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THE IMPACT OF RUSSIAN-OLIVE IN THE UNITED STATES

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by

Rachael A. White

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Theodore C. Crusberg, Project Advisor

1. southwest
2. exotic
3. Russian-Olive

ABSTRACT

This paper focuses on the impact Russian-Olive (an invasive exotic plant species) has had in the United States. The report includes a detailed description of the properties of the tree, arguments both for and against cultivating it, and descriptions of where and how this species has become established and/or naturalized. Methods of control are presented and examined as a possible solution for inhibiting the spread of Russian-Olive.

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1. INTRODUCTION

An exotic plant is a plant that is not native to an area, and has been introduced to that area from a place where the plant grows naturally. The dictionary defines the word exotic in part as "from another part of the world; foreign." Exotic plants are common in the United States. In order to migrate around the world, the plant has to have a mode of transportation. There are many routes by which non-native species can enter a country, including (but certainly not limited to) migration of the plant over a long period of time (such as corn coming from Mexico), importing the plant for ornamental purposes, and purely accidental transport from its native home.

Many of these imported and non-native species are not troublesome in the least; one would laugh at the site of a corn stalk or a bonsai tree growing as a weed in the backyard. On the other hand, there are countless species of plants that have proven extremely difficult to control. These plants have made themselves so at home in the United States that there is little chance now that their influence on this country can be eradicated. This might not be a problem, but for the fact that ecosystems are all in a balance and these introduced species can, and do, interrupt that balance, causing massive destruction to precious environments. These plants are so adaptable and competitive that they can take over the areas where they grow, completely strangling native plant life.

When many of these species were imported for ornamental or other purposes long ago, there was little consideration for the long-term repercussions involved. It simply did not occur to people that these plants might fare so well in their new environment that they could take over and essentially ruin vast areas of land. After a period of time, people began to realize that these new species were causing a problem. Since then, people have been researching exotic plants, trying to find a way to reverse the damage that has been caused and to prevent future damage. Though this is an enormous and complex problem, this paper attempts to study one of these exotics: Russian-Olive.

2. HISTORY IN THE UNITED STATES

Russian-Olive (which is most often described as a shrub or small tree) was introduced to the United States in Colonial Times, and was extensively planted in the western half of the country. Originally, it was used as a windbreak, an ornamental, or a living barrier hedge to prevent erosion or snowdrifts. Russian-Olive is native to central Asia, the western Himalayas, and southern Europe [1]. The tree's prevalence in gardening is surely because of its tolerance to a wide variety of environments as well as being tolerant of weather, bugs, and diseases. Also, because of its unusual silver color, it is desirable for complementing the other kinds of greenery in gardens. Essentially, it is the perfect addition to any controlled garden. But, Russian-Olive is so tolerant and adaptable that it has escaped cultivation (and control). Furthermore, it has become naturalized (meaning that it is established as if it is a native species) in much of the western half of the United States.

At first no one realized the imminent danger Russian-Olive presented to the ecosystem of the western half of the country, so for years it was left to spread. About a half-century after it was introduced, the effect of the shrub was finally realized, and by that time it was too late. Russian-Olive had run rampant in crop fields, stream beds, and anywhere else it could go, driving out native flora. The preventable loss of native plants is not something to be proud of, and reconstruction efforts have been attempted numerous times. Unfortunately it is nearly impossible to reinstate the old ecosystem, and unique environments have been lost. The best that can be done now is to get back as much as possible, and find ways to prevent this from happening in the future.

It is clear why the examination of Russian-Olive is necessary: its ability to tolerate many different climates and soil types makes it easy for this plant to spread to unwanted places. This causes elimination of natural plants and changes the ecosystem of the entire area drastically. While this plant may be a beauty and may be helpful to gardening aesthetics everywhere, there is an overwhelming need to both understand and control it.

