on top.

> "The straw bale slab hasn't worked as a warm floor However there are no signs of degradation of the straw in the floor to date. To improve comfort levels a wood floor with one inch rigid insulation between it and the slab was added as our family grew to include children."(203)

In hindsight owners would have installed a shallow insulated slab with radiant heat. They do not recommend straw bales in a slab foundation, as they found they do not mitigate the cold sufficiently for the amount of work and material needed.

6.1F Walls

Of the 34 buildings profiled seven of these are load bearing structures and of these, most were built before 1999. The trend is currently towards infill systems, and away from load bearing. This seems due to a growing appreciation of the challenges inherent in building load bearing structures in a wet climate. Despite this, interest in load bearing systems remains. Perhaps some of the thinking around weather sensitive logistics associated with load bearing construction could look to work done in this area in the United Kingdom by Amazon Nails.



Graph 6.1F

Comments from the Profiles:

1. Maintain integrity of exterior of bale walls – with as few transitions of materials as possible – where there are transitions, detail the materials so that water will not find a easy path into the walls and so that the plaster can respond evenly to differential temperature swings. (213, 202, 101)
2. All of the owners who have experienced moisture issues (213, 202, 101, 201)) due to cracks or deteriorating plaster, thought that, given the wind driven rains on their sites, wood siding those faces of their buildings would have been an excellent strategy. Others who had designed in wood siding from the beginning, have been very happy with that system. (102,105,107, 216, 204)
3. Insure lateral and shear loads are addressed in both load bearing and non-load bearing projects, particularly before plaster is added. In one memorable case a rare wind storm caused the whole building to lean to the ground (something that would likely have happened to a stick frame building at a similar stage of construction). The wire cross bracing used in this case was not strong enough, and it works in only one direction (like wood x-bracing) until the plaster is on. A heavier cable system should have been used. (214)
4. Excellent attention to stuffing is essential in straw bale wall construction. Using a combination of flake straw and light straw clay is a good system. Overstuffing can push bales dramatically out of alignment and should be avoided. (all)

"Wood siding on south side would have been a good treatment, given the wind driven rain from that direction." (213)

6.1G Windows:

1. Effective drip edges are essential for all windows. (202, all)
2. Flashing details are extremely important to get right. Wide flashing on all four sides of openings that are not well protected is highly recommended (202)
3. Wood shutters on French doors are a good way help keep in heat. (212)

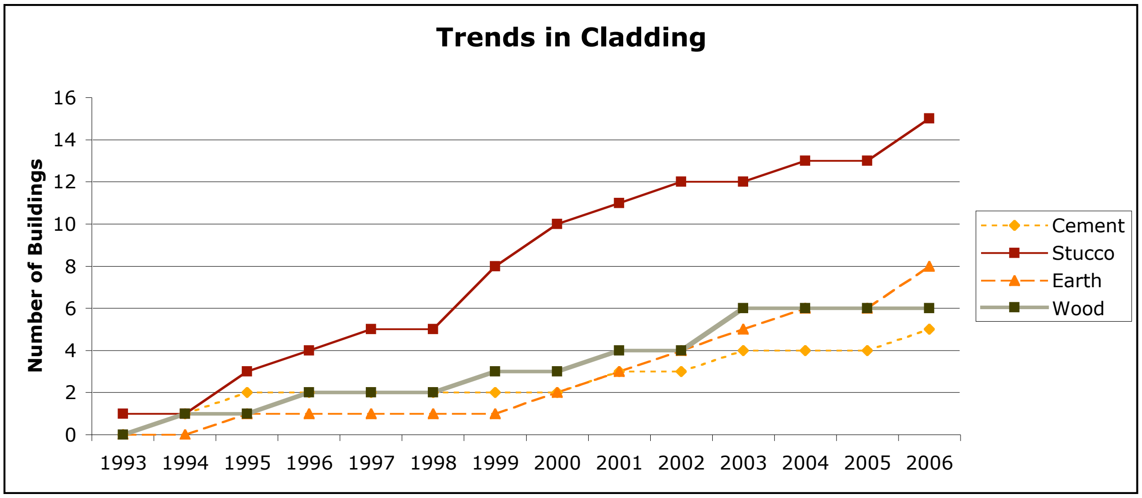
6.1H Finishes

Decisions about finishes, particularly exterior finishes, are a hugely important part of any straw bale project. Unfortunately in many cases details associated with this phase are often left late in the project, whereas if it has been established early on that wood siding, clay or cement plasters will be used, appropriate detailing can be incorporated more efficiently into the project, ultimately saving time and usually making for better construction details.

In spite of the best laid plans, only a couple of projects were able to complete their plastering phase before freezing temperatures set in. Everyone, including those who finished in time, stressed:

1. Start as early in the year as possible to insure adequate drying time. Don't plaster after freezing temperatures begin. It is possible to "horde in" the walls with tarps and add heaters and fans, but there are safety issues, and energy costs that should be balanced with those choices. (215, 101, 202)
2. Test your plasters! was another frequent comment, especially from those using earth and lime.
3. "The addition of cement sped up the drying time considerably however low temperatures likely affected curing and contributed to subsequent delamination of remaining coats in certain areas." (211)
4. "If applying earth plaster, keep the clay soil tarped when not in use, as the combination of rain and sun can turn it into unmanageable "rocks" that take a lot of time to convert it into useable render." (215)
5. "Reinforce transition areas and corners with mesh i.e. metal or plastic, or burlap." (215, 206)

6. "Use earth or earth/lime plasters rather than cement in combination with appropriate design i.e. adequate overhangs or rain screens." (106,101, 221, 201)
7. "Test your plasters!!" (all)
8. "Damp sponging of green plaster makes for a smoother finish, which is less of a dust collector." (205, 203, 209, 215)
9. "Clay rich earth combined with wheat or milk binders works well for interior plasters."(201)
10. "It is essential to have proper mix and consistent water content. Precise measurement of ingredients makes plaster easier to apply. Counting shovelfuls is not the best way as there is too much adjusting of water content (using a bucket method is more reliable)."(301)
11. TEST YOUR PLASTERS. (Was this mentioned before??)



Graph 6.1H

Note for the purposes of this report:
1. Stucco refers to a cement, lime and sand mix, (generally as per masonry cement ratios).
2. Cement refers to a Portland cement with sand mix.
3. Earth is a clay-rich earth, with sand mix.

Many people who used cement plasters echoed the comment that:

> ***"Earth plasters would have been preferable in hindsight for ease of application, repair, and "breath ability". (222)***

6.1 I Rain Screens


(102)


(103)


(107)


(105)

The use of wood cladding as a rain screen has been shown to be a very effective method for protecting straw bale walls from wind driven rain in this region. It is curious to note that rain screens were not always designed in from the beginning. In five cases they were part of the initial design, but in three other cases it was a last minute strategy employed by owners who were caught out by freezing temperatures before the exterior plaster could be completed.
The addition of full or partial rain screens has also been a remediation strategy in four cases for walls that were damaged due to precipitation.

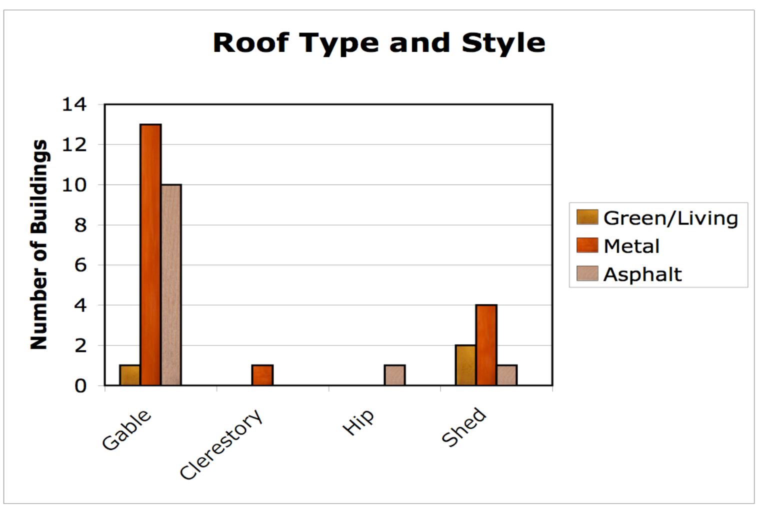
Finally, the addition of rain screens in the form of verandas and "mud rooms" has both increased the functionality of living spaces, and added extra protection to vulnerable walls for five more projects. A total of half, (or seventeen) of the thirty-four projects have wood elements in their exterior finishing.

Rain screens	# Projects
Designed in from the start (102,215,103,203,204)	5
Last minute choice before freeze up (105,107,216)	3
Additions i.e. mud rooms (201, 106, 206, 205, 211)	5
Remediation for damaged walls (202, 101, 222, 218)	4
Total Projects	17
Total possible	34

Four of the buildings (102, 107, 105, 103) did not plaster the exterior walls before attaching wood cladding. It will be interesting to see if these buildings function differently over the long term. For now the straw in the oldest of these (built 1996) remains in excellent shape, however the owner of that same building comments that the cavities between the *unplastered* bales and the wood has allowed rodents entrance, which they take advantage of!

6.1J Roof

Metal roofs were a noted preference for straw balers, and many of those who chose asphalt commented that had they been able to afford it, they would have opted for the same. There has not been a culture of green roofs in Atlantic Canada since the early settlers, however over the last year there have emerged at least two local groups which are actively promoting and researching green roofs. It is anticipated that we will be seeing more green roofs, in particular associated with straw bale buildings, in the near future.

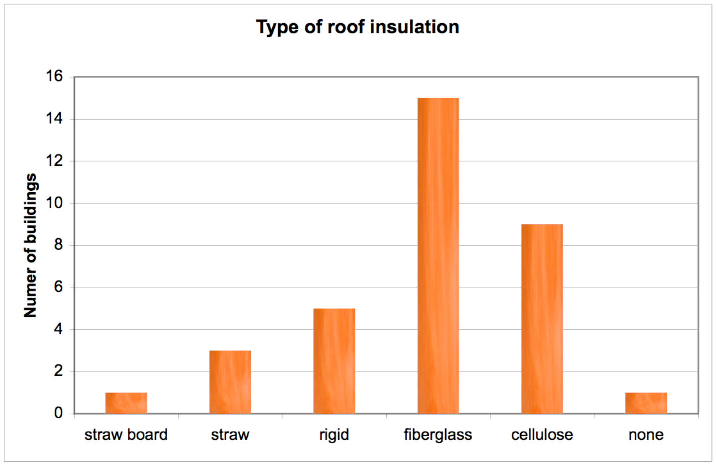


Graph 6.1Ja

Beyond basic considerations of insuring excellent roof coverage for all buildings the following comments from participants were particularly relevant.

1. Construction of the roof before wall raising is strongly recommended in our north easterly maritime climate to protect the bales during construction. (all participants)
2. The importance of good overhangs could not be overstated. They provide sun protection in summer, and rain/wind and snow protection throughout the year. (all participants). "If additional light is required, use skylights as needed." (203)

3. "Gutters were installed after plastering had begun and splash back damaged the (earth) plasters - recommend installing gutters early in the building process." (215)
4. "Follow the instructions meticulously when installing metal roofing!" (215)



Graph 6.1Jb

"Rain found its way under the roof for several months because of improper installation. The "top of the wall apron detail" turned out to be very important as the metal roof leaked due to improper installation. It kept liquid moisture from penetrating the bales." (215) See also remediation strategies 9.0

6.1K Labour and Organization

"A building project needs lots of determination, and an ability to follow the momentum. The love and support that was received from so many at that time people (during a community build) inspires one for years to come." (212)

1. "Work closely with trades people as the logistics of building with bales is different than what they are generally accustomed to. Ask questions!!" (101)
2. "Use experienced trades people to train volunteers – this is the most efficient way to complete a job and insures good quality work." (101,106, 104)
3. Use local resources, in all contexts, for supplies, and services, builds community and sustainability. (215, 212, 106, 201, 101)
4. "Ask lots of technical questions from people with experience. They know the short cuts." (203)
5. The importance of keeping an eye to quality control is essential on a building project. While the majority of owners had a very positive experience having their friends and family or other volunteers as part of the crew, every one of them stressed the need for establishing ways to insure quality control. (A few owners felt in the end it was "simply easier to do it themselves".)
6. "Use winter to prepare people, permits, materials, and hang out on site (to connect with design choices and think through staging the build)." (212)
7. "Establishing a regular spring and fall check list to identify cracks and other repairs is an excellent idea." *(212, 219)*
8. "Sharing of meals and music was important part of the energy and barn raising spirit." (207)
9. "Build a straw bale shed to become familiar with materials before moving on to house." (216)
10. "Think through time lines, and work to get a solid understanding of the total costs involved building a home. Doing the project without a mortgage has meant that it has remained unfinished much longer than needed." (213)
11. "Be vigilant on building sites to clean up loose straw, and insure that there are no potential fire hazards. Keep water hoses/fire extinguishers nearby and working." (201)

"Having had access to the internet would have helped with research, and avoiding some mistakes. Good, ongoing research while building is very important." (213, 301)

"Celebrating various parts of the process is very important." (212)

6.1L Building Inspection

Most, though not all, of the buildings included in this study have gone through the formal building code inspection process. Exceptions are generally those structures which were small enough to have been exempt at the time of construction from permitting procedures.

Generally an engineer signed off on any plans which went through the planning department, this facilitated approvals in all cases. In several instances an engineer was required not so much because of the bale system, but because wood used in the frame was not “stamped” (graded) as it was reuse lumber, or owner cut logs. (107. 218).

Various owners commented that if a structurally similar bale building had previously been constructed in their area, occasionally inspectors felt confident enough with the system, as to not require an engineer’s stamp (106,108, 202, 210, 215, 219)

6.1M Insurance and Mortgage

Obtaining insurance for straw bale buildings appears to have been a fairly straight forward process for builders in Atlantic Canada. Some of the comments that surfaced around this issue centered on the need for patience, and being prepared when speaking with insurance agents i.e. having straw bale resources in hand, or easily reference able.

Of the thirty-four projects, twenty-one received home insurance. Of those who don’t have it, many had simply made a choice not to insure their building others had applied and were refused, almost exclusively because wood was the primary heat source. No one that sought insurance was refused because of the straw bale walls.

The following is a list of agencies that provided insurance services for straw bale projects:

- ING
- Cooperators
- Zive Insurance Co
- AON REED STENHOUSE
- Hickey and Heinmann
- South Eastern Mutual
- Stanley Mutual
- PD Foster
- Eisenhower Insurance
- Cauldwell Roach

Of the thirty-four projects eleven opted for, and received mortgages.
The following is a list of lenders who have helped fund straw bale projects in Atlantic Canada:

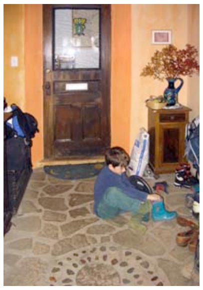
- Bank of Montreal
- Scotia Bank
- National Bank of Canada
- Royal Bank of Canada
- CMHC
- League Savings and Mortgage
- Atlantic Canada Opportunities (ACOA) Loan

6.2 Highlights and Unusual Features

Atlantic Canada has a broad range of straw bale buildings, which fall into both the new construction and renovation categories. There are examples of load bearing, infill, wraps and honeycomb matrix systems along with a variety of cladding materials which include clay/earth, lime, cement and wood. The observations and vignettes that follow briefly describe some highlights and unusual features encountered during the course of this study, with occasional comments on the relative success of each. While not every strategy is recommended, what becomes evident, reading through this section is just how ingenious and resourceful straw bale builders can be.

6.2A Trailer wrap
The family in this project had newly arrived in Nova Scotia and needed immediate lodging on their remote seaside property. They purchased a trailer which they set on a gravel pad foundation. Then, concrete posts were poured to support a straw bale wrap, and an addition was built that nearly doubled the original floor space.

A 2x6 stick frame with 16' centres surrounds the mobile and creates the extension spaces. Bales were set on edge so that they were standing tall in compression within the frame (with strings to the outside). Full bales of straw were squeezed in between rafters in the new section. Over the mobile they were simply left to lie on the existing roof with a vented space above. Rafters were hand cut from a local mill.


