# Protocols for attribution of EOSD classes to video tiles:

# Example application using Vancouver Island as the population

Version 1.0
January 2005

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Please cite as:

Wulder, M.A., S. McDonald, and J.C. White, 2004; Protocols for attribution of EOSD classes to video tiles: Example application using Vancouver Island as the population, Version 1, Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada, January 13, 2005, 57p.

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## I. Abstract

Independent validation data are required to assess the accuracy of Earth Observation for Sustainable Development of Forests (EOSD) land cover map products. Validation of EOSD products can be undertaken using samples collected from airborne video data. The validation chips are video frames selected at regular time intervals from the continuous video data. Manual attribution of the video samples is required to enable the use of the video chips to assess the accuracy of the EOSD land cover projects. This document provides a description of the process of attributing video chips and guidelines for using the video data in validation efforts. A description of the EOSD legend classes are provided along with the hierarchical scheme used for class definition. Methods are also provided for selecting primary and secondary classes and, guidelines for determining forest density classes and mixed forest classes. To aid in consistent attribution, an identification key, which includes representative samples from the video, is provided. The background and recommendations in this document are designed to develop a consistently attributed validation data set for land cover applications.

## II. Introduction

Large area land cover mapping efforts are ongoing throughout Canada as part of the Earth Observation for Sustainable Development of Forests (EOSD) program at Natural Resources Canada (Wulder et al., 2003). The need to both calibrate and validate mapping activities is important in order to assess the accuracy of land cover products. Airborne video provides a potential source of relatively low cost, information rich data for validation of land cover products. In order to test the utility of video for validation a pilot study was conducted on Vancouver Island in August of 2004. It was anticipated that if successful, this method would be extended at a national level.

The purpose of this document is to provide a video classification key designed to aid interpretation in attributing the video system data. This document contains a description of the land cover used for the EOSD mapping, provides a classification hierarchy used for class selection, differentiates between selecting first and second classes, illustrates various conifer density classes, and describes categorizing mixed class and differentiating between forest species.

## III. Background

Procedures for classifying satellite data for the EOSD project have been documented (Wulder et al., 2004) and are available on-line[1]. Given that land cover - not land use- is under the EOSD mandate is mapped, there are few non-vegetated classes included in the EOSD legend. The classes mapped by EOSD, due to the integration with the National Forest Information (NFI), are a component of a hierarchical classification scheme. The

[1] EOSD land cover legend and methods documents: http://www.pfc.forestry.ca/eosd/cover/legend_e.html

classification scheme used in the EOSD project is hierarchical and is closely linked to the NFI scheme (Wulder et al., 2001; Wulder and Nelson, 2003).

## IV. Data

Using a digital camcorder and a Red Hen GPS devise mounted to a Cessna 206 aircraft, over 10 hours of continuous video were flown along four transects running along the length of Vancouver Island (Figure 1). The continuous video was sampled every 30 seconds to generate 2651 video chips.

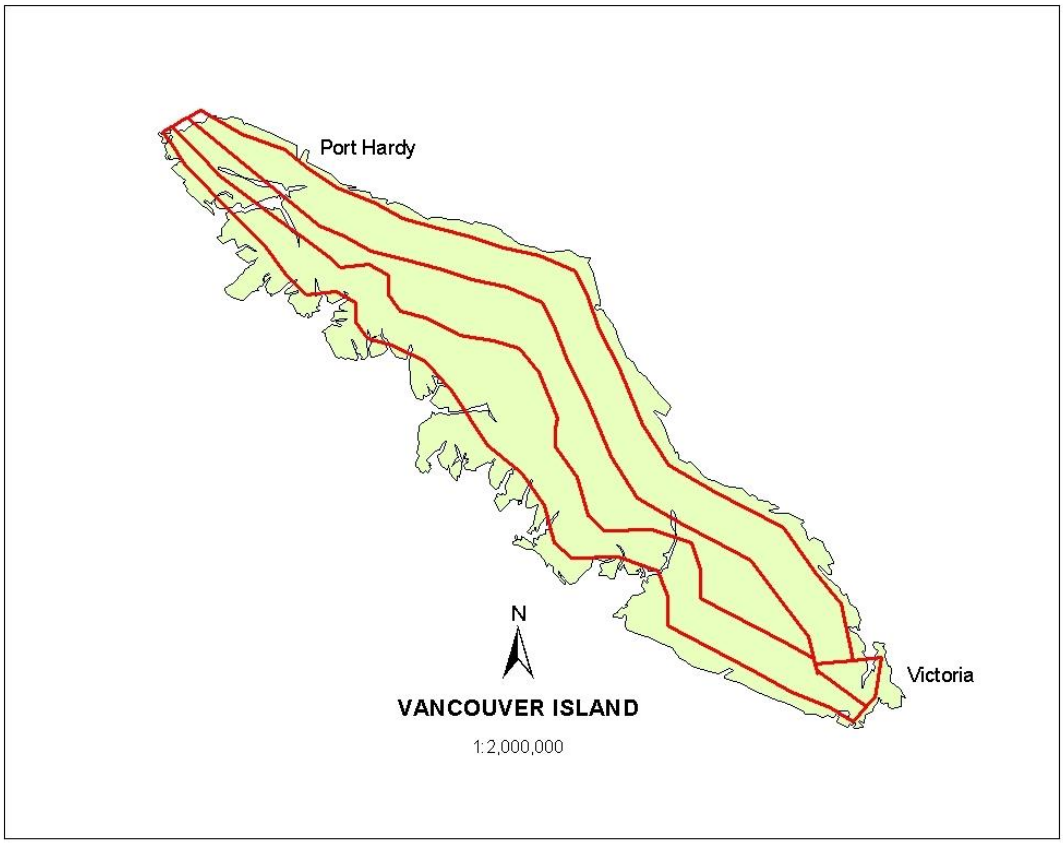



**Figure 1: Flight Lines over Vancouver Island**

## V. Methodology

### *a. NFI Land Cover Classification Hierarchy*

The NFI provides the classification hierarchy for EOSD. When interpreting the video chips the entire hierarchy can be considered. The distinctions between classes should be evident when viewing the key (Figure 2).

