Section II. Change Agents—Current and Future

Chapter 6. Terrestrial Invasive Plant Species

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Introduction

Invasive plant species negatively affect many native species and can profoundly alter the structure and function of ecosystems. The negative effects of invasive species include displacement of native communities, degradation of habitat quality and forage, and alteration of fire regimes (Rowland and Leu, 2011). There also can be interactions among invasive species and other Change Agents. For example, the spread of invasive plant species can be promoted by development activities. Recent regionwide surveys for invasive species detected the following invasive species: Russian knapweed, crested wheatgrass, cheatgrass, whitetop, curveseed butterwort, Canada thistle, halogeton, perennial pepperweed, Russian thistle, tumblemustard, and tamarisk.

We compiled data from Bureau of Land Management (BLM) field offices in the project area on the following priority species data (Ken Henke, Bureau of Land Management, written commun., September 2013): desert alyssum, halogeton, leafy spurge, hoary cress, Russian knapweed, cheatgrass, Russian olive (also known as oleaster), and tamarisk (also known as saltcedar). There were insufficient regional data from the BLM on the distribution of invasive plants for assessing the effects of invasive plants on the Conservation Elements. Species-distribution models for cheatgrass, Russian olive, and tamarisk were available and used to predict the probability of occurrence of these invasive species in the Wyoming Basin (Jarnevich and others, 2010, Jarnevich and Reynolds, 2011; Jarnevich and others, 2011; Nielson and others, 2011). However, the results of the cheatgrass model were unsatisfactory, in part due to the large-scale nature of the available model (which may perform better at predicting differences among regions) and in part due to the lack of regional data for use in the model (see the Invasive Species section in the Appendix). Consequently, we determined that we would be unable to evaluate cheatgrass as a Change Agent for any species or communities in this REA.

The Russian olive and tamarisk models were useful for assessing potential risk from these invasive species for the Riparian Forests and Woodlands, but the models are also highly relevant to all other aquatic Conservation Elements (see Chapter 10—Riparian Forests and Shrublands). Because these species are broadly distributed in the Wyoming Basin and potentially affect so many other species, we provide an overview and summary of the key findings. We include information on cheatgrass because of its importance as a Change Agent in the Wyoming Basin. In addition to the invasive plants, we evaluated introduced diseases and nonnative fishes for several species evaluated for this REA (table 6–1).

Russian Olive, Tamarisk, and Cheatgrass

Russian olive, a small tree introduced from Eurasia in the early 1900s, was planted for ornamentation and to create windbreaks, particularly along riparian areas (Katz and Shafroth, 2003; Lesica and Miles, 2001a). Tamarisk is a drought- and salt-tolerant Eurasian shrub originally imported for horticultural use in the 1800s (Lehnhoff and others, 2011). Both species have since become naturalized and are found along many western streams including parts of the Wyoming Basin (Katz and Shafroth, 2003; Merritt and Poff, 2010). Russian olive and tamarisk have life-history characteristics that allow them to effectively compete with, and in some areas dominate, other native riparian species. Both native and nonnative trees and shrubs of riparian areas can resprout after disturbance (Stromberg and Rychener, 2010). Russian olive can become established under a cottonwood canopy, unlike shade-intolerant cottonwoods (Katz and Shafroth, 2003; Lesica and Miles, 2001a, b).

Table 6–1. Invasive species evaluated as Change Agents for the Wyoming Basin Rapid Ecoregional Assessment.

Conservation Element[1]	
Riparian	Russian olive and tamarisk
Five-needle pine forests	White pine blister rust
Cutthroat trout	Whirling disease; nonnative trout
Sauger	Walleye
Three-fish assemblage	White sucker and burbot
Northern leatherside chub	Nonnative trout

[1] Additional background information and methods can be found in the relevant chapters for each species or assemblage.