(206) Interior


(206) Exterior

Renovations were undertaken while the family continued living in the off grid trailer. The result was an eminently practical and beautiful space with bales in the walls and the roof creating a super insulated building that is able to withstand the demanding ocean weather it is exposed to. (206)

6.2B Round Design
Two buildings in the study focused on building round. (301, 216) The owners both mentioned that the benefits of round design are particularly noticeable when there are big winds. One of the two nudged the idea of round even further by building in the round, around a courtyard, however in hindsight the owners don't recommend courtyard design because of space inefficiencies within the building shell. A third owner used rectilinear shapes for his roof, frame and foundation in order to keep costs low and then built round within the frame - "extra" space around the perimeter became storage or seating areas.


(301)


(216)

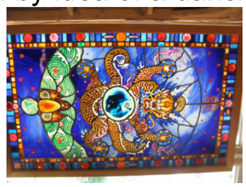
"The building feels very secure and quiet, even in the biggest winds, due to its round shape, and density of the bales." (resale owner, 301)

6.2C Double Ladder Design
Double (or "mirrored") stick frame construction was used for two projects (107, 216) within which "on–edge" bales were sandwiched. In both cases, the final exterior finish was wood, one with boards laid horizontally and not plastered on the outside, the other with boards laid vertically with the bales plastered before cladding.

6.2D Honey Comb Matrix
Two buildings (216, 204) used plaster between the bales and on top of each course. One of these, built in 1994, used cement plaster, the other built in 2001 used a clay rich earth plaster between the bales and a clay/lime mix on the exterior. Fans were used in the latter to speed up drying time.

6.2E Reuse Materials and Timber Frame
This inspired eight-sided studio (221) is based on a "perfect" feng shui number. The radius of its' octagon is 16', and there is an eight sided lotus on main floor. A stairway winds itself around the massive central tree support, glorious stained glass windows and a Torii gate/entrance all add to the whimsy and beauty of the space.
The central tree concept was inspired by idea of a dancing ballerina supporting the building.


(221)


(221)

Many of the construction materials in this project are reuse pieces i.e. the frame was cut from salvaged elm (damaged from Dutch Elm Disease), the second floor joints are 7"x11" beams from an old wharf, and the second floor deck was made from salvaged bowling lane hardwood.

"Straw bale reminds you that building is part of life's process. (221)

6.2F Straw Floor Insulation
Seven projects used straw as insulation in the floor or foundation.
Two of these used half bales squeezed between the floor joists above a crawl space, where the foundation was constructed of concrete piers in one case, and recycled telephone posts in the other. Four other projects had "floating floors" with flakes of straw sandwiched between various wood systems and a vapour barrier at grade.

One building in particular (301) had an unusual combination of elements: basically the foundation consisted of a rubble pad with a reinforced grade beam. Straw was fitted into voids in wood pallets, then concrete and granite slabs were laid on top of this. The massive granite floor (3 feet thick) created a heat sink within the building to complement the passive solar design. The advantages for the owner were that the system was low tech, it used recyclable materials and it increased the energy efficiency of the building. The method was however very labour intensive.

6.2G Hypocaust
An ancient and ingenious system for heating public baths and private houses found its way into one straw bale building in the Maritimes.(106) The floor is raised off the ground by pillars, hot air from a furnace circulates through open areas left between the pillars and the stem wall. The floor is also situated to provide intentional mass for passive solar gain.

6.2H Foundation Forms
Bales were used as foundation forms on at least two slabs in the survey (106, 203). Owners in (106) commented that the bales often shifted from the weight of the concrete which left a somewhat wavy final slab.

6.2I Drop Step Mud Room
"A drop form in the slab pour detailed a mud room one step below the main house, to help isolate wet and mud from the main building." (215)

6.2J Green Roof
A simple and affordable green roof design on this straw bale building (203) consists of: plywood sheathing with an Ice and Water Shield membrane (peel and stick type asphalt product) and about 300 bales of straw, broken open on top. A footer with a gutter keeps the straw from slipping off the roof, and drains water away from the house. Cellulous insulation is packed between the rafters and pine boards finish off the interior face.


(203)

Ice and Water Shield is highly recommended, by the owner, as a tough and easy to apply membrane. It needs a little maintenance and has tended to wear only at the edges where the straw has pulled away because of wind. The owners later added extra soil to weight the edges. Sedum is recommended for plantings as it handles both severe drought and rains. There are 350 bales on the roof.

6.2K Rotating photovoltaic system
"In order to most efficiently capture solar energy, photovoltaic panels were mounted beside this house, on the ground, in such a way that they could be rotated to maximize solar gain according to the season." (106)

6.2L Spot the Gaps
One resourceful owner used a Non Contact Infrared Thermometer, of a type that electricians use to identify air leakage to identify weak areas or gaps in straw stuffing between bales. This tool is available at many electronics stores for about $50. (102)

6.2M Many "green" choices
This building (203) creatively incorporates many permaculture elements with an eye to the efficiency and interrelatedness of them all in a including a green roof, root cellar, a sauna, a compost toilet, constructed wet lands for grey water, a constructed swimming pond, a straw bale slab, and being off grid. Several renovations to the home, since 1995, have altered its use considerably, including additions of the 10'x10' sauna, an extended kitchen and the compost toilet. Each time penetrations were made in the building skin the owners were impressed by the freshness of the straw and the condition of all structural elements.

6.2N Other Insulation
These owners purchased bagged cellulose and "fluffed" it in place between the floor joists, with rigid poly tacked to the joists. On top of cellulose is a second layer of 6 ml poly vapour barrier and a plywood sub floor. In hindsight they do not recommend use of cellulose in this application because of exposure to dusty chemicals, they recommend trying wool instead.

6.20 Cistern
In project (106) a recycled agricultural liquid container of dense plastic served as cistern. Rainwater collected on north side of the roof channeled into this 1100 gal insulated tank, and was then pulled into house with a pony pump and pressurized inside the house. Drinking water was obtained from a hand pump well shared with a neighbour.

6.2P Water treatment
A constructed wetland pond with "Canadian water weed", cattails and mixed flora was built to handle grey water. Ten years later the pond appears very healthy and supports diverse frog, heron and fish populations. No negative effects have been noted - the water remains clear.
The original pond was dug ten feet deep, but it has silted in somewhat. Only sink and sauna water enter the pond, and special care is taken in choice of cleaning products that would enter the pond from the kitchen.
A sawdust compost toilet and an outhouse are used for humanure.
The owners highly recommend this low impact, low maintenance combination of grey and black water systems, however planning permission can be difficult as there are few examples of this approach in Atlantic Canada to refer to.

6.2Q Giant Bales

(303) Four bale high barn

Huge bales, both round and square varieties, are becoming common place across the country. A farmer with access both to the large bales and machinery to stack them has built a barn using the same.

6.3 Additional Tips and Ideas from Straw Bale Owners

These notes refer to ideas or observations that do not necessarily tie into the Best Practices section, but seemed important to capture.

6.3A Design

1. "Single storey design can be an advantage as the owners age." (205)
2. "By not starting with a totally finished set of plans people were able to give meaningful input to design as the building moved from stage to stage." (202)
3. "The amount of glazing in a building should not be more than one fifth floor area, and there needs to be a place to store the heat." (204)
4. "Wool is an underutilized resource in our region and can be successfully incorporated into many aspects of a building for insulation." (218)
5. "To produce an interesting and cost effective floor, scribe the slab using long boards as rulers while concrete is green to simulate large tiles. These lines can be later filled with grout." (210)
6. "Having the posts disconnected (and interior) to the straw bale walls meant we had to treat the wall system as load bearing. We chose this system to encourage air circulation (natural convection) and to avoid possible cracking in the plaster created by shifting beams. On the downside, this method occupies useable living space, and plastering behind the posts/beam is challenging." (104)
7. "It was a challenge to blend straight edge interior partitions with "curvy" exterior walls - more details on this type of connection would be useful. One idea would be to pre frame the partition walls and plaster to them in the same way as insuring that all plaster stops are predetermined." (219)

"Lots of determination and spirit is needed for any building project." (105)

6.3B Organization

1. "Responsibility for work can become fragmented when owner is general contractor i.e. if there are problems, there is a tendency for each trade to point to the other to assume responsibility. Insist on clarity for timing, pricing etc. with all sub trades." (211)
2. "Having specific jobs ready for volunteers takes the pressure off coming up with tasks while working. It is challenging having to make big decisions under pressure." (101)
3. "Inclusion of Katimavik groups and WOOFers can add a great volunteer component to a project." (101)

"I loved the energy and participation of volunteers, and that it gave the building had an immediate history, but I would recommend hiring help as well, if finances permitted." (207)

6.3C Windows

1. “Cover windows before applying silica paints. If it drips onto the glass and dries, it will etch the glass.” (215)
2. ”Thermal panes without frames are very affordable and can be set into simple bucks with drip edges cut into the sills.” (222)
3. “Decreasing overhangs on sides of the house which get less weather will allow more light into the house. Sky lights, solar tubes and clear overhangs are other strategies for bringing more light in.” (205)
4. “Search out flashing details for windows and doors, as there is a shortage of these in the books which show good connections to plaster. One option is to use windows with a channel in which to fit flashing that extends a minimum of four inches around the entire window.” (219)
5. “Burlap glued to the flashing will help the plaster stick.” (215)
6. “Insulated window coverings like Hunter Douglas shades increase the energy efficiency of glass openings.” (211)

6.3D Plasters

1. “Local hard clay soil was soaked in a barrel or pit and agitated with shovels till thick clay slip was in suspension, and aggregate had settled to the bottom of the container. Slip was then “harvested” off the top, poured through a screen and sprayed on prepared bales.” (201)
2. “An air compressor, and car under coat spray gun with a two liter hopper makes a very efficient way to apply slip.” (201) (image below).
3. “The application of potassium silicate paint will stabilize lime renders or paints which sometimes dust or are crumbly. After which it is possible to add on an alis or other clay based paints.” (201)
4. “EcoHouse in Fredericton produces a variety of environmentally friendly paints that may be applied to mineral surfaces to make them more water resistant.” (202)
5. “Lime splashes on wood leave permanent marks. If not dealt with immediately they will calcify and be next to impossible to remove.” (101)
6. “Mold was blooming on slow drying clay plasters - after adding borax to an alis, it hasn’t returned.”(221)
7. ”A lawn mower or a whipper snipper in a large barrel work well for chopping straw. A drill with long plaster attachment is useful for making lime putty and slip. (215)
8. “The loose straw at the bottom of a mow or in a barn often has perfect, ready made chopped fibre.” (302)
9. ”A flowering of plaster bugs occurred several months following the (earth) plaster application. Once the plaster fully dried, these disappeared.” (221)


Clay slip spray option


Covering wood with burlap

7.0 Remediation Strategies

This is the section of the report that many will flip to first - in every part of our lives we all want to know what didn't work, why, and ultimately how to fix it. Problem areas which were encountered amoung the straw bale buildings profiled, are thematically clustered, and where possible a story illustrates common issues.

All of the people involved in this study were risk takers and visionaries of one kind of or another. The level of risk however has changed dramatically since the first bale build in the region, in 1993. Where then there were only a handful of people involved in the field, now there are dozens of books, thousands of articles, building code (in some parts); and perhaps most importantly, a dynamic and on-going convergence of minds, spirit and experience via the internet, and in person, at regular natural building colloquium that supports straw bale projects world wide.

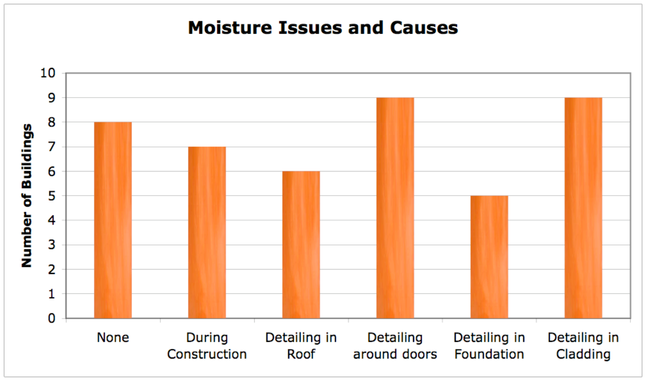
With growth in the availability of building resources, and a critical mass of projects to point to what has worked and what didn't, there has emerged a collection of remediation strategies to deal with the miscalculations, carelessness, acts of nature and violence, and sometimes just the joy (and importance) of pushing an "experiment" a little too far.

Every one of these "mistakes", when it is shared, is a gift that the next generation of builders has improved on. It is an exciting time to see how, by understanding the nature and performance of straw bale systems in a grassroots, and more recently a more rigorously scientific way, so many excellent details and improvements have emerged. New ways of doing continue to surface daily – some ideas work "better" than earlier iterations, and others not so, but the quality of construction and the understanding of where to go from here, has vastly improved.

So Many Ways to Do It...
Every project considered in this study is unique. Every one of them pushes and extends existing knowledge of how we can build with bales. Constrained budgets, challenging sites, experimental design all of these aspects and more nudge our creativity into unexpected places. The success of each solution is open for interpretation, where "success" can take many forms but ultimately work, if the details are taken care of.

The determination of straw bale owners to resolve building issues that arise with humour, and resourcefulness, is truly inspiring. These are people who are deeply committed to the concept of building with bales, and willing to go the extra mile to make them work. It is interesting to that note that only seven of these thirty-four projects were initiated by people who had a background in building, and only three contracted out the bulk of the bale work.

While rain and snow account for most of the damage done to the straw bale buildings in Atlantic Canada, there are have been occasional problems arising from wind storms, rodents, fire, and floods i.e. natural phenomena that challenge all buildings. Many of these problems could have been mitigated by using other flashing details, or different plaster mixes, rescheduling or choosing more appropriate materials.



Graph 7.0

A. The Problem: **Wind driven rain/exposure**
The damage that wind driven rain can do to buildings on exposed sites has been appreciated by builders in this region since the earliest shelters were erected. Intense freeze thaw cycles, and horizontal rains can send water into buildings in unimaginable ways (see Weather, Appendix III).

Three projects (202, 213,101) in particular have had to undergo major repairs due to wind driven rain finding its way into plastered straw bale walls. All of these were constructed on very exposed sites, all were two storey plastered timber frames, and all had problems that could be traced back to leaks around windows, or details to do with plaster mixes and its application. All, it appears, are due to problems that could be avoided given the experience we have today with building with bales.


(202) original


(202) after renovation


(213)


(101)

Some common observations were that:

- once water found its way into the skin of the building, generally at flashed joints, through cracks in the plaster or where different materials transitioned, it appeared to follow the frame, and caused damage as it worked its way out from there.
- wherever rigid materials like wood or metal engaged with a plaster surface that hadn't been bridged with some kind of mesh, or super reinforced plaster, the finish plaster appeared to be vulnerable to cracking, likely due to differential contraction and expansion between the materials.

A Solution: All three of these projects have either completed, or are considering installation of wood rain screens (see 8.1), in addition to improved flashing, in order to remedy their problems. They all have removed sections of bales from the interior of the buildings, leaving the exterior plastered wall intact while bales were restacked and tied back to the frame from the inside. Where repairs are complete, it seems the problems have been resolved.

On a fourth building (219) the owners had to remove most of the unplastered bales, which had been installed in the fall, and tarped for the winter. Rain and snow broke through the tarps wetting the bales over the course of the winter; in the spring all the bales were removed, replaced and the project was completed.


(219) Tarped for the winter


(219) New spring bales


(219) Plastered

See Highlights and Unusual Features (8.2) for more information on rain screens.

B. The Problem: Overhangs
On this project, bales were originally intended to be set interior to the posts, however after the frame was erected the owner moved the bale walls to outside the posts in order to create additional floor space. This change considerably reduced the span of the existing roof overhang. “The exterior cladding consists of a frame of 1”x2”s which was constructed over the bales to create a frame onto which to attach wire mesh, so even though the earth plaster does engage somewhat with the bales it is not (necessarily) worked well into them. The building site is quite sheltered but prevailing winds and rain, and run off from the roof have significantly eroded the earth plaster on one particularly exposed section.” (221)
A Solution: The owner intends to lime plaster the earth coat, construct a rain screen, and perhaps extend the roof on the vulnerable section.

C. The Problem: Roof details
In one case gutters were not yet installed when the earth plasters were applied to the bale walls. During rain storms splash back began to mark and wash out sections of the plaster. The same home had problems where the metal roofing had been improperly installed which allowed rain to run under it and into the walls (215). In a couple of other instances there have also been fairly predictable problems with ice-damming which are standard roof insulation issues.
A Solution: Gutters were installed, then it was a simple task to sponge back the plaster, and resurface the wall. Once the earth coat was dry the walls were finished with lime render. The roof was reinstalled, correctly and in this case because the top of the wall had been “aproned” with Typar the water traveled into the plaster rather than the interior of the bale. This temporarily water damaged the walls, they have since been replastered which provided an opportunity for some creative inlay.