3. PLANT CHARACTERISTICS

3.1 Branch Structure

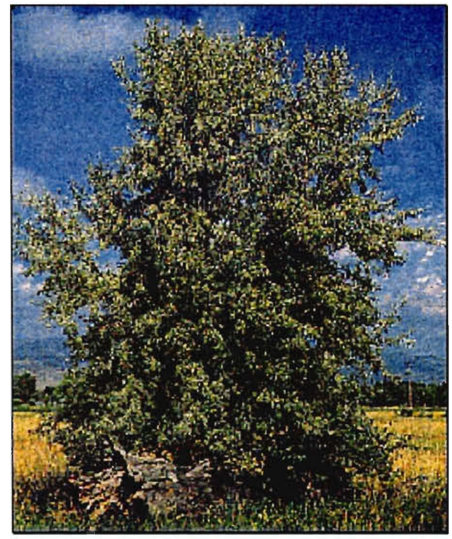

Figure 3.1. Russian-Olive Tree [3]

Russian-Olive (*Elaeagnus angustifolia*) is a tree or shrub that has multiple stems, as opposed to one main stem. Un-pruned, mature Russian-olive trees have around five main stems that spread from 10 to 20 feet starting close to the ground. Dense thickets are formed when the plants grow close together [1]. When growing alone, they grow as trees 12 to 45 feet tall [2]. These plants can grow up to 6 feet a year.

3.2 Twigs, Bark, and Leaves

Russian-Olive has thin bark, with "flexible, silvery-scaly" twigs [3]. The leaves are narrow and oblong, 1.7-3.5 inches long, and are covered in soft gray fur. Some of the twigs bear a tough spine that is about an inch long, which works well to protect the plant. The large spines on the lower branches of the plant make it particularly useful as a barrier plant. The leaves (1.7-3.5 inches) are a silvery color, and both the leaves and twigs are covered in a "gray, scaly pubescence" [2].

Figure 3.2. Russian-Olive Branch [3]

3.3 Flowers and Reproduction

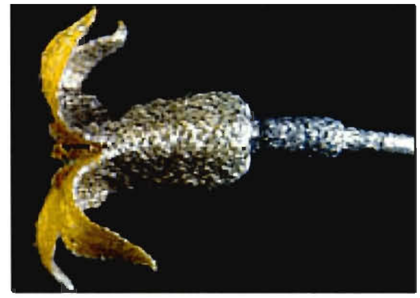
Figure 3.3. Russian-Olive Flower [3]

The trees mature and can produce fruit between the ages of 3 and 5 years in most areas [2]. The flowers are yellow on the inside and silvery on the outside. They have four parts and include both types of reproductive organs. The fruits produced are "dry, olive-like, sweet drupes" that are about an inch wide and have "a single 8-striate [seed] [3]." The seeds of Russian-Olive are called achenes, and their outer layer is impermeable to digestive juices.

3.4 Miscellaneous

E. angustifolia is a member of the oleaster family [4]. It is used most commonly in gardens for its aesthetics: the silvery color provides a contrast to the much more common green foliage [1]. The tree is found in 35 of the 50 states, along with some of Canada's provinces and Mexico. Temperature ranges for Russian-Olive area in the area of –50°F to 115°F, and the tree has been reported to grow from sea level to 8,000 feet in elevation [2]. The plant is very tolerant of alkalinity and its lower pH tolerance is 6. It is only somewhat tolerant of shade. When under stress, Russian-Olive trees exude amber colored gum. Interestingly, Russian-Olive is a nitrogen fixing species, which means it can increase the

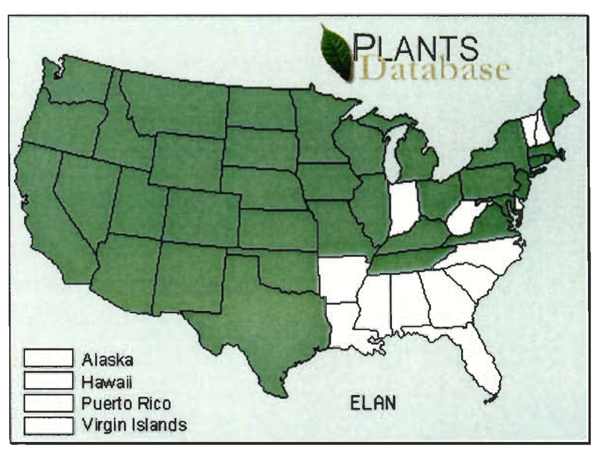

Figure 3.4. States that have Russian-Olive [4]

available nitrogen in the soil around it. The wood has no commercial importance whatsoever.

