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جمعية التحريج في لبنان
LEBANON REFORESTATION INITIATIVE

Lebanon 2019

Post-Fire Assessment

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(Executive summary of the technical report)

June 2020

This report was developed by the Institute of the Environment at the University of Balamand upon the request of the Lebanon Reforestation Initiative NGO under the Livelihoods in Forestry project funded by the United States Agency for International Development.

Field data collection reported in this document was carried out as a joint collaborative effort by the teams of the Lebanon Reforestation Initiative **(LRI)**, the Association for Forests, Development and Conservation **(AFDC)** and the Institute of the Environment at the University of Balamand.

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List of Acronyms

AFDC	Association for Forests, Development and Conservation
CBI	Composite Burn index
dNBR	Differenced Normalized Burn ratio
GIS	Geographic Information System
IOE	Institute of the Environment
LNR	Land and Natural Resources Program
LRI	Lebanon Reforestation Initiative
NBR	Normalized Burn Ratio
NIR	Near Infra-Red
SWIR	Short Wave Infra-Red
UOB	University of Balamand

Scope of Work

The 2019 fire season experienced nation-wide wildfires affecting different land cover/land uses at different severity levels. As a result, the need to assess the impact of fires at the landscape level and provide recommendation for post-fire management was identified. More specifically, the specific objectives of work were as follows:

1 - Mapping of all areas burned in 2019 using satellite images and listing towns affected by fires with area of fire per town.

2 - Identifying location of sampling plots and validation of fires using field data.

3 - Assessing losses in different land cover / land uses.

4 - Mapping vegetation fire severity using high resolution satellite images.

5 - Assessing vegetation fire severity of large scale fires using the composite burned index approach in the field.

6 - Assessing post-fire degradation risk in the first vegetation growing season after the 2019 fire season (i.e., spring 2020).

7 - Developing restoration and rehabilitation plans for large fires.

Methodology

The methodology of work comprised the combined use of satellite data and field data for assessing fire severity. In addition, a model for mapping post-fire degradation risk was developed using a Geographic Information System (GIS).

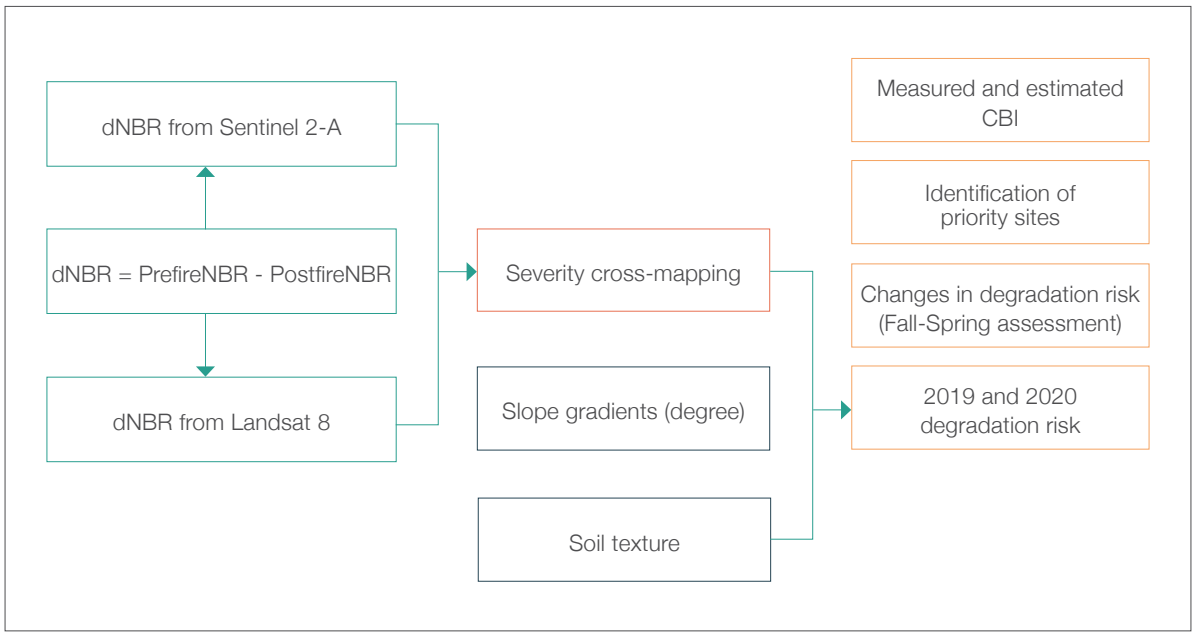


Figure 1. Flowchart of the methodology

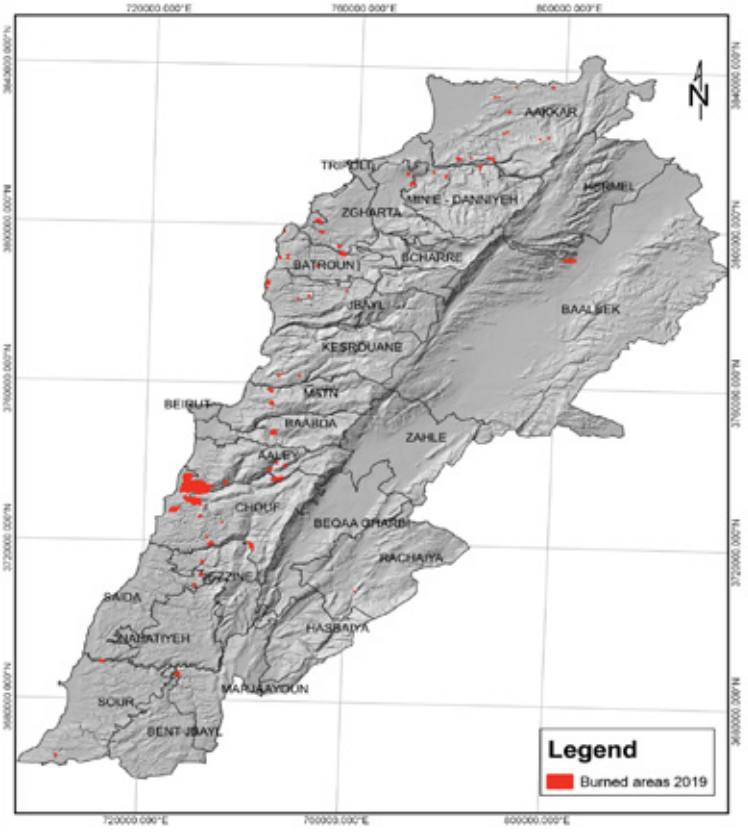
Burned areas were assessed through field visits by filling the composite burned index (CBI) field form for each fire affected site. A total of 117 polygons/sites were visited by the teams of Land and Natural Resources at the Institute of the Environment, University of Balamand (LNR-IOE-UOB), Lebanon Reforestation Initiative (LRI) and the Association for Forests, Development and Conservation (AFDC) in order to collect field data, validate fires and assess the vegetation fire severity. The first survey was conducted in November 2019 and the second survey was conducted in April 2020 resulting both resulting in seasonal CBI scoring.

Mapping the extent of burned areas was conducted with the use of satellite images (i.e., Sentinel 2-A of 10 m resolution). Accordingly, it was possible to map fires burning over a minimum area of 200 m^2. More specifically, the Normalized Burned Ratio (NBR) as derived from the Sentinel 2-A imagery (10 m resolution) was employed to help in the mapping of burned areas. The difference between the pre-fire and post-fire NBR obtained from the images was used to calculate the delta NBR (dNBR or ΔNBR) for estimating burn/fire severity.

Two different assessments, namely fall and spring assessments, were conducted to map post-fire land degradation risk. Each of these two assessments consisted initially of two steps, namely 1) mapping fire severity based on cross-mapping between the dNBR as derived from the multi-temporal data (i.e., pre-fire and post-fire) of the two employed satellite images (i.e., Sentinel 2-A and Landsat 8), and 2) mapping final degradation risk based on cross-mapping between the results of fire severity and slope gradients. An image differencing of the 2019 and 2020 degradation risk maps was computed in order to identify the final post-fire degradation risk. Measured and estimated CBI data from the field and GIS-based soil data were employed to identify priority areas/sites for intervention after each seasonal assessment.

Results

The total number of identified fires was 117 and the total extent of delineated burned areas was 2,679 ha (Figure 2). Areas of fires per affected town/village were provided in Table 1.



Map produced in January 2020 by the Land and Natural Resources Program at the Institute of Environment at the University of Balamand (LNR-IOE-UOB) under the "Livelihoods in Foresty" (LIF) project funded by the United States Agency for International Development (USAID) and implemented by the Lebanon Reforestation Initiative (LRI). Projection: UTM WGS 84 - Zone 36 North.

