CARBON DECISIONS INTERNATIONAL

Risk Mapping

… work in progress …

CDI

Objective

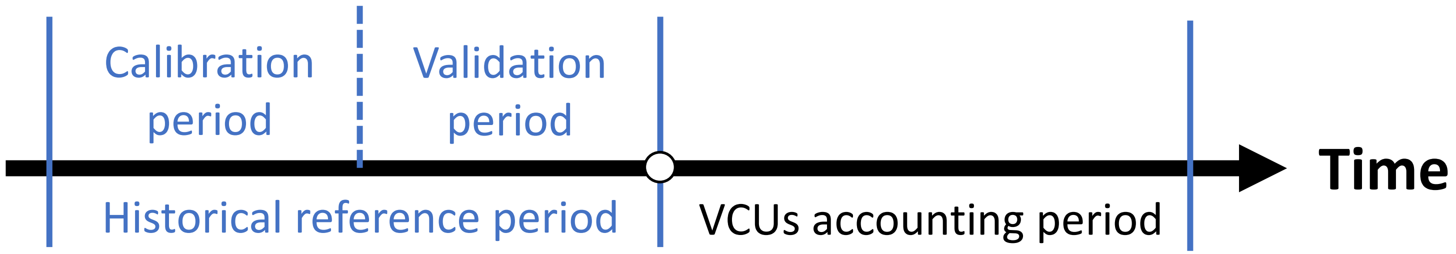
- Develop and test a risk mapping methodology that is robust and credible enough for application in the context of JNR-baseline allocation.
- The risk mapping methodology should be:

1. Accurate in predicting future risk
2. Hard or impossible to bias
3. Capable of recognizing areas of “Zero Risk”, because these areas do exist (i.e. remote areas)
4. Simple and replicable (i.e. easy to understand, applicable with minimum data requirements, etc.)

CDI

Approach

- Hypotheses: The "local" deforestation rate of the recent past is a good predictor of the risk of deforestation in the immediate future.
- To test this hypotheses we divide the historical reference period in two sub-periods called "calibration period" and "validation period".



- If a risk map developed with data from the "calibration period" is capable to accurately predict the risk of "future deforestation", i.e. of the "validation period", then the risk mapping methodology should be considered OK.
- We then apply the risk mapping methodology using the data from the entire "historical reference period" to predict the risk of deforestation in the "VCUs accounting period".

CDI

Approach

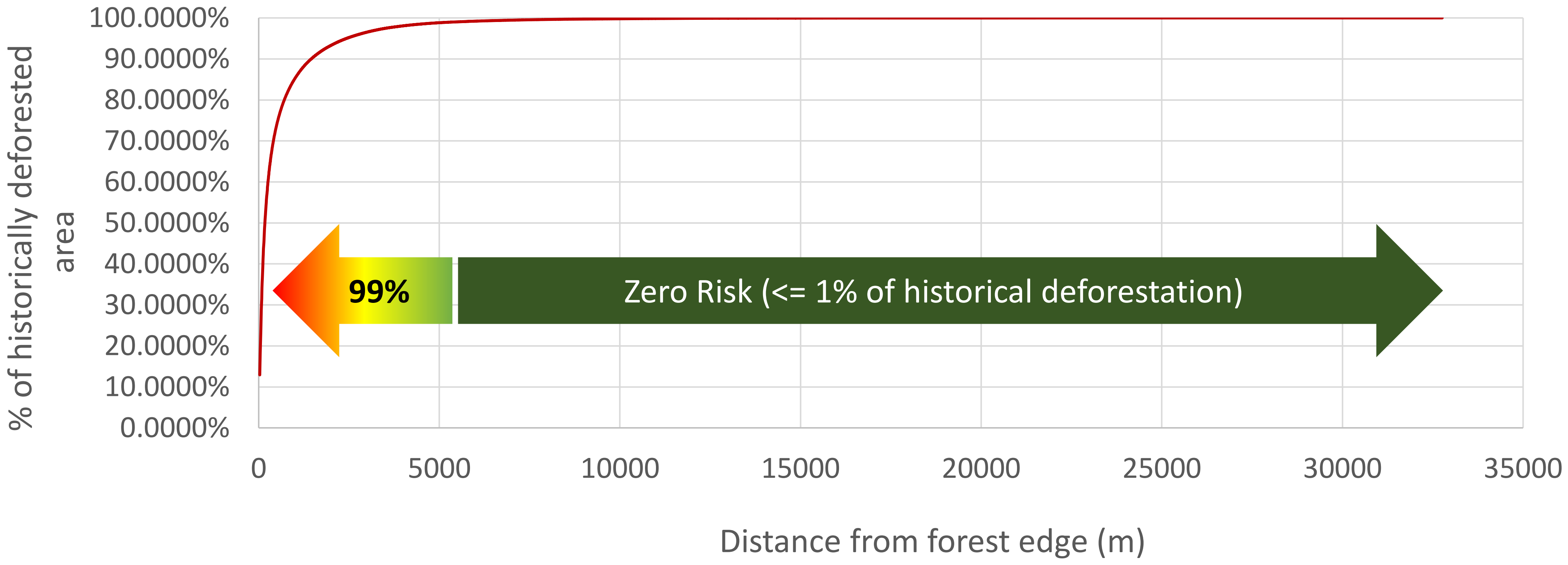
- Hypotheses: The “local” deforestation rate of the recent past is a good predictor of the risk of deforestation in the immediate future.