3.5 Edibility

Although more than 50 species of birds and mammals eat the fruit, communities where Russian-Olive predominates are considered to be inferior to native vegetation [2]. In a comparison between Russian-Olive dominated stands of vegetation and native species dominated vegetation 40 species of wildlife were found in the Russian-Olive stand, and 56 species were found in the native vegetation [1]. Clearly, the diversity in a Russian-Olive dominated community is substantially lower than that of a native community.

Though less suitable for diversity in wildlife, Russian-Olive is rated fair in protein and energy value [2]. Palatability to several kinds of animals has been evaluated for Colorado, Montana, North Dakota, Utah, and Wyoming. The ratings are as follows:

(Table 3.1. Palatability of Russian-Olive to some Animals)

	CO	MT	ND	UT	WY
Cattle	Poor	Fair	Fair	Poor	Poor
Sheep	Fair	Fair	Good	Fair	Fair
Horses	Poor	Poor	Poor	Poor	Poor
Pronghorn	----	Fair	----	Fair	Poor
Elk	----	----	----	Good	Fair
Mule Deer	----	Poor	Poor	Good	Good
White-tailed deer	Good	Fair	----	----	Poor
Small mammals	Good	----	----	Good	Good
Small non-game birds	Good	Good	Fair	Good	Good
Upland game birds	----	Good	Good	Good	Good
Waterfowl	----	----	----	Fair	Good

On average, Russian-Olive rates well for palatability to these animals. This can be considered as a benefit to having wild/naturalized Russian-Olive. In contrast, this means that the plant is easily spread when the animals excrete the undamaged seeds, which is a nuisance for the unusually delicate Western habitats.

3.6 Ground Cover

In addition to being edible, Russian-Olive provides good cover and nesting ground for some mammals and birds. The cover rating for various types of animals has been evaluated in Colorado, Montana, North Dakota, Utah, and Wyoming. The ratings are as follows [2]:

(Table 3.2. Cover Value for some Animals)

	CO	MT	ND	UT	WY
Pronghorn	----	----	Fair	Fair	Poor
Elk	----	----	----	Good	Good
Mule Deer	----	Fair	Good	Good	Good
White-tailed Deer	Good	Good	----	----	Good
Small Mammals	Good	Fair	----	Good	Good
Upland Game Birds	Good	Good	Good	Good	Good
Waterfowl	----	----	----	Good	Fair

The tree rates good to fair overall; this is a benefit to both having trees in the wild and to gardeners hoping to spot an animal or two.

3.7 Summary

In summary, Russian-Olive is a fast-growing, multi-stemmed tree. The twigs and leaves are covered in a gray fur, and the bark of the tree is thin. Russian-Olive trees are tolerant of many wildly varying conditions, including pH, elevation, and temperature. It reproduces through bi-sexual flowers; its seeds are small, hard and impermeable to digestive juices. The fruit is successfully eaten and digested by many animals. Other animals use the tree as cover from predators, weather and other threats.

It seems that Russian-Olive is completely indestructible and unstoppable, but that is not entirely true; there are a scant few diseases that can infect and kill the trees over a period of time.

4. DISEASES OF RUSSIAN-OLIVE

Russian-Olive is resistant to a lot of things: bugs, weather, temperature, etc, but the shrub does have a breaking point. Though it is resistant to many diseases, there are two common, potentially fatal fungi for Russian-Olive: Tubercularia Canker (*Tubercularia ulmea)*, and Phomopsis Canker (*Phomopsis arnoldiae, P. elaeangni*). This is a relatively short list, and diseased Russian-Olive trees have historically been uncommon. However, the fungi have been reported to be spreading in recent years, so the repercussions of these diseased plants are worth discussing. The following information will be useful in two ways: for gardeners looking to heal their wounded plants, and for landowners looking to eradicate Russian-Olive from their property (yes, it is contradictory). When necessary these diseases can be used as effective long-term control of the plant (see control section below). Both diseases can cause the eventual death of the infected plants. Though the symptoms are nearly identical, the diseases merit individual discussion.

