Building for climate change

A quick guide for homeowners and builders

Produced by the SOUTHWEST NEW BRUNSWICK SERVICE COMMISSION

With aid from the Province of New Brunswick through its Environmental trust fund

snbsc.ca

The residents of Southwest New Brunswick have been front and centre in weather-related news in the last decade. The floods of 2010, ice storm of 2013, and aftermath of post-tropical storm Arthur drove home the devastation of weather upon the region. Add to that the storms elsewhere, and the looming reality of forest fires in a region known for its rural lifestyle and camps, and the potential for loss of property – if not life – at the hands of Mother Nature loom large.

While the risk cannot be eliminated, thoughtful building and development approaches can reduce the risks presented by fire, flood, wind and heavy precipitation. Incorporating some or all of the ideas presented here will help homeowners reduce the chance of loss or damage to their property.

This handbook will focus on building and landscaping approaches to address four key threats:

Wildfire

Flood

Extreme precipitation

Extreme wind

Disclaimer:

The suggestions made here summarize and draw from best practices, codes and methodologies applied in other jurisdictions (A companion document, "Building for Climate Change, a Comprehensive Guide for Builders and Planners," provides references and greater detail.) They are by no means exhaustive, nor intended to provide absolute protection against the effects of climate change. For a proper assessment, the reader is encouraged to consult with a qualified professional who could provide specific solutions for the reader's property.

Unless stated otherwise, the enclosed building practices are not required by the National Building Code currently in force. The reader should also be aware that permits may be required for certain developments or changes to buildings or structures. Questions may be forwarded to the SNBSC office at tel: (506)-466-7369, web: snbsc-planning.com, or to the planning authority serving the reader's jurisdiction.

Building for wildfire

Many homes in southwest New Brunswick are rural in nature, nestled against forests. That natural environment we prize also presents a significant risk of property loss and damage from wildfire. One need only reflect upon the staggering fires in Fort McMurray AB (2016) or the northern part of BC (2018), to understand how powerful - and devastating - wildfires can be.

Fires like those in B.C. underscore the risk of building near forests. Image courtesy BC Wildlife Service

Good practice: specify non-combustible roofing (metal, clay, concrete, Fiberglas composite. Standard asphalt shingles are also quite resistant to firebrands.)

Avoid: wood shakes and shingles on roof, even if deemed "fire retardant."

Homes with wood shake or shingle roofs are *two to 12 times more likely* to suffer fire loss related to adjacent wildfires.

Better roofs

A key cause of structure damage and loss due to forest fires is not – as one might think – related to direct exposure to flames. Rather, burning embers (called *firebrands)* from nearby forest fires contact with combustible elements of a building, of which the roof is the most likely to endure contact with these firebrands.

Firebrands carried by wind can spark fires more than a kilometre away from a main blaze. Fanned by wind, those embers turn into secondary fires that then cause damage to the home.

Better siding

After roofing material, the next element of a home most vulnerable to fire is its cladding, or siding.

During a wildfire, the outside walls of a home are more likely to suffer damage due to direct exposure to flame. For this reason, flammable siding (vinyl) is a risk, especially if there is not sufficient clearance from nearby combustible material at ground level.

Good practice: Use brick fascia, stucco, metal, and fibre-concrete (Hardiplank) siding products.

Avoid: combustible siding, especially vinyl.

Concrete-fibre board is a time-tested non-combustible siding product.

Best practice: Use flat soffits, which minimize trapped heat and gas experienced with attaching soffits to sloped rafter/truss members

- **minimize roof overhangs**
- **consider installing 5/8" exterior grade gypsum board as backing to other soffit materials**
- **avoid vinyl soffit material**
- **Install a secondary shutter system over gable-end vents**

Protecting soffits

Soffits are often made of vinyl. Even on homes with brick fascia or metal cladding, this represents a weak point in terms of fire defense. Those living near forests and woodlands should consider alternatives to vinyl soffits. Metal panels are not considered the best alternative, as they conduct heat and can warp if exposed to fire. An alternative (used in California, among other places) is to install either cement-fibre board of some nature, or wood painted with a fire-resistant paint.

Best practice: Install fine mesh over attic vents, HRV vents, and other openings in the building envelope. Alternately, create a "forest fire plan," that includes temporarily closing these openings with Fiberglas insulation or mechanical devices.