Wet walls from roof leaks (215)


Repaired plaster with inlay art (215)

D. The Problem: Grade
Inadequate drainage around slab resulting in puddling at base of walls. (203) (202) (205)
A Solution: Add weeping tile and regrade the land to slope away from the house. Construction of an addition will also help to minimize the amount of water that travels there.

E. The Problem: Window detailing
Insufficient flashing around windows resulting in water penetration. (205) (101) (216) (218)
A Solution: Wide (min. 4 inch) flashing around all sides of windows that are exposed to wind driven rain. Layering several mechanical flashing details to prevent the water from finding its way into the building i.e. not relying solely on caulk. Many detailing problems are not specific to bale buildings, such as seals in skylights or cracking of wood frames, however where plasters (earth, lime, or cement) have been used, special care needs to be taken where plasters meets window and door materials.

A large load bearing building (205) was sited such that it received considerable wind driven rain on the south side, so much so that in its first year there would be large puddles on the floor. The owners experimented with drying out the bales with vacuums and heaters to no avail. In the end they simply jacked–up the damaged window, replaced the wet bales for dry, repaired the flashing detail and replastered thereby remedying the leak and the damaged bales.

The Problem: Soft bales
The experimental nature of this project (220) meant that details very much evolved as it progressed i.e. after raising the load bearing walls the bales compressed more than expected (they were particularly soft bales), which caused differential settling of the roof.

A Solution: The owner erected a 2x4 balloon frame around the perimeter of building and reset the roof on that. The bales were then stitched back to the frame and plastered.

F. The Problem: Wind
Originally constructed as a load bearing building this home (214), was hit by a rare high wind called a “weather bomb” during construction. The bales were not yet installed in the gables, and some of the cross bracing had been removed to prepare for the next phase of bale installation. When the wind hit the roof blew off and the walls leaned over “two bale degrees”.
A Solution: The owners took “little time to mourn the loss” – they unscrewed the roof, and removed it themselves, as they couldn’t get a crane in to do it. The bales were taken out and over wintered in a barn (about 50 were lost to wet). The next spring a frame was raised on the existing foundation, the bales installed and the project completed. Where it had taken two people one week to raise the load bearing bales, it took them three weeks for the infill.

G. The Problem: Cracks in cement, lime and earth plasters.
Cracks in cement plasters are common, particularly where wood or metal details interrupt the skin of the render. Or because of movement in the building because of frost heave. (201) (211) (213) (202)
A Solution: Most owners have repaired the cracks with silicone caulks, others have caulked with lime then lime plastered the walls, one owner (201) used a cob like material as a “caulk” and turned the cracks into an opportunity to create a relief wall sculpture. A second owner etched the damaged wall in order to provide a tooth on which to apply a third coat of cement/lime plaster. Where earth plasters cracked (on a small building because of heave) repair was a relatively simple matter of sponging out the cracks. (201)

Cracks in cement plaster caulked with silicone.

Cracks in earth plaster caulked with cob.

H. The Problem: Fire.
Three bale buildings have fire stories attached to them. In one (201) fire began under the house while the owner was trying to release frozen water pipes. The floor, joists and the bale-in-floor insulation were damaged, however the fire department was very impressed with how the bales slowed the fire, and commented that had the building been made of anything else it is likely the home would have burned to the ground.
A second unoccupied building was enveloped in an intense bush fire which destroyed it.
The third is a curious story where there is evidence of vandals trying to burn unplastered straw exposed in a truth window. No information is available on this incident, however the obvious attempts to ignite the wall were unsuccessful.
A Solution: While the fire retardation properties of tightly baled and plastered straw are impressive, they are not indestructible and typical preventative measures against fire should be taken. Extra caution is advised pre plaster, and during a build, when loose straw can be a hazard.

I. The Problem: Plaster recipes
The issue here revolves around good testing of plaster recipes, particularly with earth mixes. Soil composition can vary radically from site to site as can how the soils respond to additives like manure, lime, sands etc. In this case there was possibly not enough clay and too much sawdust mixed with manure in the mix which caused it to be crumbly and unstable. (221)
A Solution: It may be possible to stabilize the base coat by wetting it down, and applying a strong clay rich coat on top - more likely is that the crumbly surface will need to be raked off and fresh plaster applied.

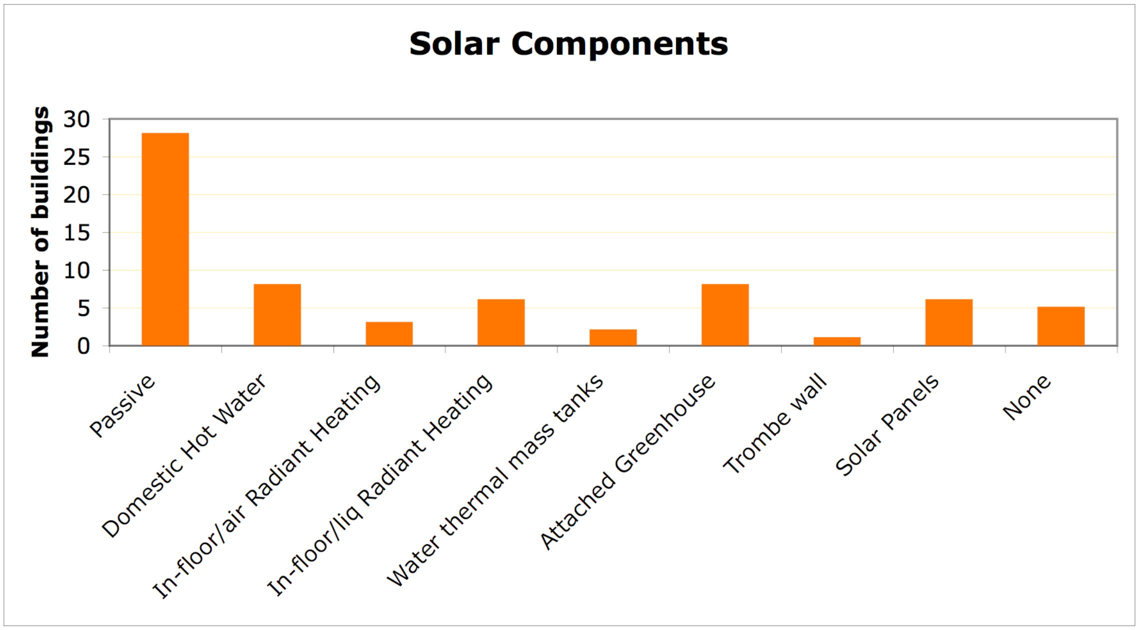
J. The Problem: Not completing plastering before freeze-up
A Solution: At least five projects were caught off schedule with freezing temperatures before they were able to complete their homes. The solution for most of them was to move indoors and work from there. Basically earth, sand, tarps and/or mixers moved to interior spaces and plastering was completed from the inside out. For others, where exterior walls were involved people applied some serious tarping strategies to get through the winter, or opted to face the walls with wood instead of plaster. (202), (107), (101), (206), (105)

K. The problem: Rodents
Rodents can be a problem in any home, they are not necessarily attracted to a building simply because it is made of straw. Three home owners mentioned mice as an issue. In one home the mice were able to enter because the exterior walls were unplastered behind exterior wood sheathing, in another the interior of an unoccupied building was left unplastered over a winter, and in a third they were likely entering through an opening in the roof.
A Solution: In all cases screens were installed where mice were getting in. A cat or two pretty much took care of everything else.

8.0 Observations on Energy Consumption

The majority (28/34) of buildings in the project had passive solar design elements incorporated into them. The projects that didn't commented that their sites were either too wooded, or were aligned in such a way that passive solar was not an option. All were aware of the benefits of solar designed buildings and would look for ways to include solar features in the future.

About half of the participants had taken one of the courses offered through Solar Nova Scotia[7] on solar designed homes, and all recommended a course of that nature as a good introduction to solar design.



Graph 8.0

Twenty-six percent (8) of the projects managed their power needs by using off grid systems. Another three had wind generators, and six had solar panels.

It was challenging to isolate energy consumption for heating the buildings profiled in the study as most used more than one system and there was a wide range of efficiency amoung the wood stoves used. Three quarters (26) of the buildings used wood, often in combination with another system.

Heating Systems Used Uniquely or in Combination

System	Number of Buildings
Wood	26
Electricity	18
Oil	2
Propane	1

"Heartland is an excellent Canadian made wood burning cook stove." (106)
"Keslings in Blockhouse are good resource for masonry stoves." (211)

[7] Solar Nova Scotia: http://www.solarns.ca/

9.0 Building the Network: Atlantic Straw Bale Builders Gathering

> ***"The act of building can be so inspiring for other parts of your life. Learning that one can ask for help, and receive it is a huge gift." (212)***

One of the early goals of this research project was to bring together the survey participants for a gathering where they could meet one another to share stories, ideas and current best practices for straw bale construction.

There was a tremendous response to this idea, and about seventy adults and eleven children attended a two day event on the Eastern Shore of Nova Scotia, coming from New Brunswick, PEI and Nova Scotia. About 37 of those attending fell into the "experienced" category i.e. people who had already built a bale building, the remainder were "soon-to-be-experienced" folks who had a project in the works for the next year. Within that group of seventy, there were also ten people who had been involved with straw bale building professionally, either through design or construction.

In the majority of cases, beyond the core group of ten who had worked on a number of the projects, most of these were first time meetings, with folks whose projects they had only heard about before.

As seems to be the case when people involved in the natural building field get together, there was a lot of laughter, sharing of resources and a genuine camaraderie. The weather was glorious (the black flies were too), and the event, beyond solely helping to further shape this research, served also to catalyze a common sense of purpose amoung the regional straw bale network.

Participants determined that this should be an annual event, and that everyone would work toward strengthening these initial connections in order to support more and better bale buildings in the east.

Agenda and notes from the Gathering are found in Appendix IV.
See also video documentary titled: Welcome to the Atlantic Canada Straw Bale Community.

> ***"At the time I built there were only 10 photocopied pages on straw bale construction. I contacted Steve McDonald, then Matts Myhrman and Judy Knox, and finally Bill and Athena Steen who were writing the Straw Bale House book at that time. All were incredibly generous with their time and knowledge. They (with others) set the tone for care and quality that is at the heart of the natural building movement, and have sustained it." (201)***

10.0 Steps Forward

This has been an exciting and practical study of straw bale construction in Atlantic Canada, it is hoped that the research performed to date can be built upon:

1. By conducting a follow up study which focuses specifically on identified moisture issues and remediation strategies for buildings in the region
2. By contacting regional straw bale organizations, and key people involved in straw bale construction in Canada, and encouraging them to use the tools developed in this project.
3. By regularly updating the regional map and the database.
4. By supporting the creation of an interactive on-line map which shows existing buildings and "hot spots".

Glossary

Reference: Wikipedia: www.wikibooks.org/wiki/Straw_Bale_Construction
The Last Straw: http://www.thelaststraw.org/resources/rg06/word.html

Air-Source Heat Pumps: Air-source heat pumps draw heat from the outside air during the heating season and reject heat outside during the summer cooling season.

Aliz: A clay slip applied to an earth-plastered wall, similar to paint it is used to seal and beautify the surface.

Apron: Water resistant material, like building paper, used to cover the horizontal surface of bales, generally at window openings or at the tops of walls, as a measure of added protection against potential water damage.

Bale Needle: A pointed metal rod with a handle at one end and a hole at the other used to push twine through bales and stitch them from one side to the other in order to hold mesh tightly to each surface or for retying custom bales.

Bales On Edge: Bales laid in a wall such that the string sides are those which receive finishing treatments.

Bales On the Flat: Bales laid in a wall so that the strings are interior to the wall system.

Cob: Clay and sand-rich soil mixed with straw and water. Generally formed into stiff loaves and mortared together with a similar mix. Produces a monolithic, load-bearing earth walls.
Adding more straw makes a material which can be used to fill voids in straw-bale walls prior to applying exterior/interior coatings.

Cold Bridge: A structure made of various materials, where some insulate more than others, can create paths where warmth can escape. For example a well insulated house with solid aluminum windows creates a cold bridge which transfers large amounts of heat/cold through the structure.

Earthbags (also called Superadobe): Are bags filled with moistened clay-bearing soil, laid in courses, tamped solid and held together by barbed wire to prevent slippage. Used for domes, walls, in-fills and foundations. Can be plastered or finished in various ways.

Ecological Footprint: The land, air and water that a city or nation needs to produce all of its resources and to dispose of all its waste, given prevailing technology. It is a way to determine if the lifestyle of a community is sustainable.

Embodied Energy: The total energy used to bring a product or material to its present phase in its life cycle. It includes the energy required to extract or produce raw materials, their transport to the place of production, and the energy used for manufacturing. It can also include the energy used in the distribution and retail chain, for maintenance processes, for repair, etc.

Gabion: A metal cage full of hard material, typically rock or urbanite. Often used for retaining walls especially on riversides. Can be used as part of a building foundation.

Hay: Grass, clover, alfalfa etc. mown and dried for fodder. Hay is not straw.

Heat Exchanger (furnace): A structure that transfers heat from the hot combustion gases inside the furnace heat exchanger to the circulating room by air flowing across the exterior of the heat exchanger.

Heat Recovery Ventilator (HRV): A device used in central ventilation systems to reduce the amount of heat that is lost as household air is replaced with outside air. As fresh air enters the house, it is warmed as it passes through the HRV core and heated by the warm outgoing air stream.

Hydronics: Hydronics, or heating with water, consists of a compact boiler (fired by any fuel) that heats water, which is distributed to a network of slim baseboard, panel or space radiators, or under floor tubing by a circulator. This term also applies to the science of heating (or cooling) with water.

Hypocaust: Floor raised on piers, heated by hot air circulating beneath it.

Infill wall: Straw bales used between the load bearing frame of a structure to form non-bearing walls and act as insulation.

Nicho: A small hollowed out space in a wall, which is typically plastered, and serves as a shelf or storage area.

Post and Beam: A construction using vertical elements (posts) and horizontal elements (beams) to form a structural framework. The term often refers to using a smaller number of larger than normal timbers compared to conventional wood framing.

R value: Standard insulation value which measures the Resistance in a material to the passage of heat.

Radiant Floor Heating: Under floor heat is distributed by flexible tubing. Most often found in slab floors which provide direct-contact thermal mass for heat storage.

Rubble Trench Foundation: A trench dug into the ground and filled with a rigid material such as demolition rubble, stone or sea shells. Provides excellent drainage.

Pre-compression: Compressive building elements added before a structure is completed to stop plaster cracking after it is finished, in case of further settling.

Stem wall: A stem wall is the part of the foundation between the floor level and ground level, often made of concrete blocks or formed concrete.

Straw: The dry cut stalks of grain (wheat, oats, rye, rice, etc.) used as a material for bedding, thatching, and straw-bale construction.

Straw/clay or Light Straw-clay (from the German Leichtlehm): Lightweight mixture of straw and clay slurry which coats each strand of straw; the wet material is compacted into a formwork (removed the same day) resulting in a precise wall with enough texture to accept mud plaster without further preparation or lathing. Often used as an “outsulating” wall around a timber-frame structure; can also be used an as infill material between deep structural members

Toe-ups: A wood or concrete curb attached to the slab or floor deck to protect the bales from water that might pool on the floor during construction or a plumbing or drainage problem.

Top Plate: Ladder like system (typically wood) used to precompress bale walls, as a roof connection, and to help distribute roof weight.

Truth Window: An exposed portion of the interior a structure so that people know "in truth" what it is made of. Truth windows which expose a straw detail are a creative addition to many straw-bale buildings.

Urbanite: Broken concrete and other reuse materials, used in foundations, walls and floors. It is often a free, and strong building material with the added advantage of keeping the same out of landfills.

Wattle-and-Daub: A substrate for cob-like earthen materials, made from small branches or twigs woven into a lattice.