  - “local” in the approach tested in Peru is a squared “window” that moves across the entire landscape.
  - The “local” deforestation rate is calculated for the area delimited by the window each time it moves to the next pixel.
  - The calculated “local” deforestation rate is assigned to the corner pixel of the window.

	1	2	3	4	5	6	7	8	9	10	11	12	13	
A	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A
B	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B
C	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C
D	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D
E	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E
F	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F
G	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G
	1	2	3	4	5	6	7	8	9	10	11	12	13	

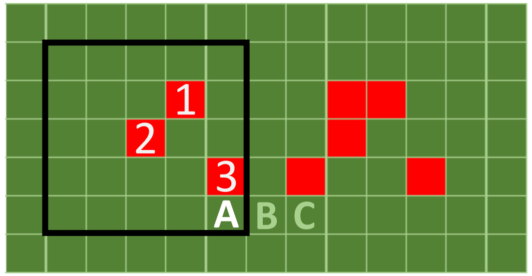
Creation of the risk map

Areas at a distance from the forest edge at which less than 1% of the historical deforestation happened during the historical reference period are to be considered of having virtually 0 risk of deforestation.

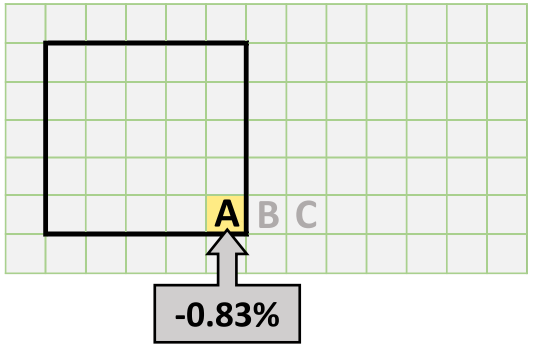


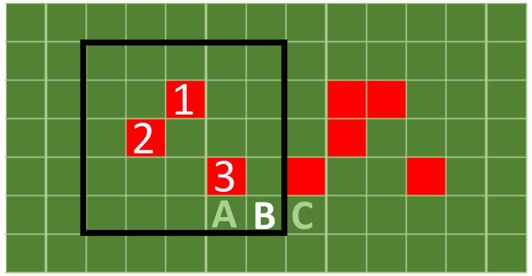
CDI

Creation of the risk map

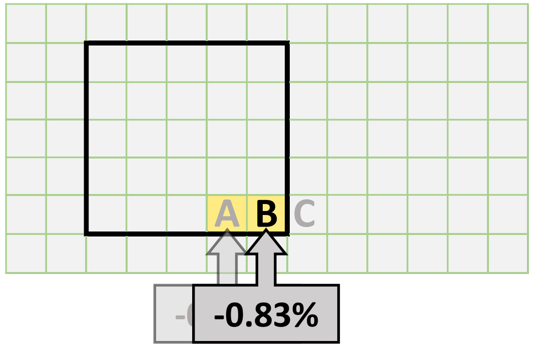


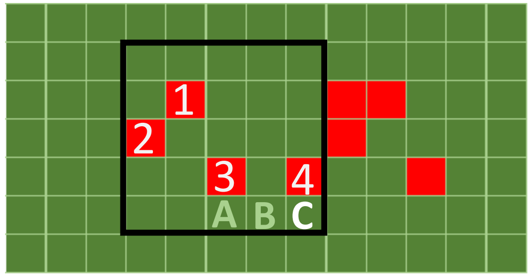
Window: 5 x 5 = 25 pixels
Period (T): 10 years
Deforestation: -3 pixels (= 22–25)
Deforestation rate: $DR_A = \underbrace{1/10}_{-3} * \ln(22\text{-}25) = -0.83\%$



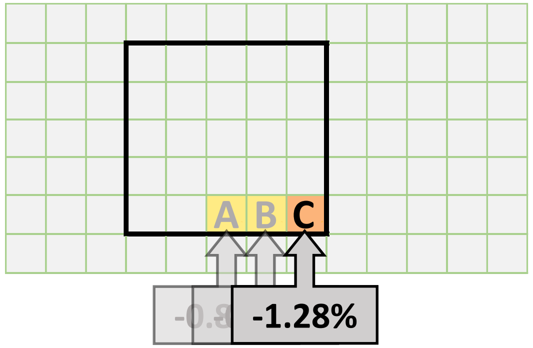


Window: 5 x 5 = 25 pixels
Period (T): 10 years
Deforestation: - 3 pixels (=22-25)
Deforestation rate: $DR_B = 1/10 * \ln(22\text{-}25) = -0.83\%$



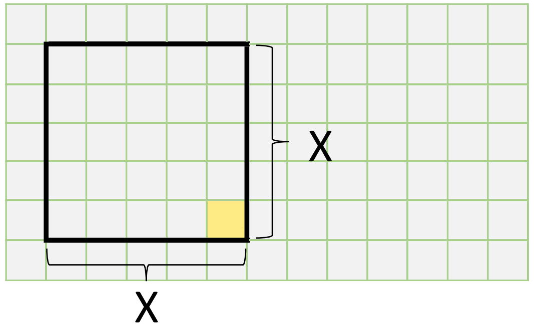


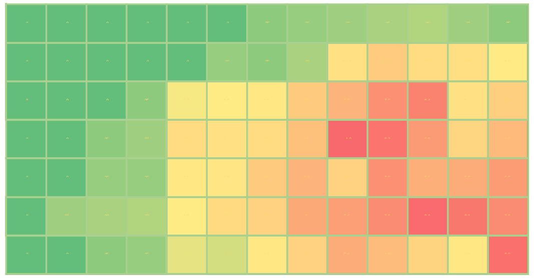
Window: 5 x 5 = 25 pixels
Period (T): 10 years
Deforestation: -4 pixels (21-25)
Deforestation rate: $DR_C = 1/10 * \ln(21\text{-}25) = -1.28\%$



Creation of the risk map

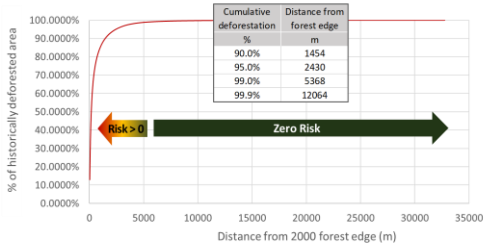
Step 1: Continuous risk map
Created using a moving window of X x X pixels.

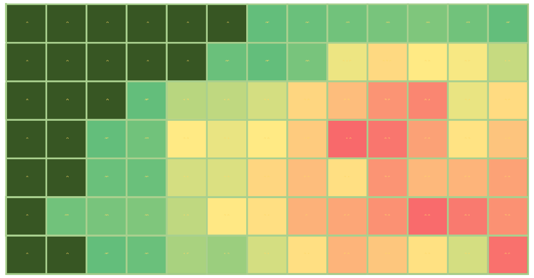




Output 1:
Continuous surface with “local” deforestation rate values.

