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Monitoring of Invasive Alien Plants in Protected Areas of Georgia

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ABSTRACT. Like most other areas worldwide, Georgia is facing an increasing problem with invasive alien plants (IAP). While in a first step, IAPs of Georgia have been identified (e.g. *Ambrosia artemisiifolia*, *Robinia pseudoacacia*), we now report and propose a monitoring program for IAPs. For this, we have set up twelve monitoring sites in five different Protected Areas in the west and in the east of Georgia, and collected initial baseline data. Based on the hypothesis that roads facilitate the introduction and establishment of IAPs, starting points of our monitoring sites were always roadsides and stretched away from the road. The sites being close to roads facilitated at the same time the accessibility of the sites and therefore efficiency of the data collection. The monitoring scheme was kept simple so that more data can be collected in a time and cost effective way over larger areas. For statistical analyses we used linear mixed-effect models with the nested random factors Region, Protected Area and Site, the distance from the road as the explanatory variable and the percent cover of IAPs and native plant species as the response variable. Our results show that IAPs in Protected Areas start spreading along roads and that their density decreases with the distance from the road, most notably in the tree and shrub layer. We also observed that certain areas are more affected by a higher number of IAPs (e.g. Mtirala National Park) than others.

Key words: plant invasions, protected areas, IUCN, conservation, *Ambrosia artemisiifolia*

Being situated in the Caucasus, one of the world's biodiversity hotspots, Georgia is known for its high plant biodiversity and endemism. There are some 2700 endemic plant species in the Caucasus, with 278 of them being strictly endemic to Georgia [1]. However, with 380 non-native plant species, from which 16 are invasive [2], Georgia is facing a serious problem. A recent study identified which areas of high conservation value are having a high nvironmental habitat suitability for nine selected invasive alien plants (IAP) in present and future climate conditions and are therefore prone to plant invasions [3]. The phenomenon of plant invasions has risen in the past century and is becoming increasingly a serious problem for agriculture, human health and the local biodiversity [4,5]. While some countries have already established procedures for the management of IAPs, e.g. USA

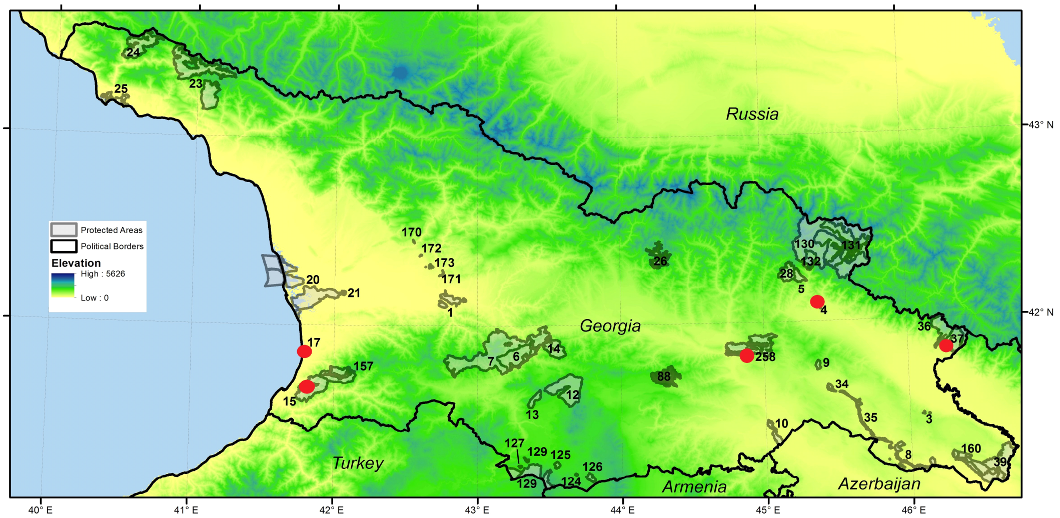

Fig. 1. The 43 Protected Areas in Georgia (based on IUCN criteria I - VI) and the 5 Protected Areas (red dots) in which we monitored a total of 12 sites.

or Switzerland [6,7], other countries are still in the proces s of evaluating the threats and risks caused by IAPs. To assure a cost and time efficient management plan against IAPs, a solid monitoring plan for IAPs is necessary [8].

To date there are no established monitoring programs for IAPs Georgia. A logical step is thus to establish a nationwide monitoring program in Georgia, preferably in Protected Areas to start with, where there is staff available to do the monitoring and subsequent control measures. It is crucial that the monitoring design is kept simple, so that data collection can also be done by practitioners with less experience in invasive species management, e.g. staff of Protected Areas. In this way data can be collected quickly and in a cost efficient way.

With roads being a main entry port for IAPs into the adjacent vegetation due to their high disturbance level [9,10], the invasion progress and velocity of invasion of IAPs can best be determined by monitoring the area away from the road, where IAPs are present.