Figure 2. Post-fire assessment map 2019

Table 1. Areas of fires per affected town/village

Polygon ID	Location	District	Mohafazat	Area of fire per town (ha)
1	Mounjez	Akkar	North	6.72
2	Omar el-Beikate	Akkar	North	0.73
3	Haytla	Akkar	North	0.39
4	El-Ghozaili	Akkar	North	1.94
5	El-Tleil	Akkar	North	0.89
6	Sfeinite El-Dreibe	Akkar	North	0.24
7	Mazraat Balde	Akkar	North	3.96
8	El-Hed	Akkar	North	3.52
9	Akkar El-Atika	Akkar	North	1.67
10	Akkar El-Atika	Akkar	North	1.62
11	Bazbina	Akkar	North	0.67
12	Rahbe	Akkar	North	3.49
13	Rahbe	Akkar	North	1.88
14	Bzal	Akkar	North	17.14
15	Habchite	Akkar	North	1.23
16	Habchite	Akkar	North	2.01
17	Habchite	Akkar	North	0.03
18	Habchite	Akkar	North	0.33
19	Harare	Akkar	North	0.85
20	Harare	Akkar	North	1.67
21	Harare	Akkar	North	8.11
22	Qabbait	Akkar	North	0.57
23	Qarhaiya	Minieh-Danieh	North	6.10
24	Qarhaiya	Minieh-Danieh	North	0.00
25	Debaael	Minieh-Danieh	North	0.71
26	Azka	Minieh-Danieh	North	1.96
27	Acheiche	Zgharta	North	8.70
28	Bakhoune	Minieh-Danieh	North	8.19
29	Bakhoune	Minieh-Danieh	North	0.55
30	Kfar Chlane	Minieh-Danieh	North	0.02
31	Kfar Habou	Minieh-Danieh	North	9.70
32	Danhi	Zgharta	North	17.73

Polygon ID	Location	District	Mohafazat	Area of fire per town (ha)
33	Chekka	Batroun	North	17.99
34	Chekka	Batroun	North	9.49
35	Chekka	Batroun	North	2.92
36	Kfar Hazir	Koura	North	11.73
37	Hamat	Batroun	North	2.25
38	Majdel	Koura	North	14.27
39	Harbta	Baalbek	Bekaa	0.12
40	Ejdabra	Batroun	North	1.86
41	Jebla	Batroun	North	0.43
42	Dael	Batroun	North	45.76
43	Kfar Obeida	Batroun	North	5.24
44	Edde	Batroun	North	1.75
45	Al-Kharayeb	Baalbek	Bekaa	38.36
46	Sbouba	Baalbek	Bekaa	45.77
47	Chabtine	Batroun	North	9.43
48	El-Mouncef	Jubail	Mount Lebanon	2.55
49	El-Mouncef	Jubail	Mount Lebanon	4.58
50	El-Mouncef	Jubail	Mount Lebanon	3.23
51	Jage	Jubail	Mount Lebanon	1.67
52	El-Rihane	Jubail	Mount Lebanon	5.89
53	Saki-Rechmaya	Jubail	Mount Lebanon	0.13
54	Berket Hejoula	Jubail	Mount Lebanon	5.96
55	Bintael (Fdar-El-Soufla)	Jubail	Mount Lebanon	2.44
56	Kornet Chahouane	El Metn	Mount Lebanon	8.50
57	El-Atchane	El Metn	Mount Lebanon	12.81
58	Nabiyeh	El Metn	Mount Lebanon	10.76
59	Ras el Meten	Baabda	Mount Lebanon	66.64
60	Majdel Baana	Aley	Mount Lebanon	6.34
61	Bedghane	Aley	Mount Lebanon	7.50
62	El-Mechrefeh	Aley	Mount Lebanon	0.71

63	Naamat	Chouf	Mount Lebanon	114.32
64	Litige	Aley	Mount Lebanon	0.10
65	Habramoun	Aley	Mount Lebanon	0.56
66	Bisrine	Aley	Mount Lebanon	10.45
67	Bisrine	Aley	Mount Lebanon	2.84
68	Baouarta	Aley	Mount Lebanon	53.41
69	El-Ramliyeh	Aley	Mount Lebanon	6.20
70	El-Ramliyeh	Aley	Mount Lebanon	2.06
71	Maasraiti	Aley	Mount Lebanon	1.85
72	El-Mreijate	Aley	Mount Lebanon	0.25
73	El-Bennaye	Aley	Mount Lebanon	16.95
74	Kfarnice	Chouf	Mount Lebanon	72.93
75	Kfarnice	Chouf	Mount Lebanon	2.53
76	Damour	Chouf	Mount Lebanon	416.28
77	Dakkoun	Aley	Mount Lebanon	75.02
78	Kfar Matta	Aley	Mount Lebanon	1.77
79	Kfar Matta	Aley	Mount Lebanon	448.22
80	Kfar Matta	Aley	Mount Lebanon	4.26
81	El-Mouchref	Chouf	Mount Lebanon	264.05
82	Kfar Matta	Chouf	Mount Lebanon	106.20
83	Debbiyeh	Chouf	Mount Lebanon	271.59
84	Dmite	Chouf	Mount Lebanon	1.10
85	El-Moghayriye	Chouf	Mount Lebanon	3.98
86	El Jiyeh	Chouf	Mount Lebanon	29.93
87	El-Bkaya	Chouf	Mount Lebanon	14.47
88	Wadi Abou Youssef	Chouf	Mount Lebanon	12.93
89	Bkhchtaine	Chouf	Mount Lebanon	1.41
90	Baassir	Chouf	Mount Lebanon	60.04
91	Baassir	Chouf	Mount Lebanon	6.44
92	El-Berjaine	Chouf	Mount Lebanon	2.87
93	Debbiyeh (Ain el Haour)	Chouf	Mount Lebanon	7.27

Polygon ID	Location	District	Mohafazat	Area of fire per town (ha)
94	Gharife	Chouf	Mount Lebanon	1.40
95	Hasroute	Chouf	Mount Lebanon	0.14
96	Zaarouriyeh	Chouf	Mount Lebanon	1.87
97	Bater	Chouf	Mount Lebanon	22.79
98	Kraya	Chouf	Mount Lebanon	1.31
99	Mazraet El-Dahr	Chouf	Mount Lebanon	15.88
100	Mazmoura	Chouf	Mount Lebanon	7.58
101	Bkifa	Chouf	Mount Lebanon	14.84
102	Bhanine	Jezzine	South	30.00
103	Kherbet Bisri	Chouf	Mount Lebanon	0.39
104	Sfarai	Jezzine	South	8.01
105	Berti	Saida	South	9.24
106	Kfar Melki	Saida	South	0.30
107	Bakkifa	Rachaya	Bekaa	0.79
108	Jernaya	Jezzine	South	7.56
109	Kfar-Challal	Saida	South	0.25
110	Ain Abou Abdallah	Sour	South	13.26
111	Froune	Bint Jubail	Nabatiye	1.30
112	Adchite El-Koussair	Marjaayoun	Nabatiye	33.01
113	Alma Chaab	Sour	South	5.96
114	Kornet-El-Hamra	El Metn	Mount Lebanon	24.82
115	Ain El-Rihane	El Metn	Mount Lebanon	1.76
116	Daraoun	El Metn	Mount Lebanon	1.53
117	Mazraet Mrah el-Mir	El Metn	Mount Lebanon	2.48
Total				**2679.15**

Figure 3 showed that 51% of the total fire area occurred in forests, 11% in grasslands, 7% in mixed forest-urban areas and 6% in croplands (i.e., mixed with forests/other wooded land/dispersed trees and shrub). Additionally, 25% of the total fire area affected other land cover classes. The total burned area within each of the land cover classes is shown in Figure 4.

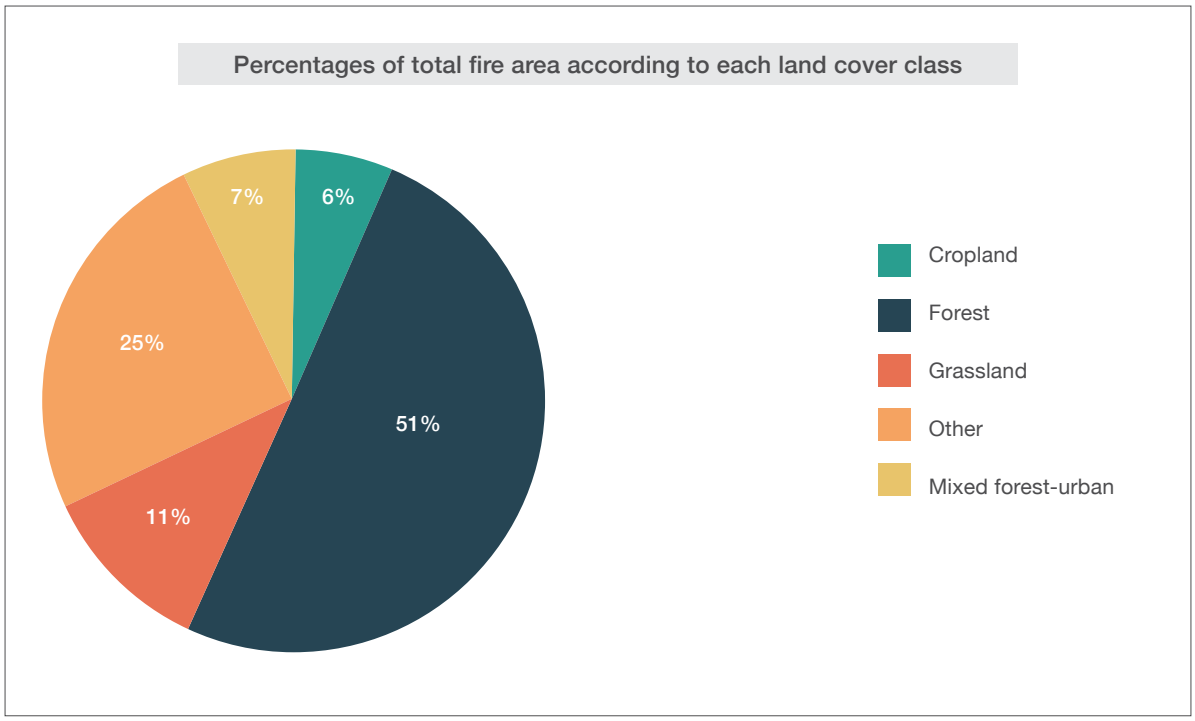


Figure 3. Percentages of total fire area according to each land cover class

Figure 4. Total burned area in each land cover class

As shown in Figure 5, the highest number of fires was in the Mohafazat of Mount Lebanon (i.e., 59 fires), followed by North Lebanon (i.e., 44 fires). Furthermore, a total burned area of 2,249 ha was mapped in Mount Lebanon and an area of 236 ha was mapped in North Lebanon (Figure 6).