[2] Additional invasive species originally considered, but not evaluated, for the Rapid Ecoregional Assessment include chytrid fungus (spadefoot toad assemblage) and cheatgrass (sagebrush steppe, desert shrublands, greater sage-grouse, sagebrush-obligate songbirds, pygmy rabbit).

It was initially assumed that cold intolerance restricted tamarisk to the desert Southwest, but tamarisk have been expanding into the northern Great Plains since the 1950s. Tamarisk productivity, however, may be lower in colder climates such as the Wyoming Basin (Lesica and Miles, 2001b). Both Russian olive and tamarisk produce copious amounts of seed that disperse easily and remain viable longer than those of cottonwoods or willows (Jarnevich and Reynolds, 2011; Lehnhoff and others, 2011; Nielson and others 2011). Russian olive and tamarisk can access groundwater to depths of 3 meters (m) (9.84 feet [ft]), which is deeper than the rooting zones of cottonwoods and willows (Katz and Shafroth, 2003; Nagler and others, 2011). Russian olive and tamarisk can colonize disturbed riparian areas after prolonged periods of streamflow reduction (Katz and Shafroth, 2003; Nagler and others 2011; Mealor and others, 2012). Compared to native cottonwoods and willows, Russian olive is less favored by browsing animals (Lesica and Miles, 2001a). Tamarisk may increase fuel loads of riparian areas, although observed increases in fire frequency in some riparian areas may be due to the absence of scouring floods and resulting fuel accumulations on regulated rivers (Stromberg and Chew, 2002).

Cheatgrass is a cool-season (C_3) annual grass introduced to North America via contaminated packing and seed material and has subsequently spread throughout the West (Natural Resources Conservation Service, 2008). Cheatgrass is widely dispersed across the Great Basin sagebrush steppe, where it has replaced native grasses across extensive areas (Bradford and Lauenroth, 2006). In the Wyoming Basin, cheatgrass is widespread, primarily in lower elevation communities, such as the sagebrush steppe and desert shrub. Young cheatgrass is palatable to livestock and wildlife, but mature plants are not (Natural Resources Conservation Service, 2008). Moreover, life-history traits of cheatgrass allow it to often dominate and sometimes supplant native grasses. For example, it is a prolific seed producer (Nielsen and others, 2011), and the barbed awns on the seeds easily snag on fur, clothing, and tire treads, thus facilitating rapid transport many miles from the source plant (Natural Resources Conservation Service, 2008). Cheatgrass also can quickly colonize and spread within burned areas (Mealor and others, 2012).

Cheatgrass germinates after fall precipitation events and remains dormant over winter, while establishing an extensive fibrous root system, and subsequently completes its life cycle in the spring (McCarlie and others, 2001). Potential for altered precipitation patterns in the Wyoming Basin, such as increased fall or winter precipitation and decreased summer precipitation, could favor cheatgrass. In sagebrush shrublands at elevations of 2,149–2,169 m (7,050–7,116 ft), a shift in moisture regime from snow-melt derived to one derived from spring rainfall could increase cheatgrass expansion (Concilio and others, 2013). Compared to soil moisture, physical and chemical soil properties seem to have little influence on cheatgrass establishment (Bradford and Lauenroth, 2006).

Compagnoni and Adler (2014) found a positive correlation between warmer temperatures and soil-moisture availability on cheatgrass survival and growth. Using climate projections, they also found that late snowpack reduces cheatgrass survival and concluded that earlier snowmelt at lower elevations would increase the survival and viability of cheatgrass in these areas. Moreover, as a C_3 (cool season) species, cheatgrass effectively uses CO_2 (Smith and others, 1987; Smith and others, 2000; McCarlie and others, 2001), and elevated CO_2 levels have been shown to increase the above-ground productivity of cheatgrass (Smith and others, 1987; Smith and others, 2000, Ziska and others, 2005). Because CO_2 levels have already risen from 310 parts per million (ppm) in 1960 to approximately 400 ppm in 2013 (Thompson and Climate Central, 2014), this could lead to a competitive advantage in cheatgrass.

