Interpretation guide of natural geographic features from ETM+ Landsat imagery and aerial photography: Palsa bog

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Introduction

The purpose of this project is to create a visual interpretative guide to the natural geographical entities in the geospatial database (GDB) using Landsat7 ETM+ imagery and aerial photography. The methodology and information fact sheet were developed by Provencher and Dubois (2004a), and the application of this procedure to a test case has already garnered a consensus among the staff of CTI at Sherbrooke (Provencher and Dubois (2004b). The meanings of the sections of the fact sheets are explained in the appendix.

The eight natural entities in the GDB (Centre for Topographic Information, 2004) fall under eight themes that are grouped into three domains: hydrography, landforms, and vegetation (Table 1). In practice, for interpretive purposes they are often subdivided further and represented by 17 fact sheets.

N.B.: Elaboration of the illustrative examples and potential elements of confusion was constrained by the limited time allocated to this guide. It is recommended that they be supplemented as other cases are documented, especially from Landsat ETM+ imagery.

Table 1: Hierarchy of natural geographical entities

Domain	Theme	Sub-theme	GDB entity	Fact sheet
Hydrography	Watercourse	Perennial watercourse	Permanent water	Permanent water
		Alluvium	Intermittent water	Intermittent water
		Waterfall	Water disturbance	Waterfalls and rapids
		Rapids	Water disturbance	Waterfalls and rapids
	Waterbody	Perennial freshwater body	Permanent water	Permanent water
		Alluvium, rocky surface	Intermittent water	Intermittent water
		Saltwater	Permanent water	Permanent water
		Alluvium, rocky surface (tidal flat)	Intermittent water	Intermittent water
		Reef	Water disturbance	Reef
	Wetland	Tundra pond	Saturated soil	Tundra ponds
		Palsa bog	Saturated soil	Palsa bog
		Marsh, swamp, and uniform peat bog (wetland)	Saturated soil	Wetlands (marshes and swamps, peat bogs
		String bog	Saturated soil	Wetlands (string bog)
Landforms	Glacial landform	Glacial debris	Landform	Glacial debris
		Esker	Landform	Esker
		Moraine	Landform	Moraine
		Glacier, glacial ice cap, and ice shelf	Permanent snow and ice	Permanent snow and ice
	Periglacial landform	Polygonal soil	Landform	Tundra polygon
		Pingo	Landform	Pingo
	Littoral landform	Barrier beach and spit	Landform (sand)	Barrier beach and spit
	Eolian landform	Dunes	Landform (sand)	Dunes
Vegetation	Wooded region		Wooded region	Wooded region

1- Name of entity

Palsa bog

2- Hierarchy

Hydrography – saturated soil – palsa bog

3- Definition

A boggy zone featuring mounds of peat and ice, generally less than 10 metres high (CTI, 2004).

Palsa: a circular or elongated mound comprised of a layer of peat covering an unconsolidated mineral formation and a core of ice (Boivin, 2005). According to Brochu and Michel (1994), palsa is a flat-topped knoll that forms over an ice core, frozen peat, or frozen mineral material.

4- Summary table of elements of identification

Table 2: Summary table of elements of identification for palsa bogs

Shape	View from top: circular or elongated View from side: flat-topped knoll
Dimensions	Diameter: decametres
Topographic position	Associated with peat bogs
Drainage	Average to good
Vegetation	Absent
Emplacement process	Development of an ice lens
State	Active form; stable in the human timeframe
Spatio-temporal variations	Evolves slowly (decadal scale); formation or disintegration
Environment	A peat structure in an environment of discontinuous permafrost
Identification on imagery	Bands 4-3-2 and band 5
Identification with B/W aerial photography	Pale hue Circular or egg-shaped
Elements of confusion	Pingo

5- Characteristics

5.1- Specific to the entity

5.1.1- Shape

Palsa is circular or elongated and its top is generally flat. According to Brochu and Michel (1994), palsen (plural of palsa) usually occur in clusters, as in the region east of the Hudson Sea.

5.1.2- Dimensions

Diameter: from approximately one decametre to a few decametres.

Height: from one to five metres.

Area: Palsen fields may extent over 1 km in length and over 200 m in width (Brochu and Michel, 1994).

5.1.3- Topographic position

Same topographic position as the bogs in which they form.

