ENHANCING FINANCIAL SUSTAINABILITY

OF THE PROTECTED AREAS SYSTEM IN GEORGIA

TECHNICAL ASSISTANCE GRANT AGREEMENT

Monitoring of Short-listed Invasive Alien Plant Species in Selected Protected Areas of Georgia

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NACRES

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1 Introduction

This report details findings of monitoring of short-listed invasive alien plant species (IAPs) in selected protected areas of Georgia, specifically in Ajara autonomous republic – Kintrishi Protected Areas, Mtirala and Machakhela National Parks. In addition, data on occurrence of other alien species was collected in the above protected areas.

The field surveys were carried out under the supervision of NACRES ecologist – Sandro Kolbaia in June, 2021. Other experts involved in field data collection were as follows: (1) Dr. Zurab Manvelidze, International Communications and Programs Coordinator, Batumi Botanical Garden, (2) Dr. Davit Kharazishvili, Deputy Director of Batumi Botanical Garden, (3) Dr. Nino Memiadze, Head of Local Flora and Conservation Dept., Batumi Botanical Garden and (4) Maradi Iakobadze, Chief Specialist of Natural Resources, Machakhela National Park.

Collected field data was statistically processed and analyzed by Prof. Dr. Zaal Kikvidze, Institute of Botany, Ilia State University and David Kikodze, Deputy Director, Institute of Botany, Ilia State University.

2 Invasive Alien Plant Monitoring Methodology

Monitoring scheme of IAPs was set up based on the hypothesis that roads facilitate introduction and establishment of invasive plants (Mortensen et al. 2009). Starting points of monitoring sites were selected in the roadsides with clear signs of infestation by invasive plants (Slodowicz et al., 2018).

At each monitoring site within a protected area, ideally three plots of 2x50m in a T-shape were established, with the first plot being along the road and the second and third plots - perpendicularly away from the road towards less disturbed / pristine habitat and centered at plot 1 (Fig. 2-1). A similar design was already applied successfully by MIREN (Mountain Invasion Research Network) in their study on non-native plants in mountain areas around the globe (Seipel et al. 2012). For each plot, GPS coordinates, photodocumentation, % cover of IAPs and native vegetation, number of IAP specimens, their mean height and level of disturbance were recorded.

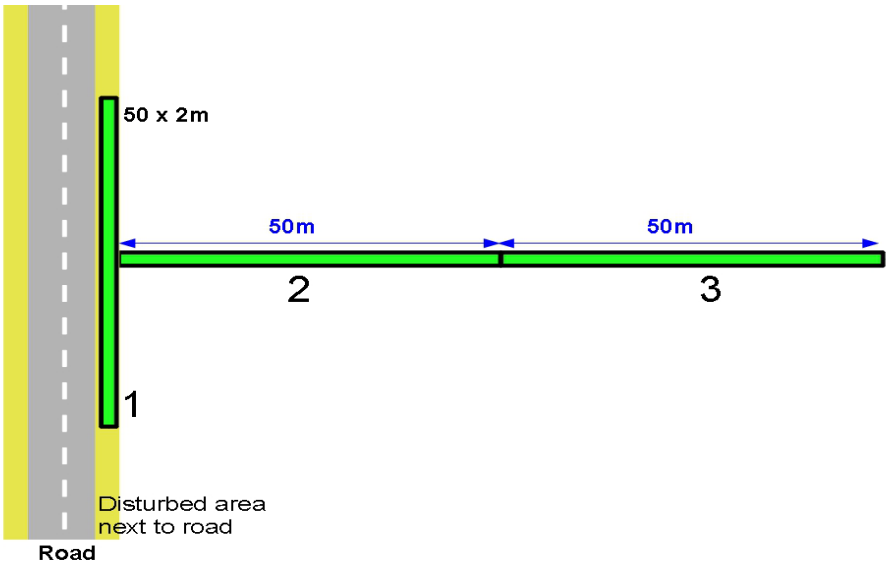

Figure 2-1 Scheme of IAP monitoring transect

Prior to the fieldwork, three target IAPs were selected due to associated potential threat to the local biodiversity. These species are as follows:

1. Japanese spirea (*Spiraea japonica* L.)
2. Chinese silver grass (*Miscanthus sinensis* Anderss.)

3. Common ragweed (*Ambrosia artemisiifolia* L.).

The following criteria were applied in the selection of the target monitoring species:

1. Invasive species status in Georgia
2. Species listed in the "Fifty Worst Invasive Species List of Georgia" ("Elaboration of the Indicators S3 "*Population sizes of selected species"* (Part 1: Flora) and P9 "*Number and distribution of invasive species" - (50 worst alien plant species in Georgia)* (2014). Technical report prepared by Institute of Botany, Ilia State University for Sustainable Management of Biodiversity (SMB), South Caucasus)
3. Records of occurrence in the target protected area.

The following classification system (Kikodze et al., 2010) was used to identify status of the above and other alien plants recorded in the course of the field surveys:

- **Neophyte plants** (or neophytes): alien plants introduced during modern times (after 1500 A.D.) and which have become naturalized.

- **Archeophyte plants** (or archeophytes) are those that were introduced before 1500 A.D. This report does not treat the two groups separately.

- **Casual plants** (transient plants, ephemeral plants): alien plants that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions or habitat disturbance for their persistence.

- **Adventive plants**: casual alien plants that have been accidentally introduced as a result of human activity.

- **Subspontaneous plants**: casual alien plants escaped from cultures.

- **Naturalized plants**: Alien plants that reproduce consistently and sustain populations over many life cycles without direct intervention by human (or in spite of human intervention); they often recruit offspring freely, usually close to adult plants, and do not necessarily invade natural, semi-natural or human-made ecosystems.

- **Invasive plants** (plant invaders): Naturalized plants that produce reproductive offspring, often in very large numbers, at substantial distances from parent plants, and thus have the potential to spread over a considerable area. Invasive plants can affect the invaded natural or semi-natural communities in various ways. Invasive plants can also affect mainly human-made habitats and have direct economic effects. The term environmental weeds is sometimes used for those invasive plants having an impact in natural areas and semi-natural areas; and the term alien weeds is sometimes used for those alien plants that are weedy in managed habitats, such as agriculture.

Information on occurrence of IAPs in the target protected areas was collected via direct observation, personal communication with local experts and literature and herbarium[1] data.

