Remote Sensing Models for Whitebark and Limber Pine Mapping

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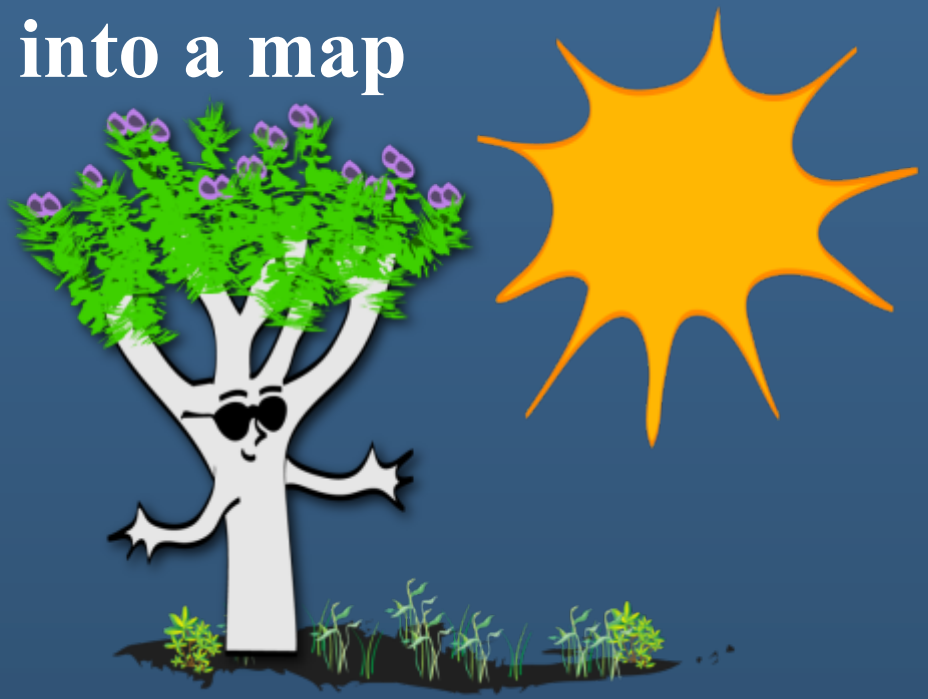
Introduction: Raison d'être

1. **Build a model**
   - Ideally, a model would compliment known controls on whitebark and limber pine distribution

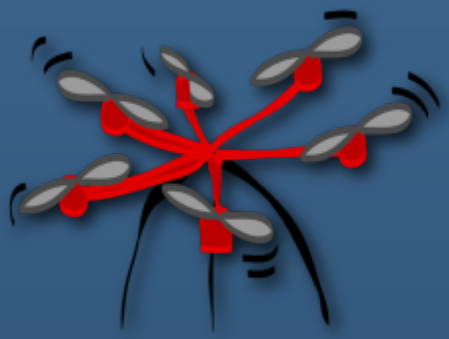
2. **Convert the model into a map**

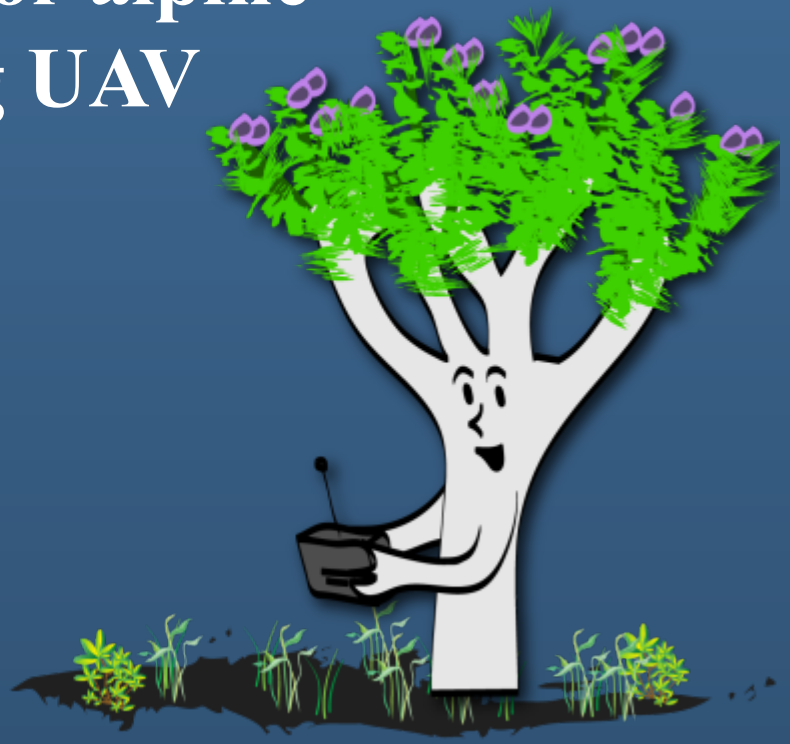


Introduction: 2 Main Things

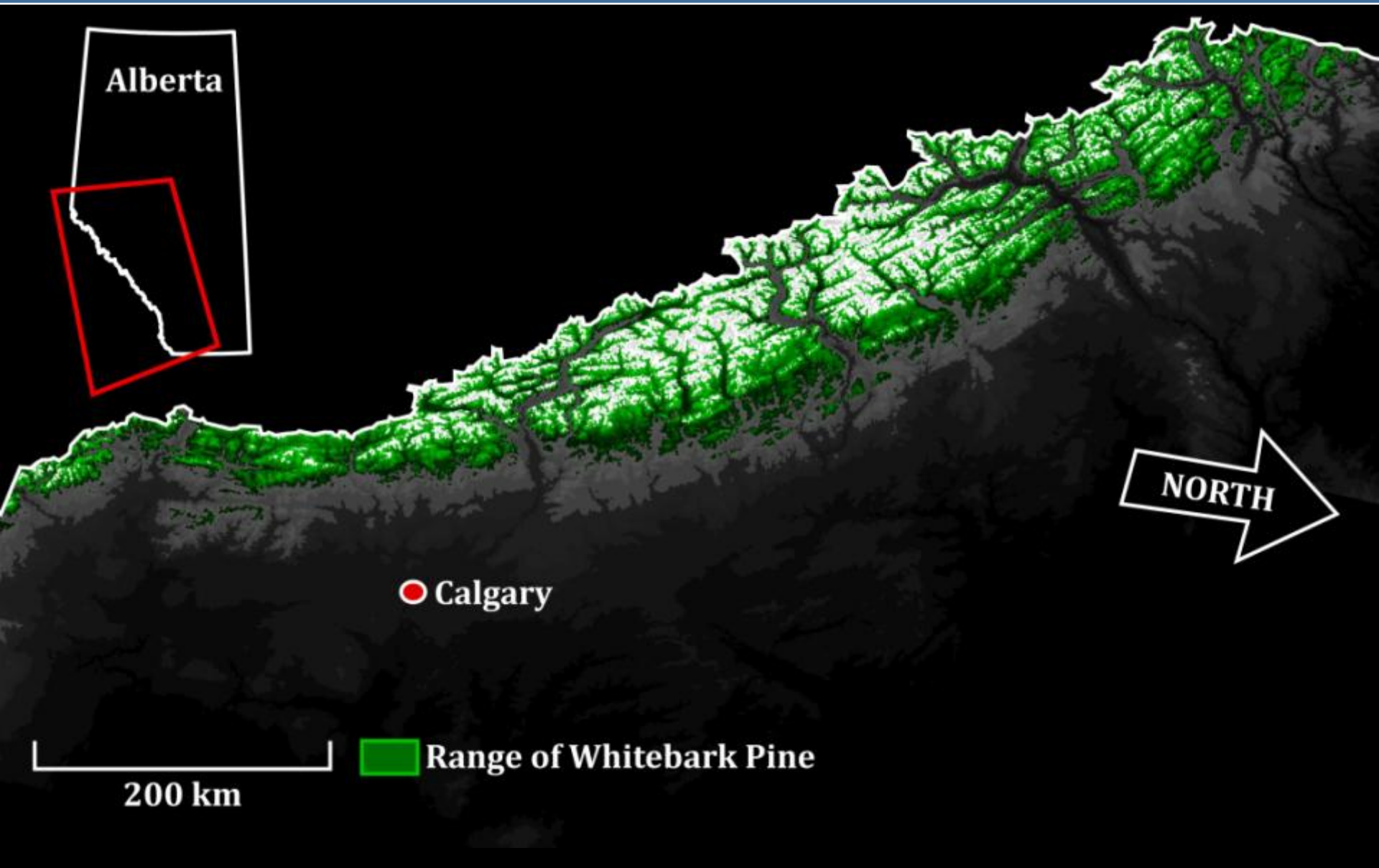
1. Model → Map software

2. Equipment & methods for alpine vegetation surveys using UAV





Introduction: Study Area



Model Building: Ground Truth

1. ACIMS Archive
2. Field Campaigns
3. Aerial Photo Interpretation

Ground Truth: ACIMS Archive

Element Occurrence Record

2010-05-06
Page #: 78

Pinus albicaulis

SRank: S2 Are Occurrences Tracked?: Y
Global Rank: G4
Alberta Wildlife Act Designation:
AlbertaGeneral Status: May Be At Risk

whitebark pine

Element Code: PGPIN04010 Occurrence Code #: 022 Eo_id: **18020** Type: **Sub** Data Entry Quality Checked? : N
Identification OK?: Actual Mapping Precision (m): 15 Precision Code: S
Data Sensitive?: N

