DIRECTION DES INVENTAIRES FORESTIERS

Photographic Interpretation Guide for Forest Species in Southern Québec

2015 Edition

Québec

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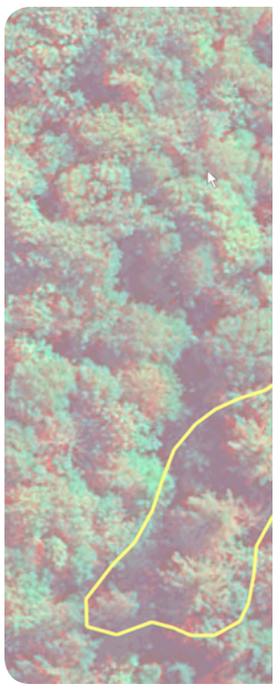

Photographic Interpretation Guide for Forest Species in Southern Québec

TEXT
Antoine Lebœuf, Forest Engineer, *Ph.D.*
Éric Vaillancourt, Forest Technician

COORDINATION
Anne Morissette, géomorphologue, M. Sc.
Isabelle Pomerleau, ingénieur forestier
Valérie Roy, Geomatics Technician

PHOTOGRAPH SELECTION
Éric Vaillancourt, Forest Technician
Jasmin Bergeron, Forest Technician

REVISION OF FRENCH TEXT
Hélène D'Avignon, F.Eng., Professional Writer

GRAPHIC DESIGN AND PAGE LAYOUT
Claude Baillargeon, Graphic Designer
Élisabeth Dufour, Geographer, M.Env.
Valérie Roy, Geomatics Technician

For additional information, please contact the MFFP in Québec City:

Direction des inventaires forestiers
5700, 4e Avenue Ouest, A-108
Québec (Québec) G1H 6R1
Telephone: 418 627-8669
Toll-free: 1 877 936-7387
inventaires.forestiers@mffp.gouv.qc.ca
www.mffp.gouv.qc.ca/fr/forets/inventaire

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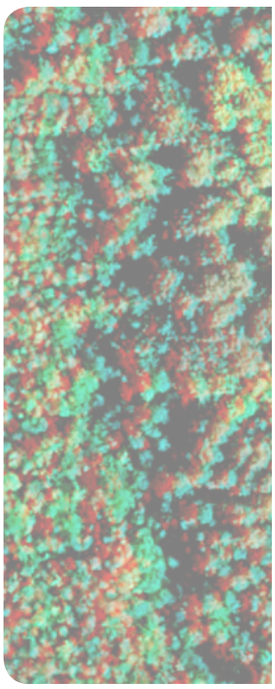
Foreword

The Direction des inventaires forestiers (DIF), ministère des Forêts, de la Faune et des Parcs du Québec (MFFP), is responsible for producing ecoforest maps of southern Québec. The maps are produced from aerial photographs. Photographic interpretation of the various species found over the entire potential range of land conditions is an extremely complex task. Species identification has been facilitated by the use of aerial photographs projected onto 3D screens, using textural, shape and characteristic colour criteria for each species. The purpose of this Guide is to assist photographic interpreters regardless of their level of experience.

The Guide documents the photographic interpretation of Québec's main commercial forest species, specifically those that are visible in the canopy. Understory species, such as young fir trees, cannot be seen by the aerial sensor, and are therefore not described in the Guide. The identification criteria provided in the Guide are taken from 30 cm frame-by-frame high-resolution digital aerial photographs, and are applicable only to aerial photographs of this resolution. However, we would like to broaden the application to include other types of aerial photographs.

Please contact the authors if you would like to make comments on particular aspects of the Guide. Your comments will be used to improve subsequent versions.



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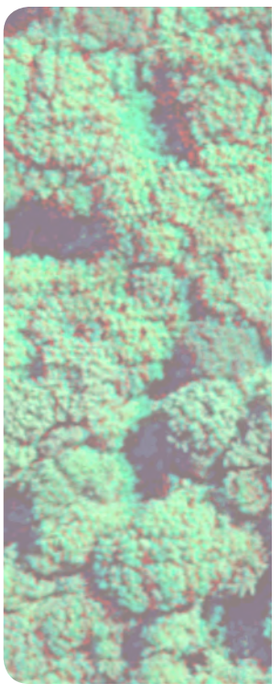


Introduction

The Guide provides the information required to identify commercial hardwood and softwood species through the interpretation of 3D aerial photographs, using shape, textural and characteristic colour criteria.

The first two sections of the Guide presents a table showing the shape, textural and colour criteria used to distinguish (1) hardwood species from other hardwood species, and (2) softwood species from other softwood species. The table is followed by information sheets on each species, including the sites on which they are generally found and their distribution within the bioclimatic domains (Saucier et al., 1998). Additional information on each species' shape, textural and colour criteria is supported by a red-green-blue (RGB) aerial photograph, an infrared aerial photograph (NIR) and a 3D colour aerial photograph (anaglyph RGB). This latter photograph must be viewed using red/cyan glasses that can be purchased cheaply on the Internet.

Sections three to six present the criteria used to interpret canopy density, stand height, age and natural disturbances. In each of these sections, the criteria are described, examples are given and the pitfalls to avoid are listed.

The last section presents the criteria used by the 3D viewing software, Summit Evolution (DAT/EM Systems International, 2012), to enhance the images. It is easier to differentiate between species on enhanced photographs, due to the additional contrast. All the species descriptions presented in this Guide are based on these criteria. In other words, the colour descriptions are based on enhanced images, not on raw images.

1. Identification Criteria: Softwood Species

Summary table of criteria used to differentiate softwood species

Species	Section of document	Shape and texture	RGB colour	NIR colour
Black spruce	1.1	Linear, tube-shaped crown. Much narrower than white spruce	Yellower than white spruce	More ash-coloured than white spruce
Balsam fir	1.2	Perfectly conical crown with a very narrow top. The top usually has a white tip	More blue or green than white spruce	More brownish or pink than white spruce
White spruce	1.3	Roughly conical crown. Broad tip	Slightly darker brown, brown-yellow and green-yellow than black spruce	Slightly darker brown or pinkish brown (young) than black spruce
Red spruce	1.4	Differentiated from white spruce mainly by its star-shaped crown	Same colour as white spruce	Same colour as white spruce
Jack pine	1.5	Crown less well-defined than red pine. Smaller and narrower crown	Paler than red pine	Paler than red pine
Eastern white pine	1.6	Much broader and taller crown than other pine species. More star-shaped crown than other pine species	More grey-green (duller) than Jack pine and red pine	Greyer (duller) and lighter than Jack pine and red pine
Eastern hemlock	1.7	The distinguishing element is crown texture, which is more compact, and the crown itself is more conical in shape	Much yellower and lighter than other softwoods	Much yellower and lighter than other softwoods
Red pine	1.8	Taller, broader crown than Jack pine. Shorter, narrower crown than Eastern white pine	Redder and darker than other pine species	More reddish-brown than other pine species
Tamarack	1.9	Barer (fuzzier) star than other pine species	Greyer and paler than other softwoods	Pinker and paler than other softwoods
Eastern white cedar	1.10	The element that distinguishes this species from other softwoods is its shorter cone and its vapour-like (fuzzy) appearance	Similar to Jack pine and red pine, but redder	Similar to Jack pine and red pine, but more turquoise

N.B. Softwood species always appear darker than hardwood species.

1.1 Black Spruce – *Picea mariana* (Mill.) B.S.P.

General Description

The species is present in all Québec's bioclimatic domains, but it dominates in the fir-white birch forest, the spruce-moss forest, the spruce-lichen forest and the forest tundra. In the domains south of the fir-white birch forest, black spruce is more likely to be found on poorly drained sites, rock escarpments and rock outcrops.

In the latter domains, the black spruce prefers xeric (fast) and hydric (poor) soil drainage conditions. In the fir-white birch forest and the more northerly domains, black spruce is found across all drainage conditions.

The presence of black spruce in domains to the south of the fir-white birch forest is associated with very thin or organic deposits. Further to the north, the black spruce dominates on all types of surface deposits.

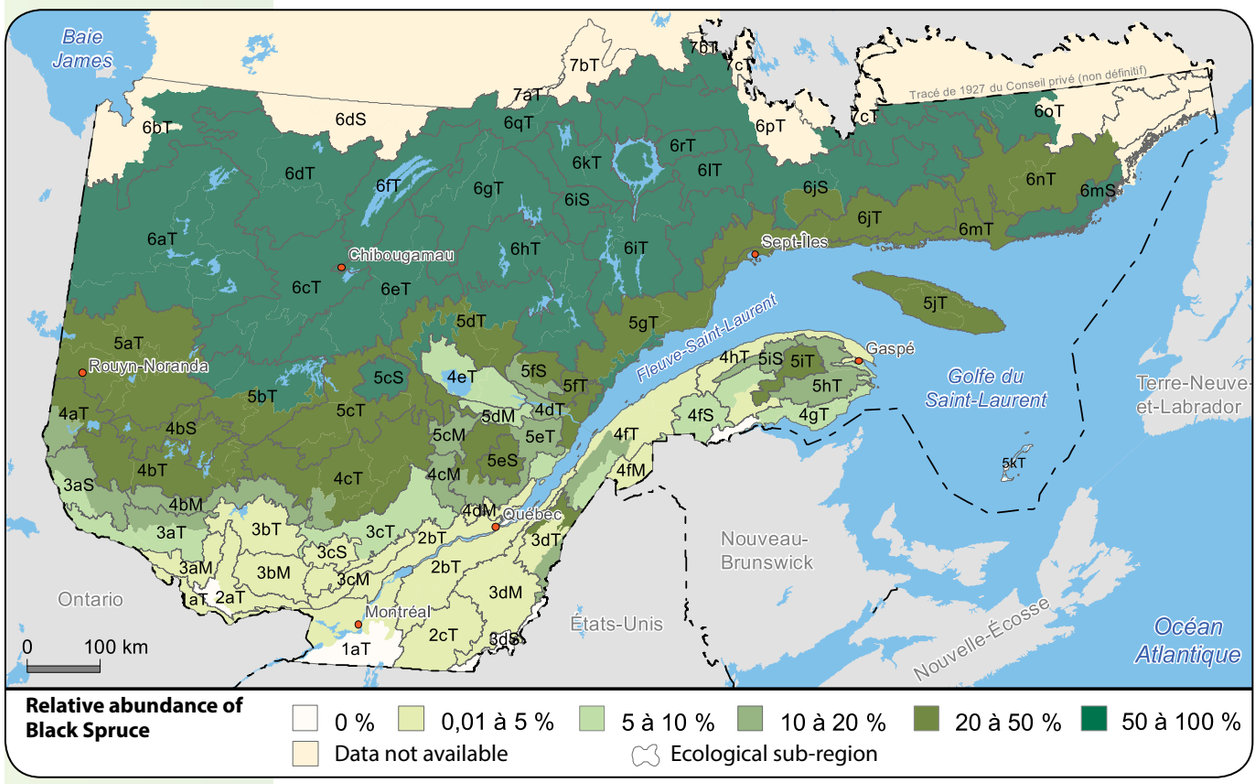
3D screen identification criteria

At maturity, the black spruce crown is distinguished by its narrow cylinder shape and its fine, pointed top. Crown diameters are small and crown textures are compact. Young crowns tend to be more conical and have a fuzzier texture.

Characteristic colours

- On RGB aerial photographs: mature forest stands are usually very dark green with a touch of brown. However, depending on the characteristics of the site or the type of aerial photography, they may also range from yellowish-green to brownish-yellow. Younger stands are lighter in colour than mature stands.
- On NIR aerial photographs: mature forest stands are usually dark grey (ash grey) to turquoise (pale). Young stands are dark pink (bordering on violet), and are duller than hardwood forests.

Distribution map



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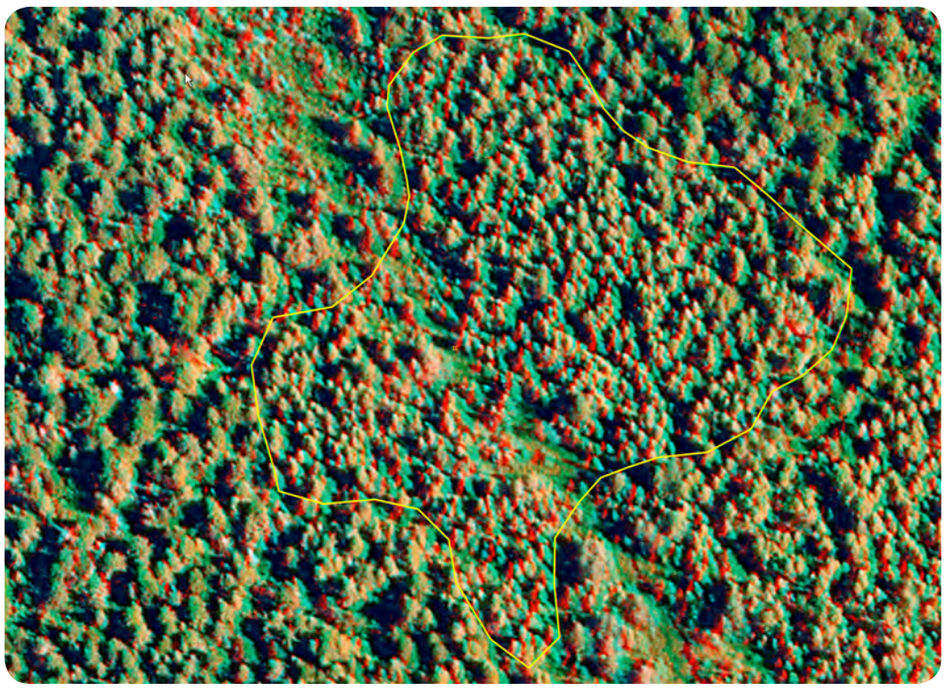
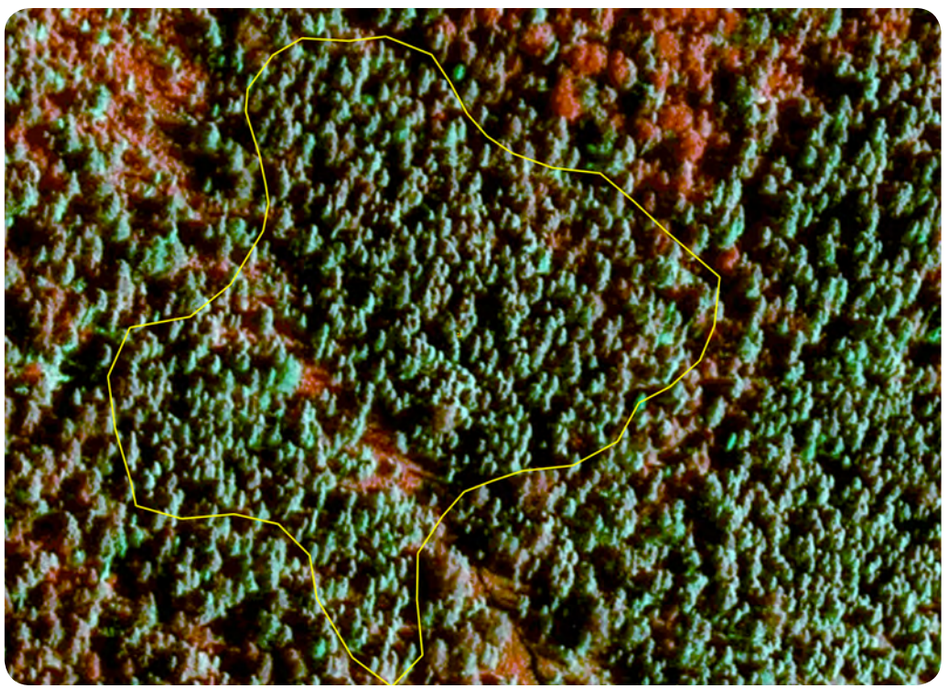


Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 73

1.2 Balsam Fir – *Abies balsamea* (L.) Mill.

General Description

The species is present in every bioclimatic domain in Québec, but dominates in the fir-white birch and fir-yellow birch forests. In domains south of the fir-white birch forest, the balsam fir tends to occupy poorer sites, such as hilltops where annual temperatures are considerably lower due to the altitude, as well as the bottom portions of cool, damp slopes and sandy plains that provide fewer nutrients. In the fir-yellow birch and fir-white birch domains, the balsam fir grows throughout the slopes, from top to bottom. In these areas, hilltops and plains are more usually occupied by black spruce. In the spruce-moss forest, the balsam fir can be found on the upper halves of slopes, and also, fairly frequently, on well-drained stream banks. In the eastern portion of the spruce-moss forest (Côte-Nord and Basse-Côte-Nord), the species also tends to colonize poorer sites, including plains and hilltops, In the western portion of the spruce-moss forest, it grows on mesic sites with infrequent fires (e.g. sites to the east of peat bogs, exposed slopes to the north, etc.). The species is also present sporadically in the spruce-lichen forest, on the best sites (the middle portion of well-drained slopes that are rarely damaged by fire).

South of the fir-yellow birch forest, the balsam fir tends to be found more on subhydric soils (imperfect drainage). In both the fir-white birch and fir-yellow birch forests, it grows in all drainage conditions except for hydric soils. In the spruce-moss forest, it tends to be more common on mesic soils (good drainage).

Surface deposits have less of an influence on balsam fir distribution than drainage. However, the species rarely grows on organic deposits; this is true across all bioclimatic domains. In the spruce-moss forest, the balsam fir is associated with medium-textured deposits (till), but also grows on well-drained clay sites.

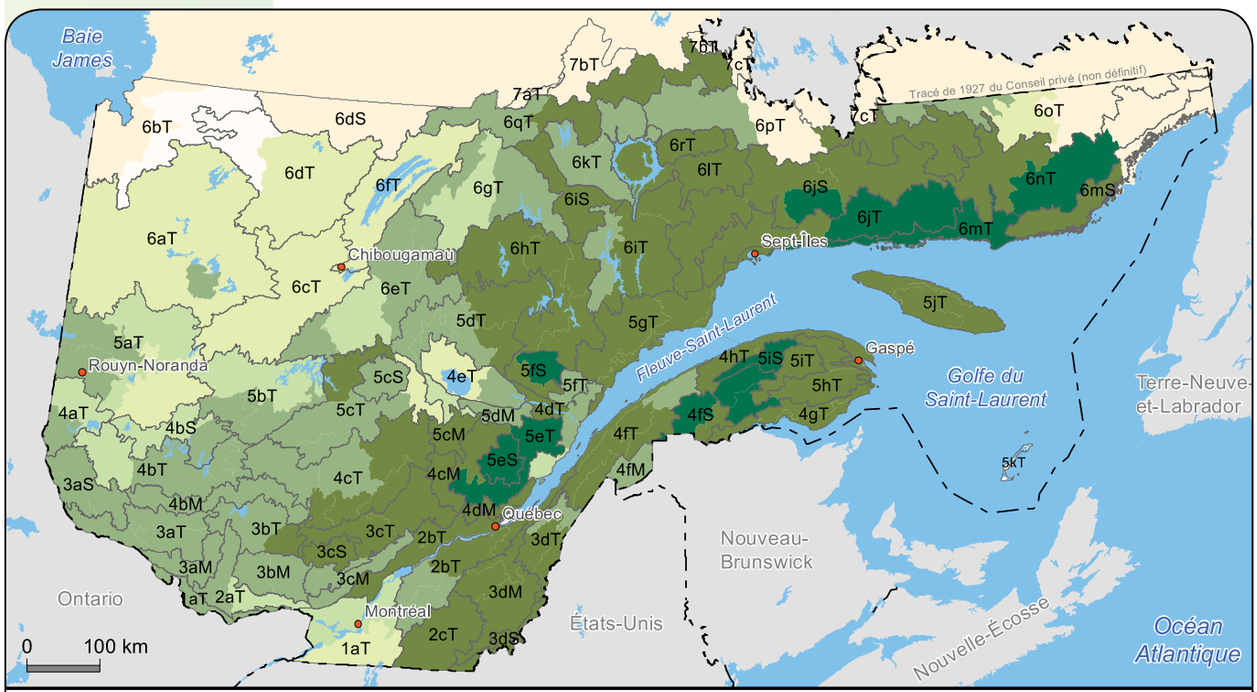
Mature balsam fir crowns are characterized by their narrow conical shape, drawn out towards the top. The crown of this species is more pointed than that of other softwoods, Crown diameters are moderate and the texture is compact. Young crowns tend to be conical in shape and have a fuzzier texture.

3D screen identification criteria

Characteristic colours

- On RGB aerial photographs: mature forest stands appear purplish dark blue, while young stands are very dark green with a bluish tint. A stand that has been defoliated by an insect infestation is light red in colour.
- On NIR aerial photographs: mature forest stands range from dull brown to pinkish brown, while younger stands are pinkish brown. A stand that has been defoliated by an insect infestation is turquoise in colour.

Distribution map



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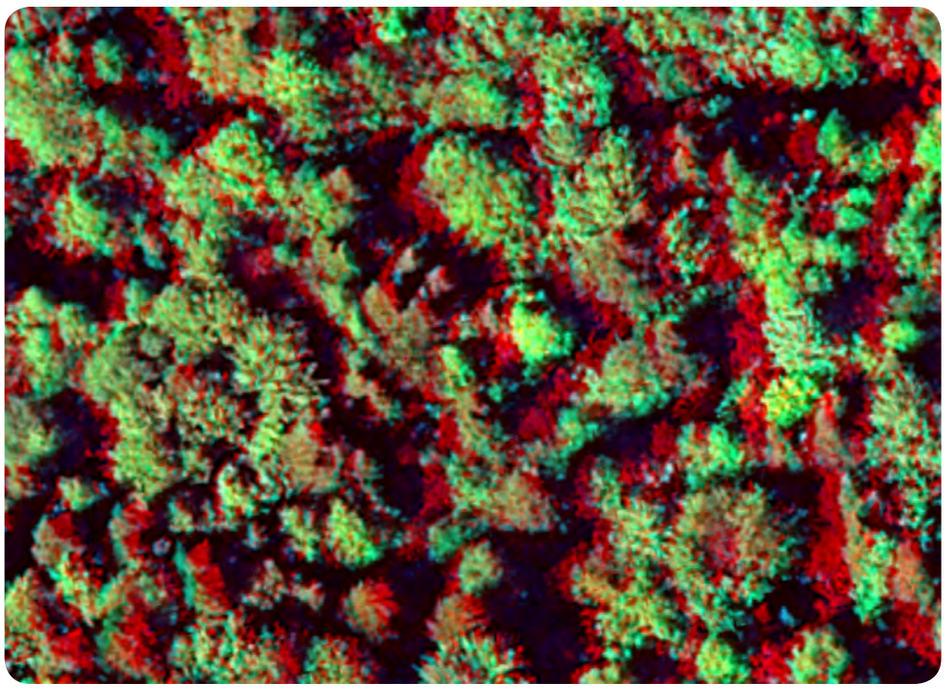
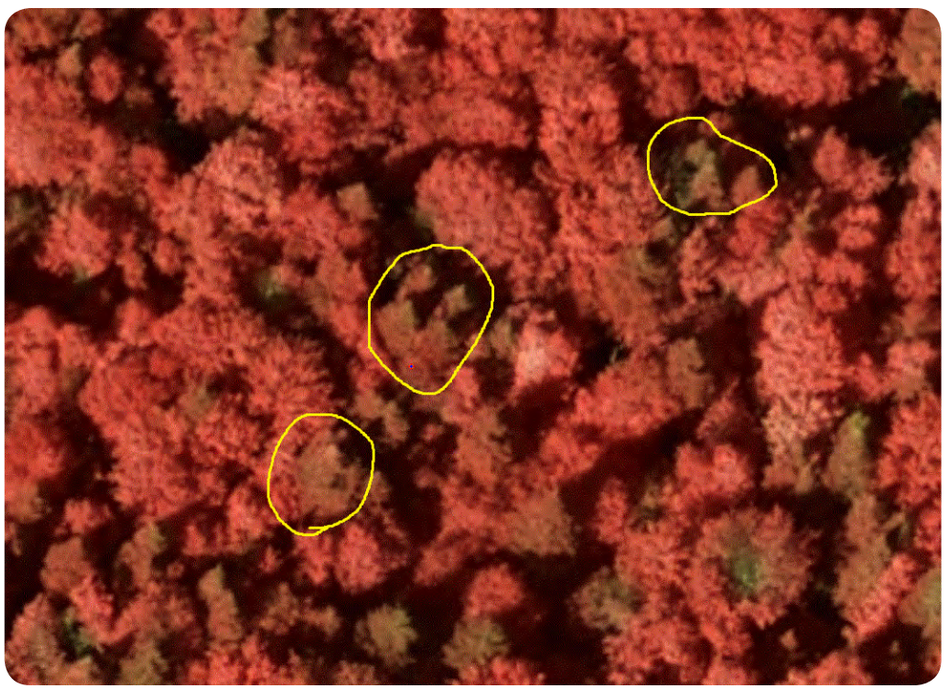


Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 74

1.3 White Spruce – *Picea glauca* (Moench) Voss

General Description

White spruce usually grows mid-slope, on sites where drainage conditions range from good to moderate. Surface deposit and soil texture have less of an impact on the species' presence than topographical location and drainage.

The species regenerates poorly post-fire. It therefore grows in a broad variety of environments in the fir-white birch, fir-yellow birch and maple (hickory, linden and yellow birch) forests further to the south, where fires are rare. In the spruce-moss and spruce-lichen forests, where fires are more frequent, the species tends to become established on sites that are protected from fire, such as seashores, watercourse shores, dry ravines and high-altitude massifs.

In the agricultural sectors of the maple (hickory, linden and yellow birch) domains, the stands that contain a significant percentage of white spruce trees tend to be situated on former pasture land or wildland. White spruce rarely dominates in eco-forest stands (4 ha or more), except for those located along seashores. The species is also found in the fir-yellow birch domain, and grows extensively on Anticosti Island.

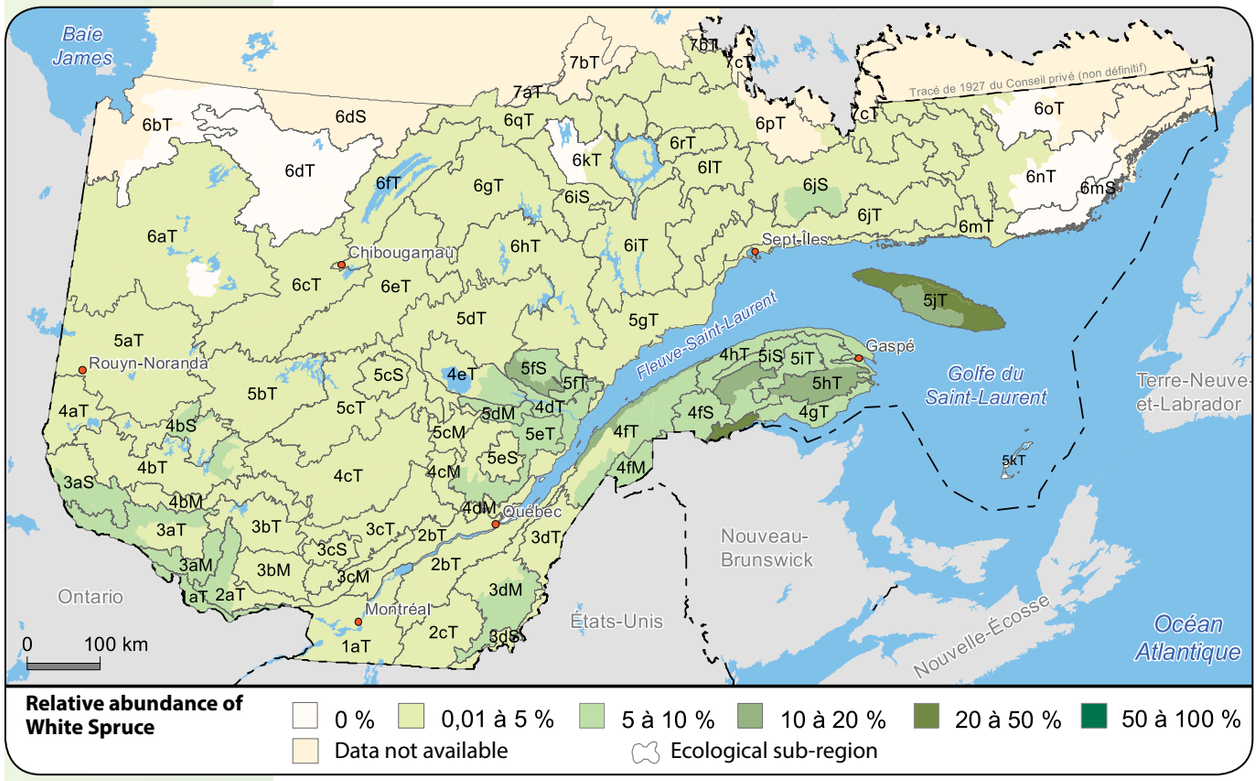
3D screen identification criteria

White spruce trees are taller than other trees in the stand. The crown is dense and conical in shape, with a rounded top. From above, the crown appears to be star-shaped, although this particular characteristic is more marked in the red spruce.

Characteristic colours

- On RGB aerial photographs: brown, yellowish brown and yellowish green
- On NIR aerial photographs: brown, pinkish brown (young)

Distribution map



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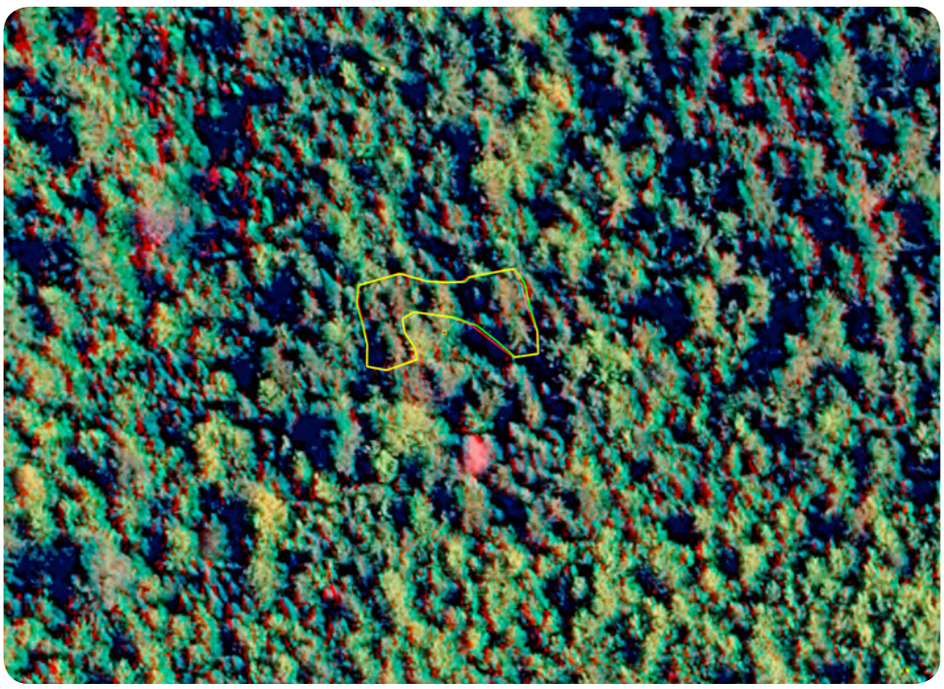
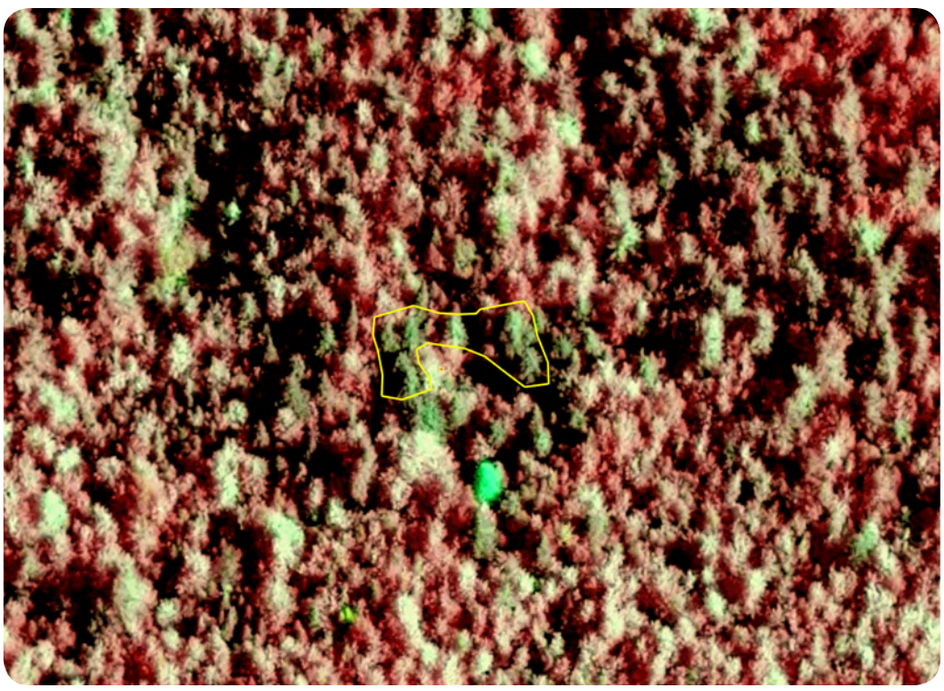


Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 74

1.4 Red Spruce – *Picea rubens* Sarg.

General Description

The red spruce is found more commonly in the fir-yellow birch domain and in the maple domains. In fir-yellow birch forests, it grows in topographical locations ranging from plains to mid-slopes. In maple forests, it can be found on poorer sites (e.g. subhydric soils) or on slopes with thin but well-drained deposits.

In the fir-yellow birch domain, the red spruce can be found on sites with drainage conditions ranging from good to imperfect, on all types of surface deposit except for organic deposits. In maple forests (hickory, linden and yellow birch), it tends to occupy subhydric sites (imperfect drainage) and poor sites (e.g. rapidly drained rough deposits).

Although less plentiful than white spruce, red spruce can also grow on sites that have been impoverished by agriculture (e.g. wild land).

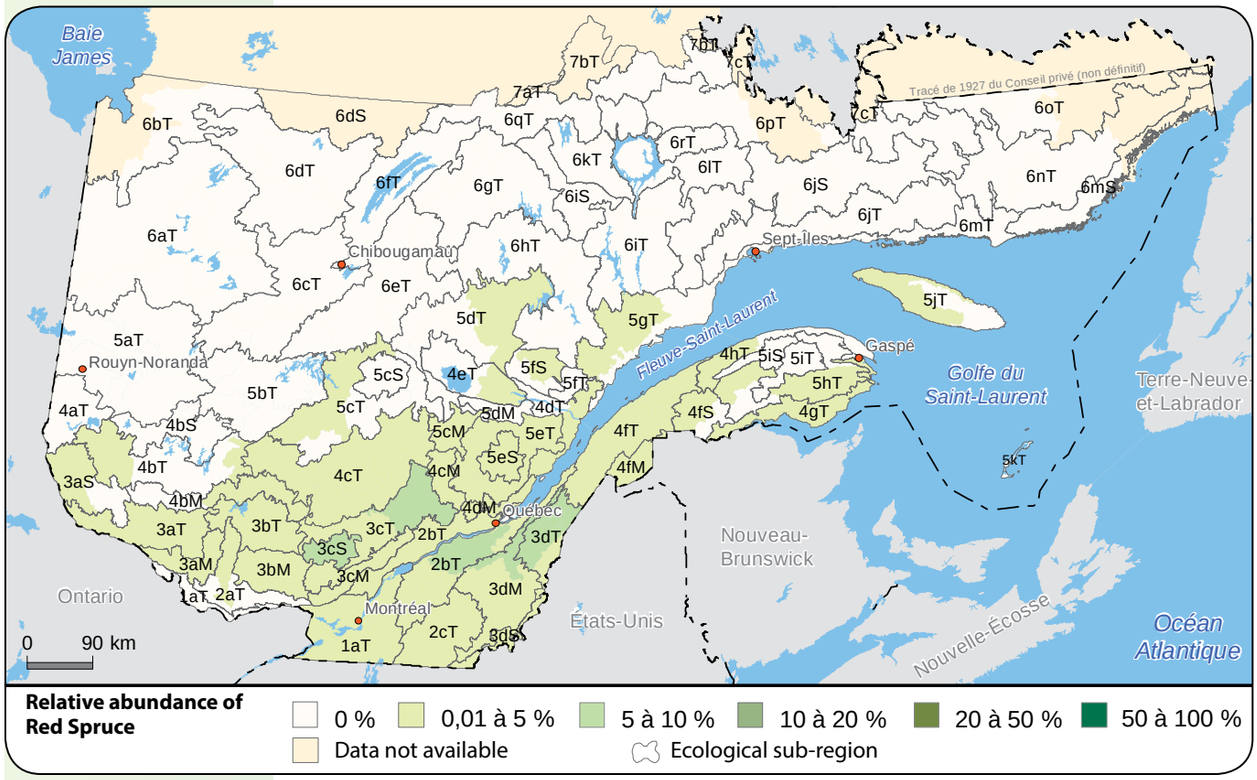
3D screen identification criteria

Red spruce crowns are distinguished by their star-like shape. They are fuzzier than white spruce crowns, and tend to be cylindrical, of average size, pointed and sparse.

Characteristic colours

- On RGB aerial photographs: yellowish red
- On NIR aerial photographs: yellowish brown

Distribution map



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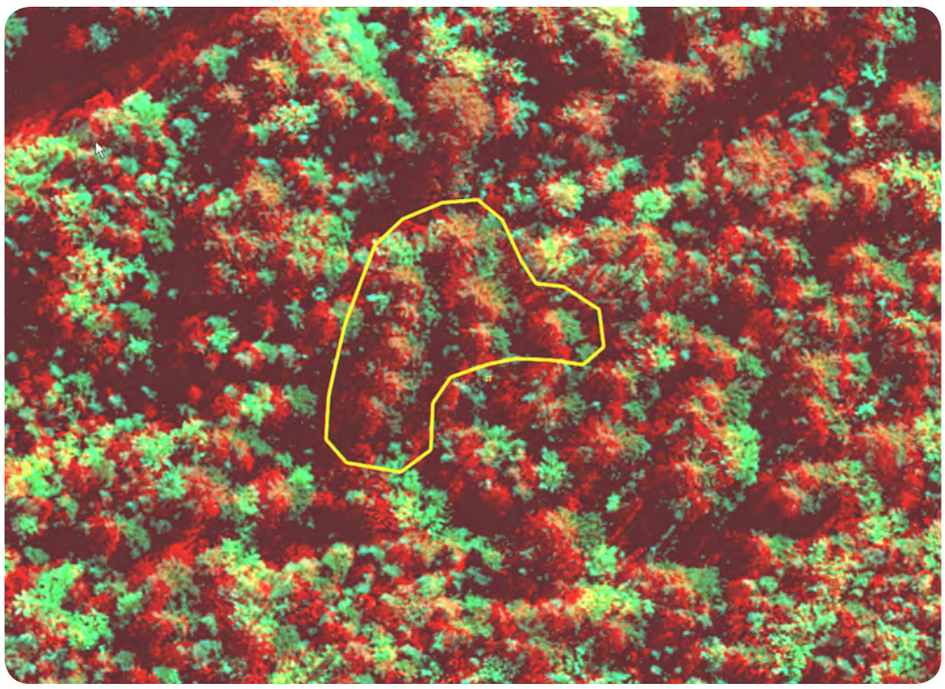


Anaglyph RGB

Naturally coloured aerial photograph (RGB)

Infrared (NIR) aerial photograph

1.5 Jack Pine – *Pinus banksiana* Lamb.

General Description

The jack pine grows in the western sections of the spruce-moss and fir-white birch domains. It has also made inroads into the fir-yellow birch forest to the west, in glacial outwash plains with coarser surface deposits. Given that its presence is promoted by frequent fire, the species is more common on drier sites.

It is found more frequently on well-drained sites (good drainage), but also grows on sites where drainage is moderate.

The species is associated with all types of surface deposits conducive to fast water runoff. It is found mainly on sandy deposits, thin tills and dead-ice moraines, although it also grows on sites with thick till deposits where fires frequency is high.