Wrap: Wall system where bales are laid up in a running bond, either entirely exterior to the frame or entirely interior to it, rather than being notched to accommodate a frame within the bale system.

nicho

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The Climate of Nova Scotia:
http://atlantic-web1.ns.ec.gc.ca/climatecentre/default.asp?lang=En&n=61405176-1

The Climate of Prince Edward Island:
http://atlantic-web1.ns.ec.gc.ca/climatecentre/default.asp?lang=En&n=CACEE433-1

The Last Straw: www.thelaststraw.org/resources/rg06/word.html

The Ontario Straw Bale Building Coalition: www.strawbalebuilding.ca/

Wikipedia: http://en.wikibooks.org/wiki/Straw_Bale_Construction/Glossary

World Book Encyclopedia: www.worldbook.com

Appendices

Appendix I Thumbnail Images and Mini-Profiles

Appendix II Summary of Graphs

Appendix III Climate Information for Atlantic Canada

Appendix IV Notes and Agenda from the Atlantic Canada Straw Bale Gathering 2006

Appendix V Human Resource Information for Atlantic Canada Straw Bale Builders

Appendix VI General Information and Resources on Straw Bale Construction

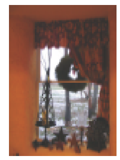
Appendix VII File Maker Pro Database Profiles (large file)

Appendix I Thumbnail Images and Mini-Profiles

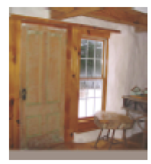
Thumbnail Profiles
Straw Bale Construction - Atlantic Canada 1993 - 2006

NB ID# 101
Timber frame Infill
Home
1800 sq. ft. 21'x 30'
Spring 2006


NB ID# 102
Stud frame Infill
Home
2300 sq.ft. 40'x40'
October 2003

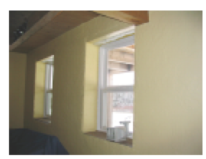



NB ID# 103
Timber frame Infil
Museum
600 sq.ft. 20'x20'
Spring 1999

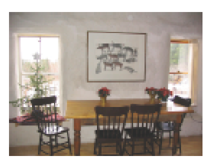



NB ID# 104
Timber frame Infill
Home
1600 sq.ft.
Spring 2007


NB ID# 105
Timber frame Infill
Home
2245 sq. ft.36' x 36'
June 2003

NB ID# 106
Load bearing
Home
600 sq. ft. 18' x 24'
May 2003

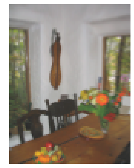



NB ID# 107
Stud frame Infill
Home
2200 sq. ft.
January 1996


Thumbnail Profiles
Straw Bale Construction - Atlantic Canada 1993 - 2006

NB ID# 108
Timber frame infill
Home
2800 sq. ft. with loft
2006


NS ID# 201
Load bearing
Home
1500 sq. ft 25'x 30'
November 1993

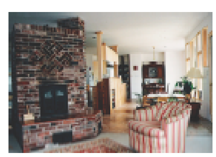



NS ID# 202
Timber frame infill
Home
1800 sq.ft.
April 2004


NS ID# 203
Timber frame infill
Home
1900 sq. ft. 63x33
December 1995


NS ID# 204
Honey comb matrix
Home
1600 sq. ft.
Spring 1994


NS ID# 205
Load bearing
Home
2045 sq.ft.
September 1995

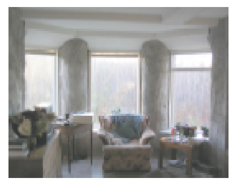
NS ID# 206
Stud frame infill
Home
1700 sq. ft.
October 2000


Thumbnail Profiles
Straw Bale Construction - Atlantic Canada 1993 - 2006

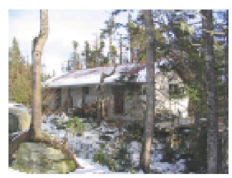
NS ID# 207
Stud frame Infill
Home
1500 sq. ft 30'x33'
December 2002


NS ID# 208
Timber frame Infill
Community
1140 sq. ft. 33'x30'
Summer 1999


NS ID# 209
Timber frame Infill
Home
2600 sq. ft. 32'x34'
2001

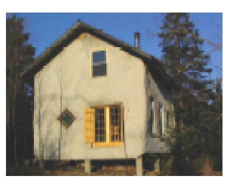
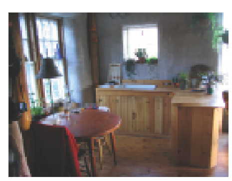



NS ID# 210
Load bearing
Garage
450 sq. ft. 25' x 18'
November 1997

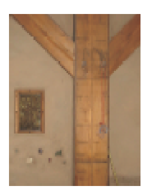



NS ID# 211
Timber frame Infill
Home
2780 sq. ft.
January 1999


NS ID# 212
Load bearing
Home
700 sq. ft. 19' x 22'
November 1999

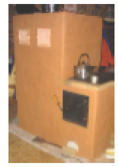



NS ID# 213
Timber frame Infill
Home
2000 sq. ft. 44'x39'
December 2006

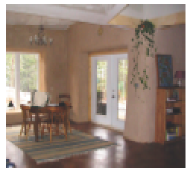



Thumbnail Profiles
Straw Bale Construction - Atlantic Canada 1993 - 2006

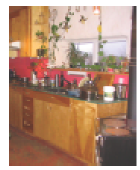
NS ID# 214
Stud frame Infill
Home
820 sq. ft. 24'x 30'
Fall 2002

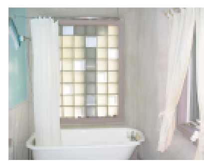
NS ID# 215
Stud frame Infill
Home
1640 sq. ft.
December 2004



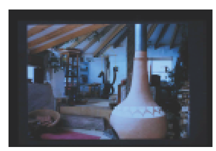

NS ID# 216
Stud frame Infill
Home
1700 sq. ft.
2001

NS ID# 217
Stud frame Infill
Home
3836 sq.ft. 28'x60'
June 2000

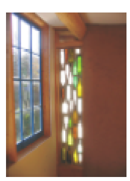



NS ID# 218
Stud frame Infill
Addition
450 sq. ft. 15'x 30'
November 1995

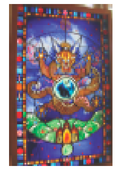
NS ID# 219
Timber frame Infill
Home
3200 sq. ft.
December 2005


NS ID# 220
Stud frame Infill
Greenhouse
325 sq. ft. with loft
2003

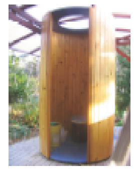



Thumbnail Profiles
Straw Bale Construction - Atlantic Canada 1993 - 2006

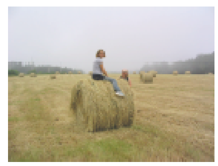
NS ID# 221
Timber frame infill
Studio/workshop
1300 sq. ft.
June 2000

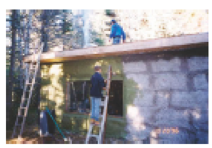
NS ID# 222
Load bearing
Studio/workshop
615 sq.ft.
Fall 1996

PE ID# 301
Timber frame infill
Studio/workshop
650 sq. ft.
September 2001

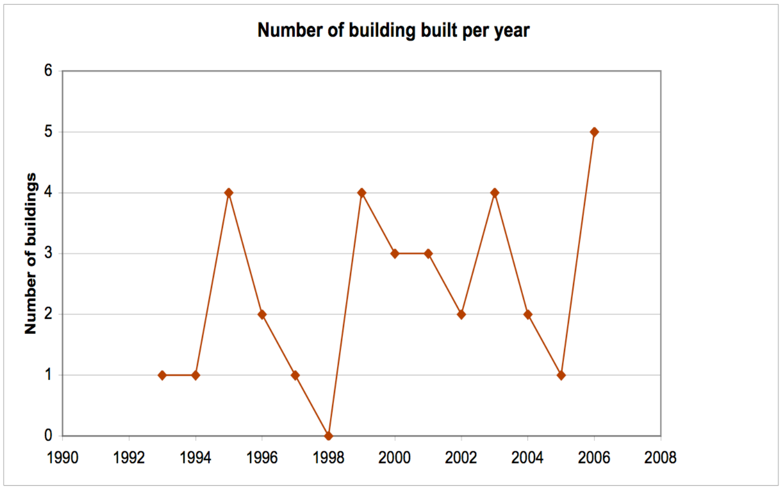
PE ID# 302
Honeycomb matrix
Cottage
448 sq. ft. 16’ x 28’
1995



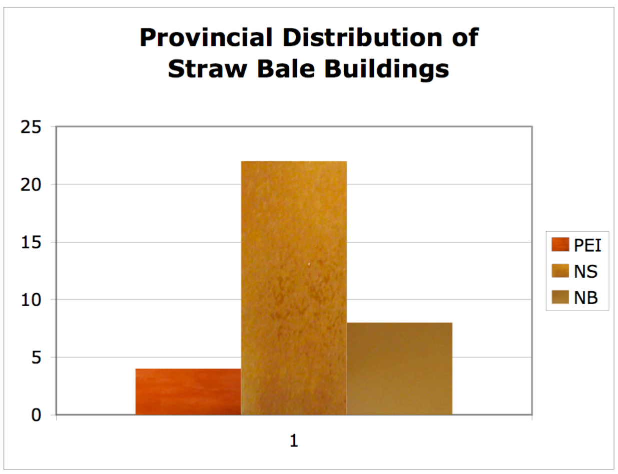

PEI ID# 303
Load bearing
Barn
1824 sq. ft. 48’x38’
Fall 2006


PEI ID# 304
Timber frame infill
Home
1200 sq. ft.
October 2006

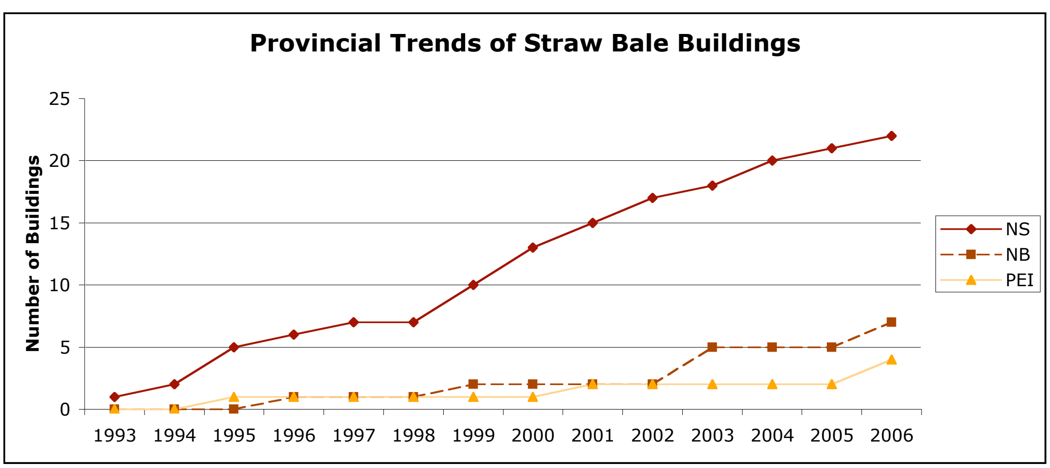

Appendix II Summary of Graphs



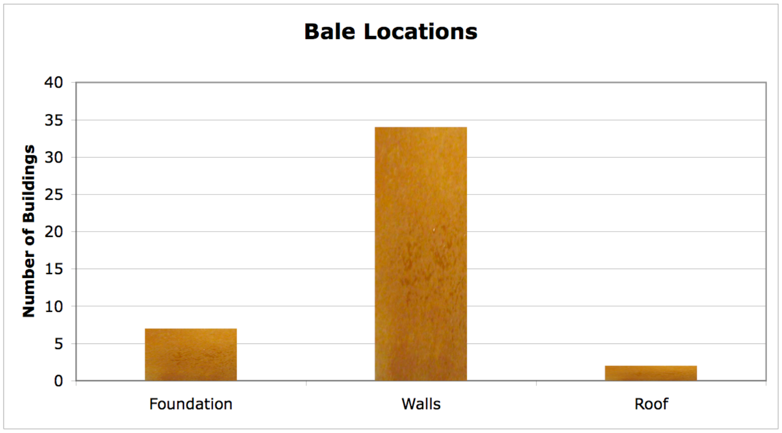
Graph 3.1 Shows the number of buildings built each year since 1993.



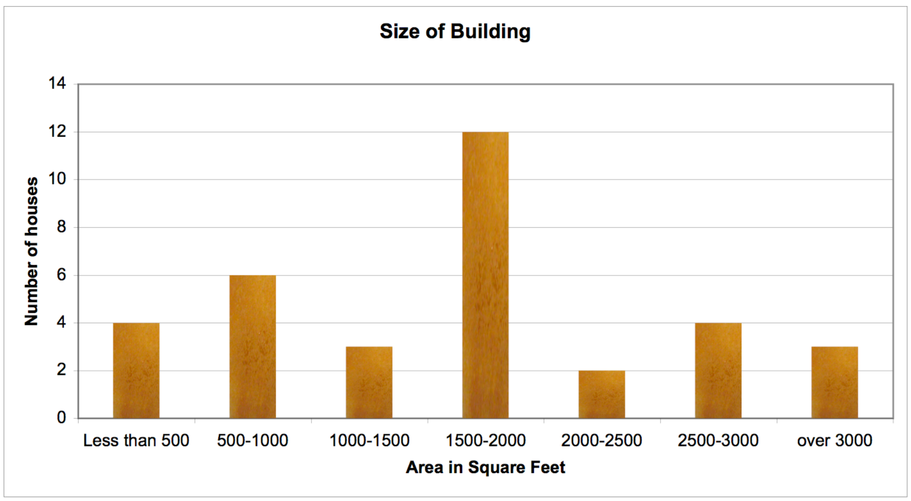
Graph 3.2 Provincial distribution of straw bale buildings for Prince Edward Island, Nova Scotia, New Brunswick.



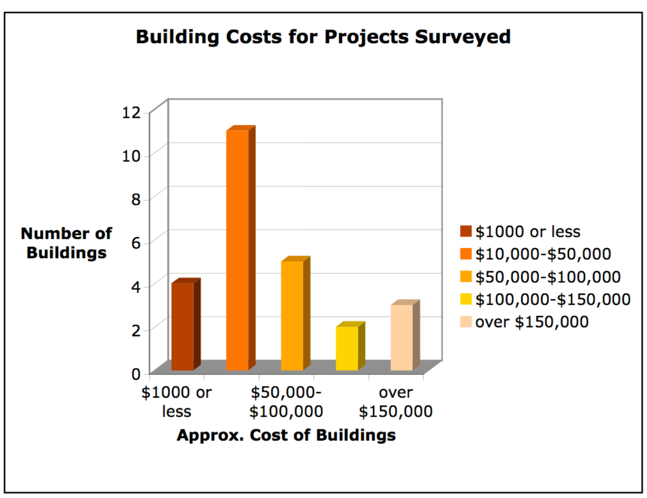
Graph 5.3 Number of straw bale buildings constructed between 1993 and 2006 in Nova Scotia, New Brunswick and Prince Edward Island.



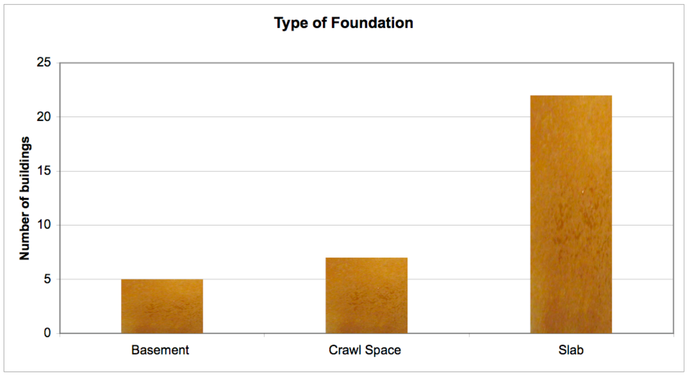
Graph 3.4 Number of buildings that have bales in the foundation, walls and roof.



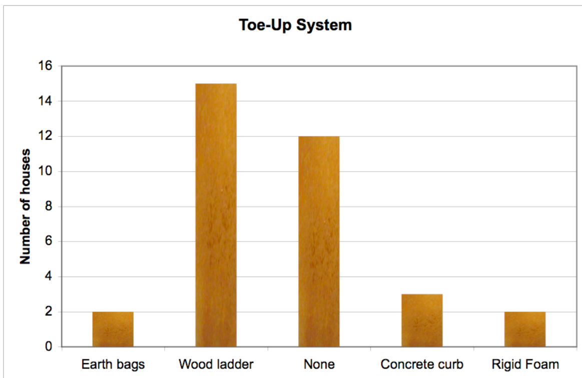
Graph 6.1 Shows the number of buildings in relation to area per square foot.