Survey Date: 2003-07-15 Last Observed: 2003-07-15 First Observed: 2003-07-15

Occurrence Type:

Related Occurrence (EO)	Master (M) or Sub (S)
251	M

Note:
A Sub EO will show only the related Master EO in this list.
A Master EO will list all Sub EOs related to it.
A Master EO is always related to itself).

Location ***(Coordinates shown are "centroid" of occurrence polygon(s))***

UTM Grid Zone: **11** UTM Easting NAD83 (m): 494315 UTM Northing NAD83 (m): 5780683

10TM Easting NAD83 (m): 357619 10TM Northing NAD83 (m): 5780411

Latitude: 52°10'35.74" Longitude: -117°4'59.31"

Directions: Banff National Park; Backside of Parker Ridge
General Description: Open Pinu alb and closed Pinu alb - Abie las

Minimum Elevation: 2153 m Slope: 50.00 Size of Occurrence: 0.00
Maximum Elevation: 2164 m Aspect:

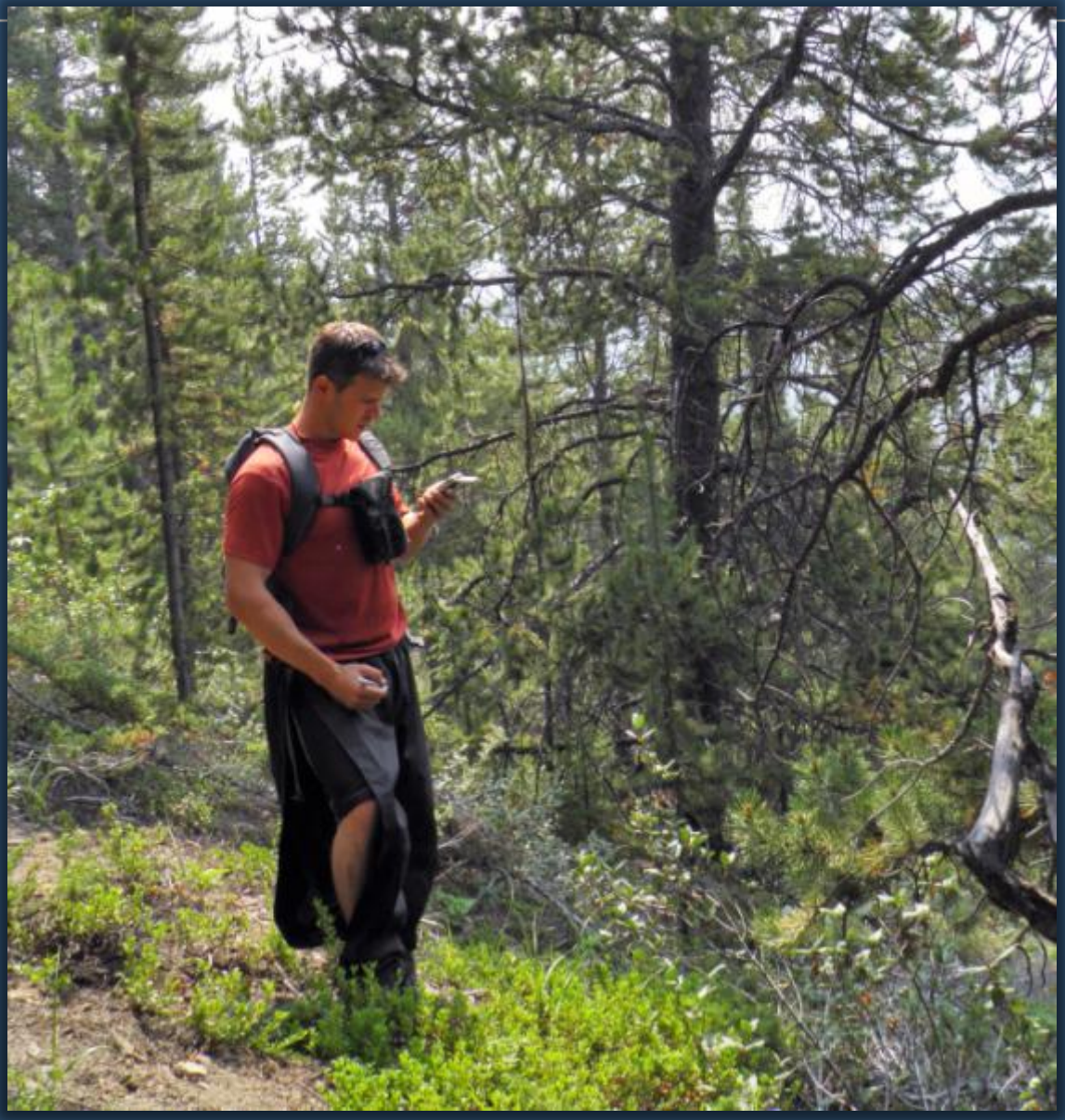
Occurrence Data

Ground Truth : ACIMS Archive

Single Point or Area Plot assumed to be in center of stand
Point is at location of a tree (within 15m)
Point has been verified (or moved) to lie within a homogeneous stand between two or more verified points
Point is halfway between two close proximity points on a two-point transect
Point is halfway between two close proximity points on a multiple-point transect
Point is average of a cluster of points on a multiple-point plot
Point placed on a transect between 30-100m from endpoint - based on RGB imagery
May need work: Point is halfway between two distant proximity points on a two-point transect
Point may not represent a stand - only one or two trees spotted or not representative
Bad point - reasoning specified in plot notes