Statistical analysis of the field data collected along the established transects was conducted using box-plots constructed from the mean values and 95% confidence levels of each variable (vegetation cover, cover of target IAP, abundance and mean height of target IAPs and level of disturbance). If the 95% intervals did not overlap, the difference between the plots was considered statistically significant.

After characterisation of each transect with variables, ordination and correlation analyses were used to identify relationships between the variables. For ordination, the Principal Component Analysis method (PCA) was applied. This method reduces variability and produces principal components along which the variables and plots are ordinated on a graph. The position of a plot in this graph (biplot) indicates the differences between the variables and identifies the contributors. Correlation analysis further tests

[1] Occurrence data was extracted from the target species herbarium labels stored at National herbarium of Georgia (international acronym - TBI), Herbarium of Museum of Georgia (TGM) and Herbarium of Batumi Botanical Garden (BAT)

which are the variables that are related and change in a similar pattern along the disturbance gradient. For this, correlation coefficient (Pearson) was calculated for all possible pairs of variables and a correlation matrix was constructed.

All statistical analyses were performed using software PAST.4.03.

The described statistical analysis methodology largely follows Kent & Martin (2011) and Hammer et al. (2001).

3 Alien Invasive Plant Survey Findings

3.1 Monitoring Results

It should be noted that roadsides supporting at least one target invasive plant species were identified only in Mtirala National Park. Moreover, no populations of Common ragweed (*Ambrosia artemisiifolia*) were recorded in any of the monitored protected areas despite indication of historical records on its occurrence in majority of protected areas in West Georgia. This can be explained by significant interannual fluctuations in coverage and abundance of populations of this notorious annual IAP.

Taking into consideration the above, monitoring targeted two IAPS: (1) Japanese spirea (*Spiraea japonica*) and (2) Chinese silver grass (*Miscanthus sinensis*).

Both invasive species are classified as neoindigenophytes (Davitadze, 2001), which indicates that they have become established in native vegetation.

Japanese spirea is an East Asian deciduous shrub introduced into Colchis region since late XIX c. It was collected for the first time in 1960'es in Batumi environs. At present it is widely established from the seaside lowland to the mid-mountain zone; it is associated with forest margins, scrub, windbreaks, abandoned arable land and plantations of subtropical crops. It frequently forms pure stands along roadsides.

Figure 3-1 Japanese spirea, Mtirala National Park

Chinese silver grass is an East Asian perennial herb established in Colchis since 1920’es. It is an ornamental grass first collected as naturalized plant in 1926 in Chakvi vicinity. This plant is widespread from the seaside lowland to the foothills. It is found in roadsides, forest margins and scrub, rarely in plantations of subtropical crops.

Figure 3-2 Chinese silver grass, Mtirala National Park

In total, four transects were established in Mtirala National Park. However, only two transects allowed setup of all three plots. Other two transects are represented by one sampling plot each due to terrain restrictions.

The collected data are given in datasheets contained in Appendix 1.

Statistical analysis shows that vegetation coverage varies significantly in disturbed and infestated plots (Q1) with mean value of 50% while less disturbed plots (Q2 and Q3 respectively) are characterized by more or less identical values (mean value = 90%). As anticipated, vegetation coverage increases with distance from the roads towards less modified habitats.

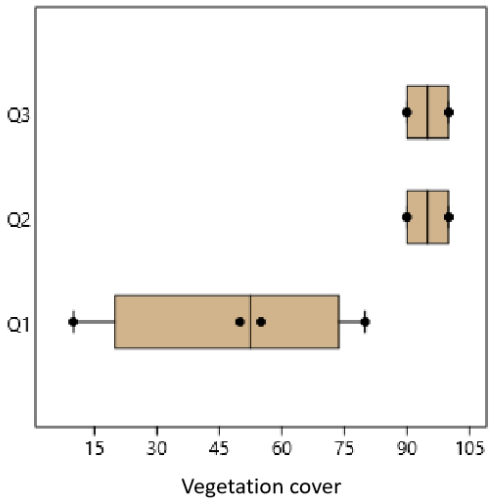

Figure 3-3 Per cent vegetation coverage in sampled plots

Existing disturbance levels[2] vary significantly in the sampled roadsides along all transects while differences are substantially lower in other plots more remote from the roads. However, variability is very significant between the transects due to different magnitude of impacts.

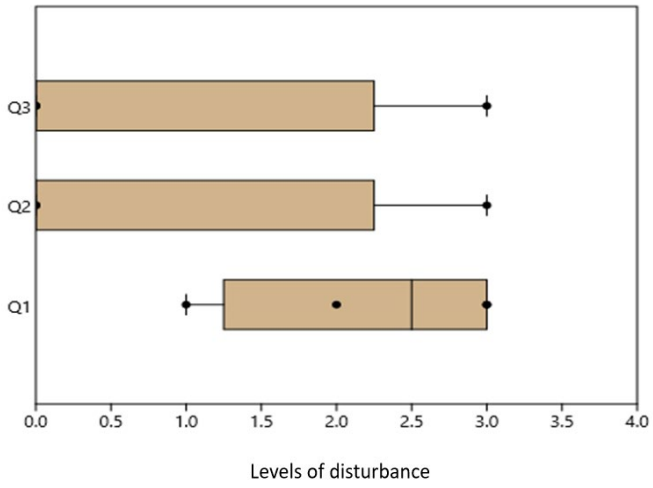

Figure 3-4 Disturbance levels in sampled plots

Coverage of Japanese spirea characterized by the highest mean value in Plots Q1 varies between transects while it decreases in plots remote from the roadsides (Q2 & Q3 respectively). There is a clear and statistically significant trend that the cover of Japanese spirea decreases sharply with distance from the roadsides.

[2] Four-level scale was applied, viz.: 0 – no disturbance; 1 – low disturbance; 2 – moderate; 3 - severe

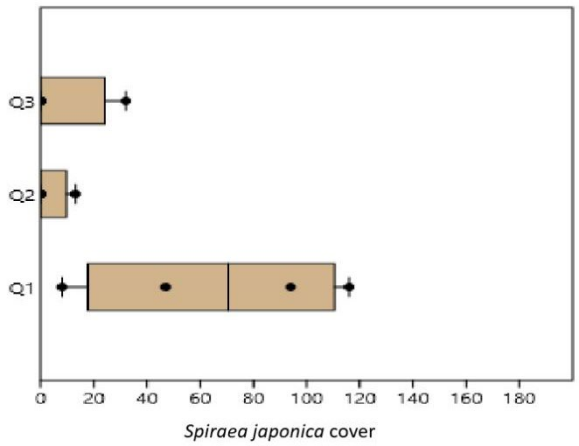

Figure 3-5 Per cent coverage of Japanese spirea in sampled plots

Plots Q1 established in the roadsides support the highest abundance (number of individuals) of Japanese spirea. There is a clear trend that the abundance of *Spiraea japonica* decreases significantly with distance from the disturbed sites.

