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Chapter 1

Botanical Survey of the Nakauvadra Range, Ra Province, Fiji

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SUMMARY

The flora of the Nakauvadra Range is described from a rapid assessment survey of its principle habitats. A total of 418 plant taxa (including eight undetermined angiosperm species) were recorded comprising 75 ferns and their allies, five gymnosperms and 338 angiosperms. Of all the recorded species, 338 were native species and 80 were aliens. The 338 native taxa could be divided into two groups; (i) indigenous species (200 species), and (ii) endemic species (138 species) equating to an endemicity of 41% of the native flora and 34% for the entire flora. Two species of particular interest were *Degeneria roseiflora* (rare on Viti Levua) and *Neoalsomitra integrifoliola* (rare in Fiji).

Four principle vegetation types were identified: (1) Talasiga Vegetation, (2) Lowland Rainforest, (3) Upland Rainforest, and (4) Cloud Forest. Most of the lower elevation vegetation types were disturbed or partially disturbed while the higher elevation vegetation types were generally primary forest.

The findings are discussed in a conservation framework that highlights the taxonomic and/or ecosystem value of notable plant species and vegetation types.

INTRODUCTION

The botanical survey in relation to previous surveys

The range of mountains comprising Nakauvadra lies on the northeast side of Viti Levu. It is a mix of disturbed vegetation, such as grasslands, plantations, agroforests, and secondary forest in the relatively flat and accessible land near villages. Native lowland forest, upland forest and cloud forest occur in the more rugged areas and higher elevation areas. There are no known records of any previous botanical expeditions to the Nakauvadra Range as reflected in the lack of botanical specimen records deposited in the SUVA herbarium. In 2004 a forest tree inventory was carried out by Fiji's Department of Forestry but this was restricted to native timber tree species only.

The current survey was conducted in November 2008 and involved several botanists and vegetation ecologists including Mr. Marika Tuiwawa (Curator of the South Pacific Regional Herbarium) and Dr. Art Whistler (University of Hawai'i Botany Department) who were assisted by Mr. Talie Foliga, Mr. Isaac Rounds, and several local field guides. Other scientists not specifically part of the botanical team but involved in the RAP also helped with the collection of fertile specimens encountered during the course of their field work.

METHODOLOGY

Field base camps

The actual fieldwork began at the village of Vatukacevaceva where the team hiked through the grasslands up the slope and into the forested mountains. Field base camp 1 (herein referred to as Camp 1, see Maps 1b, 2) was set up on a flood plain next to the confluence of the Nabiya and Toluwalu streams which are headwaters of the Volivoli Creek, a tributary of the Wainibuka River for three days. The research team then established Camp 2 (see Maps 1b, 2) near the Vuniqesa Creek at 320 m elevation and spent four days at this base camp. Camp 3 was set up at approximately 600 m elevation by the Bird and Mammal Groups where they opportunistically collected botanical specimens. These teams spent only one night at Camp 3 before they were rejoined by the rest of the expedition team hiking out of the mountains along a path that in places exceeded 600 m elevation.

At Camps 1 and 2 reconnaissance trips were made into the surrounding forests, during which time plant specimens were collected and vegetation qualitatively and quantitatively sampled. Several 1000 m^2 plots were set-up and sampled and involved measuring the diameter at base height (dbh) of trees in the delineated plots. Specimens collected were processed as herbarium specimens and were later dried at the primary base camp in a government quarters in Rakiraki Town. Fertile specimens were photographed before preliminary identification was carried out.

Botanical Surveys

Flora survey

The flora survey involved the compilation of a comprehensive annotated checklist of plants (see Appendix 1) based on qualitative field observations and the quantitative assessment of vegetation growth status and plant distributions observed in and around the sections of the mountain range visited.

In addition to the qualitative and quantitative surveys, fertile (bearing fruits and/or flowers) and sterile specimen samples were collected, labeled and brought back to the field base camps from the vegetation survey plots. The samples were trimmed or arranged to the requisite size of herbarium voucher specimens and placed between sheets of newspaper numbered according to field notes. All collected specimens were then prepared for drying at the main base camp in Rakiraki Town.