Although communities at lower elevations may be more susceptible to cheatgrass expansion, there has been significant expansion of cheatgrass at elevations of 1,900–2,700 m (6,232–8,856 ft) in the Southern Wind River Mountains of the Wyoming Basin (Ziska and others, 2005; Mealor and others, 2012). Although it is not uncertain whether cheatgrass can become dominant in all the sagebrush ecosystems of the Wyoming Basin, it has become dominant in the No Water Basin of the Southern Bighorn Basin. To various degrees, cheatgrass has become an established component of most sagebrush ecosystems in the Wyoming Basin (Ken Henke, Invasive Species Coordinator, Bureau of Land Management, Wyoming State Office, oral commun. with Robert E. Means, August 2014).

The interactions between invasive species and fire can exacerbate the negative ecological consequences of these Change Agents. Cheatgrass can increase fire frequency and promote larger fires, which in turn can promote the expansion and dominance of cheatgrass (Balch and others, 2013). Cheatgrass-dominated areas in the Great Basin had significantly larger fires and burned four times more often than native vegetation; the calculated fire rotation for cheatgrass was 78 years (yr) versus 294 yr for all native vegetation cover, compared to 199 yr in sagebrush (Balch and others, 2013). In contrast, there is limited evidence that the presence of Russian olive or tamarisk alters fire regimes. Rather, observed alteration of fire regimes may result from a lack of scouring floods that remove dead fuels as opposed to higher fuel flammability of nonnative compared to native riparian shrublands (Stromberg and Chew, 2002). See Nielson and others (2011) for additional discussion of invasive species in the Wyoming Basin.

Methods

We compiled occurrence data for all three species from BLM field offices within the Wyoming Basin and the Global Invasive Species Information Network (at www.gisin.org) to develop distribution models for each of the primary invasive plants (Jarnevich and Reynolds, 2010; Jarnevich and others, 2011). LANDFIRE (LANDFIRE, 2010) was used to evaluate model results for Russian olive and tamarisk. Model output for cheatgrass showed fairly high probability of occurrence across the ecoregion and lacked concurrence with other regional models (see for example, Nielsen and others, 2011).

We evaluated the risk of invasive species occurrence currently and for 2030 (covering the period from 2016–2030), 2060 (2046–2060), and 2090 (2076–2090) using available models developed by using BLM field observations (Jarnevich and Reynolds, 2011; Jarnevich and others, 2011). We used BLM field observations collected between 1998 and 2013 to build the invasive-species risk model because distribution maps of invasive plant species derived from LANDFIRE data have a high degree of uncertainty due to the difficulty of using remotely sensed imagery to distinguish native and invasive riparian species. Climate variables used in the model were derived from monthly averages of precipitation, minimum temperature, and maximum temperature for climate scenario II (Geophysical Fluid Dynamics Laboratory's Coupled Climate model 2.1, emissions scenario A2) (Maurer and others, 2007). We trained the model with climate variables for the period 1980−2009 and used projected values for the climate variables for 2030, 2060, and 2090 to examine the potential for expansion of the bioclimatic conditions suitable for tamarisk and Russian olive, summarized by 5th-level watershed. We categorized the expansion risk using equal breakpoints for probability of occurrence (that is, low <0.33, medium 0.34−0.66, and high >0.67). We compared modeled future distributions to recent distributions of Russian olive and tamarisk derived from BLM field observations and LANDFIRE, because regional surveys of invasive species are limited.

We summarized the model output for Russian olive and tamarisk by fifth-level watersheds. To compare observed and predicted occurrences, we identified watersheds that contained invasive riparian vegetation (presence of Russian olive and tamarisk) using LANDFIRE (see Invasive Species section of the Appendix). Below are the Management Questions for Russian olive and tamarisk (table 6–2).

Management Questions

Table 6−2. Management Questions addressed for Russian olive and tamarisk for the Wyoming Basin Rapid Ecoregional Assessment.