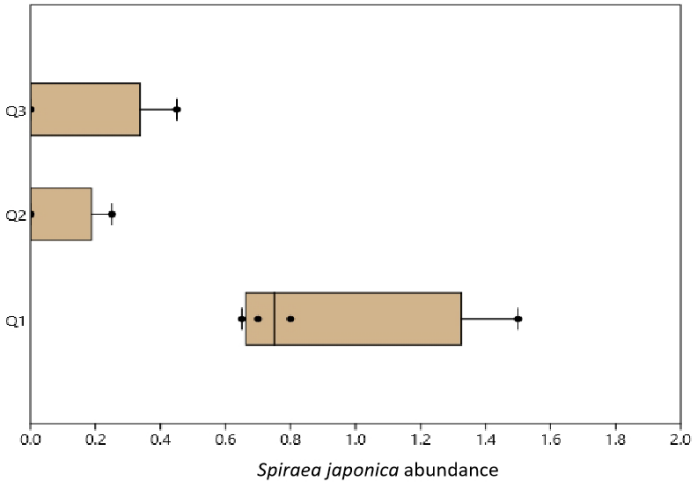

Figure 3-6 Abundance of Japanese spirea in sampled plots

Similar trend is evident in terms of mean height of Japanese spirea plants, viz.: the tallest plants are found in Plots Q1 with mean height decreasing in plots remote from the roadsides.

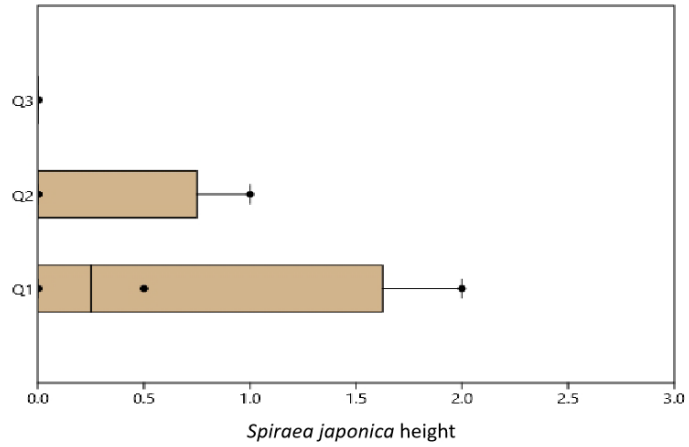

Figure 3-7 Mean height of Japanese spirea in sampled plots

Similar trends were determined in terms of per cent coverage, abundance and mean height of Chinese silver grass (see Figures 3-6 – 3-8 respectively).

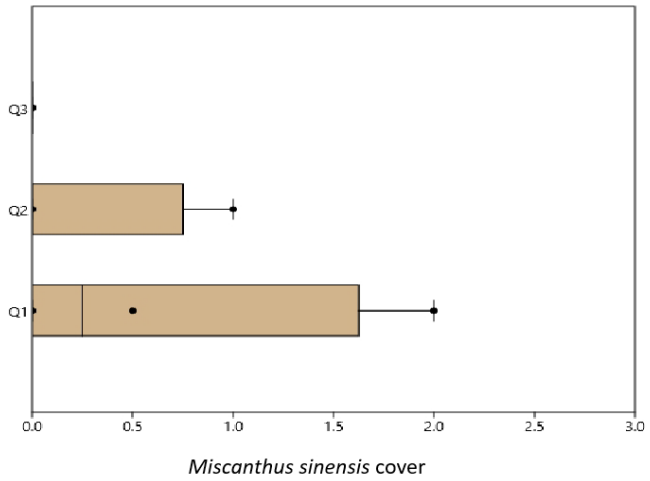

Figure 3-8 Per cent coverage of Chinese silver grass in sampled plots

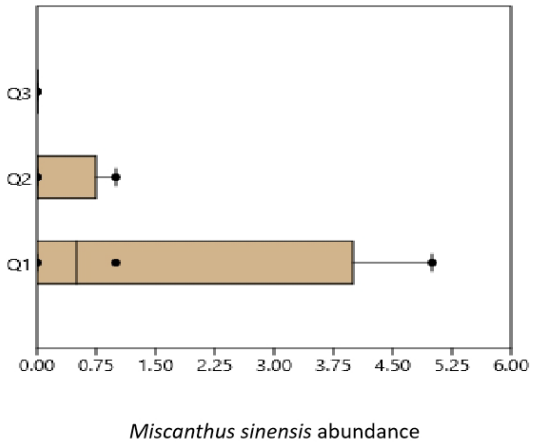

Figure 3-9 Abundance of Chinese silver grass in sampled plots

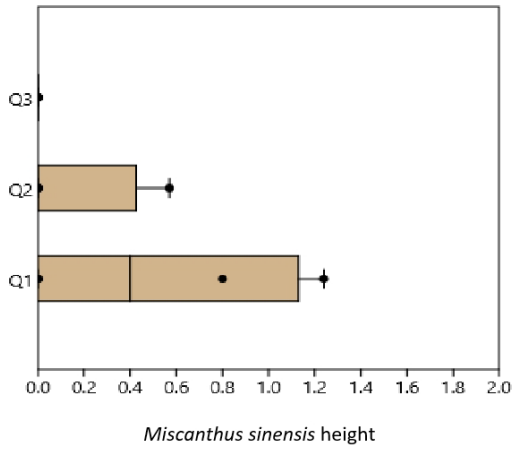

Figure 3-10 Mean height of Chinese silver grass in sampled plots

Principal Component Analysis (PCA) showed that first two components (per cent coverage and level of disturbance) accounts for over 87% of variation in the data (Table 3-1). These two components also showed eigenvalues above 1, which indicate the importance of PCA components; having an eigenvalue more than 1 means that a given component has a considerable power in explaining the variation in the data set.