TYPE	CREW	DATE_	StartX	StartY	StopX	StopY	Tdistance	TX	TY	UTMX	UTMY	N83Z11X	N83Z11Y	PDOP	ELEV	SLOPE	ASPECT
Transect	Ainsley/Benner	02/08/2005	710132	5477734	710041	5477779	102	710087	5477757	709980	5477809	710087	5477757	25	1432	27	204
Transect	Gould/Allen/Meijer	13/06/2007	679859	5671772			0	679859	5671772	679822	5671904	679859	5671772	25			
Transect	Gould/Allen/Meijer	13/06/2007	679802	5672040			0	679787	5672055	679822	5671904	679787	5672055	25			
Point Plot	Blake	01/08/2009					0	309892	5986180	310195	5986309	309892	5986180	25			
Point Plot	Blake	01/08/2009					0	310285	5986256	310195	5986309	310285	5986256	25			
Point Plot	Blake	01/08/2009	310368	5986604	310319	5986619	0	310343	5986611	310195	5986309	310343	5986611	25			
Transect	I.Smith	03/07/2003	563961	5679850	563932	5679848	29	563947	5679849	563902	5679847	563947	5679849	15	2048	62	200
Transect	I.Smith	04/07/2003	596982	5672204	596948	5672195	35	596965	5672200	596972	5672223	596965	5672200	15	2117	50	190
Transect	I.Smith	04/07/2003	596951	5672263	597015	5672205	86	596983	5672234	596972	5672223	596983	5672234	15	2113	70	30
Transect	I.Smith	07/07/2003	599317	5667089	599275	5667058	52	599296	5667074	599272	5667135	599296	5667074	15	2205	70	230
Transect	I.Smith	07/07/2003	599262	5667155	599239	5667218	67	599251	5667187	599272	5667135	599251	5667187	15	2232	40	260
Transect	I.Smith	15/07/2003	494332	5780693	494302	5780703	32	494317	5780698	494315	5780683	494317	5780698	15	2164	50	190
Transect	I.Smith	15/07/2003	494329	5780680	494310	5780658	29	494320	5780669	494315	5780683	494320	5780669	15	2153	55	240
Transect	I.Smith	16/07/2003	534005	5764971	533987	5765018	51	533997	5764995	533994	5764998	533997	5764995	15	2217	55	240
Transect	I.Smith	22/07/2003	561026	5720351	561087	5720358	61	561057	5720355	561057	5720355	561057	5720355	15	2265	65	190
Transect	I.Smith	23/07/2003	562023	5719912	562042	5719887	31	562033	5719900	562047	5719907	562033	5719900	15	2145	45	240
Transect	I.Smith	23/07/2003	562071	5719905	562053	5719925	26	562062	5719916	562047	5719907	562062	5719916	15	2175	65	230
Transect	Leslie/I.Smith	14/06/2004	676376	5562826	676452	5562857	82	676414	5562842	676417	5562894	676414	5562842	15	2160	60	170
Transect	Leslie/I.Smith	14/06/2004	676393	5562936	676446	5562975	66	676420	5562956	676417	5562894	676420	5562956	15	2232	65	150
Transect	Leslie/I.Smith	15/06/2004	673575	5564351	673566	5564331	22	673571	5564341	673571	5564341	673571	5564341	15	2200	30	220
Transect	Leslie/I.Smith	15/06/2004	673527	5565295	673525	5565262	33	673526	5565279	673526	5565279	673526	5565279	15	2324	35	240
Transect	Leslie/I.Smith	05/07/2004	616205	5645047	616205	5645106	59	616205	5645077	616205	5645077	616205	5645077	15	2109	65	110
Transect	Leslie/I.Smith	13/07/2004	573685	5683728	573643	5683737	43	573664	5683733	573689	5683775	573664	5683733	15	2120	60	190
Transect	Leslie/I.Smith	13/07/2004	573734	5683808	573694	5683825	43	573714	5683817	573689	5683775	573714	5683817	15	2165	70	200
Transect	Leslie/I.Smith	26/07/2004	516949	5752756	516834	5752612	184	516920	5752724	516834	5752591	516920	5752724	15	2067	60	60
Transect	Leslie/I.Smith	26/07/2004	516828	5752568	516790	5752608	55	516809	5752588	516834	5752591	516809	5752588	15	2070	70	60
Transect	Leslie/I.Smith	27/07/2004	505368	5770771	505362	5770824	53	505365	5770798	505389	5770798	505365	5770798	15	2020	60	240
Transect	Leslie/I.Smith	27/07/2004	505428	5770779	505378	5770837	77	505403	5770808	505389	5770798	505403	5770808	15	2022	70	210
Transect	Leslie/I.Smith	29/07/2004	547784	5718364	547829	5718317	65	547807	5718341	547830	5718379	547807	5718341	15	1966	40	230
Transect	Leslie/I.Smith	29/07/2004	547864	5718392	547845	5718447	58	547855	5718420	547830	5718379	547855	5718420	15	2011	70	250
Transect	Leslie/I.Smith	29/07/2004	536037	5725692	535968	5725697	69	536003	5725695	536018	5725672	536003	5725695	15	2116	60	180
Transect	Leslie/I.Smith	23/08/2004	491049	5783335	490995	5783370	64	491022	5783353	490994	5783351	491022	5783353	15	2058	40	210
Transect	Leslie/I.Smith	23/08/2004	491010	5783329	490937	5783364	81	490974	5783347	490994	5783351	490974	5783347	15	2065	65	210
Transect	Leslie/I.Smith	25/08/2004	492166	5783091	492134	5783065	41	492150	5783078	492150	5783078	492150	5783078	15	2034	20	160
Transect	I.Smith	06/08/2003	425220	5870854	425142	5870965	136	425181	5870910	425142	5870914	425181	5870910	15	2005	30	210
Transect	I.Smith	06/08/2003	425047	5870943	425059	5870907	38	425053	5870925	425142	5870914	425053	5870925	15	2038	20	180

Ground Truth : Field Campaigns



Ground Truth: Aerial Photos

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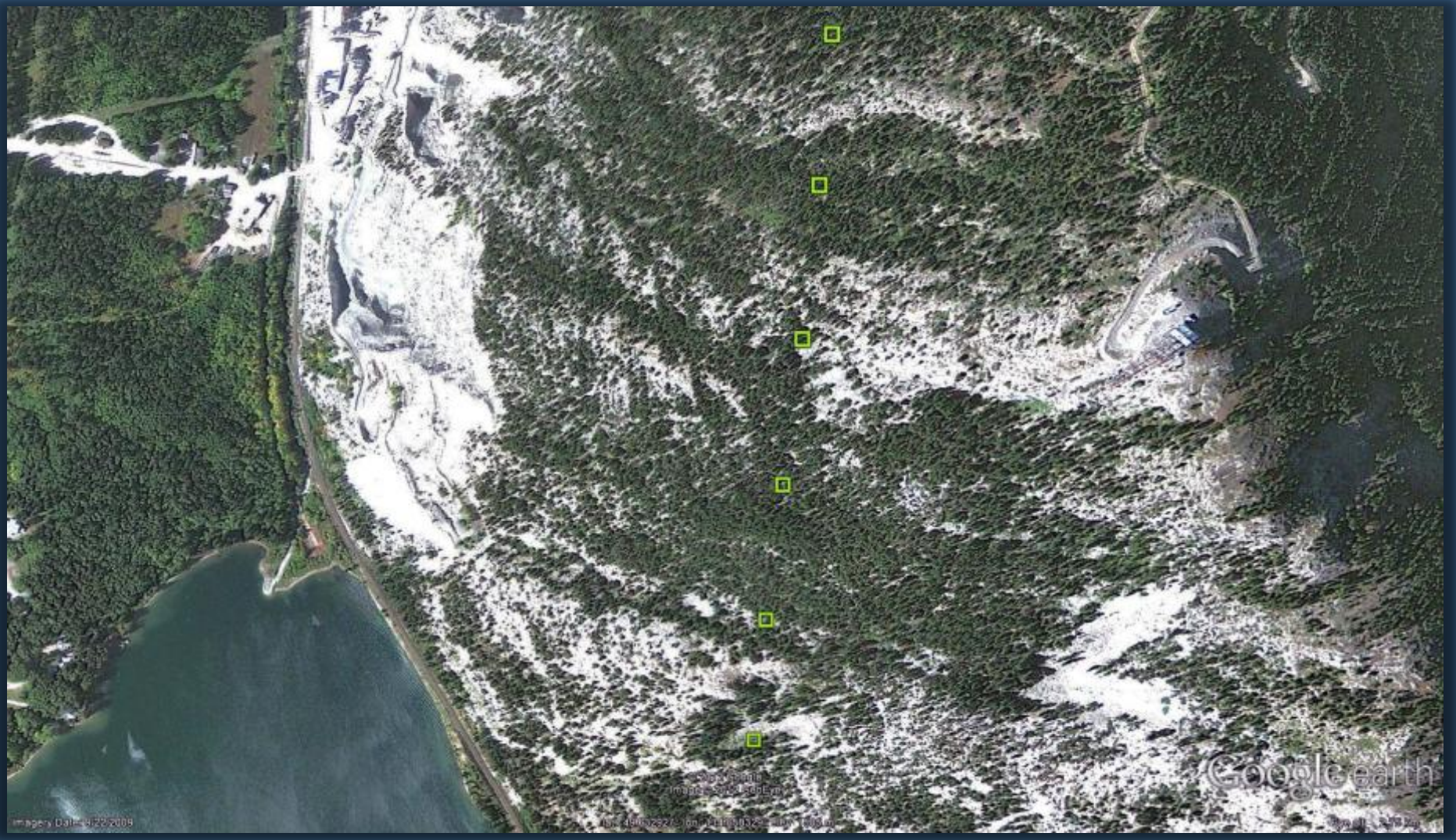