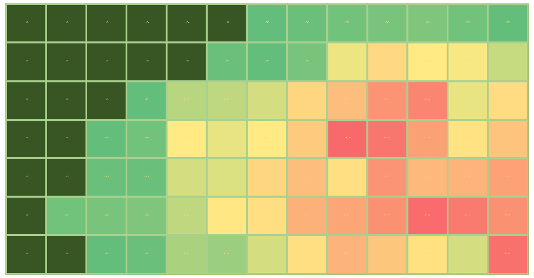
Step 2: Zero Risk class
Mask out areas of “Zero Risk” using distance form forest edge criterion.





Output 2:
Continues risk surface with Zero Risk class.

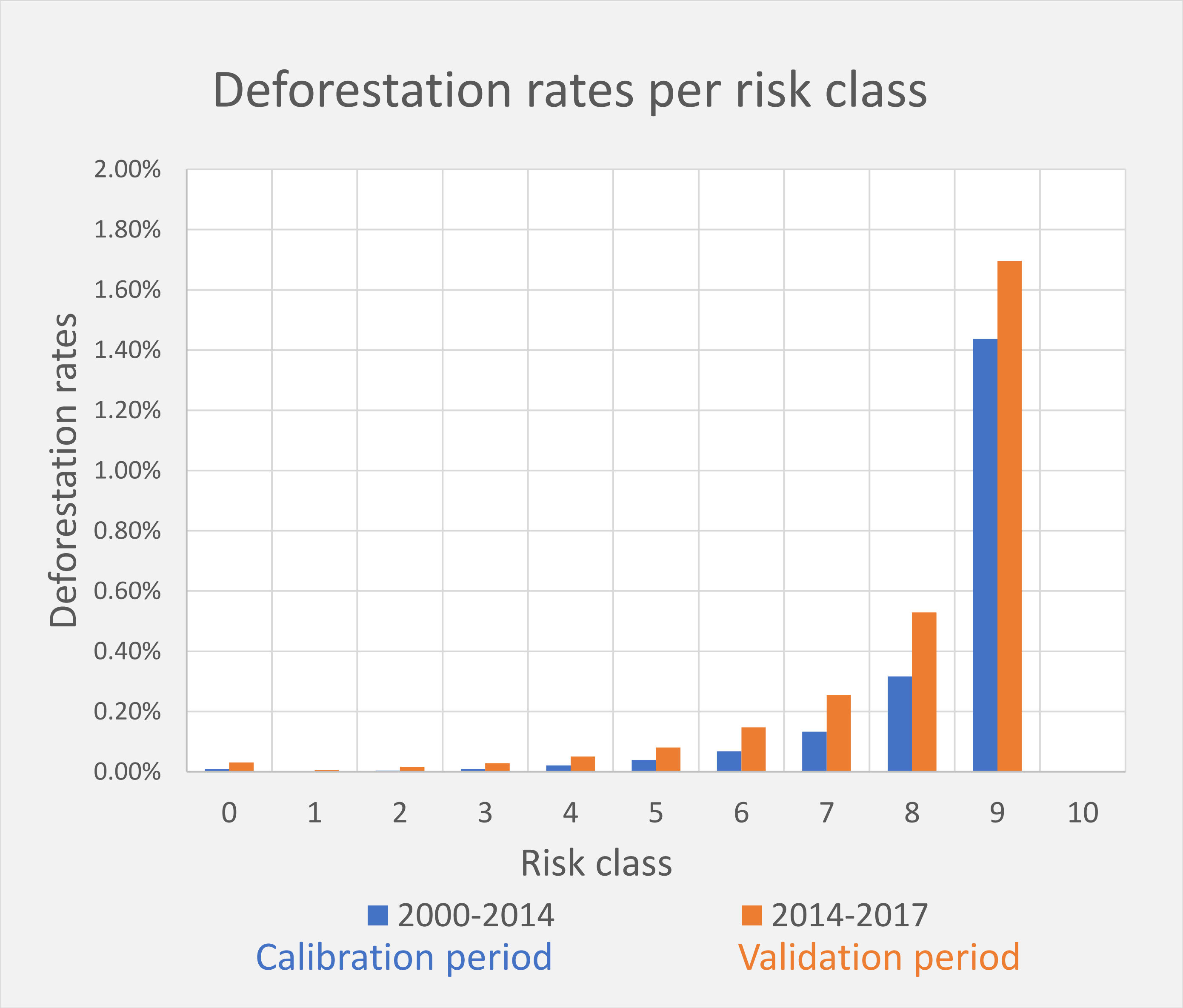
Step 3: Risk map with discrete categories
Slice the continuous risk map in ***n*** risk classes of equal area.