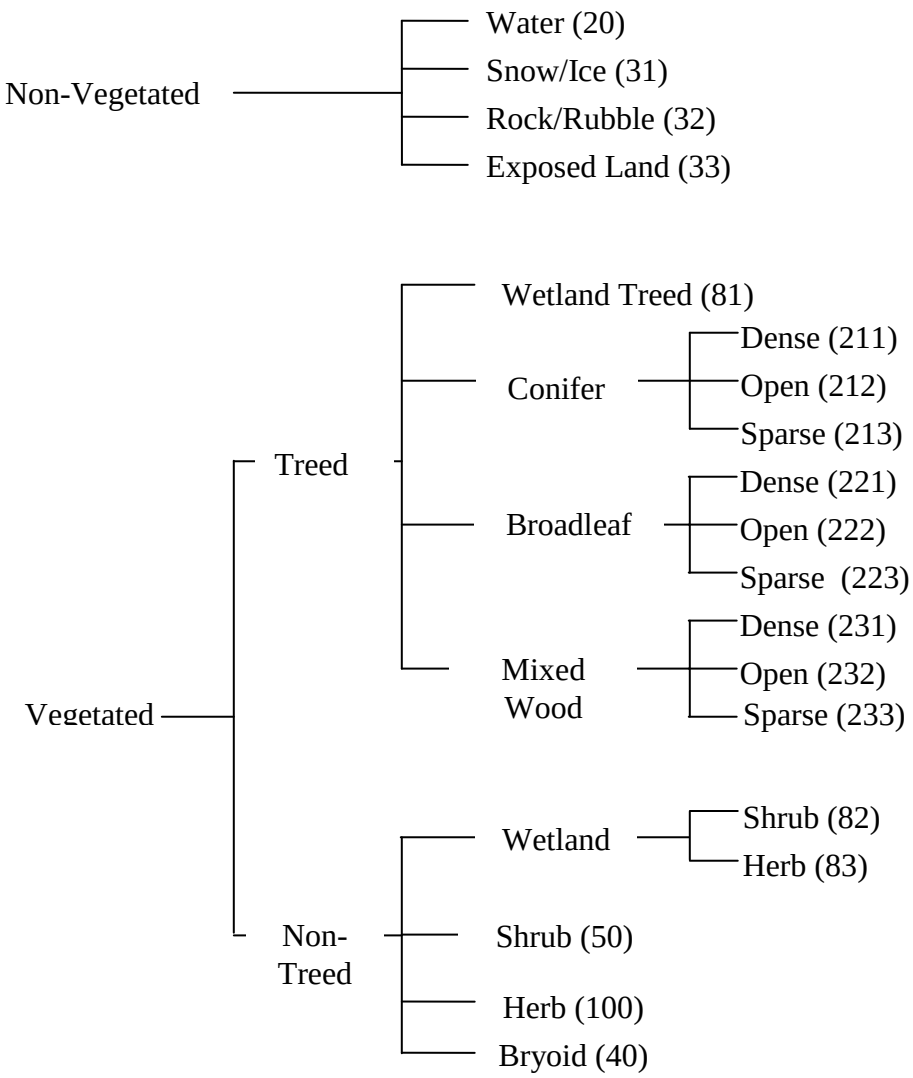



**Figure 2: EOSD class hierarchy, based upon the NFI (Numbers in parenthesis indicate EOSD numeric code)**

### *b. Class Definitions*

As described in the EOSD Land Cover Classification Legend Report (Wulder and Nelson, 2003), the EOSD legend is used to classify the forested regions of Canada. Table 1 provides a class code, name, and description. While the EOSD classification documentation specifies the distinction between tall (51) and low (52) shrub operationally it is not often possible to differentiate between the two levels. Based on a preview of video for the pilot study, it was felt that this discrimination could not be made and therefore a general shrub class (50) is used for the attribution.

**Table 1: EOSD Classes and Descriptions**

| CODE | | CLASS | DESCRIPTION |
|---|---|---|---|
| 0 | | No Data | |
| 12 | | Shadow | |
| 11 | | Cloud | |
| 31 | | Snow/Ice | Glacier/snow |
| 32 | | Rock/Rubble | Bedrock, rubble, talus, blockfield, rubbley mine spoils, or lava beds. |
| 33 | | Exposed Land | River sediments, exposed soils, pond or lake sediments, reservoir margins, beaches, landings, burned areas, road surfaces, mudflat sediments, cutbanks, moraines, gravel pits, tailings, railway surfaces, buildings and parking, or other non-vegetated surfaces. |
| 20 | | Water | Lakes, reservoirs, rivers, streams, or salt water. |
| 51 | | Shrub - Tall | At least 20% ground cover which is at least one-third shrub; average shrub height greater than or equal to 2 m. |
| 52 | | Shrub - Low | At least 20% ground cover which is at least one-third shrub; average shrub height less than 2 m. |
| 100 | | Herb | Vascular plant without woody stem (grasses, crops, forbs, gramminoids); minimum of 20% ground cover **or** one-third of total vegetation must be herb. |
| 40 | | Bryoids | Bryophytes (mosses, liverworts, and hornworts) and lichen (foliose or fruticose; not crustose); minimum of 20% ground cover **or** one-third of total vegetation must be a bryophyte or lichen |
| 81 | | Wetland - Treed | Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is coniferous, broadleaf, or mixed wood. |
| 82 | | Wetland - Shrub | Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is tall, low, or a mixture of tall and low shrub. |
| 83 | | Wetland - Herb | Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is herb. |
| 211 | | Coniferous - Dense | Greater than 60% crown closure; coniferous trees are 75% or more of total basal area. |
| 212 | | Coniferous - Open | 26-60% crown closure; coniferous trees are 75% or more of total basal area. |
| 213 | | Coniferous - Sparse | 10-25% crown closure; coniferous trees are 75% or more of total basal area. |
| 221 | | Broadleaf - Dense | Greater than 60% crown closure; broadleaf trees are 75% or more of total basal area. |
| 222 | | Broadleaf - Open | 26-60% crown closure; broadleaf trees are 75% or more of total basal area. |
| 223 | | Broadleaf - Sparse | 10-25% crown closure; broadleaf trees are 75% or more of total basal area. |
| 231 | | Mixed Wood - Dense | Greater than 60% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area. |
| 232 | | Mixed Wood - Open | 26-60% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area. |
| 233 | | Mixed Wood - Sparse | 10-25% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area. |

### *c. Sample Size Definition and Rationale: Vancouver Island Pilot Study*

The objective of the chip selection and attribution is to provide a validation data set for the accuracy assessment of a Landsat land cover classification of Vancouver Island. With a total of 2651 video chips, an appropriate overall sample size was defined and allocated to each of the EOSD land cover strata.

The scenarios presented in Table 2 indicate how the precision of the estimates of overall accuracy vary with sample size. Based on the range of possible samples sizes, and the potential overall accuracies and their associated confidence intervals, a sample size of 500 was selected. This sample size was a reasonable trade-off between the level of effort required to attribute the video samples and the confidence in the estimate generated Additional samples provide only marginal improvements in precision (Czaplewski, 2003).

**Table 2: Variation in precision of estimates for overall accuracy measures, with various samples sizes.**

| **Estimated accuracy** | 60% | 65% | 70% | 75% | 80% | 85% |
|---|---|---|---|---|---|---|
| **Total samples** | **1000** | **1000** | **1000** | **1000** | **1000** | **1000** |
| **Proportion correct** | 600 | 650 | 700 | 750 | 800 | 850 |
| **Upper** | 56.89% | 61.95% | 67.05% | 72.19% | 77.38% | 82.63% |
| **Lower** | 63.05% | 67.96% | 72.83% | 77.66% | 82.44% | 87.16% |

| **Estimated accuracy** | 60% | 65% | 70% | 75% | 80% | 85% |
|---|---|---|---|---|---|---|
| **Total samples** | **500** | **500** | **500** | **500** | **500** | **500** |
| **Proportion correct** | 300 | 325 | 350 | 375 | 400 | 425 |
| **Upper** | 55.56% | 60.64% | 65.77% | 70.96% | 76.22% | 81.56% |
| **Lower** | 64.32% | 69.18% | 73.99% | 78.74% | 83.42% | 88.02% |

| **Estimated accuracy** | 60% | 65% | 70% | 75% | 80% | 85% |
|---|---|---|---|---|---|---|
| **Total samples** | **250** | **250** | **250** | **250** | **250** | **250** |
| **Proportion correct** | 150 | 162.5 | 175 | 187.5 | 200 | 212.5 |
| **Upper** | 53.64% | 59.40% | 63.91% | 69.37% | 74.50% | 80.18% |
| **Lower** | 66.12% | 70.71% | 75.61% | 80.06% | 84.78% | 89.01% |

| **Estimated accuracy** | 60% | 65% | 70% | 75% | 80% | 85% |
|---|---|---|---|---|---|---|
| **Total samples** | **100** | **100** | **100** | **100** | **100** | **100** |
| **Proportion correct** | 60 | 65 | 70 | 75 | 80 | 85 |
| **Upper** | 49.72% | 54.82% | 60.02% | 65.34% | 70.82% | 76.47% |
| **Lower** | 69.67% | 74.27% | 78.76% | 83.12% | 87.33% | 91.35% |

A stratified random sampling approach was selected, with the EOSD land cover classes forming the strata. Samples were allocated proportional to the area of each stratum in the EOSD land cover product. This samples size ensures that each stratum has a sufficient number of samples to calculate the variance for each class. The relative sample sizes for both the EOSD have been calculated. Classes have been selected using the EOSD classification to provide an indication of likely class proportions that will be used to define the sample size for each class.

To summarize, the sampling approach was as follows:

1. Overall sample size of 500.
2. Adopted a stratified random sample.
3. Strata are defined by the EOSD land cover classes.
4. Samples were allocated proportional to the area of each stratum (Table 3).

From this, measures of overall accuracy are calculated using error matrices with marginal proportions as per Czaplewski (2003).