Vegetation survey

The vegetation was surveyed by sampling trees found in five 1000 m^2 plots. The sites where the plots were placed were selected based on three criteria; 1) the area was undisturbed or disturbed to a minor extent; 2) the area was representative of the dominating topographic feature (i.e., creek flat, ridge top, slope) and; 3) the area was relatively accessible from the field base camps.

To facilitate sampling, ten 10 x 10 m subplots were marked off within each plot. These subplots were usually aligned in a straight line, but because it was sometimes difficult to find a suitable 100 m long patch of homogeneous vegetation, the subplots were occasionally arranged in a different pattern (depending upon the situation). Once the subplot boundaries were laid out, the field crew went through and measured every tree with its diameter at breast height (dbh) greater than 5 cm. This was done by means of a "dbh tape" wrapped around the trunk at breast height (ca. 1.6m). These measurements along with the identity of the trees were recorded. If the tree could not be immediately identified, flowers, fruits, and/or leaves were collected by means of long poles or by someone climbing the trunk. Voucher specimens were collected, including those plants that could not be identified in the field, for further taxonomical treatment back at the Herbarium at the University of the South Pacific in Suva. Non-tree species were also recorded in each of the plots. These primarily included terrestrial ferns, herbs, epiphytes (mostly orchids, ferns and fern allies), lianas, and shrubs.

The tree data for the five plots sampled is shown in Appendix 2. To produce the tree plot data tables in Appendix 2, the total basal areas (the cross sectional area of the trunk at breast height) for all species were determined by adding up the dbh measurements of all the individual trees. This is displayed in the column headed "Basal Area." The species were arranged from highest to lowest basal area. The column headed "No. of Trees," is the total number of trees of each species found in the plot. This is an indicator of frequency, but the trees may be small and have a low overall dominance because of relatively small dbhs. The third column, "No.>15 cm," is an indicator of typical tree size. If all of the trees of a species are under 15 cm dbh, this often indicates that the tree is small and not a canopy species. The

last column, "Rel. Dom." (relative dominance), is the parameter for determining "dominance." It is obtained by dividing the basal area of each species by the total basal area of all trees in the plot. The total basal area of all trees in the plot is found in the lower right-hand corner of the table.

RESULTS

Flora

A total of 418 plant taxa (including eight undetermined angiosperm species) were recorded for the Nakauvadra Range (see Appendices 1 and 2). Of the recorded species, 338 were native and 80 were alien species.

The 338 native taxa recorded included ferns and their allies (75 species), gymnosperms (5 species), and angiosperms (258 species), and could be divided into two groups; (i) indigenous species (200 species), and (ii) endemic species (138 species). This equates to an endemicity of 41% of the native flora and 34% for the entire flora. Two species of particular interest were *Degeneria roseiflora* (rare on Viti Levua) and *Neoalsomitra integrifoliola* (rare in Fiji).

The alien species were divided into two groups: those that were aboriginal introductions (22 species) and modern introductions (58 species). The four aboriginal introductions that have become naturalized include *Cordyline fruticosa*, *Syzygium malaccense*, *Artocarpus altilis* and *Aleurites molucana*. Similarly the exotic weeds *Sporobolus diander*, *Pennisetum polystachyon*, *Panicum maximum* and *Derris malaccensis* have become naturalized.

Despite the high number of alien species recorded, the overall abundance of the native flora and intact status of the vegetation on the mountain range will make further botanical studies for the area very interesting.

Vegetation

The vegetation of the study area in Nakauvadra Range can be divided into several entities based upon the type or habit of species that dominate (e.g., trees, grasses, etc.), elevation, topography and species composition. During the fieldwork, four principle vegetation types based on Mueller- Dombois and Fosberg (1998) (not including the distinctly disturbed communities, such as plantations) could be distinguished: (1) Talasiga Vegetation, (2) Lowland Rainforest, (3) Upland Rainforest, and (4) Cloud Forest.

Talasiga vegetation

This community is anthropogenic in nature (i.e., created by human activities). The term *talasiga* ("sun burnt land" in Fijian) is the term applied to the fire-modified or fire-degraded grasslands and fernlands that cover much of the dry side of the larger Fijian islands (Parham 1972, Smith 1979). Fires, mostly intentionally set, regularly devastate this community, preventing the successful re-establishment of native tree species. *Talasiga* covers about a third of the area of the two main Fijian islands, Viti Levu and Vanua Levu, mostly in the poorer, eroded areas of the dry zone on the western sides of these islands.