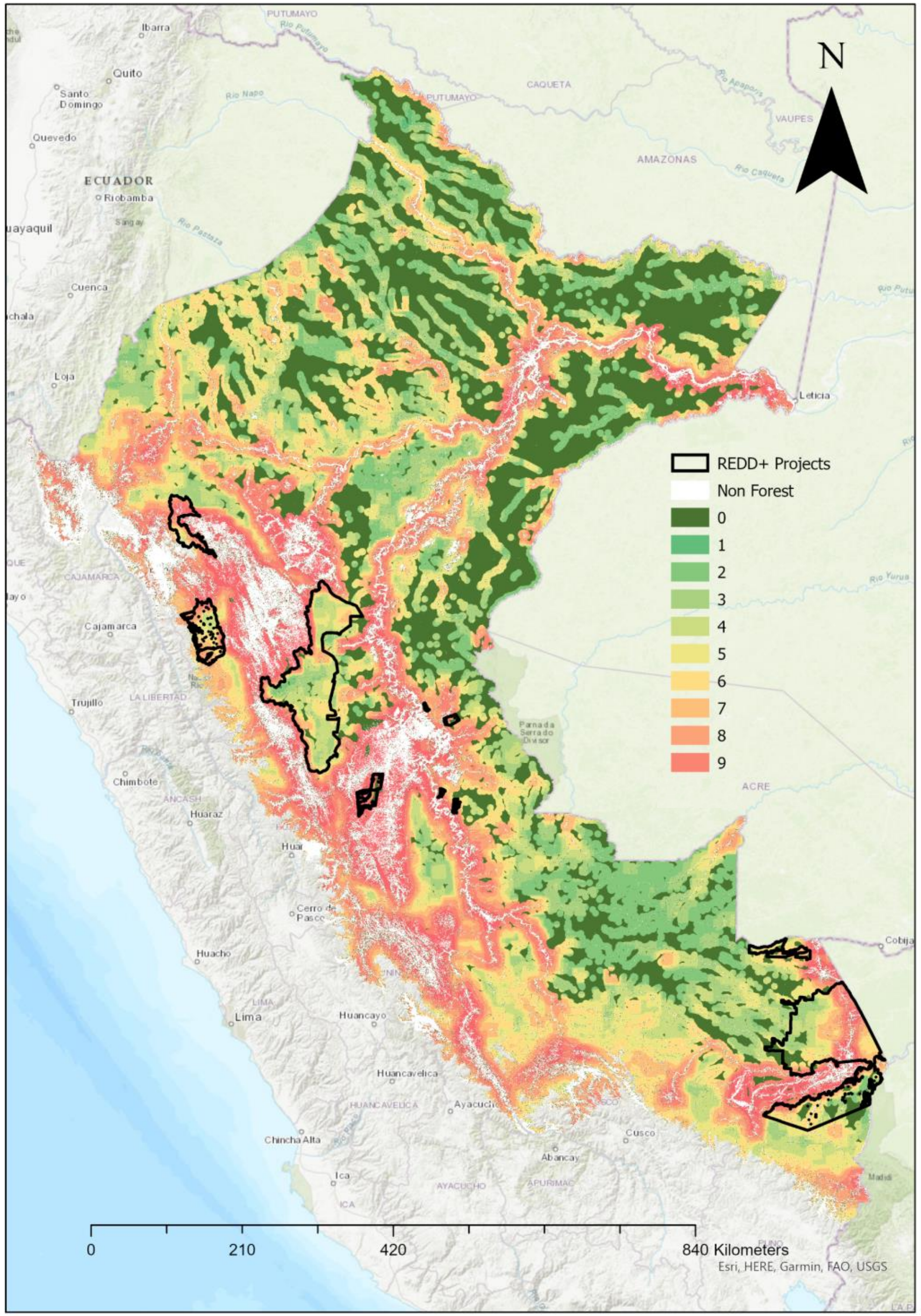


0	0	0	0	0	0	0	0	2	2	2	1	2
0	0	0	0	0	1	1	2	3	4	3	3	2
0	0	0	1	2	2	2	4	5	8	8	2	4
0	0	1	1	3	1	3	4	10	9	7	3	5
0	0	1	1	2	2	4	5	3	8	6	6	7
0	1	1	1	2	3	3	6	7	8	10	9	8
0	0	1	1	2	1	2	3	6	5	4	3	10

Output 3:
Risk map with ***n*** discrete risk classes (including the “Zero Risk” class).

Result

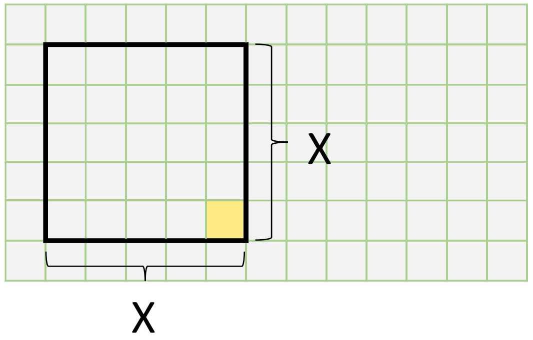

Deforestation rates per risk class
Deforestation rates
2.00%
1.80%
1.60%
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
0
1
2
3
4
5
6
7
8
9
10
Risk class
2000-2014
Calibration period
2014-2017
Validation period


N
REDD+ Projects
Non Forest
0
1
2
3
4
5
6
7
8
9
0
210
420
840 Kilometers
Esri, HERE, Garmin, FAO, USGS
ECUADOR
Quito
Cuenca
Cajamarca
Trujillo
Chimbote
Lima
Huancayo
Ayacucho
Cusco
Ica
Leticia
AMAZONAS
ACRE

CDI

Risk map validation

<u>Step 1: Continuous risk map</u>
Created using a moving window of X x X pixels



What is the optimal window size (X x X pixels) that should be used to construct the risk map?

