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SHORT COMMUNICATION

Fallopia japonica (Houtt.) Ronse Decr. in southern Chilean Patagonia and its local environmental governance implications

Fallopia japonica (Houtt.) Ronse Decr. en la Patagonia chileno austral y sus implicancias de gobernanza ambiental local

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RESUMEN

La especie introducida *Fallopia japonica* (Houtt.) Ronse Decr. es registrada por primera vez en las ciudades de Puerto Natales y Punta Arenas en la Patagonia chilena. En este trabajo se entregan evaluaciones de los envolventes climáticas en Patagonia y explora a las implicancias de la gestión ambiental en el control de esta especie invasora.

This is the first registration of various presences of *Fallopia japonica* (Houtt.) Ronse Decr. (Polygonaceae), commonly known as Japanese knotweed (or "JK"), in Southern Patagonia, specifically in the cities of Puerto Natales (51.73 °S, 72.73 °W) and Punta Arenas (53.17 °S, 70.93 °W). JK is an infamous invasive plant that offers many challenges to effective management across scales (Martin 2019), beyond the usual ecological concerns that invasive species generate. JK has myriad human-facing factors to consider, including growing through asphalt and concrete (Payne & Hoxley 2012) and increased flood damage (Colleran & Goodall 2014). Its effects on infrastructure has impacted housing markets (Francis & Chadwick 2015) and is a concern in watershed management (Delbart *et al.* 2012).

Due to its various negative impacts, there is a great effort in North America and Europe to understand and asses the northern edge of its range. JK has been described as far north as Tromsø (67.65 °N) in Europe (Holm *et al.* 2018), as far north as 50 °N in eastern Canada, and in Sitka, Alaska at 54 °N (Barney 2006). Models indicate a poleward distribution limit of JK can be predicted by three climatic variables – the length of the growing season (≥ 2505 degree-days), minimum annual air temperature (-30.2 °C), and annual precipitation (≥ 735 mm) – which form an envelope of climate thresholds (Bourchier & Van Hezewijk 2010).

Below, we (1) examine the initial observed distribution of JK in southern Chilean Patagonia, (2) place JK in the climatic envelope context described by Bourchier & Van Hezewijk (2010), and (3) provide a brief evaluation of the management implications of JK presence in Southern Patagonia to explore the potential of managing a potential silent invasion.

MATERIALS AND METHODS

During austral spring and summer months of 2020 and 2021 (September through February), informal front-yard surveys in the cities of Puerto Natales, Punta Arenas, and Porvenir (53.29 °S, 70.37 °W) and along highways throughout the Magallanes Region of Chile, was conducted following an initial identification of JK in Puerto Natales. Informal front-yard surveys followed each city's grid pattern, looking for

JK in front yards; only older neighborhoods were evaluated, since these tended to have houses with front yards. Highway evaluation focused on likely areas of JK growth (i.e., gardens of estancia houses and at river crossings). Each occurrence of JK was georeferenced and photographed.

To explore the possible extent of JK growth in Southern Patagonia, an initial evaluation using JK climate thresholds (Bourchier & Van Hezewijk 2010) was developed in QGIS (QGIS Development Team 2020). Historic monthly climate data from WorldClim (Fick & Hijmans 2017) provided annual precipitation and annual minimum air temperature. The number of degree-days was also calculated using WorldClim data, following Greer *et al.* (2016). These data layers were then queried, using the JK climate thresholds (minimum temperature > -30.2 °C, annual precipitation > 735 mm, and degree-days ≥ 2,505) to identify areas of Patagonia with the presence – and overlap – of the three thresholds.

RESULTS

A total of eighteen occurrences of JK were found, georeferenced, and photographed (Fig. 1a). Specifically, JK were found in 15 locations in Puerto Natales, and 3 locations in Punta Arenas, and appeared to be limited to garden plantings. JK were not encountered in Porvenir, nor along the principal highways in the Magallanes Region (Fig. 1b). Visual surveys at river crossings in the cities and along the main highways showed no presence of JK along banks, implying that it is currently unlikely that rivers serve as a fluvial vector (Colleran *et al.* 2020). Note that the number of occurrences in each city should not be used to evaluate the relative presence of JK in each location, but to indicate that – even with an informal survey from the road – it was possible to detect this plant. Observed plants were nearly always robust, many were tall (over 2m in height), and some covered a breadth of up to 5m. In a few cases, they were growing out from the foundations of buildings or walls.

The JK climate thresholds (Bourchier & Van Hezewijk 2010) identify possible areas in Southern Patagonia suitable for JK growth (Fig. 1b). Locations satisfying all three climate factors are mostly in small pockets along the Pacific coast, where precipitation is not limiting. However, much of the Pacific coast has insufficient degree days. Eastward, in the Andean rain shadow, only the minimum temperature threshold is satisfied. Closer to the Atlantic coast, the threshold for degree days is also satisfied, although precipitation continues to be limiting.