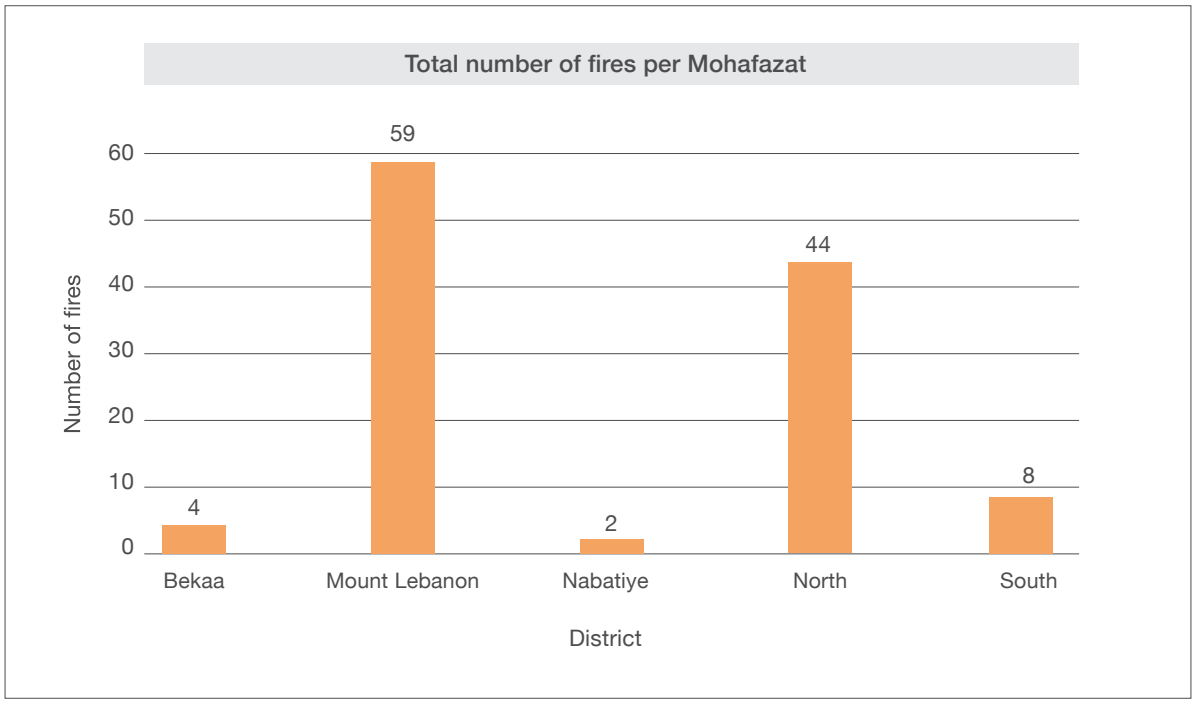


Figure 5. Total number of fires per Mohafazat

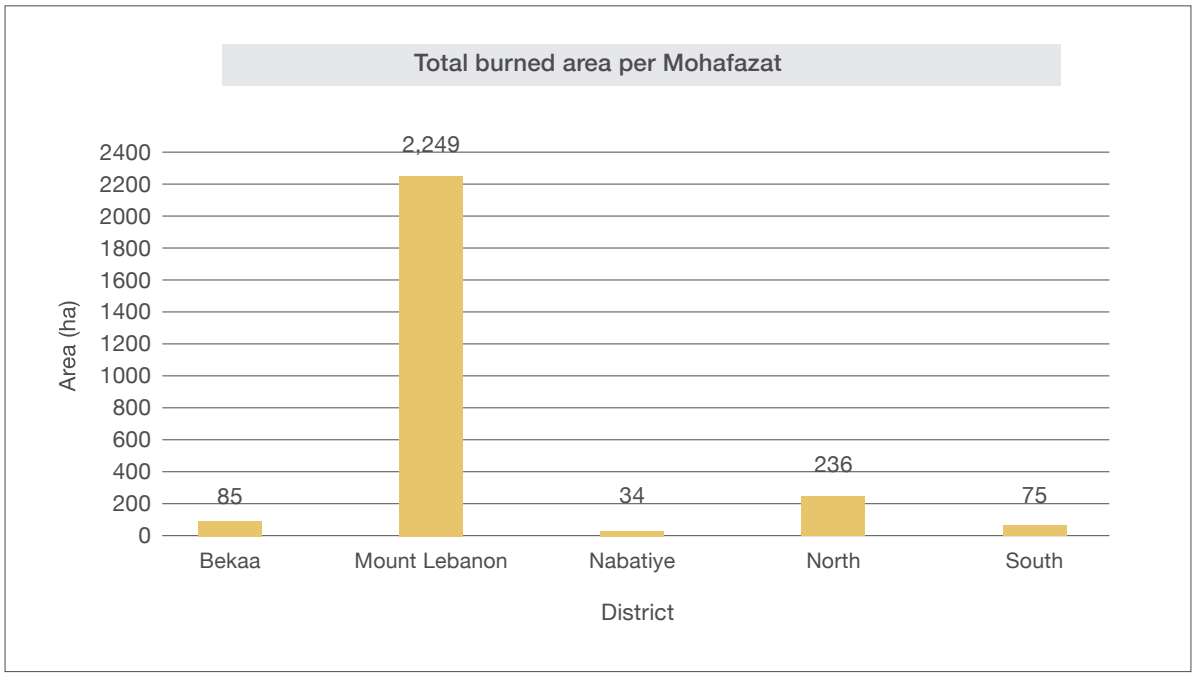


Figure 6. Total burned area per Mohafazat

Fires occurred in 18 districts out of 26. The district of Chouf was the most affected by number of fires (i.e., 26 fires), followed by Akkar (i.e., 22 fires), then Aley (i.e., 17 fires), Batroun (i.e., 10 fires) and Jubail/ Minieh-Danieh (i.e., 8 fires) (Figure 10). Moreover, Figure 11 shows that the total burned area was 1,455 ha in Chouf, 638 ha in Aley, 97 ha in Batroun, 84 ha in Baalbek and 67 ha in Baabda.