5.1.4- Drainage

The drainage of the bog containing the palsa is poor. However, owing to its elevation above the surrounding bog and its steep slopes, the actual palsa drains quite well.

5.1.5- Vegetation

Palsa is devoid of vegetation.

5.2- Relative to the entity's dynamics

5.2.1- Emplacement process

Palsa forms around a lens of ice in a boggy environment. The coalescing of segregated ice causes this core of ice to crystallize in an environment that is cold and saturated with water. The lens of ice raises the overlying layer of peat, thus pushing up the knoll. During a subsequent phase, splintering of the surface caused by buckling allows heat to penetrate and results in a gradual thawing of the ice and the collapse of the knoll.

5.2.2- State

Palsa is a current and active formation in zones of discontinuous permafrost.

5.2.3- Spatio-temporal variations

Palsa is stable in the human timeframe. It appears and evolves on a decadal scale, in terms of both its formation and disintegration by melting.

5.3- Relative to the environment

Palsa is found in discontinuous permafrost environments in Canada's near north region.

6- Optimal conditions for identification on satellite imagery

Because they are associated with peat bogs, palsen are easily detected on aerial photography.
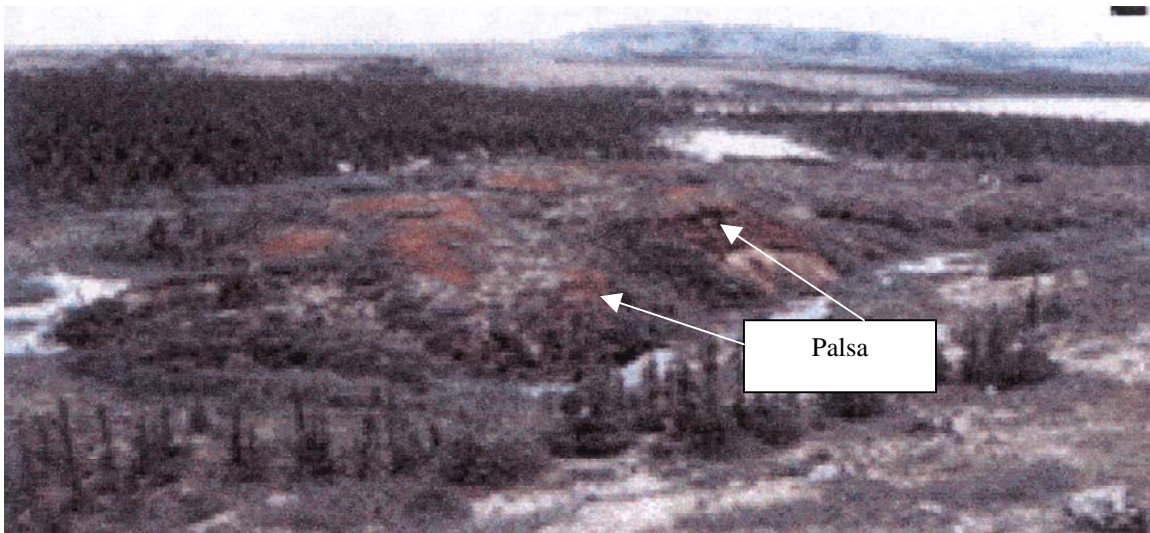
On ETM+ imagery, it should be possible to distinguish individual palsa from the bog, provided the knoll is large enough to register.
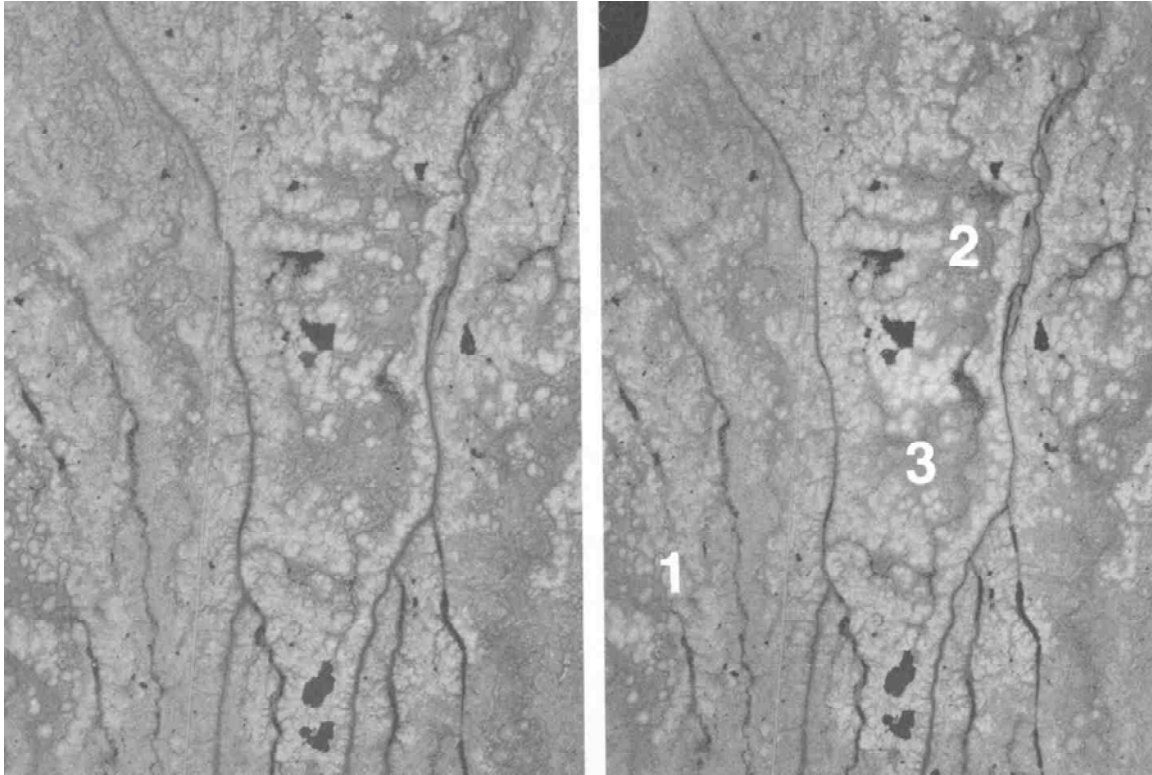
7- Examples