Tubercularia Canker infects and spreads during the winter [1]. It is transmitted to the tree by the following methods: animals, rain-splash, and open wounds in the bark. True to its namesake, the tree causes "cankers" to appear on the branches. The cankers can be identified by visibly sunken and discolored tissue. The stress caused by Tubercularia Canker can cause Russian-Olive to exude gum from the cankers. Trees that are under other environmental stresses such as temperature fluctuations, severe water conditions, hail and ice will succumb more easily to the disease. *T. ulmea* has also been linked to another possible disease called "Decline and Gummosis of Russian-Olive." Scientists are not sure if this is a new disease, or if it is merely symptoms of other infectious fungi [5]. Affecting primarily older plants, Tubercularia Canker can kill a tree in one to seven years. As stated above, Phomopsis Canker has very similar symptoms to Tubercularia Canker.

Though the symptoms are similar, Phomopsis Canker affects trees of younger age (saplings and seedlings). It enters the tree primarily through surface wounds, such as a branch stub or a damaged thorn [6]. The trees develop oval-shaped cankers (1-6 inches in length) and exude the amber colored gum to a greater extent than with Tubercularia Canker. The cankers can be identified by bark ranging in color from orange-brown to dark reddish-brown. Once the canker engulfs the entire circumference of a branch, the branch will wilt and die. This fungus does not over-winter in the soil, but it does remain throughout the cold season in cankers as pycnidia and mycelium. Pycnidia, or "pimple-like eruptions", erupt from the canker and stay there for about a year afterward. Like Tubercularia Cankers, this disease is more likely to attack plants that are weakened by environmental stresses. Smaller trees may be killed as quickly as a month after infection.

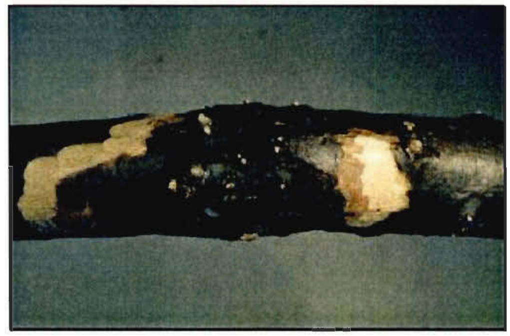

Figure 4.1. Phomopsis Canker with Bark Removed [6]

There are other reports of fungi attacking Russian-Olive, such as Verticillium wilt and *Fusarium* and *Phytophthora* fungi, but these diseases are less common, and presumably less destructive to the plants. Depending on who you are, infected Russian-Olive trees can either be very handy (if you need to get rid of them), or a pain (if you want to keep them). Another thing to keep in mind is the potential threat of the diseases to other trees and plants surrounding Russian-Olive stands. Tubercularia Canker and Phomopsis Canker may not be limited to Russian-Olive. When either of these two diseases is being used as a control agent, care must be taken to avoid infecting desired species. One must remember though, that diseased trees are still fairly uncommon, and that disease is not a big issue with Russian-Olive. A much bigger issue is determining where Russian-Olive is getting out-of-control, and how to harness its destructive powers.

5. PROPERTIES OF SITES INFESTED WITH RUSSIAN-OLIVE

In a study done by Carman and Brotherson in 1978 [7], characteristics of sites infested and not infested with Russian-Olive were classified. This study is useful in predicting where Russian-Olive will or will not invade. The repercussions of this are obvious, by knowing more about what environments are susceptible to Russian-Olive, preventative action can be taken. For example, if a farmer is aware that some of his/her land is in danger of being invaded by Russian-Olive, he/she may be able to use that information to his/her advantage. Even if he/she cannot prevent it from happening, he/she can be prepared for it and know what to do about it to keep it in check; rather than being surprised by it after the invasion has already occurred. Carman and Brotherson's research can be used as a basis for preventative action, so it is important to study their findings. Fifteen infested and non-infested sites were subjectively chosen for the analysis. Using "multi-group discriminant" analysis, Carman and Brotherson were able to obtain fairly consistent results for the prediction of Russian-Olive infestation. Several types of indicators were used, but the two most important were plant and soil indicators. Carman and Brotherson hoped to predict whether or not Russian-Olive would be likely to invade a site by using these indicators.