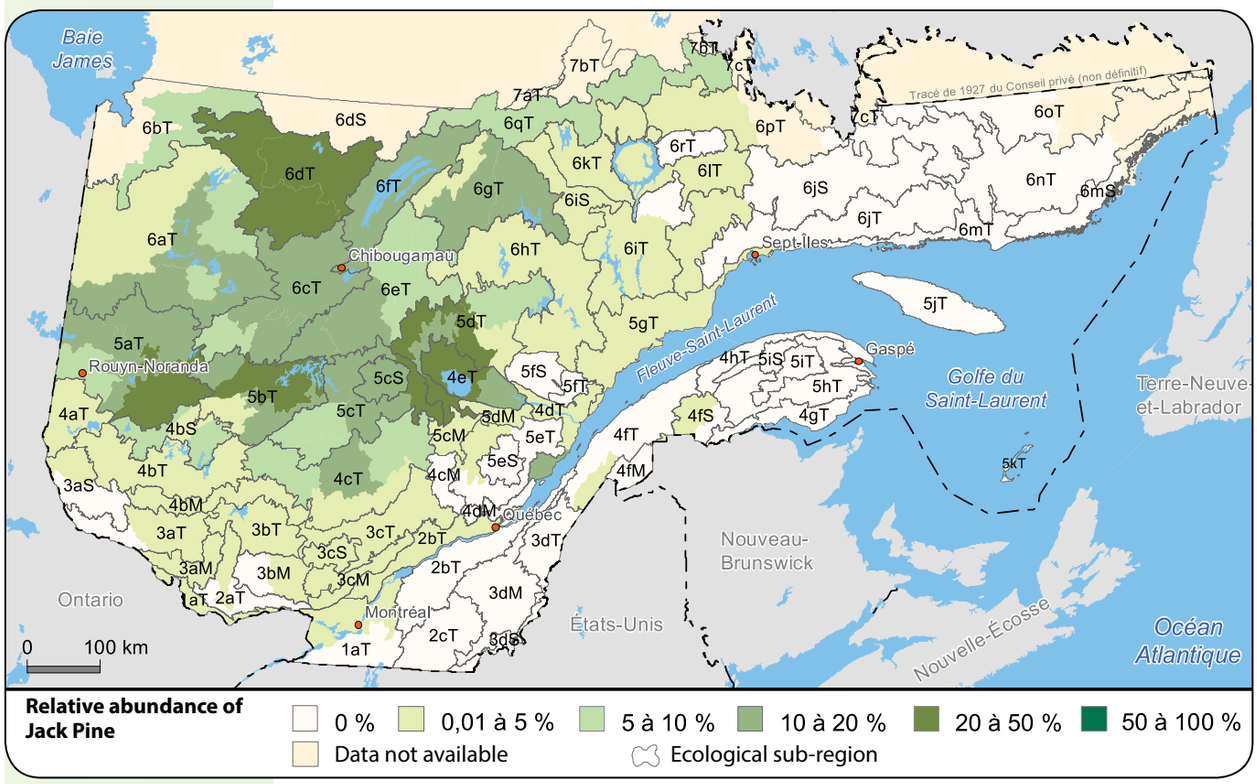
3D screen identification criteria

Jack pine crowns are irregular in shape, may sometimes be star-shaped, and are smaller in diameter than the crowns of the other pine species. It is difficult to identify crown edges on aerial photographs; in appearance, they look somewhat like a ball of steam. The jack pine is usually taller than other softwoods, although less so at maturity.

Characteristic colours

- On RGB aerial photographs: brownish to pinkish brown (greenish brown to pinkish brown)
- On NIR aerial photographs: pinkish brown to caramel brown

Distribution map



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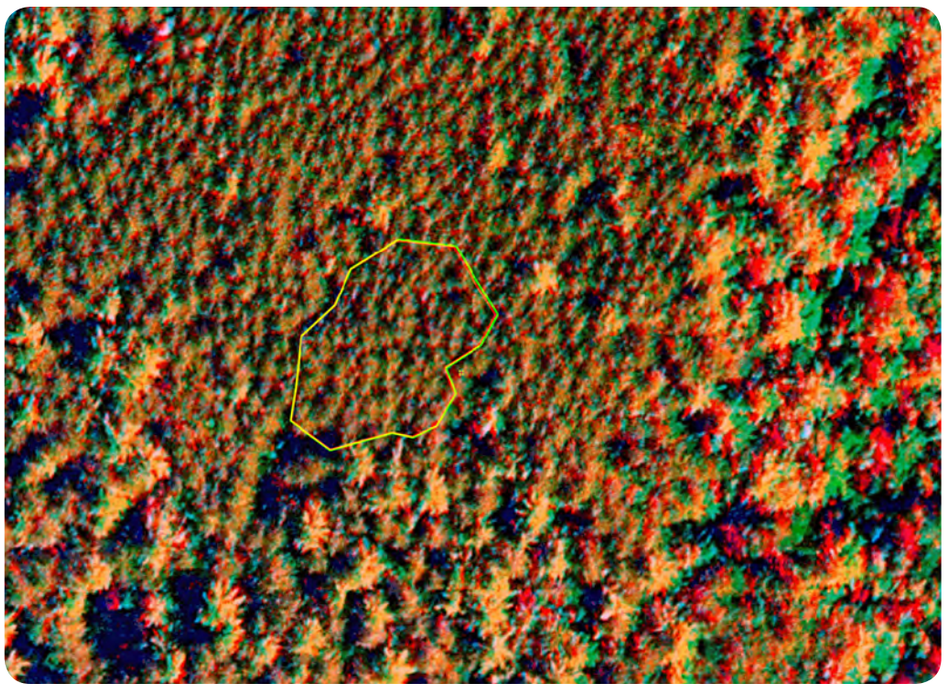

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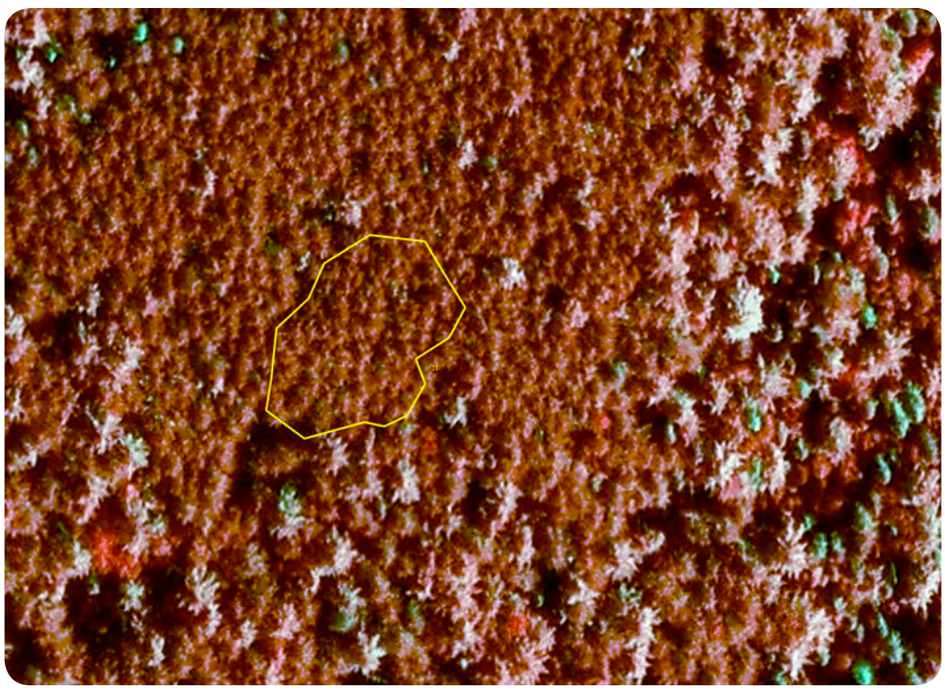


Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 75

1.6 White Pine – *Pinus strobus* L.

General Description

The white pine dominates in sectors to the west of the maple (hickory, linden and yellow birch) bioclimatic domains, and can also be found in the southern portion of the fir-white birch domain. White pain stands grow on sandy plains, very steep slopes, and very thin surface deposits. In the maple (hickory, linden and yellow birch) domains, the species grows on a wide variety of sites (deposits and drainage).

The white pine benefits more from fast to good drainage, but can also cope with moderate drainage.

White pine trees tend to be associated with coarse or very thin deposits.

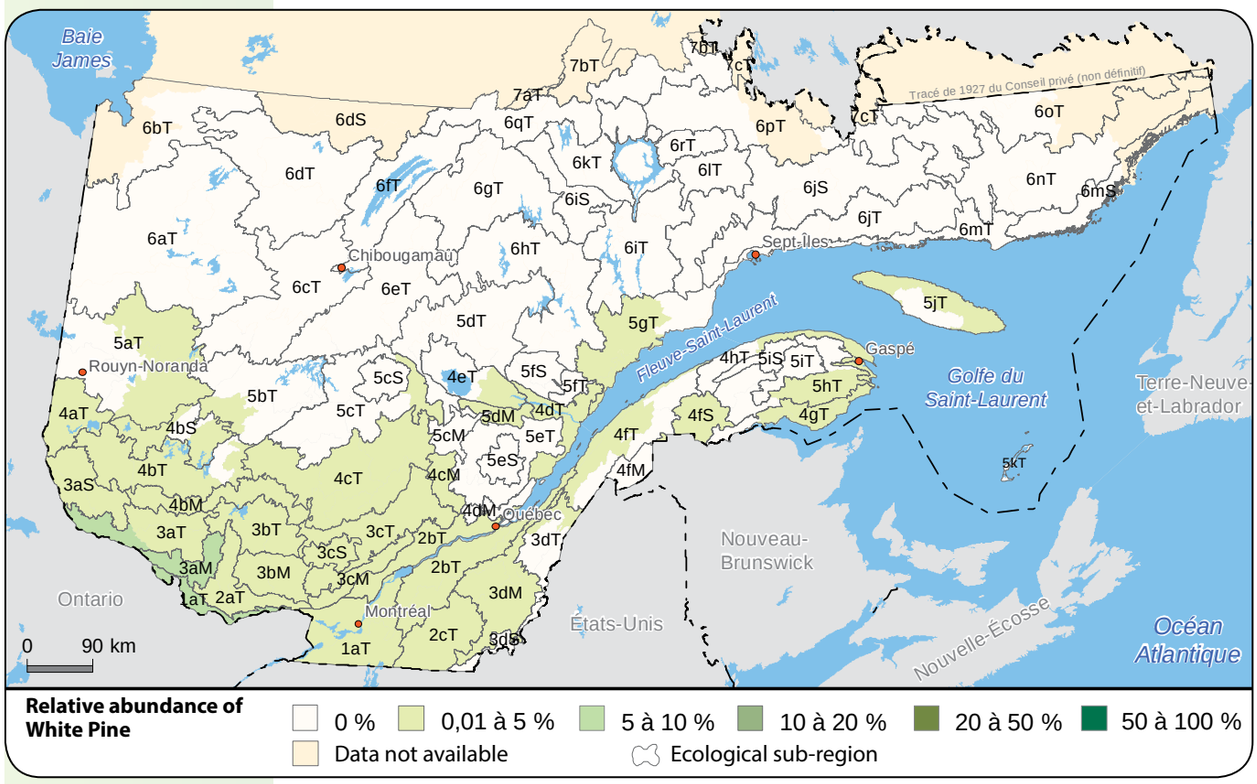
3D screen identification criteria

The species' large, irregular, star-shaped crown stands taller than the other trees, and will often lean in the same direction as the dominant wind.

Characteristic colours

- On RGB aerial photographs: pale greyish green
- On NIR aerial photographs: brownish green

Distribution map



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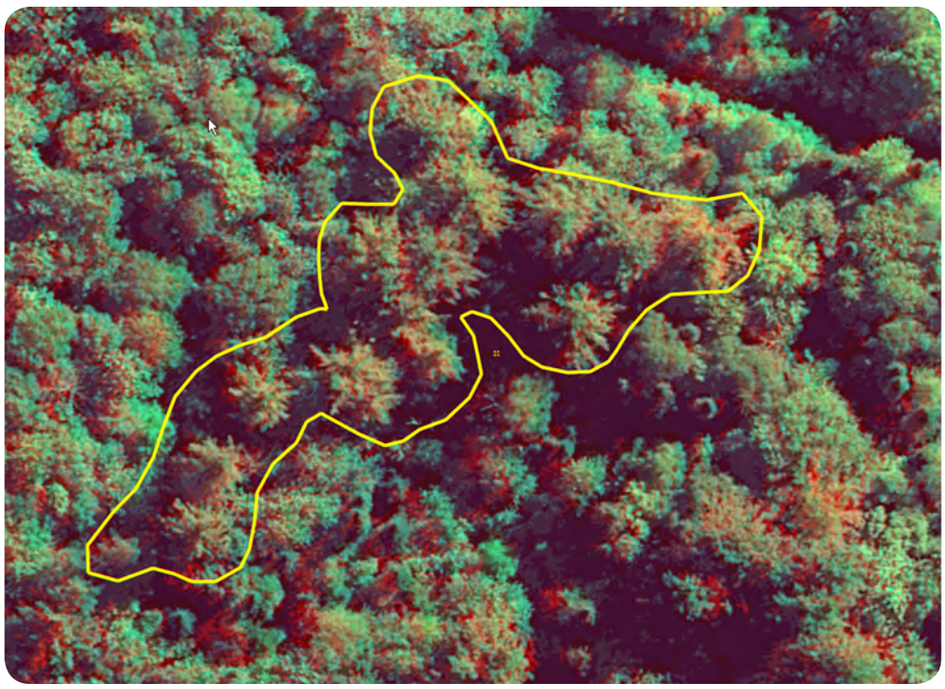
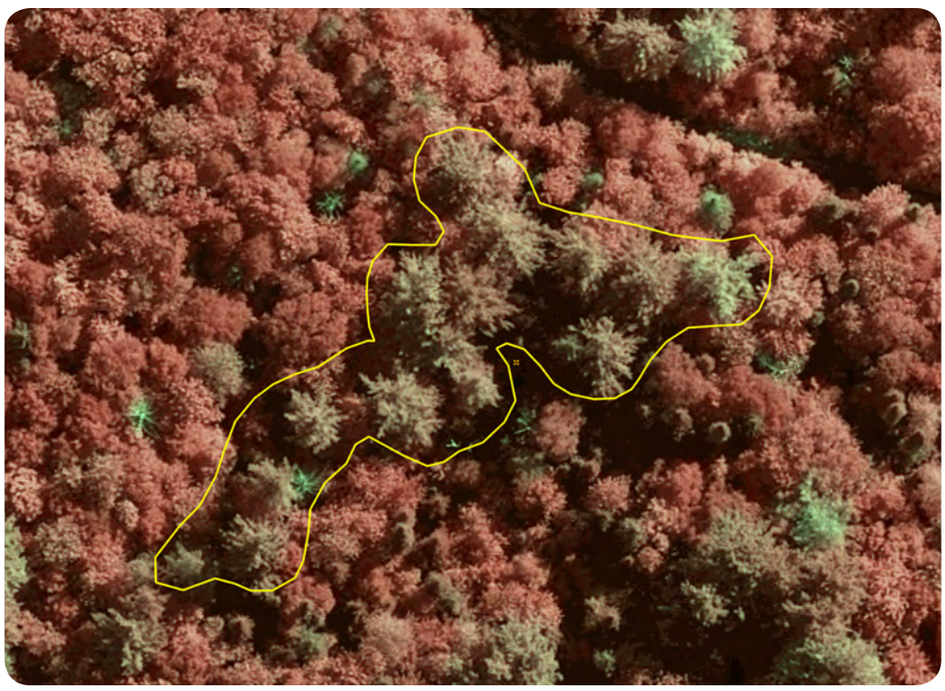


Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 76

1.7 Eastern Hemlock – *Tsuga canadensis* (L.) Carr.

General Description

The Eastern hemlock grows in the maple (hickory, linden and yellow birch) bioclimatic domains. Stands are usually found on sites less conducive to growth, such as steep slopes. The species also grows on plains and on subhydric soils (imperfect drainage). It is found in drainage conditions ranging from fast to good, on coarse or very thin surface deposits.

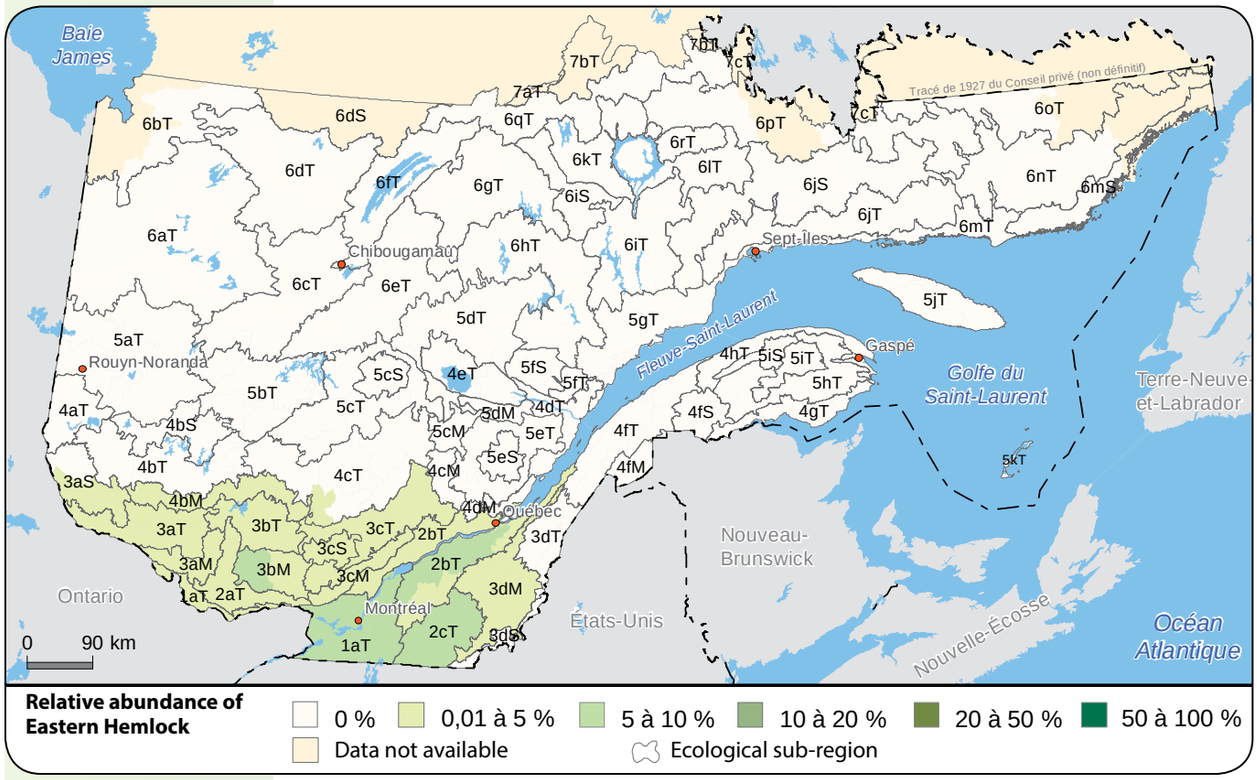
3D screen identification criteria

Eastern hemlock crowns are conical in shape, rounded at the top. They are broad and compact, with an oval projection. They are also distinguished by their well-lit and shaded facets. In the southern portion of the province, crowns appear fuzzier and duller on the screen, and can sometimes be confused with red maple.

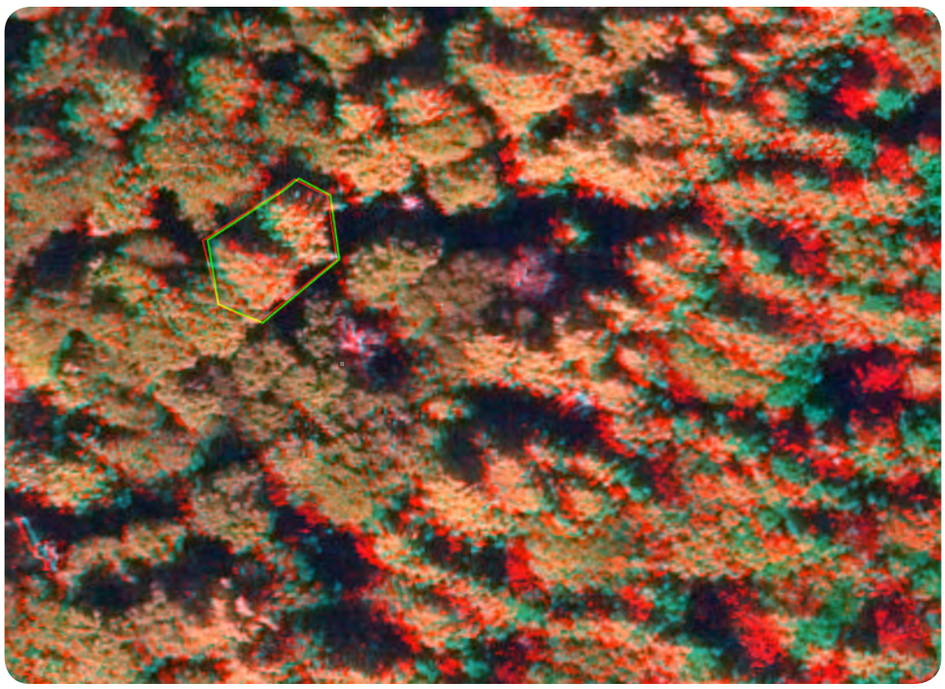
Characteristic colours

- On RGB aerial photographs: yellowish green to brownish yellow
- On NIR aerial photographs: yellowish brown

Distribution map

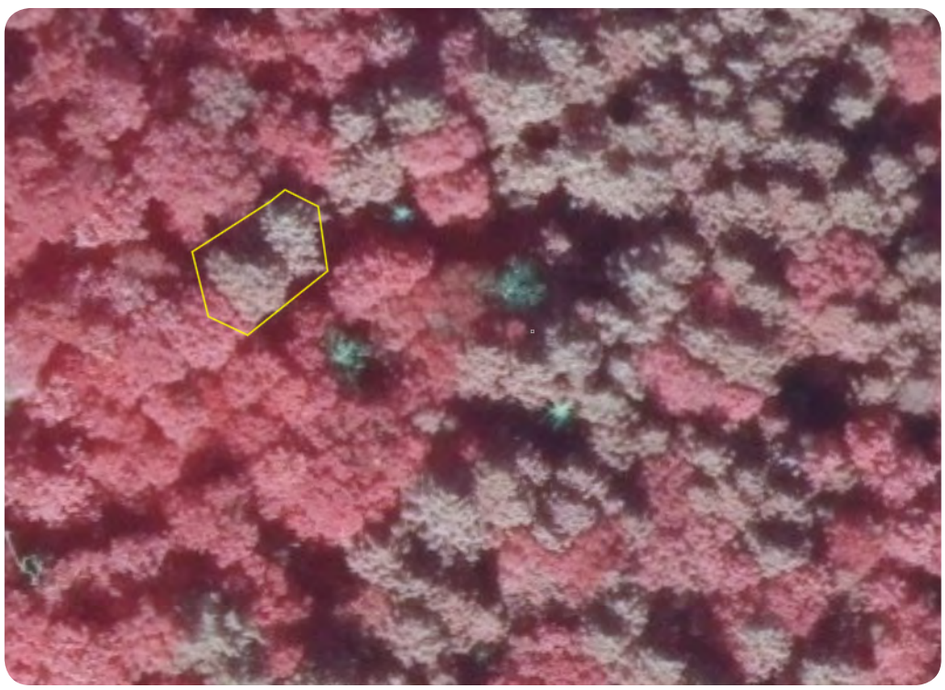


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 76

1.8 Red Pine – *Pinus resinosa* Ait.

General Description

Like the white pine, the red pine dominates in sectors to the west of the maple (hickory, linden and yellow birch) bioclimatic domains. It is also found in the southern portion of the fir-yellow birch forest. Red pine stands grow on sandy plains, on very steep, well-drained slopes and on very thin surface deposits. In the maple (hickory, linden and yellow birch) domains, it grows on a wide variety of sites.

The red pine benefits from drainage conditions ranging from fast to good, but moderate drainage is also suitable.

Red pine trees tend to be associated with coarse or very thin deposits.

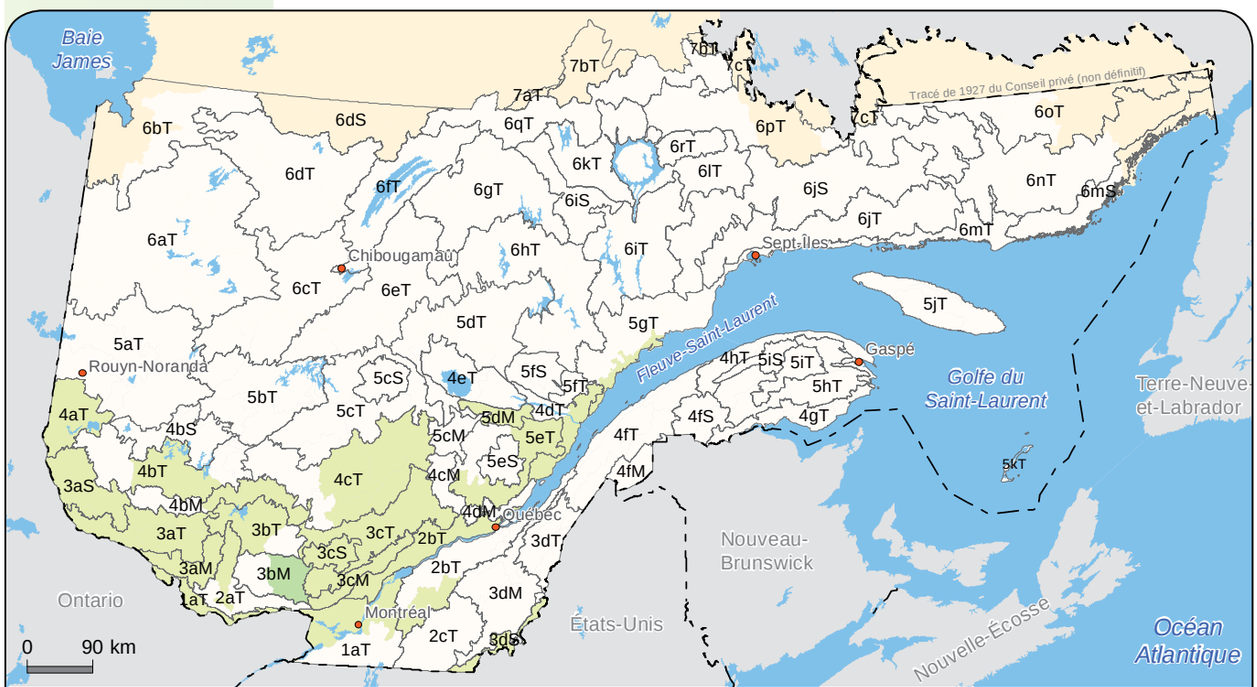
3D screen identification criteria

Crowns are of moderate size, compared to the white pine, and are elongated oval in shape. Crown edges are difficult to identify on aerial photographs. They resemble dishevelled, jagged balls and are denser than jack pine crowns. Red pine trees are usually taller than accompanying species.

Characteristic colours

- On RGB aerial photographs: red-brown (reddish to pinkish brown)
- On NIR aerial photographs: dark brown to caramel brown

Distribution map



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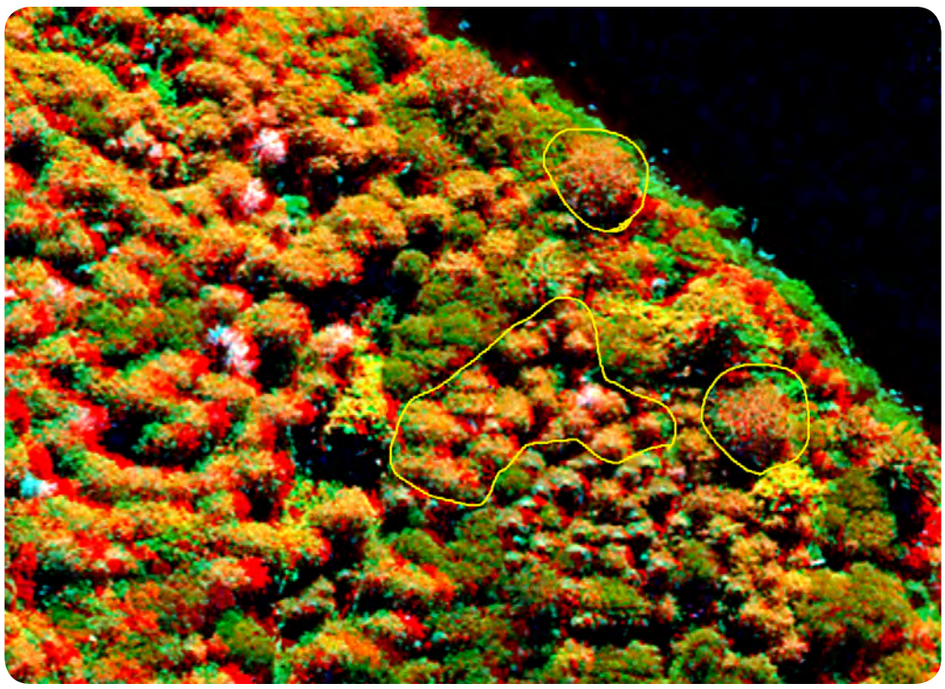
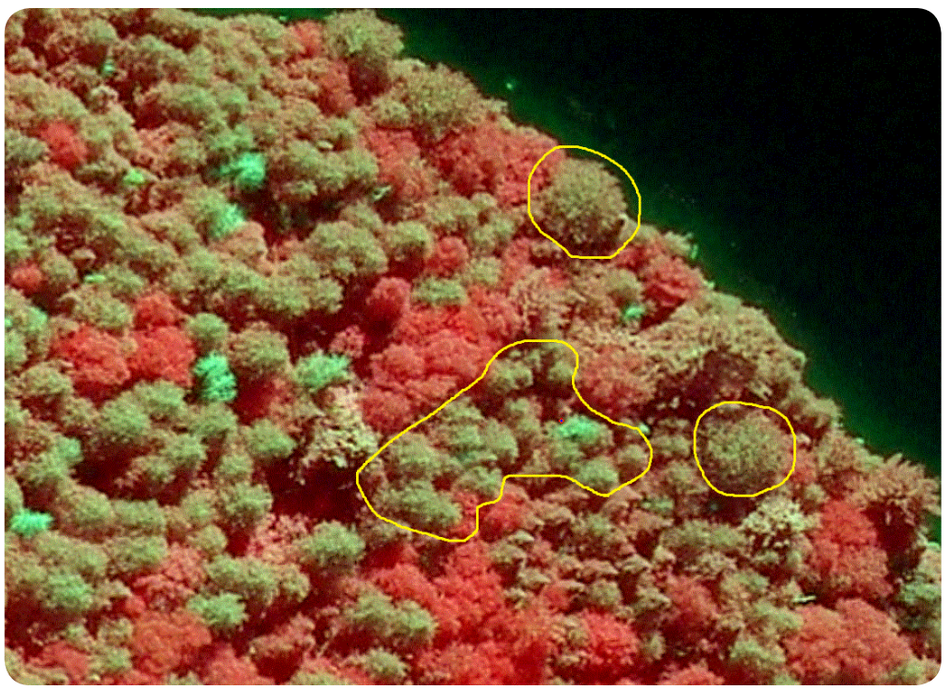


Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 77

1.9 Tamarack – *Larix laricina* (Du Roi) K. Koch

General Description

The tamarack grows in all the bioclimatic domains. In the domains south of the spruce-moss forest, it is found on hydric soils (poor drainage), and sometimes on subhydric soils (imperfect drainage). In the spruce-moss and forest tundra domains, it also grows on subhydric and mesic (moderate drainage) soils.

It is most commonly associated with sites where drainage is poor, and sometimes with those where drainage is imperfect.

Surface deposits and soil textures have little impact on its distribution. Only poor drainage conditions are indicative of the species' presence on a given site.

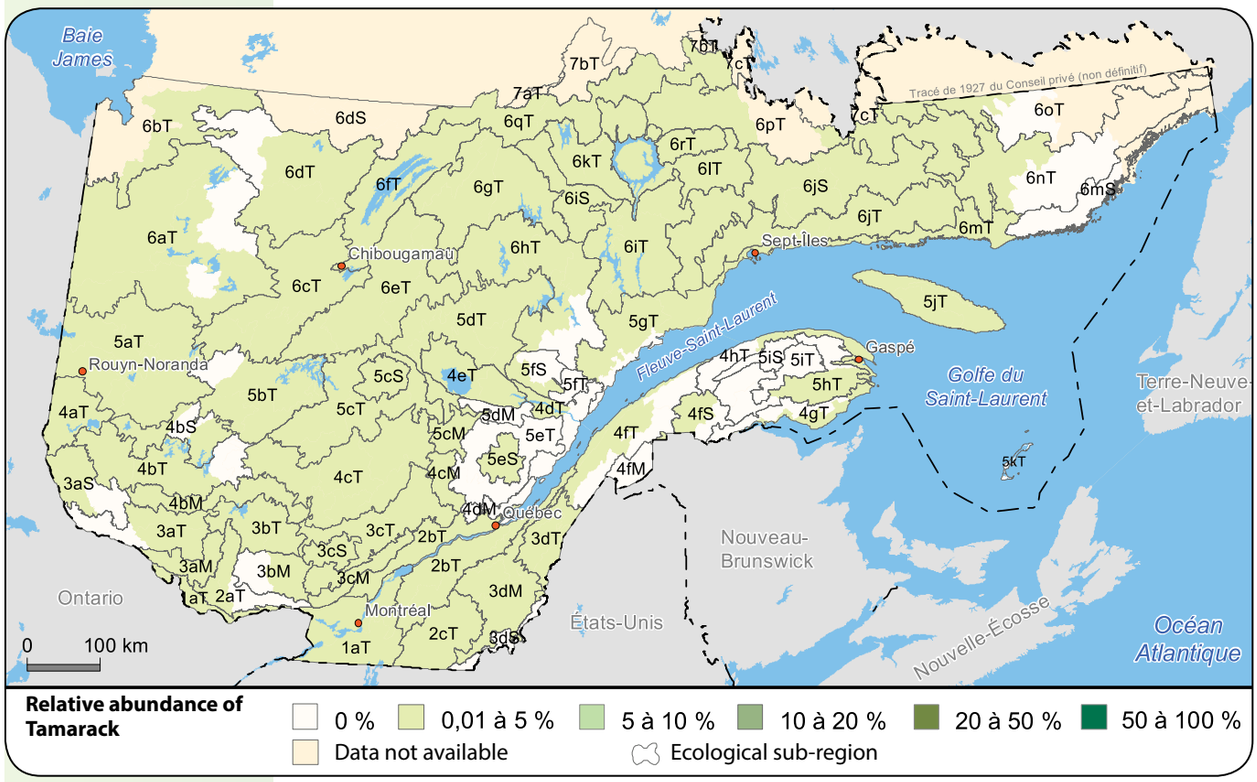
3D screen identification criteria

Tamarack crowns are distinguished by their cylindrical, star-like shape. Compared to other star-shaped softwood crowns, the tamarack crown is barer and has fewer points. It is also less well-defined and shinier than pine crowns.

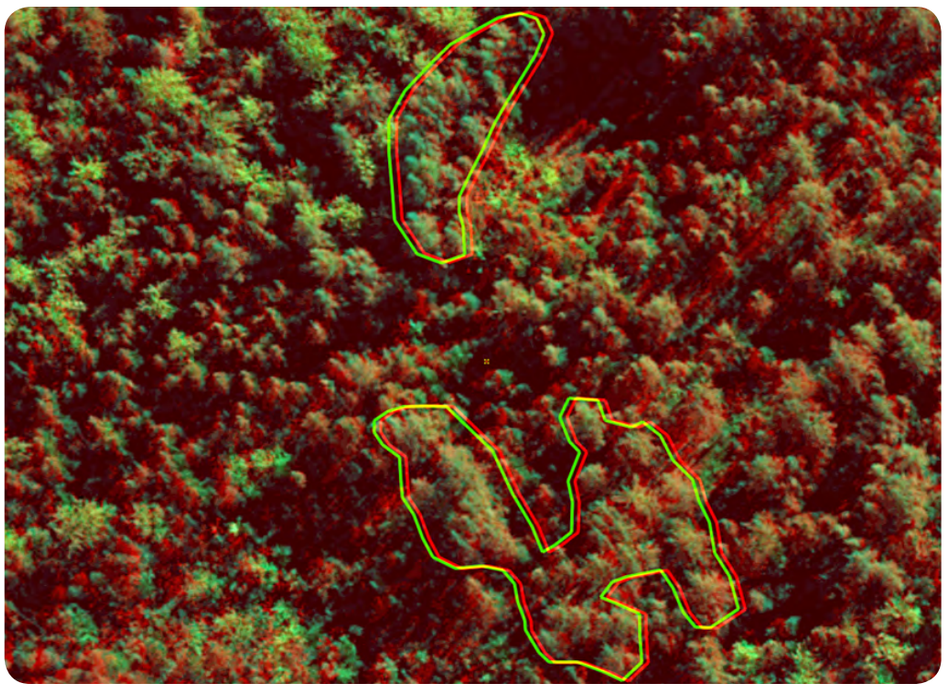
Characteristic colours

- On RGB aerial photographs: very pale greenish grey (may be confused with hardwoods)
- On NIR aerial photographs: bright, very pale pink (may be confused with hardwoods)

Distribution map

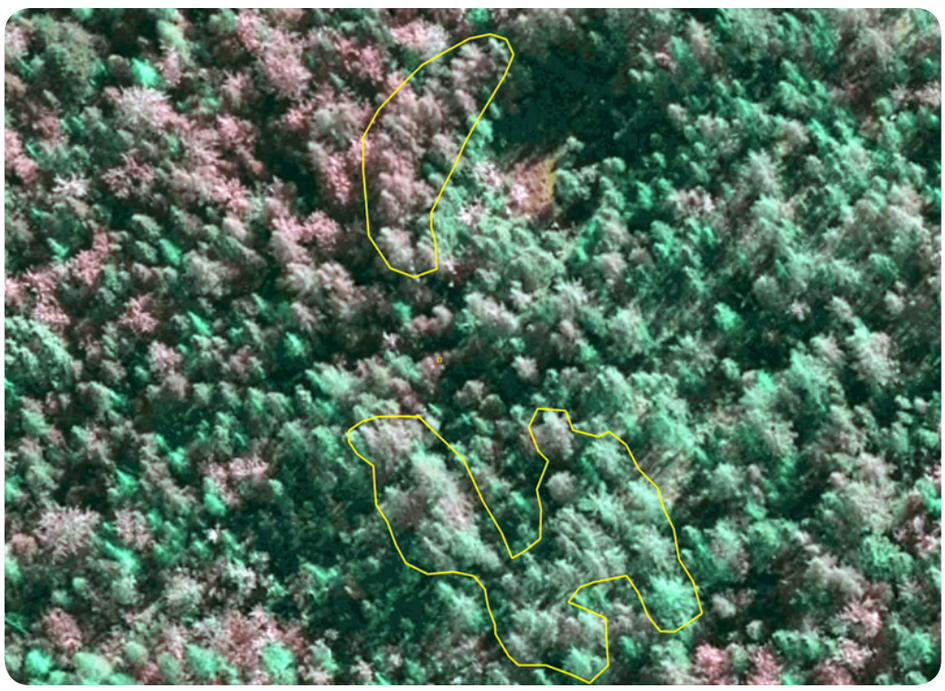


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

1.10 Eastern White Cedar – *Thuja occidentalis* L.

General Description

The Eastern white cedar can be found in the maple (hemlock, linden and yellow birch) bioclimatic domains, and in the fir-yellow birch forest. It can occasionally be found in the sectors of the fir-white birch and spruce-moss domains that are most conducive to growth. Generally speaking, it prefers basic pH sites (e.g. Trenton limestone in the St. Lawrence Valley) with sedimentary or meta-sedimentary rocks. In the maple (hemlock, linden and yellow birch) domains, the species also grows on poorly-drained sites, on steep slopes

On limestone sites, the Eastern white cedar will grow in all drainage conditions, while on other sites, it tends to be associated with hydric soils.

Surface deposits and soil textures do not impact its presence.