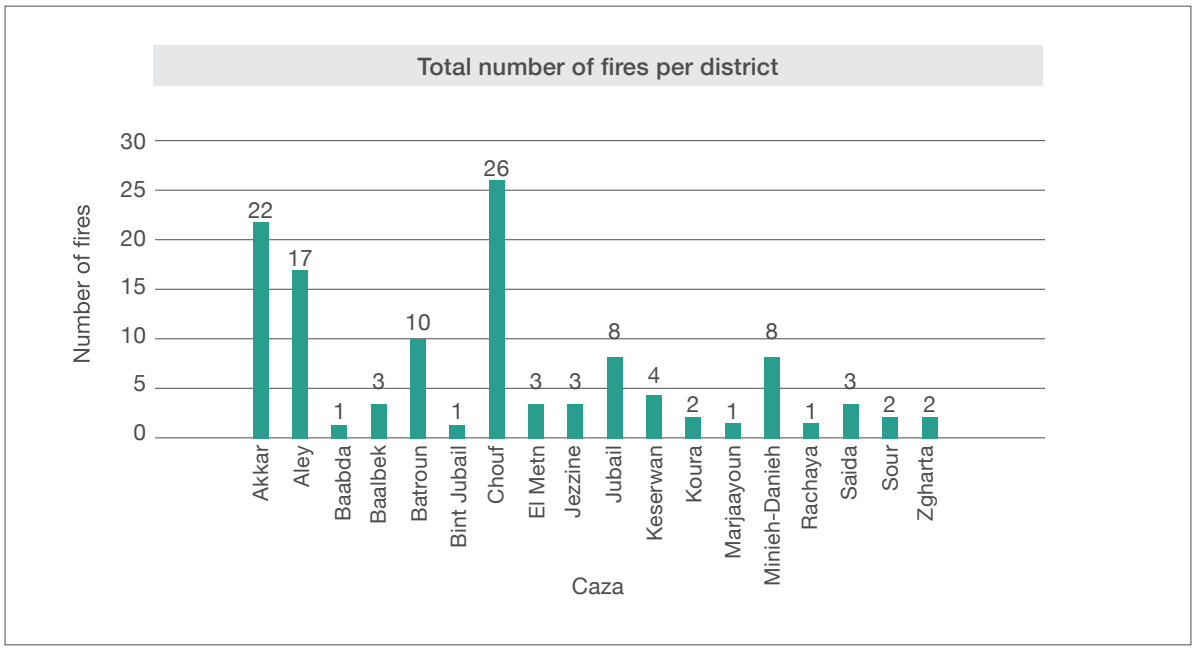


Figure 7. Total number of fires per district

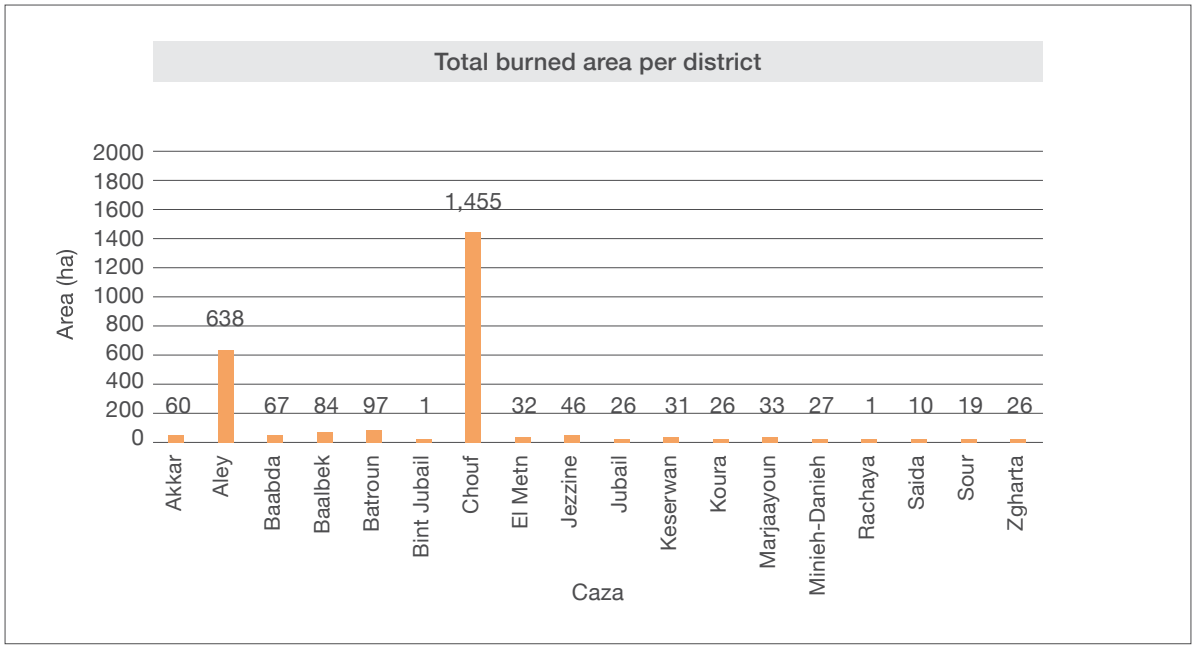


Figure 8. Total burned area per district

Table 2 summarizes the results of the post-fire risk change detection (Spring 2020) in comparison to the results of the first round of assessment (Fall 2019). The results show a significant increase in low risk area (i.e., 64%). However, the high risk area and low risk area decreased respectively by 23.69% and 9.8% showing a relatively positive impact of vegetation recovery.

Table 2. Post-fire Risk change area

	2019 Initial risk area (m^2)	**2020 New risk area (m^2)**	**Difference (m^2)**	**Post fire risk change detection (%)**
High risk	4,229,680	3,227,329	-1,002,351	- 23.69%
Low risk	4,306,275	7,063,329	2,757,054	+ 64.02%
Moderate risk	17,895,688	16,140,985	-1,754,703	- 9.8%
Grand Total	26,431,643	26,431,643		

The final post-fire degradation risk maps of the spring 2020 assessment are presented in Annex 1.

Reforestation and Rehabilitation Plans

The implementation of post-fire restoration and rehabilitation plans highly depend on the post-fire degradation risk maps of Spring 2020 (presented in Annex 3). More specifically, areas characterized by high recovery need to be protected from further disturbances and closely monitored for future risk of fire occurrence. The future vegetation recovery on lands characterized by slight to moderate recovery needs to be closely monitored in the coming two years. Assisting vegetation recovery should be considered as an option in case of possible vegetation regression in the future. Initially, passive restoration should be applied to lands characterized by low to moderate degradation risk. However, active restoration should be addressed in case of further vegetation regression. In this context, passive restoration consists of protecting the burned area from further disturbances and let ecological succession work as vegetation regeneration may occur from seeds and shrub recovery may occur from resprouting of burned trees and stumps (i.e., basal resprouting). Further steps in management of natural recovery of vegetation imply assisted restoration. This might involve thinning including the selection of shoots in coppices in addition to the control of unwanted vegetation and protection of recovering vegetation from grazing animals.

In areas of high risk of degradation, emergency interventions are needed. Such "first-aid" interventions are needed to stabilize fire affected areas, prevent degradations processes and minimize associated risks. In most of the cases, such interventions aim at ensuring soil protection to avoid erosion and decrease water runoff. Prevention of tree pests and diseases should be closely looked across all fire affected lands. In addition, active post-fire restoration activities and implementation of rehabilitation plans must address priority sites of high degradation risk. These will be based on recommendations for best practices[1] in relation to 1) plant cover regeneration, 2) reduction of soil erosion, 3) preservation of soil fertility, and 4) reduction of subsequent fire risk. Specific recommendations for plant cover regeneration include:

- Leave all the trees that show signs of life and those with dry leaves. Preserve all the burned scrub and avoid driving machinery over it.
- Unless there are stands of non-serotinous pines, the site does not need to be prepared for plantation.
- In the case of non-serotinous pines, preserve the live pines on the unburned patches of vegetation and on the unburned perimeter so that they can disperse their seeds over a short, adjacent strip of land.
- In the case of stone pine, preserve all the live pines and those whose canopy is partly uncharred. This is vital for the regeneration of the burned areas
- Applying mulch (e.g., chipped debris or cereal straw), does not negatively affect the regeneration of the plant cover.
- Do not allow animals to graze in the regenerating forest areas at least 5 years after the fire event.
- Cutting 90% of the burned trees and pruning the branches is recommended on sites of Pinus brutia. At the same time leaving the timber on the ground (i.e., covering approximately 40% of the surface area up to a height of between 0 and 10 cm, and 60% of the surface area up to a height of between 11 and 50 cm) reduces solar radiation and the temperature of the soil, while increasing its humidity.
- To encourage resprouting in oak burned sites, a smooth, clean cut without tears must be made close to the ground, so that rain water can run off easily.

1] Mauri, E. & Pons, P. 2019. Handbook of Good Practices in Post-wildfire Management. 2nd ed., Anifog Project I+D+i CGL2014-54094-R, Universitat de Girona. 169.

Preliminary and initial recommendation for reduction of soil erosion:

- Preserve as much of the ash, burned debris and leaf litter as possible, as these help retain rainwater.
- Do not allow vehicles with chains to circulate.
- How vulnerable the soil is to erosion is related to its mother rock, the slope, the proportion of surface area of bared soil, the thickness of the layer of leaf litter, and the type and severity of fire. It is always recommended to avoid salvage logging the trees, creating new roads, circulating machinery off the roads and hauling the stems where the soil is at maximum risk of erosion.
- In general, soil is highly vulnerable to erosion when it is comprised of sand, chalk, or marl with a slope of > 20 degree, a surface area of naked soil of > 60%, and where the thickness of leaf litter is < 1 cm.
- During the first year after a moderate or severe fire, do not circulate with machinery in the forest when the soil is excessively humid, frozen or snow-covered, because this causes deterioration in its structure.
- Applying mulch is the most efficient treatment (i.e., covering at least 70% of the soils with mulch that could be made from woody debris can reduce erosion by up to 90% compared with an untreated burned area). In the case of not enough woody debris, mulch made from straw and chipped bark produces the best results.
- It is possible to mix the seeds of native grass species with the mulch. This technique should be prioritized on steep slopes with little vegetation cover and a high risk of erosion, and it should be applied soon after the fire and before the autumn rains.
- Avoid allowing animals to graze on the site in the following the fire, as this can considerably reduce the abundance of grass and scrub species.
- On steep slopes of burned pine forest (> 20 degree) and soft soil, it is possible to use downed pine stems to create erosion barriers, by placing them parallel to the contour lines that retain the eroded soil.

Preliminary and initial recommendation for preservation of soil fertility:

- Preserve as much of the ash, burned debris and leaf litter as possible, as these help retain rainwater. In pine stands, a covering of dead needles seems to be more efficient at preventing erosion than a covering of branches without needle.
- Avoid whole-tree harvesting across the entire burned area and do not allow the movement of vehicles with chains.
- Wait at least a year before entering the forest with machinery (if need be) to give the plants the chance to germinate, as it is during the first year after the fire that the soil is most sensitive.
- One way of accelerating the incorporation of the nutrients from the dead stems and branches of a burned pine stand, is to remove some of the burned trees, cut off the branches and chop them up to increase the surface area of the wood in contact with the soil, if possible covering more than 45% of the surface area.8
- Prioritization of cutting or chipping the branches and stems with a smaller diameter is suggested because in the case of pines, the thickest trunks decompose more quickly than the thinner ones.
- Where there is risk of erosion, wood can be chipped and scattered over the burned area as mulch.
- Avoid allowing animals to graze on the site following the fire, as this can considerably reduce the abundance of grass and scrub species, whose roots retain rainwater and stabilize and structure the soil and, in the case of leguminous plants, enrich the soil with nitrogen.