Plant indicators are plants that occur in sites either infested or not infested by Russian-Olive. By tabulating the statistical information about their sites, Carman and Brotherson determined that bearded wheatgrass (*Agropyron subsecundum*), redtop (*Agrostis alba* L.), common ragweed (*Ambrosia artemisiifolia* L.), and tansyleaf aster (*Machaeranthera tanacetifolia*) were among the plants found in sites infested with Russian-Olive. However, just 11% of these plants were found in more than 50% of the sites. Although a correlation was found, the relationship between plant indicators and Russian-Olive presence is relatively weak. Carman and Brotherson suggest that this indicates that Russian-Olive "can tolerate conditions conducive to a variety of understory communities." As for soil indicators, phosphorous was the best indicator of sites *not* infested with Russian-Olive; while clay content, magnesium concentration and high pH were indications of a Russian-Olive-infested site. Another indicator used was a more general version of the plant indicator, lifeform indicators.

A table of indicators, indicator values, and relative contributions was made from the results of the descriminant analyses; but for the purposes of this paper, only a listing of indicators and relative contribution is necessary:

(Table 5.1. Various Indicators and their Relative Contributions)

Indicator Variable	**Relative Contribution**	**Indicator Variable**	**Relative Contribution**
Soil Indicators	(%)	Common spikerush	11
P	36	Poverty weed	9
Salt	40	Downy brome	8
pH	18	Common dandelion	8
Clay	16	Foxtail barley	7
Plant Indicators		Testiculate buttercup	4
Intermediate wheatgrass	14	*Lifeform Indicators*	
Common ragweed	13	Grasses	36
Bearded wheatgrass	12	Sedges	36
Hoary cress	12	Shrubs	29

The term "relative contribution" means the contribution of each indicator to the classification function. Essentially, the higher the relative contribution, the more you can depend on the indicator actually indicating the presence of Russian-Olive. Though none of the values for relative contribution are higher than 50%, the information is still useful. In general, one can state that the presence of a lot of phosphorous, or a lot of grasses and sedges in the soil makes a site more susceptible to Russian-Olive invasion.

Therefore, this crude information is already helpful in determining whether or not Russian-Olive is a threat. The study does not stop there; it also includes an analysis of how accurate their analyses are.

Carman and Brotherson compiled a table of the adequacy of their discriminant analysis. For the purposes of this paper, it is only necessary to partially reproduce the table:

(Table 5.1. Classification of Sites by Characteristic)

		Sites Correctly Classified by Characteristic:		
Site Description	*Total Sites*	*Soil*	*Plant*	*Lifeform*
Infested	15	11	15	12
Uninfested	15	12	15	12
Total	**30**	**23**	**30**	**24**

From this table, one can see that although the information is not highly sophisticated, predicting the presence (or threat) of Russian-Olive is feasible. The plant indicator proved to be the best, properly classifying all of the sites studied, while the soil indicator proved to be the "worst" with 23 of 30 sites classified correctly. Perhaps (in the future) a combination of the three main indicators could present a consistently accurate prediction of Russian-Olive infestation. This information provided the researchers with a broad enough view of Russian-Olive infected (or not infected) sites, that they were able to draw some conclusions about the conditions under which Russian-Olive will thrive.

From this research, Carman and Brotherson concluded that Russian-Olive grows in areas of "low to medium concentrations of soluble salts," and that other plant life at sites infested with Russian-Olive "were typical of mesic meadows." They also noted that if the species being used for plant indicators started growing after the Russian-Olive infestation, these results would be misleading, but that their calculations suggested that the "indicator species were present prior to infestation." Although none of these variables can give 100% confidence in the prediction of Russian-Olive, this study could prove to be a very useful tool.

6. RUSSIAN-OLIVE ESTABLISHMENT: THE EAST

Though it may seem like it, Russian-Olive is not limited to the Western United States; it occurs throughout the 48 contiguous states. The difference is, in the Eastern half of the country, Russian-Olive has not become naturalized. The environment of the lush, green eastern United States is much more conducive to supporting a wide variety of plants than the dry and dusty western states. Unlike the west, there is so much water available, that many plants and trees have a chance of survival, not just the toughest. Also, eastern states generally do not have soils of pH high enough to support Russian-Olive. The environment of eastern seaboard inland to the Mississippi river is such that Russian-Olive cannot take over, and its growth is therefore limited. However, some states such as New Hampshire, Virginia, and Massachusetts are aware that Russian-Olive presents a risk to the environment, and have issued a warning about the plant. In general, these warnings come from state agencies or from college or universities who are doing relevant research.