Source : Le Québec en images, photographie 16 240, Jamésie, Dubois J.-M.M. (79-8-33)

Figure 1 : Example of a palsa in peat depression

Source : Van Vliet-Lanoë, (2005), Boniface area , East of Hudson Bay (Québec)

Figure 2 : Aerial view of an 8 m high palsa

Source : photo A17406 (56-57), map 54 L/08, 58°25' N – 94°07' O, Bygot area (Manitoba), Molland et James (1985, p. 391)

Figure 3 : Example of palsa in a peat plateau in 1, 2 and 3

8- Interpretation

8.1- Critical path

The critical path encompasses two phases: distinguishing and delimiting the form, and identifying it.

8.1.1- Distinction and delimitation

On aerial photography, the distinction and delimitation of palsa is facilitated by the fact that it is a raised mound that stands out from the surrounding bog. Its hue being paler than that of the bog also makes it easier to distinguish and delimit.

On ETM+ imagery, palsa should stand out in band 5, which captures the difference in humidity with the bog.

8.1.2- Identification

The identification process for palsa requires that the analyst address the various elements of confusion and distinction (Table 3). The greater the analyst's knowledge and experience, the more accurate the outcome of this labour of discrimination will be.

8.2-   Cross-checking with complementary sources of information

Consult the *Atlas of Canada* (http://atlas.gc.ca) for the distribution of discontinuous permafrost zones, and Hamelin and Cook (1967) for supplementary information on the geomorphology of palsa.

9- Elements of confusion

Table 3: Elements of confusion and recognition between palsa and other entities or forms

Entity or form	Elements of confusion	Elements of recognition	Examples
Pingo	- Similarity of shape	- Size and height - Geomorphic context	

10- Bibliography

Boivin, A. (2005) Les principales formes périglaciaires : essai de classification et de synthétisation, Département de Géographie et télédétection, Université de Sherbrooke, Sherbrooke, 81 p.

Brochu, M. et Michel, J.-P. (1994) Dictionnaire de géomorphologie à caractère dimensionnel, Édition ESKA, Gérin Universitaire, Montréal, 298 p.

Dallimore, S.R. (2004) Palse à Churchill, Manitoba. Natural Tesources Canada, Terrain Sciences Division, Cancadian Landscapes,Ressources Naturelles Canada, Gouvernement du Canada, (http://geodiscover.cgdi.ca/gdp/rs?action=gerSummaries)

Hamelin, L.-E. et Cook, F.A. (1967) Le périglaciaire par l'image, Les presses de l'Université Laval, Québec, 237 p.

