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DPSIR FRAMEWORK – A DECISION – MAKING TOOL FOR MUNICIPALITIES

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Abstract

Many municipalities in Central Europe deal with the problem of invasive species in their natural ecosystems. Invasive vegetation eradicates native species and causes dense stands that damage the natural environment. This work shows how important it is to have an informative tool for municipalities to be successful in their struggles with invasive species. A Driver – Pressure – State – Impact - Response (DPSIR) framework is a decision - making tool, and this one is particularly applied to the species Fallopia japonica. Fallopia japonica is an extremely invasive and aggressive weed, and it is very often found in riverbank vegetation. This specific framework can be used as a tool for municipal managers to highlight all the problems with Fallopia japonica and define all the responses that should be provided by the municipalities. The work points out the steps that show how important it is to have a strategy or a clear concept of how to begin with such a serious issue as the presence of Fallopia japonica in riverbank vegetation and its eradication. This framework provides simple steps that cannot be excluded when a municipality start actions against Fallopia japonica. All the indicators used in the model are based on the information known about Fallopia japonica that are presented in the literature.

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Key words

- DPSIR, invasive vegetation,
- Fallopia japonica,
- Riverbank vegetation.

1 INTRODUCTION

The documented effects of alien invasive species are numerous, including direct threats to human health and the loss or alteration of goods and services regarding fisheries, farming, forestry, drinking water, hydrology, climate stabilization, pollination, culture and recreation (Le Maitre, 2004; McNeely, 2005; Lovell et al., 2006; EEA, 2012). Other impacts are less severe and are the result of long-term transformations affecting the functioning of habitats and ecosystems (Hulme, 2007).

Fallopia japonica is a herbaceous clump-forming perennial, which is part of the Polygonaceae family. It has tall, dense annual stems (Fig. 1) that are light green, often with reddish flecks, branched and can reach up to 3 m in height (Beerling et al., 1994). The stems' maximum height is 3-4 m and their growth is renewed annually from stout, deeply-penetrating rhizomes. *Fallopia japonica* is higher in the countries where it was introduced than in the countries of its origin (0.3-1.5m) (Makino, 1997). The flowers are white (Fig. 2).

During winter, the plant usually dies, but some of its stems remain during the winter at a lower height (around 1 m). *Fallopia japonica* comes from East Asia, Japan, China and Korea. In Europe it is classified as an invasive plant. *Fallopia japonica* is an extremely invasive and aggressive weed, despite the fact that it lacks extensive sexual reproduction in most of the countries where it was introduced.

Fig. 1: *Stand of Fallopia japonica.*

It can sprout from very small sections of rhizomes and is often spread via the movements of topsoil or construction traffic (Shaw, 2013). Rhizome fragments as light as 7 g fresh weight are able to regenerate, provided a node is present. Some clones of *Fallopia japonica* can persist in localities for >130 years. *Fallopia japonica* is functionally dioecious. The flowers are exclusively entomophilous. Only one piece of *Fallopia japonica* of the female clone has been introduced and spread over Europe, earning it the nickname of the "world's largest female". The number of flowers per stem exceeds 190,000. They can be fertilized by the pollen of *Fallopia sachalinensis*, resulting in *Fallopia* × *bohemica*, or by the congeneric climber *Fallopia aubertii*, in which case only a low percentage are fertilized and the establishment of seedings are inefficient. When seed is produced, the winged achenes are dispersed by wind and water (Pyšek 2006).

The known consumers of *Fallopia japonica* are sheep, donkeys, goats, cattle, and horses as the species is palatable to them. House sparrows have been observed removing *Fallopia japonica* achenes. The extrafloral nectaries present at the base of the leaves attract consumery ants. *Fallopia japonica* is a host to several fungal species. Although herbivorous insects feeding on the foliage of both *Fallopia japonica* and *Fallopia sachalinensi* in Japan can consume >40% of its total leaf area, invertebrate consumerss do not cause damage to the range invaded. *Fallopia japonica* can be found in the literature under different names such as: *Reynoutria japonica Houtt., Polygonum cuspidatum Sieb. & Zucc., Pleuropterus cuspidatus (Siebold & Zucc.) H. Gross, Polygonum sieboldii Reinw. ex de Vries, Polygonum zuccarinii Small, Tiniaria cuspidata (Houtt.) Hedb., Tiniaria japonica (Houtt.) Hedberg* (Pyšek, 2006).