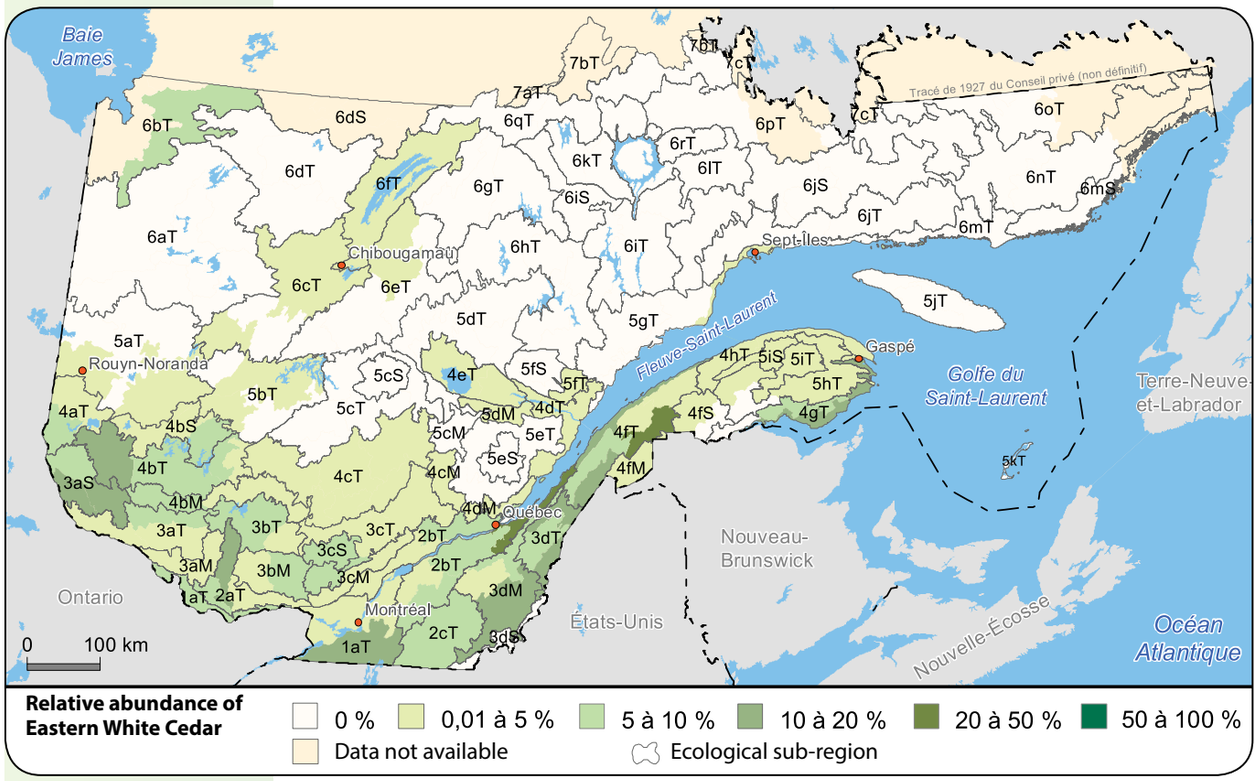
3D screen identification criteria

Eastern white cedar crowns are small and conical in shape, with rounded tops. Crown edges are difficult to identify on aerial photographs, since they resemble clouds of steam (fuzzy). Eastern white cedar trees are generally smaller than the accompanying species.

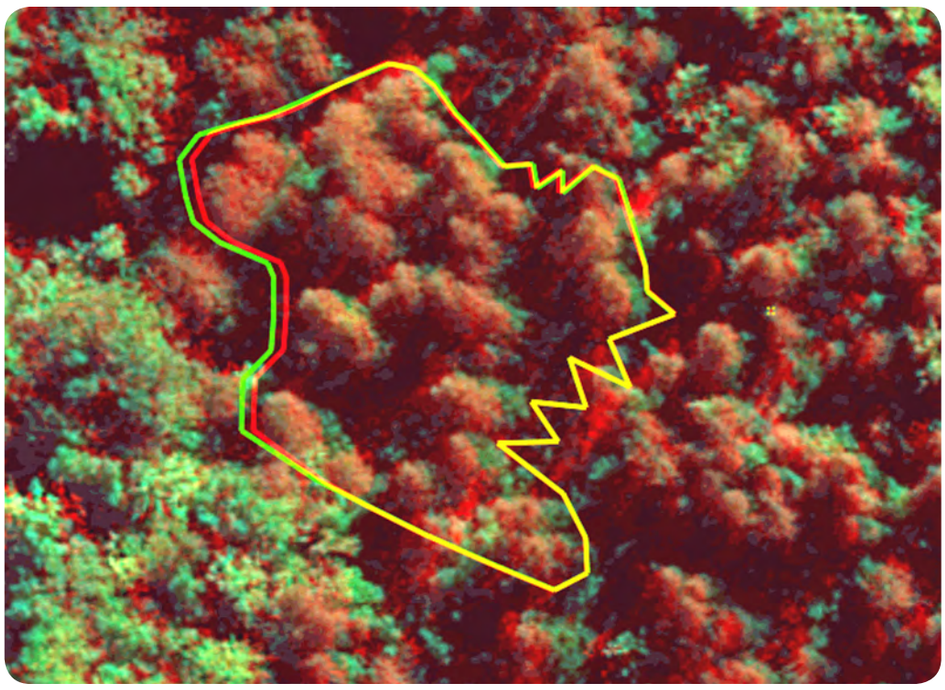
Characteristic colours

- On RGB aerial photographs: rusty brown (mature) and pinkish brown (young)
- On NIR aerial photographs: combination of turquoise and pale brown (mature) and pale brown (young)

Distribution map



Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)

Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 78

2. Identification Criteria: Hardwood Species

Summary table of criteria used to differentiate softwood species

Species	Document section	Shape and texture	RGB colour	NIR colour
Sugar maple	2.1	The most compact of the hardwoods, resembling a head of broccoli	Lighter green than yellow birch but darker than red maple	Lighter pink than yellow birch but darker than red maple
Red maple	2.2	Crown is slimmer and narrower than sugar maple. Sparser texture, less dense, less compact. Dark holes visible in the crown	Lighter green than sugar maple and lighter than yellow birch	Lighter pink than sugar maple and lighter than yellow birch
Yellow birch	2.3	Oval shape, drawn out towards the top and narrower than sugar maple. Crown is fuzzier than sugar maple and red maple	Darker green than the maples	Darker pink than the maples
White birch	2.4	Flatter, less well-defined crown than yellow birch. More intermingling of crowns than for yellow birch	Darker green than the maples but lighter than yellow birch	Darker pink than the maples but lighter than yellow birch
Grey birch	2.5	Shorter than the other hardwoods, with a narrower crown. However, colour is the main distinguishing factor	Much yellower than the other hardwoods	Brownish yellow
Trembling aspen	2.6	Taller than other stand species. Bulb-like crown	More bluish-green than the maples and birches	More orangey-pink than the maples and birches
American beech	2.7	Irregular crown, less round than other hardwoods. Crown is fuzzier than the maples and birches	More brownish-green than the maples, birches and aspens. Yellower and paler than red birch	More brownish-pink than the maples, birches and aspens. Paler than red birch
Northern red oak	2.8	Taller and broader crown, shaped like a flat half-circle	More brownish-green than the maples, birches and aspens. Less yellow and darker than the beech	More brownish-pink than the maples, birches and aspens. Darker than the beech

Summary table of criteria used to differentiate softwood species

Species	Document section	Shape and texture	RGB colour	NIR colour
Balsam poplar	2.9	The balsam fir crown is shaped like a flat half-circle. It is compact and fuzzy, with a texture composed of bumps and large hollows (speckled appearance)	Dark brownish green to greenish brown	Dark pink to orangey pink
Large-toothed aspen	2.10	Generally taller than other hardwoods in the stand. The crown is broad and sparser than the trembling aspen	Brownish green to pale brown	Darker orangey pink than the trembling aspen
Eastern poplar	2.11	Very open crown, not very dense. Small, highly visible ascending branches	Greenish brown	More beige
Linden	2.12	The linden crown is easily recognizable from its half-egg shape. Its texture is regular and fuzzy	Dark green	Dark orange
Ash*	2.13	Ash crowns are moderate in size and are shaped rather like a slender flame. The texture is often fuzzier. The black ash crown is usually more airy than the crowns of other ash species	Very light green	More peach-coloured and paler than other hardwoods. Pink
American elm	2.14	The American elm crown appears narrow and parabolic on an aerial photograph. Its texture is regular and clean	Dark green	Orangey red
Hickory**	2.15	Hickory crowns are very narrow, irregular and flat. They are the same height or shorter than the rest of the stand	Fleshy carnation colour. Fluorescent green.	Fleshy carnation colour. Salmon beige

* The black ash is used as an example, but the same information applies to all other ash species

** The bitternut hickory is used as an example, but the same information applies to all other hickory species

2.1 Sugar Maple – *Acer saccharum* Marsh.

General Description

In the maple bioclimatic domains (hickory, linden and yellow birch), stands occupy every position on the slope. In the fir-white birch domain, however, they are generally limited to the higher portions of slopes.

They are most often found on sites where drainage varies from good to moderate.

Surface deposits and soil textures have less impact on the species' presence than slope position and drainage conditions. Sugar maples tend to be found only in the southern portion of the fir-yellow birch domain.

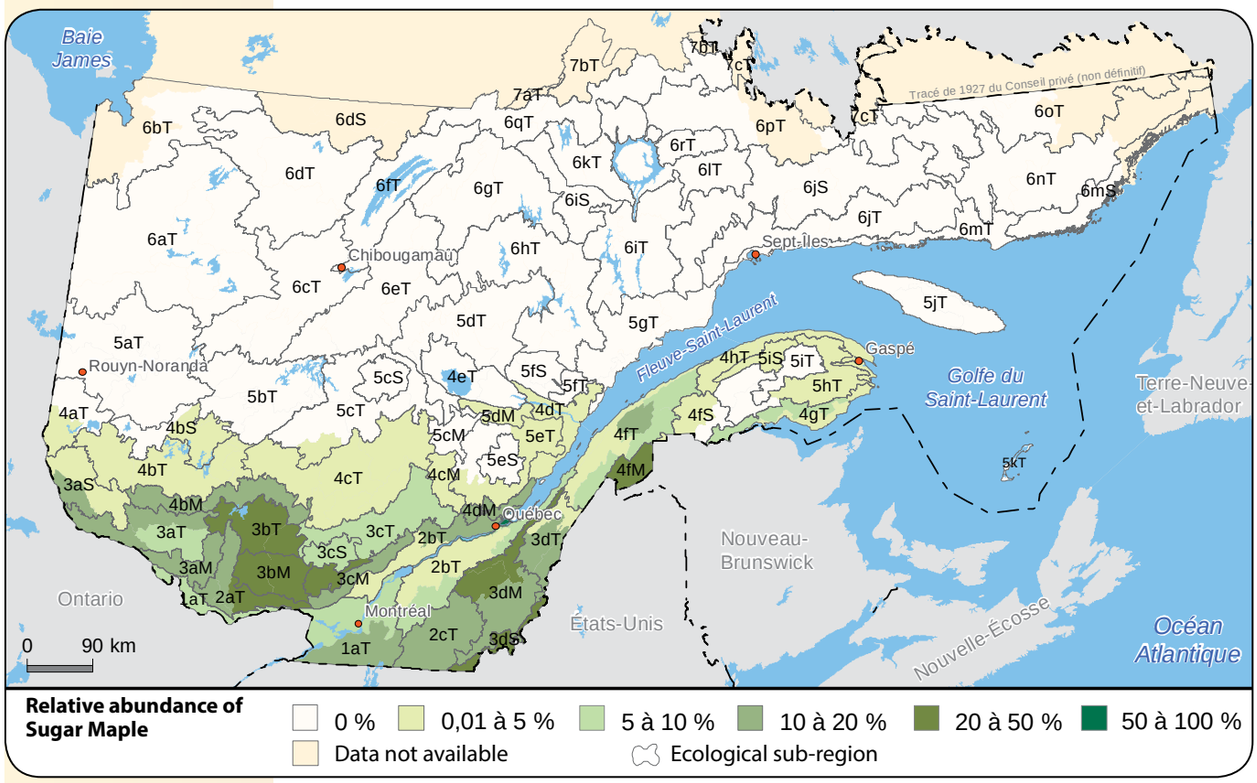
3D screen identification criteria

A sugar maple crown is distinguished by its flat curve shape. Because of its compact appearance and texture composed of bumps and hollows, it resembles a broccoli head. This is due to the way its branches are structured, at a more perpendicular angle to the trunk than is the case for red maple. The sugar maple also has foliage at every stage of the crown, because it is more shade-tolerant.

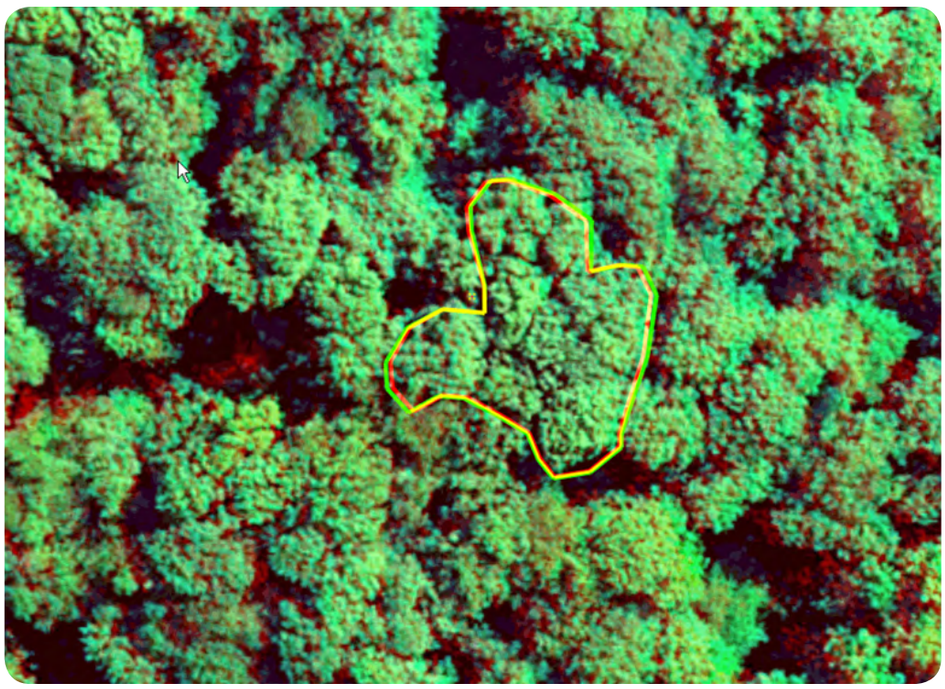
Characteristic colours

- On RGB aerial photographs: light green (young) to bluish green (old)
- On NIR aerial photographs: pale pink to dark pink

Distribution map

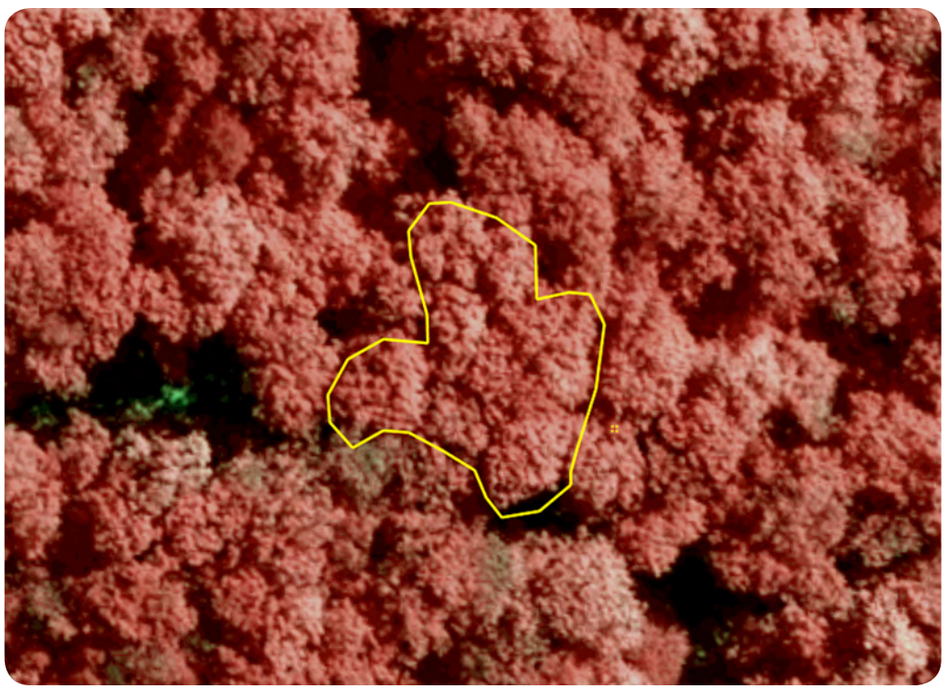


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 79

2.2 Red Maple – *Acer rubrum* L.

General Description

The red maple is found in the maple (hickory, linden and yellow birch) domains and in the fir-yellow birch domain. Stands occupy every part of the slope, although the species tends to be more plentiful in mixed stands and on the lower portions of slopes.

Suitable drainage conditions range from moderate to poor, although the species is seen more frequently in imperfect drainage conditions.

Surface deposits and soil textures have less impact on the species' presence than slope position and drainage conditions.

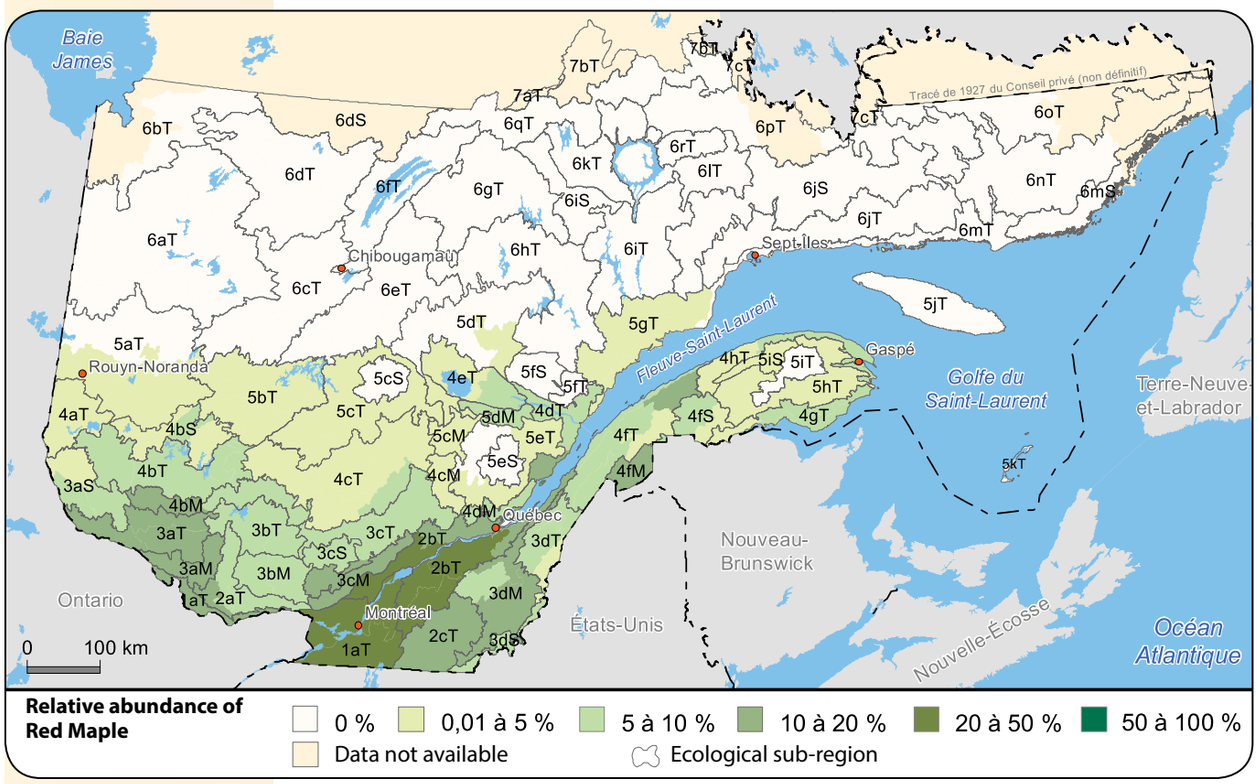
3D screen identification criteria

The red maple crown has a similar flat curve shape to the sugar maple, but differs from that species due to its less well-defined appearance and smaller size. The shade and light (hollows and lumps) structure seen on aerial photographs is due to the fact that the crown branches point upwards (often in a feather-type arrangement). In addition, the centre of the crown is higher than the sides.

Characteristic colours

- On RGB aerial photographs: paler light green than the sugar maple, sometimes shinier
- On NIR aerial photographs: paler light pink than the sugar maple, sometimes shinier

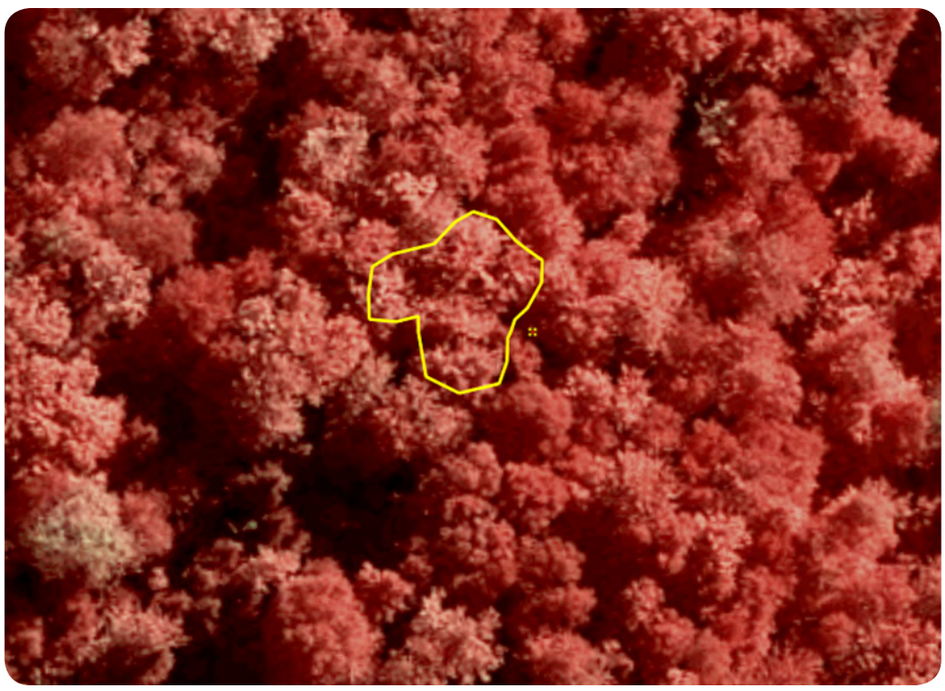
Distribution map



Source: Data from temporary and permanent sample plots from the 3rd inventory.

Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 80

2.3 Yellow Birch – *Betula alleghaniensis* Britt.

General Description

The yellow birch grows in the maple (hickory, linden and yellow birch) and fir-yellow birch domains, and is present sporadically in the fir-white birch domain. In the maple domains, the species is found mainly on the lower portions of slopes, whereas in the fir-white birch domain it tends to prefer the middle and upper portions of slopes. In the fir-white birch domain, it is usually found in the upper portions of slopes on moderate hills.

In the maple domains, the species is associated more specifically with subhydric soils (imperfect drainage), but can also be found as a companion species on moderately-drained sites. It is commonly found in ravines. In the fir domains, it grows in all types of landscapes, on well-drained sites (moderate drainage).

Surface deposits and soil textures have less impact on the species' presence than topographical location and drainage conditions. In the fir-white birch domain, the yellow birch usually grows in the southern margins of the landscape.

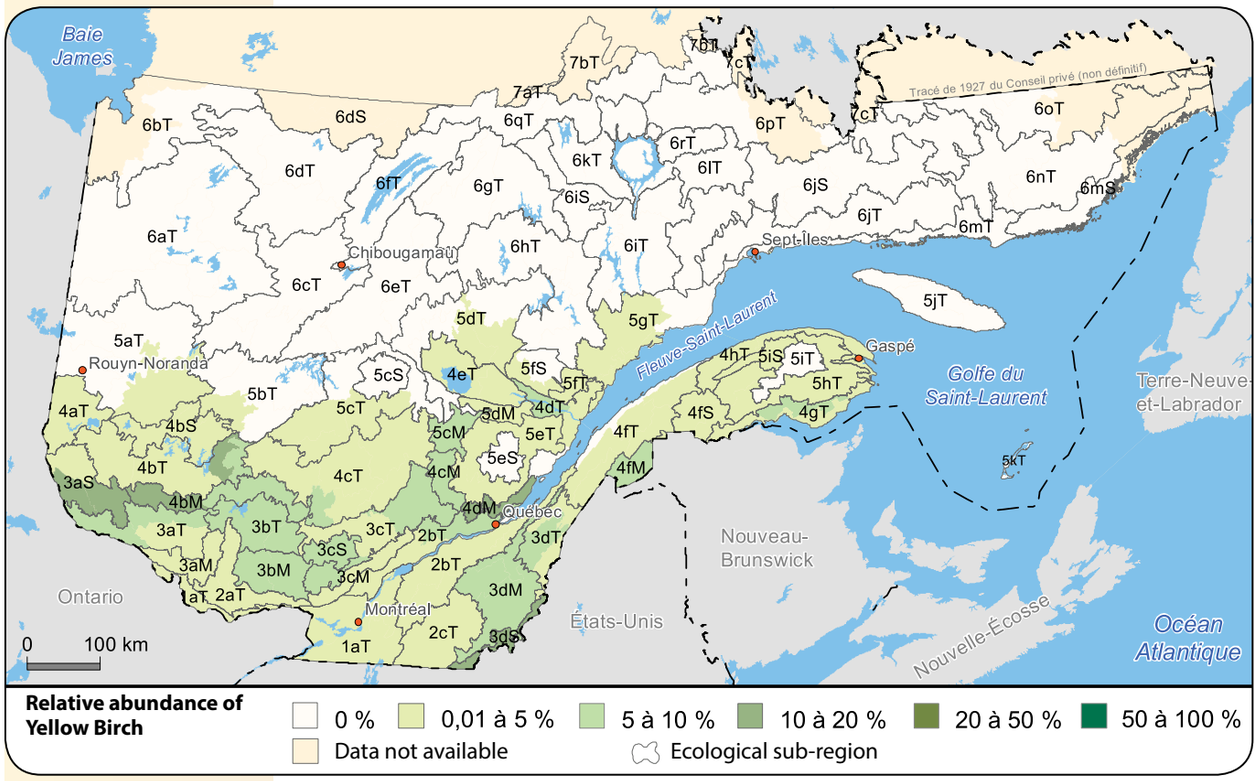
3D screen identification criteria

The yellow birch crown is distinguished by its half-oval shape. On aerial photographs, its crown appears similar to the sugar maple, although slightly less well-defined. Its texture also appears smoother than the sugar maple's texture, and fuzzier.

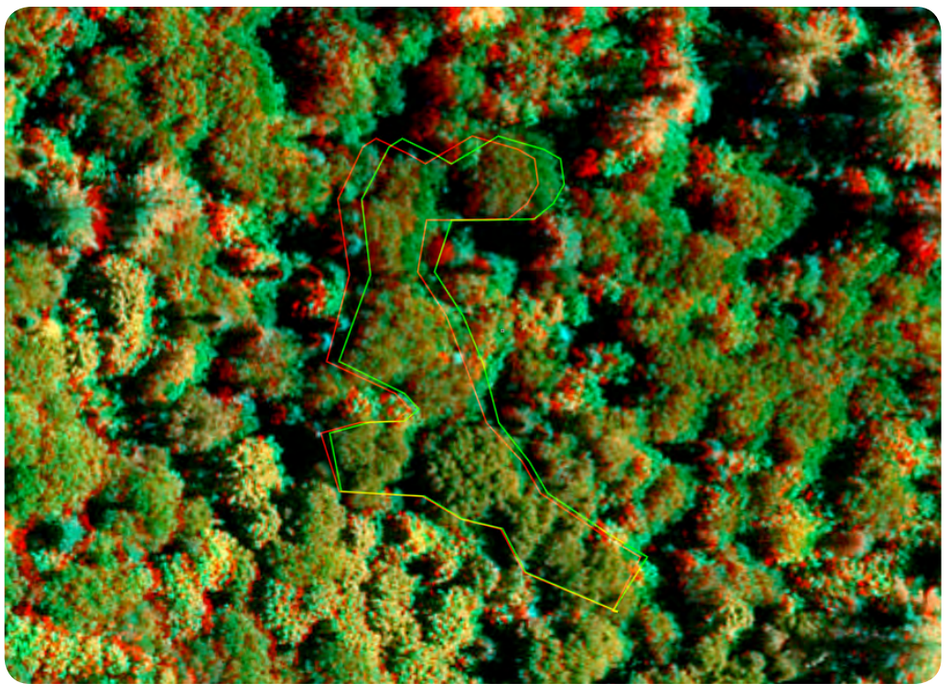
Characteristic colours

- On RGB aerial photographs: dark green
- On NIR aerial photographs: dark pink

Distribution map

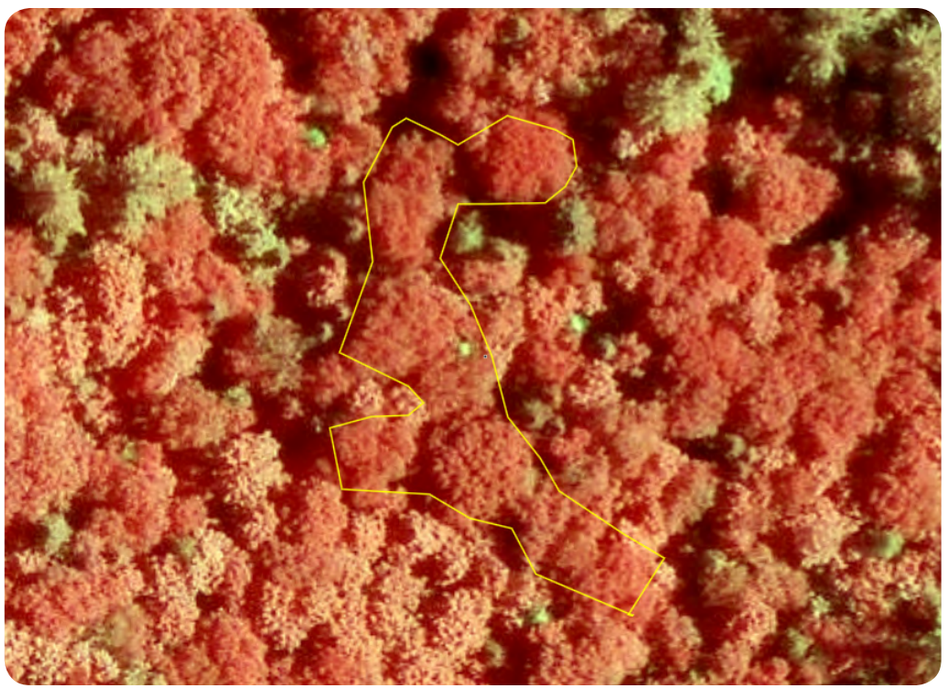


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 80

2.4 White Birch – *Betula papyrifera* Marsh.

General Description

The white birch can be found in every bioclimatic domain south of the forest tundra. In the spruce-moss domain, it grows in landscapes near the tops of slopes on moderate hills. In the other domains, it can be found across the entire topography.

It grows in all types of drainage conditions except for hydric and subhydric soils.

The species has no preference for any specific surface deposit or soil texture, although it is unlikely to be found on sites with organic deposits.

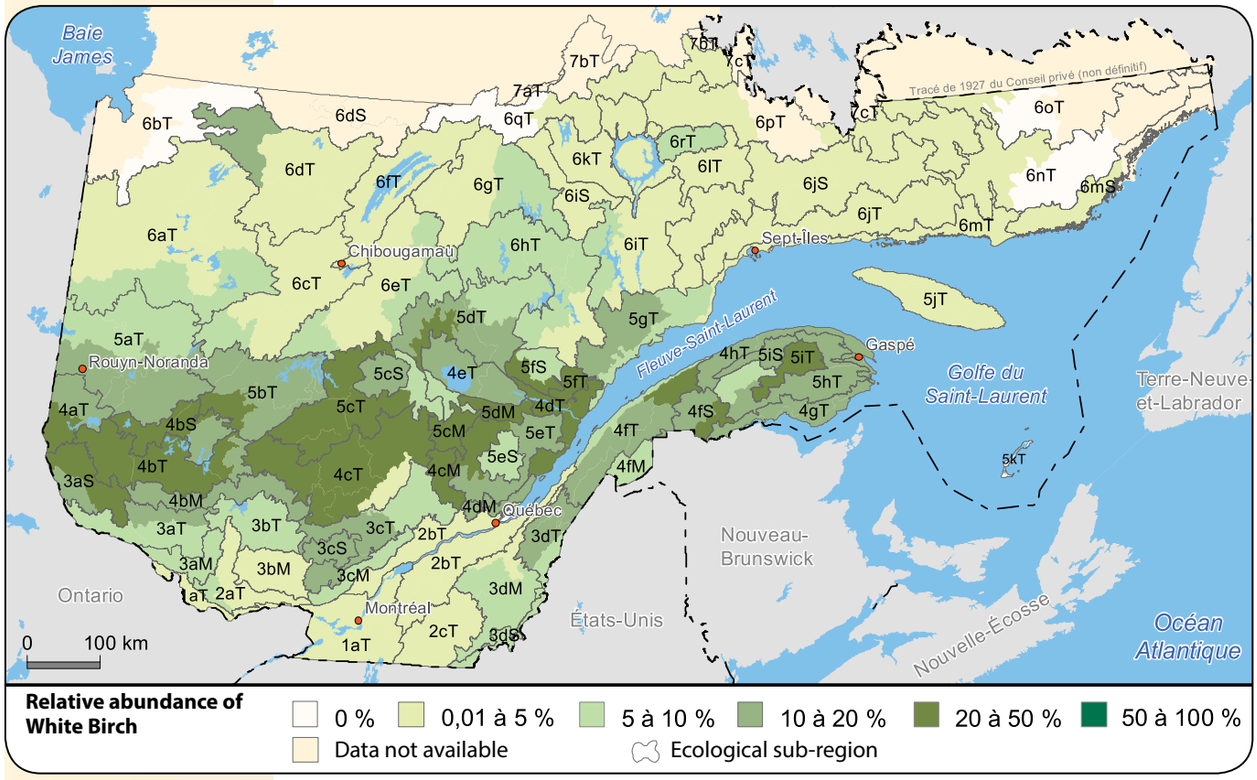
3D screen identification criteria

The white birch crown is distinguished by its very flat half-circle shape. The crown surface is irregular and fuzzy, and the species is usually shorter than the yellow birch or sugar maple. White birch crowns appear to merge together (difficult to "separate").

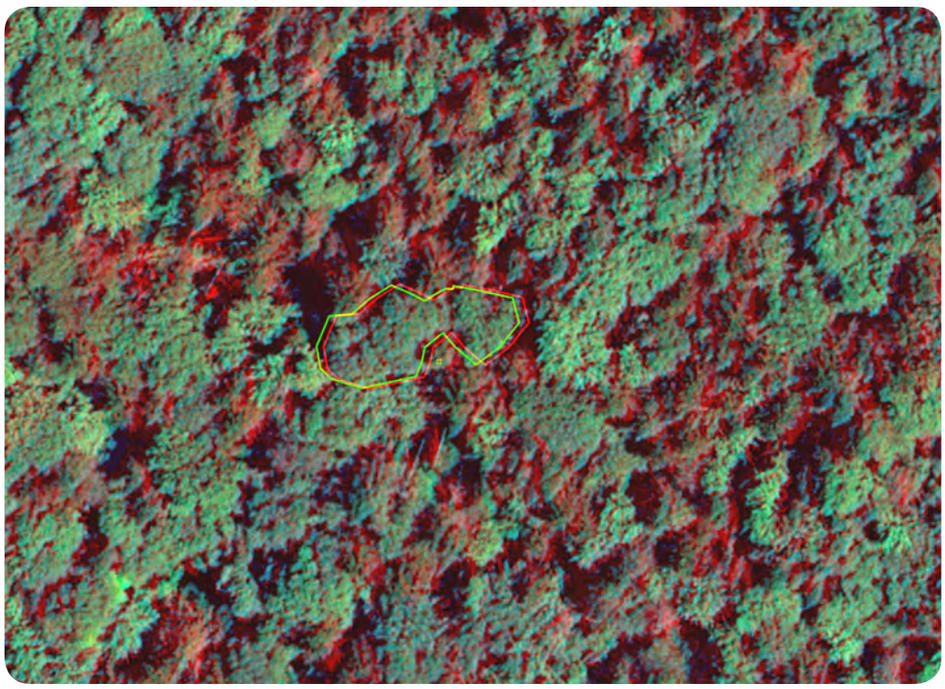
Characteristic colours

- On RGB aerial photographs: lighter dark green than the yellow birch, with a touch of yellow that gives it a brownish appearance
- On NIR aerial photographs: lighter dark pink than the yellow birch

Distribution map

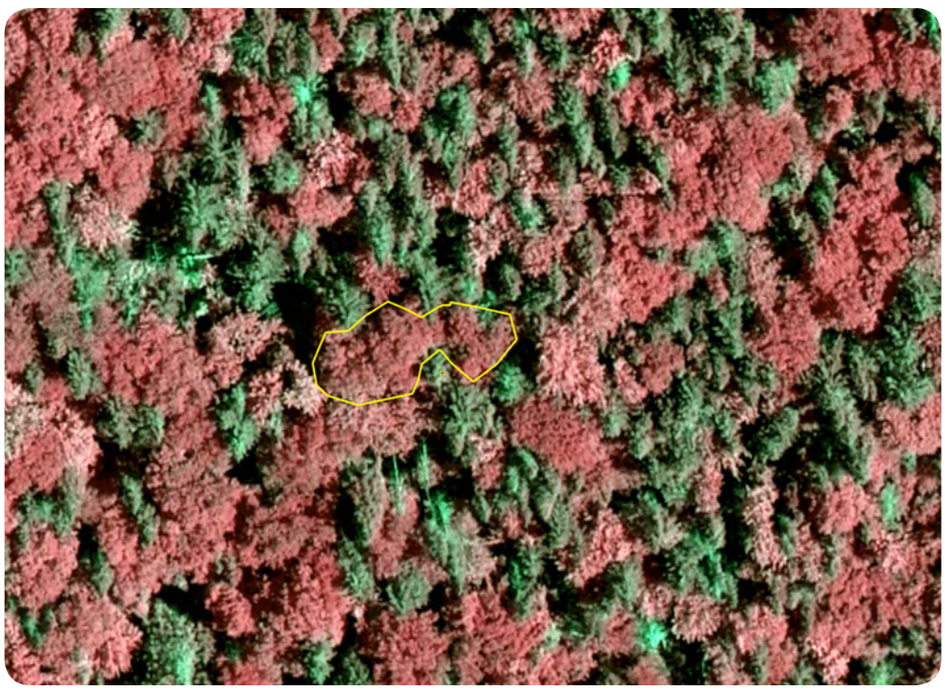


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 81

2.5 Grey Birch – *Betula populifolia* Marsh.

General Description

The grey birch is present in the maple-linden and maple-hickory domains, and grows sporadically in the maple-yellow birch domain. It is found throughout the entire topography, but is associated specifically with the upper portions of slopes on moderate hills in the St. Lawrence plains. North of its distribution area, it often grows in virtually pure stands. It is strongly correlated with former wildland and old logging areas. In other bioclimatic domains, the species shows no preference for any given topographical position.

It also grows in all drainage conditions, and is not associated with any specific surface deposit or soil texture.

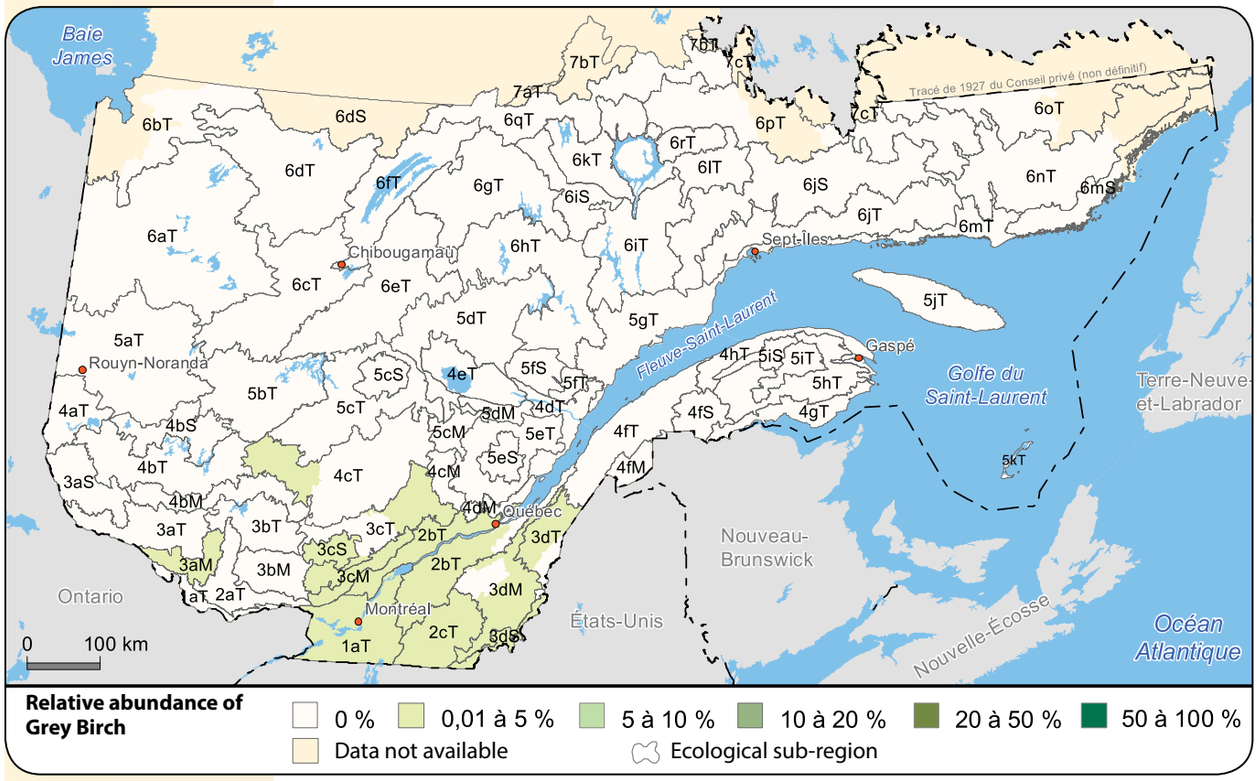
3D screen identification criteria

The grey birch crown is distinguished by its cylindrical shape and rounded top. The surface is fuzzy. The species is also shorter than the species that accompany it.