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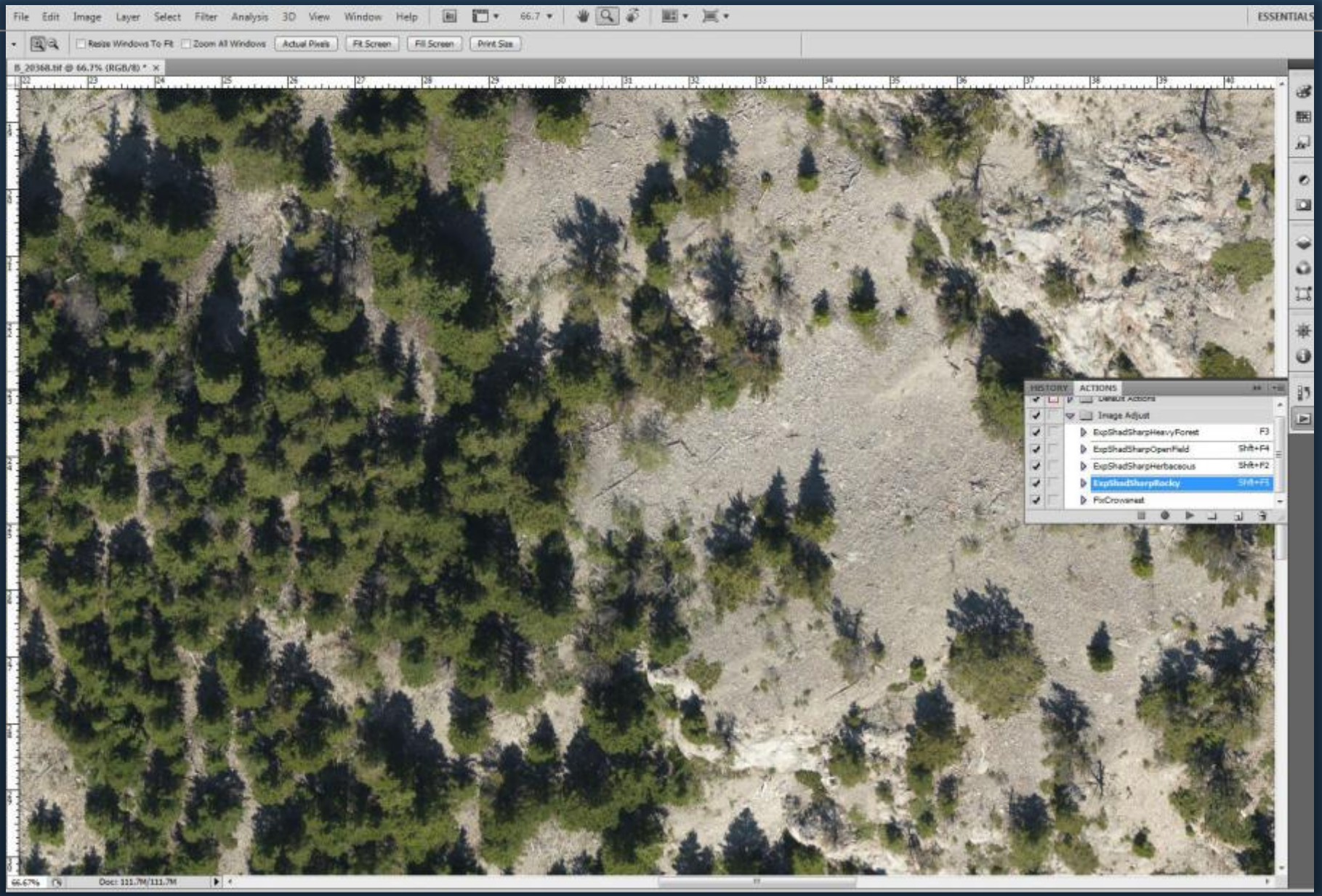

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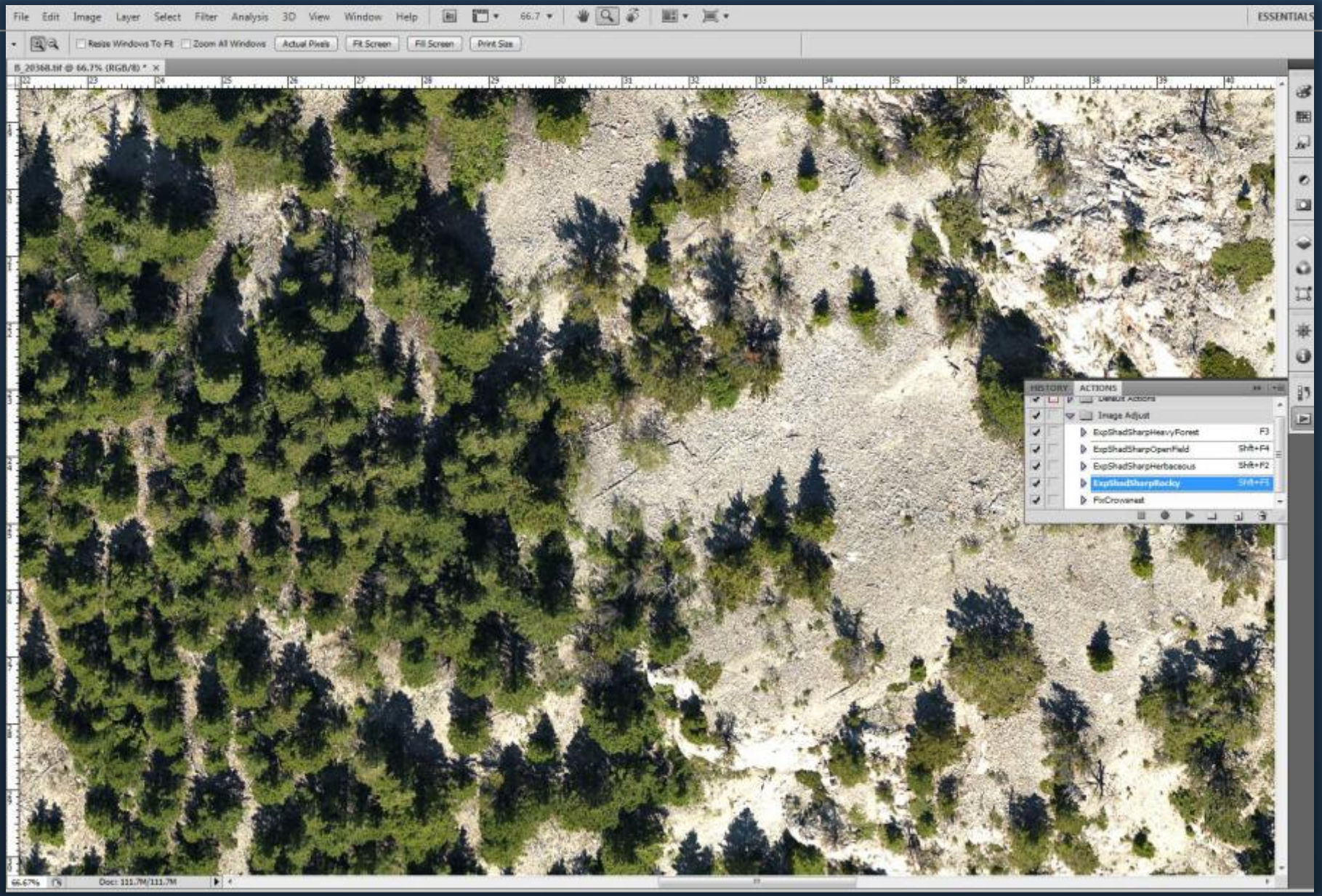