2 MATERIAL AND METHODS

2.1 The DPSIR Approach

The Driver-Pressure-State-Impact-Response (DPSIR) framework is a helpful method to manage the expansion of invasive species; in this paper we applied this method for the species *Fallopia japonica*. The DPSIR framework is a tool that was developed by the Organization of Economic Cooperation and Development (OECD, 1993) and the European Environmental Agency (EEA, 1995).

The aim of managing water resources is to safeguard human health, whilst maintaining sustainable aquatic and associated terrestrial ecosystems. It is therefore important to quantify and identify the current state of, and the impacts on, water environments and how these are changing over time (Kristensen, 2004).

The indicators used in the model have been classified according to the well-known international DPSIR indicator framework (Fig. 3). The DPSIR frameworks are widely used for assessing, measuring and providing a guide to managing the environment. The DPSIR framework is arguably a Problem Structuring Method (PSM). Smeets and Weterings (1999) posit that the primary value of DPSIR is for policy-makers and argue that from a policy point of view, there is a need for clear and specific information on:

(1.) Driving forces and
(2.) the resulting environmental pressures, on
(3.) the state of the environment and the
(4.) impacts resulting from changes in the environmental quality and on
(5) the societal response to these changes in the environment

Fig. 2: *Flowering Fallopia japonica.*

The DPSIR framework usually starts with the driving forces, passes through to the pressures on the state of the environment and the impacts on the ecosystem and human welfare, thereby leading to societal responses (EEA, 1995; Gari et al. 2015)

The Water Framework Directive (WFD) uses the DPSIR framework to protect groundwater, inland surface water, estuaries and coastal water (Borja et al. 2006) and for assessments of the pressures from alien species (Uktag, 2013; Gari et. al 2015).

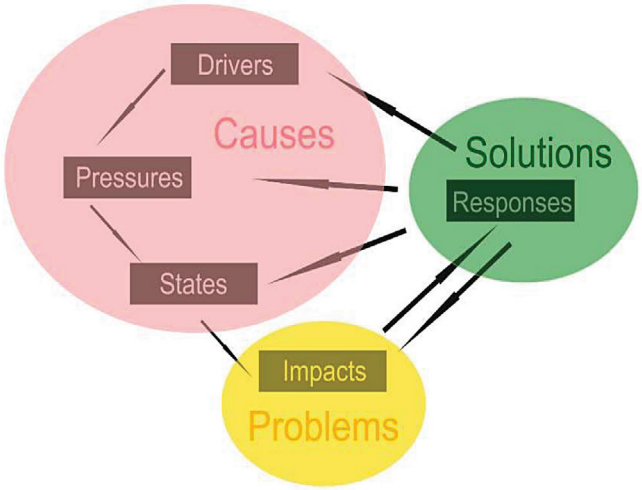

Fig. 3: *DPSIR framework based on the scheme from Giuppon (2002).*

2.2 Data collection

The data used in the model are all general and are not applied to a specific area. All the indicators used in the DPSIR framework for *Fallopia japonica* were chosen based on existing scientific articles about *Fallopia japonica*. The most important factors that can be determinants in the decision making about its invasion are used as indicators in the model.

3 RESULTS

It is very difficult to make generalisations about invasive species because they all have various impacts on the environment. All the modifications that are caused by the alien species are different; therefore, it is necessary to focus on each species separately. A general DPSIR framework about invasive species cannot be applied to every species, so there is a need to create a specific DPSIR framework in this case for *Fallopia japonica*.

This DPSIR framework was created based on the facts that are known about *Fallopia japonica,* and all the indicators were chosen from already-known facts from the existing literature on *Fallopia japonica.*

The model is represented by the scheme of the indicators (Fig. 4), which are divided into 5 groups for the DPSIR framework. The indicators chosen for the part of drivers are varied, and we can consider as the main driving force for the establishment of *Fallopia japonica* the fact that landscape architects previously considered *Fallopia japonica* to be an ornamental plant. The plant was introduced to Europe by landscape architects, and they grew it in botanical gardens. Unfortunately,