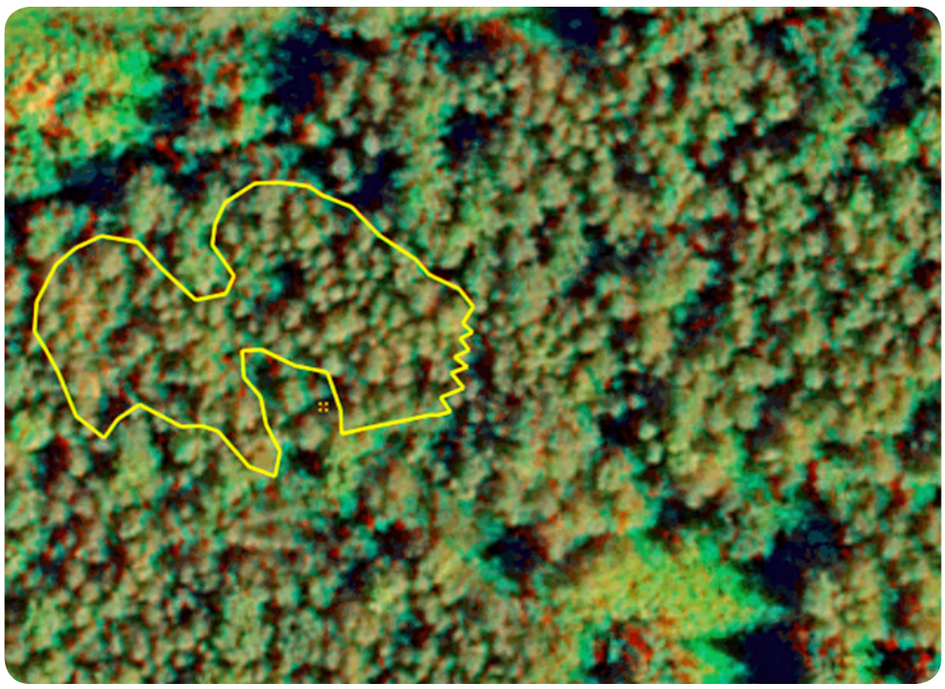
Characteristic colours

- On RGB aerial photographs: yellowish brown to pinkish brown
- On NIR aerial photographs: brownish yellow

Distribution map

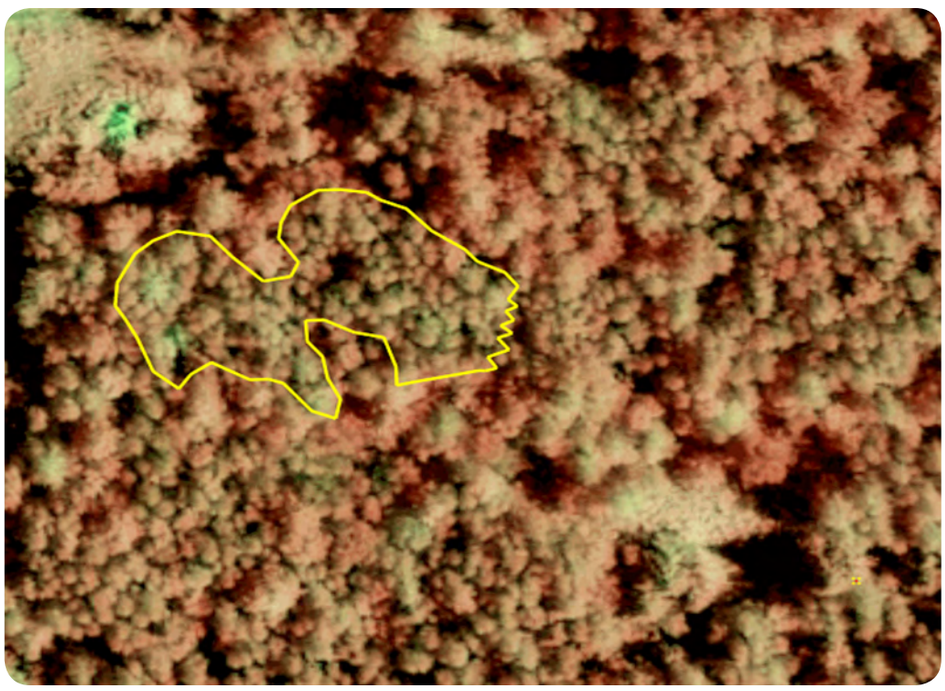


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 82

2.6 Trembling Aspen – *Populus tremuloides* Michx.

General Description

The trembling aspen grows in all bioclimatic domains south of the forest tundra. In the spruce-moss domain, it can be found on the upper portions of slopes on moderate hills. In the other bioclimatic domains, it grows across the entire topography, in all types of landscapes.

All drainage conditions except for hydric soils are suitable.

Similarly, the species grows on all kinds of surface deposits (except organic deposits) and in all soil textures.

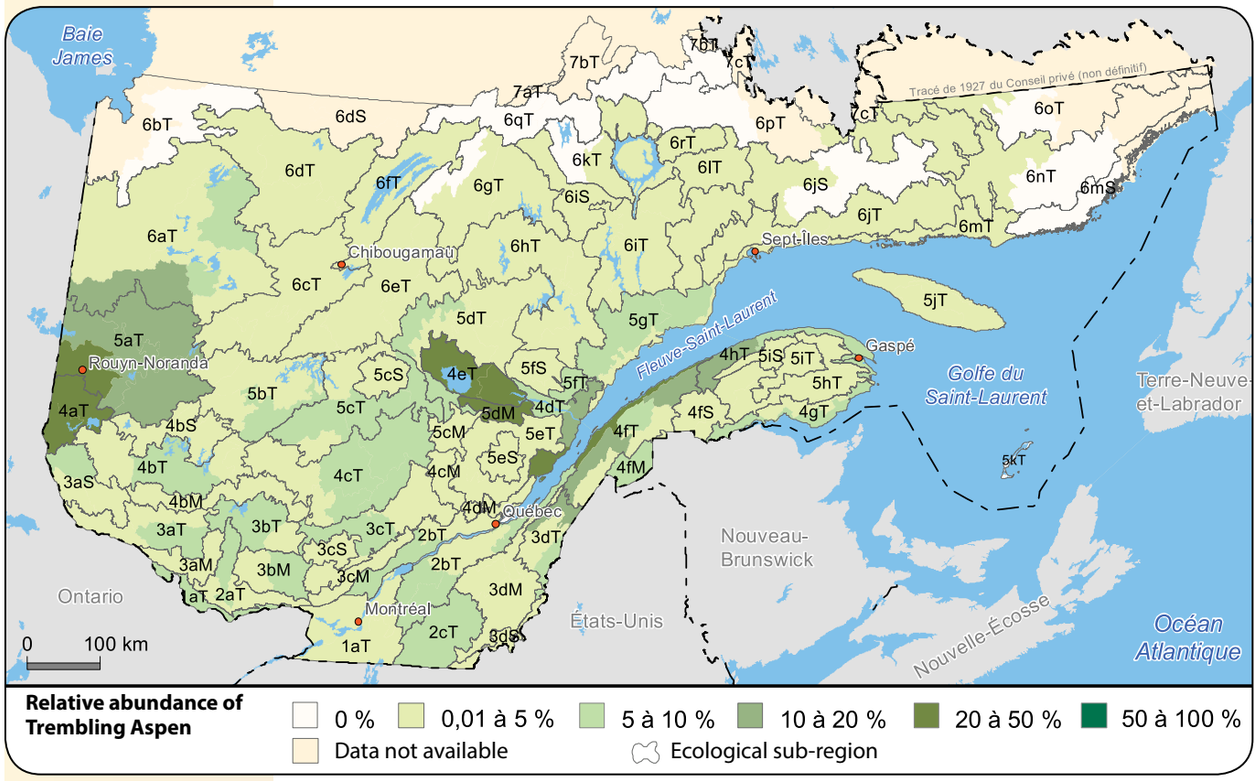
3D screen identification criteria

The trembling aspen is distinguished by the fact that it is usually taller than other species in the stand. Its crown has a regular, fuzzy surface, shaped like an electric light bulb. Aspen crowns are more detached from one another than white birch crowns.

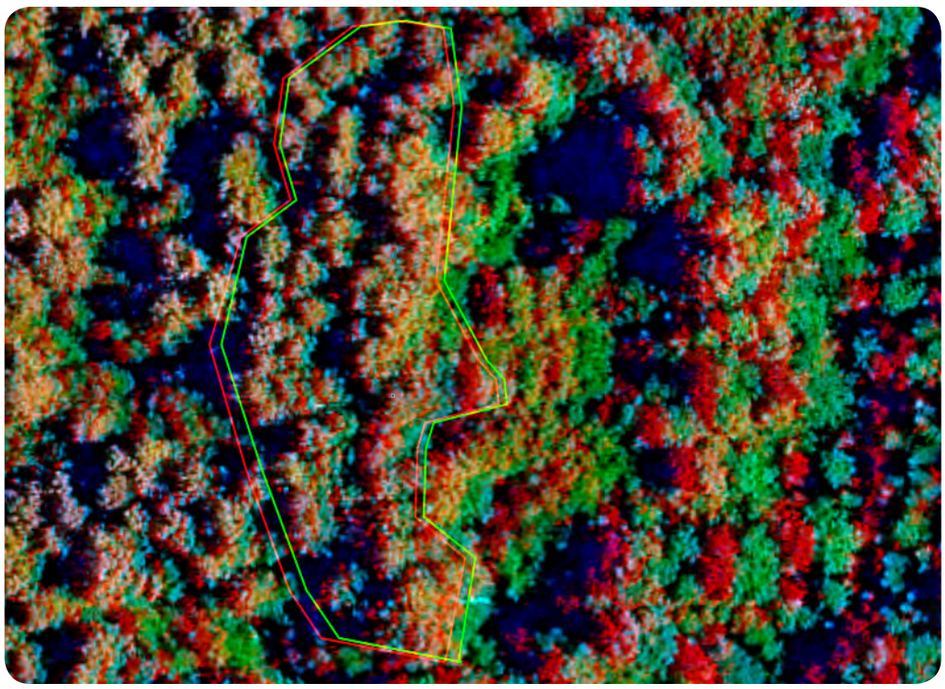
Characteristic colours

- On RGB aerial photographs: bluish green
- On NIR aerial photographs: orangey pink

Distribution map

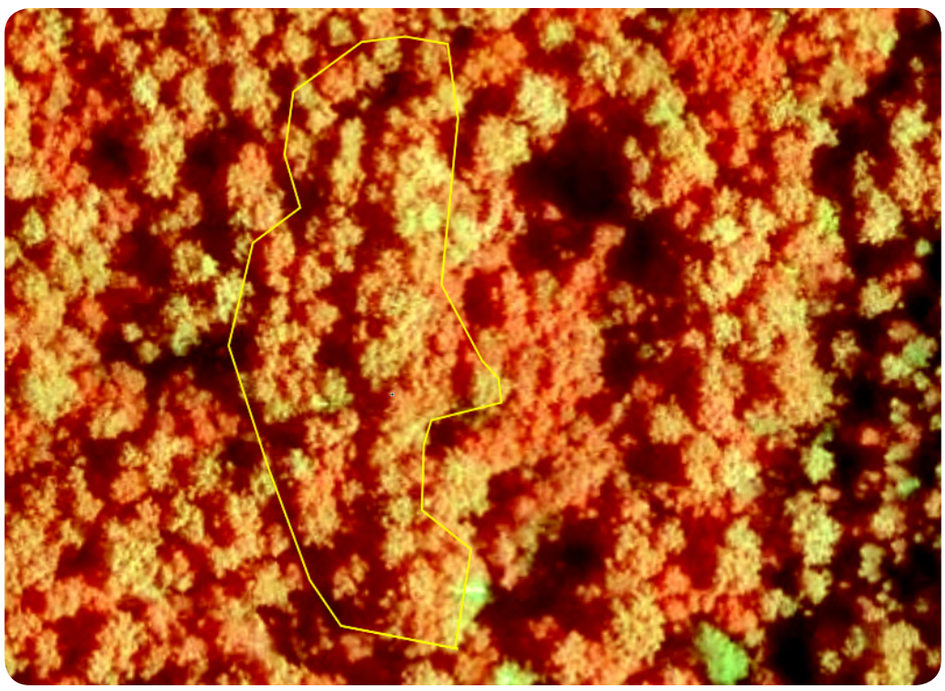


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 83

2.7 American Beech – *Fagus grandifolia* Ehrh.

General Description

The American beech is found mainly in the maple domains (hickory, linden and yellow birch), and only sporadically in the fir-yellow birch domain. Stands containing American beech trees grow across the entire topography.

The species prefers sites on which drainage conditions vary from good to moderate. Its presence does not depend on any specific type of surface deposit or soil texture.

The only indicator of its presence is good to moderate drainage.

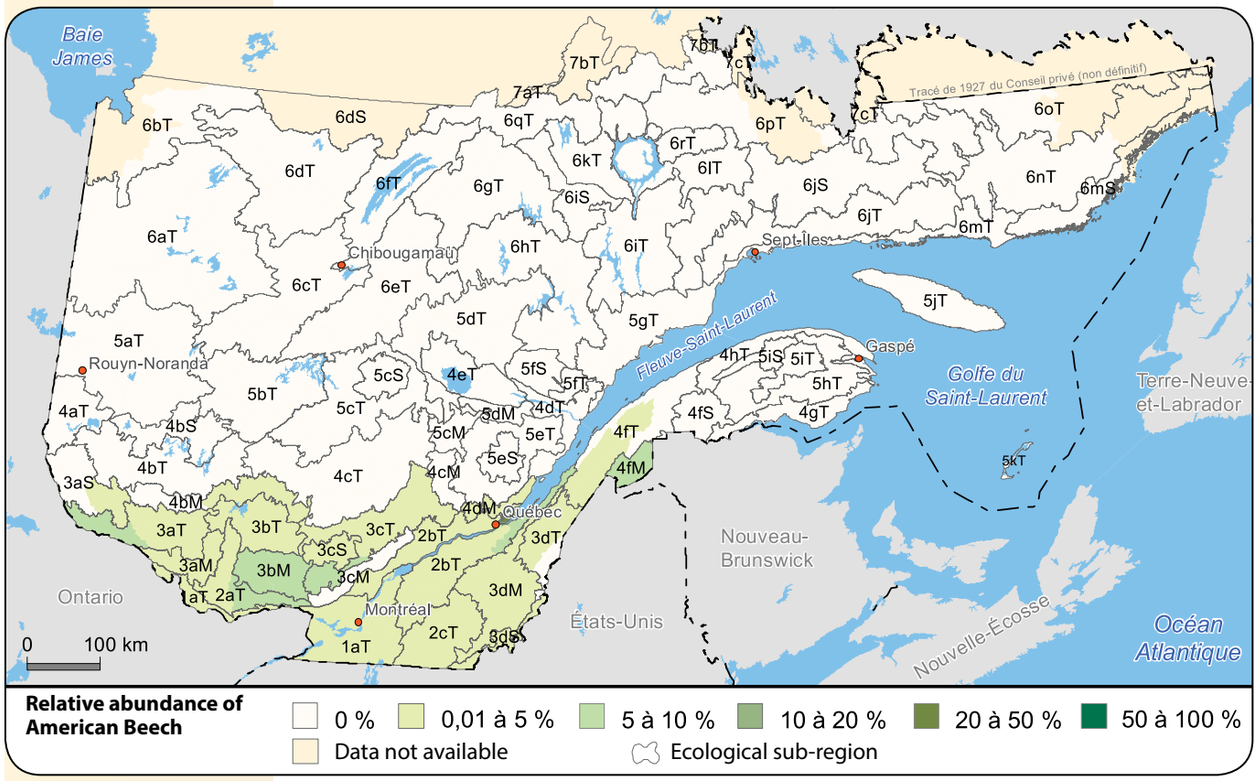
3D screen identification criteria

The American beech crown is distinguished by the lack of roundness in its structure. Its surface is irregular (bumps and deep hollows), and fuzzy.

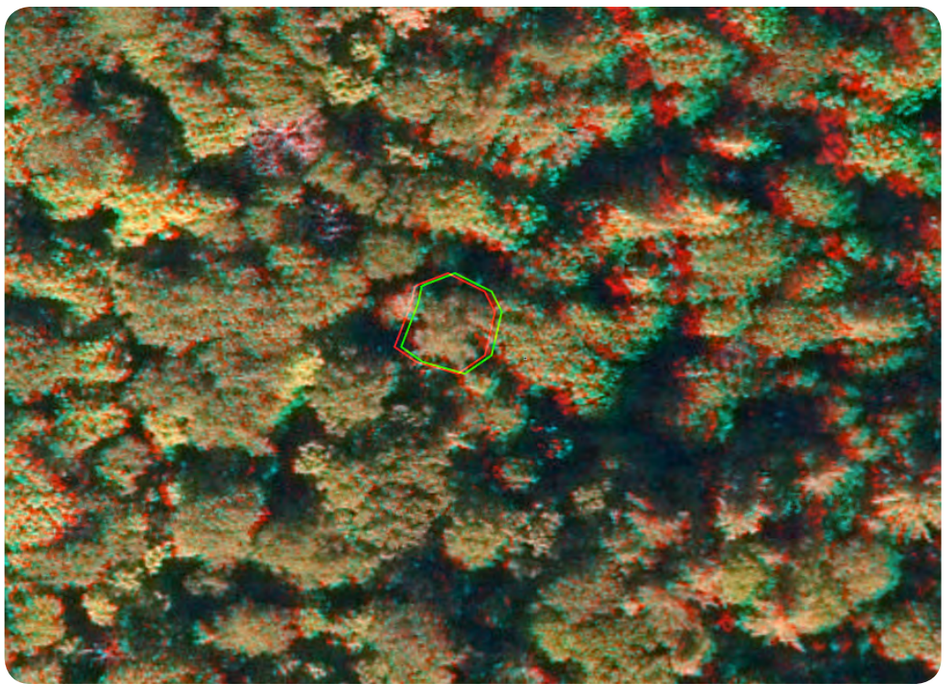
Characteristic colours

- On RGB aerial photographs: brownish to brownish green
- On NIR aerial photographs: orangey pink to brownish pink

Distribution map

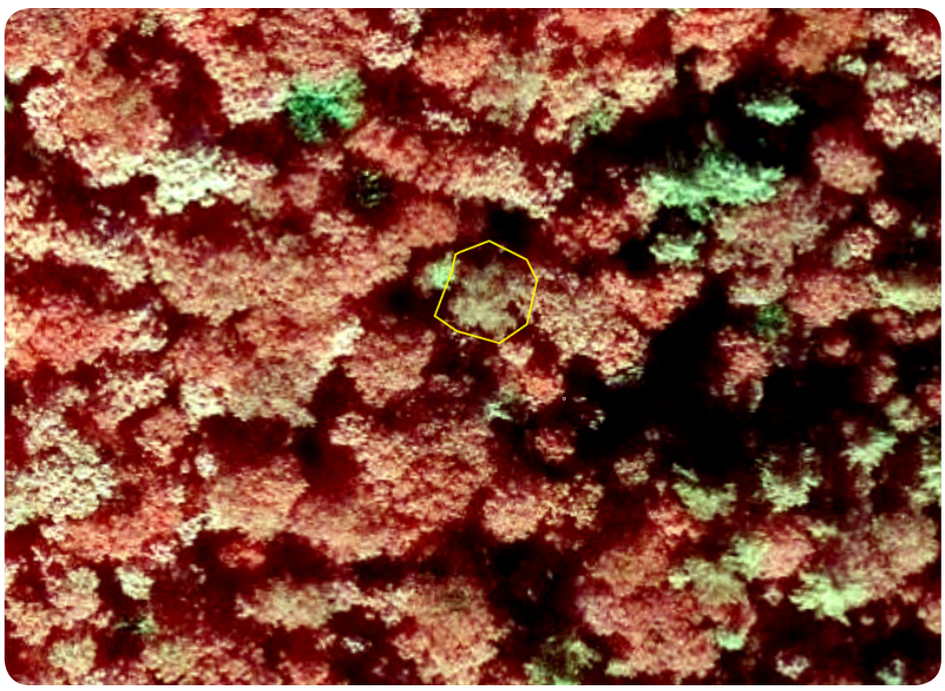


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 82

2.8 Red Oak – *Quercus rubra* L.

General Description

The red oak is found in the maple domains (hickory, linden and yellow birch). Stands grow across the entire topography; the key factor that determines their presence is drainage.

Red oak trees are usually found on very well-drained sites (drainage described as excessive, fast or good).

The species is often associated with thin surface deposits.

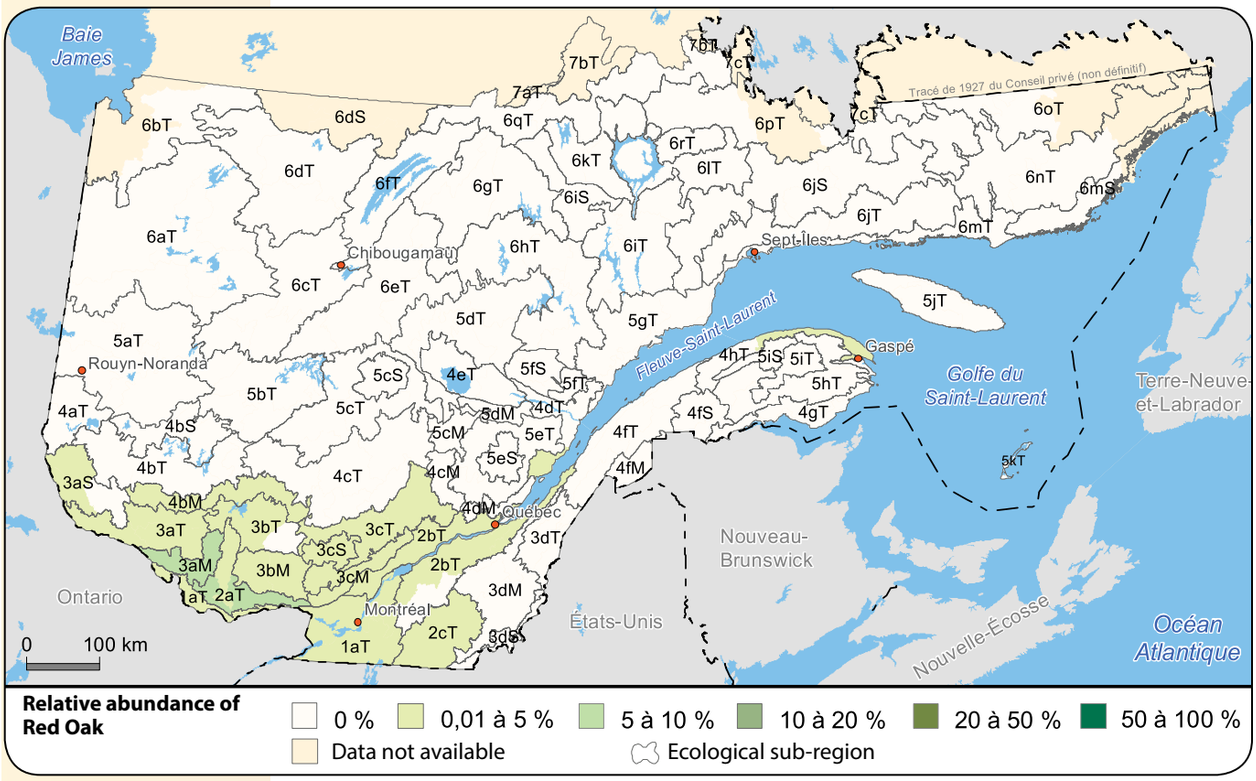
3D screen identification criteria

The red oak crown is shaped like a flat half-circle. It is compact and fuzzy, with a texture composed of lumps and large hollows, giving it a "stained" appearance.

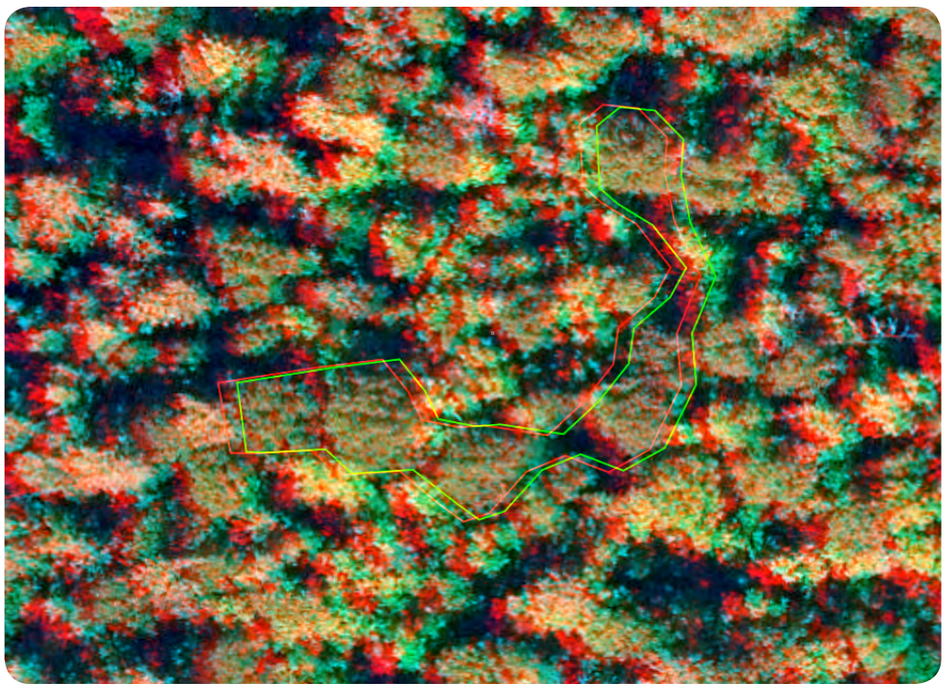
Characteristic colours

- On RGB aerial photographs: brownish green to greenish brown
- On NIR aerial photographs: dark pink to orangey pink

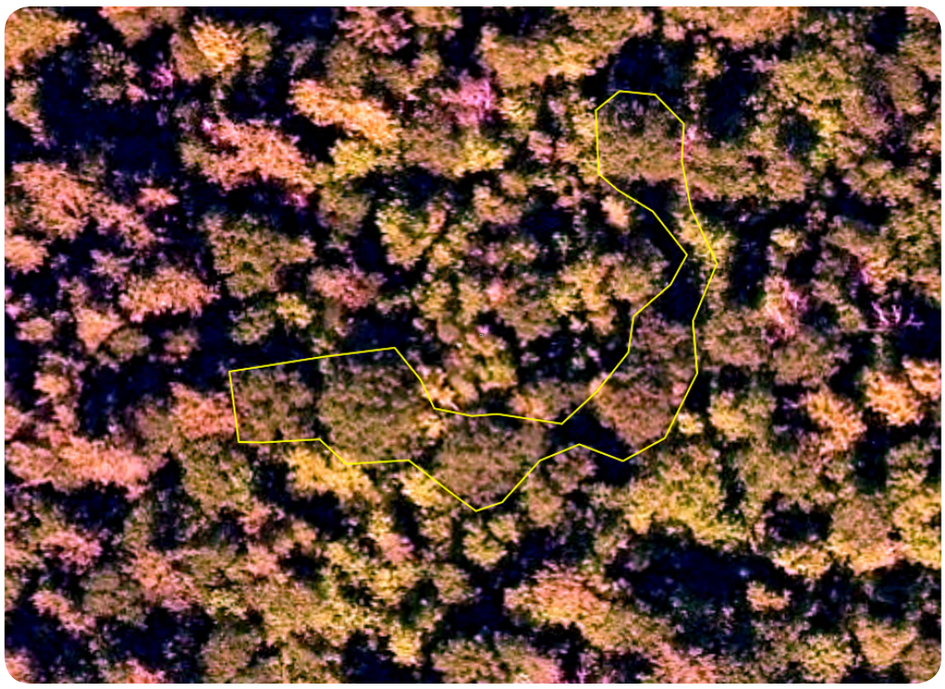
Distribution map



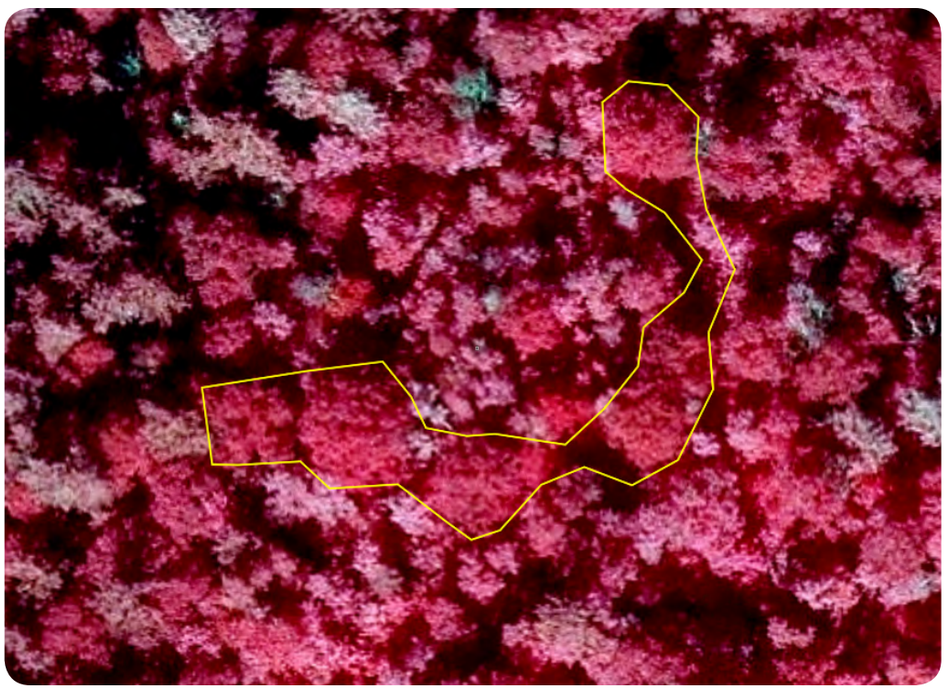
Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB



Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 84

2.9 Balsam Poplar – *Populus balsamifera* L.

General Description

The balsam poplar can be found in all the bioclimatic domains. It grows on the lower portion of slopes and on plains that are rich in nutrients. It often grows along watercourses.

It grows on sites offering moderate drainage conditions (good, moderate, imperfect).

The species adapts to all kinds of surface deposits (although is rarely found on organic deposits) and soil textures.

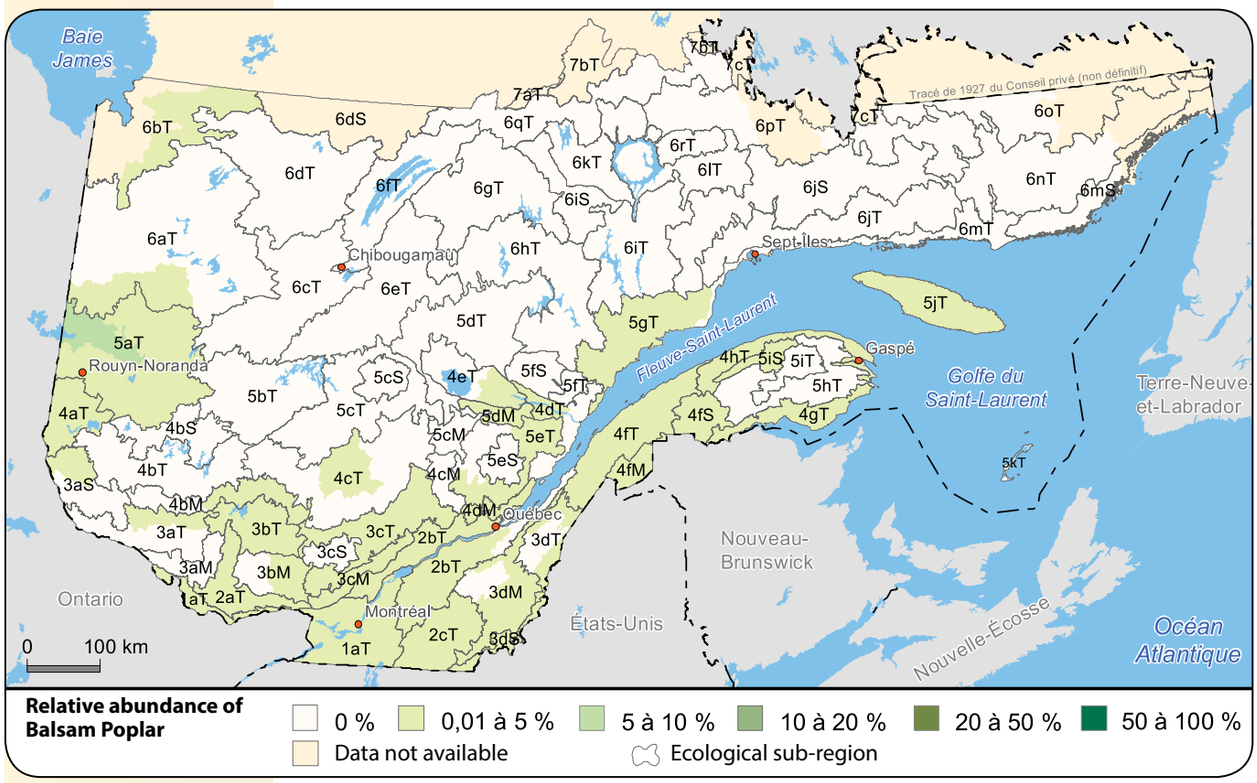
3D screen identification criteria

The balsam poplar is generally taller than other hardwoods in the stand. Its crown resembles the trembling aspen crown, but is narrower and more pointed. Its surface is regular and fuzzy.

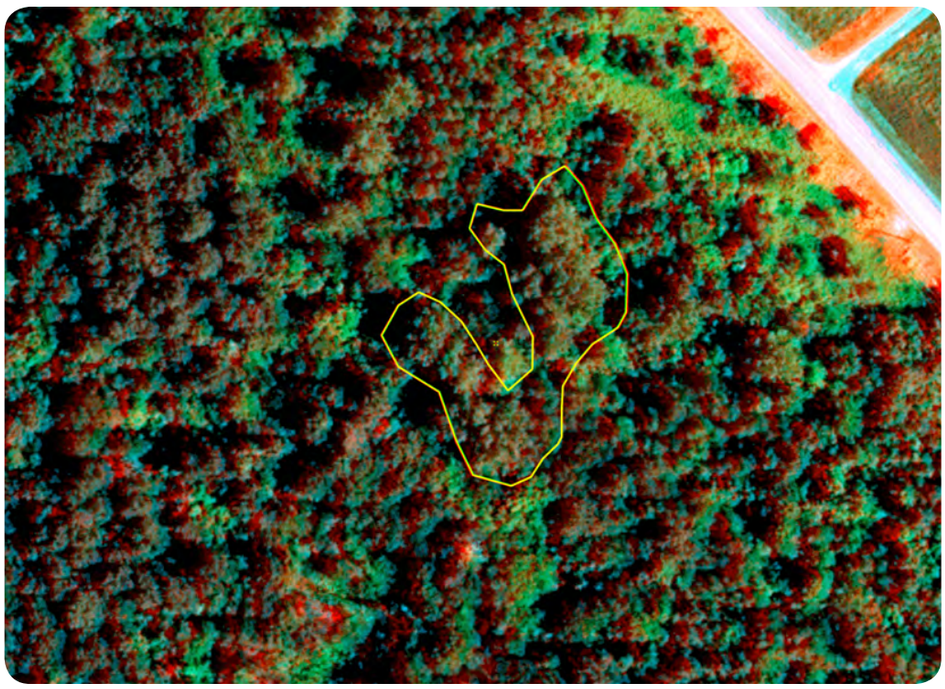
Characteristic colours

- On RGB aerial photographs: light to dark brown, darker than the trembling aspen
- On NIR aerial photographs: dark orange to brownish pink

Distribution map

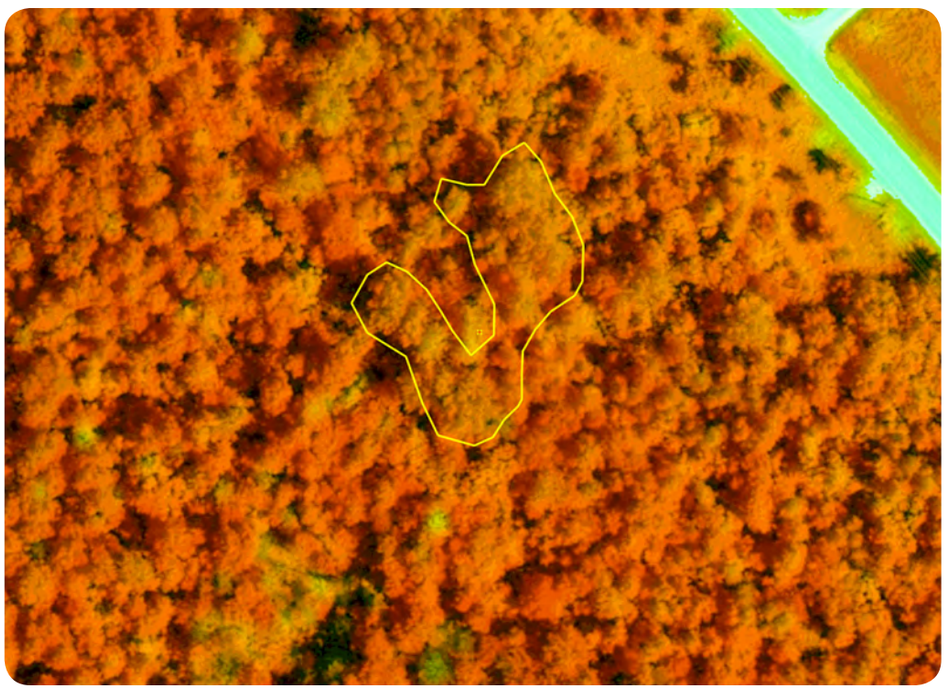


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

2.10 Large-Toothed Aspen – *Populus grandidentata* Michx.

General Description

The large-toothed aspen grows in the maple (hickory, linden and yellow birch) domains, and is present sporadically in the fir-yellow birch domain. Stands grow throughout slopes. This particular aspen is almost never the dominant species in a stand.

The species is found in all types of drainage conditions except for very poor drainage (hydric soils).

The species is not associated with any particular kind of surface deposit or soil texture, although it shows an affinity for soils with moderate to fine textures that are rich in nutrients. It is unlikely to grow on organic deposits.

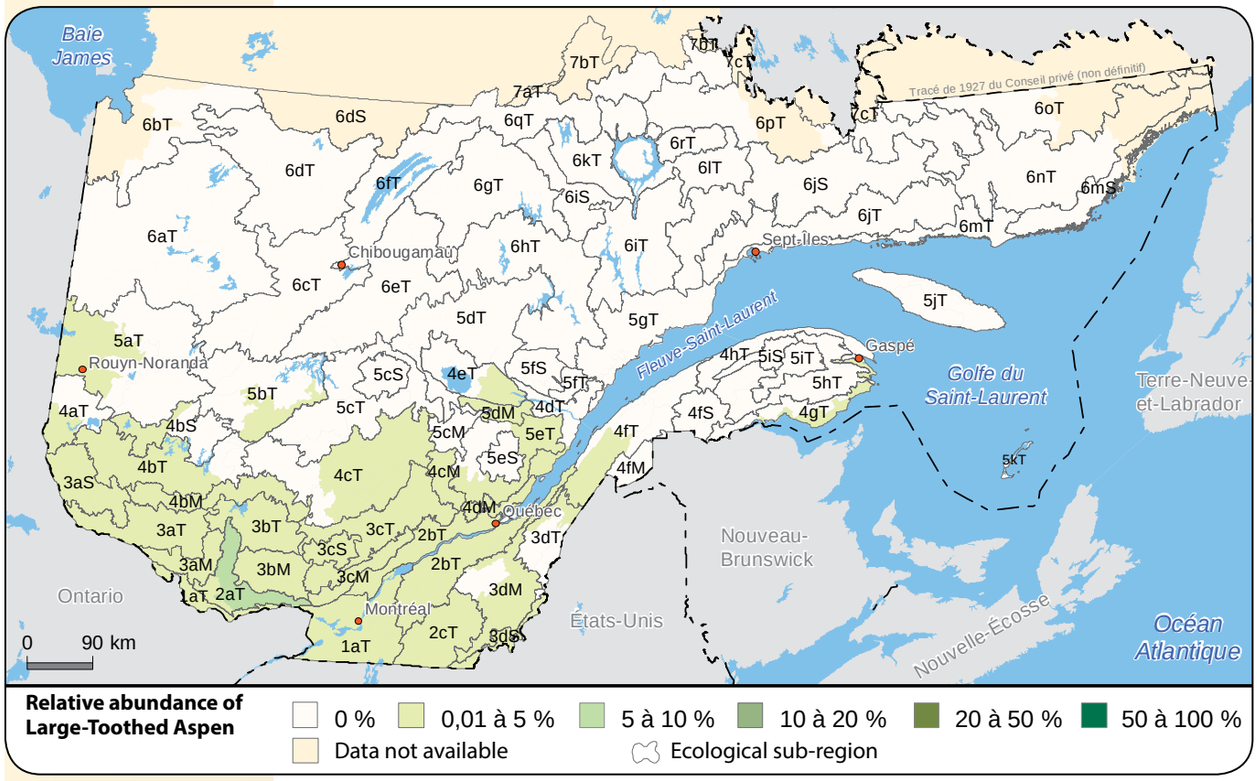
3D screen identification criteria

The large-toothed aspen is taller than other hardwoods in the stand. Its crown is regular and fuzzy, and tends to be broader and sparser than the trembling aspen crown.