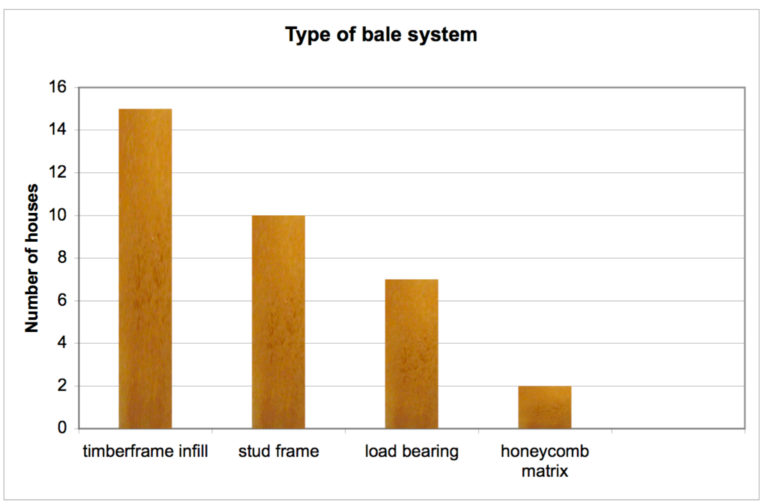
Graph 6.1B Number of buildings constructed within a particular price range.



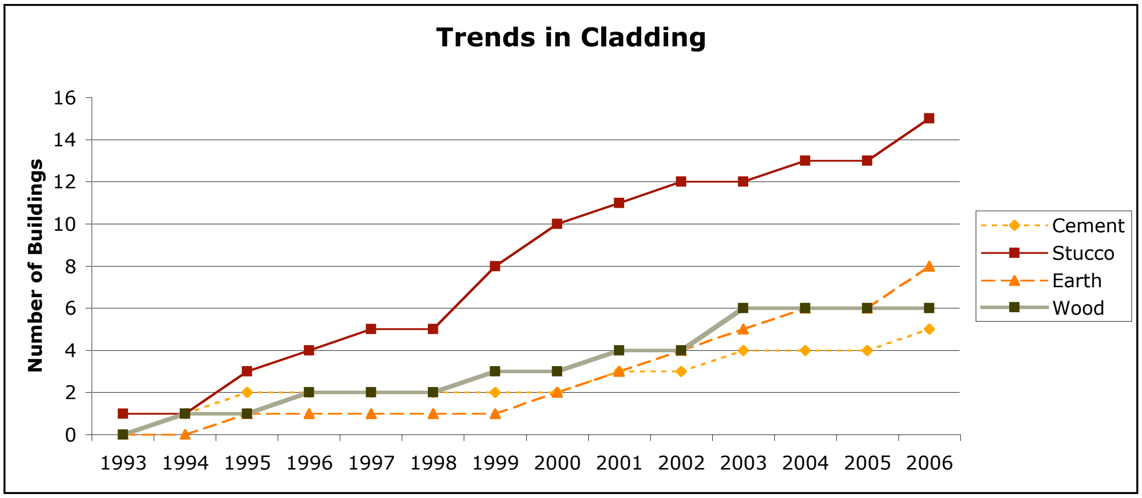
Graph 6.1Da Number of buildings constructed using a particular type of foundation.



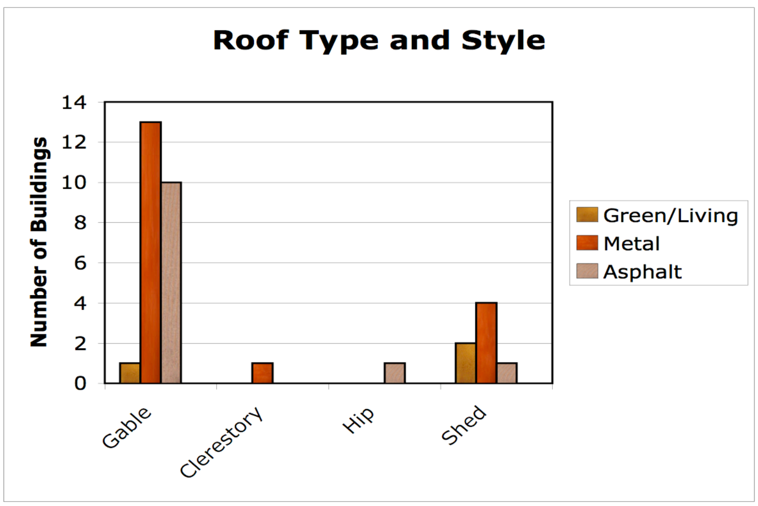
Graph 6.1Db Number of buildings constructed using various types of toe-ups.



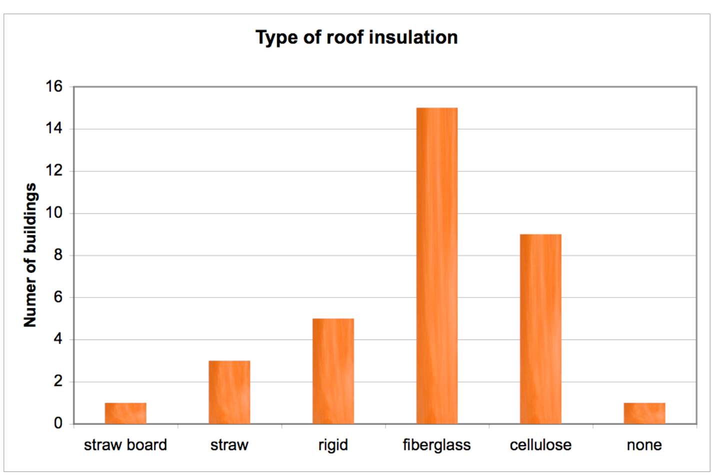
Graph 6.1F Number of buildings constructed using a particular bale construction method.



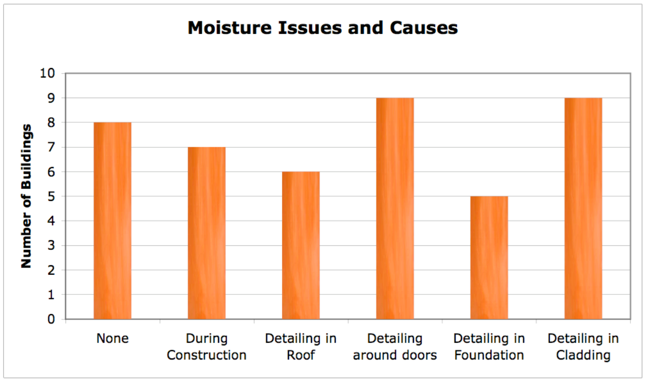
Graph 6.1H Number of buildings that used cement, stucco (cement/lime), earth or wood cladding during the period1993-2006.



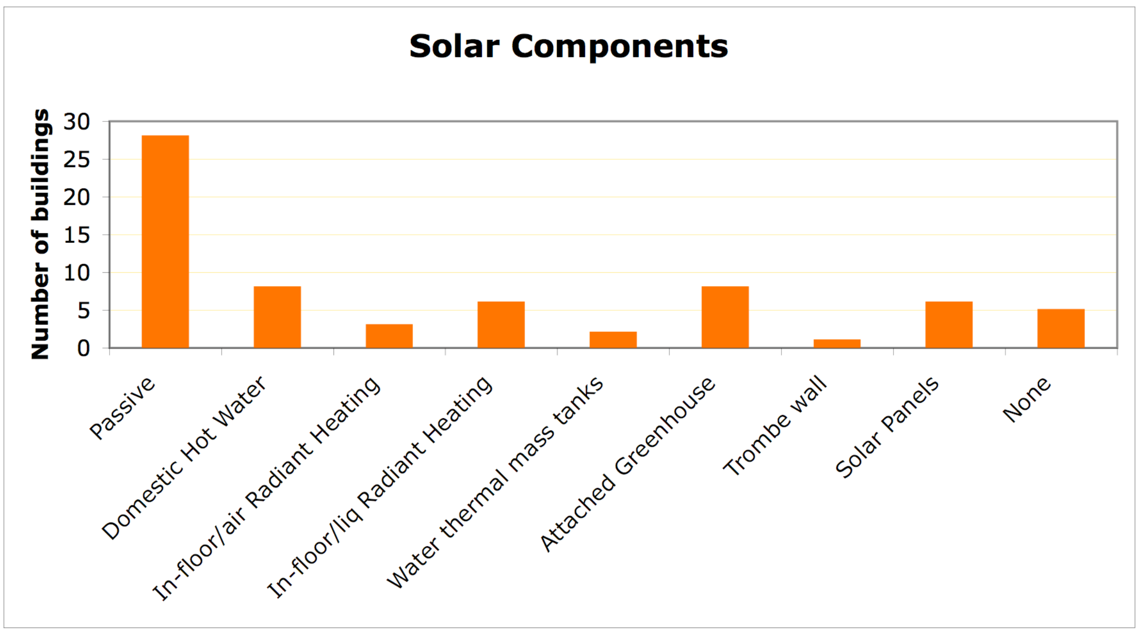
Graph 6.1Ja Number of buildings constructed using a particular roof type and style.



Graph 6.1Jb Number of buildings constructed using insulation systems, in addition to straw bales.



Graph 7.0 Number of buildings which have experienced a variety of moisture issues.



Graph 8.0 Number of buildings utilizing various solar energy strategies.

Appendix III Climate Information for Atlantic Canada

Maps and graphs excerpted from: World Book Encyclopedia: www.worldbook.com
Text excerpted from: Environment Canada's The Climates of Canada:
http://atlantic-web1.ns.ec.gc.ca/climatecentre/default.asp?lang=En&n=0D8BAF5C-1

The Climate of New Brunswick

http://atlantic-web1.ns.ec.gc.ca/climatecentre/default.asp?lang=En&n=7A6129C7-1

No part of New Brunswick lies more than 200 km from the ocean, yet the province has a typically continental flavour to its climate. During the winter, cold air, largely unaltered, frequently flows across New Brunswick from the centre of North America, and most storms affecting the province originate either over the North Pacific or the Gulf of Mexico. In summer, the predominant air mass is warm continental, with occasional incursions of hot, humid air from the Gulf of Mexico. On the other hand, influxes of moist Atlantic air produce mild spells in winter and periods of cool weather in summer.

Northwestern and central New Brunswick are the parts of the province that are least affected by the ocean. The north and east shores are modified by the Gulf of St. Lawrence, but less so than their proximity might suggest. The extent of the sea-effect depends to a large degree on the wind direction, with onshore winds causing the most moderation. The cold Gulf waters retard warming of the air in spring, keep the summer maximum temperature low, and provide a slight warming of the air in fall--provided the winds are off the water. Near the Bay of Fundy, continental air masses are modified by the ocean. Coastal locations such as St. Andrews and Saint John experience moist Atlantic air most of the year, producing mild periods during the winter and cool weather the rest of the year.

Yet, in spite of their by-the-sea location, New Brunswick coastal areas are not good examples of true marine climates. Continental climates, compared with true maritime climates, have an earlier spring and shorter fall, wider fluctuations of temperature from day to day and from season to season, and more snowfall but less total precipitation. Near the coast there is a blending of these continental and maritime influences, with the temperature moderating effect of the ocean increasing the closer we get to the coast.

Temperature: A Province of Contrasts

January is the coldest month in New Brunswick and July is the warmest. Along the Fundy coast, average daytime highs vary between 20° and 22°C in the summer. These temperatures are reached fairly early in the day, by 11 a.m. or noon, before the sea breeze sets in and causes them to drop sharply. The sea breeze is not as prevalent along the Gulf coast, however, partly because the Gulf tides are not as pronounced as the Bay of Fundy's. Also, as the warm season progresses, the shallow waters of the Gulf heat up faster and reach higher temperatures than those of Fundy, thus diminishing the difference between air and water temperatures. Since it is precisely this difference which creates the sea breeze, the strength of the breezes off the Gulf are decreased.

As we move inland, the moderating effect of the ocean diminishes, and the interior regularly experiences temperatures of 25°C and higher during the summer. Along the Gulf of St. Lawrence, afternoon temperatures regularly reach 24°C, except on those days when the cool sea breeze prevails. On several occasions, extremes in New Brunswick have exceeded 37.8°C (100°F). The highest temperature ever recorded in the province is 39.4°C, set at Nepisiguit Falls, Rexton, and Woodstock on August 18 and 19, 1935.

In winter, temperatures decrease noticeably from south to north. The interior, which has elevations above 600 m and is more directly in the path of continental air masses, experiences very cold winters. At Edmundston, the January mean temperature is -12.2°C. As we move south, however, this coldness is gradually tempered by the effects of latitude and, to a greater extent, the sea. Along the south-eastern shores, the January mean is around -7.5°C.

Frigid temperatures are not infrequent, with most settlements in the north-west reporting extreme low temperatures of -30° to -35°C every winter. The all-time provincial low is -47.2°C, recorded at Sisson Dam, a weather station near Plaster Rock, N.B., on February 1, 1955. This is also the lowest temperature recorded anywhere in the Maritimes.

Perhaps the most significant feature of a New Brunswick winter is the marked variability in temperature from day to day. This is a product of the highly contrasting and fast-moving weather systems which traverse the province every two or three days.

The usual differences between coastal and inland localities are also seen in the length of the frost-free season. Along the Fundy shore 140 to 160 frost-free days occur on average, whereas in the central highlands of the Miramichi there are less than 90 days. A four-month frost-free season extends along the Gulf coast, and along the south shore of the Bay of Chaleur the growing season is extended by another week

Precipitation: The Snowiest But Not the Wettest

Generally across the province, as the winter snowfall increases from place to place, the total precipitation for the year decreases. Cold winter temperatures and stormy northeasterlies combine to make New Brunswick the snowiest of the three Mar time provinces. Northwestern New Brunswick generally receives between 300 and 400 cm of snow annually, for about 33% of its annual total precipitation (rain and snow combined). On the other hand, the eastern and southern sections of the province receive 200 to 300 cm of snow, less than 20% of their annual total precipitation. Winter storms frequently bring rain to the Fundy coast and snow to the interior.

At Saint John the season's average snowfall of 293 cm occurs on 59 days between the middle of November and the middle of April. Although snowfalls are often deep, the snow cover comes and goes quickly. This pattern may repeat itself three or more times during the winter. In the northwest, however, the snow cover season lasts 160 days and is both reliable and persistent.

Spring and early summer are notably dry over New Brunswick, but there is ample water during the growing season. The interior highlands record about 1200 mm of rainfall a year, with the heaviest amounts falling during the summer months, a pattern characteristic of a continental-type climate. On the other hand, the southern shoreline receives a like amount, but with a slight maximum in fall and early winter. Elsewhere, 1000 mm is a representative yearly amount.

Stormy Weather

On average, thunderstorms occur between 10 to 20 days a year at any place in New Brunswick, and this is higher than over the remainder of Atlantic Canada. Normally only one thunderstorm a year is severe enough to produce hail. Tornadoes are rare but occur more often in New Brunswick, especially in the northwest, than in Nova Scotia. Even though tornado sightings are unusual, evidence of trees blown down by strong winds is not. When tornadoes do strike, they are usually rated as minor. Freezing precipitation is a hazard on about a dozen or more days a year in New Brunswick. Hours of freezing rain or drizzle range from 34 hours a year at Fredericton to 59 hours at Moncton.