**Table 3: Proportional allocation of samples under various scenarios.**

| | | EOSD | | | |
|---|---|---|---|---|---|
| | | **1000** | **500** | **250** | **100** |
| EOSD class | Proportion of sampled population mapped as x | Sample size of x | Sample size of x | Sample size of x | Sample size of x |
| 20 | 0.0461 | 49 | 25 | 12 | 5 |
| 31 | 0.0217 | 37 | 19 | 9 | 4 |
| 32 | 0.0000 | 26 | 13 | 7 | 3 |
| 33 | 0.0324 | 43 | 21 | 11 | 4 |
| 50 | 0.0420 | 49 | 24 | 12 | 5 |
| 81 | 0.0074 | 30 | 15 | 8 | 3 |
| 82 | 0.0016 | 27 | 14 | 7 | 3 |
| 83 | 0.0013 | 27 | 13 | 7 | 3 |
| 100 | 0.0792 | 66 | 33 | 16 | 7 |
| 211 | 0.0705 | 62 | 31 | 15 | 6 |
| 212 | 0.5391 | 296 | 148 | 74 | 30 |
| 213 | 0.1015 | 77 | 39 | 19 | 8 |
| 221 | 0.0185 | 36 | 18 | 9 | 4 |
| 222 | 0.0377 | 45 | 23 | 11 | 5 |
| 223 | 0.0007 | 27 | 13 | 7 | 3 |
| 231 | 0.0000 | 26 | 13 | 7 | 3 |
| 232 | 0.0000 | 26 | 13 | 7 | 3 |
| 233 | 0.0002 | 26 | 13 | 7 | 3 |
| **TOTAL** | **1.0000** | **1000** | **500** | **250** | **100** |

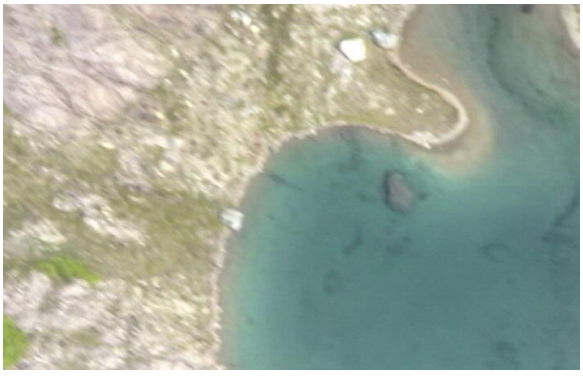
### *d. Procedures for Selecting Primary and Secondary Classes*

Generally, the interpreter is advised to identify the class found at the center of the video sample. However, in some instances, more than one class dominates the sample. The

selection of the primary and secondary class accounts for positional error and fuzzy nature of vegetation class distribution.

Primary Class: Exposed Land (33)
Secondary Class: Snow/Ice (31)
Rational: Exposed rock is at the scene center with snow and ice surrounding the rock.

Primary Class: Exposed Land (33)
Secondary Class: Conifer Dense (211)
Rational: Exposed land (post harvest) is at the scene center with dense conifer in the right portion of the scene.



Primary Class: Water (20)
Secondary Class: Exposed Land (33)
Rational: Water is at the scene center with exposed land in the left portion of the scene.

Primary Class: Exposed Land (33)
Secondary Class: Herb (100)
Rational: Exposed land (a road) is at the scene center with herb (grass) surrounding the scene center.

Primary Class: Exposed Land (33)
Secondary Class: Conifer Dense (211)
Rational: Exposed land (a road) is at the scene center with dense conifer surrounding the road.

Primary Class: Water (20)
Secondary Class: Dense Conifer (211)
Rational: Although both classes appear to be at the scene center, the water class is at the centroid with dense conifer in the left portion of the scene.

### *e. Procedure for Accounting for Invalid Chips*

Included in the video data are chips that do not contain valid information. Issues leading to a chip being unsuitable for attribution includes unfocussed chips, chips captured during flight, and chips obscured by shadow and cloud. Any chip felt to be unsuitable for labeling should be given a code of 999. The chip will not be included in the assessment of image accuracy.

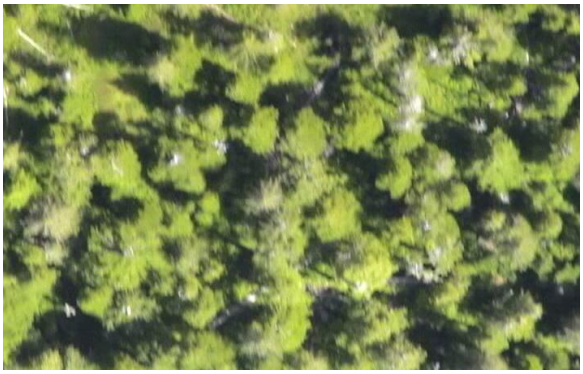
### *f. Procedures for Determining Density Classes*

The EOSD density classes are listed as dense (greater than 60% crown closure; trees are 75% or more of total basal area), open (26-60% crown closure; trees are 75% or more of total basal area) and sparse (10-25% crown closure; trees are 75% or more of total basal area). Density, for the purpose of this report, is analogous to crown closure, and can be described as the condition when the crown of trees touch and effectively block sunlight from reaching the forest floor (Ministry of Forests, 2004). Much debate over the open versus closed density range exists primarily around the transition between dense and open, which occurs at 60% crown closure. For the purpose of the pilot, interpreters may account for any uncertainty in density estimation by selecting both a primary and secondary class label (e.g. primary = dense conifer (211); secondary = open conifer (212)).

Conifer Sparse




Conifer Open

Conifer Dense




### *g. Procedures for Determining Mixed-Forest Classes*

A mixed wood forest occurs when neither coniferous nor broadleaf trees account for 75% or more of total basal area in the stand. Hence, when one tree species dominates a stand, the presence of another species may not indicate a mixed wood forest stand unless the other species accounts for more than 25% of the total basal area in the stand.

Class: Broadleaf Closed (221)
The trees circled in red indicate coniferous trees, however, due to the small number the tile is considered broadleaf closed.

Class: Coniferous Open (212)
The trees circled in red indicate broadleaf trees, however, due to the small number the tile is considered coniferous open.

Class: Mixed Wood Open (232)
As defined, this forest is comprised of mixed wood where neither coniferous nor broadleaf trees account for 75% or more of total basal area. Coniferous trees are circled in red and broadleaf trees are circled in blue.

### *h. Procedures for Differentiating Species*

In order to differentiate between the vegetated treed classes, it is important to understand the characteristics of conifer and broadleaf trees as viewed in the video chips. Guidelines are set forth to assist the photo interpreter as described in the "Colour Sterogram Handbook" (Ministry of Forests and Lands, 1987), see Appendix 1 for examples from this handbook. Generally, a conifer tree appears to be conical in shape with a narrow, slender pointed tip, with some conifer species having a dead spike. The broadleaf tree appears broad, almost "fluffy", with branches that are spreading tufted with irregular and patterns.

Conifer Stand

Individual Conifer Tree

Broadleaf Stand

Two Broadleaf Trees

### *i. Procedures for Video Chip Attribution Spreadsheets*

In order to assist with EOSD product validation, a component of the pilot study included an exercise of attributing the video samples.

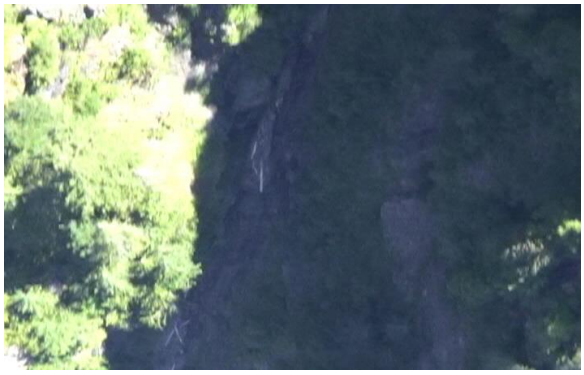
The process for doing this included:

1. Randomize the 2651 video samples;
2. Rename video chips with the following convention vc_000#.jpg;
3. Create a spreadsheet listing the samples in the random order, the number of required samples, the number of attributed samples and the interpreter information (Appendix 2 for examples of the spreadsheet);
4. Interpret first and second choice for each chip; and,
5. Record class attribution in spreadsheet until the required number of samples is achieved.

## VI. Interpretation Key

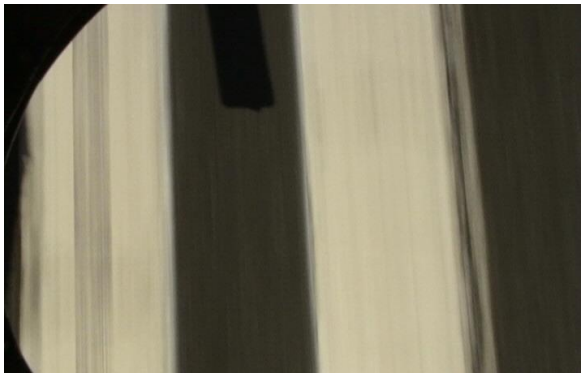
The purpose of the interpretation key is to provide video samples for each of the EOSD classes found on Vancouver Island. The video chips are shown with an overview and a zoom-in to the feature class from a Landsat scene with the location of video chip at the centroid. In general the Landsat imagery are shown as a true colour composite, with a linear enhancement applied.