Characteristic colours

- On RGB aerial photographs: brownish green to pale brown
- On NIR aerial photographs: darker orangey pink than the trembling aspen

Distribution map

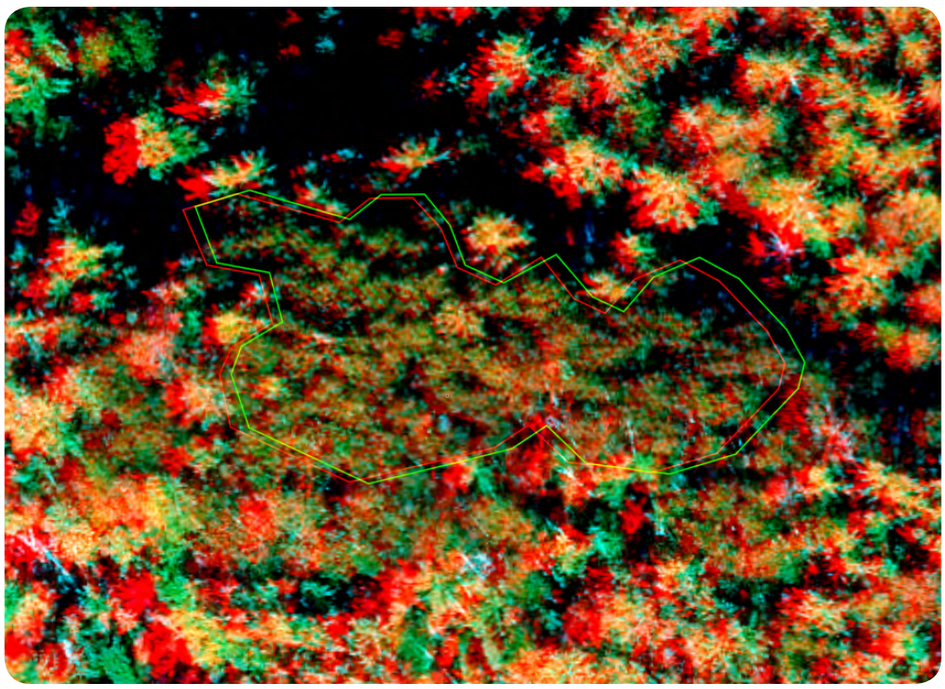


Relative abundance of Large-Toothed Aspen

0 % | 0,01 à 5 % | 5 à 10 % | 10 à 20 % | 20 à 50 % | 50 à 100 %

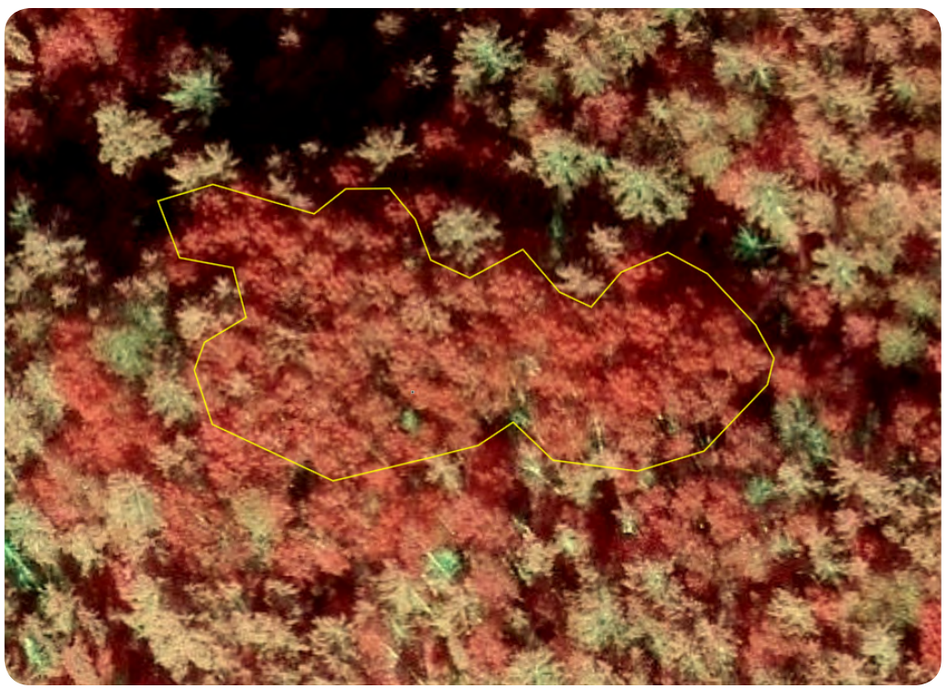
Data not available | Ecological sub-region

Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

2.11 Eastern Poplar – *Populus deltoides Bartr.* Ex Marsh.

General Description

The Eastern poplar is found mainly in the maple domains (hickory, linden, yellow birch), and sporadically in the fir-yellow birch domain. Stands grow throughout the slope, and the species is almost never the dominant species in a stand.

The Eastern poplar grows in all drainage conditions except for hydric soils. It prefers sites offering imperfect drainage (subhydric soils).

It is likely to be found on all surface deposits and soil textures except for organic deposits. It usually grows in moderate to fine soils that are richer in nutrients, and is often present along watercourses.

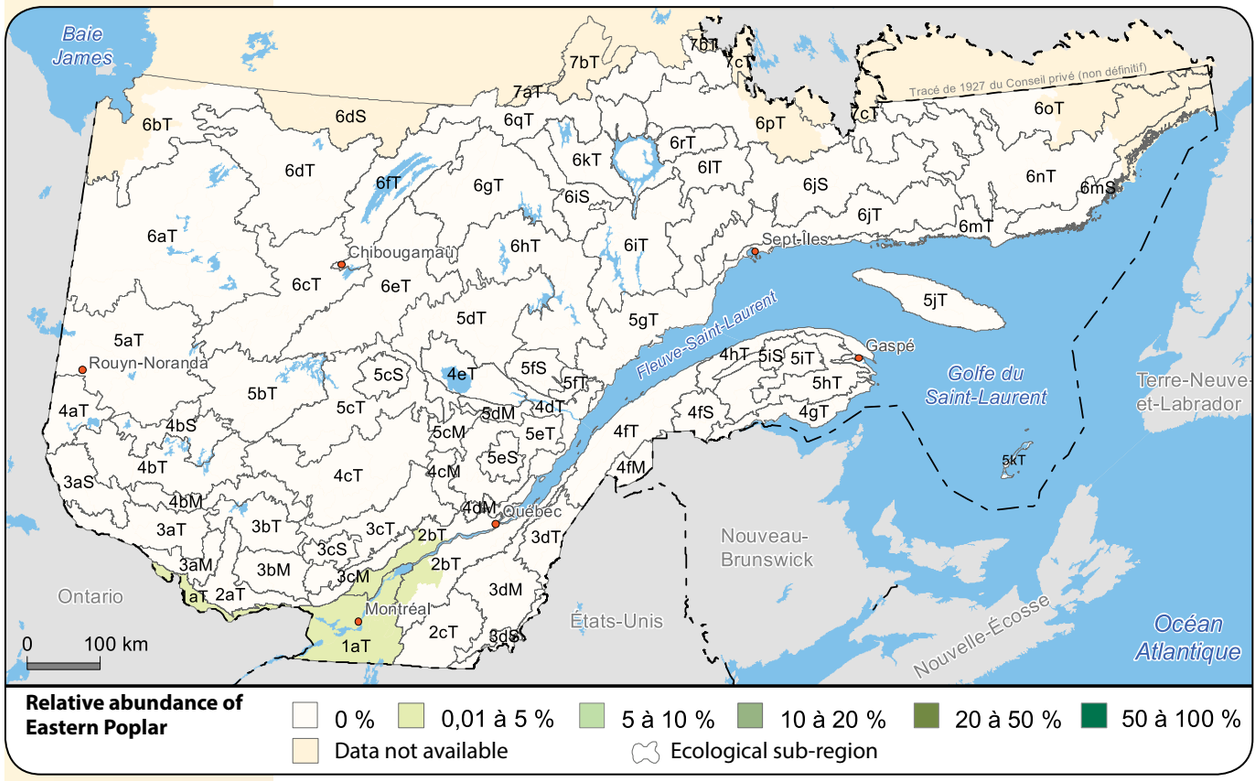
3D screen identification criteria

The Eastern poplar is often taller than other hardwoods in the stand. Its highly visible, ascending branches form a sparse, open crown with an irregular, fuzzy surface.

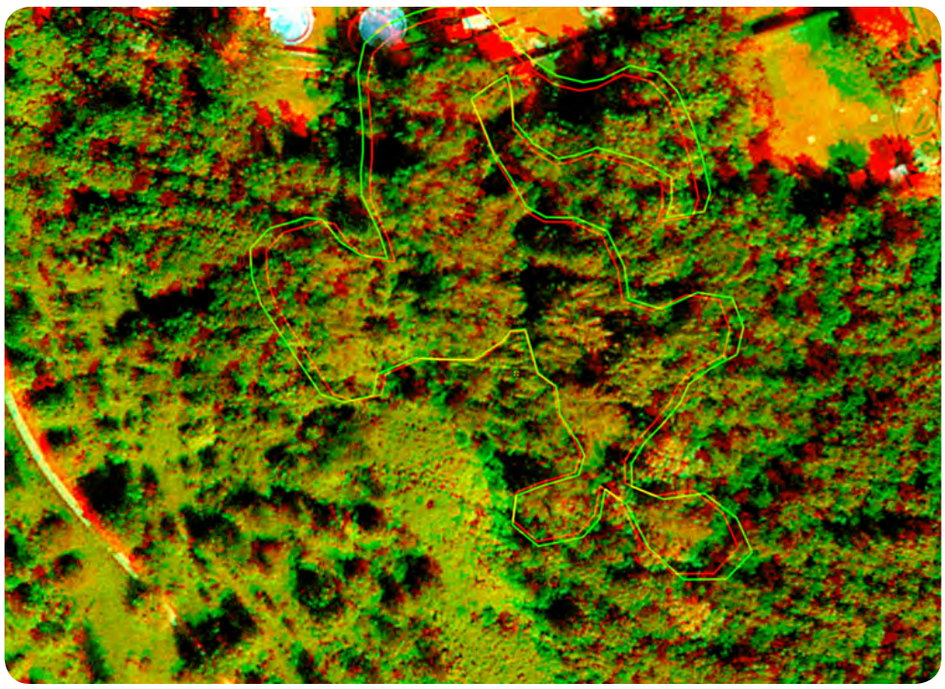
Characteristic colours

- On RGB aerial photographs: greenish brown to pale brown
- On NIR aerial photographs: more beige

Distribution map

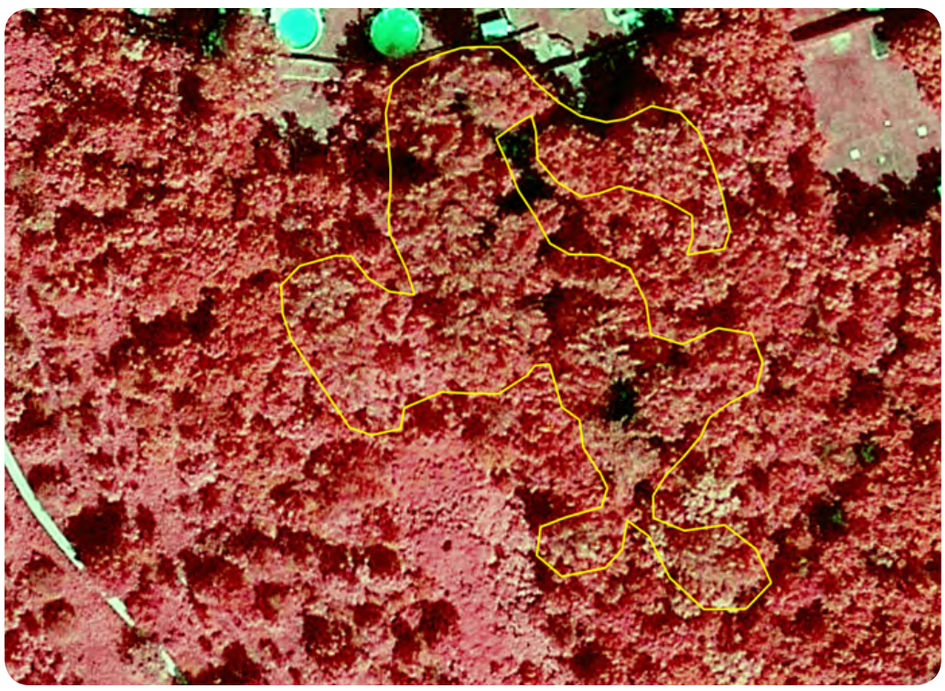


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 85

2.12 American Linden – *Tilia americana* L.

General Description

The American linden is a characteristic species of the maple-hickory and maple-linden bioclimatic domains, although it can also be found in protected sites in the maple-yellow birch domain. The American linden is almost never the dominant species in a stand. It is found in every topographical situation, although in the maple-yellow birch stand its presence is limited to the middle and upper portions of slopes.

It grows on sites where drainage varies from good to moderate.

It is found on all kinds of surface deposits and soil textures except for organic deposits, although it is more common on moderate to fine soils that are richer in nutrients.

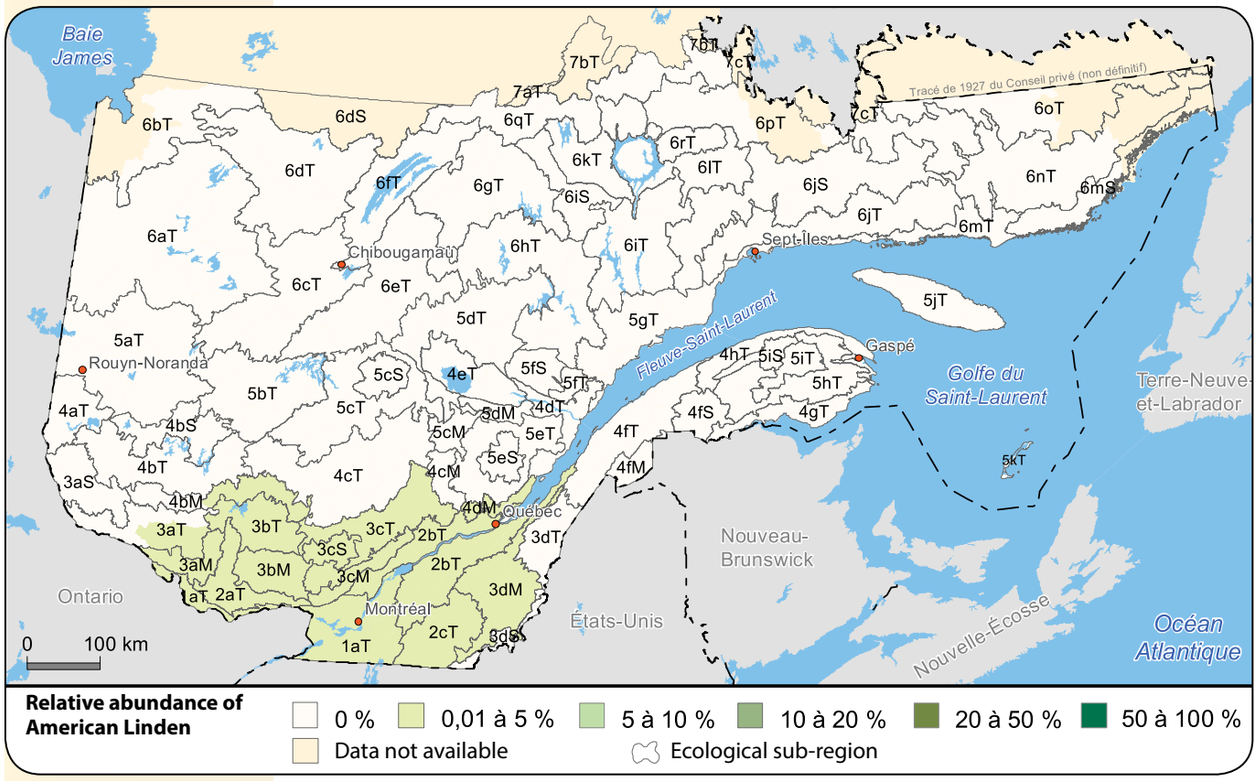
3D screen identification criteria

The American linden is distinguished by its half egg-shaped crown. The texture is regular and fuzzy.

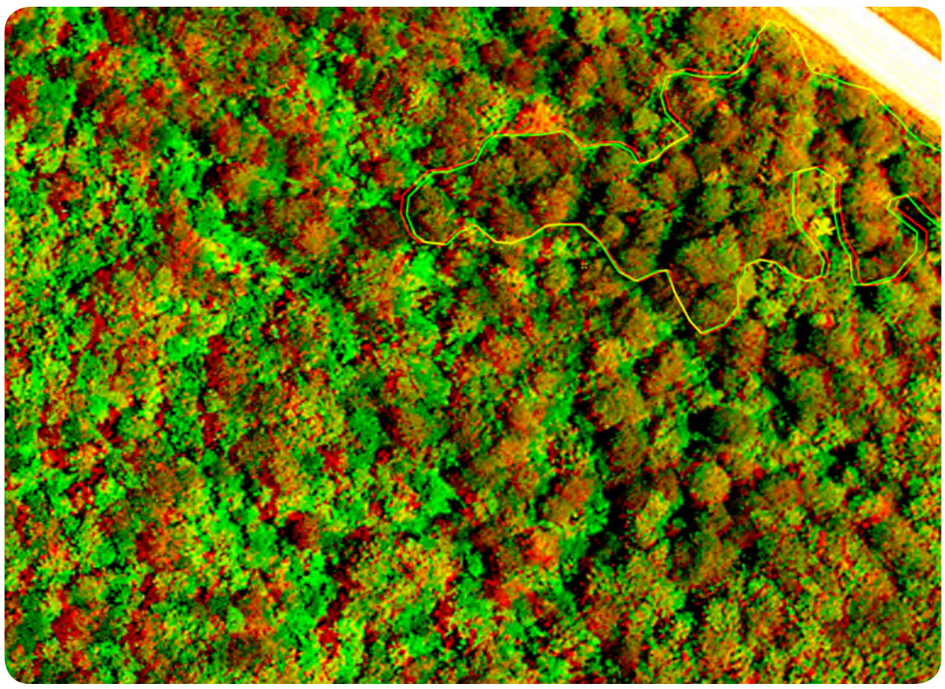
Characteristic colours

- On RGB aerial photographs: dark green
- On NIR aerial photographs: dark orange

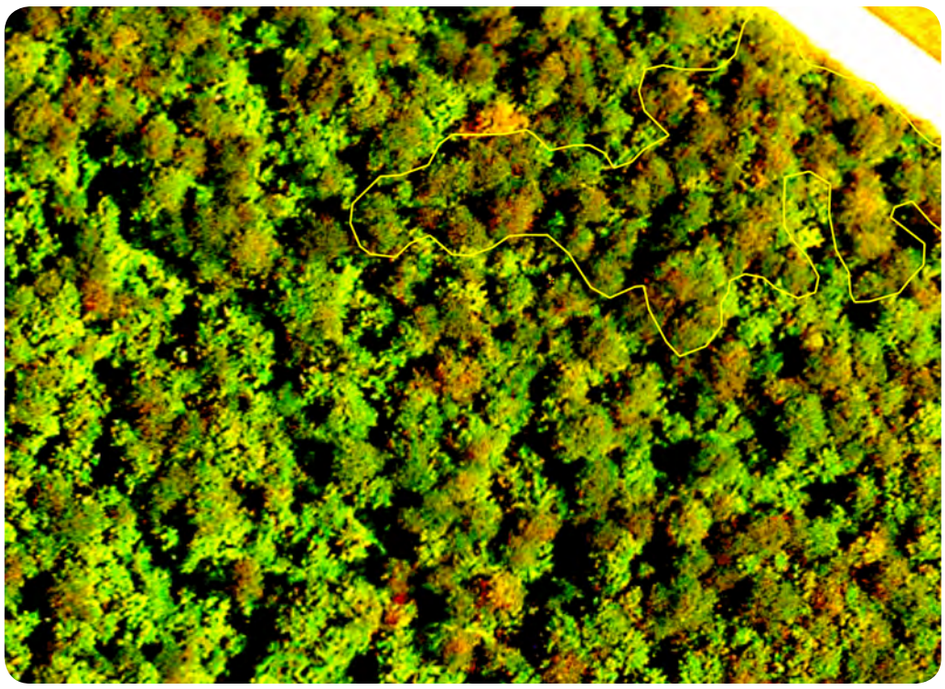
Distribution map



Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB



Naturally coloured aerial photograph (RGB)

Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 85

2.13 Ash – *Fraxinus*

General Description

The **Northern red ash** is a characteristic species of the maple-hickory and maple-linden bioclimatic domains. It has an affinity for rich subhydric soils and sites bordering watercourses.

The distribution area of the **white ash** extends as far as the maple-yellow birch domain. It grows in a broad range of conditions, except for subhydric and hydric soils.

The **black ash** is present in the maple-hickory, maple-linden and maple-yellow birch bioclimatic domains. Exceptionally, it can also be found in the fir-yellow birch domain. In the maple-hickory and maple-linden domains, it grows in subhydric and hydric soils, whereas in the maple-yellow birch and fir-yellow birch domains, it tends to occupy rich subhydric soils and sites alongside watercourses. The species plays the role of accompanying species in stands.

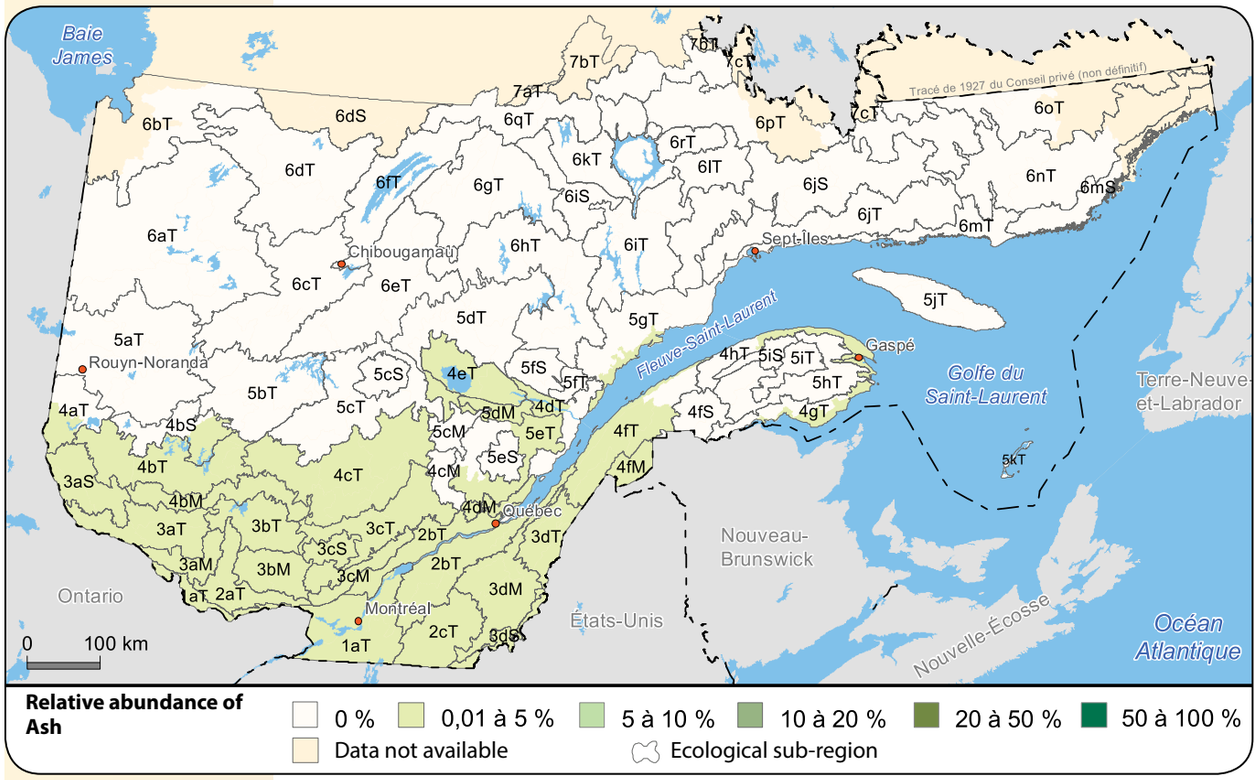
3D screen identification criteria

Ash crowns are of moderate size, often fuzzy, and are shaped like a slender flame. Black ash crowns are usually airier than those of other ash species.

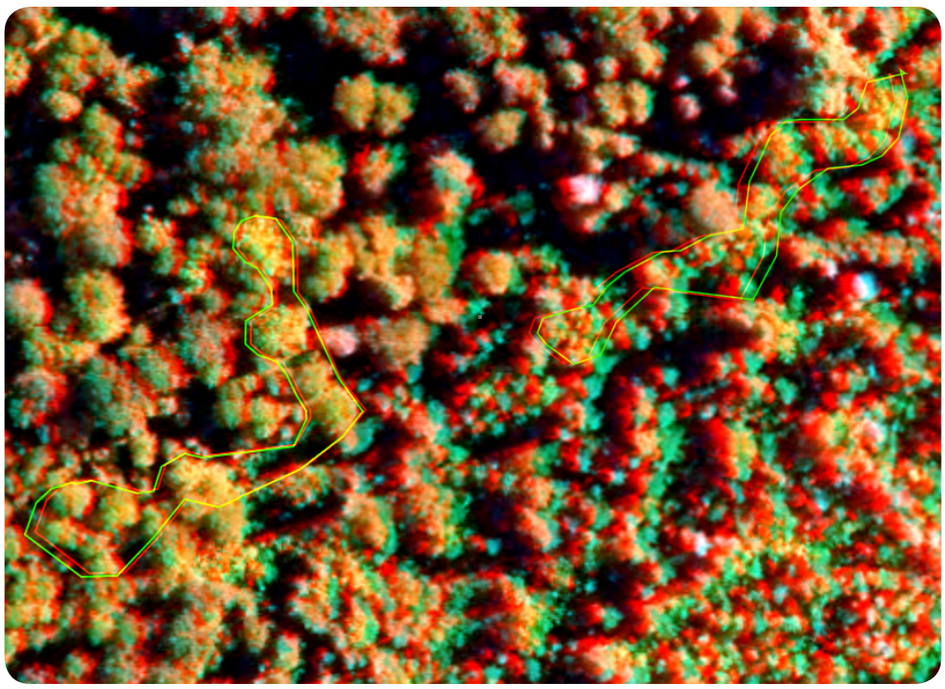
Characteristic colours

- On RGB aerial photographs:
  Northern red ash: light brownish green
  White ash: light greyish green
  Black ash: very light green
- On NIR aerial photographs:
  Northern red ash: greyish orange
  White ash: salmon beige
  Black ash: pink

Distribution map



Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)

Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 86 AND 87

2.14 American Elm – *Ulmus americana* L.

General Description

The American elm is found mainly in the maple (hickory, linden and yellow birch) domains, as an accompanying species to the main stand species. It is more abundant along watercourses and on very rich sites, and tends to grow on plains and on the lower portion of slopes.

It benefits from sites where the drainage varies from good to poor.

It grows most frequently in moderate to fine soils that are richer in nutrients.

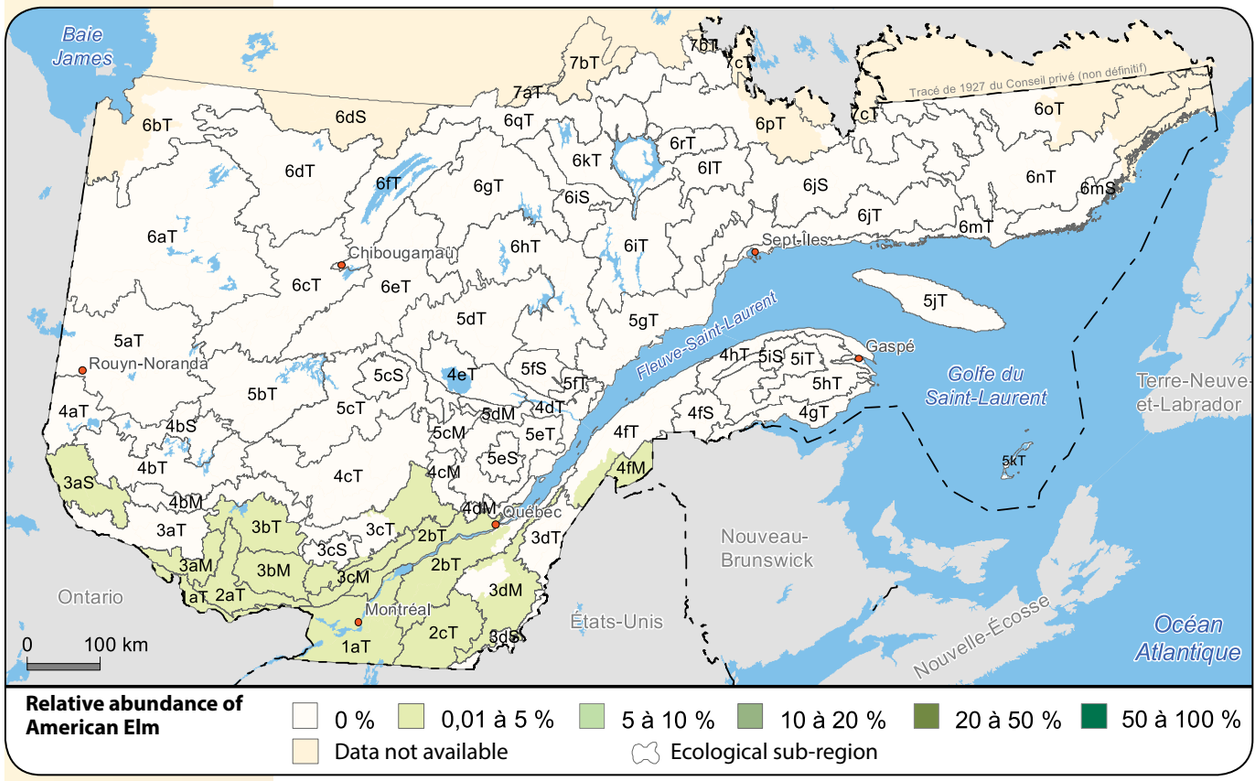
3D screen identification criteria

The American elm crown is distinguished by its narrow parabolic shape and its regular, clean texture.

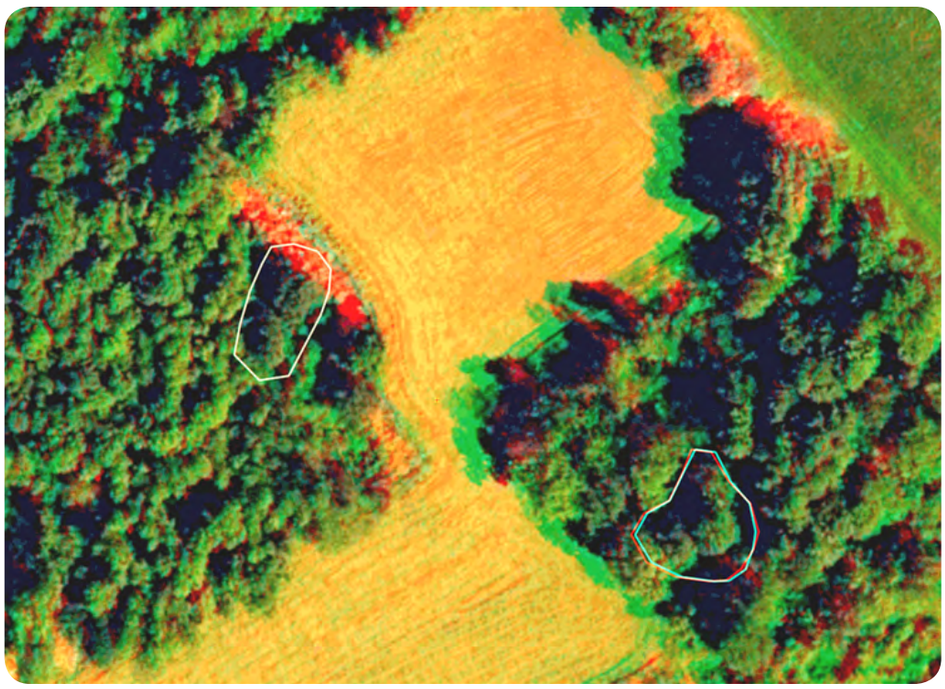
Characteristic colours

- On RGB aerial photographs: dark green
- On NIR aerial photographs: orangey red

Distribution map

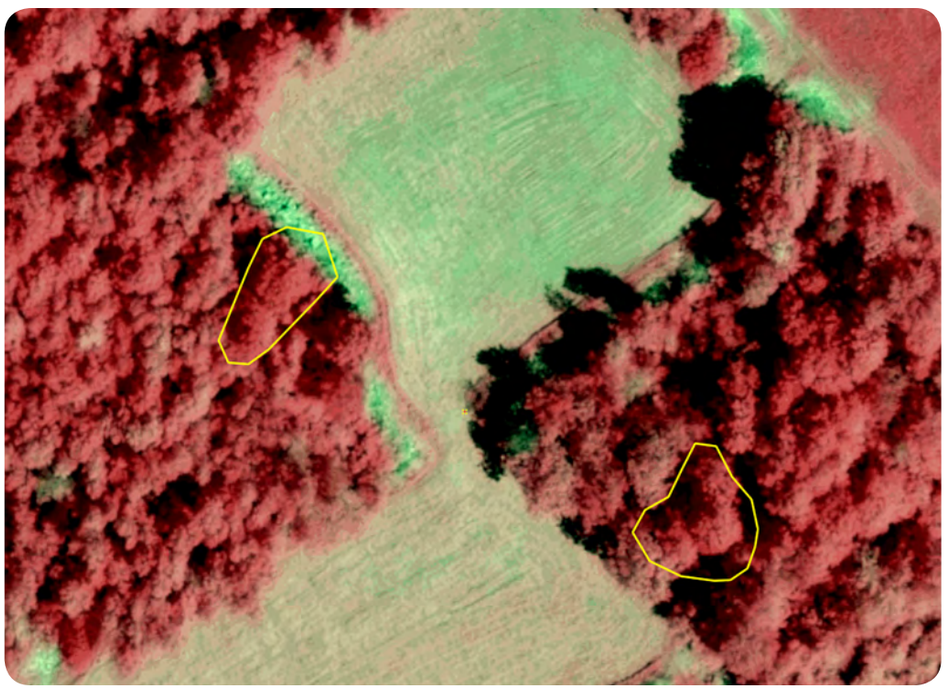


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

2.15 Hickory – *Carya*

General Description

Hickory is the identifying species for the maple-hickory domain, and can also be found exceptionally in the maple-linden domain. The hickory is an accompanying species for the main stand species, and is suited to all topographical locations.

The hickory is associated most with drainage conditions varying from good to moderate, but poor drainage is also appropriate.

Its presence is highly correlated with moderate to fine soils that are richer in nutrients.

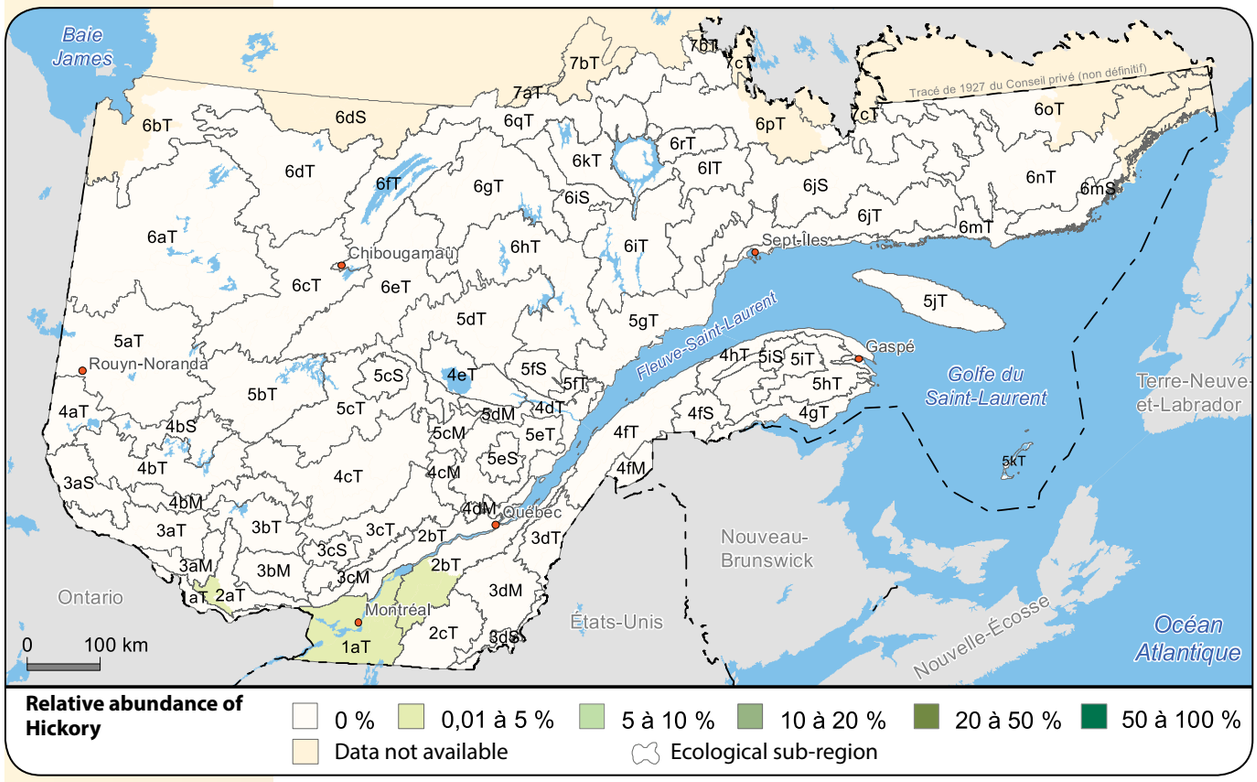
3D screen identification criteria

The hickory crown is very narrow, irregular and flat. Hickory trees tend to be shorter or the same height as other trees in the forest.