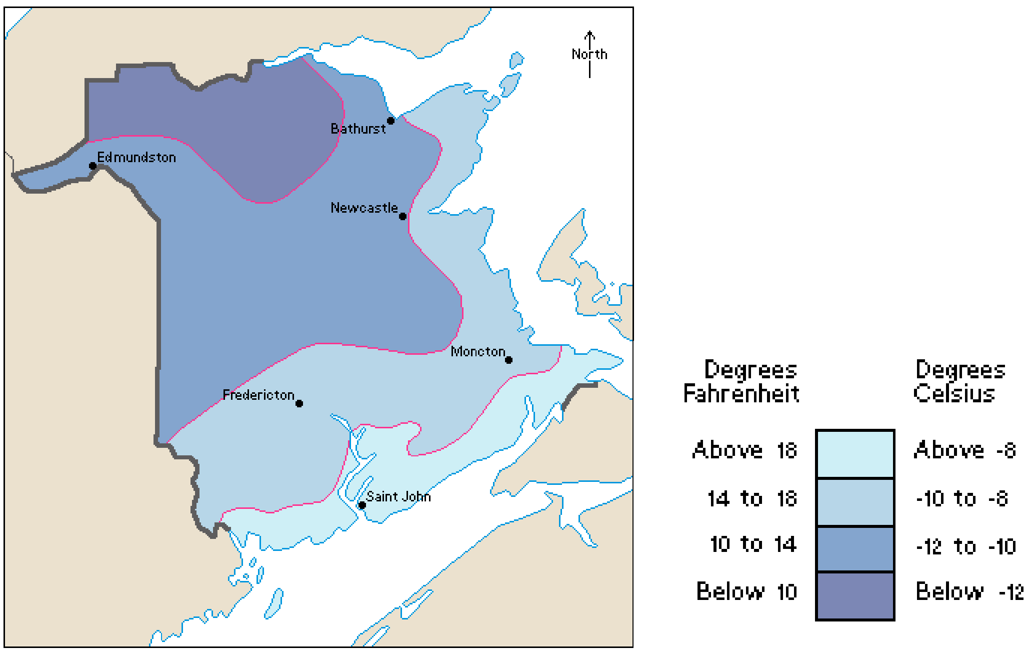
Storms associated with low pressure areas can occur at any time of the year but tend to be more severe and frequent in winter. These winter storms pack strong winds with snow often changing to rain and back again to snow. One of the most memorable storms of this kind in recent history struck eastern New Brunswick on January 4, 1986, walloping Moncton with 110 km/h winds and 67 cm of snow in 24 hours.

In the summer and fall, the main storm track passes through the Bay of Fundy and northeast through the Strait of Belle Isle. Weakened tropical storms and hurricanes affect the southern portion of the province with at least one heavy rainstorm every one or two years.

Winds blow predominantly from the west and northwest in the cold months and from the south and southwest in the warm months. Wind speeds average 15 to 20 km/h in winter and 12 to 15 km/h in summer. With some exceptions, winds tend to be lighter farther away from the sea coast. Along the coast, sea breezes are frequent, especially in the early afternoon on warm, sunny days under light regional winds. Local exposure is very significant. Open, treeless localities and the tops and slopes of ridges and hills are often very windy. Also, local topography causes funneling of the wind in many circumstances. Windless conditions occur more frequently inland, anywhere between 5 to 12% of the time depending on local exposure. Coastal sites have fewer calms, with windless conditions occurring only 1 to 5% of the time. Strong winds above 50 km/h blow mainly from the west. Severe winds approaching hurricane force occur an hour or two each year along the coast, but are rarely measured at distances inland.

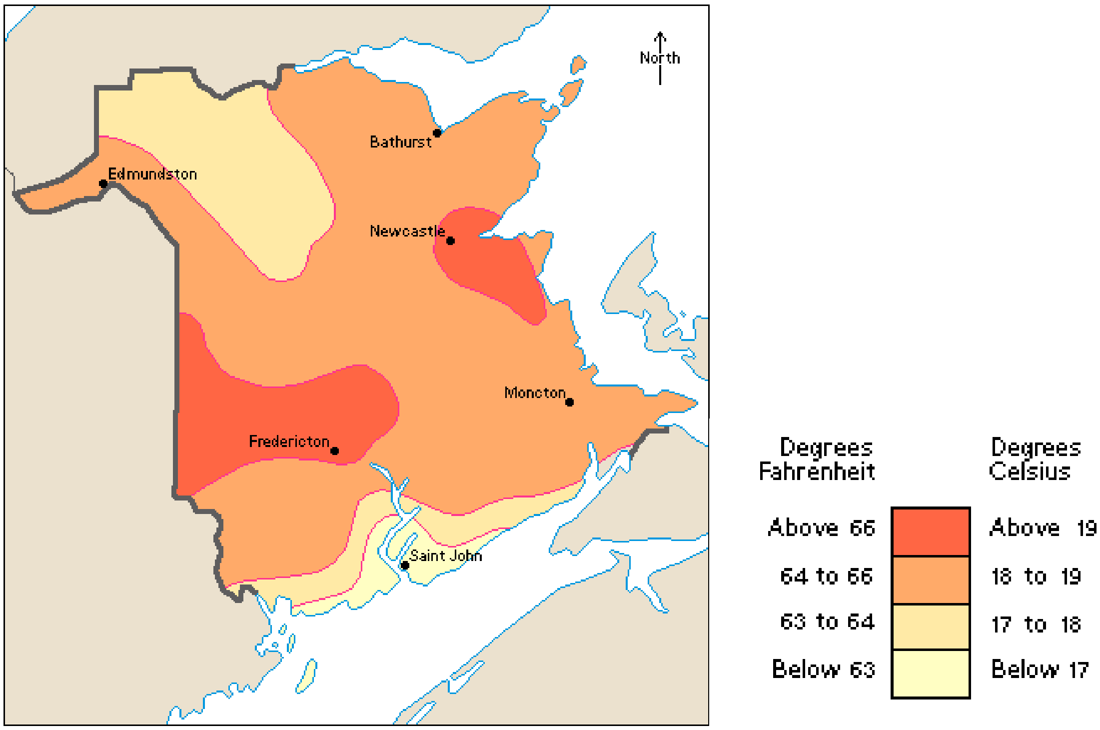
This information came from Environment Canada's The Climates of Canada.

Average January Temperature
The coastal regions of New Brunswick are milder during wintertime than the inland sections to the northwest.

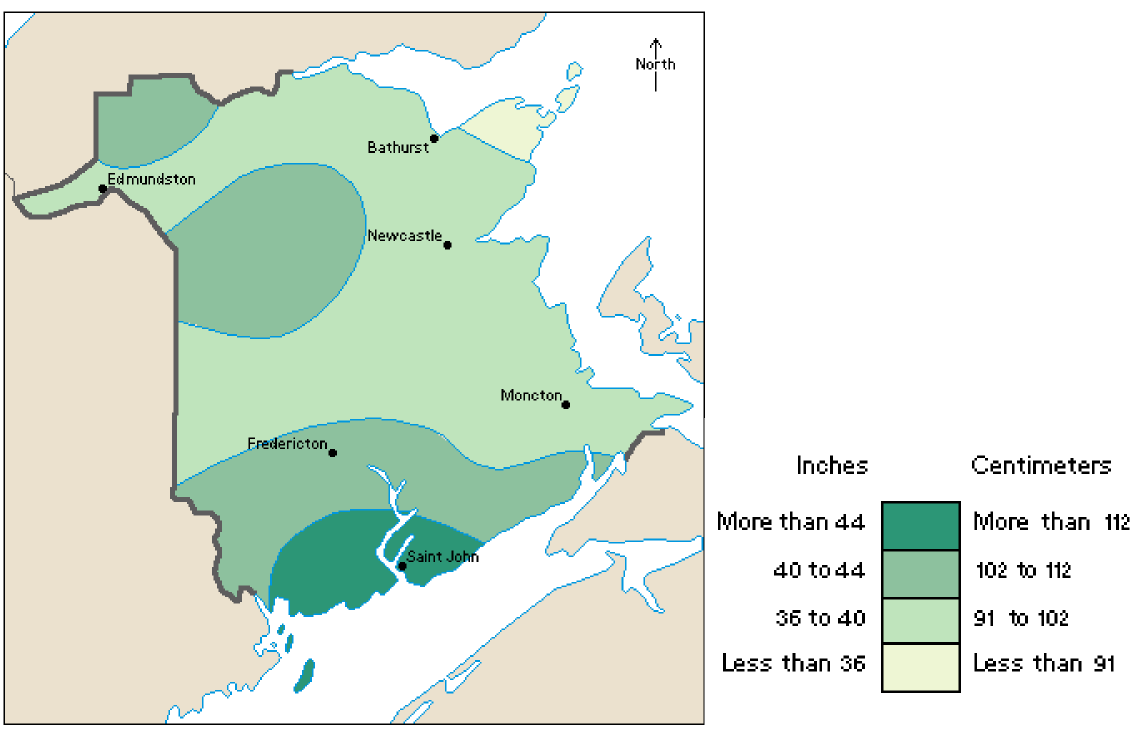


July Temperature

New Brunswick has mild summers with generally even temperatures throughout the province. Precipitation in New Brunswick is heaviest along the southern coastal region and the lightest in the northeastern area.



Average Yearly Precipitation



The Climate of Nova Scotia
http://atlantic-web1.ns.ec.gc.ca/climatecentre/default.asp?lang=En&n=61405176-1

Described on a provincial vehicle license plate as Canada's Ocean Playground, Nova Scotia owes everything to the sea, especially its climate. Robust winters, reluctant springs, fresh summers, and lingering falls; reliable precipitation and lavish snowfalls; misty sunlight, thick fog, and expansive sea ice -- all of these, and many more, are a part of Nova Scotia's maritime climate. The influence of the sea is not surprising. The province is virtually a peninsula surrounded by seas: the Gulf of St. Lawrence to the north, the Bay of Fundy to the west, and the Atlantic Ocean to the south and east.

By the Sea
Atlantic and Fundy waters are relatively cold (8°-12°C), and they help to keep the air temperature over southwestern Nova Scotia on the cool side in spring and summer. In January, when their temperature is between 0° and 4°C, these same waters moderate the harshness of winter. Farther offshore to the east, southeast, and south are comparatively warm 16°C waters of the Gulf Stream. It's warmth, especially from August through October, is credited with prolonging fall -- the season many Nova Scotians consider to be the best of the year.

Nova Scotia's north coast is exposed to Gulf waters which, in late August, have a maximum surface temperature of 18°C. The contrast between air and water temperatures is enough to create onshore sea breezes and to hold back the onset of fall for a few weeks. In January, however, Gulf of St. Lawrence and Northumberland Strait waters become ice-covered, effectively cutting off any marine influence for the next three months. The influence of the sea is felt in other ways. Ice conditions in the Gulf and, on occasion, in the Bay of Fundy retard the arrival of spring. Cool summer seas also help stabilize overriding air masses, thus suppressing local storm development. In addition, the merging of contrasting ocean currents -- warm Gulf Stream and the cold Labrador Current -- produces a great deal of sea fog that often moves far inland.

The effects of latitude and relief on climate are not as important in Nova Scotia as elsewhere. The highest mountains are the Cape Breton Highlands, part of the Appalachian mountain chain, but nowhere are they higher than 530m. Although this is not high enough to block the movement of air masses, it is sufficient to divert them and cause them to move in a direction parallel to the mountains. Locally, the Highlands help to wring additional moisture from passing weather systems and to cool temperatures by 1° or 2°C.

Warmest in the East
The southwest coast around Cape Sable is frost free for over half the year, longer than any other place in Atlantic Canada and comparable to localities along the shores of Lake Erie. Most agricultural areas experience a period without frost for 120 to 130 days between late May and early October, which is the effective growing season for most crops. The Annapolis Valley has up to 140 frost-free days, but the higher highlands on Cape Breton Island have less than 100 days.

Winter temperatures are moderate along the coast. Yarmouth's average January temperature of -2.7°C is the highest of any mainland station in the Maritimes. Inland, January means are between -4°C and -6°C. The most significant aspect of winter is the marked day-to-day variation caused by the alternation of Arctic and maritime air.

Summers are relatively cool in Nova Scotia. Afternoon summer temperatures reach 25°C in the interior, but along the coast are frequently 4° to 6°C cooler. At night the ocean remains a cooling source, keeping minimum temperatures along the coast about 2°C to 3°C below those inland. Halifax's July mean of 1 7.4°C and Yarmouth's 16.3°C compare closely with Vancouver's 17.3°C but are somewhat cooler than Toronto's 20.6°C.

Mainly Moist

Nova Scotia is wettest over the highlands of Cape Breton Island, where over 1600 mm of precipitation fall in an average year. The southern coast experiences almost as much, with totals of 1500 mm. By contrast, the north shore along the Northumberland Strait has less than 1000 mm a year.

Precipitation is slightly greater in the late fall and early winter because of the more frequent and intense storm activity. In most years there is a good supply of rain during the growing period. However, drought is not unknown in Nova Scotia. A prolonged warm, dry, and sunny spring in 1986 contributed to the worst forest fire outbreak in the province's history. The previous summer, several months of below normal precipitation dried up wells and streams, and water levels did not begin to recover until Hurricane Gloria brought heavy rains in late September.

On average, only about 15% of Nova Scotia's total annual precipitation originates as snow. An exception is northern Cape Breton Island, where the snow fraction is closer to 30%. Snowfall is relatively light near the warm Atlantic shore and near the entrance to the Bay of Fundy, where less than 150 cm may fall in one winter. Here, copious rain and freezing rain make up for the scanty snowfalls. Inland, the yearly snowfall increases to 250 cm. As a rule, elevated areas receive the greatest snowfall and have the longest snow cover season. Both the Cobequid Mountains and the Cape Breton Highlands receive in excess of 300 cm in an average snow year. These elevated areas also experience "sea-effect" snowfalls in the wake of winter storms. Heavy local snowfalls are also produced by winds blowing off the open waters of the Gulf of St. Lawrence and the Bay of Fundy.

The snow cover season, that is, the period when there is at least 2.5 cm of snow on the ground, varies considerably. Usually its duration extends from about 110 days a year along the southern coast to 140 days inland and in areas adjacent to the frozen seas. In coastal areas the snow cover may come and go. At Halifax, for instance, there is only a 50% chance that there will be snow on the ground for Christmas.

Some of the more notable provincial snowfall extremes are--greatest snowfall in one season: 653 cm at Cheticamp in 1964-65; greatest in one month: 224 cm, also at Cheticamp, March 1961; and greatest in one day: 69 cm at Yarmouth on March 19, 1885.

Stormy and Changeable

Storms frequently pass close to the Atlantic coast of Nova Scotia and cross the southern part of Newfoundland, producing highly changeable and generally stormy weather. Without doubt this region has more storms over the year than any other region of Canada. Winter storms are especially devastating with occasional loss of life and extensive damage to property. Packing a variety of weather conditions from hurricane-force winds to heavy precipitation, they can pass rapidly through or stall and batter the region for days. On occasion, the winds associated with these nor'easters, as they are called, exceed 150 km/h, and peak wave heights can be as high as 14 m. At high tide, these winds can cause storm surges of more than a metre. Other conditions associated with these storms include freezing spray, reduced visibility in snow, rain, or fog, and numbing wind chills, especially in the storm's wake.

In late summer and fall the remnants of a hurricane or tropical storm are felt at least once a year in Nova Scotia. The most memorable of these dying storms was Hurricane Beth on August 15-16, 1971. At Halifax, Beth brought 296 mm of rain, more than the deluge from Hurricane Hazel over Toronto and enough to wash away several bridges, damage buildings, and flood farmland.

Other severe weather phenomena include ice storms and blizzards. Each year one or two 25-cm snowfalls occur in Nova Scotia and newspaper headlines across Canada announce another paralyzing Atlantic snowstorm. When combined with strong winds, they cause enormous inconvenience and, at times, property damage and loss of life. A record snowstorm struck Halifax on February 2 - 3, 1960, producing a total of over 75 cm of snow in the downtown area and over 96 cm in the suburbs, most of it within 24 hours.

On the other hand, Nova Scotia is not known for spectacular displays of thunder and lightning. Thunderstorms occur on about 10 days of the year, about half the number that occurs in northern and central New Brunswick. Tornadoes have been recorded but are rare. One such tornado, accompanied by heavy hail and lightning, struck White Point Beach near Liverpool on January 30, 1954, but most weather watchers consider it a freakish event. Reports of waterspouts over near shore waters are received yearly.