Although Russian-Olive has been established in the east, the tree has not taken over as it has in the west. Those of you reading this from the eastern half of the country should not yet breathe a sigh of relief. You will soon learn that states as lush as Montana and Colorado have also been invaded by Russian-Olive. You may not think you have to worry now, because Montana and Colorado have soil that is alkaline enough to comfortably support Russian-Olive, which is not true of the east, right? Wrong. Russian-Olive has already proved to be both adaptable and tough; keeping a cautious eye toward the future is probably a wise course of action. Since so much has been spoken of Russian-Olive in the west, it deserves some elaboration.

7. AN ASIDE: THE RUSSIAN-OLIVE CONTRADICTION

As this paper has progressed, seemingly contradictory facts have been discussed. Russian-Olive brings about an interesting contradiction: In some places it is considered an exotic plant that is in desperate need of control, and in other places nurseries sell it and tout all of its benefits. A simple internet search using Google or another search engine results (in general) of two types of websites: The nursery websites, advertising Russian-Olive, and the state government or university websites warning about the risks of Russian-Olive. Here is a screenshot of a simple search for the terms Russian and Olive:

> Invasive Species: **Russian olive** profile
> Species Profiles. Species Profiles -> **Russian olive**. Elaeagnus angustifolia (L.). Common names: **Russian olive**, oleaster. Taxonomy ...
> www.invasivespecies.gov/profiles/russolive.shtml - 21k - Mar 23, 2003 - Cached - Similar pages
>
> Shand Greenhouse - **Russian Olive**
> ... **Russian Olive**. Common name: **RUSSIAN OLIVE**. Drought resistant; very good wildlife habitat. Latin name: Eleagnus angustifolia. Type of ...
> www.saskpower.com/greenhouse/education/ seedguide/doc13.shtml - 11k - Cached - Similar pages

An invasive species website and a greenhouse website right next to each other on the very first page of results! This is a perfect illustration of the Russian-Olive contradiction. Some of the nurseries advertising Russian-Olive are even in states that are trying to rid themselves of it!

Before any major changes in the control of Russian-Olive all over the country can occur, this contradiction must be resolved to the point where consumers and sellers alike are aware of the destructive ability of the plant and the means by which they can control it. Most, if not all, state governments have programs to alert and inform residents of potentially harmful exotic plants. Unfortunately, it is difficult to properly inform everyone about a risk to his or her environment. Perhaps the solution to this is something similar to the Attorney General's warning on cigarettes, a label on every tree:

> WARNING: Do you know what kind of plant you are buying? This plant is considered to be a danger to the environment in many states, please think carefully before buying! Given the proper conditions, this plant can take over your entire yard! Please use it wisely.

Until the large majority of people are aware, half of the country will be struggling unsuccessfully to control the plant, while the other half of the country is obliviously admiring how it looks in their gardens.

8. NATURALIZATION OF RUSSIAN-OLIVE: THE WEST

8.1 General Naturalization Data for the Western States

As one crosses the Mississippi river, the real problem with respect to Russian-Olive begins. Now is an opportune time to expand on the definition of "naturalization." The dictionary definition of the word "naturalize" is as follows: To adapt or acclimate (a plant or animal) to a new environment or to introduce and establish as if native. In the east, Russian-Olive has become established, but it does not occur as if it was natural. On the other hand, this naturalization does occur in the western half of the country because the western habitats are more suited to Russian-Olive's preferences. Furthermore, because the tree is so ecologically flexible, it pushes out the native plants, causing a huge problem in the dry environment. It is commonly found along riverbanks, floodplains, stream courses, marshes and irrigation ditches [2]. As discussed above, the word is not entirely out that Russian-Olive is a nuisance plant that can have incredibly undesirable effects on rivers and crop fields alike. Fortunately, many studies have been conducted on the invasion of Russian-Olive into these areas, so at least a limited understanding of the problem is available.

Olson and Knopf [8] investigated the scope of the naturalization of Russian-Olive in 17 of the western states: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. Olson and Knopf indicate that Russian-Olive has become naturalized in at least some areas of every one of these states. This information is important because it helps define the scope of the issue. Also, if this data is gathered over time, one can make a map plotting the expansion of

Russian-Olive, which can help in the prediction of where and how Russian-Olive spreads. Though this chronological infestation information is not currently available, a description of state distributions is useful for reference purposes.