**EOSD Class:** Invalid Video Chips (999)



Shadows commonly occur in mountainous terrain.

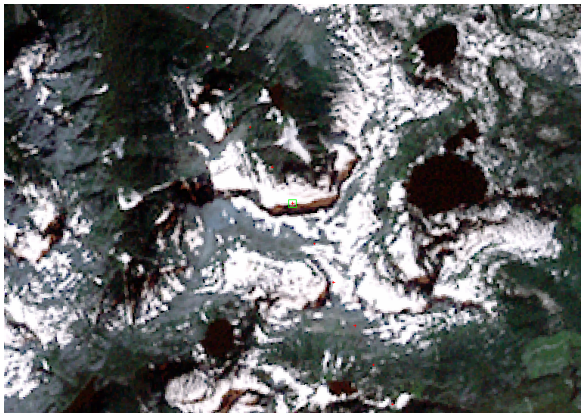
Cloud should not be present in the image as it is removed prior to labeling.



Video sample acquired during flight.

**EOSD Class:** Snow / Ice (31)
**Class Description:** Glacier/snow

Video: This video chip shows snow located in shadow due to mountainous terrain.

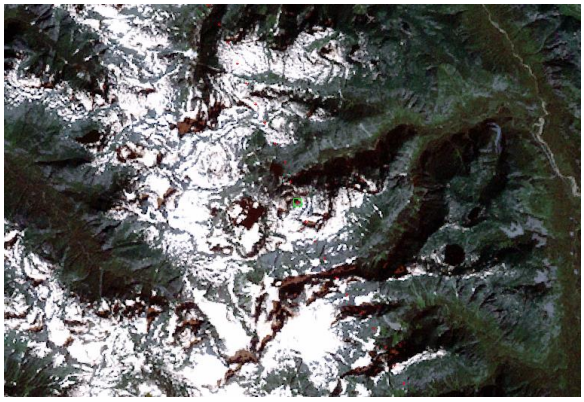


Landsat: Areas in white represent snow or ice. In the Landsat scene, the snow is in shadow as it is in the video chip.

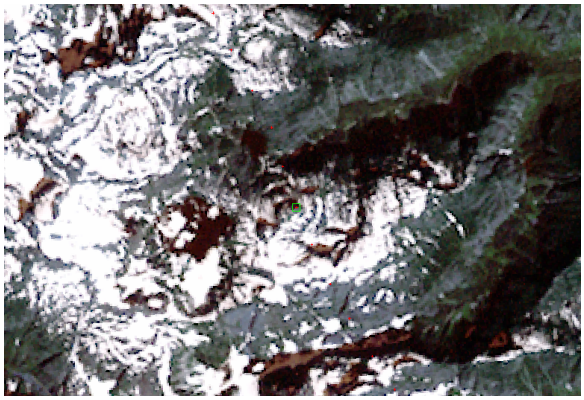
Landsat: Snow is often accompanied with exposed land (grey in colour) or black areas due to shadows.

**EOSD Class:** Rock / Rubble (32)
**Class Description:** Bedrock, rubble, talus, blockfield, rubbley mine spoils, or lava beds.

Video: Video chip with rubble partially obscured by shadow.



Landsat: Area surrounding rubble includes snow, ice and exposed land.



Landsat: Area in grey represents rubble, and is often accompanied with black or dark pixels due to shadow.

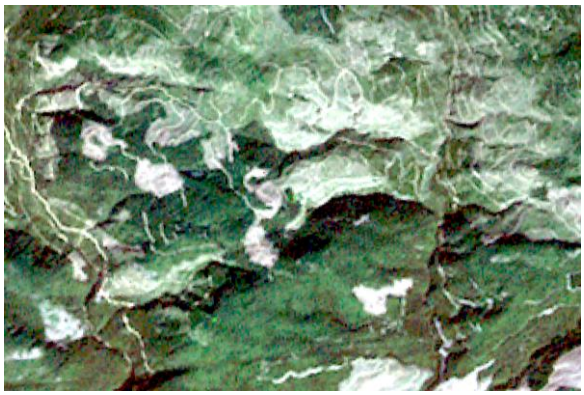
**EOSD Class:** Exposed Land (33)
**Class Description:** River sediments, exposed soils, pond or lake sediments, reservoir margins, beaches, landings, burned areas, road surfaces, mudflat sediments, cutbanks, moraines, gravel pits, tailings, railway surfaces, buildings and parking, or other non-vegetated surfaces.

Video: Video chip showing buildings and parking lots.

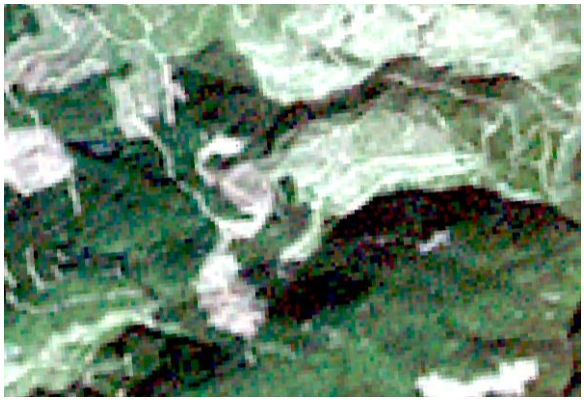
Landsat: Typical of urban areas this scene includes buildings, parking lots and forested land. Urban areas are generally comprised of various coloured pixels.

Landsat: Area in white and light grey represent buildings and parking lots, where areas in green are forests or grasslands.

Video: Video chips shows a recently harvested area with a winding road.



Landsat: Harvested area shown in white with road surfaces clearly visible.

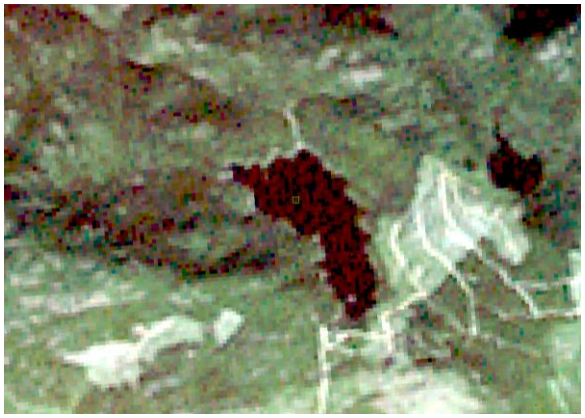


Landsat: Harvested areas range in colour from grey (mostly exposed land) to light green (herbaceous cover) to medium green (shrub cover).

**EOSD Class:** Water (20)
**Class Description:** Lakes, reservoirs, rivers, streams, or salt water.

Video: Video chip showing water.

Landsat: Lakes are often black or dark pixels in a true colour composite image.



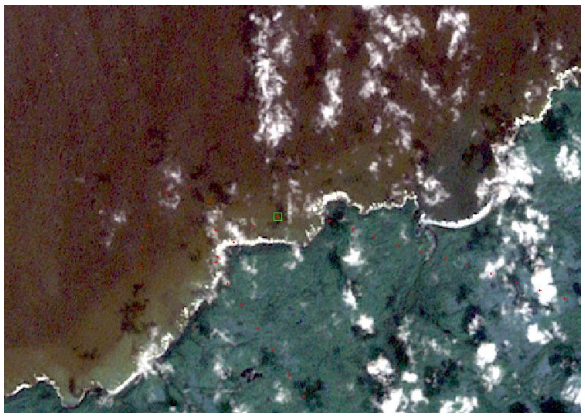
Landsat: The pixel values range in colour in lakes and can sometimes make it difficult to determine where the waters edge is located.

Video: Estuarine mixing of fresh and salt water, with deltas present in video chip.

Landsat: Brackish water is sometimes difficult to label because of the wide range of colours found in these features.

Landsat: Mixed shades of colour is illustrated, ranging from darker to lighter blue pixels. Often brackish water or water heavy with sediment is mixed in with the snow/ice class.

Video: Video chip showing sea grass under the surface of the water.