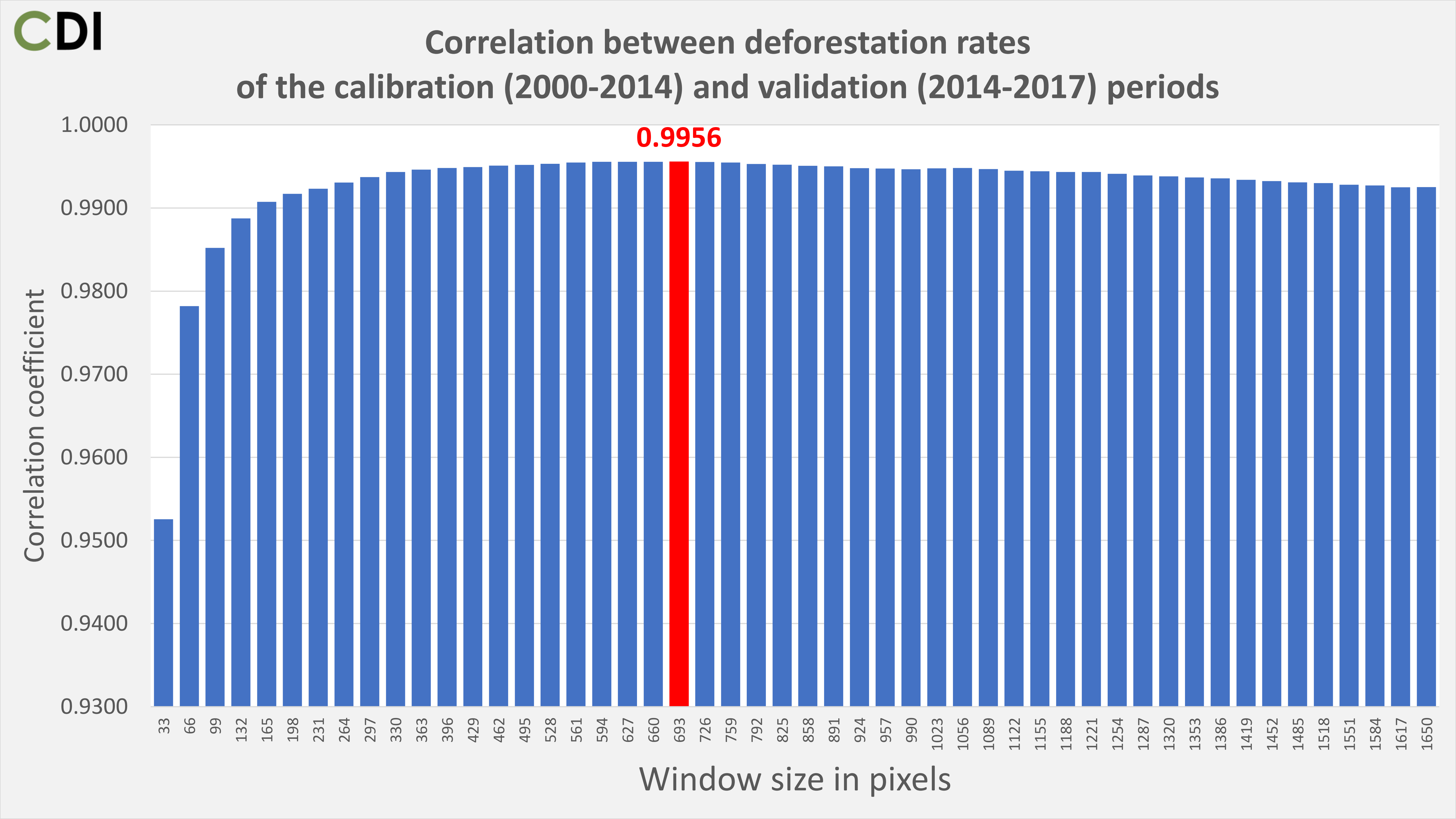
- To answer this question we developed 50 risk maps using window sizes ranging from 33 x 33 pixels (990 m x 990 m) to 1,650 x 1,650 pixels (49,500 m x 49,500 m).
- How to compare these 50 maps to select the one that "most accurately" predicts the risk of future deforestation (i.e. of the "validation period")?
- The window size of the "most accurate" risk map will be used to construct the final risk map for the "VCUs accounting period" using the pooled data of the "calibration" + "validation" periods.

CDI

Correlation between the rates of the "calibration" and "validation" periods

Risk class	FCBM 2000	FCBM 2014	FCBM 2017	Rates 2000-2014	Rates 2014-2017
	ha	ha	ha	%	%
0	15,469,665.12	15,452,957.70	15,438,608.64	0.0077%	0.0310%
1	6,151,539.87	6,150,942.09	6,149,826.90	0.0007%	0.0060%
2	6,323,160.42	6,319,952.10	6,316,898.67	0.0036%	0.0161%
3	6,487,027.65	6,478,936.56	6,473,439.27	0.0089%	0.0283%
4	6,332,095.08	6,314,102.19	6,304,573.89	0.0203%	0.0503%
5	5,900,470.29	5,868,628.83	5,854,421.34	0.0387%	0.0808%
6	5,818,392.81	5,763,493.17	5,737,998.87	0.0677%	0.1478%
7	5,874,773.31	5,766,348.15	5,722,602.21	0.1331%	0.2538%
8	6,138,507.06	5,872,249.71	5,779,809.63	0.3167%	0.5289%
9	6,597,381.87	5,394,558.69	5,126,917.86	1.4377%	1.6962%
Total	**71,093,013.48**	**69,382,169.19**	**68,905,097.28**	**0.1740%**	**0.2300%**