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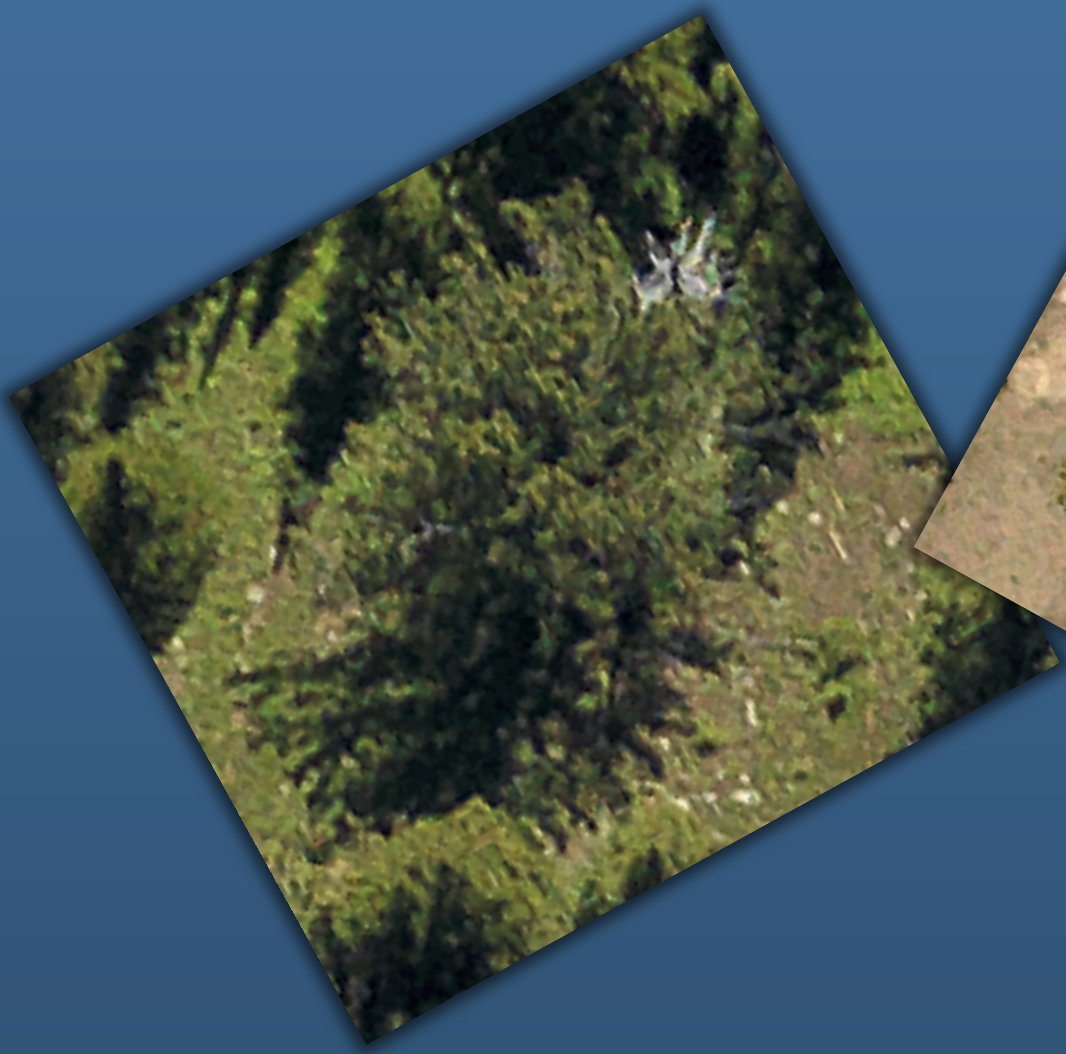

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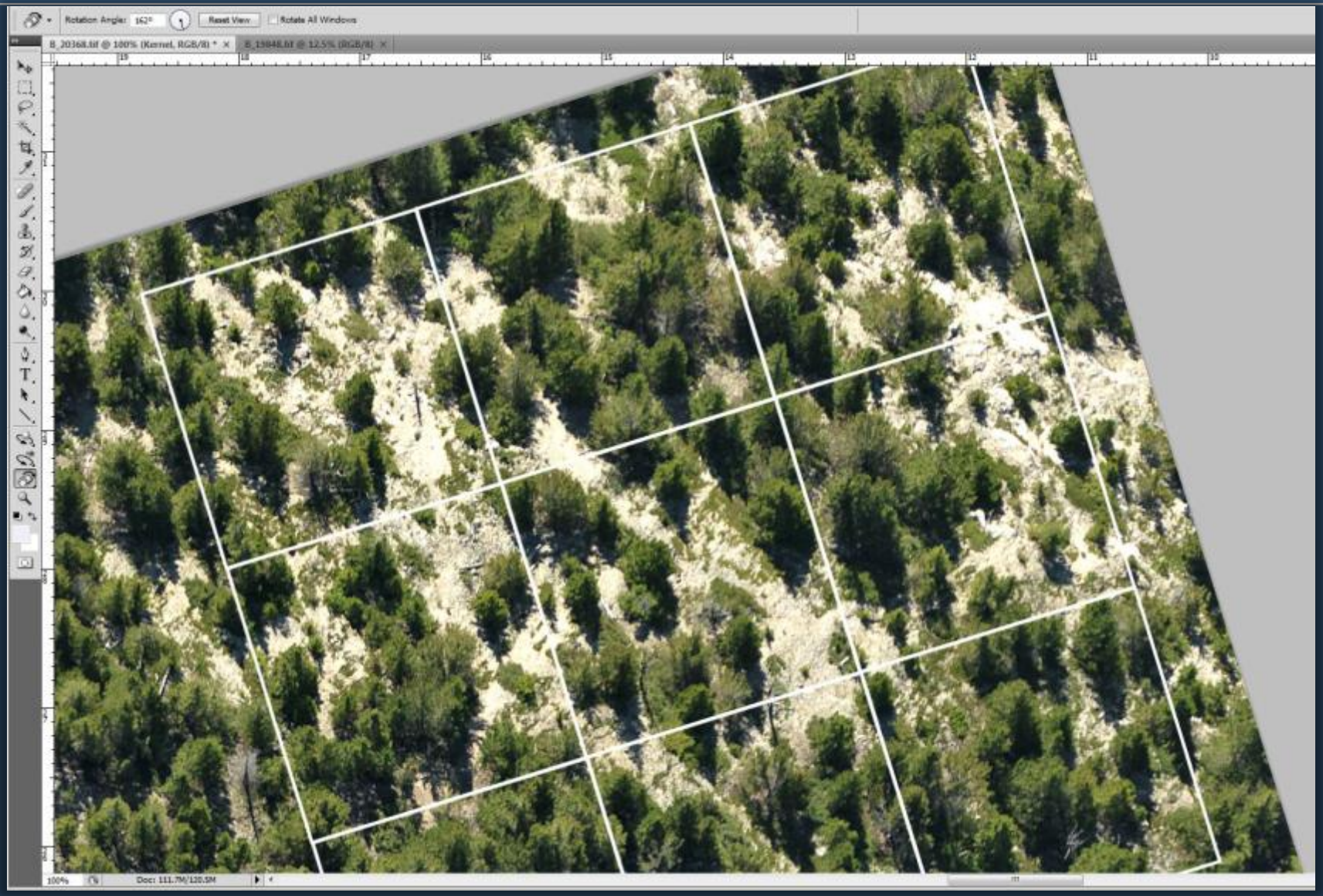