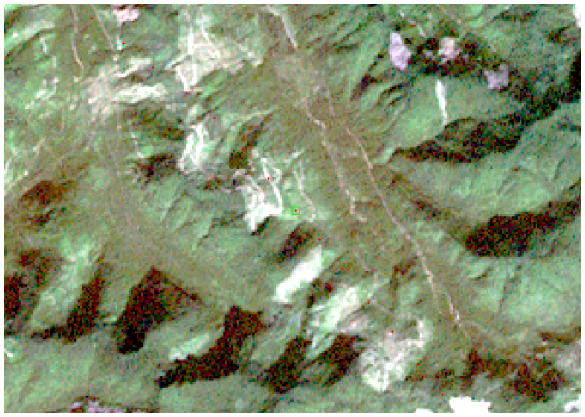
Landsat: Coastal areas are often affected by clouds as evident in this image. Changes in the intensity in the colour of the water is subtle as it deepens.

Landsat: Partially obscured by cloud, the water appears to be affected by the sea grass underneath the surface with lighter pixel tones evident.

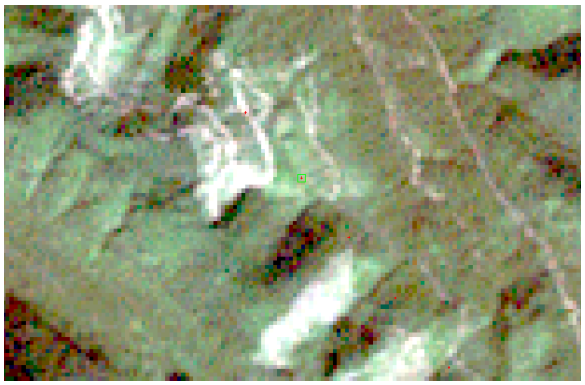
**EOSD Class: Shrub (50)**

While the EOSD classification documentation holds that tall and low shrub be classified in practice it is not often possible to differentiate between the two levels. As a result, only shrub as a more general class will be attributed. Following are examples of what shrub areas, both tall and low, appear as. And encompasses the following class definitions: At least 20% ground cover which is at least one-third shrub; average shrub height greater than or equal to 2 m; and, At least 20% ground cover which is at least one-third shrub; average shrub height less than 2 m.

Video: Video chips showing land covered by shrubs with some felled trees.

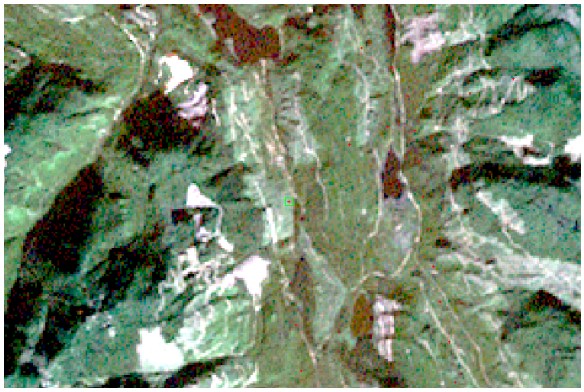


Landsat: This area was harvested and is now in a regeneration phase with tall shrubs. This is evident by the presence of roads and patches of land at various phases of growth.



Landsat: This particular area is in the middle of a regenerating stand.

Video: Shrub in an area of regeneration in video chip.



Landsat: Regeneration area can be identified by associated features including roads and patches of forests.

Landsat: It is often difficult to distinguish between tall and low shrub. A rule of thumb is that if the pixel is a green- brown colour as opposed to a more solid green colour then the pixel is low shrub.

**EOSD Class:** Herb (100)
**Class Description:** Vascular plant without woody stem (grasses, crops, forbs, gramminoids); minimum of 20% ground cover or one-third of total vegetation must be herb.

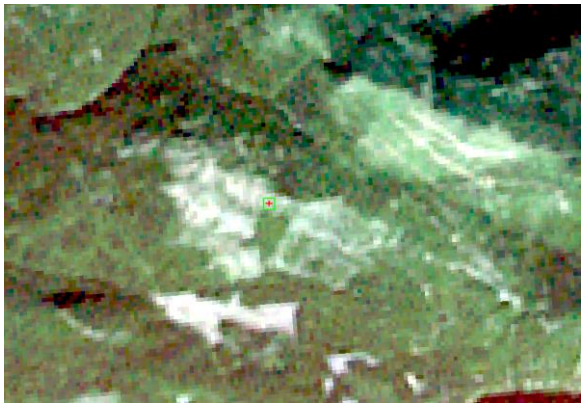
Video: Video chip of crops in a field.

Landsat: The field is located outside of a town or city evident through the road network and square features representing buildings.

Landsat: The most obvious way to identify a field is through its shape, generally fields are square or rectangular light green features.

Video: Harvested area (with road) beginning regeneration with herbaceous cover in video chip.

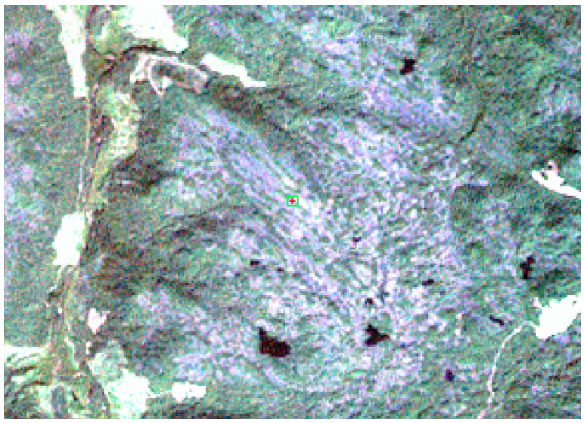
Landsat: Harvested areas with herbaceous land cover is often green - white in colour.



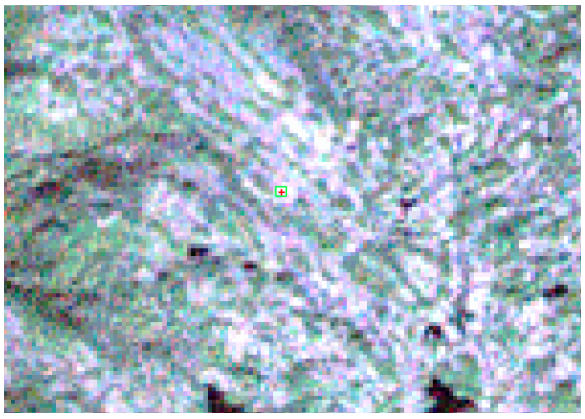
Landsat: This regenerating harvest, as shown in this example, temporally occurs right after an area has been cleared.

**EOSD Class:** Bryoids (40)
**Class Description:** Bryophytes (mosses, liverworts, and hornworts) and lichen (foliose or fruticose; not crustose); minimum of 20% ground cover **or** one-third of total vegetation must be a bryophyte or lichen.

Video: Lichen evident in video chip.



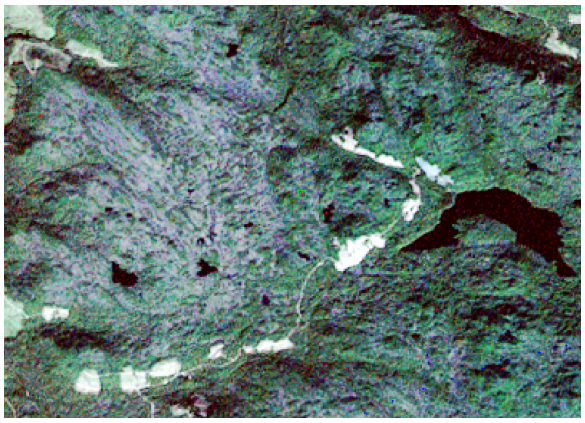
Landsat: The bryoid class appears mottled in the imagery with purple and green pixels.



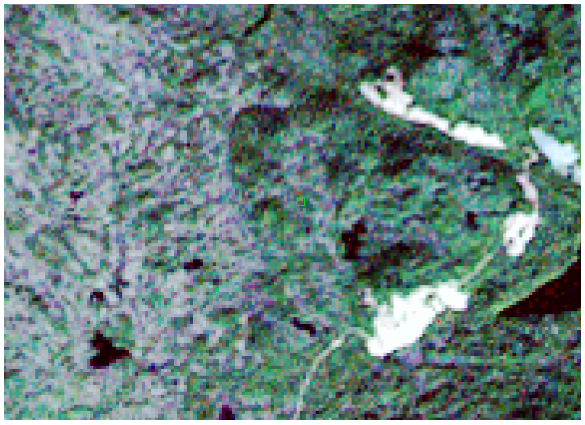
Landsat: The bryoid class is similar in spectral response to the wetland herb class, however generally is a more white – purple colour.