Table 3-1 PCA of dependence of IAP abundance on location of sampling plots

Principal Component (PC)	Eigenvalue	% variance	Cumulative
1 – per cent vegetation coverage	4.68347	58.543	58.543
2 – level of disturbance	2.2653	28.316	86.859
3 - per cent coverage of Japanese spirea	0.71337	8.9171	95.7761
4 – abundance of Japanese spirea	0.244251	3.0531	98.8292
5 – mean height of Japanese spirea	0.0785044	0.9813	99.8105
6 – per cent coverage of Chinese silver grass	0.0138848	0.17356	99.98406
7 – abundance of Chinese silver grass	1.22E-03	1.53E-02	99.999328
8 – mean height of Chinese silver grass	2.14E-32	2.68E-31	99.999328

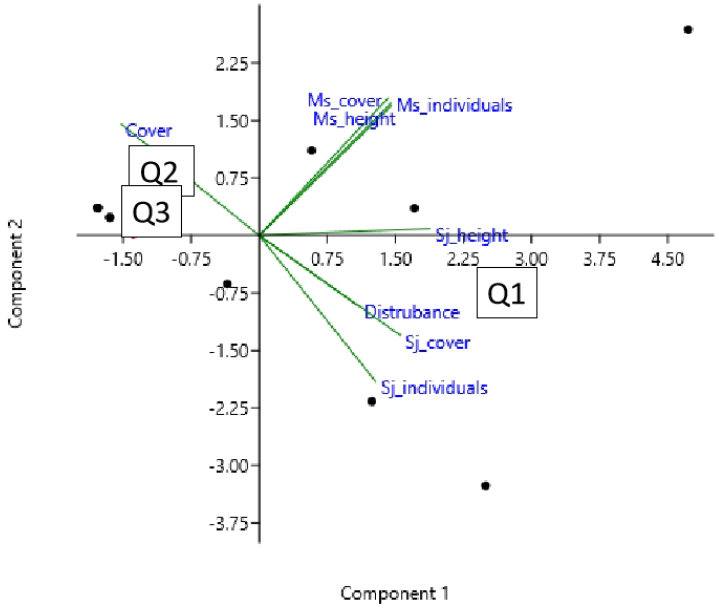

Figure 3-11 PCA biplot of dependence of IAP abundance on location of sampling plots

Table 3-2 Correlation matrix of analysed variables describing the dependence of IAP abundance on location of sampling plots

	Per cent coverage	Disturbance	Sj_coverage	Sj_abundance	Sj_height	Ms_coverage	Ms_abundance	Ms_height
Cover	X	0.18	0	0	0.01	0.42	0.32	0.46
Distrubance	-0.41	X	0.07	0.08	0.09	0.49	0.76	0.31
Sj_cover	**-0.89**	0.54	X	0	0	0.44	0.36	0.23
Sj_individuals	**-0.92**	0.53	**0.79**	X	0.02	0.82	0.72	0.94
Sj_height	**-0.75**	0.51	**0.76**	**0.64**	X	0.01	0	0.01
Ms_cover	-0.26	0.22	0.25	0.08	**0.72**	X	0	0
Ms_individuals	-0.31	0.1	0.29	0.12	**0.78**	**0.96**	X	0
Ms_height	-0.24	0.32	0.38	0.03	**0.74**	**0.94**	**0.91**	X

N.B. Sj – Japanese spirea
Ms – Chinese silver grass
The numbers above the diagonal (cells with X, from the upper left corner to the right lower corner of the above table) represent *p*-values, correlation coeffcients are given below the diagonal. Values in bold show statistically significant cases.

The PCA also indicates a very clear grouping and relations among the variables (Figure 3-11), which was confirmed and validated by correlation analysis (Table 3-2). The PCA biplot shows a clear difference between Plots Q1 *versus* Plots Q2 and Q3 located at a distance from the roadsides. Per cent coverage, abundance and mean height are strongly collinear in case of Chinese silver grass. Similar pattern is observed for Japanese spirea.

It should be noted that the two IAPs show very little correlation with each other, likely due to their different strategies and life forms (Japanese spirea is a shrub while Chinese silver grass is a perennial graminoid herb). However, abundance of both species is negatively correlated with vegetation coverage and positively – with increasing disturbance levels.

3.2 Occurrence of Alien Invasive Species in Target Protected Areas

Historical and field data were collected on IAP occurrence in Kintrishi, Mtirala and Machakhela protected areas. The list is incomplete as no invasive plant species inventories have been carried out in the above protected areas. Summary information on IAP species is given in Table 3-3 below.

Table 3-3 Summary of Alien Species Recorded in PAs

Scientific Name	Common Name	Life form	Origin	Status	Occurrence in PAs
Ailanthus altissima (Mill.) Swibgle	Tree of heaven	Tree	East Asia	Invasive	Machakhela
Ambrosia artemisiifolia L.	Common ragweed	Annual herb	North America	Invasive	Kintrishi, Mtirala
Camellia sinensis (L.) Kuntze	Tea plant	Shrub	East Asia	Subspontaneous	Mtirala
Chenopodium album L.	White goosefoot	Annual herb	South America	Naturalized	Kintrishi