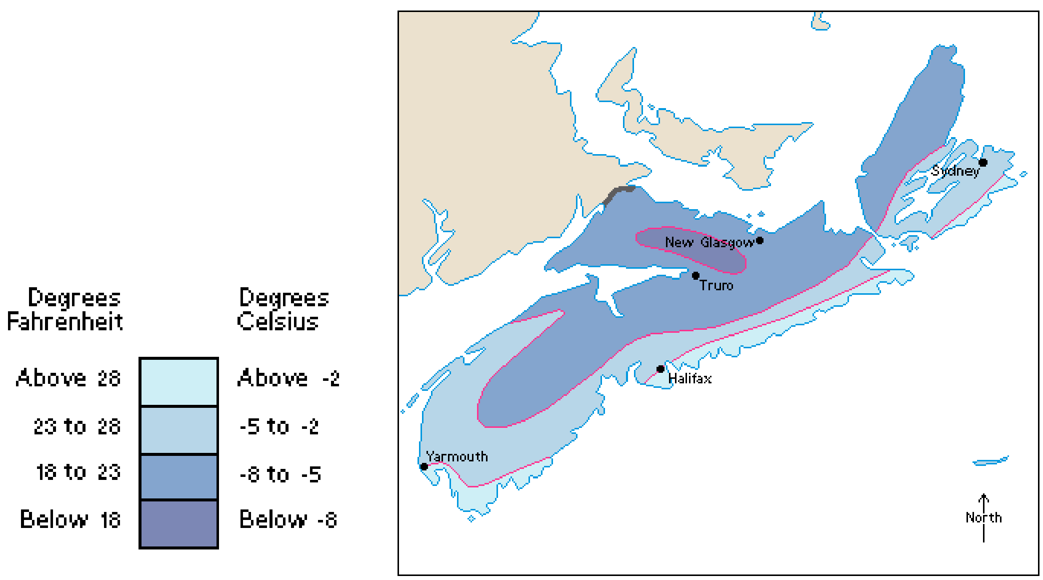
Winds

Winds blow predominantly from the south or southwest in the summer with an average speed of about 10 to 15 km/h. In the coldest months the predominant direction is from the west and northwest with an average speed of 22 km/h.

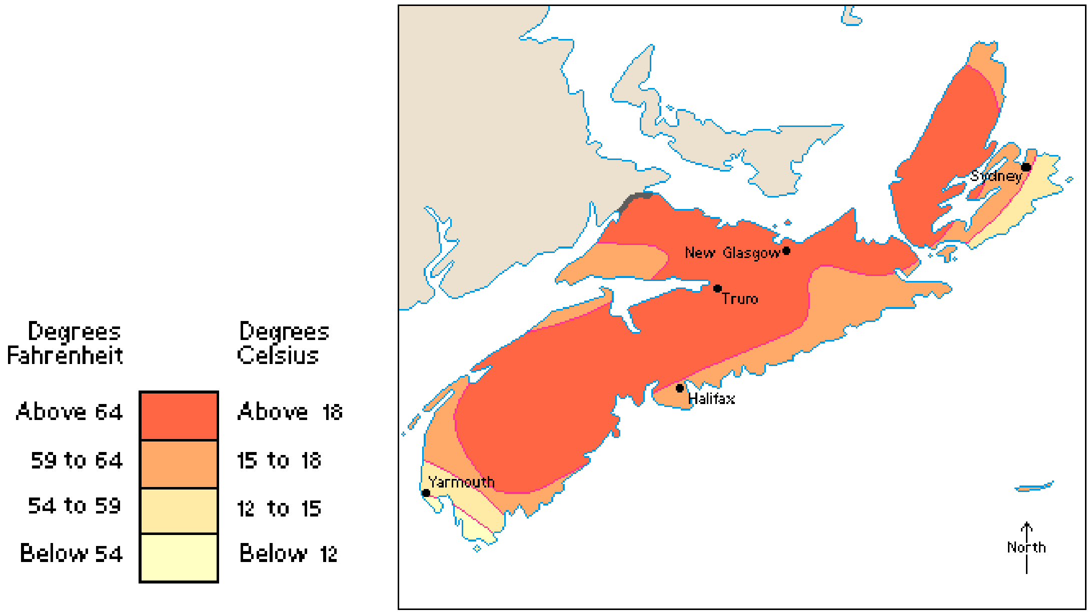
The wind at any given location is often quite different from the wind conditions which prevail even a short distance away. The variation that occurs in both wind direction and speed results from the characteristics of natural and man-made obstructions, topography, and surface cover. Along the coast, an onshore sea breeze circulation often sets up, particularly during a warm, sunny afternoon in the spring or early summer.

Average January Temperature

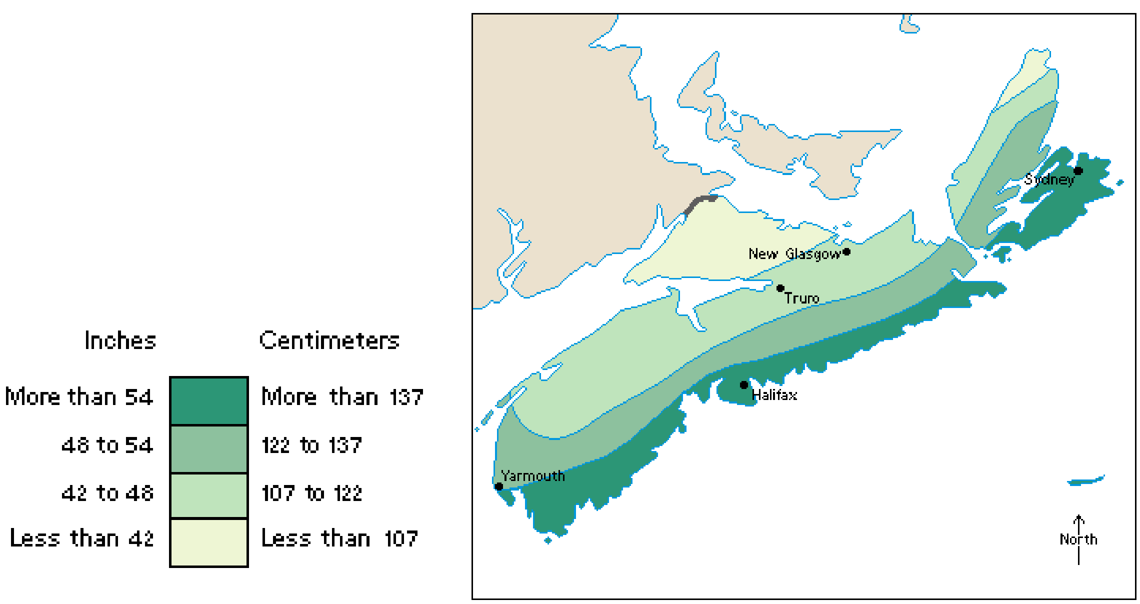
The North Atlantic coast from Sydney to Yarmouth is the mildest area of the province during the wintertime.



Average July Temperature
Nova Scotia has cool summers along the foggy Atlantic coast. Inland and to the north, temperatures are warmer.



Average Yearly Precipitation
The Atlantic coastal area is the wettest part of Nova Scotia. Precipitation declines toward the northwest.



The Climate of Prince Edward Island

http://atlantic-web1.ns.ec.gc.ca/climatecentre/default.asp?lang=En&n=CACEE433-1

Canada's Garden of the Gulf is surrounded by sea, lying between the Northumberland Strait on the south and west and the Gulf of St. Lawrence on the north and east. With the oceanic influence, the onset of the seasons is delayed several weeks. Winters are rambunctious but, on the whole, milder than in most parts of Canada. Spring is late and cool. Summer is modest and breezy. As for fall, well, Islanders will tell you they favour this season most of all, except when it involves the occasional brush with a dying Atlantic hurricane.

Oceanic Heat Pump

The island's gently rolling terrain, which generally does not rise any higher than 50 m above sea-level, presents no formidable obstacles to the weather systems that traverse the region. The sea is a much more important climate control, with no community farther than 20 km from the seashore. The seas about the Island function like a gigantic heat pump, drawing warmth from the waters in the fall and early winter and cooling the air for a greater part of the spring and summer seasons. From January to early April, when the gulf and straits become ice covered, the heat pump shuts down and the Island becomes as continental as the interior of New Brunswick.

Drift ice is often found around Island seas as late as the latter part of May, causing difficulty for fishermen and retarding the arrival of spring. The ice cover is by no means solid throughout this period, but is broken up by tides, strong winds, and occasional thaws. Just as weather profoundly affects the extent and duration of ice cover, so the relative amount of ice and water affects the weather, influencing the occurrence of fog cloud, snow, blowing snow, and extreme temperatures.

Weather Mosaic

Prince Edward Island has some of the most variable day-to-day weather experienced anywhere in the country. A specific set of weather conditions seldom lasts for long. The Island is affected by a mishmash of weather systems, bringing polar, maritime, continental, and tropical air from the Arctic Pacific, and Atlantic oceans and from the Gulf of Mexico. In summer the Island is visited most often by continental air from the west. Occasionally, warm tropical air is drawn in from the south. Winters are dominated by cold continental air masses, but storms originating in the North Pacific or the Gulf of Mexico frequently pass through, making winters stormy and unpredictable. The influence of moist Atlantic air often produces warm periods during the winter and cool weather during the summer.

Never Hot but Can Be Cold

Summers are pleasantly cool. The July average temperature is about 18.5°C, with daily highs normally in the low to mid-twenties. Maximum temperatures exceed 30°C only once or twice a year and have never exceeded 37.8°C (100°F) at any official weather station on P.E.I.

Winter temperatures reflect the presence of sea ice, becoming colder later in the winter after the surrounding sea-water freezes. Bitterly cold temperatures below -18°C occur on only four or five nights in any winter, and thaws can occur in all the winter months. Periods free from frost extend over 130 days between late May and early October, a duration which compares favourably with that north of Lake Ontario and is about a month longer than the growing season on the southern Prairies.

Wet and Breezy

Precipitation is reliable and ample year- round. Annual totals average just under 1000 mm over the southeastern tip around Montague, increasing to 1100 mm or more in the centre of the Island at Charlottetown and New Glasgow. Monthly totals are greatest in the late fall and early winter, exceeding 100 mm monthly from October to January at Charlottetown, due to the more frequent and more intense storm activity at that time of the year. Wet days number 130 to 160 a year on the Island, with snow days accounting for 30% of them. Combined with the long growing season, the generous rainfall is responsible for the Island's verdant landscape and good farming.

Measurable snowfalls are frequent over the long winter season from November to April. The Island is one of the snowiest parts of Canada. Charlottetown's 330.6 cm makes it the third snowiest city next to St. John's and Quebec. However, because the snow comes and goes throughout the winter, there is an appreciable cover for only about three-quarters of the snow season, which lasts from late November to April 20, a period of about 145 days.

Heavy snowfalls of 12 cm or more average five a year, with one or two of them leaving as much as 25 cm of snow. The biggest snowfalls are usually associated with large, slow-moving weather systems and may last for up to 4 days.

Winds on the island are on average stronger than at most Maritime locations. The strongest winds occur in the coldest months, when stormy weather prevails. The lightest winds are summer breezes. Generally, winds from October to April are from the west or northwest; in summer, winds from the south and southwest predominate.

Wide Open to Storm Fury

The Island seldom experiences violent local storms in the form of tornadoes, severe thunderstorms, and hailstorms, although waterspouts, the aquatic cousins of tornadoes, are somewhat more in evidence. Thunderstorm days number between 9 and 12 a year on average considerably less than in other parts of southern Canada, and thunderstorms are certainly not of the same intensity as those experienced elsewhere.

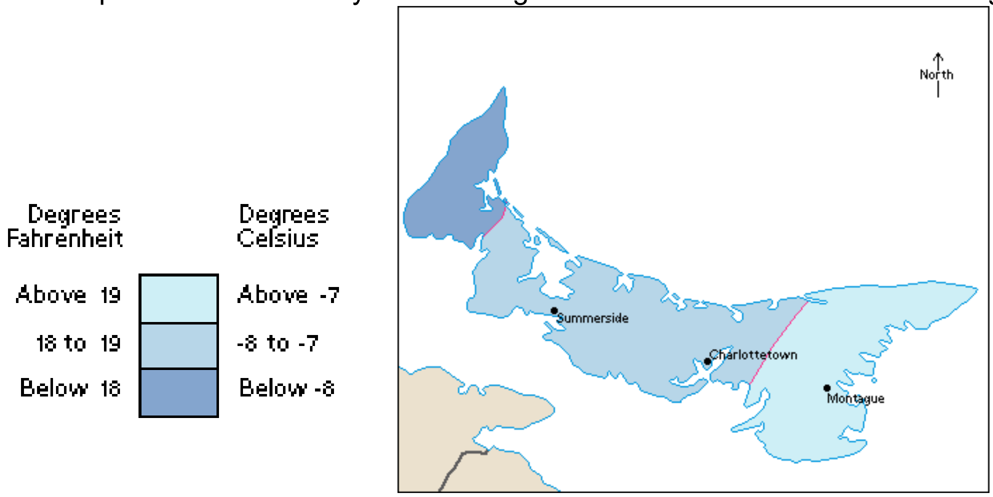
Although local storms are rarely severe, the Island is vulnerable to the destructive forces of much more powerful Atlantic storms. These bring very high tides (storm surges), strong winds, and heavy rains. About once every summer and early fall, dissipating hurricanes tracking along the Atlantic coast expend their energy and remaining rainfalls over the Island. One of the most drenching and damaging storms of this kind occurred on September 22, 1942. Charlottetown recorded 163.8 mm of rain, the greatest daily total ever recorded for any P.E.I. station.

Winter storms pose a serious challenge. Packing a variety of weather conditions from hurricane force winds to heavy precipitation in all forms, they can pass rapidly through the region or stall and batter the province for days. Winds associated with these storms on occasion exceed 100 km/h. When such storms occur at high tide, storm surges become a problem. When the centres of the storms remain to the south of the Island, precipitation reaches the Gulf and the Island in the form of snow. If the low centre passes to the north of the Island, the snow will change to freezing rain and rain. Freezing rain and snowfall may combine to paralyze the Island for days, at great cost to communications and transportation. During an average year, about 40 hours of freezing rain or drizzle fall over Prince Edward Island, coating everything in sight.

Blizzards, which unleash the threat of snow, wind, and cold, strike the province with paralyzing force about two or three times a winter.

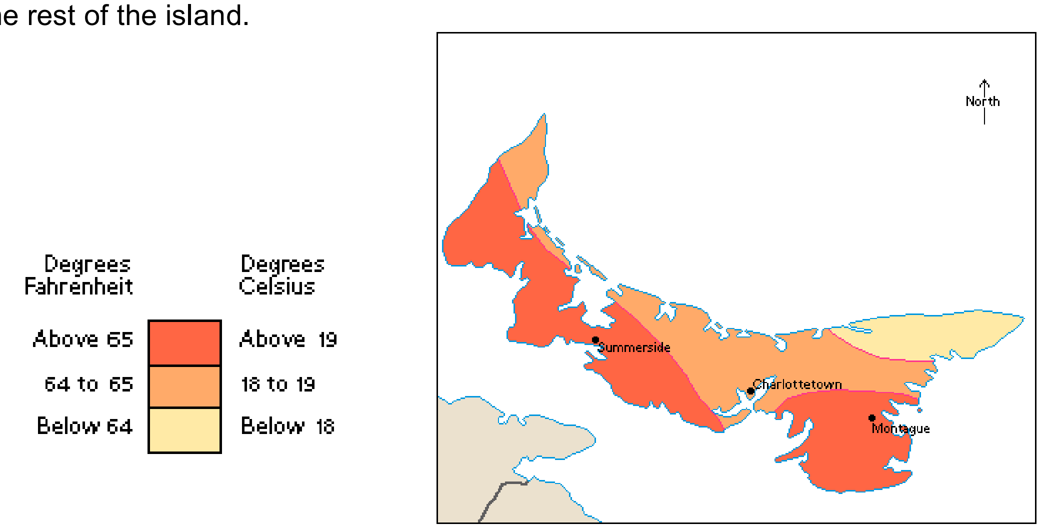
Average January Temperature

Winter temperatures are mostly even throughout the island. The southeast is slightly warmer.



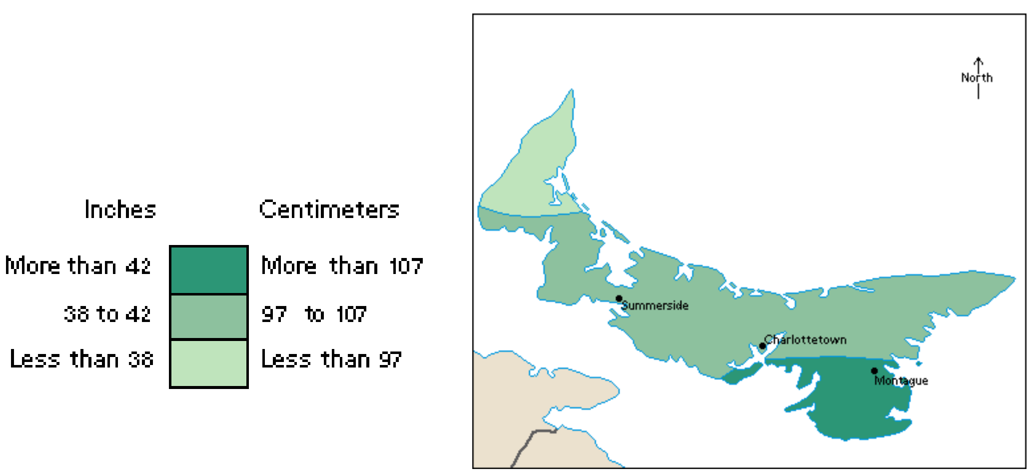
Average July Temperature

Summers are mild throughout Prince Edward Island. The northeastern corner is slightly cooler than the rest of the island.