The lower elevations fringes (100 – 250 m.a.s.l.) of the Nakauvadra Range are covered with *talasiga* vegetation especially along the slopes and ridges. Sections of this vegetation type were only briefly surveyed as it is highly disturbed and will continue to be disturbed. The flora is largely dominated by hardy, fire-resistant ferns and alien herbaceous species, mostly grasses. Mueller-Dombois and Fosberg (1998) divided this plant community into several associations, based upon which fern or grass species dominate. The Nakauvadra talasiga fits best within the association referred to as "*Sporobolus indicus* (Wire Grass) Grassland." The two dominant grass species typically are *Sporobolus indicus* and *Dichantium caricosum* with an occasional patch of the introduced *Pennisetum polystachyon*. Approximately 50 other species were also recorded here, but none of them with any abundance approaching that of the two above-mentioned grasses. The creek valley is covered with mixed forest vegetation comprising the common introduced *Albizia saman*, *Albizia lebbeck* and *Mangifera indica*, and the native *Elattostachys falcata*, *Alstonia vitiensis*, *Glochidion seemannii*, *Alphitonia* spp. and *Mussaenda raiateensis*. This area remains forested as it is not prone to becoming alight during a bush fire.

Along the upper fringes of the talasiga grassland, savannah-like vegetation was observed. Here shrubs and/or trees were common and included some of the more common succession trees like *Commersonia bartramia*, *Tarenna sambucina* the two *Alphitonia* species and *Macaranga harveyana*. Also included are *Aleurites molucana*, *Bischofia javanica*, *Cananga odorata* and *Hibiscus tiliaceus*. Shrubs included *Acalypha repanda*, *A. insulana, Morinda citrifolia, Psidium guajava, Syzygium malaccense, Glochidion*

spp. *Mussaenda raiateensis*. Herbs and vines included *Curcuma longa*, *Zingiber zerumbet*, *Heliconia paka*, *Nephrolepis* spp., *Christella harveyi*, *Dioscorea bulbifera*, *D. alata, Merremia peltata, Ipomoea indica, Mucuna platyphylla, Entada phaseoloides, Citrus spp., Musa x paradisiaca* subsp. *sapientum, Xanthosoma sagittifolium* and *Elastostema* spp.

Lowland rainforest vegetation (LRV)

The majority (about 65%) of the Nakauvadra Range is covered by this vegetation community and can be observed from as low as 200 m to roughly 500 m.a.s.l. Not all the LRV observed was primary forest as seen by the species composition in some areas. The occurrence of plants such as *Aleurites molucana* (candlenut), *Artocarpus altilis* (breadfruit), *Syzygium malaccense* (Malay apple), *Vietchia joannis*, *Bischofia javanica, Cananga odorata, Citrus* spp., *Codiaeum variegatum* and *Dioscorea nummularia* and *D. alata* in the area indicate centuries of human influence and habitation. In certain sections of the LRV these plants are common enough to classify the vegetation as "agro-forest," (vegetation that is intermediate between native forest and plantation). Segments of these agro-forest systems were observed along the "traditional highways" used by the survey team to access the mountain range. In other sections of the LRV further away from the traditional highway stands of primary forest were observed.

Five plots of LRV were sampled during the present study. LRV in the study area was not homogeneous due to variations in elevation, topography, and degree of historical and present disturbances. Based on these variations and variations in species composition, three main variations of LRV were identified in the five plots. They were "Creek Flat" forest type due to its occurrence on alluvial soil near streams; "Slope Forest" forest type due to its presence on slopes; and "Ridge Forest" forest type due to its presence on distinct ridges.

Creek Flat Forest Type (Plot 1). This forest type was probably disturbed in the past by natural events such as floods and cyclones. A total of 172 trees (with dbhs > 5 cm) representing 44 species (see Appendix 2) were recorded in the plot. By far the most common tree species in the plot was the subcanopy or understory tree *Gironniera celtidifolia*, which had more than three times as many individuals as any other species (44 individuals). The other common subcanopy and understory trees in the making up over 50% of all trees encountered included *Kingiodendron polycarpum* (12), *Dillenia biflora* (11), *Litsea* sp. (c.f. mellifera) (11) and *Pagiantha thurstonii* (10).