Scientific Name	Common Name	Life form	Origin	Status	Occurrence in PAs
Clerodendron bungei Steud.	Rose glorybower	Shrub	East Asia	Invasive	Machakhela
Commelina communis L.	Asiatic dayflower	Annual herb	East Asia	Naturalized	Kintrishi
Conyza canadensis (L.) Cronq.	Horseweed	Annual herb	North America	Naturalized	Kintrishi
Cryptomeria japonica D. Don	Japanese cedar	Tree	East Asia	Subspontaneous	Mtirala
Duchesnea indica (Andr.) Focke	Mock strawberry	Perennial herb	East Asia	Naturalized	Kintrishi
Elsholtzia ciliata (Thunb.) Hyl.	Vietnamese balm	Annual herb	East Asia	Naturalized	Mtirala
Erigeron annuus (L.) Pers.	Annual fleabane	Annual herb	North America	Invasive	Machakhela, Mtirala
Hypolepis punctata (Thunb.) Mett.	Beadfern	Fern	East Asia	Invasive	Kintrishi, Mtirala
Ixeridium dentatum (Thunb.) Tzvel.	Toothed ixeridium	Perennial herb	East Asia	Adventive	Mtirala
Lonicera japonica Thunb.	Japanese honeysuckle	Shrub	East Asia	Subspontaneous	Kintrishi, Machakhela
Lysimachia japonica Thunb.	Creeping Jenny	Annual herb	East Asia	Adventive	Mtirala
Microstegium imberbe (Nees.) Tzvel.	Japanese stiltgrass	Annual herb	East Asia	Naturalized	Mtirala
Miscanthus sinensis Anderss.	Chinese silver grass	Perennial herb	East Asia	Invasive	Mtirala
Oplismenus undulatifolius (Ard.) Beauv.	Wavyleaf basketgrass	Perennial herb	East Asia	Naturalized	Kintrishi, Mtirala
Paspalum dilatatum Poir.	Dallis grass	Perennial herb	South America	Invasive	Machakhela
Perilla nankinensis (Loir.) Decne.	Purple shiso	Perennial herb	East Asia	Invasive	Machakhela
Phytolacca americana L.	Pokeweed	Perennial herb	North America	Naturalized	Mtirala, Machakhela, Kintrishi
Rhus chinensis Mill.	Chinese sumac	Tree	East Asia	Invasive	Machakhela
Robinia pseudoacacia L.	Black locust	Tree	North America	Invasive	Machakhela
Sisyrinchium septentrionale Biecknell	Northern blue-eyed grass	Perennial herb	North America	Adventive	Kintrishi
Spiraea japonica L.	Japanese spirea	Shrub	East Asia	Invasive	Mtirala, Machakhela
Youngia japonica (L.) DC.	Oriental false hawksbeard	Annual herb	East Asia	Invasive	Kintrishi, Mtirala

In total, 26 alien species are found in the three protected areas, viz.:

- 14 aliens – Mtirala National Park

- 11 aliens – Kintrishi Protected Areas
- 10 aliens – Machakhela National Park.

Majority of the recorded alien species are annual herbs (9 species) followed by perennials (8) and trees (4). Four species are shrubs and only one species is a fern. The eighteen species originate from East Asia, six – from North America and two – from South America. Majority of the species are classified as invasives (12 species) in Georgia, eight species are naturalized, three – subspontaneous and three – adventives. Machakhela National Park supports the highest number of invasive plants (8 species). Three invasive species are known to occur in Kintrishi Protected Areas and Mtirala National park each.

Figure 3-12 Rose glorybower, Machakhela National Park

Figure 3-13 Black locust in flowers, Machakhela National Park

4 Conclusions and Recommendations

The results of IAP monitoring along four transects in Mtirala National Park provide almost no evidence of penetration of invasive plants into important protected habitats such as Colchic woodland. It is obvious that existing native communities if undisturbed are resilient to establishment of invasive plant groupings affecting local biodiversity. However, high number of invasive species is present in the surveyed three protected areas, viz.: 12 invasive species were recorded in Kintrishi, Mtirala and Machakhela protected areas, which is a very high proportion of all known invasives in Georgia (16 in total). In addition it should be taken into consideration that a total of 26 alien species were found to occur in three studied protected areas.

Taking into consideration high number of invasive plant species present, it is strongly recommended to carry out the following activities to monitor and control plant invasions in protected areas. Recommendations are listed by priorities below:

- Identification and mapping of existing and potential entry ports for establishment of invasive species such as roads, trails, different tourist infrastructure, and disturbed sites (thinned woodland, forest clearings, etc.).
- Inventory of all IAPs and identification of most harmful species with potential of forming pure stands and suppressing native communities. It is recommended to carry out inventory by invited experts. Such species will become targets for future monitoring using the methodology described in this report (monitoring should be conducted once in three years). It is also recommended to involve personnel of respective protected areas in monitoring surveys. Such personnel will be provided with detailed work instructions and training if required. Another recommendation is to use SMART application for identification and control of invasive plant species. In addition, it may be beneficial to prepare and print a manual of invasive plant species.

- Prohibition of use of introduced plant species for any activities (e.g. erosion control) in protected areas.
- Prevention of unintentional introduction through requirements for vehicle and equipment cleaning.
- Regular monitoring of entry ports to ensure early detection and rapid response to potential invasions; this could be conducted with effective involvement of the protected areas' staff and visitors, especially for IAPs that are relatively easy to spot and identify.
- Implementation of effective control and manual eradication in case of excessive IAP invasion. It is recommended to undertake pilot mechanical removal of populations of invasive species already identified in roadsides on minor plots (ca. 10-20m^2) marked in advance. Future observations of the experimental plots will show efficiency of mechanical control of invasive species.
- Rising awareness is a critical element of IAP management; it is essential to ensure that local communities understand threats posed by IAPs.

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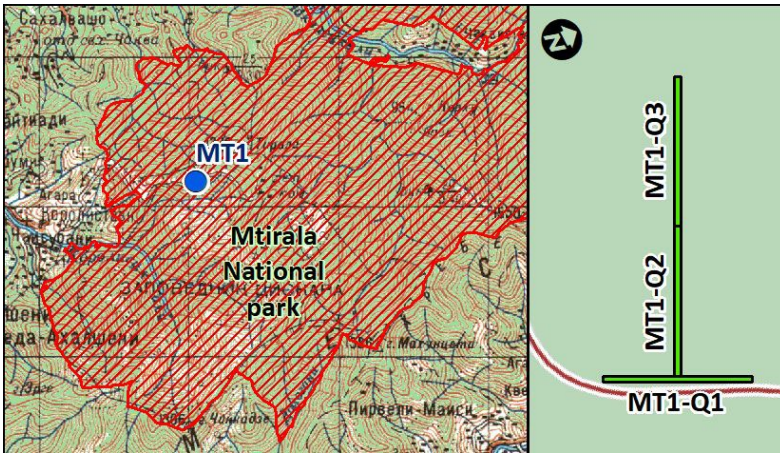
Appendix 1 Field Datasheets

Location: Mtirala National park
Transect code: MT1
Date: 18/06/2021
IAP Scientific name: *Spiraea japonica, Miscanthus sinensis*