Protecting attics

Firebrands are often quite small and easily carried by winds that accompany fires.

These embers can infiltrate ventilation openings in the home. Keep openings such as vents to a minimum, and use a fine wire mesh to restrict passage of firebrands borne by wind.

Wildfire risk reduction- Landscaping

Based on data from California, a home within nine metres of burning vegetation is 24 per cent likely to be destroyed by fire. By comparison, a home 30 metres from burning vegetation is only one per cent likely to be destroyed by wildfire.

Simply put, attention to landscaping will help prevent damage to homes during wildfires. More detail on these "Fire Smart" techniques is available from the province and elsewhere.

Those living near forests or wild areas should remove combustible material within 30 metres of their home. In areas of dense conifers, the buffer should be greater than 30 metres.

Within three metres of the home

Remove all organic/combustible material – including organic mulches – from within three metres of the home.

Retain at least a 15 cm gap between ground and cladding.

Plants should be succulent (green), well-watered, and pruned of any dead material.

No conifers (evergreens) of any kind, and no tall trees should be in this area. Small decorative trees (crabapple, etc) do not present much of a risk, but all trees should be separated from each other by at least five metres. Planted areas should feature a few non-combustible breaks (walkways, etc.)

Best practice: regularly inspect gutters and the perimeter of your home to remove needles, leaves and other debris that could serve as fuel for an errant ember (firebrand).

This will also minimize damage from severe rainfall.

Zone 1: From three to 10 metres from the home

Plants should be succulent (green), well-watered, and pruned of any dead material.

No conifers (evergreens) should be in this area. Birches, which are a deciduous (leafy) tree but burn easily, should not be numerous. Branches should be well pruned, and all dead branches cut away and disposed of.

Zone 2: From 10 to 30 metres

Only small evergreens should be kept in this area. Deadfall and other combustible material should be removed. Spacing between trees is still of concern, particularly where evergreens (conifers) are concerned.

Zone 3: Beyond 30 metres (to 100 metres)

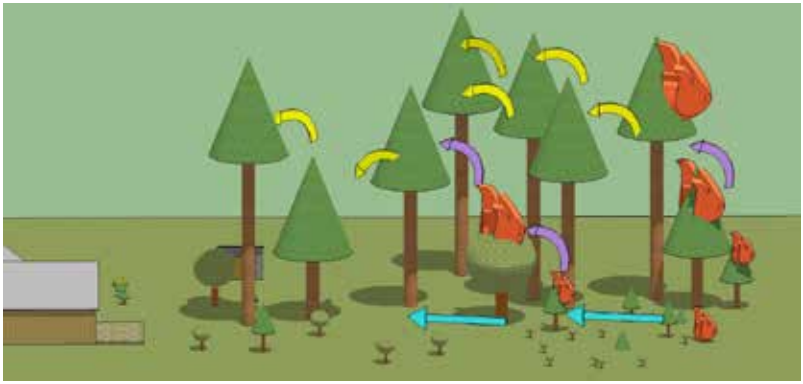
Removing dead trees and pruning dead branches will reduce the risk of fire spreading. The same goes for tending to deadfall and other vegetation.

Remove tall trees, especially conifers, within the 30-metre buffer zone, and thin other trees.

Ideally, fires will encounter reduced fuel as they approach the home, and weaken in intensity.

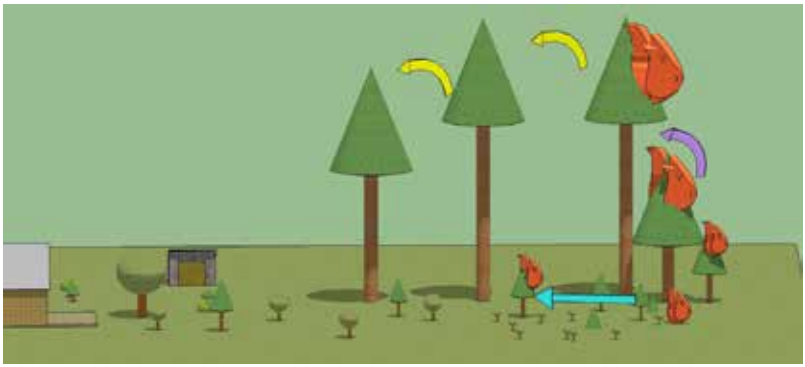
Most wildfires move along one of two fronts: along the ground, or along the crowns (tops) of trees. A large part of Fire Smart landscaping lies in trying to eliminate those pathways by pruning so ground fires can't "climb" up trees to become crown fires.