We hypothesize, that the IAP cover will be higher, closer to the road and that it will diminish with further distance from the road, while the native plant cover and diversity will increase with further distance from the road. We also hypothesize, that the IAPs will further spread in the future, with cover of IAP increasing and as a consequence that of native plants decreasing further away from road.

The aim of this study was thus to develop a monitoring scheme for the spread of IAPs and apply it in several Protected Areas in east and west of Georgia, where IAPs are already present, and secondly to collect initial baseline data. Results will get some first insights into the current situation.

Material and Methods

Study species. In our study we focused on IAPs in Georgia and on other alien plant species, which are invasive elsewhere, but not yet considered as IAP in Georgia. Among the monitored IAPs, the most noxious ones are *Ambrosia artemisiifolia* and *Robinia pseudoacacia* [3].

Monitoring IAPs in Protected Areas. Based on the hypothesis that roads facilitate the introduction and establishment of IAPs [9], starting points of our monitoring sites were always roadsides. In total, 12 sites in 5 different Protected Areas were set up in July 2014 (Fig. 1).

The Protected Areas (PA) were selected according to the following criteria: presence of IAPs, accessibility by car (roads) and no IAP eradication program in place. At each site within a PA, we set up three transects of 2x50m in a T-shape, with the first plot being along the road and

Table 1. Overview over all IAPs assessed in the 8 sites analyzed

Protected Area	IAP species tree layer	IAP species shrub layer	IAP species forb layer
Tbilisi National Park (East)		*Spartium junceum*	
Lagodekhi Managed Reserve (East)	*Robinia pseudoacacia, Ailanthus altissima*	*Phytolacca americana*	*Conyza canadensis*
Babaneuri Nature Reserve (East)	*Gleditsia triacanthos*		*Ambrosia artemisiifolia, Conyza canadensis*
Mtirala National Park (West)	*Paulownia tomentosa*	*Phytolacca americana*	*Hydrocotyle vulgaris, Conyza canadensis, Commelina communis, Miscanthus sinensis, Crassocephalum crepidioides, Perilla nankinensis, Lysimachia japonica, Microstegium japonicum, Paspalum dilatatum, Polygonum thunbergii*

the second and third plot perpendicularly away from the road and centered at plot 1 (Fig. 2). 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 [10]. For each plot, we recorded % cover of IAPs and of native plants for each vegetation layer (i.e. forbs, shrubs and trees), where the maximum cover for each layer could reach in theory 100%.

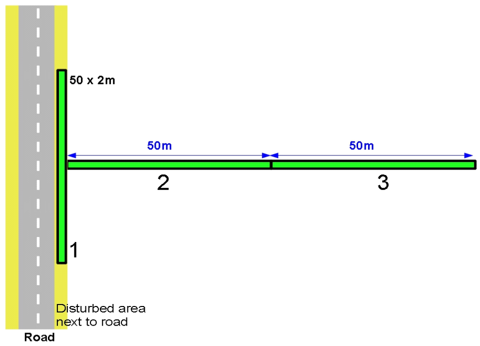

Fig. 2. T-shaped plot setup with three transect plots. Each plot is 50m long and 2m wide, with the first plot being along the road and the second and third plot perpendicularly away from the road and centered at plot 1.

Statistical Analyses. Statistical analyses were done with statistical software R [11] with the baseline data collected in the monitored sites. We used linear mixed-effect models (lme-function in R) with the nested random factors Region, Protected Area and Site. The explanatory variable was the plot ID (i.e. the distance from the road) and the response variables were the percent cover of each layer for the IAPs and natives.

Results and Discussion

We set up six monitoring sites in three Protected Areas in Eastern Georgia and six monitoring sites in two Protected Areas in Western Georgia, which were all easily accessible by car. Due to unexpected difficulties at some monitoring sites, i.e. dense scrub which made trespassing impossible (in Mtirala National Park) and uniform plant cover with no gradient (in Kobuleti Protected Area), four out of twelve site were set up in a different way as described in our setup protocol. For this reason these four sites were excluded from the statistical analyses.

Monitoring sites differed in their number of IAPs, ranging from one IAP (Tbilisi National Park) to thirteen IAPs (Mtirala National Park) and also in the IAP identity (Table 1).

Over all eight sites, which were included in the analysis, the only significant change between plots 1 and 2 (cf. Fig. 3; i.e. along the road and <50m away from the road, respectively) was the increase of natives (from 28.8% to 48.2%, p-value: 0.034) in the tree layer. The other layers showed no significant difference.