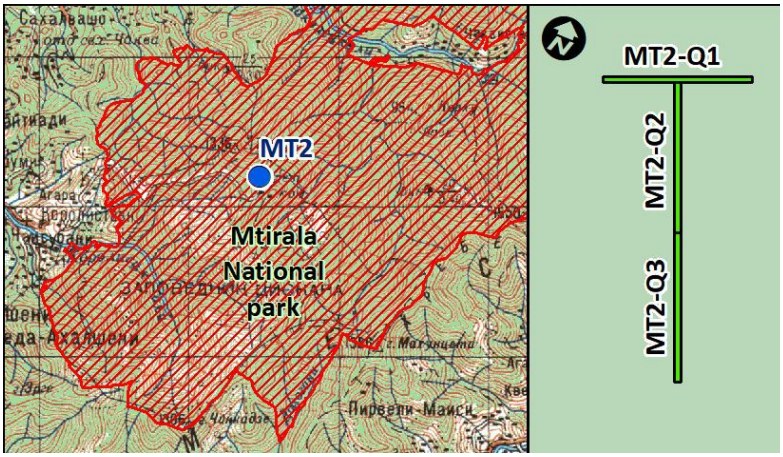


Plot #	Decimal latitude	Decimal longitude	Altitude, m amsl
MT1-Q1	41.65110	41.78654	909
Habitat	Colchic forest margin, roadside		
Number of SJ individuals	47±3		
Coverage of SJ, %	40		
Mean height of SJ individuals, m	1.5		
Number of MS individuals	5		
Coverage of MS, %	2%		
Mean height of MS individuals	1.24		
Vegetation coverage (excl. invasives), %	5		
Disturbance	Low – tourism, vehicle movement		

Plot #	Decimal latitude	Decimal longitude	Altitude, m amsl
MT1-Q2	41.65090	41.78644	907
Habitat	Colchic forest (beechwood)		
Number of SJ individuals	0		
Coverage of SJ, %			
Mean height of SJ individuals, m			
Number of MS individuals	0		
Coverage of MS, %			
Mean height of MS individuals			
Vegetation coverage (excl. invasives), %	90		
Disturbance	Very low		

Plot #	Decimal latitude	Decimal longitude	Altitude, m amsl
MT1-Q3	41.65148	41.78576	952
Habitat	Colchic forest (beechwood)		
Number of SJ individuals	0		
Coverage of SJ, %			
Mean height of SJ individuals, m			
Number of MS individuals	0		
Coverage of MS, %			
Mean height of MS individuals			
Vegetation coverage (excl. invasives), %	90		
Disturbance	Very low		

Location: Mtirala National park
Transect code: MT2
Date: 18/06/2021
IAP Scientific name: *Spiraea japonica, Miscanthus sinensis*

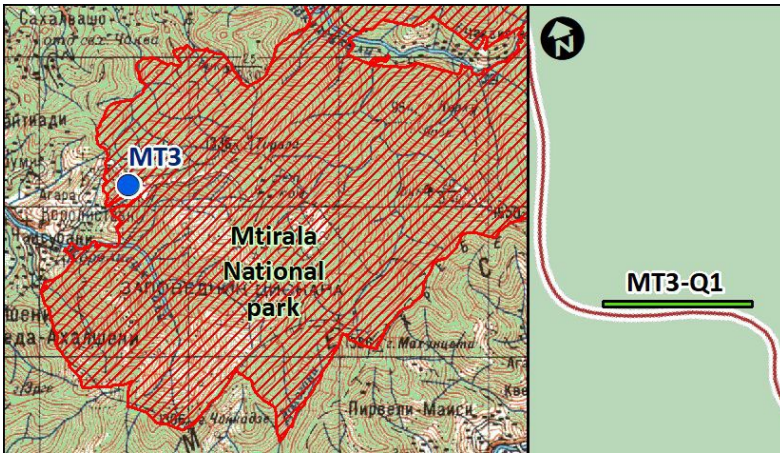


Plot #	Decimal latitude	Decimal longitude	Altitude, m amsl
MT2-Q1	41.65117	41.80606	1198
Habitat	Secondary meadow in forest		
Number of SJ individuals	57		
Coverage of SJ, %	8		
Mean height of SJ individuals, m	0.7		
Number of MS individuals	1		
Coverage of MS, %	0.5		
Mean height of MS individuals	0.8		
Vegetation coverage (excl. invasives), %	80		
Disturbance	High-vehicle movement, construction waste		

Plot #	Decimal latitude	Decimal longitude	Altitude, m amsl
MT2-Q2	41.65126	41.80632	1201
Habitat	Secondary meadow in forest		
Number of SJ individuals	13		
Coverage of SJ, %	5		
Mean height of SJ individuals, m	0.25		
Number of MS individuals	1		
Coverage of MS, %	1		
Mean height of MS individuals	0.57		
Vegetation coverage (excl. invasives), %	90		
Disturbance	High-vehicle movement, construction waste		

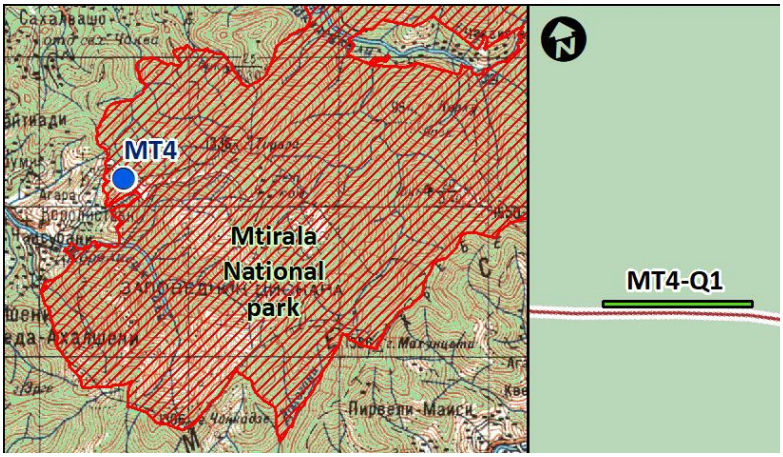
Plot #	Decimal latitude	Decimal longitude	Altitude, m amsl
MT2-Q3	41.65054	41.80697	1200
Habitat	Secondary meadow in forest		
Number of SJ individuals	32		
Coverage of SJ, %	5		
Mean height of SJ individuals, m	0.45		
Number of MS individuals	0		
Coverage of MS, %			
Mean height of MS individuals			
Vegetation coverage (excl. invasives), %	90		
Disturbance	High-vehicle movement, construction waste		

Location: Mtirala National park
Transect code: MT3
Date: 21/06/2021
IAP Scientific name: *Spiraea japonica*