In the diagram below, the yellow arrows show the path a crown fire may take, the blue arrows show the path a ground fire may take, and the purple arrows illustrate how fire can transition from ground to crowns.



By reducing these pathways - with more thinning nearer a home - the chance of fire encroaching the home is also reduced. In general, any trees within 30 metres of the home should be well-pruned, with dead branches removed along with any branches within two metres of the ground.

Avoid planting new vegetation directly underneath trees, and remove brush and shrubs from under trees - especially conifers. Trees should be thinned so at least two metres separate adjacent trees, if not more.



In the second illustration, some pathways for fire still exist, but are reduced closer to the home.

Flood resilience - Building

The Saint John River floodwaters of 2018 surround a church. Geoffrey Downey/NB Department of Public Safety

Floods generally occur due to one of two reasons: significant rainfall or snow-melt that overwhelms streams and rivers (St. George area floods of December, 2010; Saint John River system in 2018); or storm surges (extreme high sea levels associated with tropical storms or hurricanes.) New Brunswick has experienced both in the last decade.

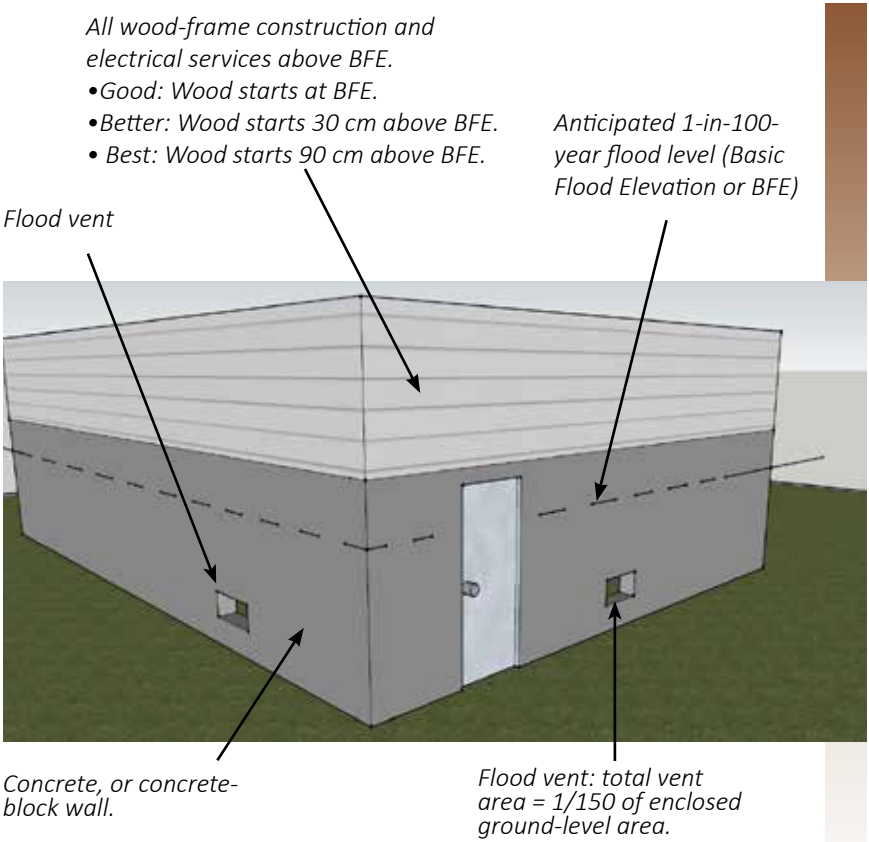
The only way to reliably avoid property loss due to flooding is to avoid building in flood-prone areas.

However, current planning guidelines - and habit - mean buildings will still be erected in flood-risk areas. Owners of buildings in flood-prone areas should assume floodwaters will engulf the home at some point and prepare by raising easily-damaged elements of the home above the expected 100-year flood level. The 100-year-flood level is often called the "Base Flood Elevation" or BFE.