Statistics	Value	Standar Error	
Correlation coefficient	0.9956	0.0332	3.33%



CDI
Correlation between deforestation rates
of the calibration (2000-2014) and validation (2014-2017) periods
0.9956
Correlation coefficient
1.0000
0.9900
0.9800
0.9700
0.9600
0.9500
0.9400
0.9300
33 66 99 132 165 198 231 264 297 330 363 396 429 462 495 528 561 594 627 660 693 726 759 792 825 858 891 924 957 990 1023 1056 1089 1122 1155 1188 1221 1254 1287 1320 1353 1386 1419 1452 1485 1518 1551 1584 1617 1650
Window size in pixels

CDI

Pros and Cons of the proposed risk mapping methodology

Pros:

1. Accurate in predicting the risk of future deforestation (?)
2. Hard to bias
3. Mandatory “Zero Risk” class
4. Simple*

Cons:

1. Methodology tested in only one country.
2. Requires a deforestation map.
3. Heavy computing requirements, if working in jurisdictions with large number of pixels*.

* Peru:

- 900+ million pixels
- ArcGIS Pro 2.6.0, 64 bits
- 24 hours to run the windows 50 times
- 12 days 24/7 for equal area slicing of the 50 maps
- Azure virtual processing machine, 256 GB RAM, 32 vCPU, Premium SSD (~ 2,300.00 USD)

CARBON DECISIONS INTERNATIONAL

Thank you very much

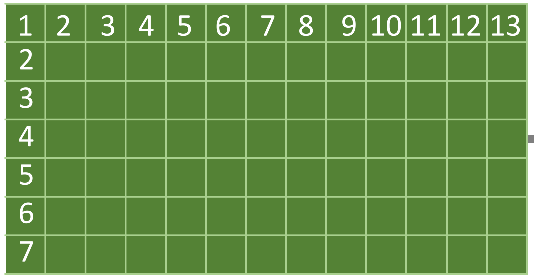
Lucio Pedroni

lpedroni@carbondecisions.com

CDI

Calculating deforestation rates

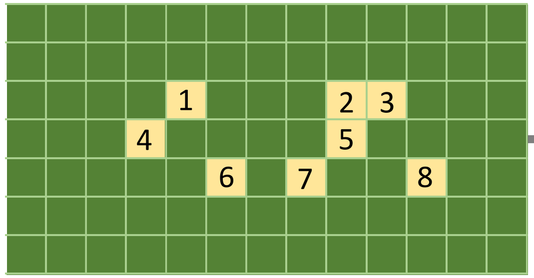
LAND USE at time t_1



Forest Land

Forest Land Area (FLA_1): 13 x 7 = 91

LAND USE at time t_2

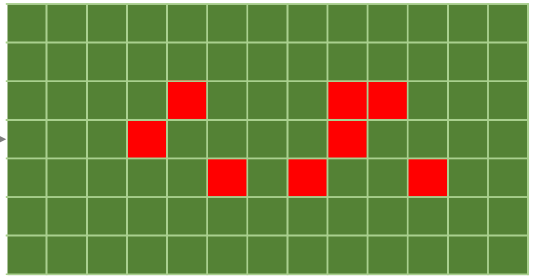


Forest Land

Non-Forest Land

Forest Land Area (FLA_2): 91 – 8 = 83

LAND USE CHANGE
in the period $T = t_2 - t_1$



Forest Land *remaining* Forest Land

Forest Land *converted to* Non-Forest Land

$FLA_2 - FLA_1 = 91 – 83 = 8$

(DEFORESTATION)

DEFORESTATION RATE (DR):

$DR = 1/(t_2 - t_1) * \ln (FLA_2 – FLA_1)$

$t_1 = 2010$; $t_2 = 2020$; $T = t_2 - t_1 = 10$

$DR = 1/10 * \ln (83 - 91)$

$DR = -0.92\%$

Year	FLA (ha)
2000	91.0
2001	90.2
2002	89.3
2003	88.5
2004	87.7
2005	86.9
2006	86.1
2007	85.3
2008	84.5
2009	83.7
2010	83.0