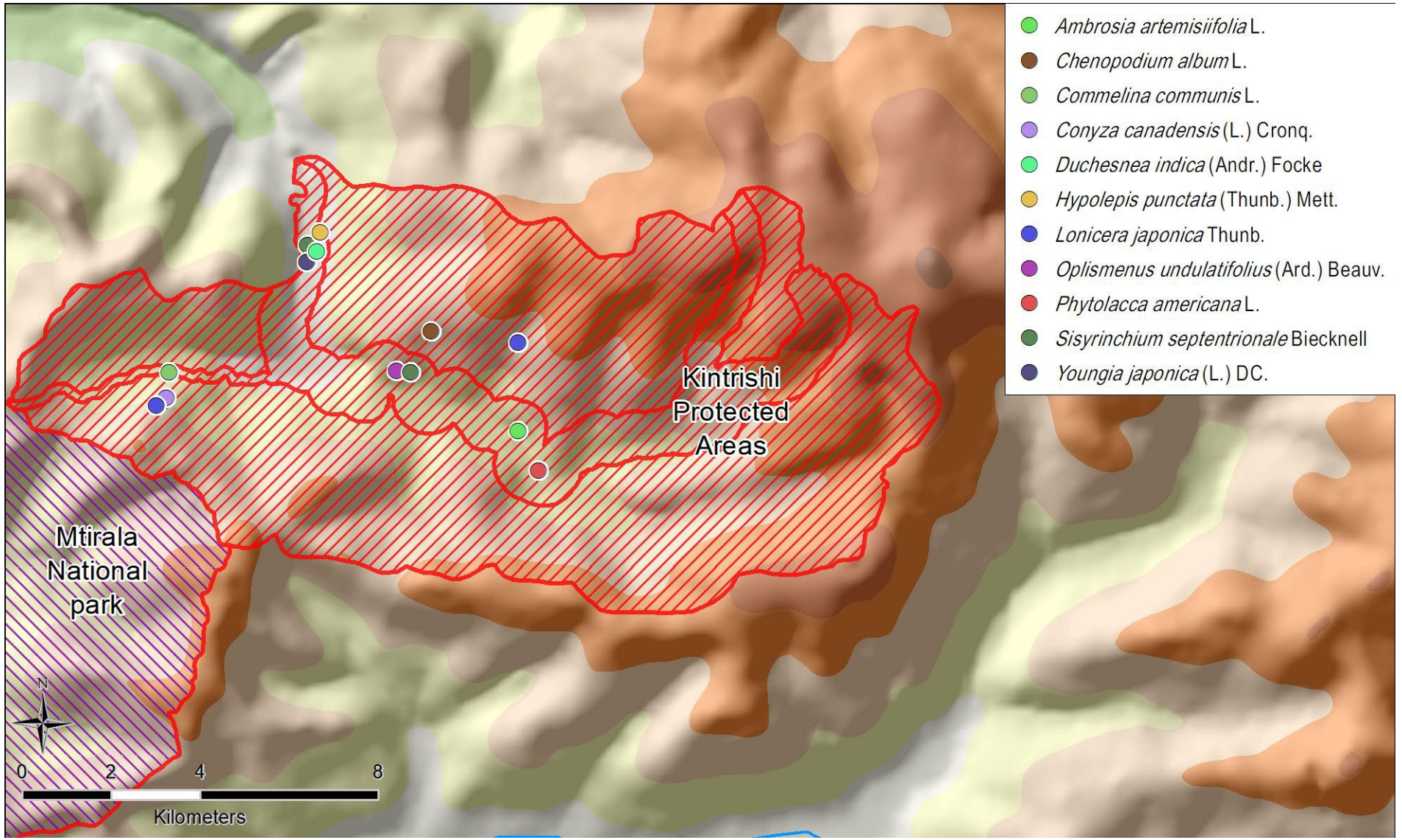
Plot #	Decimal latitude	Decimal longitude	Altitude, m amsl
MT3-Q1	41.65036	41.76424	555
Habitat	Colchic forest (alder-chestnut woodland with understory composed of cherry laurel and Pontian rhododendron)		
Number of SJ individuals	94		
Coverage of SJ, %	40		
Mean height of SJ individuals, m	0.65-0.7		
Vegetation coverage (excl. invasives), %	55		
Disturbance	High-vehicle movement, construction waste		

Location: Mtirala National park
Transect code: MT4
Date: 21/06/2021
IAP Scientific name: *Spiraea japonica*