Figure 8.1. Russian-Olive Distribution in the Western United States [8]

The distribution varies from state to state: Some states such as North Dakota and Utah have Russian-Olive both adjacent to rivers and in areas where there is no major river. Others, such as New Mexico, and Arizona have infestation solely on riverbanks. Still other states such as Montana have only limited infestation on rivers. These findings are consistent with the annual temperature of the states: Overall, Montana is much cooler than New Mexico and Arizona. One can see why Russian-

Olive is limited to riparian areas of the hotter states. However, it is still worth noting in more detail the specific areas in which Russian-Olive has become naturalized.

Olson and Knopf report that "this species has probably naturalized to a greater degree [in North Dakota] than in any other state." As of 1983, Russian-Olive was reported in 35 of 53 counties, and the area of most prevalence is the eastern third of the state. The reason for this, Olson and Knopf speculated, was the higher moisture content in the soil, removing the limitation of growing only on riversides. This is the polar opposite of Utah, which has a much more arid environment.

In Utah, it is reported that 20 of 29 counties have naturalized Russian-Olive occurring within them. The most extensive stands seem to occur around streams or rivers, but it has been reported that it "is spreading to sub-irrigated fields at Fish Springs Natural Wildlife Refuge." Obviously the spreading is hindered by the lack of water in most areas of Utah. This data could be important for predicting the spread of Russian-Olive where it is less established, such as New Mexico and Arizona.

In New Mexico and Arizona, Russian-Olive occurs almost exclusively along rivers such as the Upper Colorado (Arizona) and the Rio Grande (New Mexico). In Arizona the plant also occurs in riparian zones in the desert, while in New Mexico it occurs "wherever surface water is present" in the western and central parts of the state. It seems as though Russian-Olive has only started its reign of terror in these states, and will be spreading in the coming years. But, because of the very dry habitat, it is probably not as easy for Russian-Olive to run rampant in these states as swiftly as it can in Montana.

Finally, in Montana, the plant has been reported along rivers in northern part of the state (near Glacier National Park), and in other isolated areas in the southeast. This recurring theme of Russian-Olive spreading along rivers is the focus of another study conducted in Montana. This study is a specific example of the general naturalization information seen in the study done by Olson and Knopf. One can only go so far on generalized information, so the next study will provide a narrower and more specific view about the naturalization of Russian-Olive.

8.2 The Effect of Russian-Olive on Cottonwood Forests

The study, done by Lesica and Miles [9], took place on the Marias River, which runs from Glacier National Park into the Missouri River in Montana. It focused on the effect of Russian-Olive on cottonwood forests; a source of concern, because cottonwood forests provide an excellent (and native) habitat for a wide variety of animals, as well as being the tree of choice for beavers. By studying the spread of Russian-Olive in that area, the actual process of naturalization becomes clearer. It helps to answer questions like: How long does naturalization take? How does Russian-Olive get there? Why does it spread so easily? What specific native species are actually endangered by the presence of Russian-Olive? The study was done on a regulated portion of the river, which also demonstrates the effect of river control on the ability of cottonwood and Russian-Olive to establish themselves.