the plant escaped from the botanical gardens and spread throughout the landscape. The second important driver for the expansion of *Fallopia japonica* is the cut flower trade. Sellers that are not well informed about the high invasibility of *Fallopia japonica* use *Fallopia* stems as decorative plants in bouquets. As the species is extremely aggressive, even a 2-centimetre-long particle from *Fallopia japonica* can be a starter for a new establishment of *Fallopia japonica* stands. Socio-political factors are also significant factors that can be drivers for the expansion of *Fallopia japonica.* As the eradication and maintenance of the existing stands depend on financial resources, socio-political factors play a role as drivers for an invasion. Topsoil movements are other indicators that are dangerous at the beginning of a new invasion stand. During the design of new landscape architecture, more nutritive soil is often quite necessary. Therefore, people move the nutritive soils from one place to another, and when the soil contains small rhizome parts of the *Fallopia japonica*, the movement of the soil results in new stands of *Fallopia japonica* growing. Small parts of the plant are also present in compost, so when the compost is moved to another site, a new establishment can start. Linked to this problem, we can consider garden waste disposal as a problem too. Another problem in a landscape is floating vegetation during a flood. A river can transmit broken parts of *Fallopia japonica;* as they leave a river, they can start a new invasion on a new stand in a riverbank vegetation. Land vehicles can also be carriers of *Fallopia japonica*, as some broken parts of the plant can be carried on vehicle tyres. Climate change can also be considered as a driver, because the higher the temperatures in Europe, the broader the expansion of *Fallopia japonica*.

In the DPSIR part "Pressures", use of soil is the first indicator shown in the scheme below. *Fallopia japonica* uses soil that should be used by native plants suitable for the geographic conditions. *Fallopia japonica* also damages natural ecosystems and results in stress on natural parks. It also adversely affects rivers. The negative effects