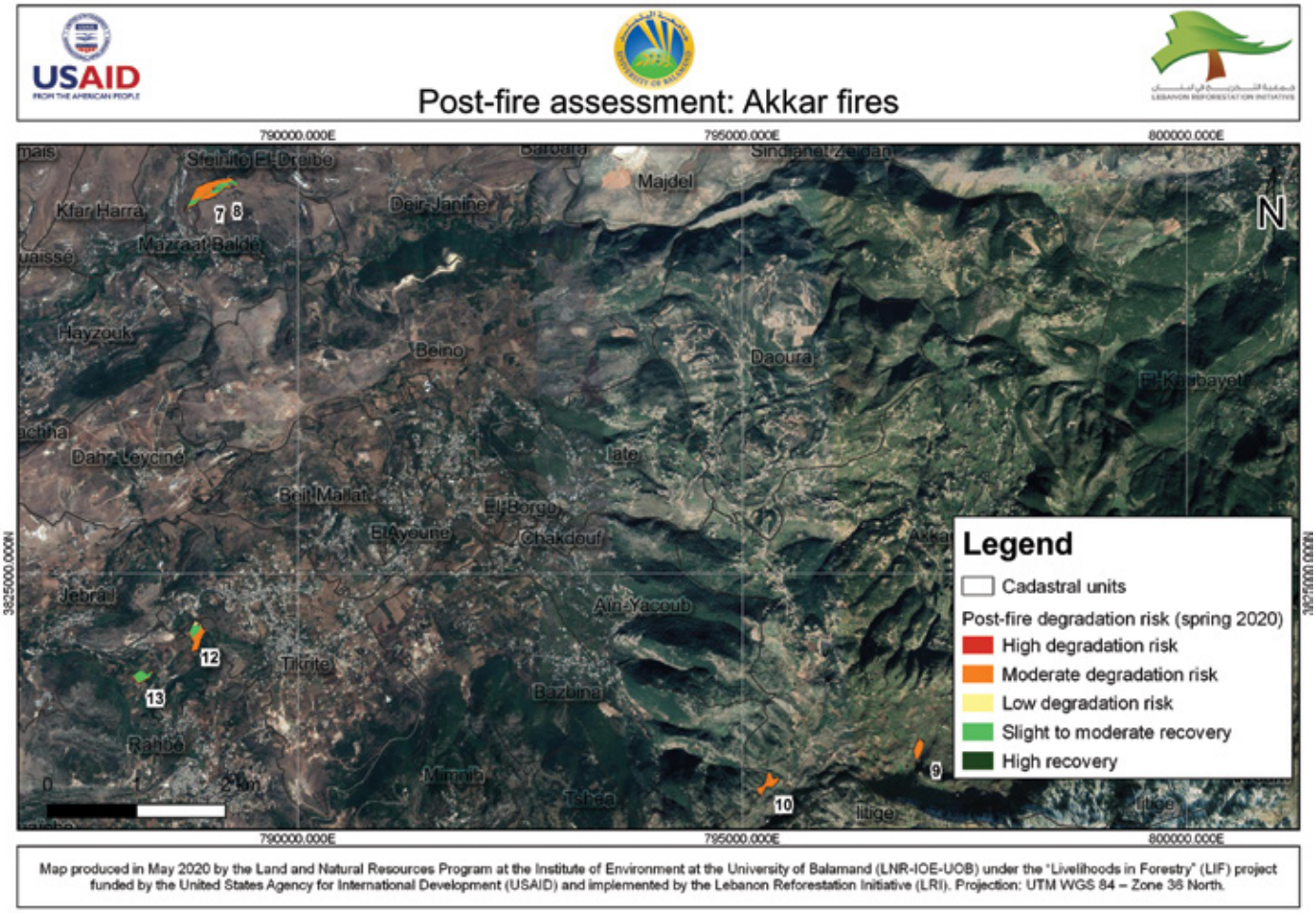
Preliminary and initial recommendation for reduction of subsequent fire risk:

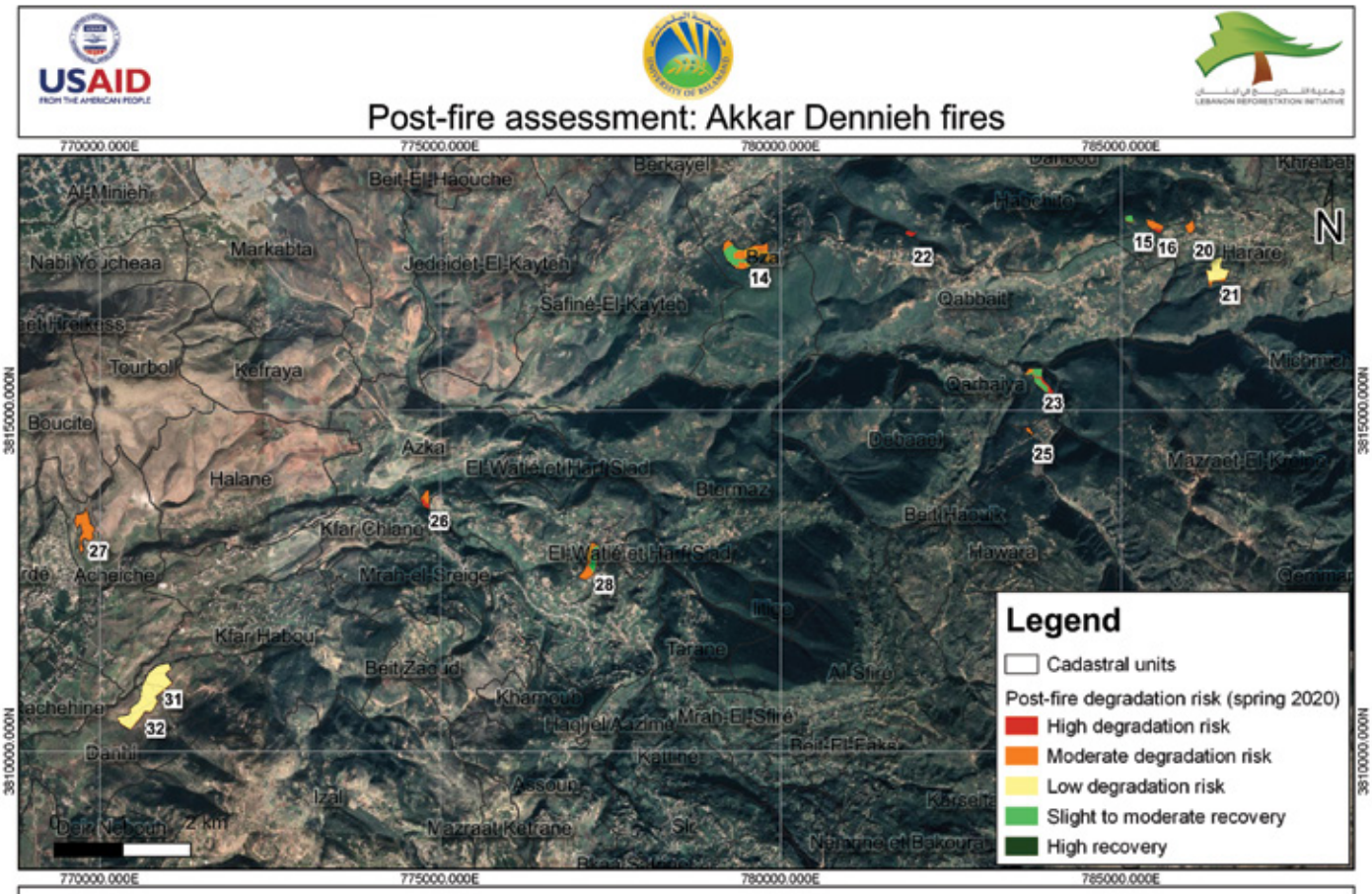
- Whole-tree harvesting is the most effective method to reduce the amount of fuel available for subsequent fires, but this might create other ecological/environmental problems (e.g., soil erosion, loss of soil fertility, etc.)
- In case of partial felling, larger diameter trees should be kept standing. Those trees hold more time upright and therefore will not accumulate surface fuel so quickly. In addition, large trunks are less flammable and spread fire more slowly.
- If after the fire regeneration is scarce and the decision is made to reforest the stands by means of planting, the soil must be cleared of dead wood debris. The debris can be chipped, chopped or used to create piles.
- It is recommended to clear debris in proximity to roads (whole-tree harvesting or partial felling are sometimes recommended near roads) and not to leave debris stretching from one side of a rural or forest trail to the other.
- Avoid accumulations of wood that form large barriers or continuous lines as these could increase the propagation of a future fire and make extinguishing it more difficult.
- When the debris is chipped, the wood chips must be scattered uniformly around the logging strip, but the layer must be no thicker than 3 cm to avoid making germination difficult and to ensure that the wood chips are in contact with the soil so that they stay humid, thus reducing their flammability.
- Burned sites should be considered as priority sites for future fire risk monitoring, control and early intervention for suppression.

Finally, the importance of future monitoring and evaluation of fire affected sites must not be ignored. Undertaking this additional effort can provide a lot of future opportunities to learn from past successes and failures in Lebanon. One example of evaluation comprises the assessment of post-fire plant composition within a recovering forest cover and compare it with that of a nearby un-burned land of the same forest type. There is an option as well to evaluate the social impact of restoration projects taking into account the evaluation of the different restoration outcomes beside the ecological objectives.

Annex 1.

Post-fire degradation risk maps (spring 2020)