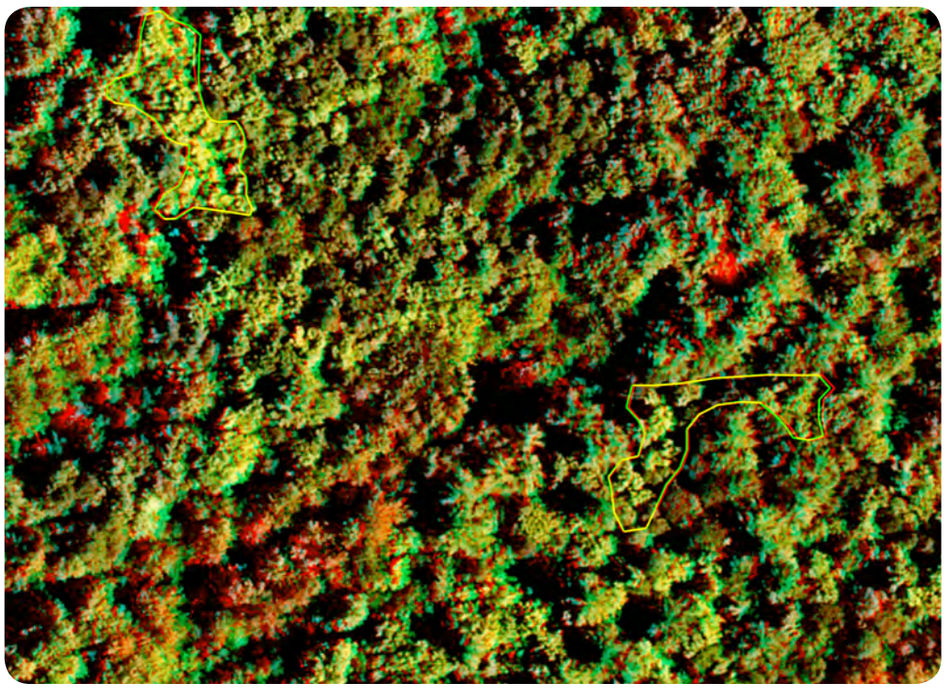
Characteristic colours

- On RGB aerial photographs: fluorescent green
- On NIR aerial photographs: salmon beige

Distribution map

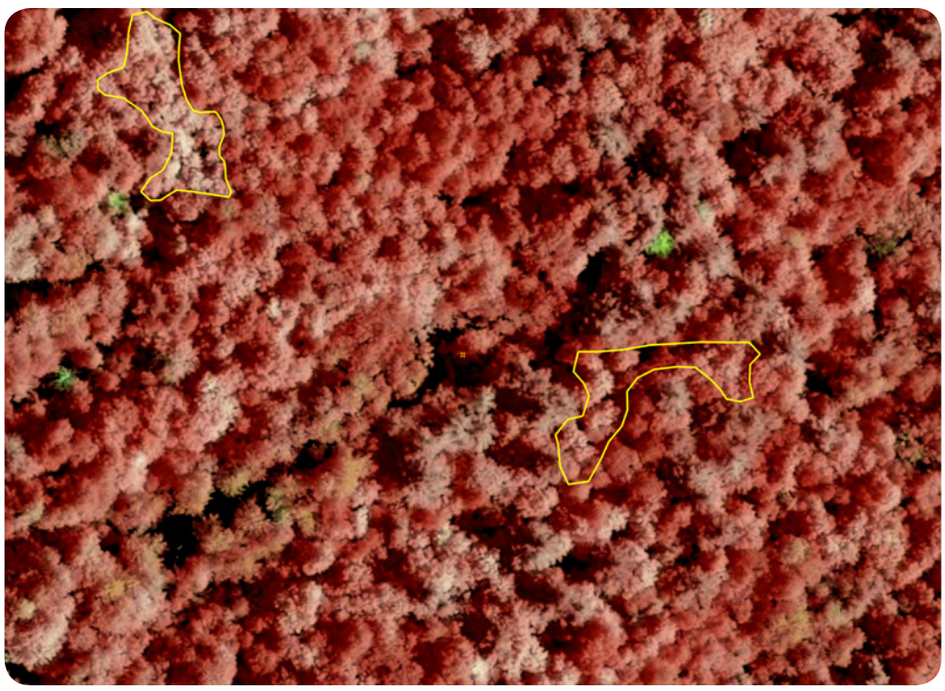


Source: Data from temporary and permanent sample plots from the 3rd inventory.



Anaglyph RGB

Naturally coloured aerial photograph (RGB)



Infrared (NIR) aerial photograph

OTHER PHOTOS ATTACHED P. 88

3. Density Interpretation Criteria

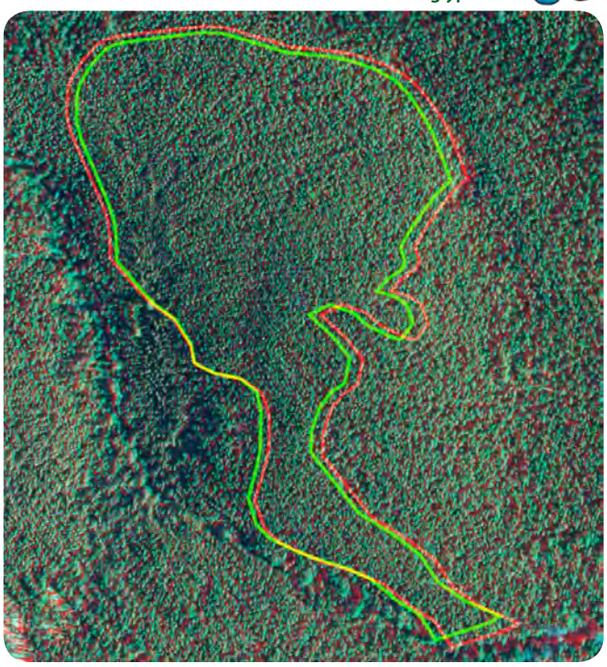
Density is the proportion of the forest floor covered by the vertical projection of the tree crowns. Density is usually divided into 10% categories, as follows:

Code	Crown Coverage (%)
95	90 to 100%
85	80 to 89%
75	70 to 79%
65	60 to 69%
55	50 to 59%
45	40 to 49%
35	30 to 39%
25	25 to 29%

The stems of all species (both commercial and non-commercial) are considered when estimating coverage percentages, although the dominant and co-dominant stems in the stand are those that are generally considered. The following pages presents different visual examples of stand density.

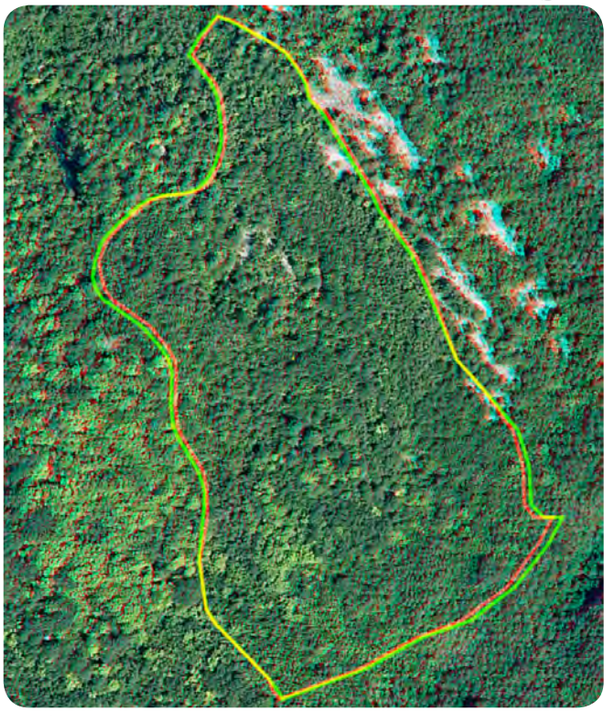
Density 95

Anaglyph RGB

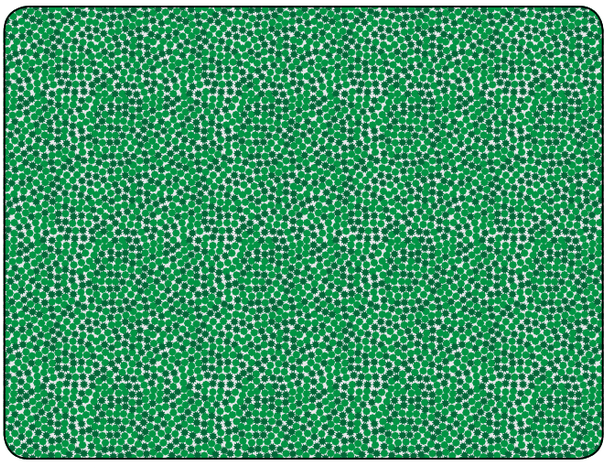


Softwood

Anaglyph RGB



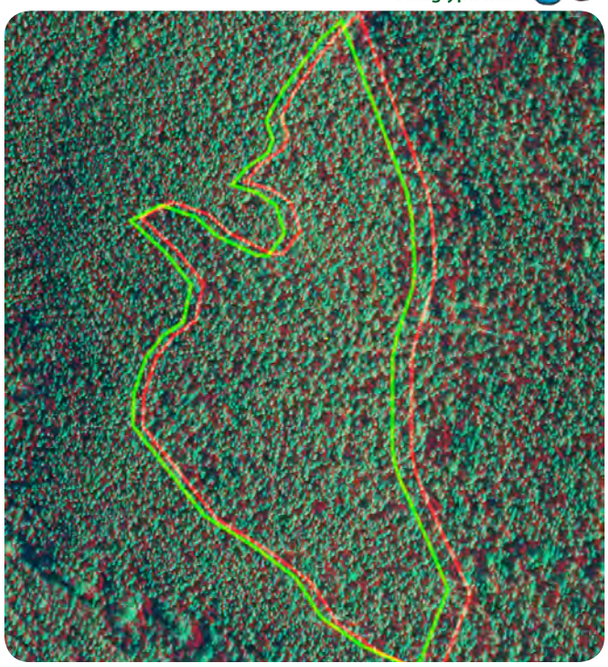
Mixed



Conceptual design

Density 85

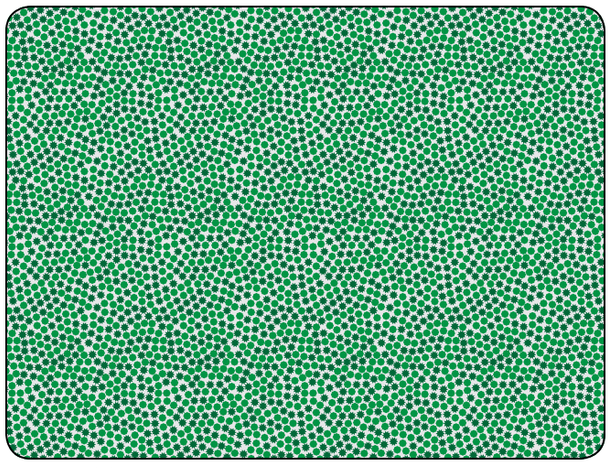
Anaglyph RGB



Softwood

Anaglyph RGB

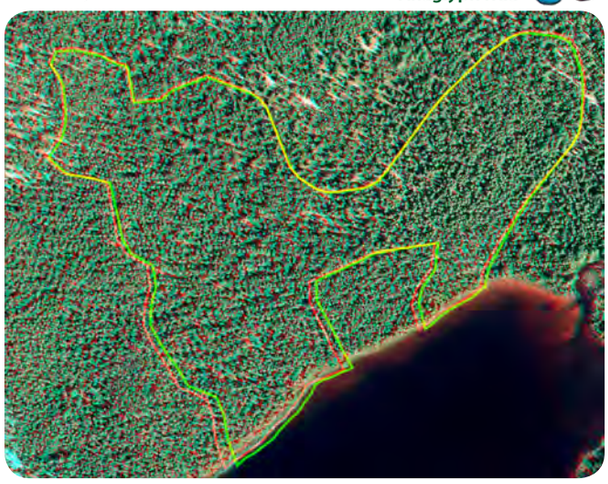
Mixed



Conceptual design

Density 75

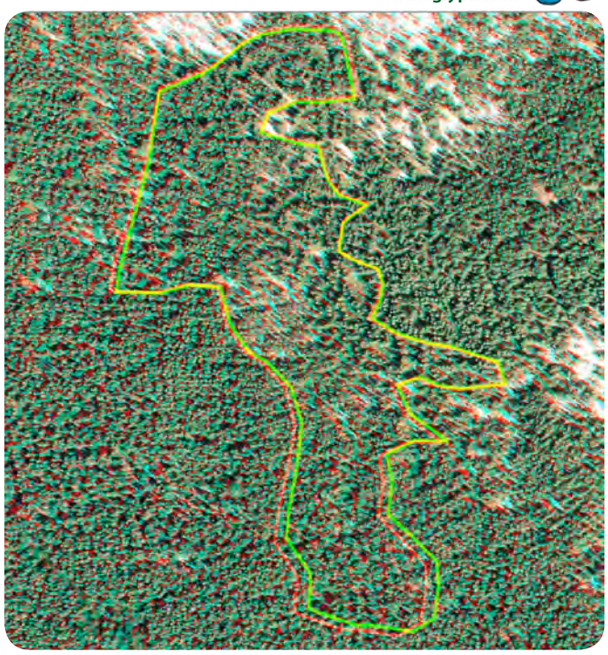
Anaglyph RGB



Softwood

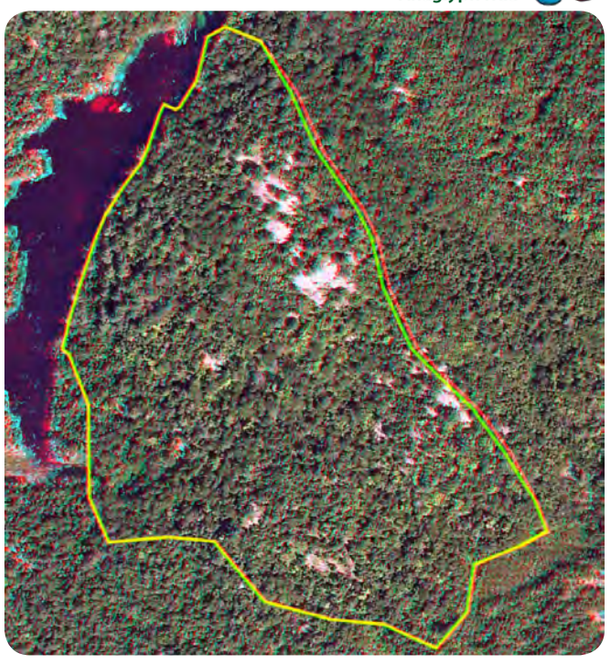
Density 65

Anaglyph RGB



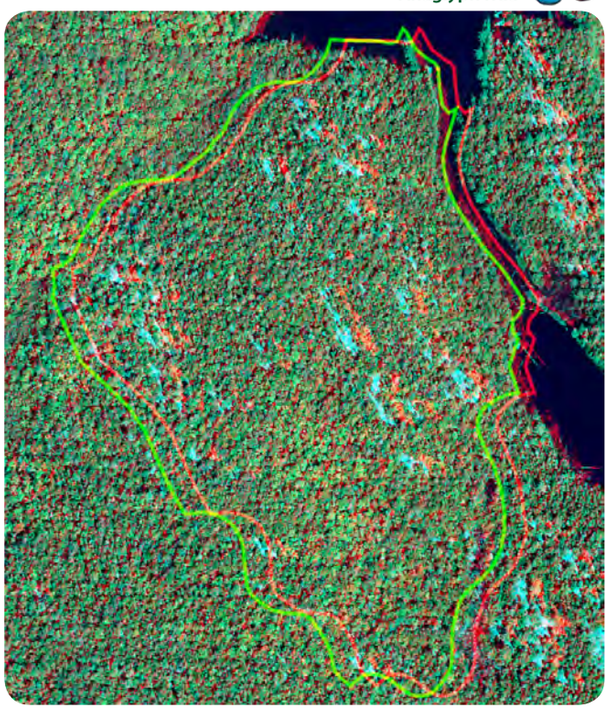
Softwood

Anaglyph RGB

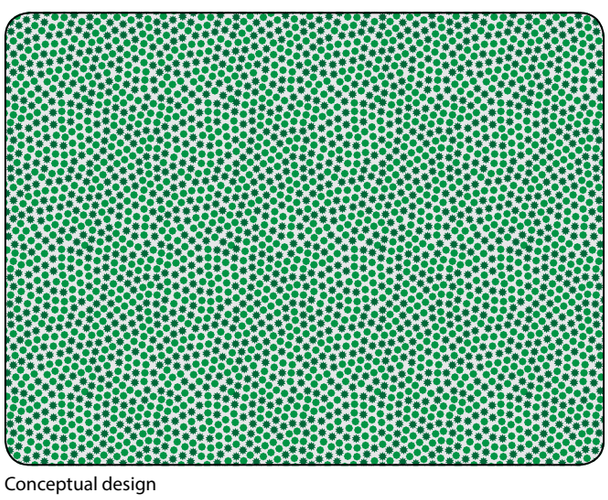


Mixed

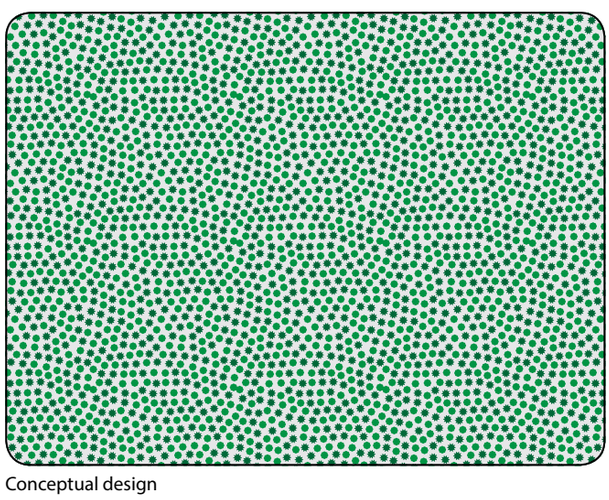
Anaglyph RGB



Mixed



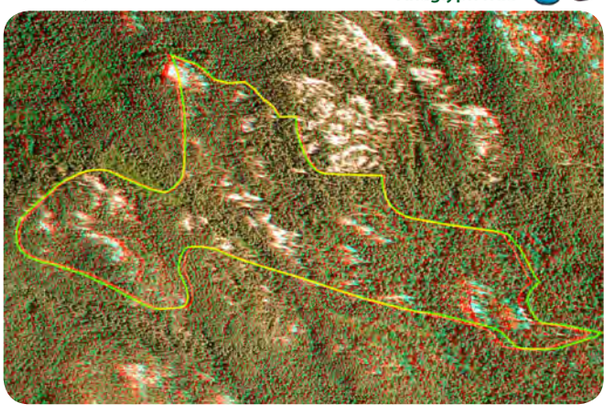
Conceptual design



Conceptual design

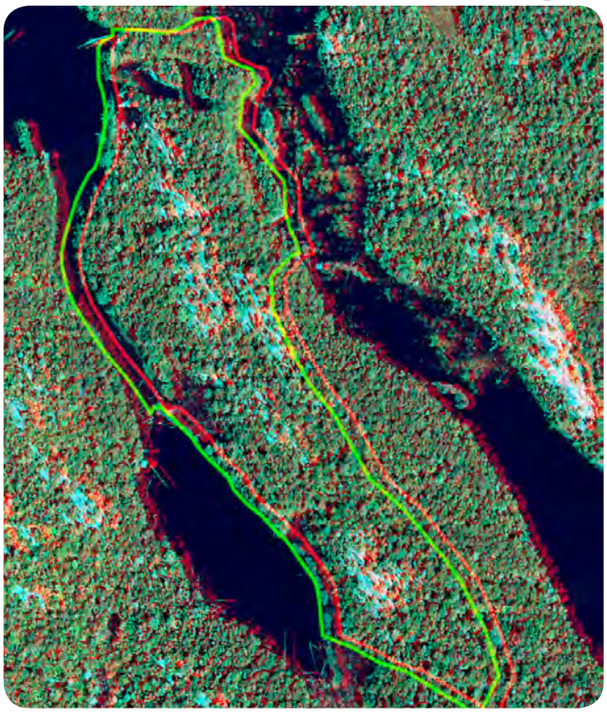
Density 55

Anaglyph RGB

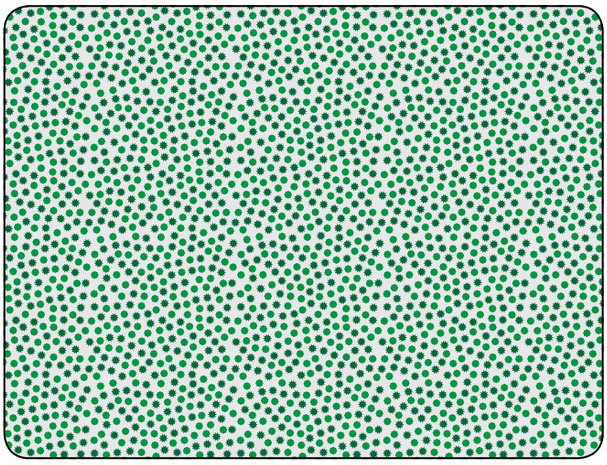


Softwood

Anaglyph RGB



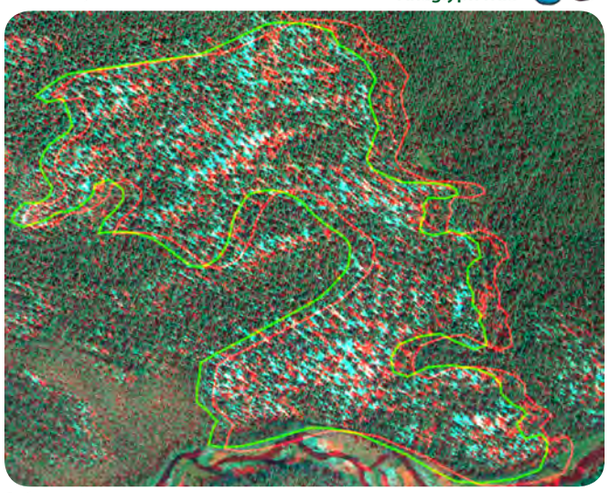
Mixed



Conceptual design

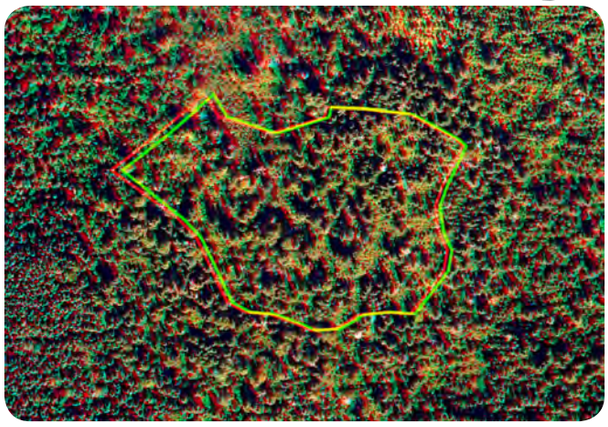
Density 45

Anaglyph RGB

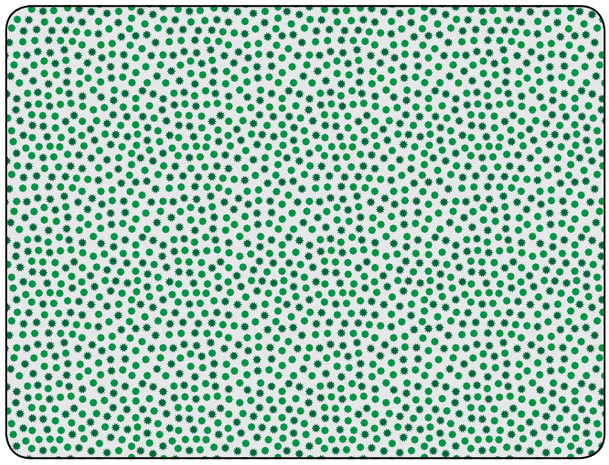


Softwood

Anaglyph RGB



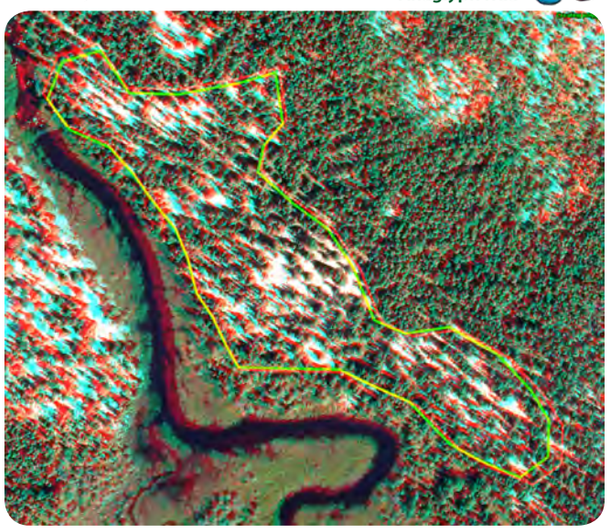
Mixed



Conceptual design

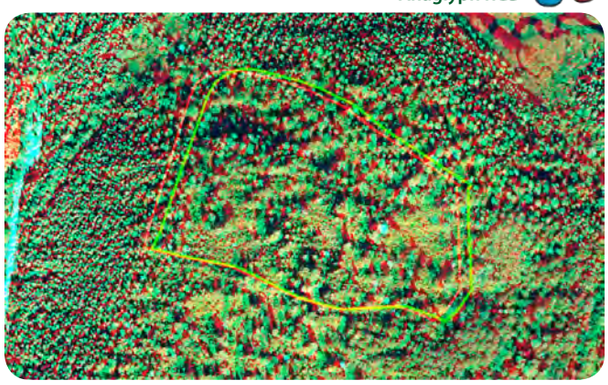
Density 35

Anaglyph RGB



Softwood

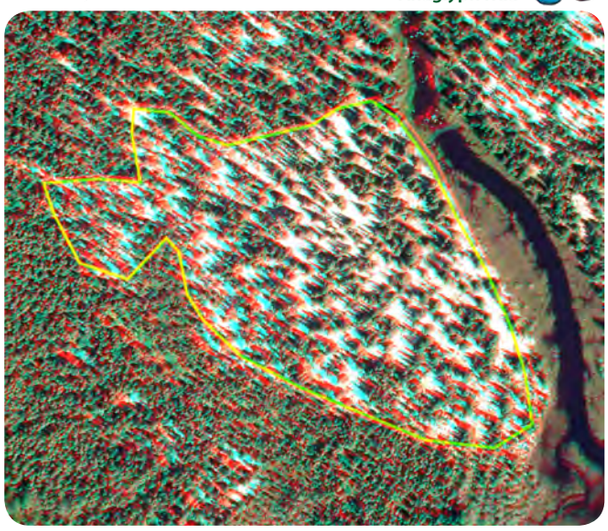
Anaglyph RGB



Mixed

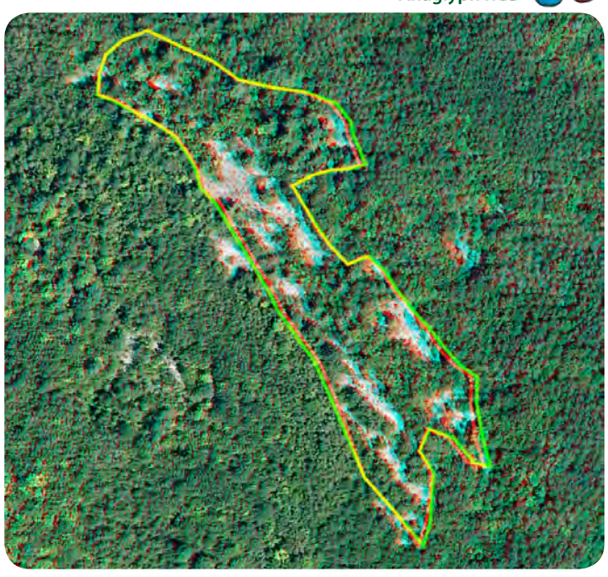
Density 25

Anaglyph RGB

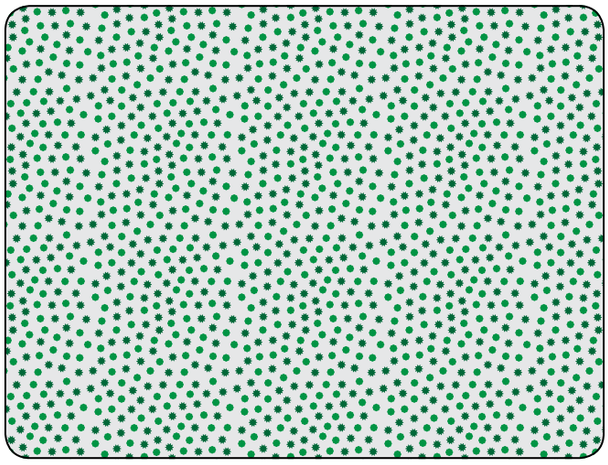


Softwood

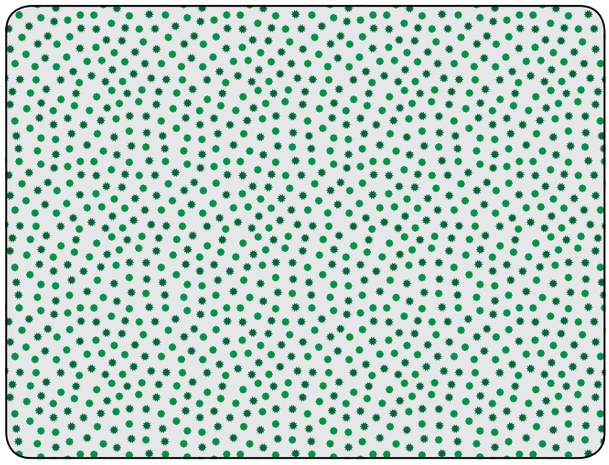
Anaglyph RGB



Mixed



Conceptual design

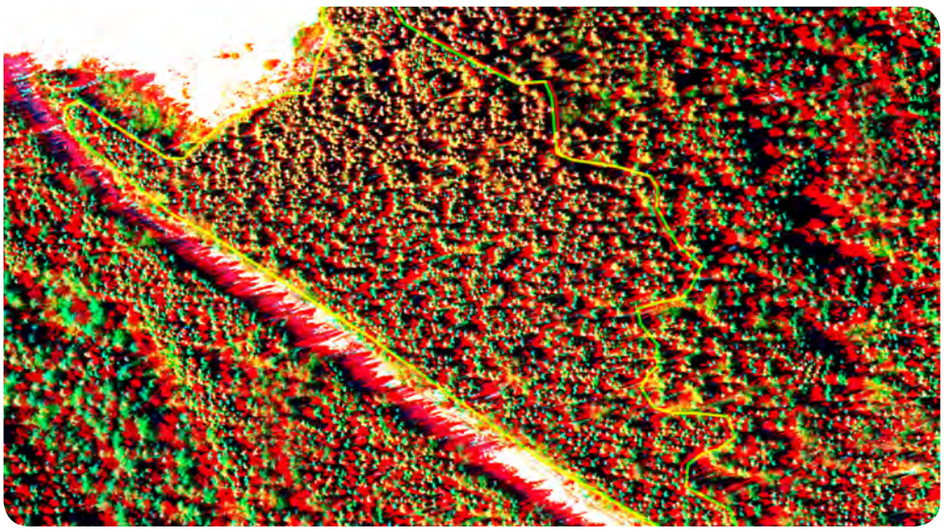


Conceptual design

There are certain factors that may cause interpreters to overestimate or underestimate canopy density. In their assessments, interpreters must consider (i) crown transparency and the angle of the sun, (ii) the position of the stand on the photograph, and (iii) undergrowth vegetation. Below are some examples.

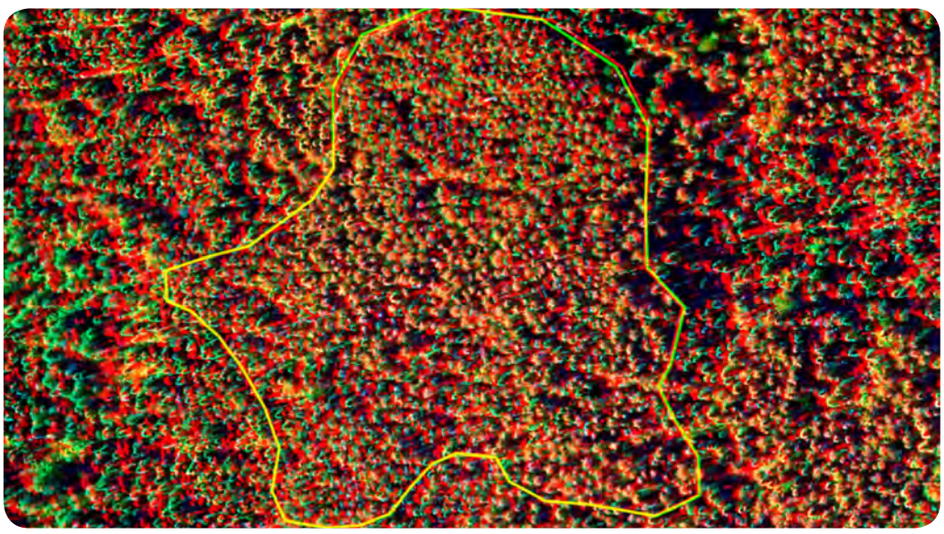
3.1 Crown transparency

Crown transparency causes density to be under-estimated. Interpreters must therefore take this into account when calculating the exact density of a stand. Jack pine is more transparent than other softwoods, and this must be considered when estimating jack pine stand density. Other factors, such as defoliation by insects, may also cause crowns to become transparent.



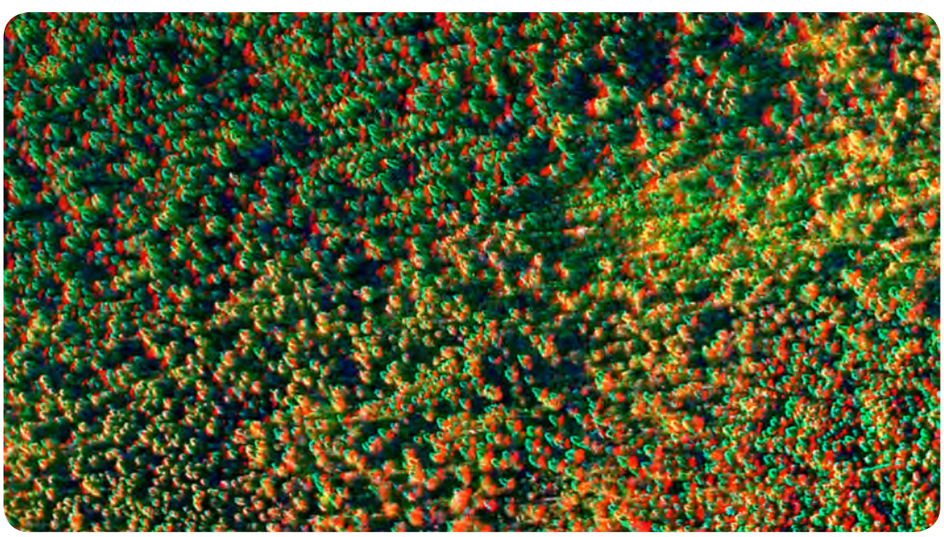
Anaglyph RGB

Black spruce stand with non-transparent crowns.



Anaglyph RGB

Jack pine stand of the same density with transparent crowns.



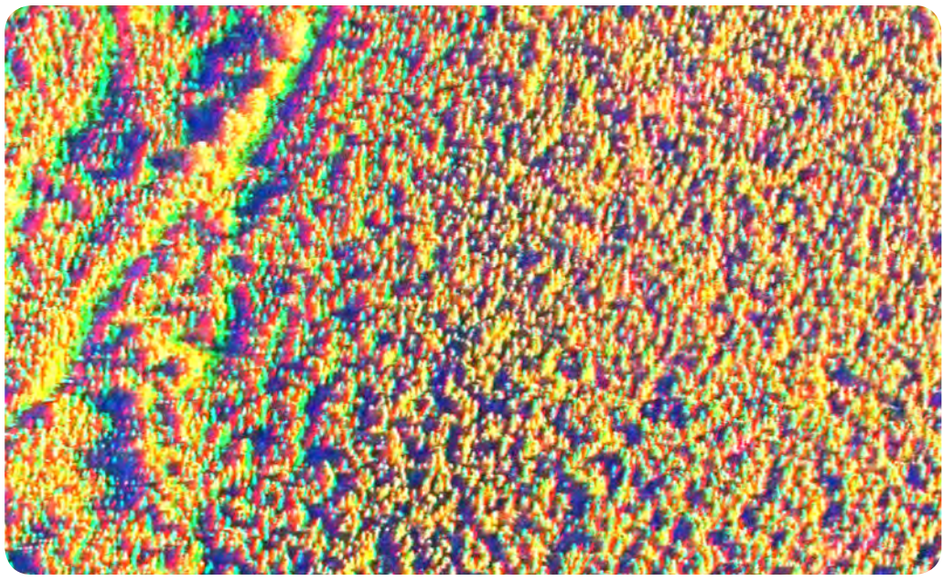
Anaglyph RGB

Balsam fir stand of the same density. The stand's aspect is transparent due to defoliation by spruce budworm.

3.2 Angle of the sun and position of the stand on the photograph

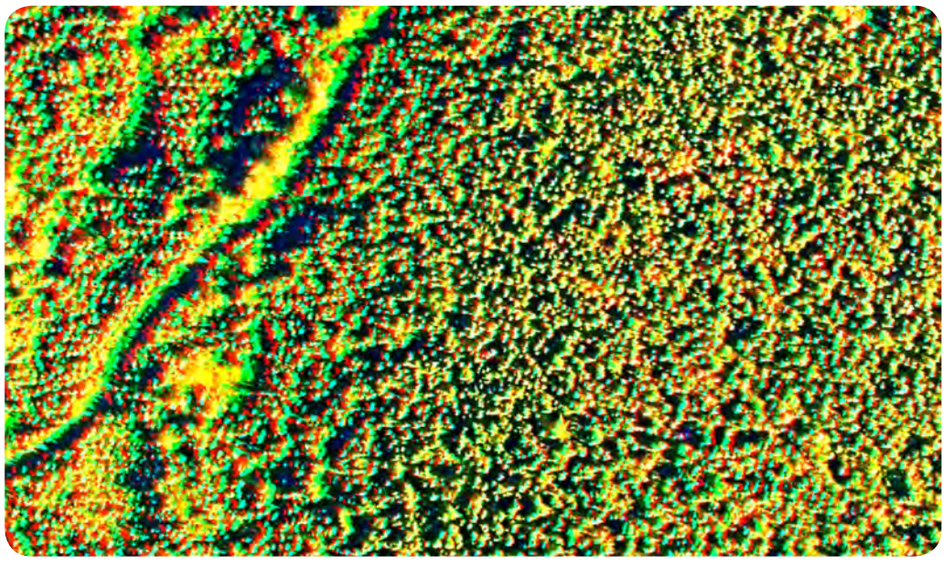
The angle of the sun and the position of the stand to be photographed may also have an impact on density interpretation. A stand on a steep north-facing slope may appear darker if the sun is at a low angle (e.g. 30% from horizontal). The location of the stand on the aerial photograph also affects the interpretation of density. Stands located furthest from the central point of the photograph are seen from the side. This angle does not provide a proper view of the stand's openings and leads to overestimations of density, compared to stands located in the centre of the photograph.

Anaglyph RGB

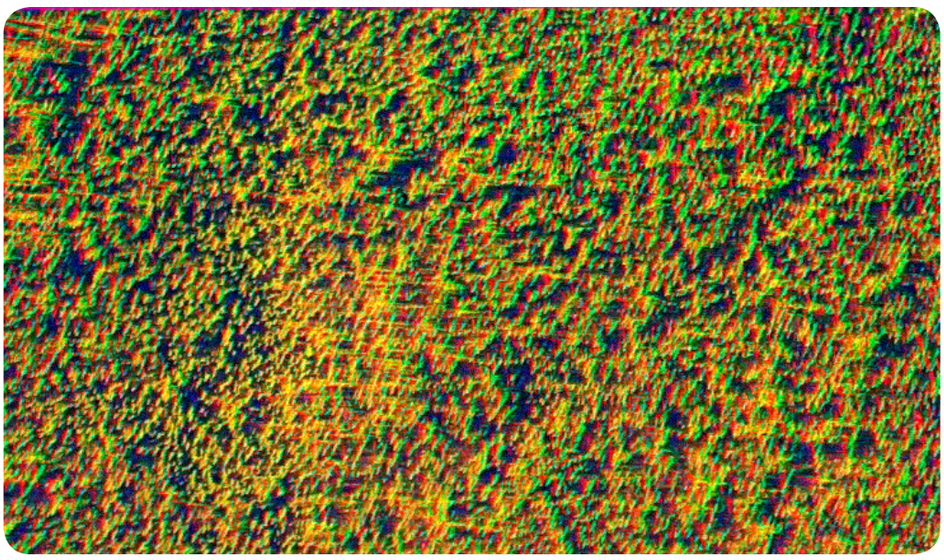


Stand located in the upper right-hand corner of the aerial photograph.

Anaglyph RGB

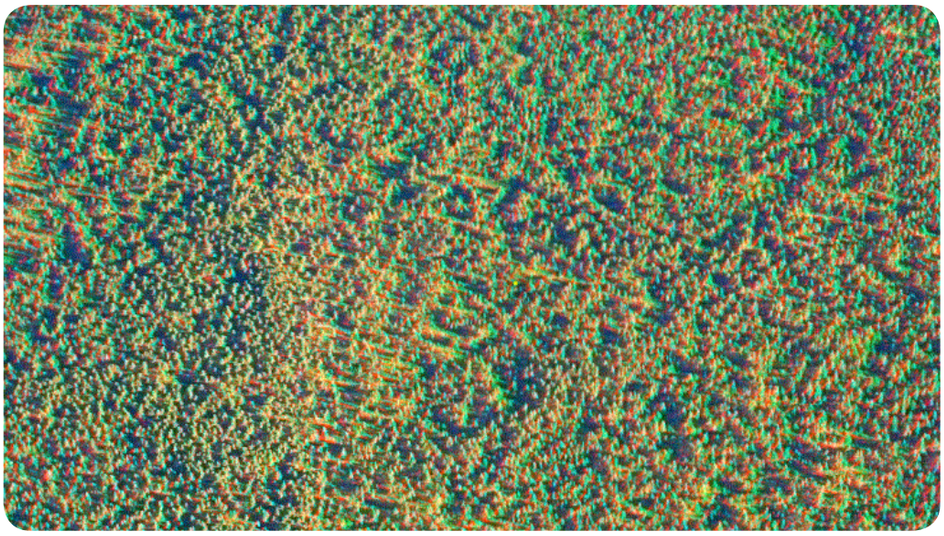


Same stand located in the centre of the aerial photograph.