Average Yearly Precipitation

The southern region is the wettest, and the northwest is the driest. The northeast receives the heaviest snowfall.



Appendix IV Notes and Agenda from the Atlantic Straw Bale Gathering 2006

Atlantic Straw Builders Gathering

May 2006 Tangier Deanery, Ship Harbour, Nova Scotia

Saturday, May 20

1:00 Registration and camp set up

2:00 Welcome

3:00 Ship Harbour Straw Bale Tour and Workshops

Workshops: A/Finishes B/Greenwood Construction

6:30 Supper – Potluck and local mussels

7:30 Presentation of CMHC research

8:00 Slide Show – and story sharing

9:30 Bonfire and music (bring your instruments)

Sunday, May 21

8:00 Breakfast

9:00 Stories – What worked, what would you have done differently?

10:30 Refreshment break

10:45 Building maintenance. Observations on best practices.

12:00 Lunch

1:00 Building the network. Up coming projects. Sharing resources.

2:30 Workshops 2: A/Yurts B/Heating

3:30 Closing

4:30 Optional Straw Bale tour

(Thompson res., Wechsler res., Harbourside and Robert Jamison Schools)

The Gathering is free for participants involved with the CMHC Atlantic Straw Bale Builders research project. Includes accommodation, meals (Saturday lunch and supper, Sunday breakfast and lunch).

Site: The Deanery is a small, rustic, ocean front camp in Ship Harbour, Nova Scotia.
There are beds for about 20 people and camping for many. It has a commercial kitchen, showers etc. and is a wonderful place from which to explore the Eastern Shore by land or water.

Atlantic Straw Builders Gathering May 2006

Summary of Working Group Notes

The following is a compilation of comments from members of five groups of experienced bale builders towards the end of the two day gathering.

Group 1
Design:
- take your time
- realistic expectations
- live on site for four seasons before building
- try to fit into land
- collect measurements of everything that seems remotely important
- think utilities (sewage, hot water, heat) when planning for big picture
- think of both summer and winter spaces
- buying bales: check them out, make sure they are tight!!!
- measure bales

Foundations:
- there are plenty of cheap alternatives, but can be problems getting permits

Work Crews:
- Know when to say stop, so things continue to be done well and properly.
- Design / Organize work party from start to finish

Group 2
Design:
- use huge overhangs
- make tension bands using cables, nylon rope
- mandala type roofs are an interesting option
- stack wood etc. to protect walls (reduce wind/water exposure)
- use resource books
- detailing is SO important

Bales:
- measure your bales before completing foundation details
- test and view before you buy
- ask lots of questions about materials

Group 3
Design:
- take your time
- get to know site and landscape
- carry a notebook and tape measure
- start with utilities
- use bubble diagrams
- consider seasonal spaces
- use properties of straw and design to their qualities

Greywater:
- set precedents to get alternative systems passed (code)
- workshops with John and Nancy Todd are a good introduction
- bring existing research into Nova Scotia

Note: Find Engineers interested in natural/alternative building!

Group 4

Foundation:

- gravel bags worked well
- use slip form and slide for irregular formwork
- build on unbroken earth
- if person is working alone, concrete pillars can be a good option

Doors / Windows :

- insure good flashing and extra overhang

Work party:

- hire an expert to organize

Roof:

- Enviro-shake is an option for roofing material
- metal roofing is long lasting and recyclable
- living roofs do well in Nova Scotia
- reuse carpets on living roof to ensure roots don't penetrate membrane

Note: Yurts are a good storage option during builds as no permit is required.

Group 5

Design

- talk to experienced builders (bale and non-bale variety)
- consider level of continual maintenance you are willing to put in when making design decisions
- factors to consider when buying windows (longevity, aesthetics, eco-impact, adherence to plaster, guarantees)
- mini bales are a good option for interior walls – available from a farmers market

Walls

- ensure even coverage of plaster one – two inches thick
- rain-screens i.e. wood siding or porches can be an excellent design option
- build on protected site
- detail flashing well
- set windows flush to outside plaster
- use full posts rather than milled
- use burlap, instead of chicken wire for nice curves
- Weed Whack walls to prepare for first plaster coat
- Share resources whenever possible from project to project

Foundation

- don't build in a dip (marsh etc.)
- rubble trenches save on concrete and give great drainage
- make sure bales are high off ground to prevent splash-back

Walls

- take your time installing the bales (well aligned, quality control)
- maintain walls
- wiring can be run through sill plate
- make curbs wider than recommended (measure bales yourself before building curb)

Appendix V Contact Information for Atlantic Canada Straw Bale Builders

d=designer b=builder a=architect e=engineer t=timber framer ed=education

Prov.	Service	Name	Company	Telephone	Email
NB	d	Leland Daugherty	Artful Acres	506-375-8623	artacre@nbnet.nb.ca
NB	b	Phil Whylie		506-372-4174	phil_wylie@hotmail.com
NB	b	A and C Acheide		506-532-9181	acheide@nb.sympatico.ca
NS	d-b	Rod Malay	ArchNet	902-830-6351	rodmalay@ns.sympatico.ca
NS	d-b-ed	Kim Thompson	Straw Bale Projects	902-453-2429	shipharbour@ns.sympatico.ca
NS	b	David Cameron	Earth Sea	902-766-4129	info@earthsea.ca
NS	d-b	Volker Klum	Quality Masonry	902-331-0011	www.qualitymasonry.com
PE	b	Ben Waterman		902.962.3240	benwaterman@hotmail.com
NS	ed	Alex &Selene Cole	Little Foot Yurts	902-542-9488	alex@lfy.ca
NS	d	Shawna Henderson	Abri Design	902- 489-1014	shawna@abridesign.com
NS	e	Pat Griggs	Griggs Engineering	902-860-0752	grigeng@ns.sympatico.ca
NS	e	Sam Roberto			
NS	e	Bill Sheppard		Tony River, NS	
NS	e	Gord Luke	Lighthouse Engineering	Chester, NS	
NS	e	Glen Buchanan		Elmsdale, NS	
NS	a-b	Gabe Prost	Prost Design	902-423-6121	gp_atlarge@hotmail.com
NS	a	Keith Robertson	SolTerre Design	902-492-1215	keith@solterre.com
NB	d	Maria Rechia		506-529-8723	mariarecchia@nb.aibn.com
NS	a	Frank Parks		Aylesford, NS	
NS	t	Dan Regan	Acorn Timber Frame	902-542-3838	projects@acorntimberframes.ca
NB	t	Chris Meier		506-529-3087	
NB	t-d	Nader Naderi	Atlantic Post and Beam	506-450-5445	engineering@atlanticpostandbear

Appendix VI Information and Resources for Straw Bale Construction

Excerpted from: Camel's Back Construction www.strawhomes.ca/building.asp

What is Straw Bale Building?

Straw bales were first used to construct homes by early settlers in the sandhills of Nebraska in the late 1800s. Faced with no trees to mill and soil too sandy to use for sod homes, they turned to the abundant supply of prairie grasses and their recently invented baling machines. Many of these turn-of-the-century homes, schools and churches are still standing.

Straw bale homes offer insulation values of R-40 to R-45, more than double that of standard frame homes. Straw bale walls can also be less expensive than wood-frame ("stud") walls. Load bearing straw bale walls replace the majority of the framing lumber, manufactured insulation and plastic barriers with an annually renewable, agricultural waste product.

Well detailed straw bale homes consistently use less than one half of the heating and cooling energy required by standard frame homes.

Any type of straw can be used, including wheat, oats, barley, rye and rice. Bales used for building are not custom-baled, but must be dry (less than 20% moisture) and tight. Two string bales are the Canadian straw bale construction standard, but in places where larger, three-string bales are the norm they too can be used and offer insulation values of R-55.

Straw bale buildings use the same foundation, flooring and roofing technologies familiar to builders of frame homes. Basements, slabs and pier foundations can all be easily adapted to straw bale construction. Similarly, prefabricated trusses can be used to provide the roof structure.

The straw bales in the walls are stacked in a manner similar to bricks or concrete blocks, in running bond. Window and door openings are created using wide, rough frame wooden bucks inserted into the walls during construction. The first course of bales is always started on a 2x4 curb, to lift the bales higher than the interior floor level, in case of flooding or spills.

There are two basic styles of straw bale construction. Post and beam style uses a structural framework to support roof loads, and the bales are either wrapped outside the framework or in filled between the framing members. While wooden post and beam systems are the most common, concrete and steel frames would also be suitable.

Load-bearing (or Nebraska) style bale buildings use the bale walls themselves to support the roof. Various systems have been used to "pre-compress" load-bearing bale walls to eliminate any "sponginess" from the bale walls and level them. A structural roof plate is placed on top of the walls, and the precompression system draws this roof plate down toward the foundation.

There are building code approved examples of both load-bearing and post and beam straw bale homes across Canada. Many have received bank mortgages and regular home insurance. Much testing has been done on straw bale wall systems, and tests to date show that they outperform a standard 2"x6" frame wall. Fire tests show a burn time more than double that of a frame wall, and structural tests show similar advantages. Canada Mortgage and Housing has been responsible for some of this testing, and they are generally supportive of straw bale building.

To date, most building inspectors have required either an architect's or engineer's approval of drawings for straw bale buildings before issuing permits. Currently bale projects must be approved on a case-by-case basis.

Natural Building Resources
Books

Alexander, Christopher, *A Pattern Language*, New York: Oxford University Press, 1977
Bee, Becky, *The Cob Builders Handbook*, Groundworks, Oregon, 1997
Bourgoise, Jean-Louis and Carolee Pelos, *Spectacular Vernacular: The Adobe Tradition,* Aperture Foundation, N.Y.
Day, Christopher, *Places of the Soul: Architecture and Environmental Design as Healing Art*, Aquarian Press/Harper Collins, California, 1990
Earth Construction, Intermediate Technology Press, Women Ink, New York, 1994
Easton, David, *The Rammed Earth House*, Chelsea Green Publishing Company, 1996
Evans, Ianto and Smith, Michel and Smiley, Linda, *The Hand Sculpted House*, Chelsea Green Publishing 2002
Farrelly, David, *The Book of Bamboo*, Sierra Club, 1984
Guelberth, Cedar Rose and Chiras, Dan, *The Natural Plaster Book*, New Society Publishers, 2003
Holmes, Stafford and Wingate, Michael, *Building with Lime*, Intermediate Technology Pub, 1997
Hunter, Kaki and Kiffmeyer, Donald, *Earthbag Building*, New Society Publishers, 2004
Jenkins, Joesph, *The Humanure Handbook, 2nd Edition*, Jenkins Publishing, PA, 1999
Kahn, Lloyd, *Homework*, Shelter Publications, 2004
Kahn, Lloyd, *Shelter*, Shelter Publications, 1973 (back in print).
Kennedy, Joseph, *The Art of Natural Building*, New Society Publishers, Canada, 2002
Kennedy, Joseph, *Building Without Borders*, New Society Publishers, Canada, 2004
Kern, Ken, *The Owner Built Home,* Charles Scribner's Sons, 1975
Khalili, Nader, *Ceramic Houses and Earth Architecture,* Burning Gate Press, 1990.
King, Bruce, *Buildings Of Earth And Straw: Structural Design For Rammed Earth And Straw Bale Architecture*, Chelsea Green Publishing Co., 1997
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Lacinski, Paul and Bergeron, Michael, *Serious Straw Bale*, Chelsea Green Publishing Co., 2000
Laporte, Robert, *Mooseprints,* Santa Fe, NM: Natural House Building Center, 1995.
Lerner, Kelly, *Natural Remodeling for the Not-So-Green House,* Lark Books, New York, 2006
Magwood, Chris and Walker, Chris *Straw Bale Details: A Manual for Designers and Builders,* New Society Publishers, 2003
Magwood, Chris with Mack, Peter and Therrien, Tina, *More Straw Bale Building,* New Society Publishers, 2005
Mazria, Edward, *The Passive Solar Energy Book,* Emmaus, PA: Rodale Press. 1979
Oliver, Paul, *Dwellings: The House Across the World*, University of Texas Press, 1988
Pearson, David, *Earth to Spirit,* Chronicle Books, 1995.
Pearson, David, *The New Natural House Book*, Simon and Schuster,1988,
Potts, Michael, *The Independent Home*, Chelsea Green Publishing Company, 1994
Roy, Rob, *Cordwood Building - The State of the Art,* New Society Publishers, 2003
Roy, Rob, *Timber Framing for the Rest of Us*, New Society Publishers, 2004
Steen, Athena and Bill and Komatusu Eiko and Yoshio, *Built by Hand*, Gibbs Smith Pub, 2003
Steen, Athena, Bill and David Bainbridge, *The Straw Bale House,* Chelsea Green Publishing, Company, 1994
Steen, Athena, Bill, *The Beauty of Straw Bale Homes*, Chelsea Green Publishing Co, 2000
Tibbets, Joseph M. *The Earthbuilder's Encyclopedia,* Southwest Solaradobe School, 1989

Periodicals
Adobe Journal, P.O Box 7725, Albuquerque, NM 87194, (505) 243-7801
American Bamboo Society Newsletter 750 Krumhill Rd., Albany, NY 12203-5976.
Designer/Builder Fine Editions, Inc., 2405 Maclovia Lane, Santa Fe, NM 87505
Environmental Building News. RR 1, Box 161, Brattleboro, VT 05301
Home Power Magazine - PO Box 130, Hombrook, CA 96044-0130
***The Last Straw*, PO Box 42000, Tucson, AZ 85733-2000.**
Permaculture Drylands Journal, PO Box 156, Santa Fe, NM 87504-0156 (505) 983-0663
Solar Today, American Solar Energy Society, 2400 Central Ave., Suite G-1, Boulder, CO 80301

Audio Visual
Building With Awareness, DVD, Syncronos Design Production, www.buildingwithawareness.com
Straw Bale Code Testing, video; Black Range Films, New Mexico; 1996
The Straw Bale Solution, Black Range Films, New Mexico, 1999

Internet Resources
There are now hundreds of internet sites with information on straw bale construction and natural building, as well as many newsgroups for on-line conversation with experienced straw enthusiasts and discussion of sustainable issues in general.
Two excellent list-serves on straw bale construction are:

http://groups.yahoo.com/group/SB-r-us/
http://listserv.repp.org/mailman/listinfo/strawbale_listserv.repp.org

Web Sites
www.solstice.crest.org.strawbale - Sustainable resource and development

www.strawbalecentral.com - Resources for straw bale construction

www.dcat.com - Development Centre for Appropriate Technology

www.cobcottage.com - Cob Cottage, Oregon

www.sustainableabc.com - Ecology and sustainability issues and resources

www.thelaststraw.org - Last Straw, natural building journal

www.ems.org/straw_bale/intro.html - Environmental Media Services

www.calearth.org - Earth Buildings of Nader Khalli

www.networkearth.org - Nat build media resources; colloquium archives

www.builderswithoutborders.org/- Not for profit building for low income or disaster relief

www.homes-across-america.org/index.cfm - Database of efficient homes

www.txses.org/epsea/design.html - The El Paso Solar Energy Association

www.gsb.columbia.edu/research/sdi/living.pdf - Green roofs research

www.greenhomebuilding.com - Vernacular architecture, building code, solar heating ….

www.greenbuilder.com - Sustainable resource and development

www.thatch.org - Thatching UK

www.naturalbuilding.ca - Research, education and resources. Nova Scotia.

www.Strawbalefutures.org.uk/ - SB construction in UK
www.skillful-means.com/ - Straw bale and green construction
http://mha-net.org/html/sblinks.htm - Surfin straw bale
www.strawbalebuilding.ca - Ontario Straw Bale Building Coalition

Appendix VII File Maker Pro Database Profiles

A PDF of the File Maker Pro database on which this study was based. This large file (109 megabytes) is 306 pages in length and contains the profiles of thirty four straw bale buildings.