Core Management Questions	Results
Where are the known populations of Russian olive and tamarisk?	See Chapter 10—Riparian Forests and Shrublands
Where is riparian vegetation at risk from expansion of Russian olive based on recent and projected climatic conditions?	Figure. 6−1
Where is riparian vegetation at risk from expansion of tamarisk based on recent and projected climatic conditions?	Figure 6−2

Where are the known populations of Russian olive and tamarisk?

- There was fairly good correspondence between LANDFIRE and predicted probability of Russian olive and tamarisk occurrence. The lack of correspondence between observed and expected occurrences in some areas may be a result of coarse-scale occurrence information (fifth-level watershed), omission/commission errors and (or) model uncertainty, or because nonnative species were planted in suboptimal conditions.
- Both invasive species are widely distributed throughout the Wyoming Basin except at higher elevations.

Where is riparian vegetation at risk from expansion of Russian olive based on recent and projected climatic conditions (fig. 6–1)?

- Currently, the Bighorn Basin has the highest risk of Russian olive expansion.
- Although climate projections for 2060 and 2090 have greater uncertainty, the models indicate the potential for the bioclimatic conditions conducive for Russian olive to expand greatly throughout the Basin for this climate scenario.

Where is riparian vegetation at risk from expansion of tamarisk based on recent and projected climatic conditions (fig. 6-2)?

- The tamarisk distribution model projects that all lower elevations have high current and near-term risk of tamarisk expansion across the Wyoming Basin. The model indicates that tamarisk occurrence at upper elevations may be constrained by cooler temperatures.
- Climate projections indicate that the bioclimatic conditions suitable for tamarisk Geophysical Fluid Dynamics Laboratory Climate Model, ver. 2.1, emissions scenario A2) put the entire Basin at risk for tamarisk expansion.