Specific to the locations where JK were detected, Punta Arenas satisfies only one climate threshold (minimum temperature), while Puerto Natales sits in a very narrow, coastal transition zone that satisfies two climatic thresholds (minimum temperature and annual precipitation). Note that both prior reports of JK presence in Southern Chile (Saldaña *et al.* 2009; Fuentes *et al.* 2011), located over 1,000 km to the north, are in areas where all three climatic factors are present (data not shown).

DISCUSSION

The initial geographic evaluation (Fig. 1b) implies that JK spread beyond gardens is likely limited (Bourchier & Van Hezewijk 2010) in Punta Arenas and Puerto Natales, let alone most of Southern Patagonia. What is of potential concern is that the nearby, world-famous Torres del Paine National Park and Biosphere Reserve, with its already invaded landscapes (Vidal *et al.* 2015), includes significant areas where all three factors are satisfied, specifically along the glacial valleys below the Tyndall, Pingo, and Grey glaciers on the western side of the National Park (Fig. 1c). This appears to be the location with the highest potential for a successful JK invasion in Southern Patagonia. Understanding the environmental governance aspect to managing potential transport of this plant from cities to the national park will likely be key to stopping any future establishment (see below).

One potentially significant factor that has not been adequately evaluated in prior studies is the impact of strong winds on JK spread. Many JK found in Punta Arenas and Puerto Natales showed some leaves with yellow stripes (Fig. 1a), which are indicative of spring-time wind damage (Beerling *et al.* 1994). Available WorldClim data only indicate average annual windspeeds, which range up to 10 m/s in Southern Patagonia (Fig. 1b), but this average does not account for seasonal changes in windspeed, nor wind gusts, which can reach 120 km/h in some places (Peri & Bloomberg 2002). These maximum wind speeds could limit growth in the wild, especially in exposed areas, but could also promote dispersal of rhizomes (*sensu* Beerling *et al.*, 1994). Given the strong katabatic winds especially in glacial valleys (Warren & Sugden 1993), more research is needed into the impacts of sustained winds and wind gusts on JK dispersal and growth.

Local environmental governance implications

Given the geographic isolation of Puerto Natales and Punta Arenas from the prior observations of JK in southern Chile (Saldaña *et al.* 2009; Fuentes *et al.* 2011), and the near-exclusive presence of JK plants in gardens, it is safe to conclude that these plants were most likely imported and deliberately planted as ornamentals. Indeed, there is a marked preference