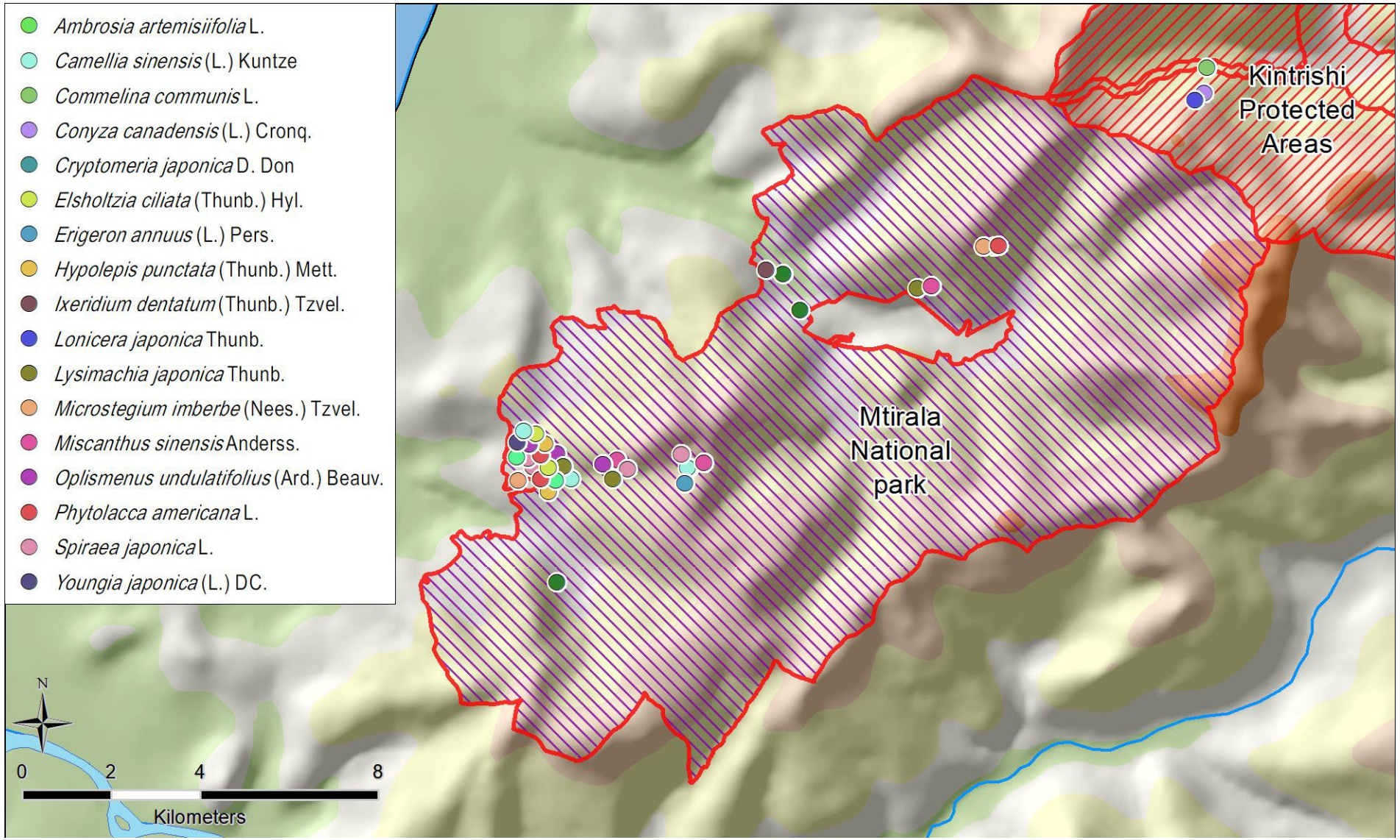


Plot #	Decimal latitude	Decimal longitude	Altitude, m amsl
MT4-Q1	41.65201	41.76286	523
Habitat	Colchic forest (chestnut woodland with understory composed of cherry laurel and Pontian rhododendron)		
Number of SJ individuals	116		
Coverage of SJ, %	80		
Mean height of SJ individuals, m	0.8		
Vegetation coverage (excl. invasives), %	10		
Disturbance	Medium-vehicle movement, soil erosion, tourisim		

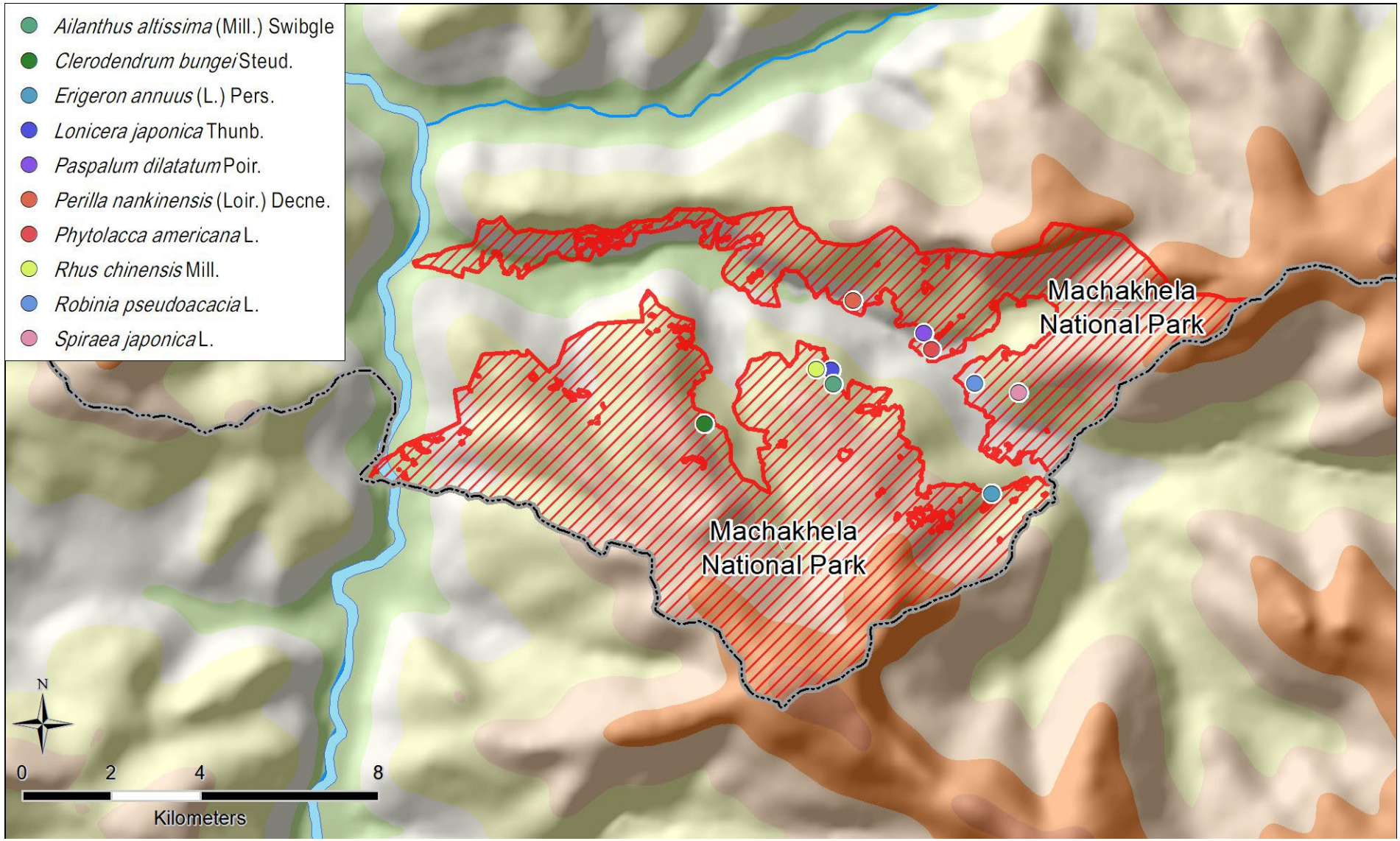
Appendix 2 IAP Occurrence in Selected Protected Areas



Map 1. Occurrence of IAPs in Kintrishi Protected Areas



Map 2. Occurrence of IAPs in Mtirala National Park and Kintrishi Protected Areas



Map 3. Occurrence of IAPs in Machakhela National Park