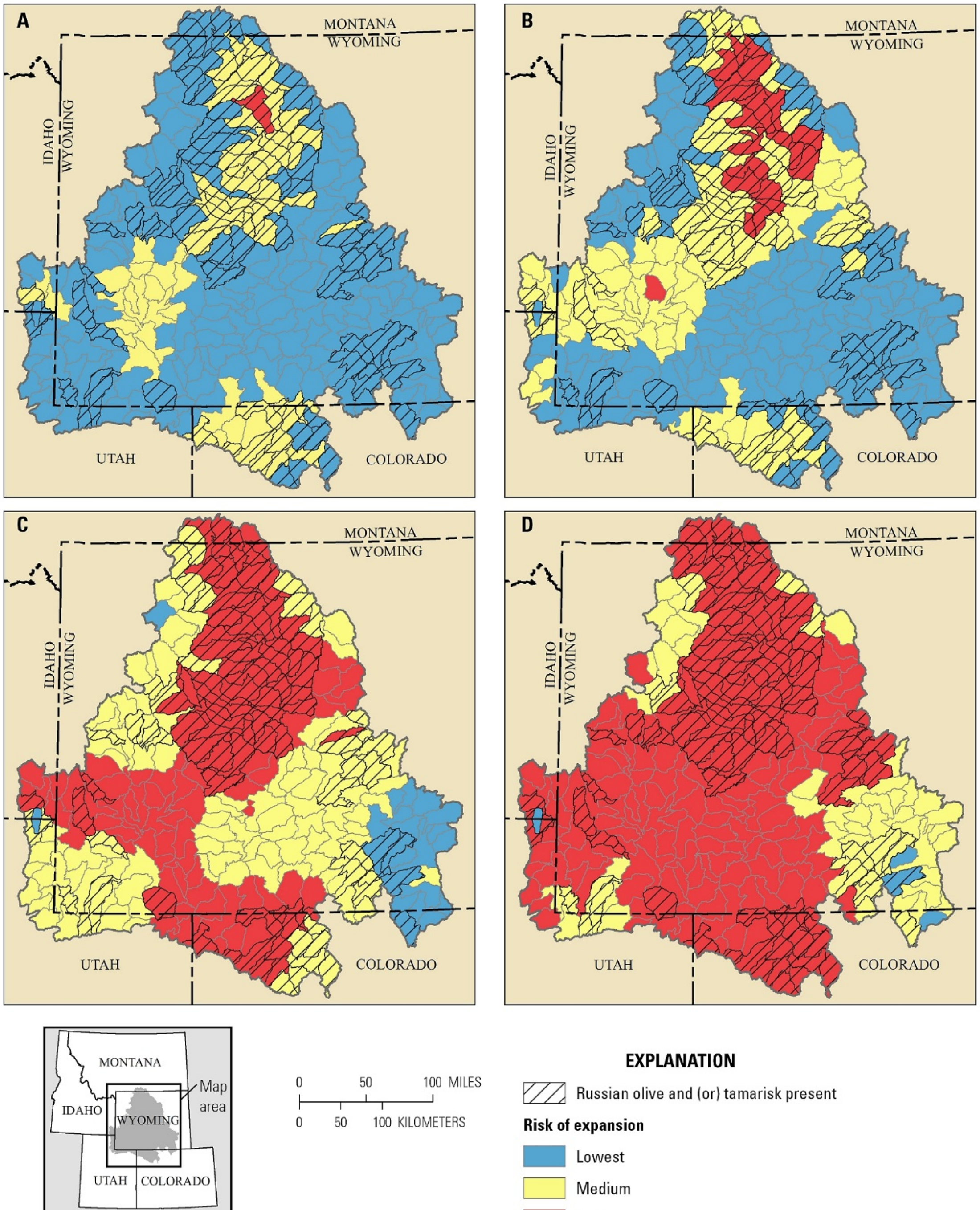

Figure 6–1. Current and projected risk for expansion of Russian olive, summarized by fifth-level watersheds in the Wyoming Basin Rapid Ecoregional Assessment project area. Current risk of expansion derived from suitability models using *(A)* recent climatic conditions (1980−2009); projected risks for climate scenario II (Geophysical Fluid Dynamics Laboratory Climate Model, ver. 2.1, emissions scenario A2) for *(B)* 2030; (*C*) for 2060; and (*D*) for 2090. Expansion risk is classified as lowest for probabilities <0.33, medium for probabilities between 0.34 and 0.66, and highest for probabilities >0.67. Probabilities are derived from occurrence models developed by Jarnevich and Reynolds (2011) and Jarnevich and others (2011). Hatched lines denote watersheds where LANDFIRE indicated Russian olive and (or) tamarisk presence.