In terms of dominance *Endiandra elaeocarpa* was ranked first (about 16% relative dominance with only eight trees). Second was *Dysoxylum* sp. (11% relative dominance but with only one tree), followed by *Kingiodendron polycarpum* (10% relative dominance with 12 trees) followed by *Gironniera celtidifolia* (8% relative dominance but with 44 trees).

Slope Forest Type *(Plot 2)*. This forest type was situated on a slope near Camp 1 at an elevation of 330 m. A total of 168 trees (with dbhs > 5 cm) representing 40 species (see Appendix 2) were recorded from the plot. The most common tree species found in was the subcanopy tree *Gironniera celtidifolia* (38 individuals). This was followed by *Vietchia vitiensis* (18), *Myristica castaneifolia* (12), *Garcinia myrtifolia* (9) and *Pagiantha thurstonii* (8). These five species represented more than 50% of trees found in the area.

The dominant tree species was *Aleurites molucana* (15% relative dominance). The next five dominant tree species were *Dillenia biflora* (10%), *G. celtidifolia* (10%), *Syzygium c.f. curvistylis* (9%) and *Endospermum macrophyllum* (8%) which combined, contributed to 50% of the total biomass of trees in the plot.

The presence of the species *A. molucana, D. biflora, V. joannis* and the common occurrence of the subcanopy trees *P. thurstonii* and *G. celtidifolia* are characteristic of "disturbed forest." This forest type had either been cleared deliberately by humans or through natural disasters like cyclone and floods or both in the recent past.

Slope Forest Type (Secondary Forest) *(Plot 3)*. This forest type was situated on a slope near the Camp 2 at an elevation of 320 m (similar to Plot 2). A total of 161 trees (with dbhs > 5 cm) representing 30 species (see Appendix 2) were recorded from the plot. The most common as well as most dominant species was *Gironniera celtidifolia*. This one species comprised 45% (72 individuals) of all the trees present with a relative dominance of 16%. The next most dominant species was *Glochidion* sp. with 14% relative dominance followed by *Dysoxylum richii* and *Elattostachys falcate*, both of which are common canopy trees in disturbed forest. The presence of *B.*

javanica, Syzygium malaccense, D. biflora and *Citrus maxima* further substantiates our conclusion that this plot was an agro-forest. It may have been cleared in the recent past for cultivating herbaceous crops, which did not persist once the forest canopy returned.

Ridge Forest Type (Primary Forest) *(Plot 4)*. This forest type was situated on a ridge above the Camp 2 at an elevation of 440 m. A total of 213 trees (with dbhs > 5 cm) representing 50 species (see Appendix 2) were recorded in the plot. The most common tree found in the forest type was the palm *Vietchia vitiensis* (35 individuals). Five other common trees observed included *Parinari insularum* (20), *Gironniera celtidifolia* (16) followed by *Pagiantha thurstonii, Myristica castaneifolia* and *Endiandra* sp. each with 11 indivduals. These six tree species make up 50% (105 individuals) of all trees observed in the 1000 m^2 plot. Plots 4 and 5 (discussed next) are the only plots where *Gironniera celtidifolia* was not the most common species.

The dominant tree species was *Parinari insularum* (21%). The next four most dominant species were *Dysoxylum richii* (10%), *Syzygium* sp. (7%), *Pagiantha thurstonii* (6%), and *Myristica castaneifolia* (5%) and contributed to 50% of the dominant trees in the plot. This plot contained 50 tree species with trunks at least 5 cm dbh, which is distinctly higher than in disturbed forests plots (compare Plot 3 above, with 30 species).

Ridge Dakua Forest Type (Primary) *(Plot 5)*. This forest type was located on a ridge at 425 m elevation. This forest type can also be encountered in the higher elevations of lowland vegetation (ca. 400-650 m) and to some extent in upland vegetation (ca. 650-900 m) in Fiji's high island forests. A total of 162 trees (with dbhs > 5 cm) representing 56 species (see Appendix 2) were recorded in the plot. This was the highest species richness recorded for any plot. The most common tree species in the plot was *Baccaurea pulvinata* with 24 individuals. This was followed by *Vietchia vitiensis* (21), *Myristica castaneifolia* (9), *Aglaia* sp. (8), *Dysoxylum* sp., *Planchonella* sp., *Cyathea hornei* and *Rapanea* sp. (with 7 individuals each). These eight species make up 60% (90 individuals) of all trees observed in the plot.