Post-fire assessment: Akkar Dennieh fires
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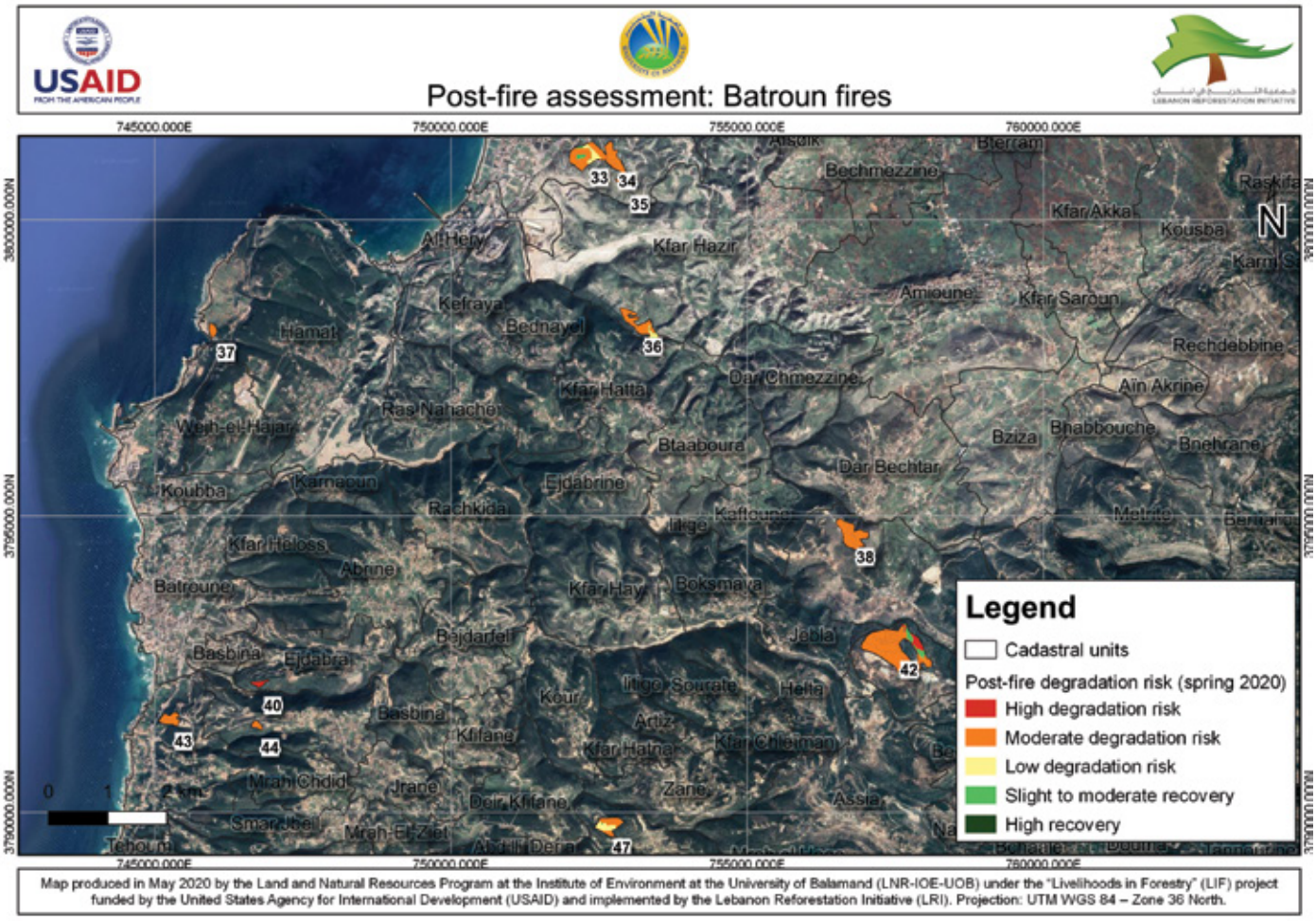
Legend
Cadastral units
Post-fire degradation risk (spring 2020)
High degradation risk
Moderate degradation risk
Low degradation risk
Slight to moderate recovery
High recovery
Map produced in May 2020 by the Land and Natural Resources Program at the Institute of Environment at the University of Balamand (LNR-IOE-UOB) under the "Livelihoods in Forestry" (LIF) project funded by the United States Agency for International Development (USAID) and implemented by the Lebanon Reforestation Initiative (LRI). Projection: UTM WGS 84 – Zone 36 North.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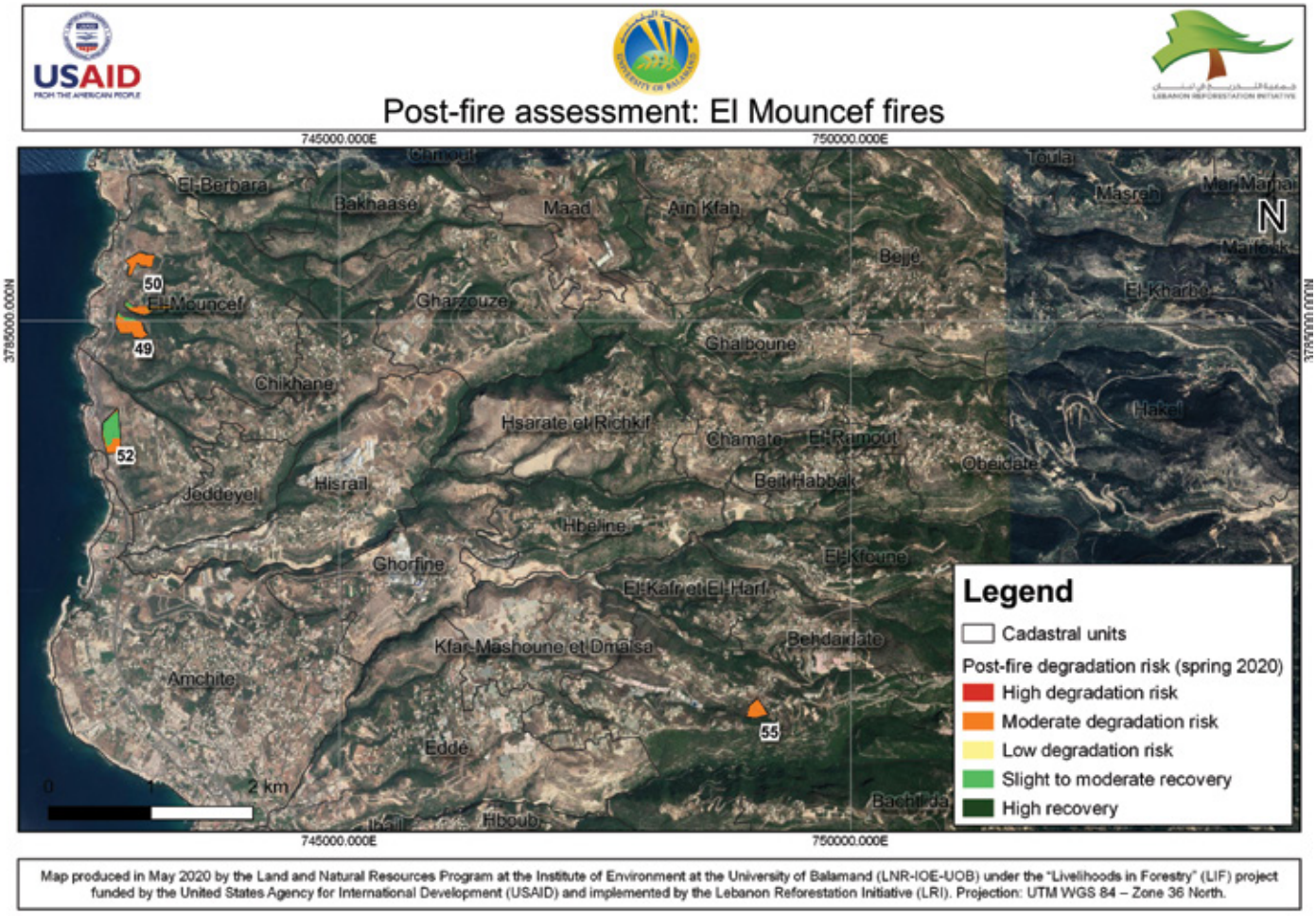
Legend
Cadastral units
Post-fire degradation risk (spring 2020)
High degradation risk
Moderate degradation risk
Low degradation risk
Slight to moderate recovery
High recovery
0
1
2 Km
Map produced in May 2020 by the Land and Natural Resources Program at the Institute of Environment at the University of Balamand (LNR-IOE-UOB) under the "Livelihoods in Forestry" (LIF) project funded by the United States Agency for International Development (USAID) and implemented by the Lebanon Reforestation Initiative (LRI). Projection: UTM WGS 84 – Zone 36 North.



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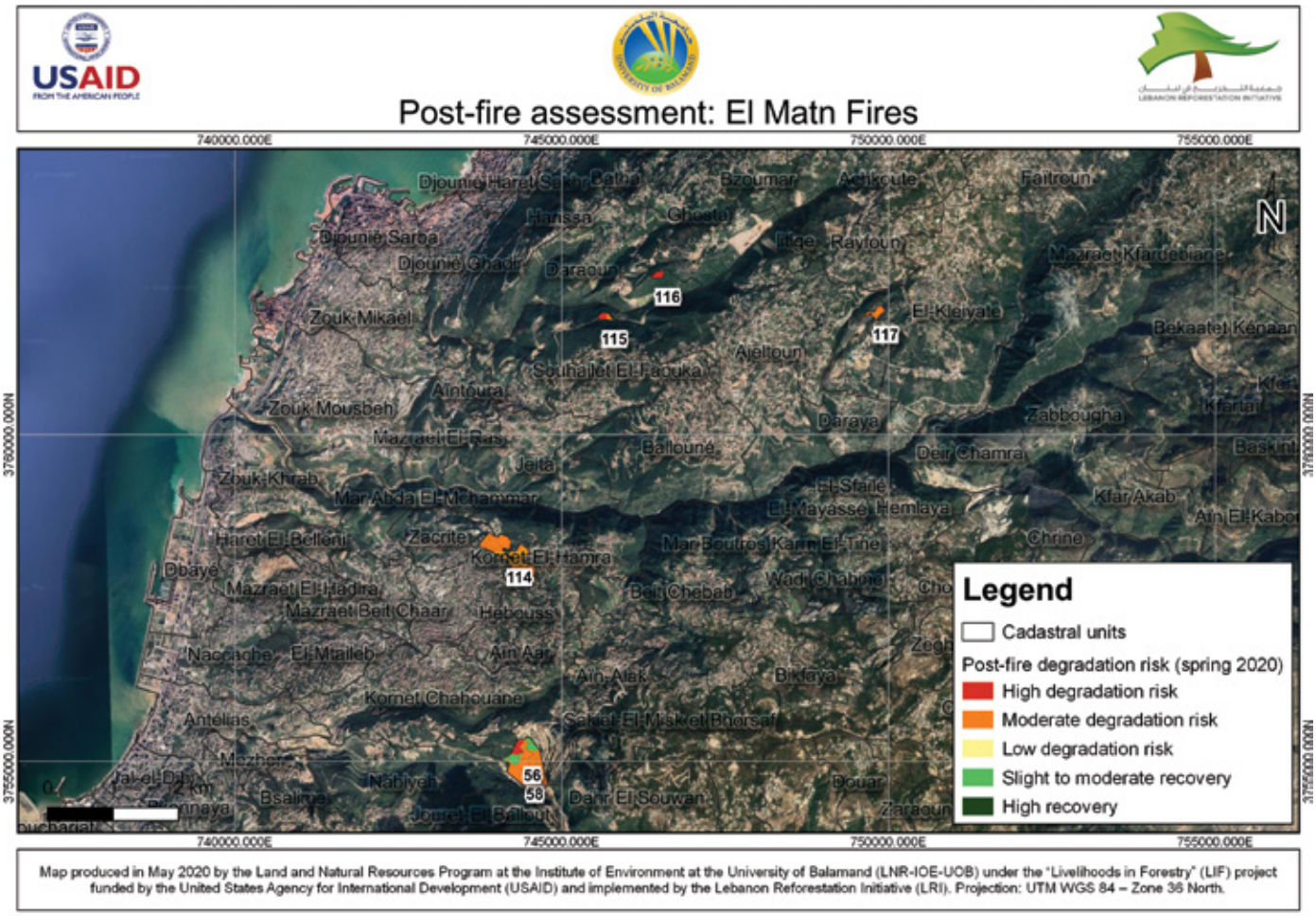