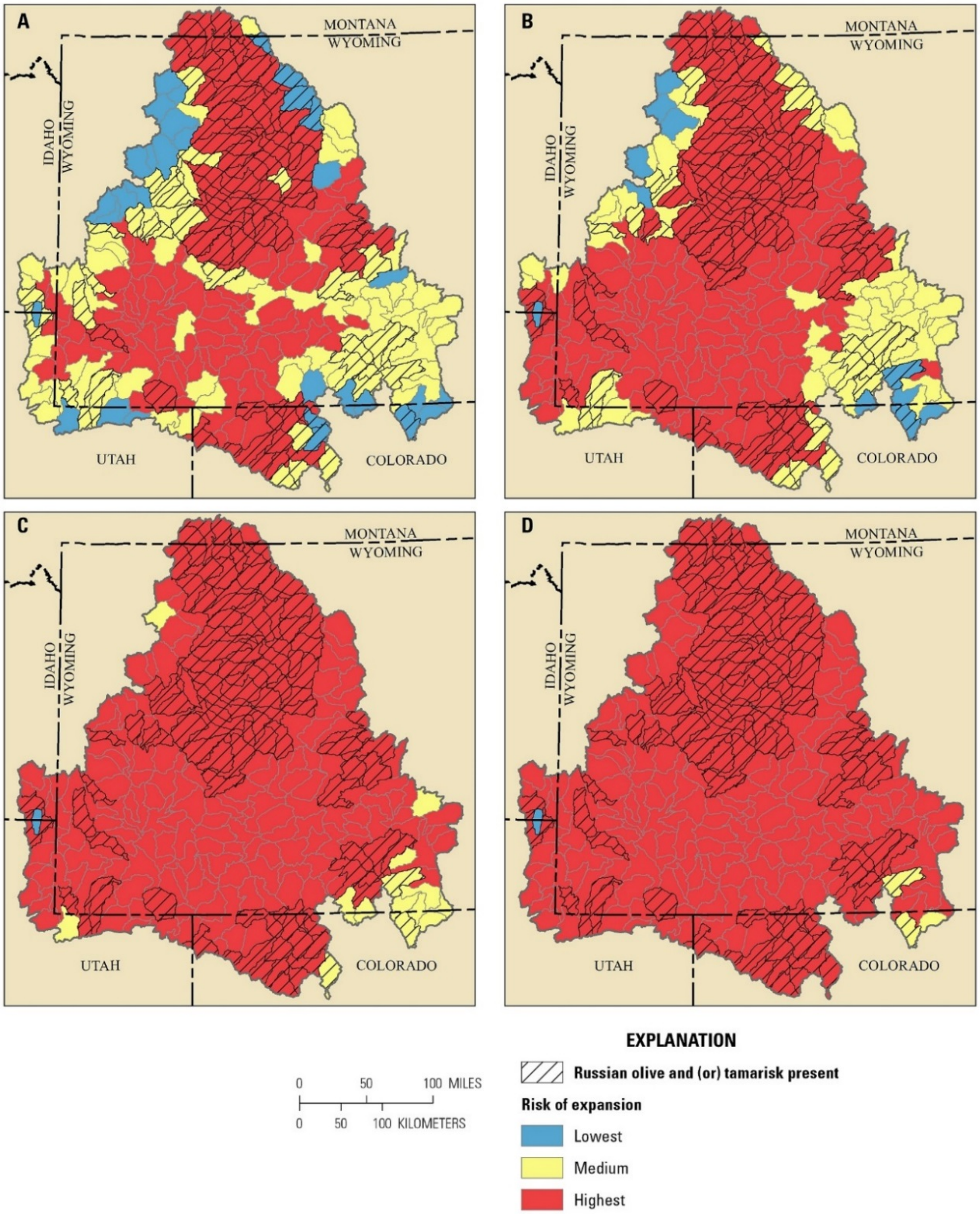

Figure 6–2. Current and projected risk for expansion of tamarisk summarized by fifth-level watersheds in the Wyoming Basin Rapid Ecoregional Assessment project area. Current risk of expansion derived from suitability models using (A) recent climatic conditions (1980−2009); projected risks for climate scenario II (Geophysical Fluid Dynamics Laboratory Climate Model, ver. 2.1, emissions scenario A2) for *(B)* 2030; (*C*) for 2060; and (*D*) for 2090. Expansion risk is classified as lowest for probabilities <0.33, medium for probabilities between 0.34 and 0.66, and highest for probabilities >0.67. Probabilities are derived from occurrence models developed by Jarnevich and Reynolds (2011) and Jarnevich and others (2011). Hatched lines denote watersheds where LANDFIRE indicated Russian olive and (or) tamarisk presence.

Summary

Currently, Russian olive and tamarisk have somewhat limited distributions in the Wyoming Basin. However, the projected climate scenarios evaluated here and the potential for altered fire regimes collectively could greatly increase the potential for invasive species to expand their ranges in the Wyoming Basin, cheatgrass in particular. Because the data were too limited, however, we were unable to model the probability of cheatgrass occurrence or make conclusions about the potential for cheatgrass to spread. Cheatgrass has become established in many areas, however, and its ability to transform arid shrublands to annual grasslands is a cause for concern throughout the Wyoming Basin.

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