A unique feature about this forest type is that it is dominated by *Agathis vitiensis* (32% relative dominance with only two trees). This is a giant of the forest. It tends to occur in patches and the small numbers present are augmented by the huge size of the individual trees. While not unusual, having at least eight trees growing close to each other with an average dbh of 100 cm (range 81-134 cm) is now a rarity in Fiji's forests. The next four dominant species *Geissois ternata* (7%), *Metrosideros collina* (7%), *Myristica castaneifolia* (5%) and *Elattostachys falcata* (5%) in addition to *A. vitiensis* make up more than half of the dominant trees observed in the plot.

Both *Geissois ternata* and *Metrosideros collina* are typically upland and/or cloud forest vegetation species in Fiji and their presence in this lower elevation forest is not unusual. All five vegetation plots had between 49 and 59 trees (average 52 trees/plot) with dbhs greater than 15 cm, so there was little difference in this aspect.

Higher elevation vegetation and forest types

The vegetation types observed at elevations above 500 m were a mix of upland and/or cloud forest vegetation types. Due to the short period spent in the area no quantitative analyses were carried out. At a summit close to Camp 3, the overall vegetation was generally stunted with trees growing on average from 2-4 m tall. In the more exposed areas, the sprawling fern *Oleandra neriiformis* was dominant. Tree trunks and branches were covered with mosses, epiphytic orchids and ferns. Some common tree species associated with cloud forest that were observed included *Podocarpus affinis* and *Syzygium c.f. effusum* (primary indicator species for cloud forest systems especially the latter with its distinctive drip tips). Other common tree species observed included *Vietchia vitiensis, Fagraea beteroana, Podocarpus neriifolius, Spiraeanthemum sp., Alstonia montana, Metrosideros collina, Cyathea alata, Scaevola floribunda* and *Freycinetia urvilleana*.

Further up the ridge prior to coming out of the mountain range, the vegetation is typical of that found in upland vegetation. Tree/shrub species growing here are relatively stunted with heights of up to 8 m. Here, as in the cloud forest, the tree trunks and branches were covered with epiphytic mosses, lichens, orchids, *Lycopodium* and ferns. Various *Selaginella* spp., sprawling and/or scandent ferns like *Pteris* spp., *Gleichenia* spp., and *Elastostema australe* dominate the ground cover. Some of the more shrubby trees species like *Ficus theophrastoides*, *F. vitiensis*, several *Psychotria* spp. and *Dysoxylum* spp., were also observed.

Vines and epiphytes

Vines, both trunk climbers (which ascend directly up a trunk by means of adventitious roots that adhere to the bark) and lianas (woody vines that twine around tree trunks and branches to ascend into the canopy), are characteristic of tropical rainforest. Epiphytes were common in the LRV, but were limited by the relative dry conditions in those areas compared to the wetter conditions in the higher elevation forest. Some epiphytes grew on tree trunks in the forest shade, but most of them were found on branches high up in the canopy (and were difficult to spot from the ground) where they get more sunlight. The number of vines recorded in the LRV plots averaged 14.5 per plot, and the number of ferns averaged 16 per plot. Ground cover was not significantly different in the different sites with ground ferns being the predominant terrestrial group.

Alien plants

What was notable about the Nakauvadra forested area surveyed was the small number of weedy alien species found overall in areas above 400 m elevation. Most of the alien plants found here were deliberately recently introduced by locals and included fruit trees like *Mangifera indica, Bambusa simplex, Musa x paradisica*, and *Artocarpus altilis* which has become naturalized. Those that are considered aboriginal introductions include *Aleurites molucana, Citrus* spp., *Cordyline fruticosa* and *Codiaeum variegatum* which have become naturalized.

Most of the invasive plant species encountered were observed along creek embankments and currently used traditional tracks and include some of the more serious invasive species like *Spathodea campanulata, Lantana camara, Arunda donax, Mikania micrantha* and *Clidemia hirta.*

DISCUSSION

The negative impacts of regular (seasonal) burning of vegetation on valleys, slopes and ridges next to villages and farming communities along the base of the Nakauvadra Range over the years has seen the steady upward receding of the fire-line almost to the top of the Nakauvadra Range. This has resulted in the complete transformation of the native vegetation to talasiga grassland. Eighty alien species were recorded in the talasiga vegetation type including invasive plant species like *Spathodea campanulata*, *Albizia lebbeck*, *A. saman* and *Leucaena leucocephala*. This grassland is a major pathway for alien plants into the more intact forest of the mountain range. It is also a fire hazard especially during a prolonged dry season.