Van Vliet-Lanoë, B. (2005) Extension de pergélisol en Europe au dernier Maximum glalciaire (20 ka BP). Centre national de la recherche scientifique, (http://www.cnrs.fr/cw/dossiers/dosclim/dechfran/4theme/paleo/pergelisol.html).

Appendix: the meanings of the sections

1. Name of entity

The name of the entity as it appears in the GDB and in Topolan7.

2. Position in hierarchy

The position of the entity in the hierarchical structure of entities in the GDB.

3. Definition

A brief description based on the entity's principal characteristics and allowing it to be distinguished from any other natural or manmade entity in the GDB.

Only the core features are part of the definition. A detailed description of the characteristics necessary for identification is given in Section 4.

4. Summary table of elements of identification

Presentation of a table summarizing the entity's characteristics (Section 5), of the optimal conditions for identification on ETM+ imagery and black and white (B/W) aerial photography (Section 6), and of the elements of confusion (Section 9).

5. Characteristics

Categorization and description of the characteristics useful for visual identification of the entity.

5.1. Specific to the entity

Characteristics unique to the entity that allow all aspects useful for its identification to be grasped.

5.1.1. Shape

Distinction between linear, point, and areal shapes, three-dimensional pattern of the entity.

5.1.2. Dimensions

Expanse (length, width, diameter) and height of the entity: minima, maxima, and means.

5.1.3. Topographic position

Location of the entity relative to major landforms: drainage basin, mountain, plateau, plain, valley, slope, etc.

5.1.4. Drainage

Surface moisture, outside of saturated zones, in connection with the texture of the materials in the entity.

5.1.5. Vegetation

Presence of vegetation typical of the entity or patterns of plant associations making it possible to distinguish the entity.

5.2. Relative to the entity's dynamics

Characteristics pertaining to the origin and the state of the entity.

5.2.1. Emplacement process

The agent or set of agents responsible for the entity's emplacement and evolution.

5.2.2. State

Dynamic state of the entity: inherited or current. In the case of inherited features, we speak of paleolandforms; in the case of current landforms, we speak of their ongoing formation.

5.2.3. Spatio-temporal variations

Variations in the entity or its appearance that are functions of cyclical conditions (seasonal, multi-year, etc.) or event driven.

5.3. Relative to the environment

Characteristic of the conditions in the entity's milieu and its relationship with other entities or forms present in this milieu.

6. Optimal conditions for identification

Drawing on documentary sources and the experience of the participants, establishment of the optimal conditions for visual identification of the entity. Using satellite imagery, determine the capability of Landset7 ETM+ to capture the characteristics of the entity and identify the band or combination of bands best for visually distinguishing and identifying the entity. Using B/W aerial photography, identify the hues and textures that are most representative of the entity. In cases in which the relief may be significant, recommend the use of stereoscopy.

7. Examples

Illustrating the entity with examples reflecting several of its aspects:

7.3. Land-based photography

Photographs of the landscape that present one or several examples of the entity's aspects, as they might be seen from the ground.

7.3. Aerial photography

Oblique or vertical aerial photographs that present on or several examples of the entity's aspects, as they might be seen from the air.

7.3. Satellite imagery

Satellite images (from Landsat7 ETM+) that present one or several examples of the entity's aspects, as they might be seen from space.

8. Interpretation

Identification of the entity proceeds from interpreting the information in the imagery or aerial photography and complementary sources of information. The quality of the outcome of this interpretive activity will depend upon the knowledge and the experience of the analyst.

8.1. Critical path

Establishing a unique critical path of interpretation for each entity from the imagery or aerial photography on the basis of its characteristics.

8.1.1. Distinction and delimitation

The possibility of distinguishing and delimiting the shape on the image or aerial photograph has been established and the criteria for success have been described.

8.1.2. Identification

Contrasting the various elements of confusion and recognition with other entities or forms for purposes of identification.

8.2. Use of complementary sources of information

Complementing or cross-checking the interpretation with additional sources of information that are easily accessible, such as those on known Internet sites.

9. Elements of confusion

Identifying the entities and forms with which the entity in question can be confused in a table, along with the differentiating features.

10. Bibliography

A list of useful documents quoted in the previous sections.