**EOSD Class:** Wetlands – treed (81)
**Class Description:** Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is coniferous, broadleaf, or mixed wood.

Video: The wetland treed class as it appears in the video chips.



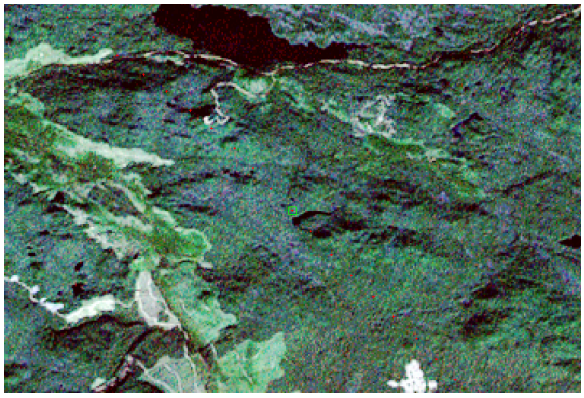
Landsat: The wetland treed class is illustrated by mottled pixels that are green, purple and blue in colour.



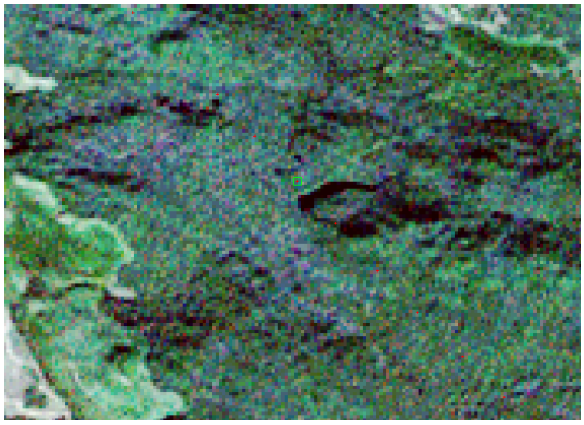
Landsat: The mottled appearance is due to the presence of both water and vegetation, and appears to have darker pixels then the bryoid and other wetland classes.

**EOSD Class:** Wetlands – shrub (82)
**Class Description:** Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is shrub.

Video: An example of the wetland shrub class in the video chips.



Landsat: The wetland shrub class contains mottled pixels that are green, purple and blue in colour.

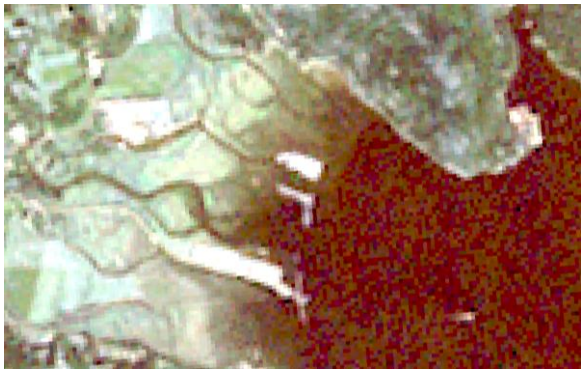


Landsat: It is often difficult to distinguish between wetland treed and wetland shrub since both are influenced by the presence of water and vegetation

**EOSD Class:** Wetlands – herb (83)
**Class Description:** Land with a water table near/at/above soil surface for enough time to promote wetland or aquatic processes; the majority of vegetation is herb.

Video: Inter-tidal zone in video chip.

Landsat: This area is unique in that for part of the time it is covered in water but when it is not, herbaceous cover is present.



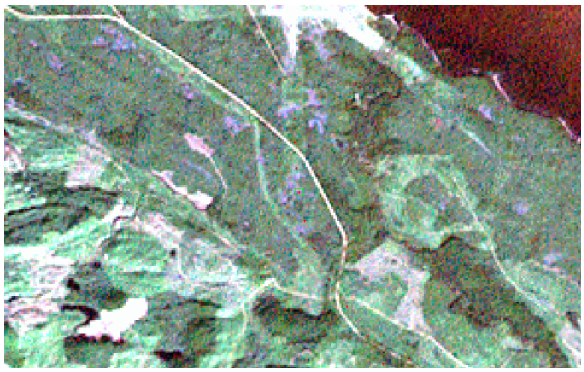
Landsat: Difficult to distinguish when the water is present, however, when not covered in water these areas are often characterized by green – brown coloured pixels.

Video: Wetland herb in video chip.

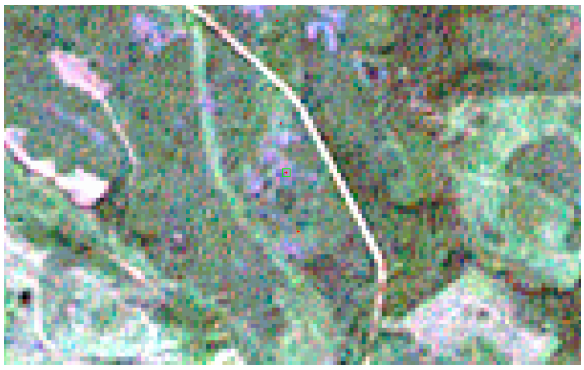
Landsat: Often in swampy, marshy patches.

Landsat: Pixels are generally purple – black in colour and are often in the shape of lake.

Video: Wetland herb land cover in video chip.



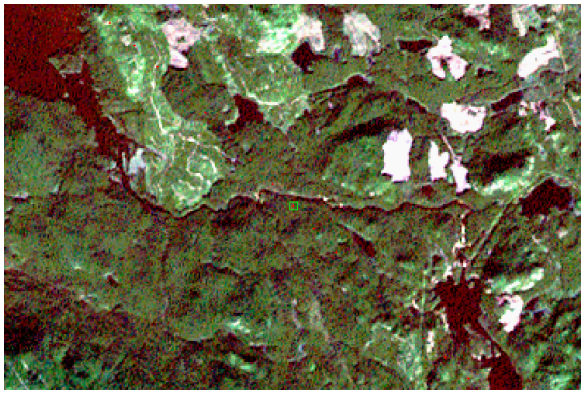
Landsat: Characterized by patchy purple – green pixels.



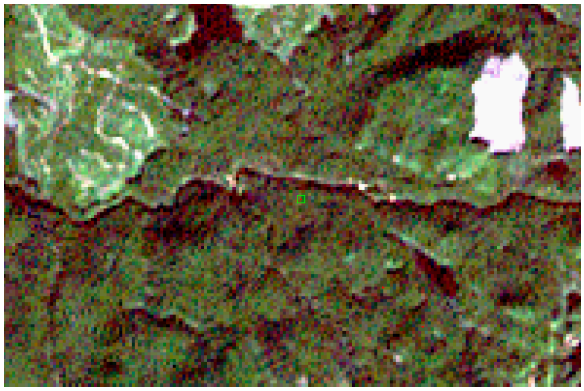
Landsat: As seen by the number of examples for this class, this class is not easily characterized with many different combinations of pixel colours.

**EOSD Class:** Coniferous Dense (211)
**Class Description:** Greater than 60% crown closure; coniferous trees are 75% or more of total basal area.

Video: Video chip of dense conifer forest.



Landsat: Dense conifer forests are often confused with shadow because of the intensity of the dark pixels. To aid in the labeling use various image enhancements.

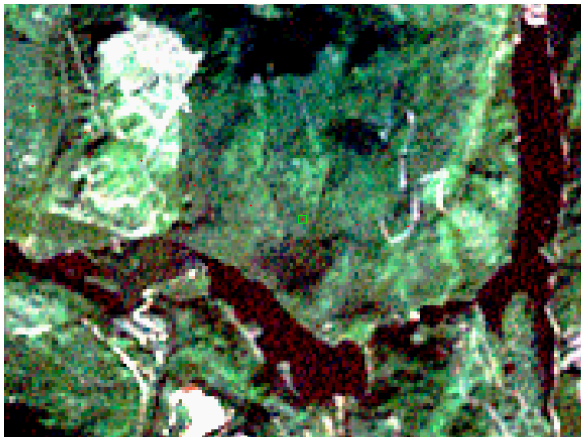


Landsat: Generally dark green pixels, sometimes black pixels.

**EOSD Class:** Coniferous Open (212)
**Class Description:** 26-60% crown closure; coniferous trees are 75% or more of total basal area.