Between plots 1 and 3 (i.e. along the road and >50m away from the road, respectively) there was a significant decrease of IAPs (from 3.1% to 0.8%, p-value: 0.047) in the tree layer and a significant decrease of IAPs (from 10.8 to 0.8%, p-value:

0.034) in the shrub layer. There was a marginally significant increase of natives (from 18.3% to 28.3%, p-value: 0.088) in the shrub layer. No differences were observed in the plant cover of the forb layer (Fig. 3)

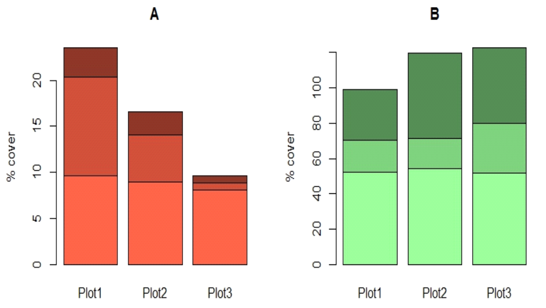

Fig. 3. Mean vegetation cover over all 8 sites analyzed for (A) IAPs and (B) natives.

Our results confirmed our hypothesis of the effect of distance to the road for the distribution of IAPs and natives, i.e. that the proportion of IAPs is higher closer to the road. This is well in line with the results gained from a study conducted by MIREN [10]. The reason for the higher cover of IAPs closer to the road might be due to the higher propagule pressure by IAP along roads caused by traffic and high soil disturbance facilitating their establishment [9]. The decrease of IAP cover further away from the road can be explained through the biotic resistance hypothesis, which states that higher plant biodiversity has higher chances in resisting plant invasions than lower biodiversity [12]. We did not assess plant biodiversity in our study in order to optimize our efforts and to keep the monitoring simple. But we found that in the tree layer the cover of natives increased with further distance away from the road.

In order to consolidate our results, this monitoring will have to be expanded over more sites in Georgia and over a longer timeframe, ideally over at least 10 years. This can only be done if the monitoring design, and therefore the procedure, is kept simple in order that data collection can be kept at minimal cost and more personnel can be involved with a minimal involvement of professional botanists. Recently, a scoring system for invasive species has been established, based on their environmental and socio-economic impact [13]. Monitored IAPs could be subjected to this scoring system to render a risk assessment more meaningful.

At a workshop, which was held in Tbilisi in July 2015 and organized by the German Society for International Cooperation (GIZ) our monitoring scheme was presented and well received. The chances of implementing our monitoring scheme over larger areas and a longer time frame are promising.

Conclusion

To tackle most efficiently the problem of plant invasions in Georgia in view of identifying their potential risk and minimizing their impact on plant biodiversity, a proper nation-wide monitoring program for IAPs is needed. Such a monitoring program will verify whether the literature and herbarium data is still up to date on the one side, and to find out which Protected Areas are most at risk by IAPs. A recent study modeled the climatic suitability of 27 IAPs and other alien plants in Georgia for present and future climatic conditions (Slodowicz et al. 2016, in revision). Results of this study will assist authorities in selecting Protected Areas most at risk and therefore being prioritized for monitoring. We hope to have set a good baseline for decision makers and stakeholders on where and how resources for IAP management should be invested in the most efficient way [8]. With the upcoming results of the monitoring in the next years, it can be decided in a cost-efficient way on when and where to invest in efficient prevention and mitigation strategies of IAPs [14–16].

An IAP-program will have higher chances of success, if all countries from the Caucasus collaborate in a unified framework to preserve their unique biodiversity. A good example on such collaborative work is the European COST action SMARTER (FA1203 on Sustainable management of *Ambrosia* *artemisiifolia* in Europe), in which scientific institutions from over 30 countries work together in finding a sustainable solution for Europe's most noxious plant invader, *Ambrosia artemisiifolia*, with Georgia as a participant of this Action.

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ბოტანიკა

ინვაზიურ არაადგილობრივ მცენარეთა მონიტორინგი საქართველოს დაცულ ტერიტორიებზე

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**ფრიბურგის უნივერსიტეტი, ეკოლოგიისა და ევოლუციის დეპარტამენტი, ფრიბურგი, შვეიცარია*
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(წარმოდგენილია აკადემიის წევრის გ. ნახუცრიშვილის მიერ)

სტატიაში განხილულია საქართველოს ფლორის ინვაზიური არაადგილობრივი სახეობების მონიტორინგის მეთოდიკა. ჩატარებულია ფონური მონაცემების ანალიზი ინვაზიური სახეობების შესახებ თორმეტ უბანზე, საქართველოს ხუთ დაცულ ტერიტორიაზე. შემოთავაზებულია ინვაზიურ სახეობათა მონიტორინგის გამარტივებული სქემა, რათა მონაცემთა შეგროვება შესაძლებელი იყოს შეზღუდული ფინანსური რე-სურსებით ხანგრძლივი დროის განმავლობაში შედარებით დიდ ფართობებზე. მიღებულ შედეგებზე დაყრდნობით შესაძლებელია შემუშავებული იყოს ეკოსისტემების დაცვისა და ინვაზიურ არაადგილობრივ სახეობათა გავრცელების პრევენციის პროგრამები, ასევე განხორციელდეს მონიტორინგი ინვაზიურ არაადგილობრივ სახეობათა გავრცელებასა და მცენარეთა მრავალფეროვნებაზე მათი ზემოქმედების შესაფასებლად.

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