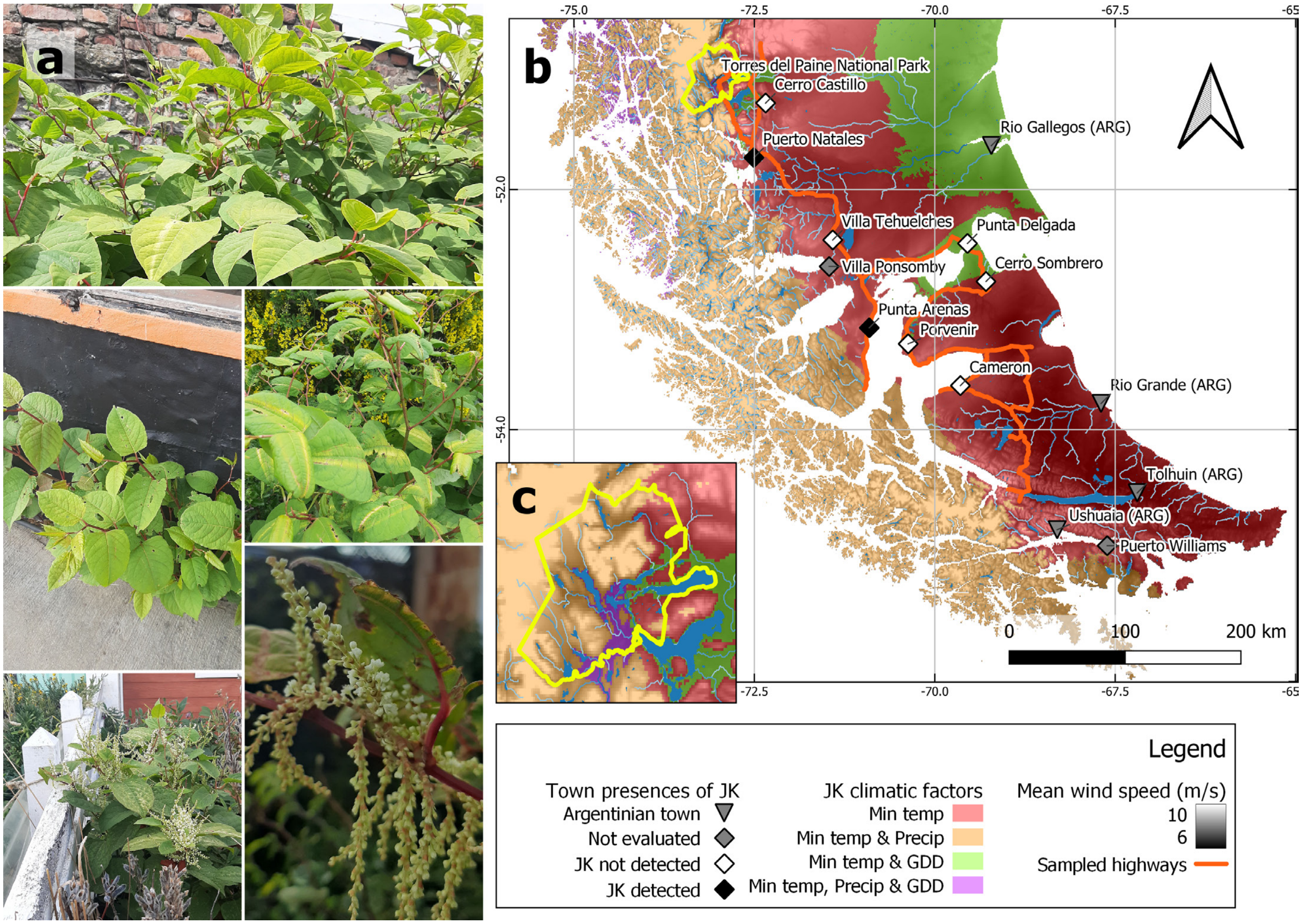

Figure 1. *Fallopia japonica* (Houtt.) Ronse Decr. (a) Photographic examples from front-yard surveys, (b) the extent and overlap of climatic thresholds (minimum temperature > -30.2 °C, annual precipitation > 735 mm, and degree-days ≥ 2,505) in Southern Patagonia, and (c) a close-up of the Torres del Paine National Park area (yellow outline). / *Fallopia japonica* (Houtt.) Ronse Decr. (a) Ejemplos fotográficos de la evaluación de patios, (b) las extensiones y sobreposiciones de los envolventes climáticas (temperatura mínima > -30.2 °C, precipitación anual >735 mm y grado-días ≥ 2,505) en la Patagonia Austral y (c) un mapa detallado del área del Parque Nacional Torres del Paine (contorno amarillo).

for non-native plants in Southern Patagonia (Rozzi *et al.* 2003; Archibald *et al.* 2020), so the importation and planting of an ornamental – as JK is often viewed where recently introduced (Rouifed *et al.* 2018) – is unsurprising.

In properties where JK was growing up from foundations, the plants were cut several times during a season. In contrast, where JK was maintained as an ornamental, cutting appeared to take place less frequently – perhaps once per season. Given the possibility of growth from cut rhizomes (Colleran & Goodall 2014), it is crucial to know what happens to disposed JK cuttings, as these locations – and transport to them – could serve as sources for JK spread.

Legal disposal of garden cuttings occurs via municipal garbage collection, ending up in municipal landfills. Punta Arenas operates a "*relleno sanitario*" (a covered, plastic-lined landfill), while Puerto Natales, merely has a "*vertedero*" (an open-air, unlined landfill). In either location, strong Patagonian winds (Peri & Bloomberg 2002) often carry light solid waste out of landfills, strewing the surrounding landscape for several kilometers' distance, which could carry rhizomes that would germinate in other locations (*sensu* Beerling *et al.*, 1994). Moreover, the *vertedero* in Puerto Natales runs the risk of being a source for vehicular vectors throughout the Última Esperanza Province, since it is the only landfill for the province. Thus, waste management operations within and around Torres del Paine National Park, with area favorable to JK growth (Fig. 1c), could inadvertently pick up JK rhizomes at the *vertedero*, and transport them back to this ecologically vulnerable landscape and crown jewel of Chile's national park system. Furthermore, the high volume of tourism in the Torres del Paine National Park (Ruiz *et al.* 2019) and increasing development surrounding the park only increases the probability of JK transport, augmenting future risks for JK spread.

A large management challenge in Southern Chilean Patagonia is that local managers are simply unfamiliar with JK and its invasiveness (*sensu* Cottet *et al.*, 2015), and many cannot identify JK species. One way of dealing with this issue is to implement a four-pronged management approach, along the lines of Cottet *et al.* (2015), of 1) prevention, 2) removal, 3) management, and 4) resilience-building. **Prevention** would focus on teaching managers and the public how to recognize JK and understand the negative effects it has on natural and built environments, not only in places like Punta Arenas and Puerto Natales, but also in locations near existing protected areas, since there is increasing development pressure in these zones.

Removal would work to help local managers effectively excise JK from places where it has been identified. Local managers would also provide professional suggestions for native plants to replace the JK.

Management would focus on monitoring the places where plants were removed and working with nurseries. Such activities would ensure that JK does not regrow and that new plantings are unlikely to take place.

Resilience-building would work to monitor buffer zones around natural protected areas, which all contain sub-polar ecosystems that are fragile to invasion. This requires coordination with multiple agencies, given how protected areas and landscapes are managed in Chile.

CONCLUSIONS

In this paper, we present the first published observations of *Fallopia japonica* (Houtt.) Ronse Decr. found in several locations in the Southern Patagonian cities of Puerto Natales and Punta Arenas, marking their southernmost observations in the Americas. Local and regional management agencies should undertake measures to identify JK presences throughout Southern Patagonia, remove individual plants, and ensure they do not negatively affect fragile Southern Patagonian ecosystems.

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