Video: Example of coniferous open video chip.

Landsat: Coniferous open areas are generally a lighter tone of green than the coniferous dense class.

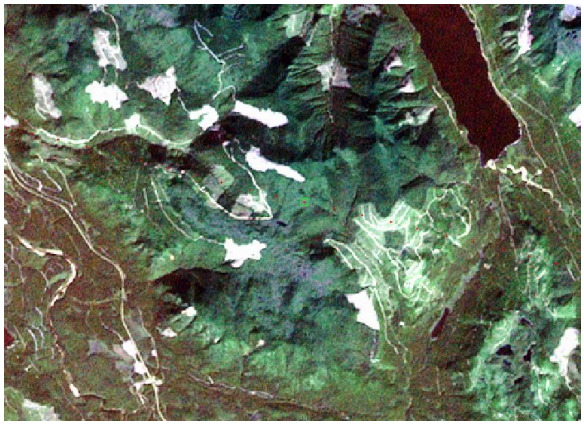


Landsat: Open coniferous forests can often be found close to dense coniferous forests.

**EOSD Class:** Coniferous Sparse (213)
**Class Description:** 10-25% crown closure; coniferous trees are 75% or more of total basal area.

Video: Example of conifer sparse class in video chip.

Landsat: Coniferous sparse forests often appear in areas that are fairly close to harvested areas (may look for contextual information, such as neighboring evidence of harvesting).



Landsat: Pixels in coniferous sparse classes are often light green to medium green in colour.

**EOSD Class:** Broadleaf Dense (221)
**Class Description:** Greater than 60% crown closure; broadleaf trees are 75% or more of total basal area.

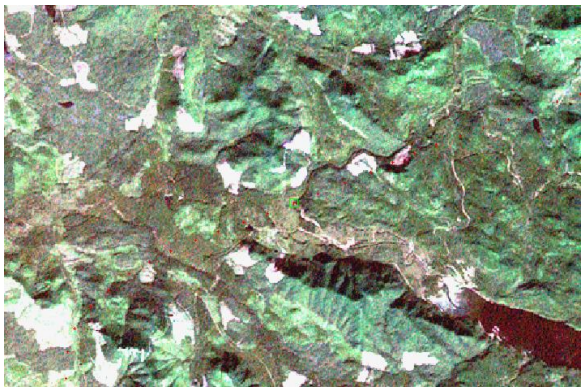
Video: Broadleaf dense forests as seen in a video chip.

Landsat: Broadleaf dense forests are generally a lighter shade of green then coniferous dense forests.

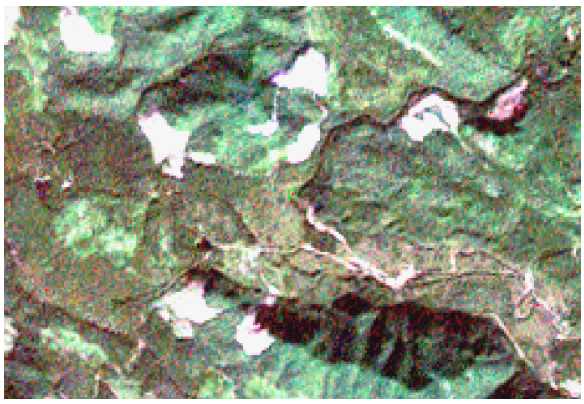
Landsat: Broadleaf dense forests are can often be found in areas where mixed wood forests are present.

**EOSD Class:** Broadleaf Open (222)
**Class Description:** 26-60% crown closure; broadleaf trees are 75% or more of total basal area.

Video: Example of broadleaf open land cover at video chip centre.



Landsat: The pixel colour of broadleaf trees tends to be brighter than those of conifer trees.

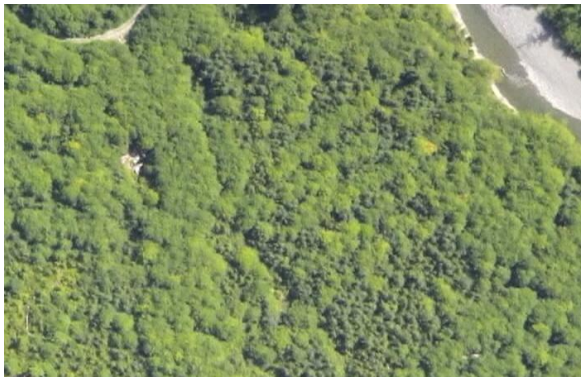


Landsat: Zoom in shows position of broadleaf trees in relation to the mixed forests evident in the video chip.

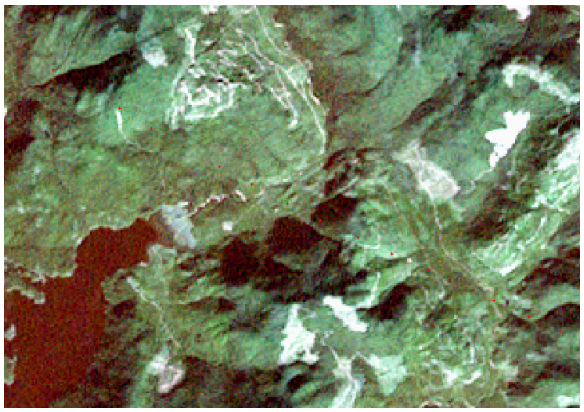
**EOSD Class:** Broadleaf Sparse (223)
**Class Description:** 10-25% crown closure; broadleaf trees are 75% or more of total basal area.

*Unable to find a representative example for this class.*

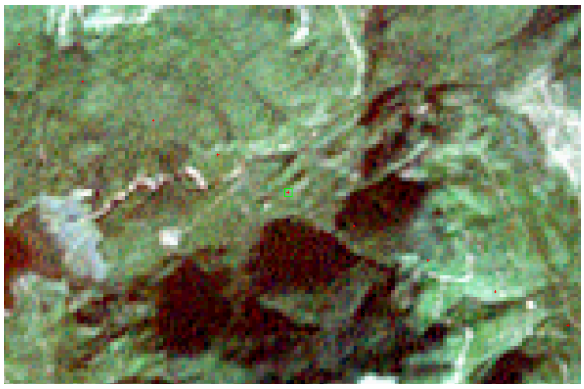
**EOSD Class:** Mixed Wood Dense (231)
**Class Description:** Greater than 60% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area.



Video: Mixed wood dense forest in video chip.

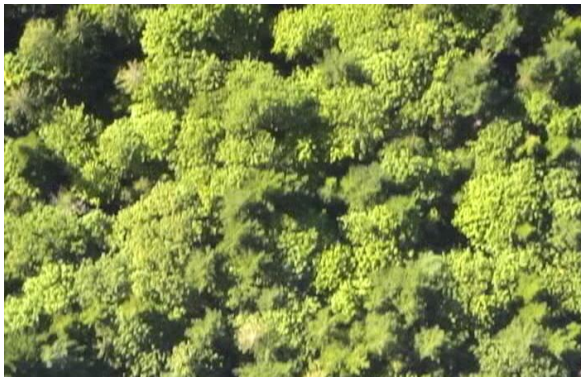


Landsat: Mixed wood dense forests often appear mottled dark and light green in colour.



Landsat: Mixed wood dense forests are sometimes mistaken for broadleaf dense forests due to the similarity in pixels colours.

**EOSD Class:** Mixed Wood Open (232)
**Class Description:** 26-60% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area.



Video: Example of mixed wood open video chip.

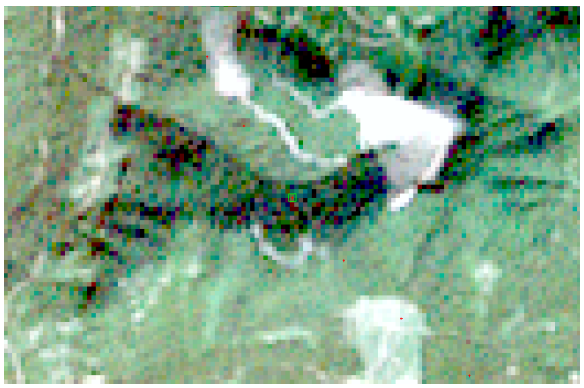
Landsat: Mixed wood open forests are often mottled green in colour and can difficult to distinguish from the broadleaf open class.

Landsat: Mixed wood open classes are generally appear to be brighter green in colour.