Consider the damage the building shown above likely suffered: waterlogged insulation, saturated drywall, potential mold in wood, along with damaged furnaces, presuming such were installed. If the water-susceptible elements of this building been raised above flood level, damage would have been reduced if not eliminated entirely.

The 100-year flood level is an ideal target to plan for. It's also called the "Basic flood elevation" or BFE for short.

The concept of elevating vulnerable construction (wood frame, living areas) above BFE is used in flood-prone areas of the southern U.S., Australia, and other nations.



This illustration shows some of the basic elements of flood-resistant building practices. This kind of construction is Code-mandated in flood-prone areas of the United States.

Water levels alone are not the only damage caused by floods: moving water imparts considerable force on fixed objects, such as trees or the walls of buildings.

The simplest way to reduce floodwater pressure lies in equalizing water level on both sides of a wall. A common practice in flood-prone areas is to build "flood vents" - purpose built openings - into the wall. Total opening should be 1/150 the total interior floor area, with vents set no more than 30 cm above the interior floor level. This approach allows water to enter (and leave), reducing horizontal stresses. Combined with the practice of building with concrete, brick, or block below the BFE, this technique has been demonstrated to dramatically reduce flood-related losses.

A water level difference of 30 cm creates lateral forces of 300 kg per square metre.

With the floods of 2010 in mind, this Bonny River homeowner chose to build on grade, and add fill to create a basement. This is a reasonable approach to flood damage mitigation.

Homes not subject to flooding can experience risk of water intrusion during significant rainfall or snow melt. New construction should take into consideration past flooding history. Slab-on-grade construction, if suited to the site, avoids leaky basements.

Best practices

- **No living space below BFE**
- **All load-bearing timber above BFE**
- **All key electrical services (service panels, electrical meters) above BFE**
- **Use building materials below BFE that are not susceptible to water damage, ie: brick, concrete, steel**
- **Build on either piers, concrete block wall, or concrete wall, such that any living space is at least 30cm, if not 90cm, above the Base Flood Elevation**

Best practice:

Anchor low-height decks to sonotubes below the frost line: this will reduce potential of damage from moving floodwaters. (It's required by Code for any deck above 60 cm in height, or any deck attached to a house.) Also anchor accessory buildings to, at the least, strip footings for the same reason.

Anchored decks/buildings are also wind-resistant.

A simple plumbing prevention

Consider installing a backflow prevention valve even if such isn't mandated by Code. Though plumbing codes require one for septic systems when bathrooms exist below grade, the use of a backflow valve in above-grade construction can prevent sewage backup when a septic system is totally overwhelmed by water.

Camps in flood-risk areas

Many residents of New Brunswick have cabins, or "camps" in remote parts of the province. Those who are planning to build camps near water should consider building on anchored piers (sonotubes sunk below ground level) to elevate the structure above potential flood levels. This not only reduces the risk of contact with floodwater, but also creates storage space for non-critical items. The exterior can be closed in with wooden walls (with flood vents) for extra security.

Flood risk reduction- Landscaping

The power of water

Moving water possesses incredible force. When siting a building in an area that may be prone to floods, do so with consideration of the direction water flows may take.

Those near riverbeds and streams should anticipate not only the expected height (BFE) of floodwaters but the direction those waters will move.

Naturally, the intuitive approach of erecting a building on the highest point of land is wise. However, there are some other factors to consider.

In the winter of 2010, massive rainfall triggered floods that left many structures subject to significant floods. Streams and rivers, such as the Magagudavic River above, were swollen with massive amounts of flowing water which damaged riverbanks, covered bridges and other properties. Jason Gaudet photo.

The 'scour' effect

Moving water will wash away earth of all kinds, removing remove material from foundation walls and footings, creating structural weaknesses. This is called 'scour.'

It's vital to note moving water will affect the foundation walls or piers of homes raised above the basic flood elevation.

The simplest means of diminishing such forces involves adding various sizes of stone or rock around the area that may be vulnerable. It would be a good idea to consider adding such stones/boulders both above and below grade to protect foundations from anticipated flood waters. Those who are looking to arrest potential storm surge waves should note that storm surge forces work in two directions: inbound from the ocean at first, and then outbound as waters flow back after the flood.