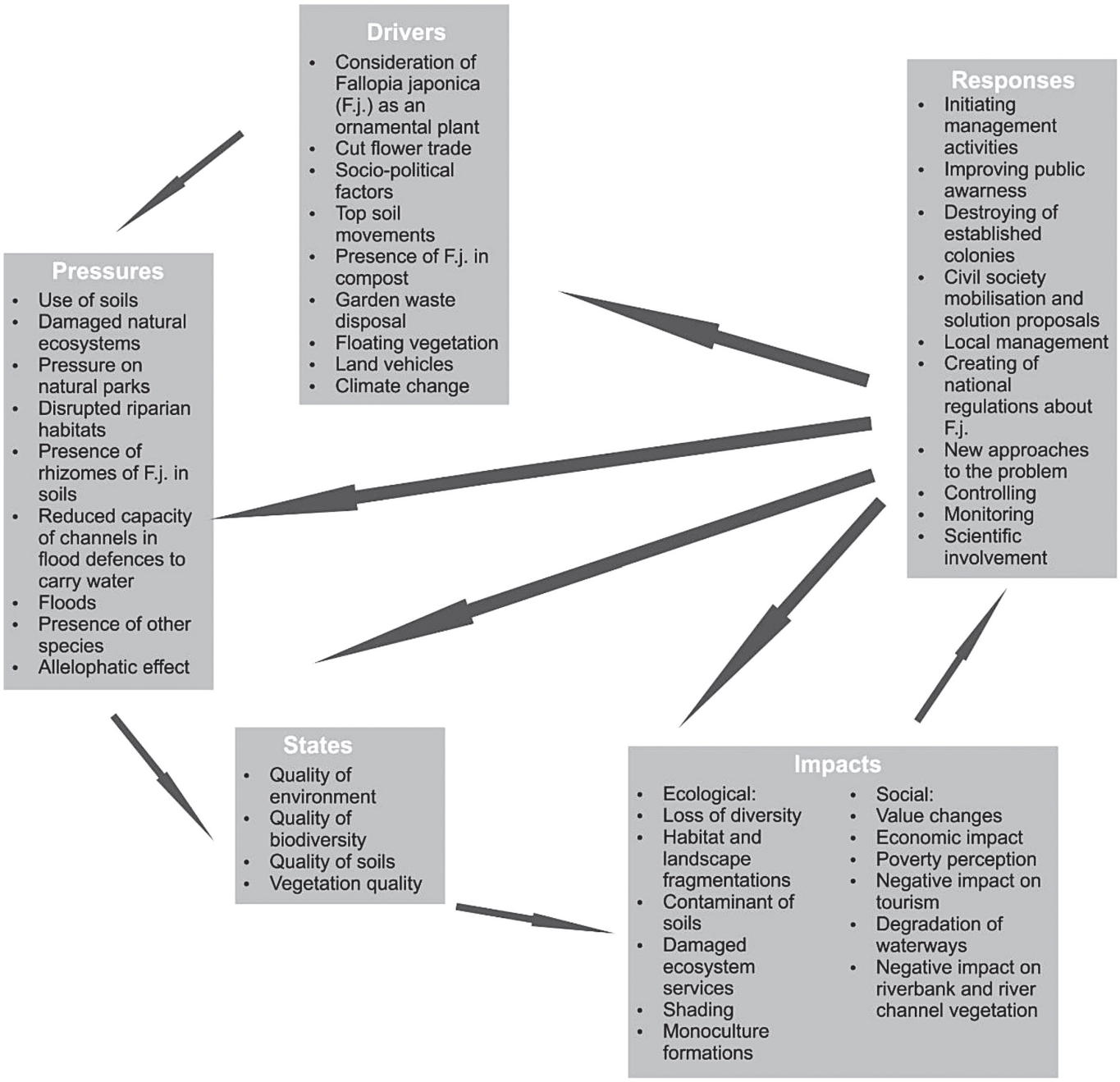

Fig. 4: *DPSIR for Fallopia japonica.*

connected to rivers are the disruptions of riparian habitats, which reduce the capacity of the channel and the flood defences to carry water and exacerbate the effect of floods in general. The presence of other species in riverbank vegetation is also an indicator that it is suffering because the *Fallopia japonica* replaces the native vegetation.

In the DPSIR field of "States," we can observe different states that are changing negatively because of the presence of *Fallopia japonica* in European landscapes. The state of the environmental quality changes negatively in general when *Fallopia japonica* is present. The quality of the biodiversity, soil and vegetation in general is decreasing as well.

From the point of view of DPSIR "Impacts", two groups are noted: ecological and social. In the ecological impact group, the first impact listed is the loss of diversity. As *Fallopia japonica* replaces the native vegetation, the overall diversity is lower. *Fallopia japonica* creates an involuntary fragmentations of landscapes. It creates extensive monoculture formations, which produce shading for the native plants. If the native plant needs a full sun stand, the shade can result in the death of the plant.

As a social impact we can consider changes in property values. The presence of *Fallopia japonica* on a site causes problems with eradication of the invasion; therefore, the value of the property is automatically lessened. Another social impact is the economic impact. The eradication of existing *Fallopia japonica* stands requires financial support, and if there are too many invasive stands in the landscape, it can result in a perception of the region where the stands are present as impoverished. *Fallopia japonica* causes negative impacts on tourism too. The high-density stands block existing pathways and impede the throughput of touristic areas. We can also classify as a negative social impact the negative impacts on riverbank and river channel vegetation. High *Fallopia japonica* stands lower the value of the native riverbank vegetation, and people cannot access the river.

The most important part of the DPSIR framework presented is "Responses". All the DPSIR frameworks are created as decision-making tools, and all the suggestions are presented in the "Responses" part. The first responses listed are "Initiating management activities." The beginning of management activities is a very important step to start the fight against *Fallopia japonica*. Another important response is to improve public awareness about the problems with the invasibility of *Fallopia japonica*. Many people do not know about the problems that are caused by invasive species in that they usually do not recognise *Fallopia japonica* and do not remove it from their property. Connected to this problem is the destruction of established colonies of *Fallopia japonica*. As soon as *Fallopia japonica* is recognised at a site, initiating management activities about its removal should begin. It would be easier to destroy the existing stands if property owners were mobilized and could find a solution together with the municipality. Another important step is to have regulations promulgated by both local management and national management. As research about *Fallopia japonica* is improving around the world, it is important to always be up to date on this topic. New information about *Fallopia japonica* will possibly initiate new approaches in finding solutions. In general, the response for every municipality should be to control and monitor existing and removed stands. In the process of finding solutions, it is also necessary to involve scientists.

4 CONCLUSION

A specific DPSIR model has been created with a particular focus on the invasive species *Fallopia japonica*. In our opinion, the issue of *Fallopia japonica* in non-native countries is very alarming, and the need to manage the expansion and establishment of this species is very urgent.

The model could be considered as a decision - making tool for municipalities that are dealing with the issue of *Fallopia japonica* invasions. The most important thing is to recognise that the invasive species is present in the areas of the municipalities; and therefore, the awareness of the inhabitants is urgently needed as we have presented in the „responses" part of the DPSIR model. The DPSIR framework for *Fallopia japonica* can be a useful tool for taking various responsive steps in the process of eradicating the invasion. The application of response management can be a key factor in the recovery of natural ecosystems and for the conservation of biodiversity.

The DPSIR framework focuses on problems in ecoystems and how to solve those problems. Therefore, this DPSIR framework for *Fallopia japonica* could be useful for all managers that are trying to find a solution for removing *Fallopia japonica* stands from their municipalities.

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