Anaglyph RGB

Stand located in the lower left corner of the aerial photograph.



Anaglyph RGB

Same stand located in the centre of the aerial photograph.

3.3 Undergrowth vegetation

Dense undergrowth vegetation, such as non-commercial hardwoods or softwood saplings, can also cause density to be overestimated. Interpreters must therefore disregard this vegetation in their density assessments. For example, while only stems measuring seven metres or more should be considered when assessing density, the visual effect of those measuring less than seven metres will cause the canopy density to be overestimated and interpreters must be careful not consider them in their assessments.

4. Stand Height Interpretation Criteria

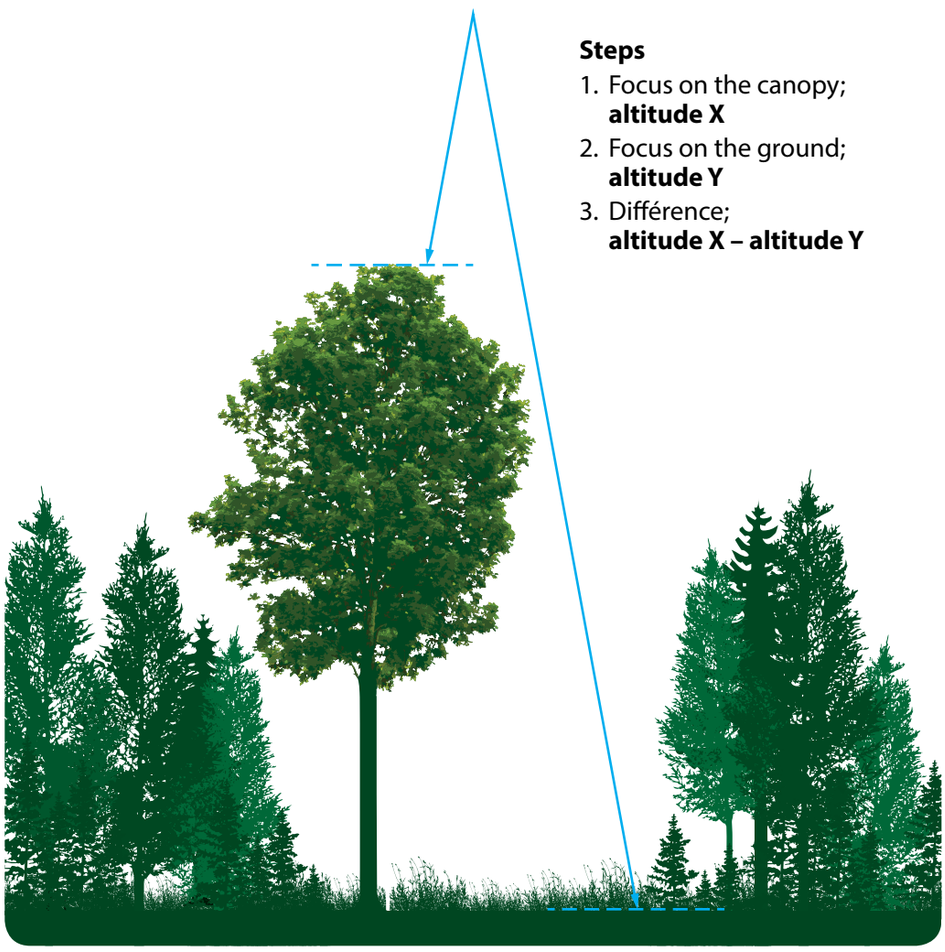
Stand height is usually assessed using photographic interpretation. Other technologies, such as aerial LiDAR, have appeared in recent years, but photographic interpretation is still the most common technique used to assess this particular attribute. To achieve an acceptable level of accuracy, however, interpreters must use calibration data, apply photographic interpretation techniques and avoid interpretation pitfalls.

4.1 Calibration data

To calibrate their interpretation of tree heights, interpreters must have calibration data. The main information used for this purpose is the fixed terrain control point, where trees representative of the stand are measured. Aerial LiDAR data or archive forest maps can also be used.

4.2 Assessment by photographic interpretation

The interpreter must first perform a calibration using calibration data, and then obtain regular measurements using 3-D viewing software, as shown in the diagram below. Measurements can be taken where the openings are large enough to focus on both the tree crown and the ground. The interpreter may then calculate stand height by association, taking the site and the species into account.



4.3 Pitfalls to avoid

Bias can be introduced into height interpretations by a number of elements, and interpreters must take them into account. First, the site's assets must be considered when assessing heights, since they have a direct impact on stand height. In addition, they may reduce the impact of relief. For example, stands growing on the bottom portion of a slope will usually be higher than those growing on the top portion of the same slope, which reduces the actual slope. In addition, steep slopes make it difficult to calculate heights, since ground measurements may be offset from crown measurements. Lastly, strong regeneration prevents ground altitude from being measured accurately.

5. Age Interpretation Criteria

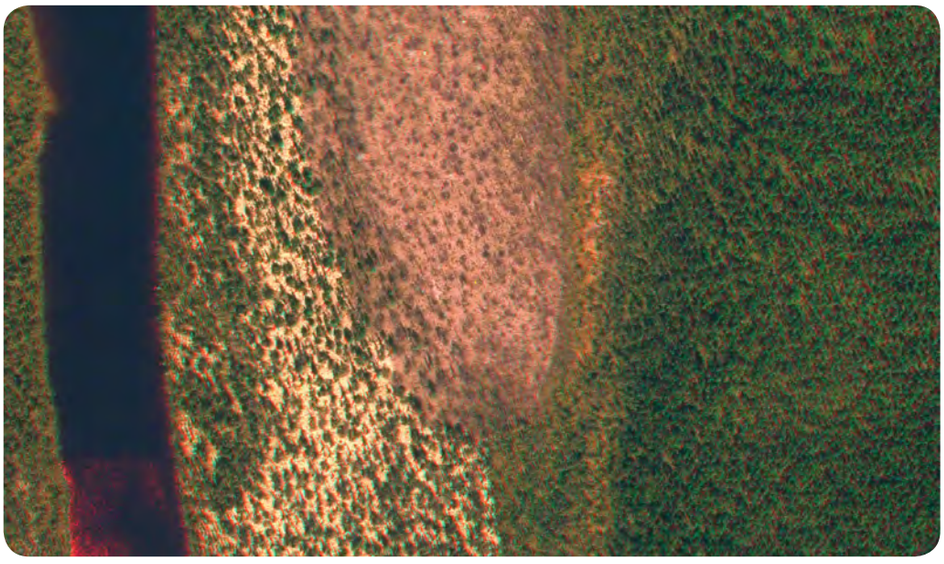
Age is the most difficult forest attribute to calculate accurately, and this is especially true for old stands. It is important to have sufficient good-quality fixed terrain control points. The main criteria used to calculate age are tree height compared to site assets, crown and stand morphology, and disturbance and logging history.

6. Natural Disturbance Interpretation Criteria

The main natural disturbances that can be interpreted are fire, insect defoliation, insect-induced mortality and windfall.

6.1 Fire

Fire can be identified fairly easily by photographic interpretation, due to the presence of dark-coloured burned wood and the scorched trees that are usually found around the fire. Contours showing fire history can be used to note the presence of a fire and the year in which it took place.



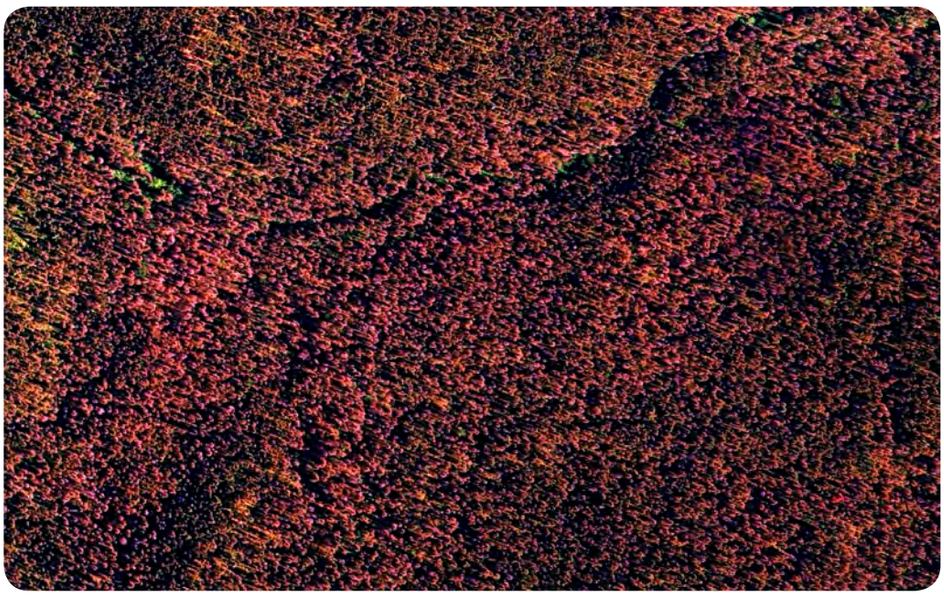
The reddish portion of the photograph denotes a recent fire.

Anaglyph RGB

6.2 Insect defoliation

Defoliation differs from mortality in that the defoliated trees are not yet completely dead. At this stage, the stand may still survive if the infestation ceases. Contours showing the history of insect damage can be used to identify defoliation. On RGB aerial photographs, affected stands are brow to yellowish in colour. On NIR aerial photographs, they are pinkish grey to grey for lightly defoliated to severely defoliated stands respectively. They appear turquoise when enhancement is applied to the photograph.

Naturally coloured aerial photograph (RGB)



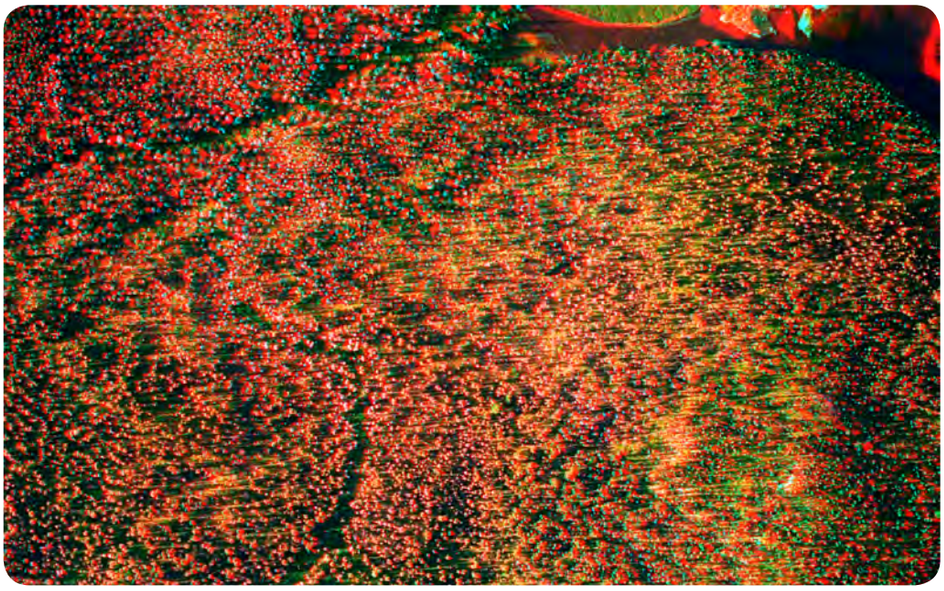
The severe defoliation shown in the centre of the RGB photograph appears as a pinkish area. The moderate defoliation around the area of severe defoliation appears orange to brown, while the area of light defoliation is khaki.

Naturally coloured aerial photograph (RGB)

Balsam fir stand with no defoliation (RGB photograph).

6.3 Insect-induced mortality

Insect-induced mortality is irreversible. Here again, contours showing disturbance history can be used. Dead stands are lighter and more transparent than defoliated stands. The ground is visible (sometimes with fallen tree trunks) even if the stand is fairly dense. The trees may be broken or overturned, creating small or large openings if the infestation has lasted for several years. Trees killed by infestations usually appear grayish to white on RGB photographs, and grayish to turquoise on NIR photographs. Generally speaking, if the trunk can be seen through the branches, the tree is dead.

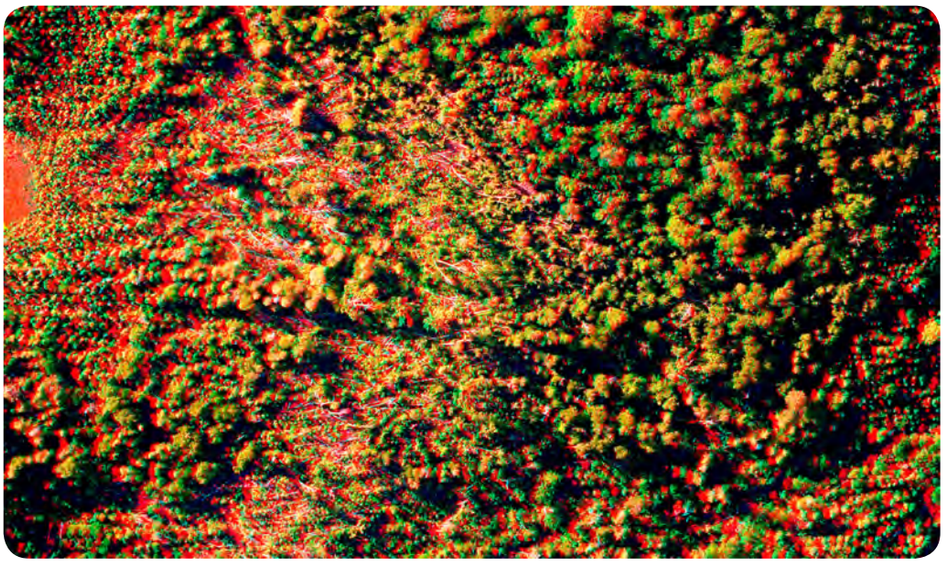


Anaglyph RGB

Dead balsam fir stand following several years of insect infestations. The mortality seen in the centre of the photograph is characterized by crown transparency.

6.4 Windfall

Stands affected by windfall (damage caused by wind) can be identified fairly easily from the presence of fallen tree trunks lying in the same direction.



Anaglyph RGB

Stand affected by windfall.

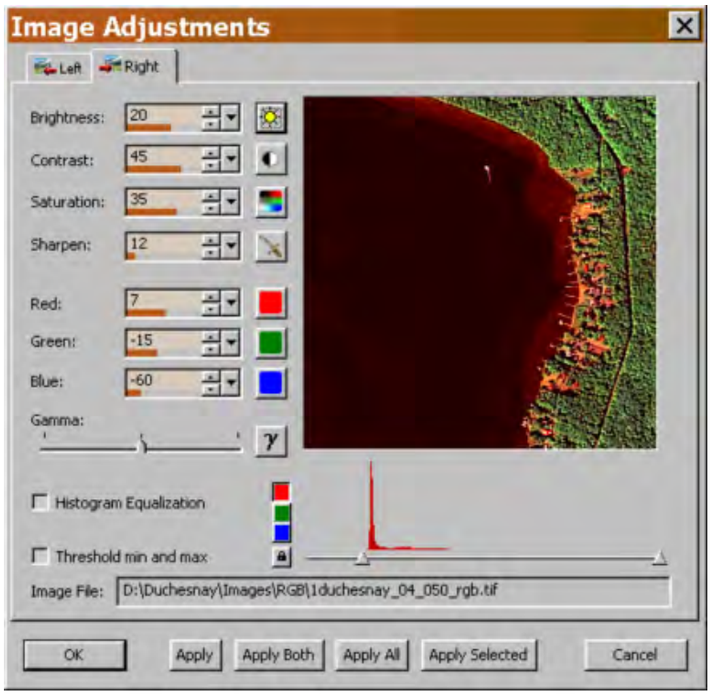
7. Aerial photograph image enhancement guide

In this section, we present the image enhancement criteria used for the colour descriptions and diagrams presented in Section 1. These enhancement techniques were applied using DAT/EM's Summit Evolution photogrammetry software. The criteria for two types of photographs (RGB – red-green-blue, and NIR – infrared colour) are presented.

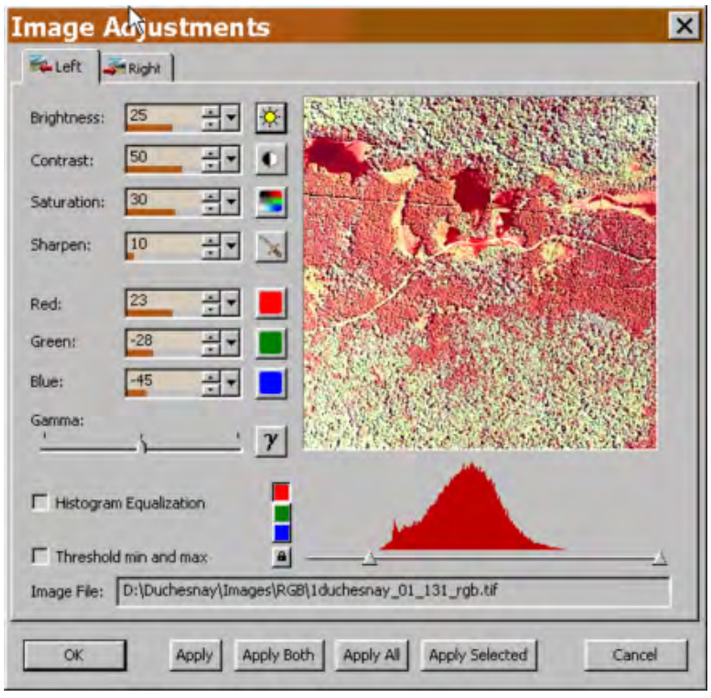
Our aim in doing this is to point out the high potential of enhancement techniques in differentiating between forest species. Of course, the success of these techniques depends on the quality of the aerial photographs on which they are used. Some photographs may be milky or saturated due to atmospheric conditions or inappropriate processing of the photograph at the time it was taken.

7.1 Enhancement of RGB aerial photographs

Adjustments to red, green and blue colour quality are the basic enhancements made to a photograph in order to differentiate between species. Adjustments to the other image settings – brightness, saturation and contrast – then complete the process. For example, on a raw aerial photograph, hemlock will appear slightly yellower than spruce. Enhancement will exaggerate these differences. Colours are adjusted by increasing or reducing the colour values. The brightness setting is then adjusted to lighten the photograph, although this does not affect the red, green and blue proportions. Adjustments to the contrast setting will intensify the difference between light and dark colours, highlighting holes in the stand and canopy. Brightness, saturation and contrast also minimize the effects introduced when the photograph was taken, due for example to the time of day or the level of atmospheric humidity. Lastly, the photograph can also be sharpened to emphasize differences between the colours.



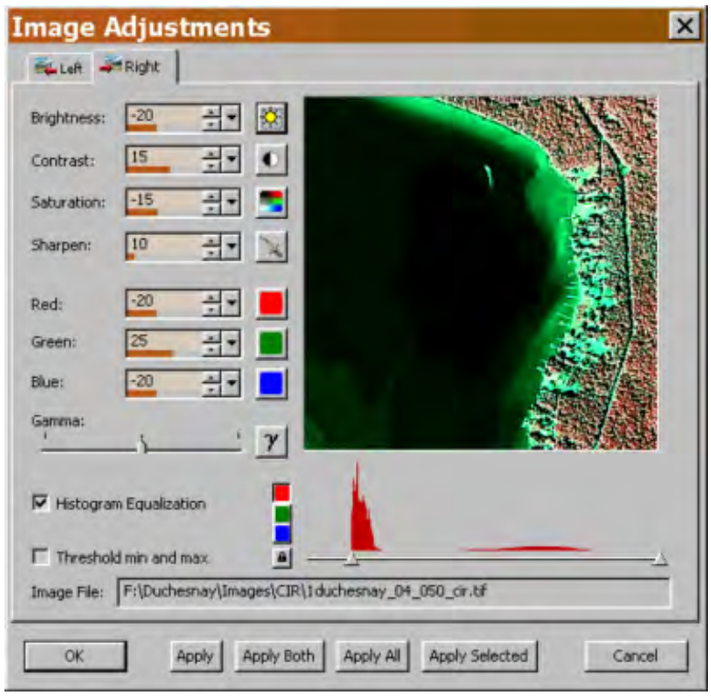
In this example, we used an aerial photograph taken in Duchesnay, north of Québec City. The presence of the lake on the left-hand side of the image has produced a peak on the left-hand side of the histogram. The enhancement settings used were 20 for brightness, 45 for contrast, 35 for saturation, 12 for sharpen, 7 for red, -15 for green and -60 for blue.



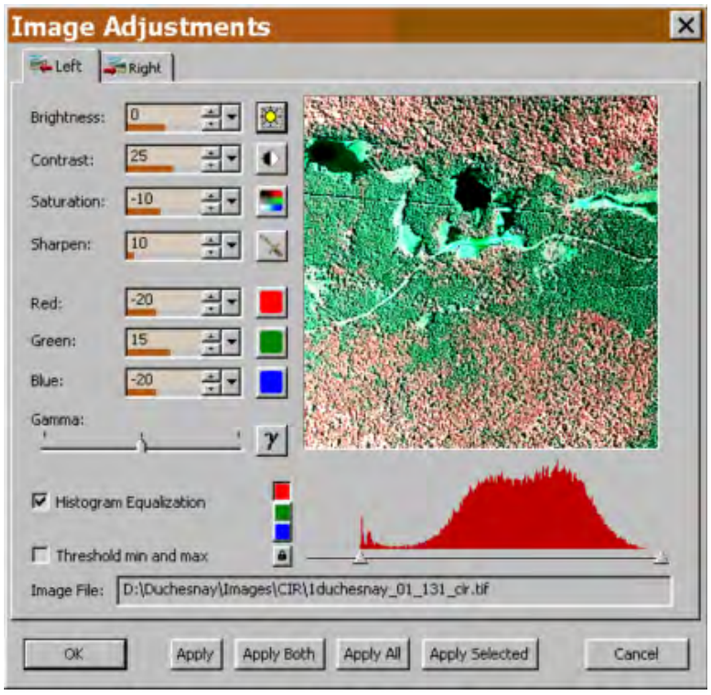
In this sample, there is less water than in the preceding example, and there are also more softwood trees. We therefore adjusted the red setting (23 in this case, compared to 7 in the preceding example). As a result, the softwoods appear red, while the hardwoods are different tones of green. The enhancement settings used were 25 for brightness, 50 for contrast, 30 for saturation, 10 for sharpen, 23 for red, -28 for green and -45 for blue.

7.2 Enhancement of NIR photographs

Adding the infrared band allows us to differentiate between vigorous and less vigorous vegetation. These NIR photographs therefore offer better potential for the identification of natural disturbances, such as defoliation by insect infestations, than RGB photographs. However, this sensitivity to vegetation vigour comes with a disadvantage, in that it creates differences within species. This effect must be considered when interpreting the images.



Once again, it is possible, in this photograph, to see the impact of the lake on the histogram. Unlike RGB aerial photographs, where softwood trees are reddish brown, softwoods on NIR photographs are shown as bluish-green, and hardwoods are pink. The enhancement settings were -20 for brightness, 15 for contrast, -15 for saturation, 10 for sharpen, -20 for red, -25 for green and -20 for blue.



This other example shows how softwoods are differentiated from hardwoods. The enhancement settings were 0 for brightness, 25 for contrast, -10 for saturation, 10 for sharpen, -20 for red, -15 for green and -20 for blue.

Publications consulted

DAT/EM Systems International. 2012. Summit Evolution. http://www.datem.com/

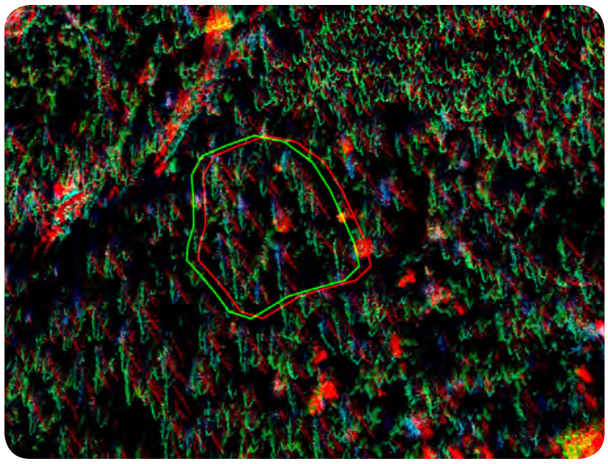
GRONDIN, P., NOËL, J. et HOTTE D. 2007. *Atlas des unités homogènes du Québec méridional selon la végétation et ses variables explicatives*. Rapport hors série du ministère des Ressources naturelles et de la Faune, Direction de la recherche forestière. 138 p.

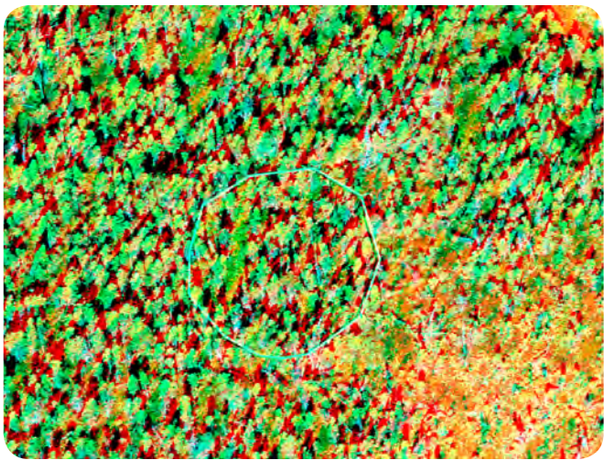
SAUCIER, J.-P, GRONDIN, P., ROBITAILLE, A. et BERGERON, J.-F. 1998. *Les zones de végétation et les domaines bioclimatiques du Québec*. Gouvernement du Québec. Ministère des Ressources naturelles.

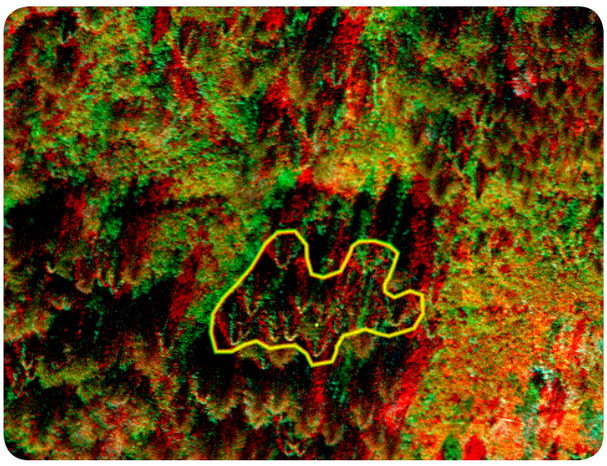
Appendix

Black Spruce

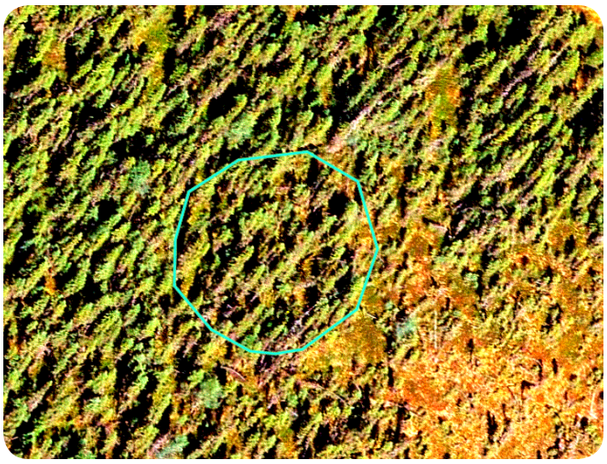
Anaglyph RGB

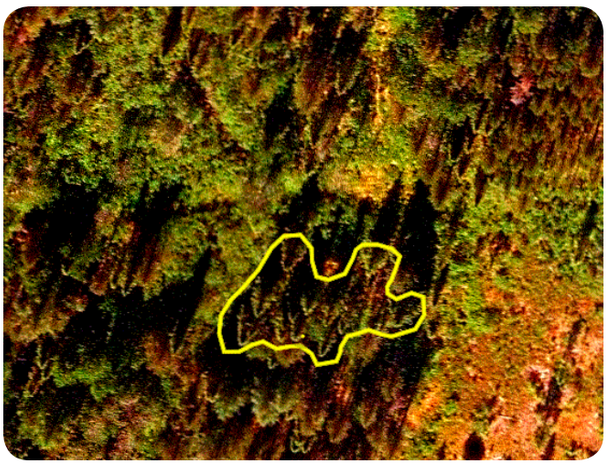






Naturally coloured aerial photograph (RGB)

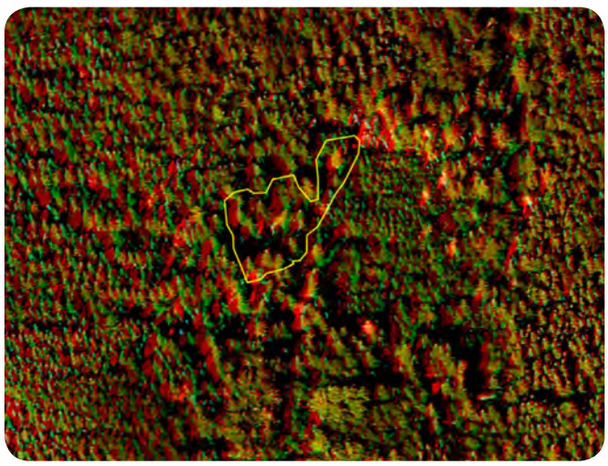


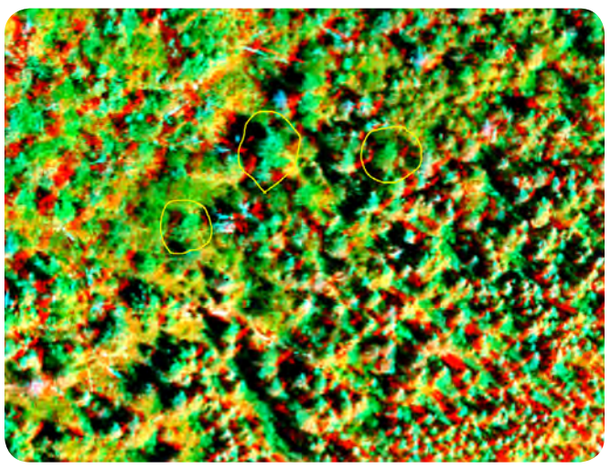


RETURN TO THE CORRESPONDING RECORD

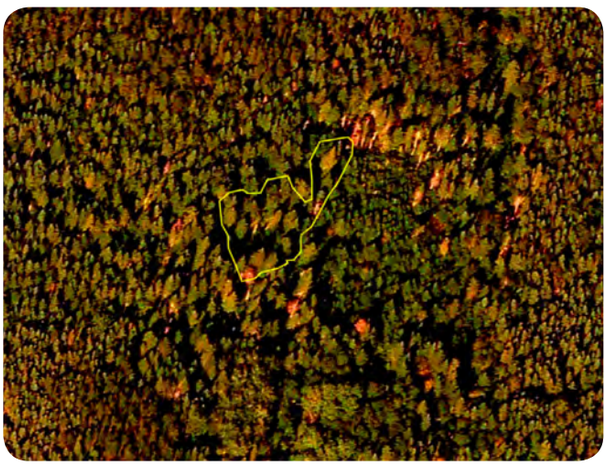
Balsam Fir

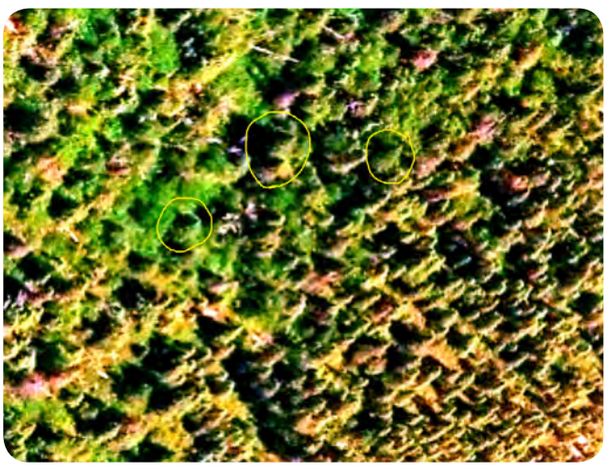
Anaglyph RGB





Naturally coloured aerial photograph (RGB)

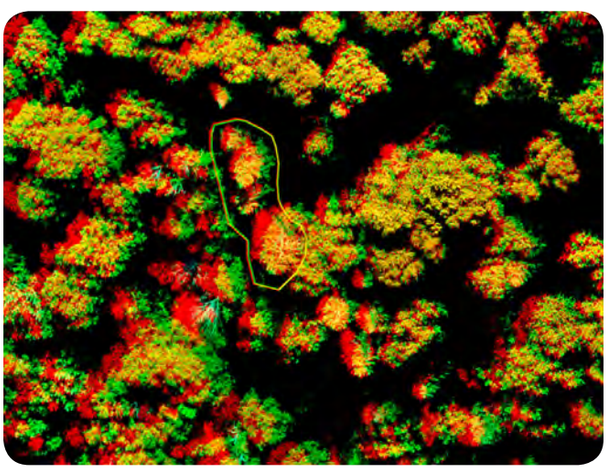




RETURN TO THE CORRESPONDING RECORD

White Spruce

Anaglyph RGB

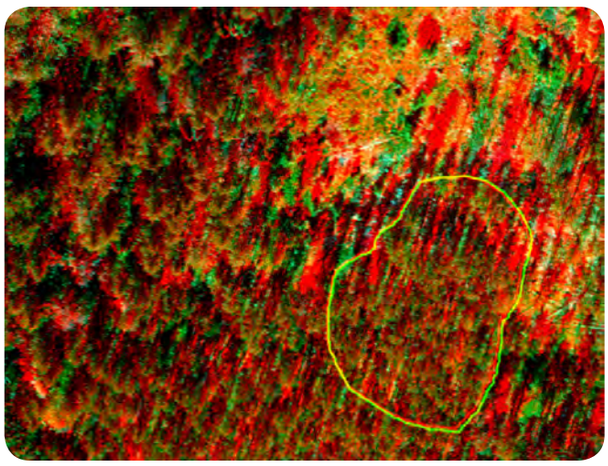


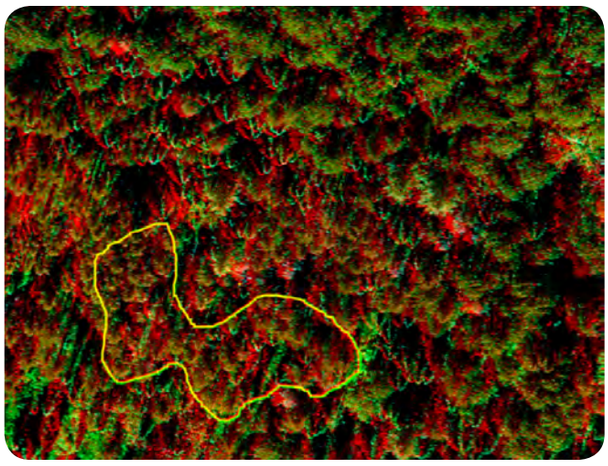
Naturally coloured aerial photograph (RGB)

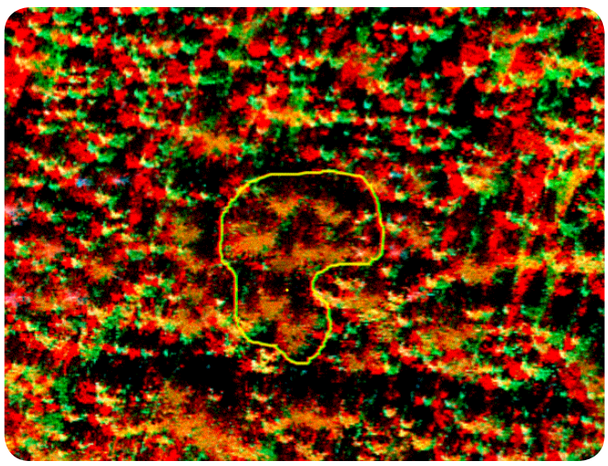
RETURN TO THE CORRESPONDING RECORD

Jack Pine

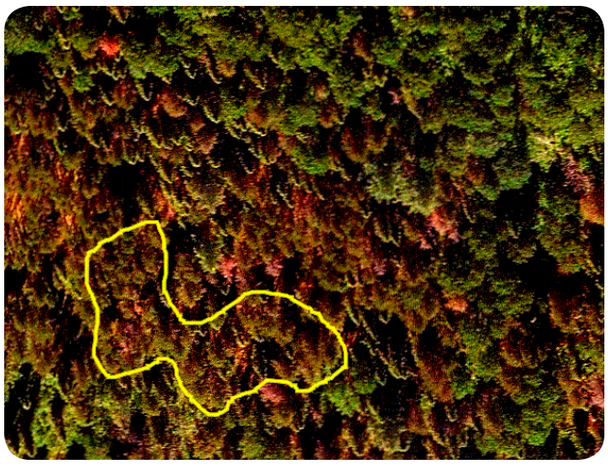
Anaglyph RGB

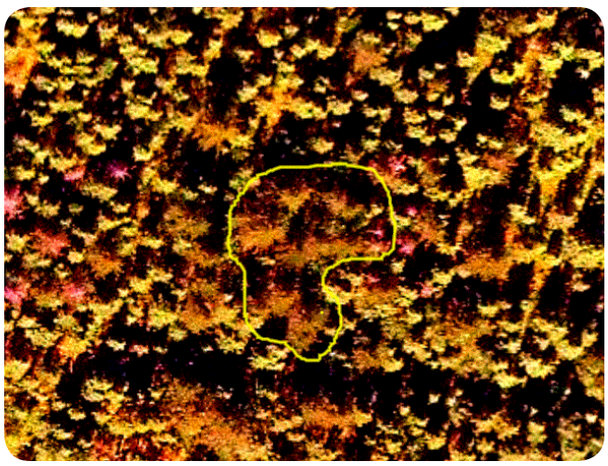






Naturally coloured aerial photograph (RGB)

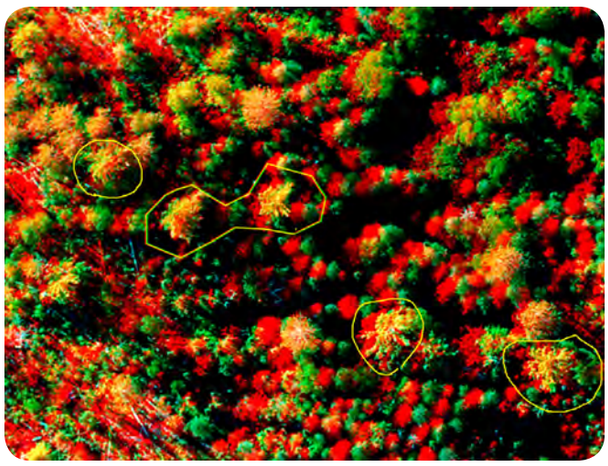




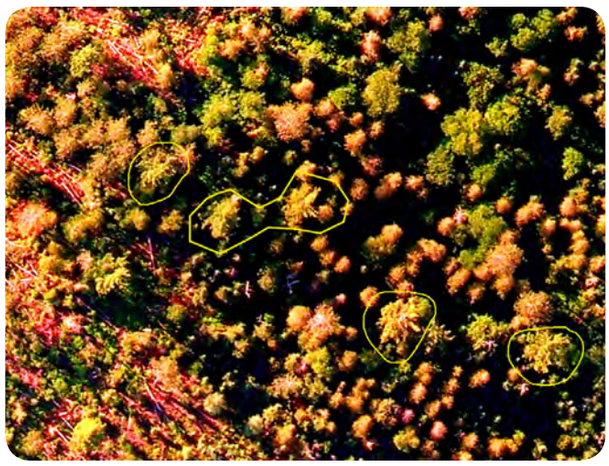
RETURN TO THE CORRESPONDING RECORD

White Pine

Anaglyph RGB



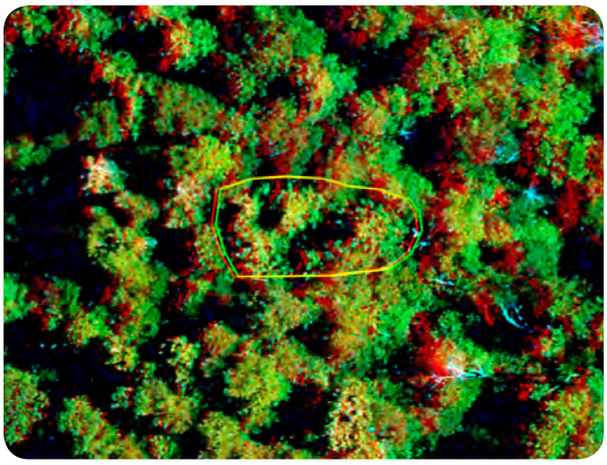
Naturally coloured aerial photograph (RGB)