Ground Truth: Aerial Photos

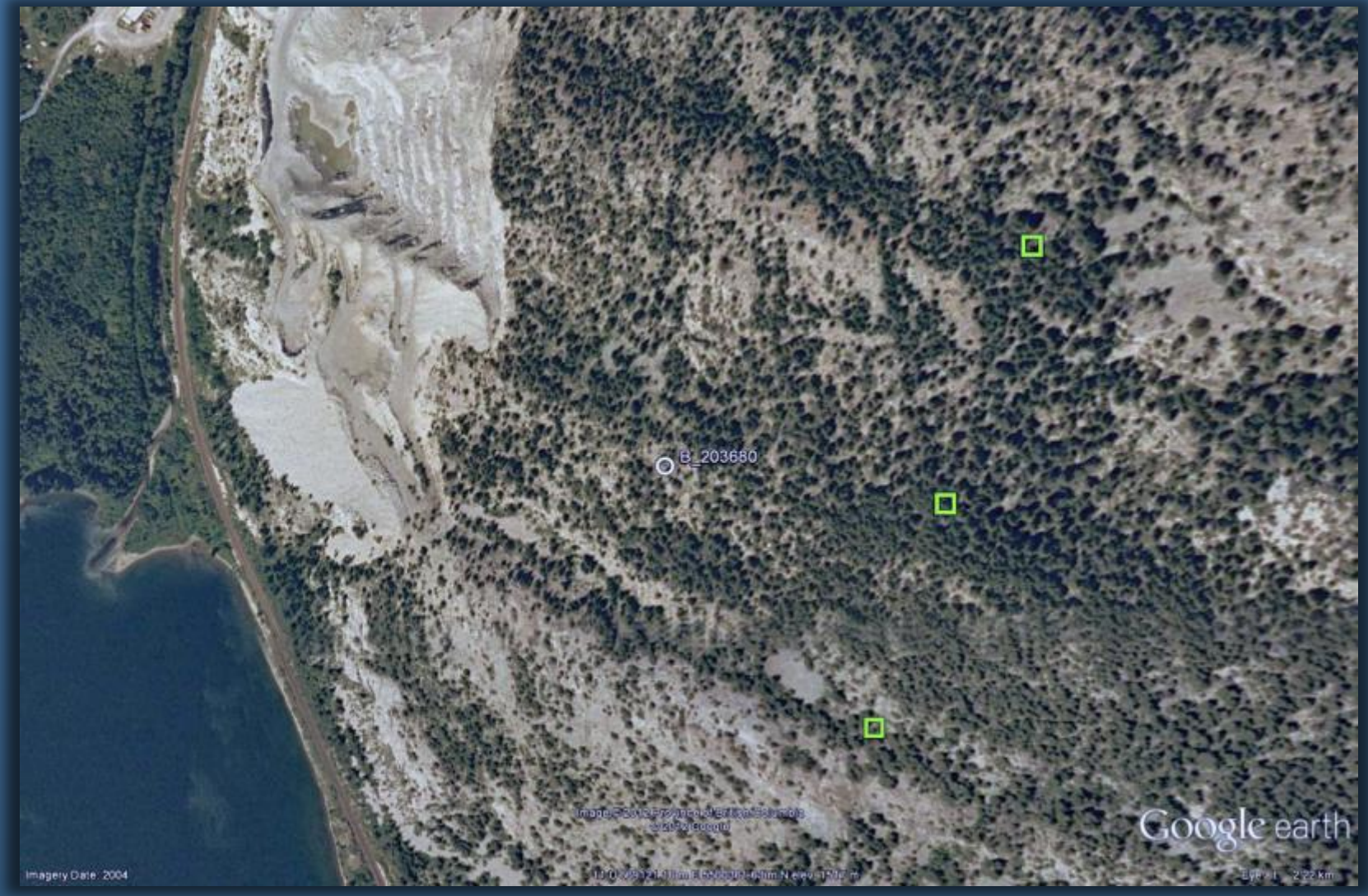
Table 1. Criteria for determining presence or absence score (SCORE)				
Score	Trees Distinguished within Kernel	Trees Distinguished within Plot	Result	Classification
0	Yes	Yes	No WBP in entire kernel	Absence
1	No	Yes	Unlikely to be WBP in kernel	Absence
2	Yes	No	If there are WBP in kernel, they're too small or their crowns are indistinguishable	Absence
3	Yes	No	Habitat in representative kernel is different from regions of confirmed absence and may contain WBP	Unconfirmed
4	No	No	The plot is likely absence, but not confirmed in surrounding kernel	Unconfirmed
5	No	No	Equal likelihood of presence or absence	Unconfirmed
6	No	No	The habitat observed indicates likely presence, but not confirmed	Unconfirmed
7	No	No	Habitat in kernel is similar to regions of confirmed presence but may not contain any WBP	Unconfirmed
8	Yes	Sort of	Confirmed WBP in plot but rare in kernel	Presence
9	No	Yes	Confirmed WBP in plot and most of kernel	Presence
10	Yes	Yes	WBP in entire kernel	Presence

Ground Truth: Aerial Photos

Table 2. Criteria for determining representative score (REP SCORE)	
Score	Certainty
0	Unusable Plot
1	Absence is obvious
2	Plot contains less than 25% homogeneity
3	Plot contains less than 50% homogeneity
4	Plot contains less than 75% homogeneity
5	Representative in plot, kernel contains less than 25% representative
6	Representative in plot, kernel contains around 50% representative
7	Representative in plot, kernel contains more than 75% representative
8	Representative for 100m
9	Representative for 300m
10	Representative for 500m

Ground Truth: Aerial Photos

Ground Truth: Aerial Photos



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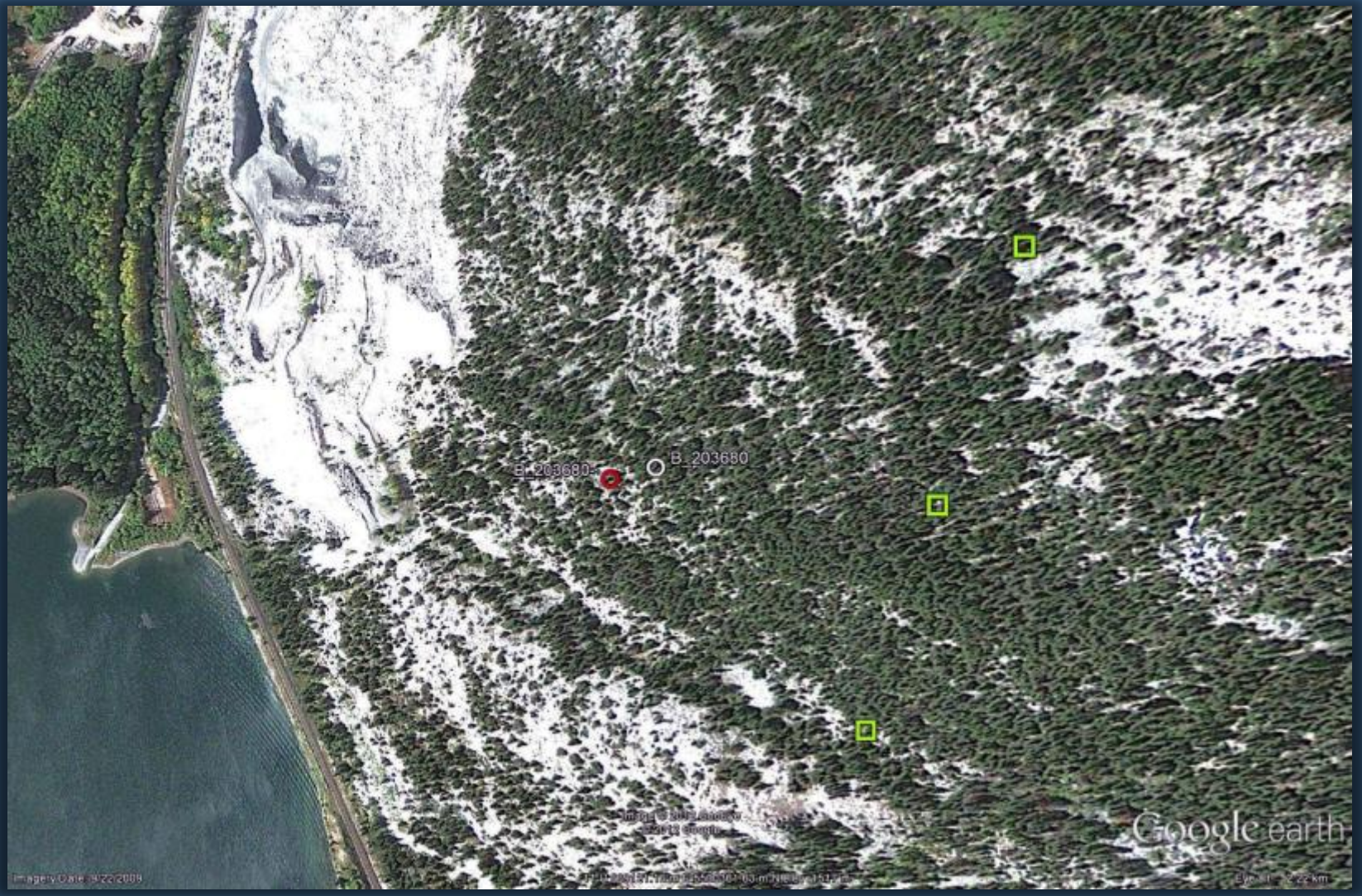
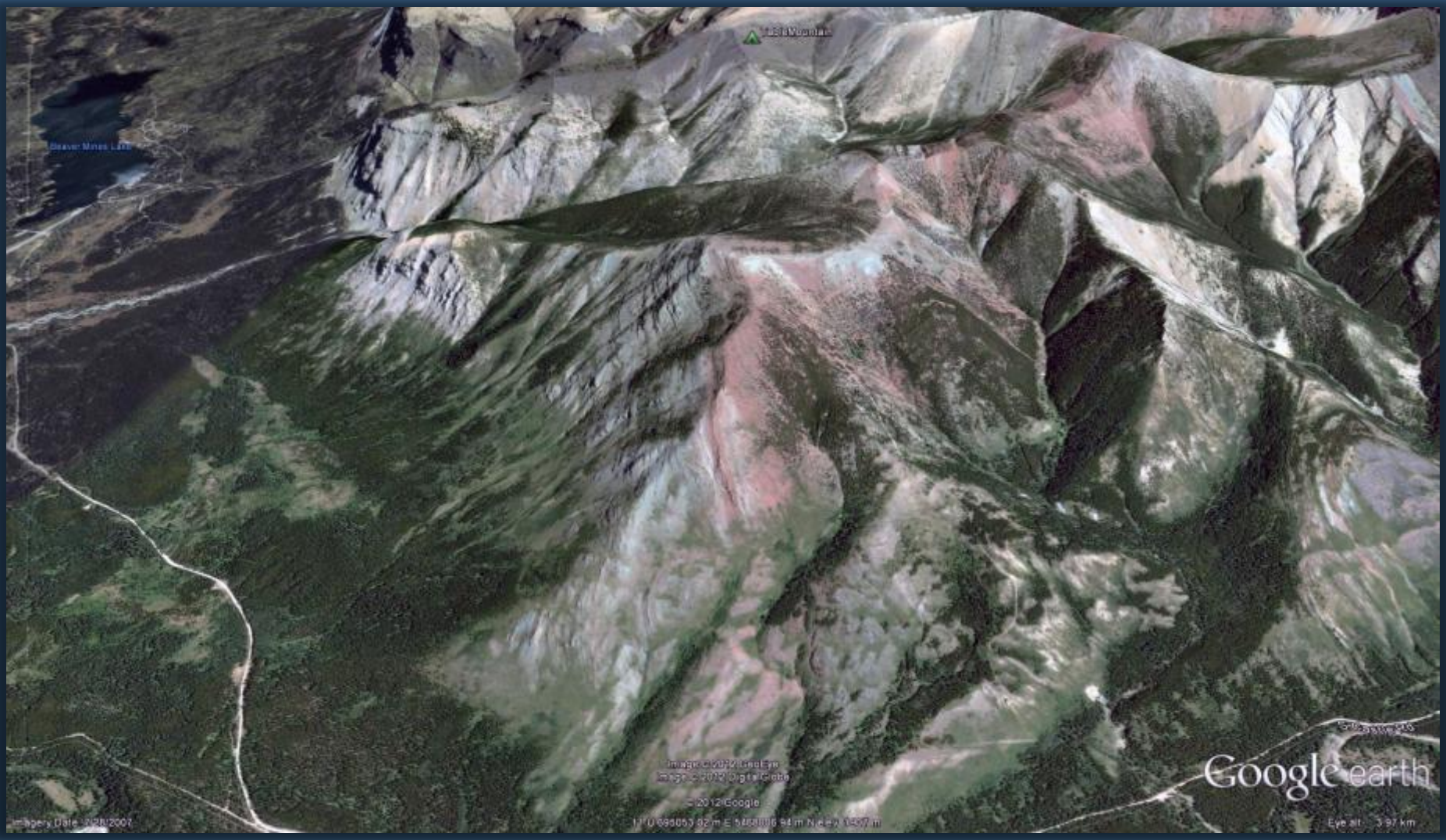