Rock works:

If possible, directly bonding foundation walls or footings to rock virtually eliminates scour.

Extreme rain/snow - Building

Annual precipitation amounts (snow in winter, rain in summer) are not just increasing, due to climate change, but more importantly, there is a greater chance of increased daily precipitation, be it a heavy rainfall or blizzard, or - as has become common in New Brunswick - rainfall in mid-winter.

In many cases, storm-related damage is as much due to water as other forces, particularly when wind drives rain past weaknesses in building envelopes.

To a large degree, modern building codes already provide for some assistance in terms of adapting to rain and snow - like the "capillary break" or "shingle backer" mandated for certain kinds of siding in this area. Proper flashing techniques around windows, doors and decks, along with the application of eaves protection material, will significantly reduce, if not eliminate entirely, any chance of water penetration into a building assembly.

However, other additions - like deeper fascia boards (i.e. six inches rather than the standard four) will help reduce wind-driven rain penetration.

Example of a "shingle backer". Water that may penetrate past these shingles has space to drain between the shingles and housewrap.

The No. 1 cause of Atlantic Home Warranty claim costs is improper window flashing. Sheathing tape is not Code-compliant flashing, even for windows labelled as "self-flashing" - a misleading name.

Best practice: regularly inspect gutters and the perimeter of your home to remove needles, leaves and other debris to ensure proper drainage.

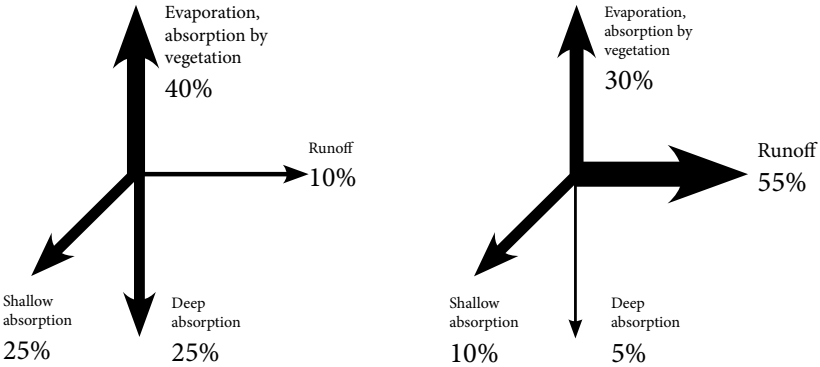
This will also reduce risk of fire caused by wind-borne embers.

Extreme rain/snow - Landscaping

Runoff courses across the asphalt driveway of this home in St. Stephen during a significant rainfall in 2010. The combination of roofs with asphalt driveways means a significant portion of most urban lots will lose 30 per cent or more of all rainfall in direct runoff, creating a flood risk to other parts of the community.
John Gardner photo

There is, naturally, an intimate link between extreme rainfall (and to a lesser degree, significant snow accumulation) and flooding. A critical function of reducing the impact of floods, as well as erosion, lies in how properties are landscaped.

Whether from rainfall or snow melt, runoff wates are a natural product of most building construction, simply because roofing material is impervious: the water once absorbed by ground and forest where the home now stands naturally goes somewhere else. This is illustrated in the graphic below.



Water dispersion patterns for forested areas, left, versus 75-100 per cent impervious surfaces.

There are many ways to retain, or delay, rainwater in heavy downfalls.

- Disconnect downspouts from any municipal storm sewer systems.
- Avoid asphalt or cement driveway and deck surfaces.
- Specify driveway and patio surfaces that absorb water (pavers, crushed gravel and certain kinds of specialized porous concrete).

These steps will allow soil around the home to act as a storage and buffer for rainwater (and help replenish aquafers that wells rely on). Water may enter nearby streams and rivers, but will do so over a longer period when compared to impervious surfaces, and the waters are filtered of debris and in some cases, pollutants.