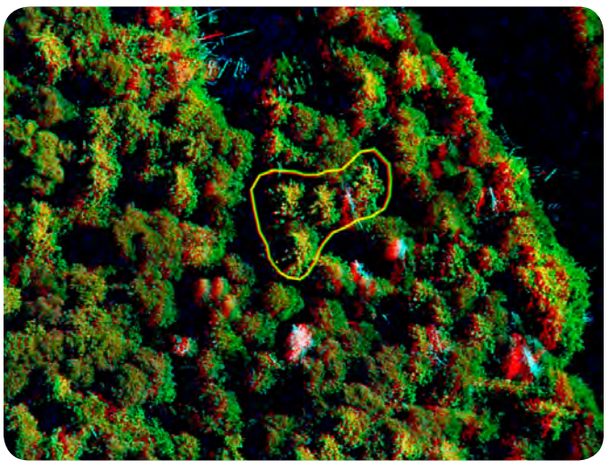


RETURN TO THE CORRESPONDING RECORD

Eastern Hemlock

Anaglyph RGB



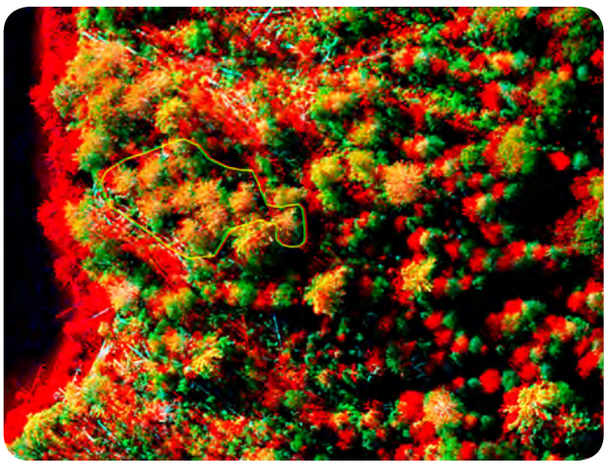


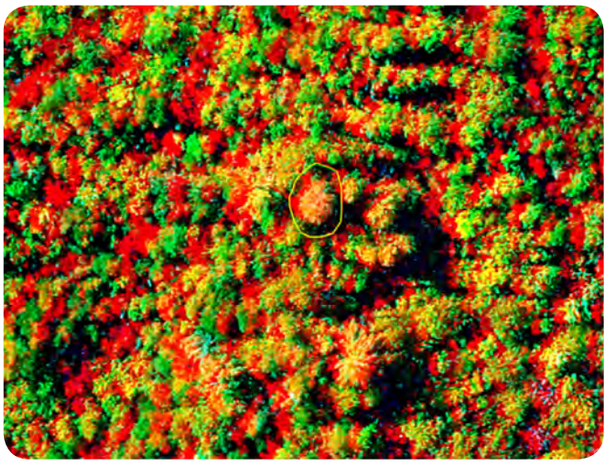
Naturally coloured aerial photograph (RGB)

RETURN TO THE CORRESPONDING RECORD

Red Pine

Anaglyph RGB 



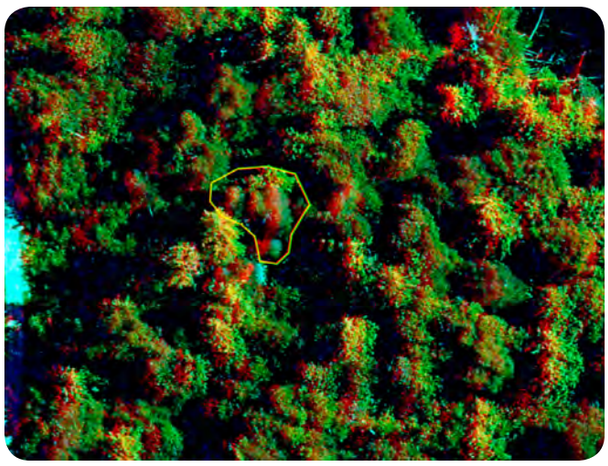


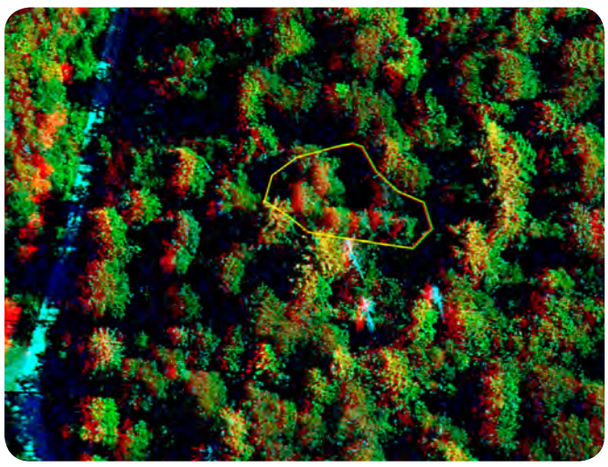
Naturally coloured aerial photograph (RGB)

RETURN TO THE
CORRESPONDING RECORD

Eastern White Cedar

Anaglyph RGB



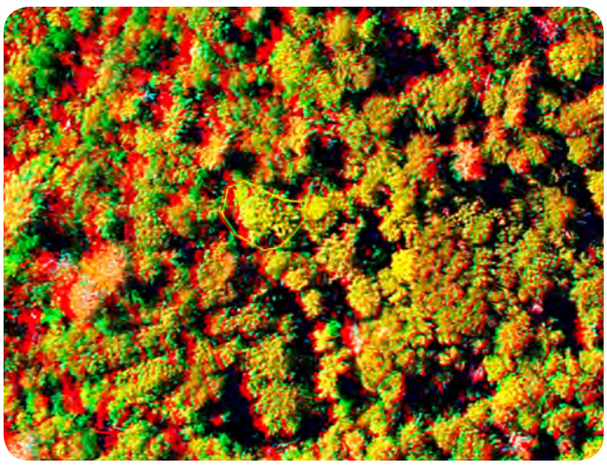


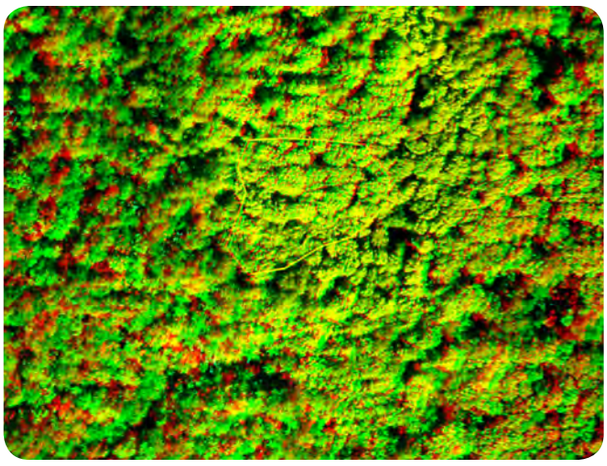
Naturally coloured aerial photograph (RGB)

RETURN TO THE
CORRESPONDING RECORD

Sugar Maple

Anaglyph RGB



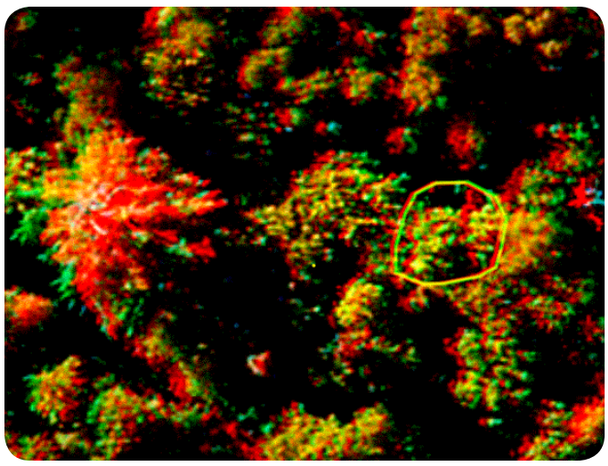


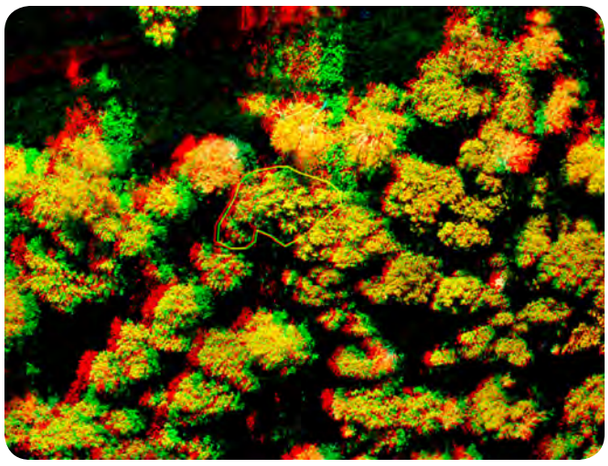
Naturally coloured aerial photograph (RGB)

RETURN TO THE
CORRESPONDING RECORD

Red Maple

Anaglyph RGB



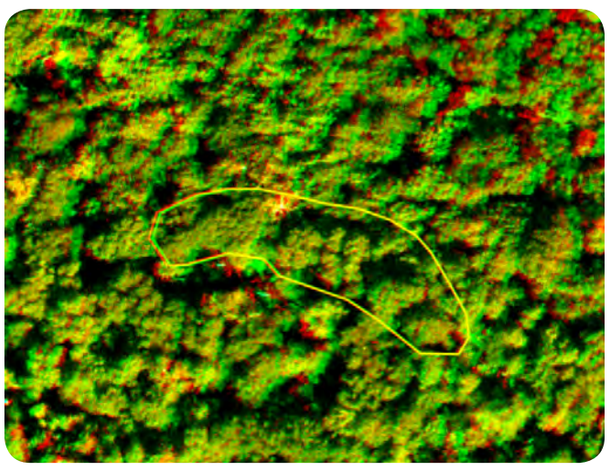


Naturally coloured aerial photograph (RGB)

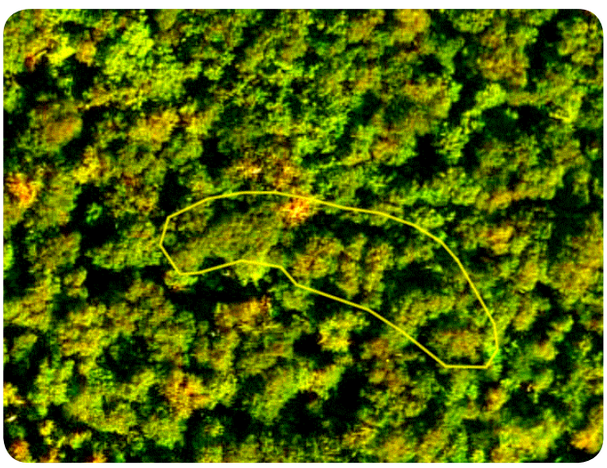
RETURN TO THE CORRESPONDING RECORD

Yellow Birch

Anaglyph RGB



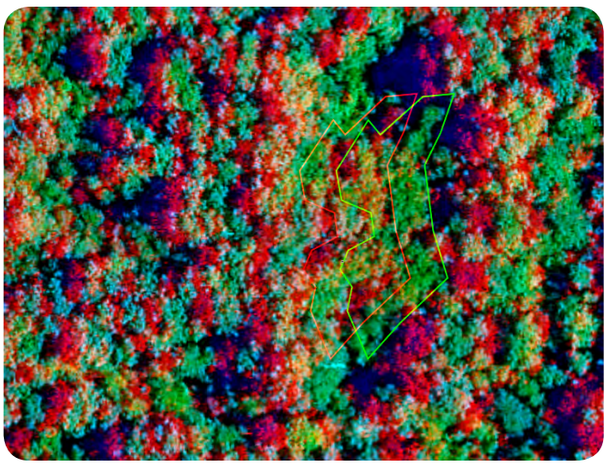
Naturally coloured aerial photograph (RGB)

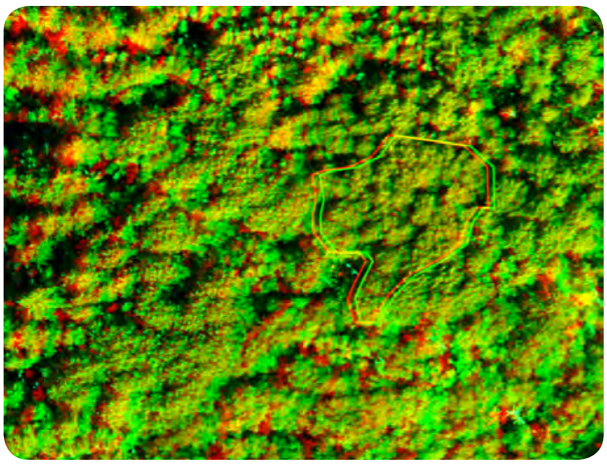


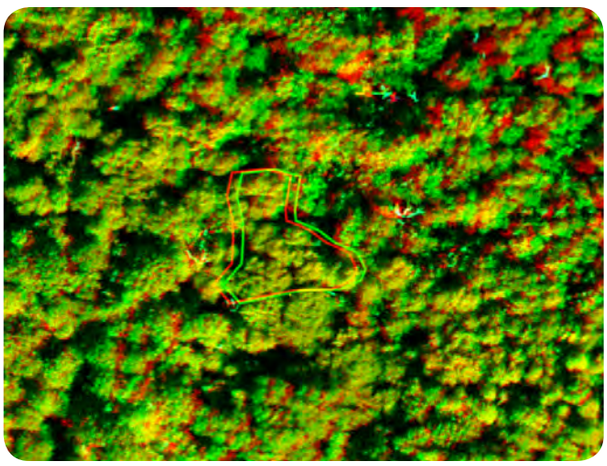
RETURN TO THE CORRESPONDING RECORD

White Birch

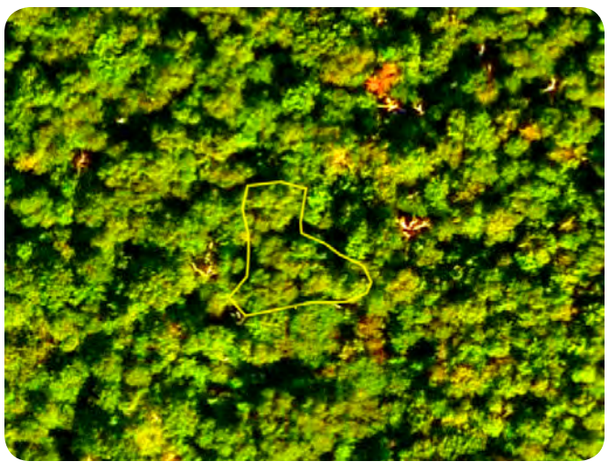
Anaglyph RGB







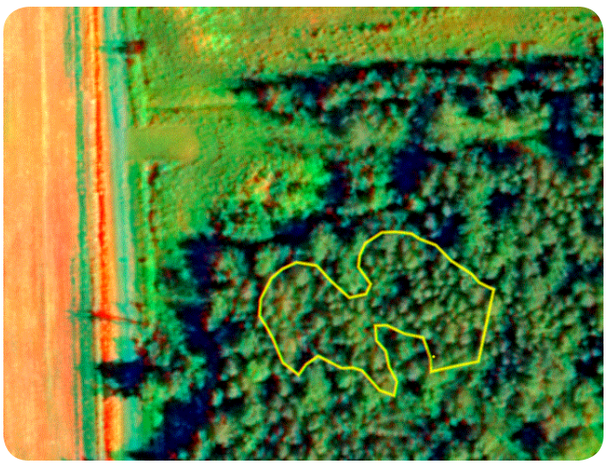
Naturally coloured aerial photograph (RGB)



RETURN TO THE CORRESPONDING RECORD

Grey Birch

Anaglyph RGB

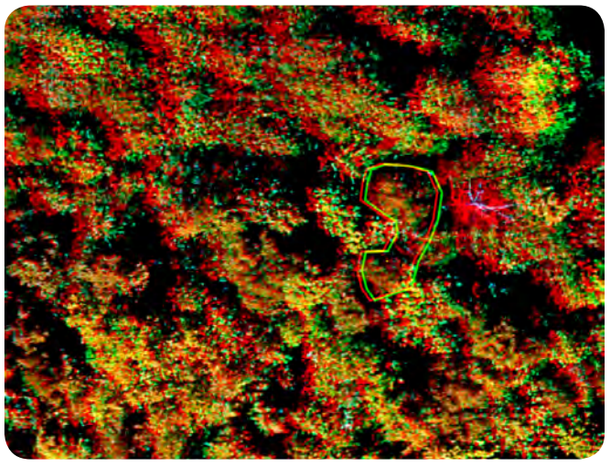


Naturally coloured aerial photograph (RGB)

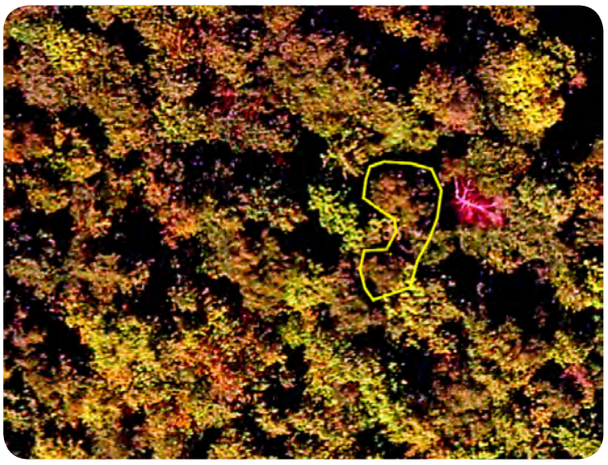
RETURN TO THE CORRESPONDING RECORD

American Beech

Anaglyph RGB



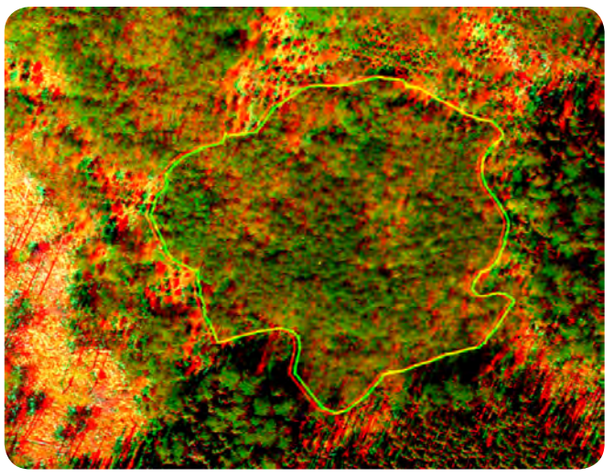
Naturally coloured aerial photograph (RGB)

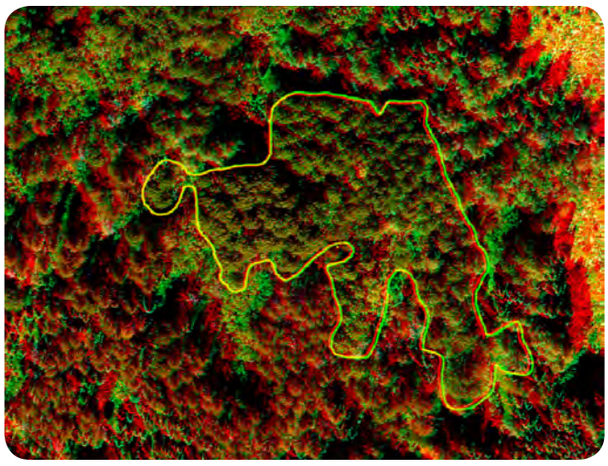


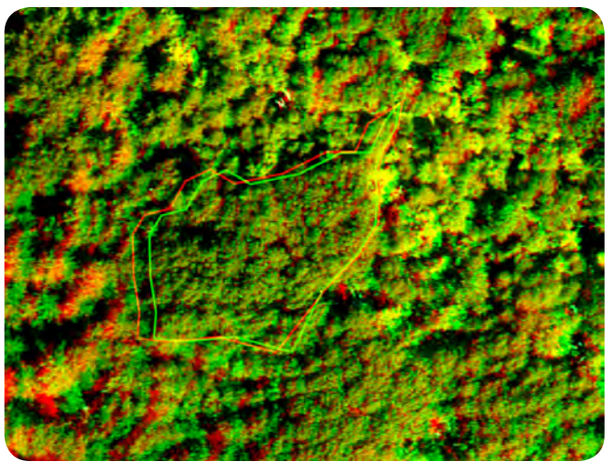
RETURN TO THE CORRESPONDING RECORD

Trembling Aspen

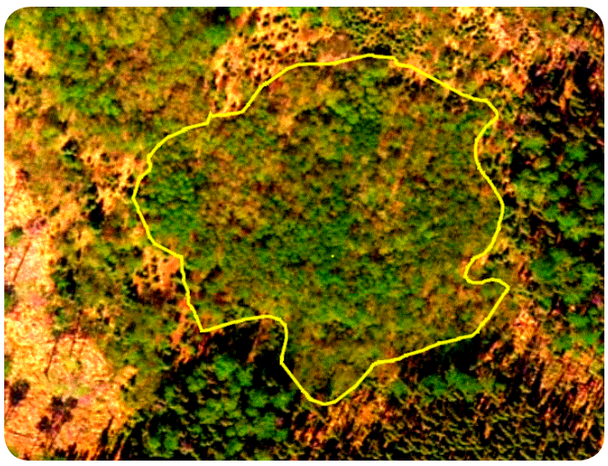
Anaglyph RGB

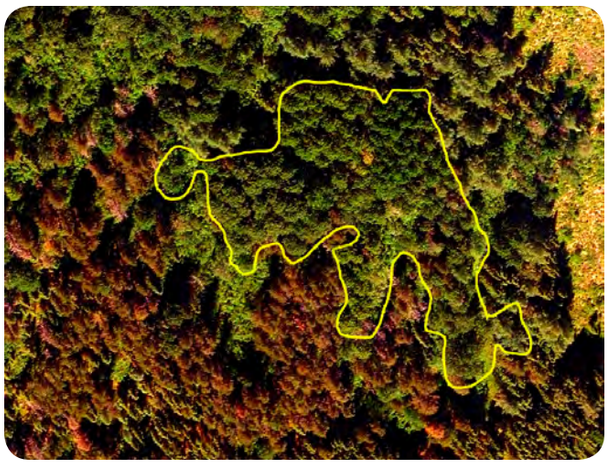


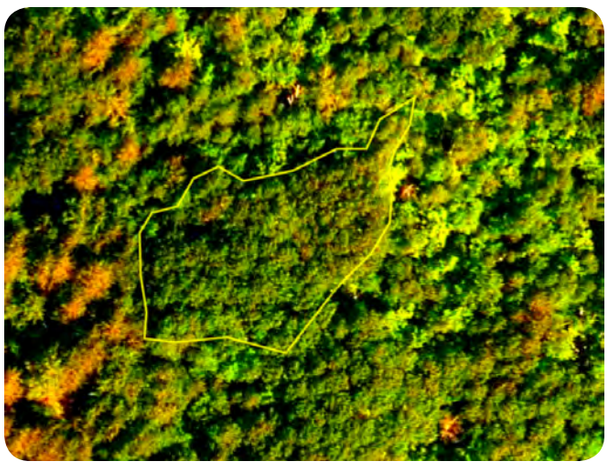




Naturally coloured aerial photograph (RGB)



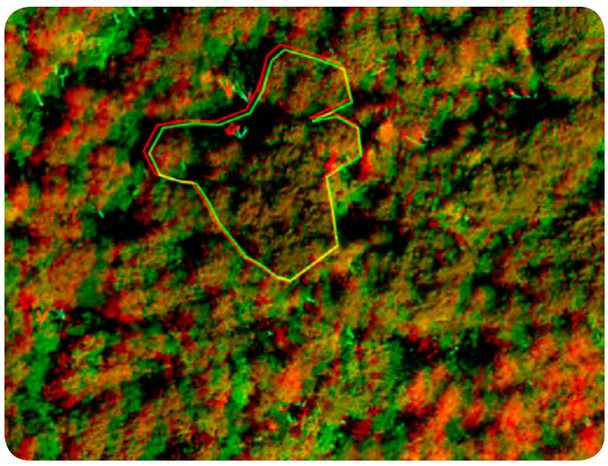




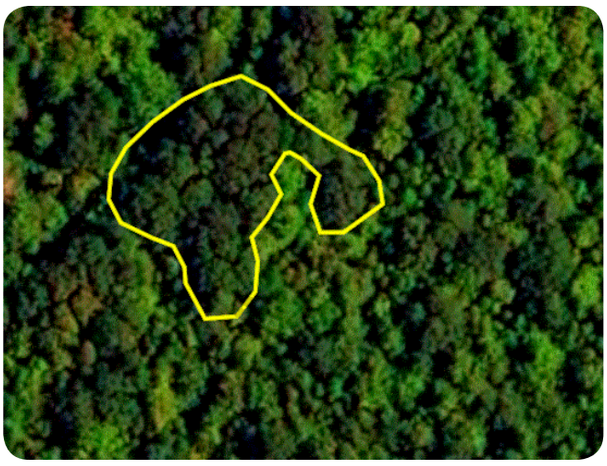
RETURN TO THE CORRESPONDING RECORD

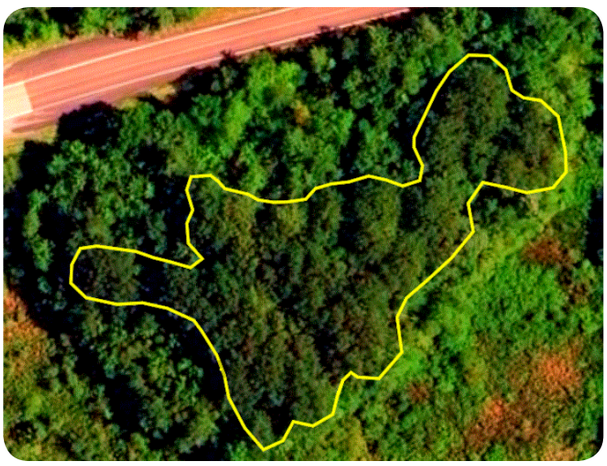
Red Oak

Anaglyph RGB



Naturally coloured aerial photograph (RGB)

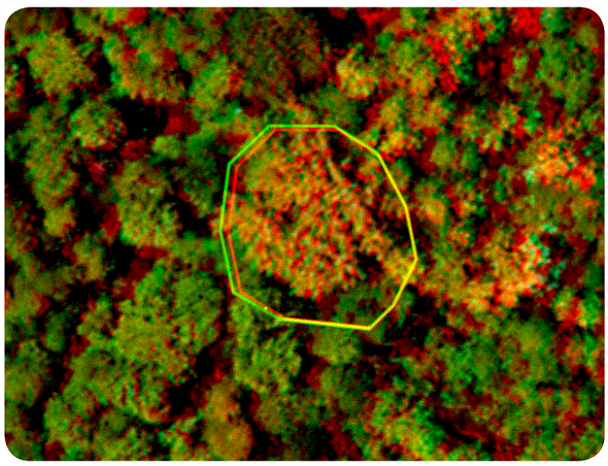




RETURN TO THE CORRESPONDING RECORD

Eastern Poplar

Anaglyph RGB

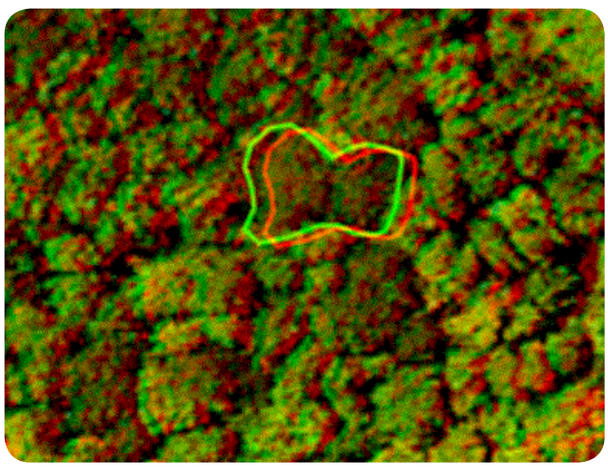


Naturally coloured aerial photograph (RGB)

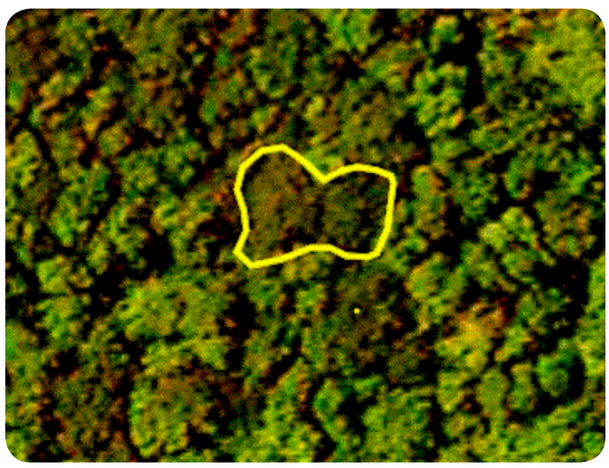
RETURN TO THE CORRESPONDING RECORD

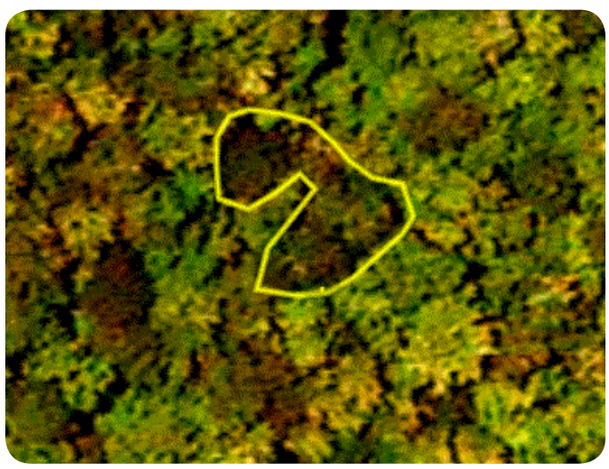
American Linden

Anaglyph RGB



Naturally coloured aerial photograph (RGB)

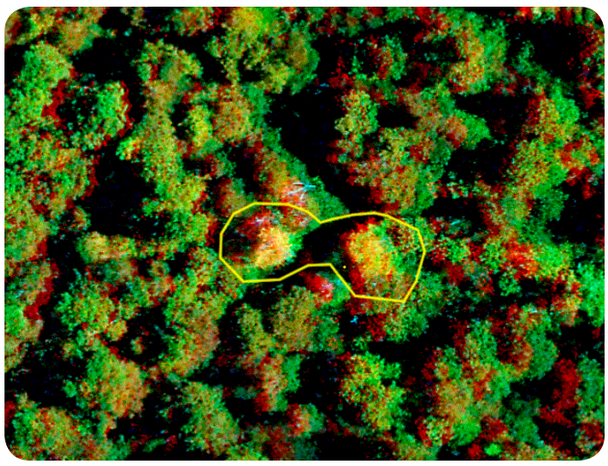


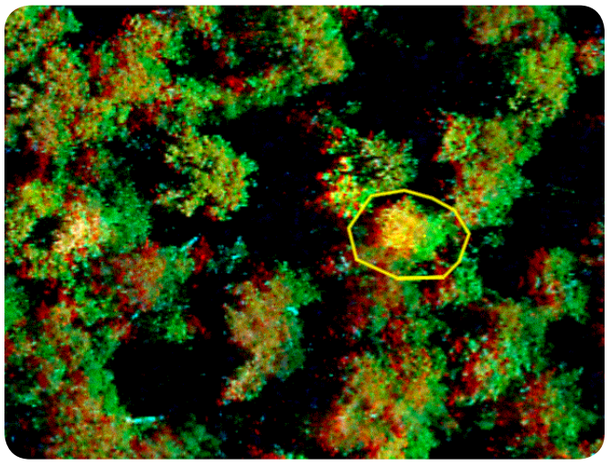


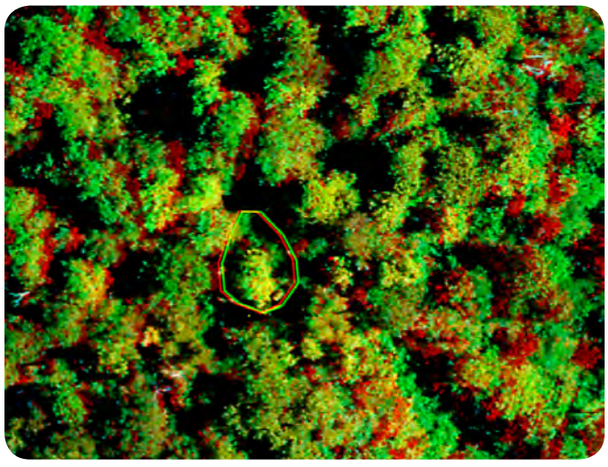
RETURN TO THE CORRESPONDING RECORD

American ash

Anaglyph RGB





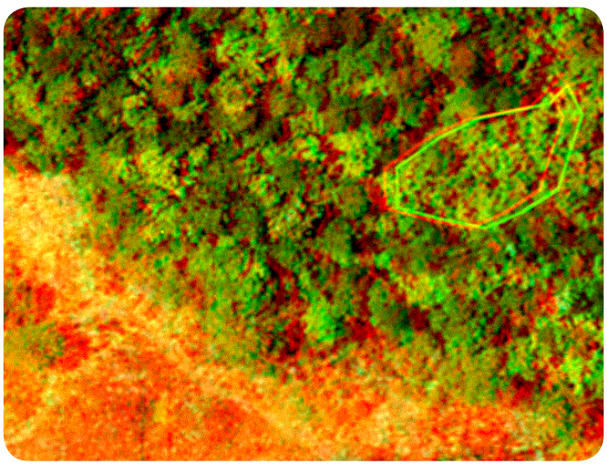


Naturally coloured aerial photograph (RGB)

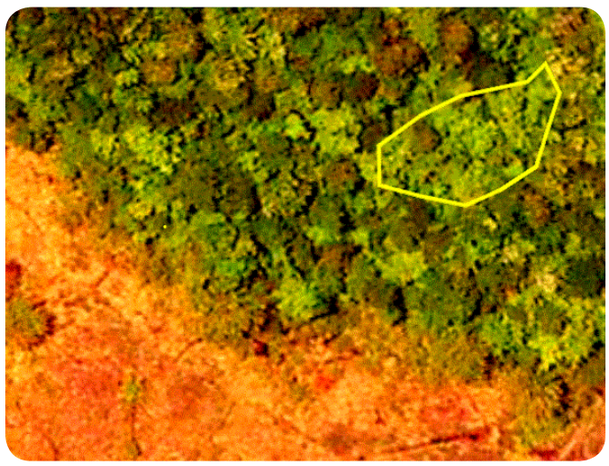
RETURN TO THE CORRESPONDING RECORD

Black ash

Anaglyph RGB



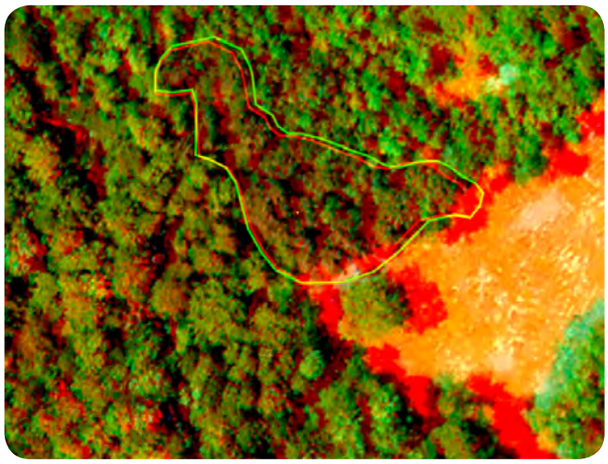
Naturally coloured aerial photograph (RGB)



RETURN TO THE CORRESPONDING RECORD

Northern red ash

Anaglyph RGB

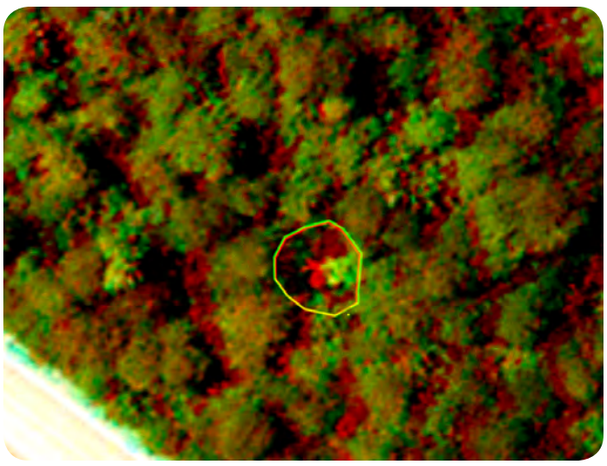


Naturally coloured aerial photograph (RGB)

RETURN TO THE CORRESPONDING RECORD

Hickory

Anaglyph RGB

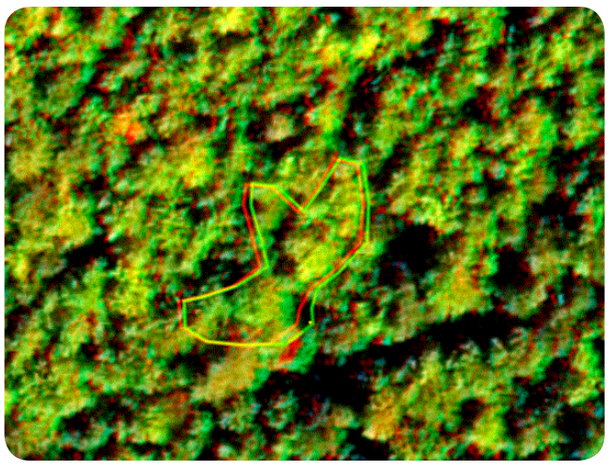


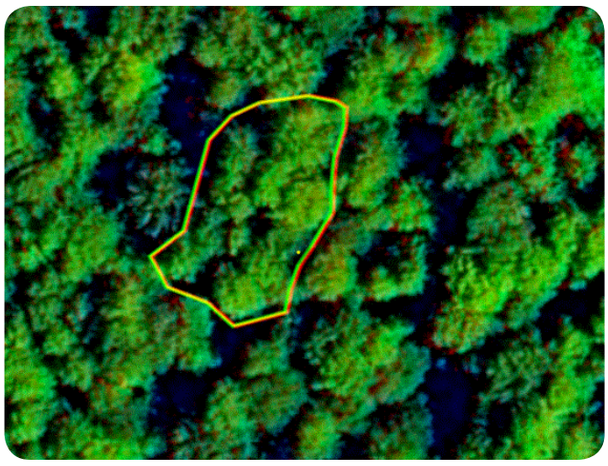
Naturally coloured aerial photograph (RGB)

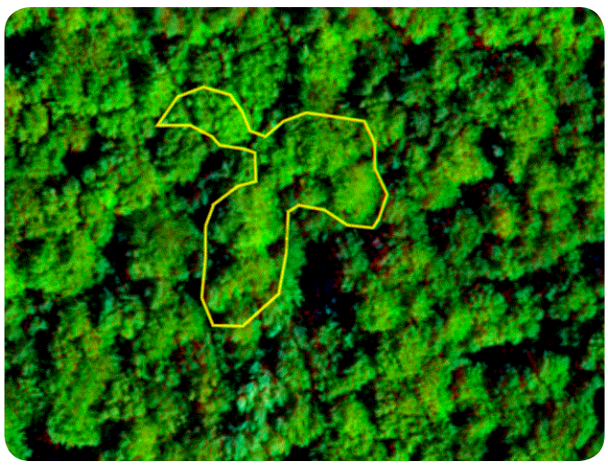
RETURN TO THE
CORRESPONDING RECORD

Silver maple

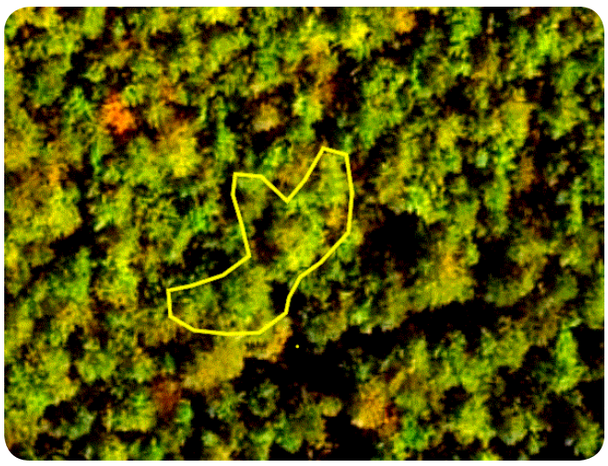
Anaglyph RGB







Naturally coloured aerial photograph (RGB)



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et Parcs
Québec