Few alien weedy species were found in the forest, the most common of which were *Blechum pyramidatum* (blechum), *Crassocephalum crepidioides* (thick head), *Mikania micrantha* (mile-a-minute vine), *Clidemia hirta* (Koster's curse), and *Piper aduncum*. Most of the weedy species, with the exception of *P. aduncum* were found in the streambeds where sunny conditions prevail during much of the day, rather than in the shady forest. One of the worst weedy species in Fijian forests is *Spathodea campanulata* (African tulip-tree) but only few individuals of this species were observed, mostly on the sunny margins of streams. It was much more common in plantations and fallow areas around the local villages and settlements. Most of these alien weedy plants were brought in by horses used by the locals for hunting and fishing.

The forests in Nakauvadra are relatively pristine, judging by the form of the vegetation (closed canopy forest) as well as the relative absence of alien weeds. The two Slope Forest Types (Plots 2 and 3) are secondary forest and register on average the lowest total tree basal area (38,000 sq. cm). This indicates that the trees in general are smaller (trunk size) when compared to the trees observed in the Creek Valley (Plot 1) and Ridge Forest Types (Plots 4 and 5) with the average total basal area of 51,000 sq. cm. Plot 5 is described as a Dakua Forest because several very large trees of the species *Agathis vitiensis* were found growing close to each other on this ridge. Two other forest types were also observed in areas not quantitatively assessed where a single species clearly dominated the area. These can be refereed to as *Metrosideros* (Vuga) Forest and *Pandanus* (Vadra) Forest.

Despite the pristine outlook of the overall forest, the higher elevation section (> 450 m) of the mountain range has forest systems that are clearly primary forest. The overall 34% endemicity of the flora during the survey indicates that the plant communities in the area are typical of that found in Fiji's native forests (Watkins 1994). If the grassland flora was excluded, endemicity would have been much higher with a flora comparable to that observed in highly diverse (native plants) areas like Waisoi in Namosi (Tuiwawa 1999) and Wabu in Naitasiri (Tuiwawa 2004).

The endemic *D. roseiflora* in the family Degeneriaceae is common on Taveuni and Vanua Levu but is rare and restricted to the drier high altitude forests on Viti Levu. Prior to this survey it was only previously recorded from the Mt Evans Range in the Ba Province, Viti Levu. *N. integrifoliola* has only been collected once by Horne in 1878 from Bua, Vanua Levu. This species currently has an eastern distributional limit of New Guinea, the Bismarck Archipelago and Queensland (Smith 1981). This disjunct range is extraordinary. For it to be found in the Nakauvadra Range (only the second recording for Fiji in the past 100 years) not only reaffirms its existence and confirms its range extension in Fiji but augurs well "unusual" flora of the Nakauvadra Range.

CONCLUSIONS AND RECOMMENDATIONS

Future surveys

The following future recommendations can be made:

1) More specimen collections are needed as only a very small area was accessed during this survey. The checklist of vascular species present is only preliminary and probably includes only 70% of the species present. The orchids are much under-represented, since many of the species are restricted to the tops of trees, where they were not observed (Fiji has about 150 native species of orchid). Epiphytic ferns are also under-represented for the same reasons.

2) More plots need to be sampled at much higher elevations (cloud forest) and further away from known traditional highways. The more difficult groups proved to be the genera *Psychotria* (76 native species in Fiji), *Syzygium* (28 native species), and the Lauraceae family (34 native species).

3) It is particularly necessary that future collections be carried out at least four months away from November to allow for seasonal variation.

Conservation Recommendations

Because of the relative pristine nature of the forests in the Nakauvadra Range and the fact that this is one of the last remaining intact forest systems on the drier side of Viti Levu, every effort should be made to work with the local villagers and relevant Government institutions to preserve these forests. Local community awareness on the negative impacts of uncontrolled burning and access into the mountain range should be carried out as soon as possible.

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