Ground Truth: Aerial Photos

B	C	D	E	F	G	H	I	J	K	L	M
LOCATION	N83Z11X	N83Z11Y	ELLIPTICAL HEIGHT	Dx	Dy	BEARINGC	SCORE	REP SCORE	HABITAT	DTS	PLOT DESCRIPTIO
Livingstone	669028	5500531	2351.504	-129	34	104.9					
Livingstone	669135	5500332	2351.504	-236	233	134.7	10	8	open climax	Pf	Pf, Se, Fa on open rocky
Livingstone	668899	5500565	2353.049	-129	32	104.0					
Livingstone	668770	5500597	2354.050	-130	31	103.5					
Livingstone	668640	5500628	2354.776	-129	30	103.2					

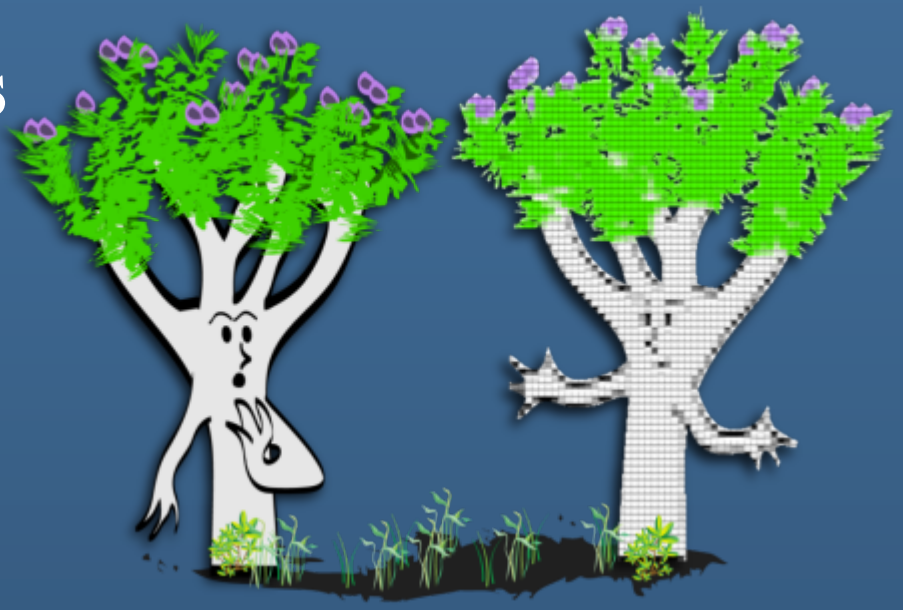
M	N	O	P	Q	R	S	T	U
PLOT DESCRIPTION	CANPCT	CANOPY	GRDVEGPCT	GROUNDCOVER	PLOTPHOTOLINK	Tree	Altitude (GE)	CH Distance
Pf, Se, Fa on open rocky slope	40	Pf,Fa	10	rocky	..\Photos\Livingstone\W08\B_20368_Plot.tif	Pf	1496	50

Model: Table Mountain, Alberta



Developing the Model

1. Explanatory Variables



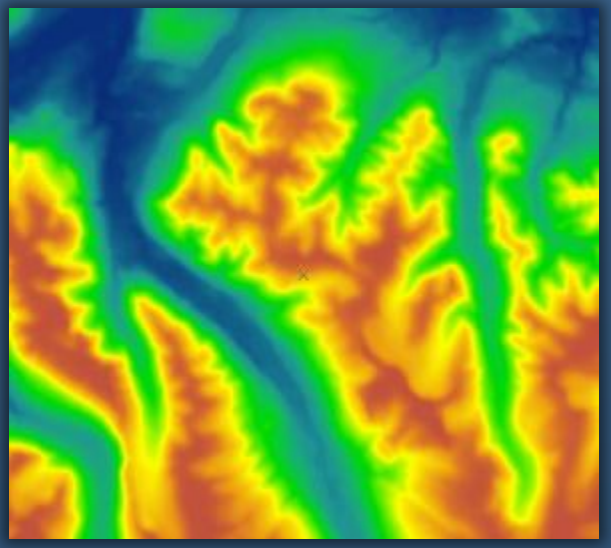
2. Choosing Model Type

3. Converting the Model to a Map

Model: Explanatory Variables

1. Spectral variables
   - Calculated from Landsat ETM

2. Topographic variables
   - Calculated from digital elevation



Model: Explanatory Variables

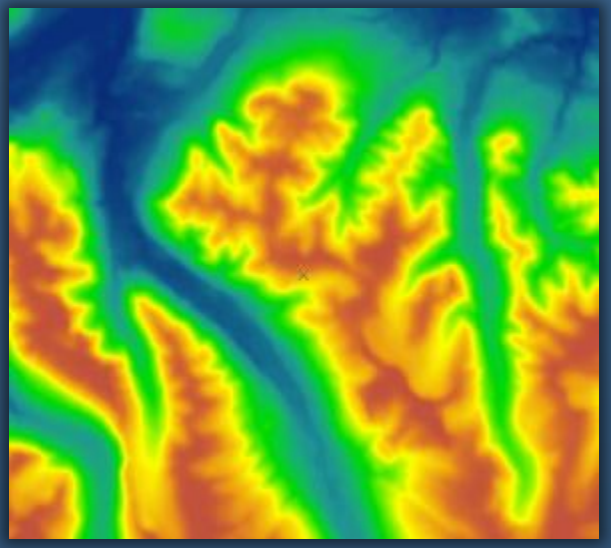
Landsat BAND	Wavelength	Use
BAND 1	Blue	Differentiates soil and rock from vegetation
BAND 2	Green	Covers green reflectance peak from leaves
BAND 3	Red	Senses chlorophyll absorption region
BAND 4	Near Infrared	Vegetation biomass and vigor; soil moisture
BAND 5	Mid Infrared	Vegetation moisture and soil moisture
BAND 6	Thermal	Vegetation stress
BAND 7	Mid Infrared	Vegetation moisture and rock type