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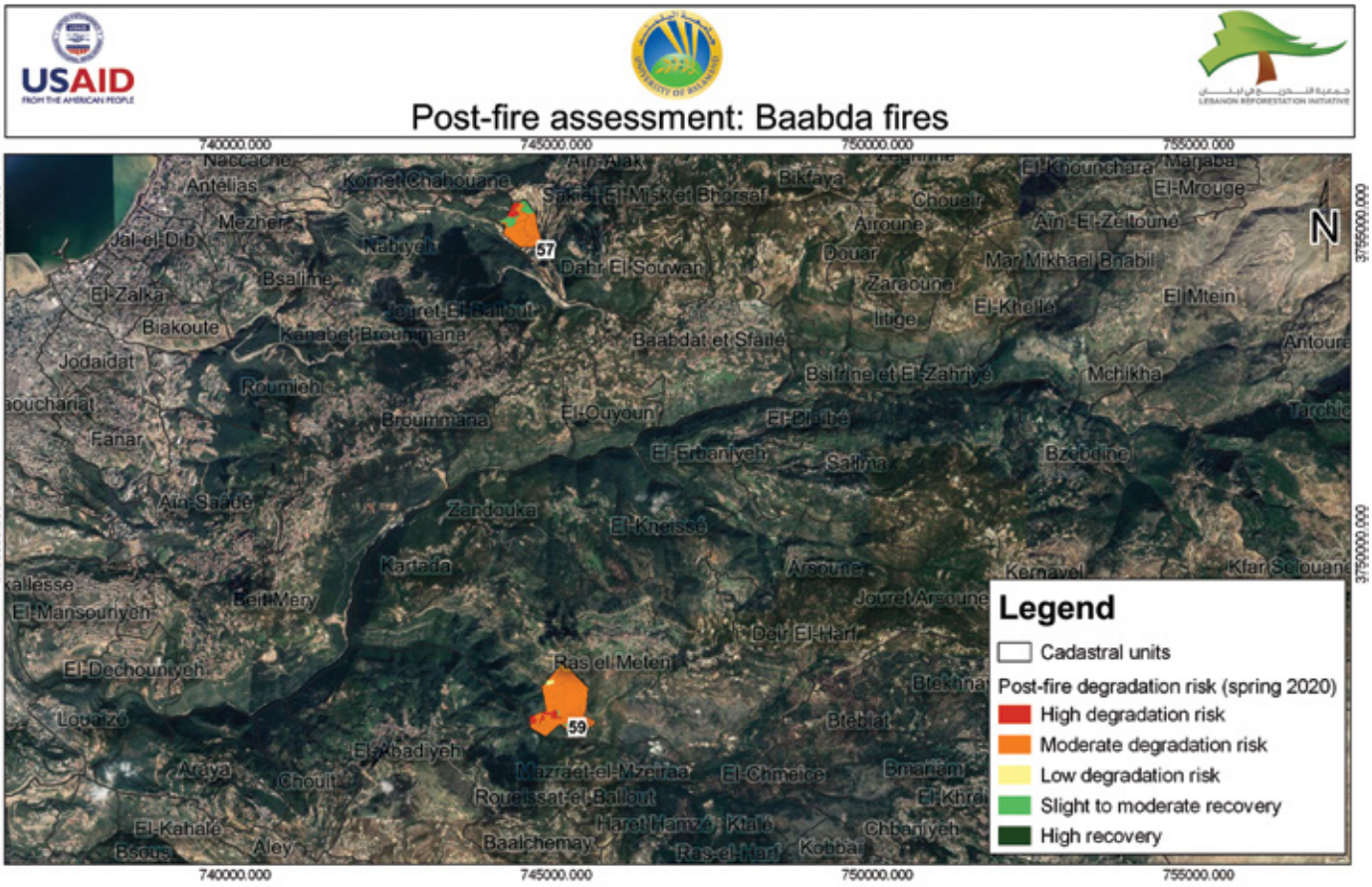

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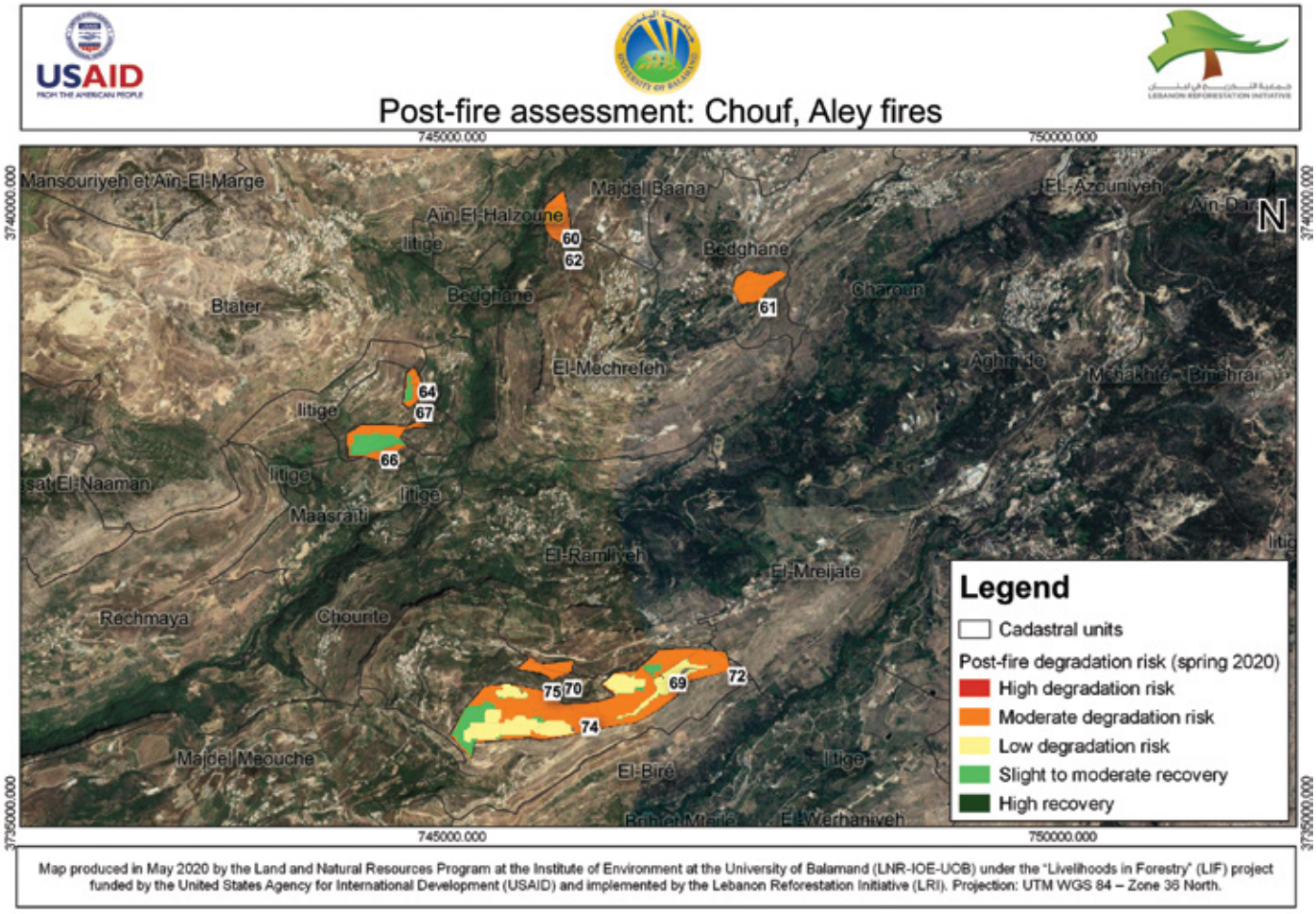