**EOSD Class:** Mixed Wood Sparse (233)
**Class Description:** 10-25% crown closure; neither coniferous nor broadleaf tree account for 75% or more of total basal area.

Video: Example of a mixed wood sparse forest in the video chip.

Landsat: Mixed wood sparse forests often occur in urban areas and can be difficult to label because the colour of the pixel is influenced by the material underneath the sparse canopy. In this particular case, the mixed wood stand is located on a hillside.



Landsat: Mixed wood sparse forests generally appear light green to light brown or white in colour.

## VII. Summary

There is a need to validate large area land EOSD cover products in Canada. Airborne video data provide a cost-effective method of establishing validation data for such mapping projects. Airborne data were acquired over Vancouver Island in August of 2004, acquiring over 10 hours of continuous video data along four transects of the island. This document provided some insight into the rationale of the project, and illuminated the need for validation of large area land cover products. The following elements were discussed in the document:

- EOSD class definitions;
- a brief description of the sampling design;
- EOSD classification hierarchy;
- primary and secondary class selection issues;
- forest density descriptions;
- differentiating between class and species mixtures; and,
- classification key illustrating representative video chips from each of the EOSD class.

This document provided a guideline for attribution video chip data and aimed to enable the consistent and transparent attribution of the validation sample.

## VIII. References


Czaplewski, R.L., 2003. Accuracy assessment of maps of forest condition. Pages 115-140 in Wulder, M.A.; Franklin, S.E. (eds.) 2003; Remote sensing of forest environments: Concepts and case studies. Kluwer Academic Publishers, Boston, 519 p.

Ministry of Forests, 2004. Glossary of Forestry Terms, http://www.for.gov.bc.ca/hfd/library/documents/glossary/index.htm, accessed October 19, 2004.

Ministry of Forests and Lands, 1987. Colour Stereogram Handbook. Ministry of Forests and Lands, Inventory Branch, Victoria, BC, Canada.

Wulder, M., M. Gillis, J. Luther, A. Dyk, 2001. A Guide to the Estimation of Canada's National Forest Inventory Attributes from Landsat TM Data, Version 2. Natural Resources Canada, Canadian Forest Service, Working paper, 84p.

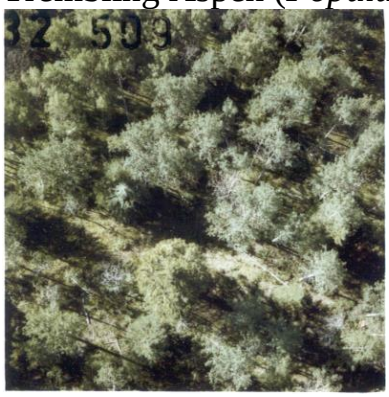
Wulder, M., M. Cranny, J. Dechka, and J. White, 2004. An illustrated methodology for land cover mapping of Forests with Landsat-7 ETM+ data: Methods in Support of EOSD Land Cover, Version 3. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada, March 2002, 35p.

Wulder, M., and T. Nelson, 2003. EOSD Land Cover Classification Legend Report, Version 2. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, BC, Canada, Jan. 2003, 83p.

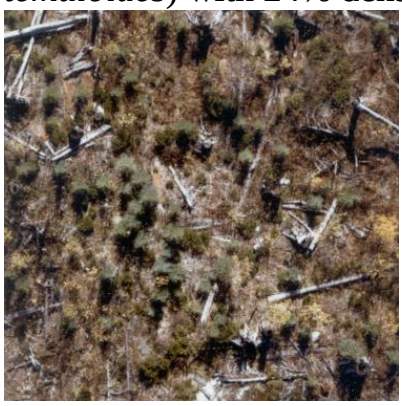
Wulder, M. A., J. A. Dechka, M. A. Gillis, J. E. Luther, R. J. Hall, A. Beaudoin, and S. E. Franklin, 2003. Operational mapping of the land cover of the forested area of Canada with Landsat data: EOSD land cover program. **Forestry Chronicle**, Vol. 79, No. 6, 1075-1083.

## Appendix 1: Handbook Examples

**1. Example of a Broadleaf Open (222) forest**
Trembling Aspen (*Populus temuloides*) with 52% density



**2. Example of a Mixed Wood Sparse (233) forest**
Engelmann Spruce (*Picea engelmannii*) and Trembling Aspen (*Populus temuloides*) with 24% density



**3. Example of a Mixed Wood Open (232) forest**
Trembling Aspen (*Populus temuloides*), Spruce (*Picea*) and Hemlock (*Tsuga*) with 52% density

**4. Example of a Coniferous Open (212) forest**

Yellow cedar (*Chamaecyparis nootkatensis*), Amabilis fir (*Abies amabilis*) and Western hemlock (*Pseudotsuga heterophylla*) with 55% density

**5. Example of a Broadleaf Dense (221) forest**

Red alder (*Alnus Rubra*) and Bigleaf maple (*Acer macrophyllum*) with 95% density

## Appendix 2: Spreadsheet Examples

Attribution spreadsheet:

| Video Chip Number | First Class Choice | Second Class Choice | Link to Video Chip | Comments |
|---|---|---|---|---|
| 1 | | | video-chips\vc_0001.jpg | |
| 2 | | | video-chips\vc_0002.jpg | |
| 3 | | | video-chips\vc_0003.jpg | |
| 4 | | | video-chips\vc_0004.jpg | |
| 5 | | | video-chips\vc_0005.jpg | |
| 6 | | | video-chips\vc_0006.jpg | |
| 7 | | | video-chips\vc_0007.jpg | |
| 8 | | | video-chips\vc_0008.jpg | |
| 9 | | | video-chips\vc_0009.jpg | |
| 10 | | | video-chips\vc_0010.jpg | |
| 11 | | | video-chips\vc_0011.jpg | |
| 12 | | | video-chips\vc_0012.jpg | |
| 13 | | | video-chips\vc_0013.jpg | |
| 14 | | | video-chips\vc_0014.jpg | |
| 15 | | | video-chips\vc_0015.jpg | |
| 16 | | | video-chips\vc_0016.jpg | |
| 17 | | | video-chips\vc_0017.jpg | |
| 18 | | | video-chips\vc_0018.jpg | |
| 19 | | | video-chips\vc_0019.jpg | |

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| | | | | |
|---|---|---|---|---|
| 2648 | | | video-chips\vc_2648.jpg | |
| 2649 | | | video-chips\vc_2649.jpg | |
| 2650 | | | video-chips\vc_2650.jpg | |
| 2651 | | | video-chips\vc_2651.jpg | |

Primary and secondary selection tally sheet (primary selection sheet shown below):

| EOSD Code | EOSD Class | Number of Chips Required | Number of Chips | Number of Chips Remaining | Total Number of Chips Attributed with EOSD Codes | Total Number of Chips Attributed |
|---|---|---|---|---|---|---|
| 0 | No Data | 0 | 0 | 0 | | |
| 12 | Shadow | 0 | 0 | 0 | | |
| 11 | Cloud | 0 | 0 | 0 | | |
| 31 | Snow | 19 | 0 | 19 | | |
| 32 | Rock | 13 | 0 | 13 | | |
| 33 | Exposed Land | 21 | 0 | 21 | | |
| 20 | Water | 25 | 0 | 25 | | |
| 50 | Shrub | 24 | 0 | 24 | | |
| 100 | Herb | 33 | 0 | 33 | | |
| 40 | Bryoids | 13 | 0 | 13 | | |
| 81 | Wetland-treed | 15 | 0 | 15 | | |
| 82 | Wetland-shrub | 14 | 0 | 14 | | |
| 83 | Wetland-herb | 13 | 0 | 13 | | |
| 211 | Coniferous Dense | 31 | 0 | 31 | | |
| 212 | Coniferous Open | 148 | 0 | 148 | | |
| 213 | Coniferous Sparse | 39 | 0 | 39 | | |
| 221 | Broadleaf Dense | 18 | 0 | 18 | | |
| 222 | Broadleaf Open | 13 | 0 | 13 | | |
| 223 | Broadleaf Sparse | 13 | 0 | 13 | | |
| 231 | Mixedwood Dense | 13 | 0 | 13 | | |
| 232 | Mixedwood Open | 13 | 0 | 13 | | |
| 233 | Mixedwood Sparse | 13 | 0 | 13 | | |
| | | | | | 0 | 0 |
| 999 | Video Chips Not Appropriate for Attribution | 0 | 0 | | | |