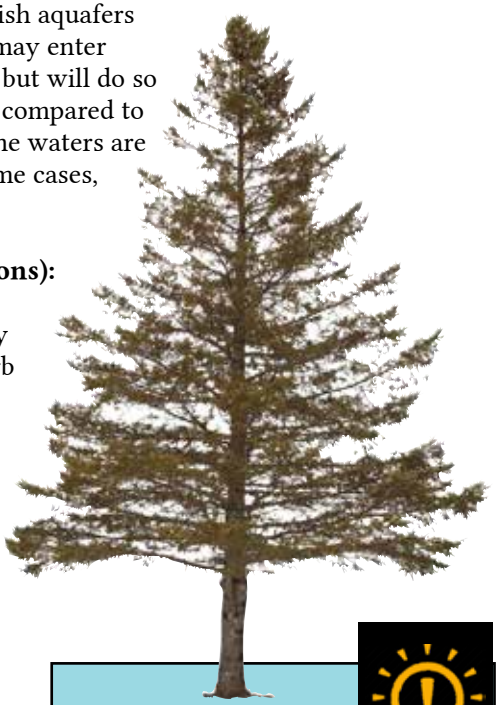
Lawn tip: Water infrequently.

A deep, weekly watering (if Mother Nature doesn't do the job herself) will help create deeper grass roots. This will not only lead to a greener lawn, but one able to better capture water during heavy rains.

Let it grow (for two reasons):

Plants are a key tool in controlling runoff. In heavy rains, vegetation will absorb significant quantities of water, which will help reduce the impact of severe rainfall on neighbouring properties. Of these, trees and shrubs - organisms with more mass/volume - are able to retain more water (runoff.)

Plants also help prevent erosion. Even in situations where there is vast amounts of rainfall or water movement, the root systems of plant matter will reduce the amount of soil lost to moving water. Trees, large shrubs and plants that naturally "sucker," or partially propagate by sending out shoots are best for this.



A British study found that a stand of spruce trees transpirated (evaporation through leaves) 690 mm of rainfall over a year.

Consider, by comparison, that 690 mm of rain is 30 mm more than the amount of annual rainfall in Saint Andrews.

Building for wind

As the strong wind gusts following post-tropical storm Arthur in 2014 demonstrated (as does the Groundhog Gale in 1976), New Brunswick will experience significant high-wind events. Analysis of damage suffered for hurricanes, tornadoes and plow winds throughout North America, shows the major point of failure lies in roof systems. Fortunately, some simple construction techniques can significantly decrease the chance of wind-related damage on a home.

Best practice: Anchor all trusses (or rafters) to the sill plate with hurricane ties.

Hurricane ties

Hurricane ties are a simple metal bracket that will bind a truss member to the sill plate of the supporting wall. Depending on size and style, these clips range in cost from 70 cents each to $1.25 each and are a time-tested and remarkably inexpensive means of improving the truss-to-roof connection. The use of a hurricane tie presents vastly greater resistance to uplift than the alternative of three nails toenailed into the sill plate. An alternative is a heel or drop-chord truss that is tied into the wall via sheathing.

Avoid: Gable roofs

The gable roof has become quite popular, largely due to cost. However, the large end wall created by a gable roof creates a weakness point for uplift. Designers for homes in high-wind areas strongly recommend hip roof designs (see illustration), instead.

Avoid: shallow roof slopes

Studies from Florida show that the shallower the roof angle, the greater the uplift caused by severe winds. A general consensus is to build with slopes between 4:12 and 6:12 (18 to 26 degree slope.)

Best house designs for wind resistance will minimize the amount of any one wall area that could be exposed to strong winds. For that reason, it's best to keep homes to one storey and as square as possible. (Alternate footprints, such as hexagonal, are even better.)

The standard soffit-and-ridge ventilation approach frequently used in this region usually provides far greater venting than required by Code, and as such, leaves significant area open to wind-related intrusion. If not needed for ventilation, gaps between the sill plate of the wall should be closed off with OSB, plywood, or some other resilient material. A six-inch fascia (rather than four) will minimize the chance of wind-driven rain infiltrating the eaves.

Nails: the more the better.

Building codes developed for areas of the southeastern U.S. suggest nailing sheathing every six inches on all truss supports. (NBC requires this on edges only.) The Partnership for Advancing Technology in Housing (PATH) also suggests use of adhesive, as done with floor underlay.

Avoid overhangs

Roof overhangs greater than two feet considerably increase the roof edge exposed to uplift.

Reducing soffit venting to Code-stipulated standards also helps with minimizing risk to wildfires.