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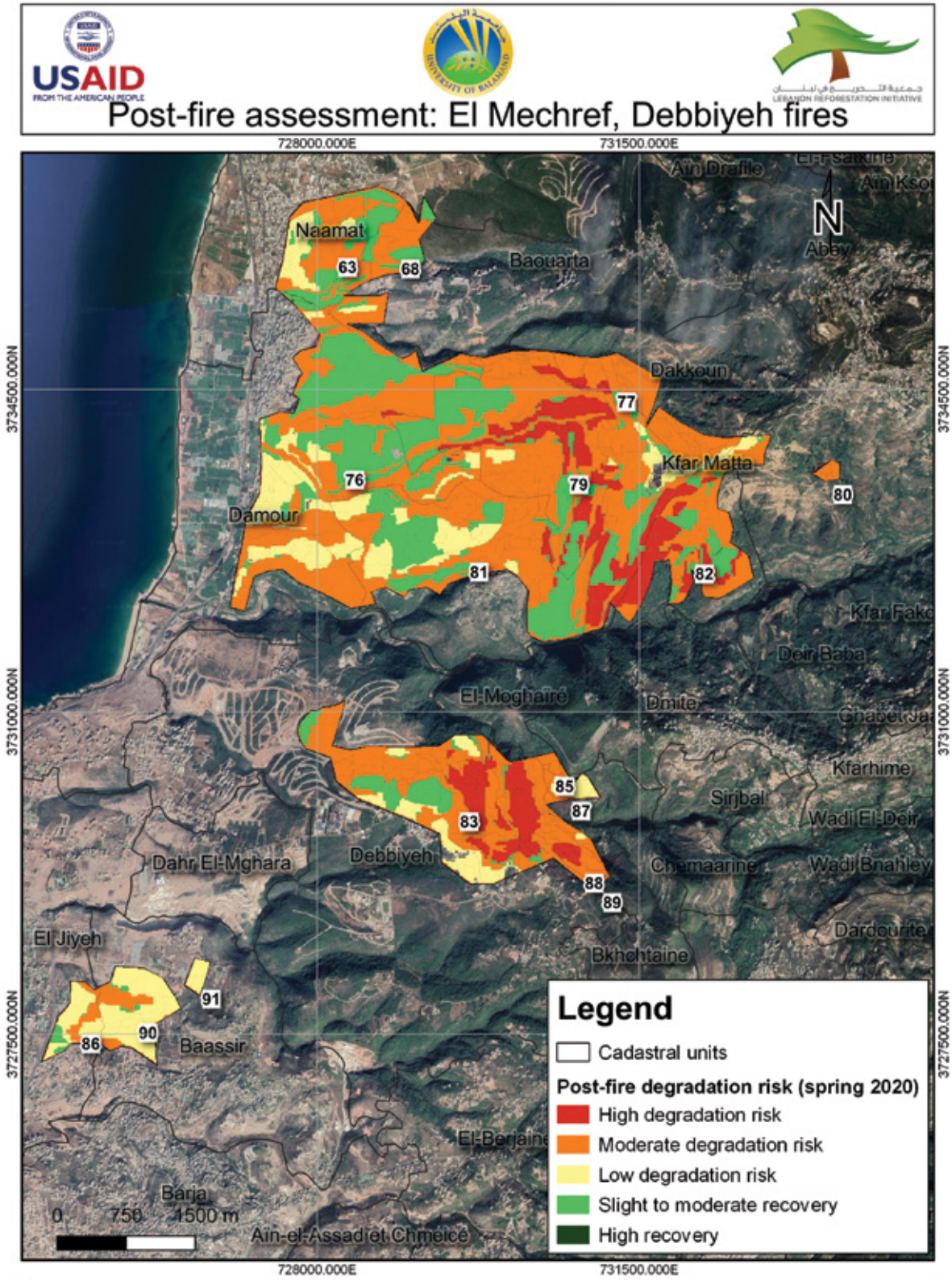

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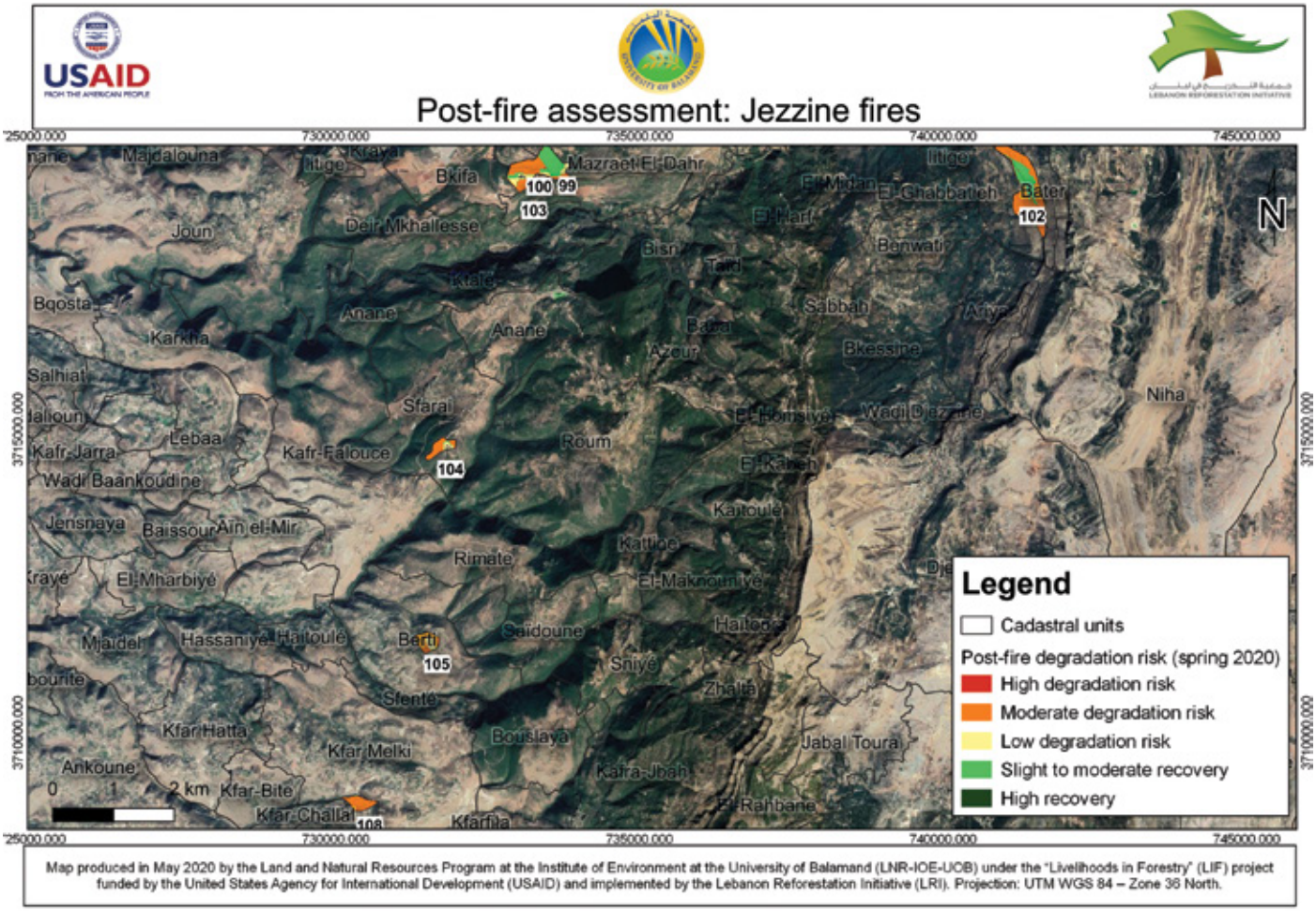

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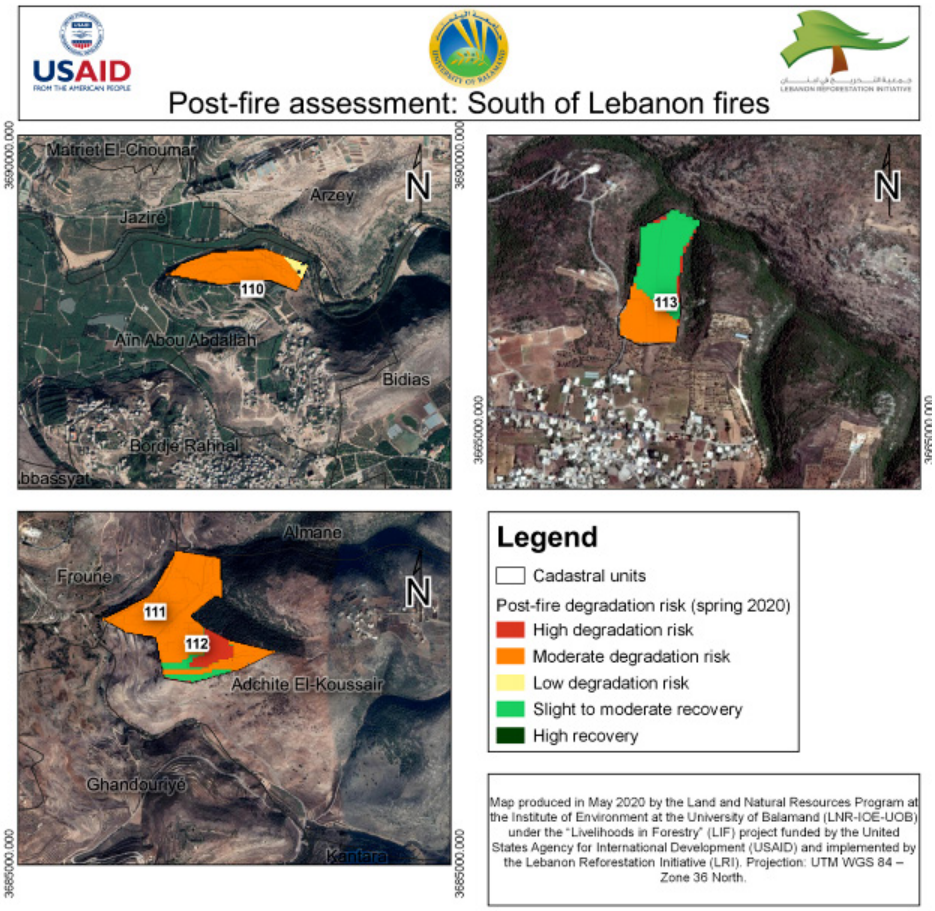
USAID
FROM THE AMERICAN PEOPLE
Post-fire assessment: South of Lebanon fires
Matriet El-Choumar
Arzey
Jazire
110
Aïn Abou Abdallah
Bidias
Bordje Rahhal
bbassyat
N
3690000.000
3690000.000
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Almane
Froune
111
112
Adchite El-Koussair
Ghandouriye
Kantara
3685000.000
3685000.000
Legend
Cadastral units
Post-fire degradation risk (spring 2020)
High degradation risk
Moderate degradation risk
Low degradation risk
Slight to moderate recovery
High recovery
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