PUBLISHABLE SUMMARY Final Report “Inspected.net”

Project No: 269206
Project Acronym: INSPECTED.NET
Project Full Name: INvasive SPecies Evaluation, ConTrol & EDucation.NETwork
Internet: http://www.uni-muenster.de/OekologischePlanung/forschung/inspected.html

Invasive Alien Species (IAS) increased rapidly during this century with extensive environmental effects on invaded habitats, human activities, and health, causing serious economic damage to agriculture and forestry. Accordingly, the European Commission (EC) devised a strategy against IAS, particularly aiming at plants, as a priority in the Horizon2020. However, the processes of biological invasions, their impacts on native ecosystems on different temporal and spatial scales, and the invasibility of different ecosystems are still not well understood. From 2012 until 2016 the Marie Curie's International Research Staff Exchange Scheme (IRSES) under the 7th EU framework programme (FP7) funded the international and multidisciplinary exchange project INvasive SPecies Evaluation, ConTrol & EDucation.NETwork (INSPECTED.NET). This project, a cooperation between the Universities of Münster (Germany), Freiburg (Germany), Lisbon (Portugal), and Viçosa (Brazil) focused on the biological invasion of Acacia plant species in Portugal and Brasil. Acacia spp. (e.g. Acacia longifolia, Acacia mangium, Acacia dealbata) are among the most aggressive invading plant species, with strong negative effects in Portuguese und Brazilian ecosystems. The impacts on ecosystem functioning include alterations of the nitrogen cycle, water balance, carbon assimilation, vegetation and plant community structure, plant diversity, litter density, soil N content and C/N ratio, and the seed bank. To understand these impacts on Portuguese und Brazilian ecosystems our multi-skilled, international group of experts in biological invasions applied the latest methods in vegetation ecology. The investigation sites are located in dune ecosystems in Portugal and Mussununga ecosystems in Brasil. Mussununga is a non-forest ecosystem associated with Atlantic Rainforests occurring in southern Bahia and northern Espirito Santo states that is characterized by sandy substrate with restricted soil depth due to a thick ortstein layer. The typical vegetation forms range from grasslands up to woodlands.

To determine the extent of competition for water and nutrients between native species and the invader, research studies in the field (University of Lisbon) and under controlled conditions in the laboratory (University of Freiburg) have been conducted. δ13C in leaves and phloem sap was successfully used to trace and model differences in water use efficiency between Acacia spp. and native species. The high water use strategy of Acacia spp. significantly affected the transpiration and assimilation of an invaded Pine forest, exacerbating total ecosystem water loss. Furthermore, spatially resolved measurements of foliar δ13C showed that effects on neighboring plants are species-specific and have distinct spatial patterns. Also, competition experiments between native species and the invader under different resource scenarios (e.g. manipulations of water and nitrogen content) showed that Acacia is a strong competitor for resources compared to native species. However, it has week adaptations to environmental stresses. Furthermore, δ15N labeling showed that Acacia is very effective in nitrogen uptake under a range of environmental conditions and outcompetes native species. We hypothesized that the invasive legume requires less phosphorus per unit of biomass produced and exhibits an enhanced nutrient turnover compared to the native vegetation, which could drive invasion by inducing a systemic N/P imbalance. Our first results emphasize that while A. longifolia itself maintains an efficient phosphorus use in biomass production, at the same time it exerts a strong impact on the N/P balance of the native system. Moreover, this study highlights the engineering of a belowground structure of roots and rhizosphere as a crucial driver for invasion, due to its central role in nutrient turnover. These findings provide new evidence that, under nutrient-limited conditions, considering co-limitation and nutrient cycling in oligotrophic systems is essential to understand the engineering character of invasive woody legumes. We applied sampling methods (plots) for vegetation structure assessment, population size class analysis and light

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regime measurements (University of Viçosa) to examine if Acacia spp. invasion causes elongation, shortening or changing to different values of the niche determinants and impacts the native biodiversity adapted to another set of niche determinants. Therefore, the light regimes of invaded and non-invaded ecosystems have been successfully assessed using Digital Hemispheric Photography. The results indicated that during the early invasion process there are lower average sunlight and higher variance of sunlight in invaded plots compared to non-invaded plots. In Brazilian ecosystems, the higher light variation at ground level in invaded plots which was positively related to leaf nitrogen indicated that competition for light became a driver of plant community composition, converting an ecosystem driven by abiotic factors (i.e. Hutchinsonian niches) into one driven mainly by interactions (i.e. Eltonian niches).

In Portugal, we assessed the invasibility of coastal dune habitats by A. longifolia. We also included Carpobrotus edulis in this study because it is a widespread invasive species in the same habitats. Grey dunes and felled woodlands showed low degrees of invasibility by A. longifolia, while dune scrub and woodland were more frequently invaded. All coastal habitats showed high invasibility by C. edulis, particularly the grey dunes and felled woodlands. Based on Generalized Linear Models of presence-absence data of the two invasive species, we mapped the habitat-specific invasibility at landscape scale taking into account differences in tree cover within the woody habitats. Furthermore, to consider the spatial dimension of the invasion process, remote sensing techniques were applied to map the distribution of invasive Acacia spp. In Portuguese coastal ecosystems (University of Münster), we could show that A. longifolia can be distinguished from native species and other Acacia spp. using vegetation indices derived from hyperspectra of leaves and plant canopies. In order to detect the distribution of Acacia spp. and to monitor the expansion of this invasion in Brazilian Mussununga ecosystems, a small Unmanned Aerial System (UAS) was used to collect various types of imagery to detect invasive Acacia spp. RGB and Near-Infrared imagery were stitched using the Structure from Motion approach followed by the orthophoto and Digital Surface Model (DSM) export. Both products were used for Acacia detection using Object-Based Image Analyses (OBIA). The successful use of a fixed-wing UAS proved to be a reliable and flexible technique to acquire ecologically meaningful data over wide areas by extended UAS flight missions.

The results of this research project have been presented in several international scientific journals, on conferences, and on workshops. For instance, in July 2016 the research group organized an International Symposium on Biological Invasion. Each member of the project group presented the achieved results to a wide scientific and international audience including representatives of invasive species management organizations. Moreover, several workshops with topics related to the project were given. Project members of the University of Lisbon conducted a workshop on stable isotopes analyses for early stage researcher. In Brasil, research members of the University of Münster gave a workshop course on spectroscopic analyses of plant leaves using an ASD FieldSpec 4. This international multiscale and interdisciplinary approach of INSPECTED.NET is the first of its kind concerning highly invasive species of the Genus Acacia. The knowledge generated by the research group will help to increase the understanding of invasive plant species, their effects on the biodiversity and support the development of further management strategies. Overall, the scientific challenges and opportunities required a European approach and INSPECTED.NET is of high relevance for the European Research Area: This project contributes to a sustainable collaboration of leading institutes in the scientific domain of invasion biology. Further, the project is understood as the first

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step towards a long-term common effort between the participants, including better access to study sites, laboratories, archives (remote sensing data, ecological studies, management experience) and expert networks for the European beneficiaries such as the EC funded project DAISIE (Delivering Alien Invasive Species In Europe: www.europealiens.org). Future efforts will include conceptual issues but also focuses on the relevance of research to guide management and decision-making, the gaps between scientific publications and access to managers, the issues of language, and the relevance of conducting research with a notion of its potential application to management (considering local context, costs, and access to information).