Resilient outbuildings

The home is not the only area of concern during high winds. If winds are strong enough to damage a home, they are also strong enough to damage an outbuilding.

Many jurisdictions, as well as planning departments of regional service commissions, allow outbuildings to be erected on blocks. That presents a risk for wind damage. Consider anchoring sheds, baby barns and other small outbuildings to concrete piers (sonotubes) or a strip footing of some nature.

Garage doors are particularly susceptible to wind damage. Reinforced garage doors will be better able to withstand both the forces of wind, as well as objects propelled by high winds.

Anchoring outbuildings on footings or slabs also reduces the chance of displacement in flood-prone areas.

Landscaping for wind

In extreme wind, damaged or aging trees can create property damage. Ray Simpson photo

In extreme weather, particularly storms with high winds, trees can topple and land on cars, houses or power lines. Branches will snap off and smash into windows.

A tree is more likely to survive storms if it is compact, with a strong, sturdy trunk and a deep, symmetrical root system. Conversely, a shallow-rooted tree with a slender trunk is more likely to suffer wind damage. An example of this would be a slender pine that was once a part of a larger collection of trees, but has been left on its own after clearing for construction. These pines require other companion trees to collectively resist winds: a cluster of pines is essentially more able to resist high winds than an individual, even in hurricane-force winds, and care should be taken to preserve stands of tall, slender-trunked trees wherever possible.

However, consider removing individual examples of tall, slender trees if collections of trees cannot be retained (i.e. to remove fuel to prevent wildfires, or left after clearing for new construction) If desired, these can be replaced with trees better able to withstand storms.

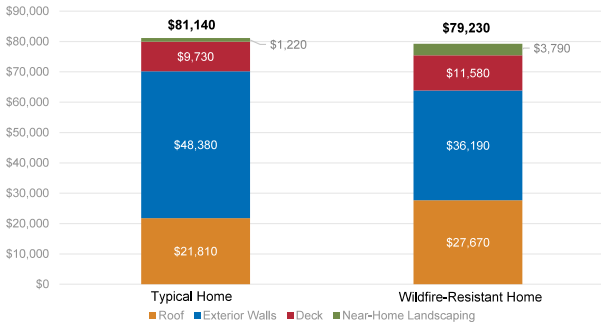
Planting tips

Select trees from the nursery that have straight (not circling) roots, one dominant trunk, and branches that are spaced apart from each other. Don't fertilize new plantings. This will encourage shrubs and trees to develop a more rigorous - and stronger - root system.

Building better might actually cost less

In some cases, adopting the suggestions made here can actually save money. Headwaters Economics, a Missouri-based nonprofit research group, analyzed the cost of building a wildfire-resilient home compared to the alternatives, and found a somewhat surprising result, specifically, that building a "fire smart" home may actually cost a little less than a typical home.

The study, published in November of 2018, compared the costs of constructing a single-storey, 2,500-square-foot, three-bedroom home, using readily available cost comparison data for multiple areas within the United States. The authors looked at the cost of building the roof, exterior walls, deck, and landscaping.



Constructing a new fire smart building might actually save money: shown here is a comparison of costs based on data gathered by Headwaters Economics. Headwaters Economics graphic

A breakdown of their findings is in the graphic above.

The study found, not surprisingly, that retrofitting existing homes was a more costly venture.

However, the information should encourage builders, designers and architects to give strong consideration to building techniques that afford resilience to various climate-related threats.

Double duty design

In many cases, one mitigation approach also serves well to address another concern. For example, gable-end vents are susceptible to extreme winds during storm events, as well as firebrand intrusion in wildfire. Yet a piece of plywood pre-fitted and ready for installation over the gable vent as needed solves both problems. A number of other multiple risk-reduction approaches exist, including but not limited to:

- anchored platforms resist wind uplift as well as flood forces,
- minimizing roof overhangs reduces wildfire exposure risk as well as wind uplift,
- brick or stone cladding is both fire-resistant as well as wind-resistantk
- the use of a drop chord or heel truss increases wind resilience, reduces ice-damming that may exacerbate loads during high-volume precipitation events, and may aid wildfire resistance.