Lillesand, Kiefer, and Chipman, 2004

Model: Explanatory Variables

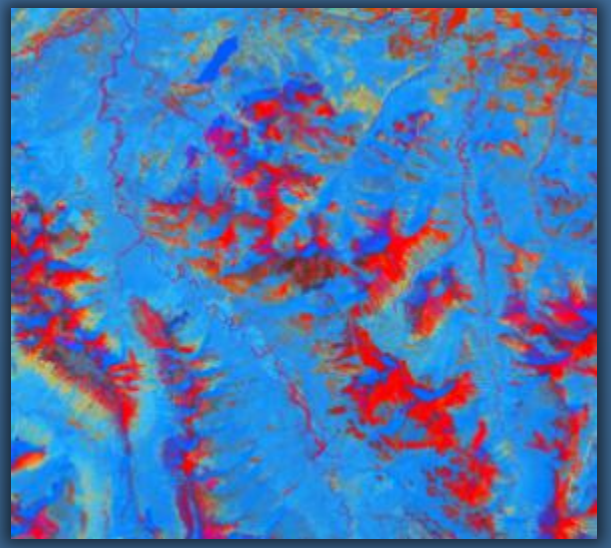
1. Spectral variables
   - Calculated from Landsat ETM

2. Topographic variables
   - Calculated from digital elevation

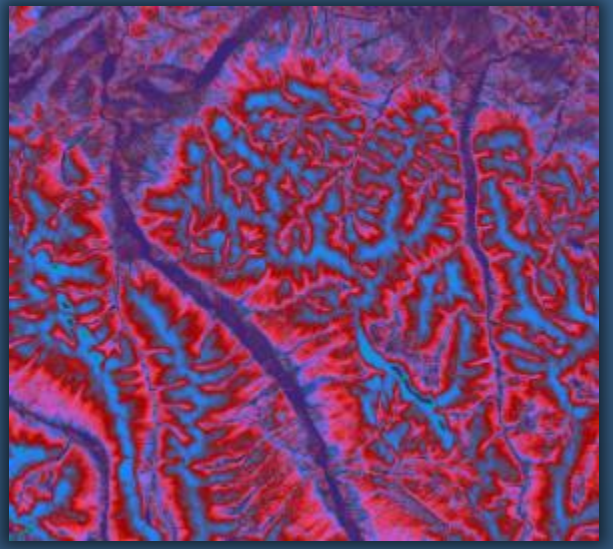


Model: Explanatory Variables

1. Spectral variables
   - Calculated from Landsat ETM
   - Tasselled Cap



2. Topographic variables
   - Calculated from digital elevation
   - CTI D-Infinity



Model: Choosing Model Type

Logistic Regression

Classification Tree Analysis

Model: Choosing Model Type

Logistic Regression

Classification Tree Analysis

Discreet classes

Model: Choosing Model Type

Logistic Regression

Continuous surface

Classification Tree Analysis

Discreet classes

Model: Choosing Model Type

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Classification Tree Analysis

Discreet classes

Intuitive

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Makes sense for binary

Classification Tree Analysis

Discreet classes

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Model: Choosing Model Type

Logistic Regression

Continuous surface

Makes sense for binary

Classification Tree Analysis

Discreet classes

Intuitive

Boosting

Model: Choosing Model Type

Logistic Regression	Classification Tree Analysis
Continuous surface	Discreet classes
Makes sense for binary	Intuitive
Thresholding/Sensitivity Analysis (ROC)	Boosting

Model: Choosing Model Type

Logistic Regression	Classification Tree Analysis
Continuous surface	Discreet classes
Makes sense for binary	Intuitive
Thresholding/Sensitivity Analysis (ROC)	Boosting
Performs Good	

Model: Choosing Model Type

Logistic Regression	Classification Tree Analysis
Continuous surface	Discreet classes
Makes sense for binary	Intuitive
Thresholding/Sensitivity Analysis (ROC)	Boosting
Performs Good	Performs Better

Model: Classification Tree

Rule 3/6: (182.7/10.3, lift 2.0)

BAND4	**<=**	**78**
NDVI	**>**	**-0.132353**
LONGCONVEX	**<=**	**0.105444**
CTIDINF	**<=**	**8.03757**
ELEVATION	**>**	**1742**

-> class Presence [0.939]

Model: Classification Tree

----- Trial 3: -----

Rule 3/1: (79.1, lift 1.9)

ELEVATION <= 1742

-> class Absence [0.988]

Rule 3/2: (28.4, lift 1.9)

BAND4 > 78

-> class Absence [0.967]

Rule 3/3: (52.7/3.2, lift 1.8)

CTIDINF > 8.03757

-> class Absence [0.924]

Rule 3/4: (37.2/2.7, lift 1.7)

NDVI <= -0.132353
LONGCONVEX <= 0.105444

-> class Absence [0.905]

Rule 3/5: (52/5.7, lift 1.7)

LONGCONVEX > 0.105444
PLANCONVEX > -0.764402
CTIDINF <= 8.03757

-> class Absence [0.877]

Rule 3/6: (182.7/10.3, lift 2.0)

BAND4 <= 78
NDVI > -0.132353
LONGCONVEX <= 0.105444
CTIDINF <= 8.03757
ELEVATION > 1742

-> class Presence [0.939]

Rule 3/7: (7.5, lift 1.9)

LONGCONVEX > 0.105444
PLANCONVEX <= -0.764402
ELEVATION > 1742

-> class Presence [0.895]

Default class: Absence

Model: Converting Model To Map

Improving The Model

1. More/different explanatory variables
   - Topographic roughness, disturbance index
2. Modelling tactics
   - Reduce variation – stratify sample
   - Utilize error values
   - Group stands into objects
3. More data
4. Better data

Better Data

- Location, location, location
  - Especially with distance surveys!
- Consistency
- Need to save money, but clustered sampling is really bad for modelling
- Fixed wing surveys seem like cheap alternative, but can be problematic
- Helicopter surveys notoriously expensive, often yield poor results

Better Data

Ecosynth

3D Tools for Ecology

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Aerial Platforms

In Testing
GWS Slow Stick
Gaui 300X-S Quadricopter

Of Interest

Planes
Multiplex Easy Star rtf: http://www.multiplexusa.com/ready-to-fly/easy_star.html
http://www.eflightwiki.com/eflightwiki/index.php?title=Multiplex_EasyStar

- Cost: ~$200.

Quadricopters (also hexa- and octo-)
AscTec Falcon 8: http://www.asctec.de/asctec-falcon-2/

- Cost: >$15K with full GPS flying capability.

AscTec Hummingbird:
http://www.asctec.de/asctec-hummingbird-autopilot-2/

- AutoPilotV2- Cost: >$4.5K with full GPS flying capability. 200g payload

http://www.asctec.de/asctec-hummingbird-researchpilot-2/

- Research Pilot V1 - Cost: $1.2K without GPS flying. 200g payload.

AscTec Pelican AutoPilotV2:
http://www.asctec.de/asctec-pelican-2/

- AutoPilotV2- Cost: >$6.7K with full GPS flying capability. 500g payload.

AscTec Funpilot: http://www.asctec.de/technics/

The Ecosynth Team Blog

Our team develops Ecosynth technology: inexpensive user-deployed systems for mapping ecology across landscapes in 3D using open-source computer vision software, commercial cameras and hobbyist aircraft.

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Tag cloud

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Thanks!

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