Rate your home or plans

Here's a quick test of your existing home – or the one you've yet to build, to see how ready it may be for the key weather-related impacts of climate change.

score

Wildfire readiness

Roofing: [choose one] cedar shakes/shingles (10); Metal (-2); asphalt (0), curved terracotta (4) ☐

Cladding: [choose one] vinyl siding or "stone look" vinyl (5); cedar shakes/shingles (3); clapboard/particleboard (2); metal (0); concrete fibreboard (-1); brick/stucco/stone (cultured/natural) (-2) ☐

Soffits: unvented vinyl (3); vented vinyl (4); angled with exposed rafter [choose one] s (2); flat, covered with wood (1); flat, covered with metal (0). ***bonus:*** for fire-rated gypsum backing (-2) ☐

Roof style: [choose one] gable, side vented, unscreened (2); gable, side vented, screened (1); gable, roof vent (0); hip (0); cathedral, unvented (-1) ☐

Windows: [choose one] single-pane (3); modern low-E (1); tempered/ glassblock/wired (-1) ☐

Deck: [choose one] wood platform: large (3), medium (2), small (1) OR non-combustible platform: large (1), medium (0), small (-1) ☐

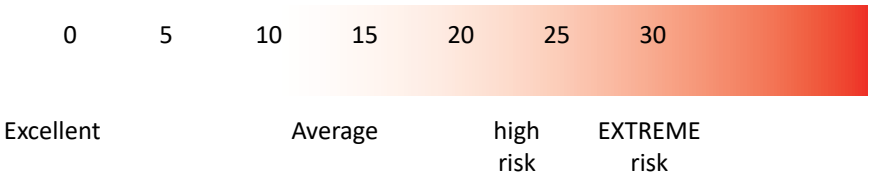
On the table below, choose the highest number on each row that applies.

	Conifers (needles) Distance from home (m)			Deciduous (leafy) Distance from home (m)			Score
	<3	4-10	11-30	<3	4-10	11-30	
Tall (15m+)	5	3	2	3	2	1	
Med (3-14m)	4	2	1	2	1		
Small (<3m)	2	1		1			

Firewood storage: Under deck/against exterior wall (3); stacked >3m away (1); stored >10m away (0) ☐

Organic mulch within 3m of home (2) ☐

total score for fire resilience ☐



Flood readiness

score

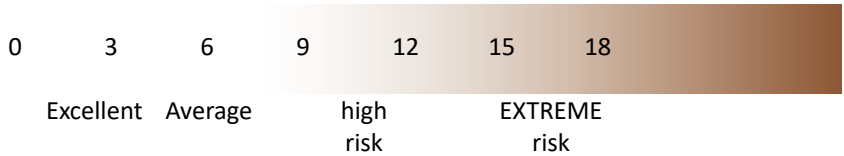
Location: [choose one] Frequent/known flood area (floodplain) (10); occasional flood area (5); near river/lake/pond (2); near river/lake/pond but no recent flooding (0) on high ground (-5).
bonus: IF positive answer above (-6) if living area, wood construction elevated above BFE on concrete wall/piers

Landscaping: [only if answer above is positive] Boulders/landscaping to mitigate scour (-1); Outbuildings on blocks (3)

Construction: [choose all that apply] Living area below ground (2); wood construction at or below known flood level (3); backflow valve on sewer (-2); Sump pump on independent power (-1); No basement (-2); crawl space without equipment (-1)

History: Minor basement flooding (1); basement flooding >1m (2). ; above ground flood damage within 20 years (4)

total score for flood resilience



Wind and precipitation readiness

Roof: [choose all that apply] Gable (1), Hip (-1), Slope >45 degrees (1); slope <30 degrees (-1) sheathing nailed every 6” (-1) Shingled roof, overdue for replacement (2)

Home: [choose all that apply]: two storey (1); three-storey (2); wood shingles on wall >20 years old (1)

Trusses/Rafters: [choose all that apply] Nailed to sill plate (1), overhang >2’ (1); hurricane ties (-2); drop-chord truss tied to wall sheathing (-2)

Walkways/driveway: Impervious (1); Pervious (-1)

Roof runoff: municipal storm sewer (1), to ground (0), to pond/bioswale (-1)

Landscaping: tall trees >15m within 15m of home (2); medium trees (~10m) within 10m of home (1)

total score for wind/precipitation resilience