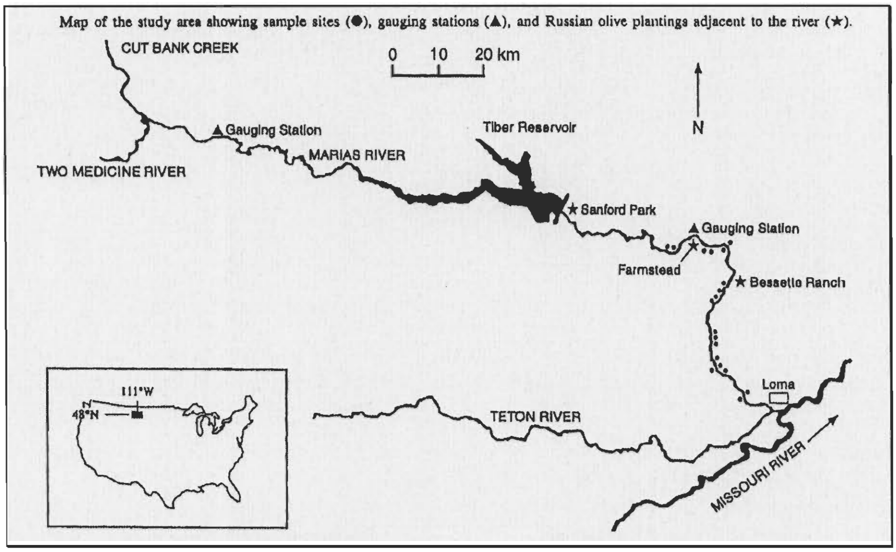

Figure 8.2. Marias River Russian-Olive Establishment [9]

The study examined the edges of the river, recording a variety of information about the species present along the river: number, age, beaver usage, etc. The map above shows the locations of the dam, sample sites, and Russian-Olive plantings along the Marias River. Three different elevations were studied: sandbars (0.3 m above river level), low terraces (0.9 m above water level, 25 m away from bank), and high terraces (2.0 m above water level, 160 m away from bank). Russian-Olive did not occur on the sandbars, and occurred in 89% and 43% of the low- and high- terrace sites respectively. Lesica and Miles presented a graph of the density of Russian-Olive, differentiating between saplings, poles and mature trees:

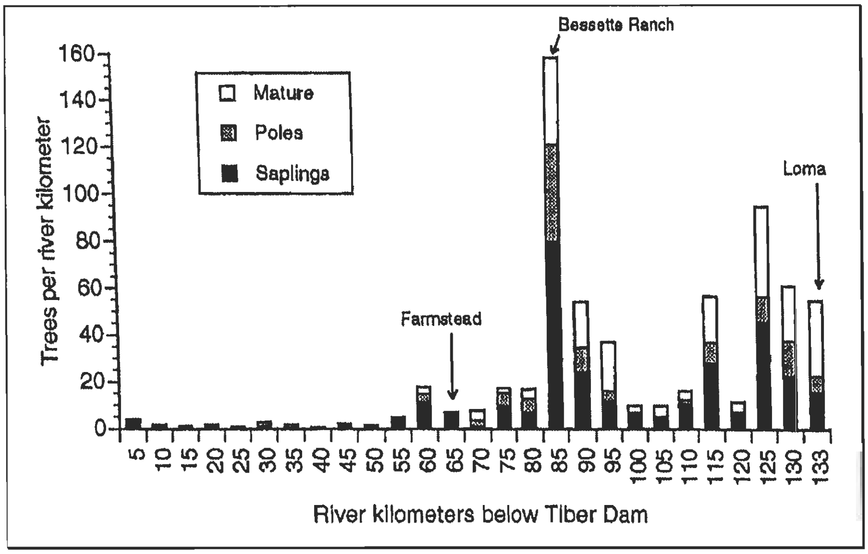

Figure 8.3. Russian-Olive Population below Tiber Dam [9]

The large number of trees occurring at Bessette Ranch is due to a windbreak that was planted in 1962. The study was unable to determine why the density of Russian-Olive plants just after the Tiber Dam was so low. Consideration of the way Russian-Olive spreads may shed some light on this. Along with being spread by birds and other animals, Russian-Olive seeds are buoyant [1]; therefore a seed can travel down a river and lodge in the riverbank, effectively spreading the shrub. The presence of the dam may impede the seeds from spreading as much as they otherwise could in the area just after the dam. Since Russian-Olive seeds are distributed more often than not by birds, which tend to excrete their waste in "forested habitats", the study concluded that the high-terrace sites are the most likely location for initial invasion of Russian-Olive. This might suggest that the infestation starts at the high-terraces and then spreads to the low-terraces, but Lesica and Miles "did not detect an age difference in the age of Russian-Olive" on the two types of site, which indicates that the invasions were not dependent on one another. This conclusion also backs up the theory that the plants are spread by seeds traveling down the river as well as by the droppings of birds. The spread likely occurred simultaneously through the river and through the droppings, resulting in parallel but not co-dependent colonization of the high- and low- terrace sites.

As mentioned above the other consideration of the study is the effect of beavers on the cottonwood population. The study determined that beavers almost never use Russian-Olive, while cottonwood trees are the preferred species overall.

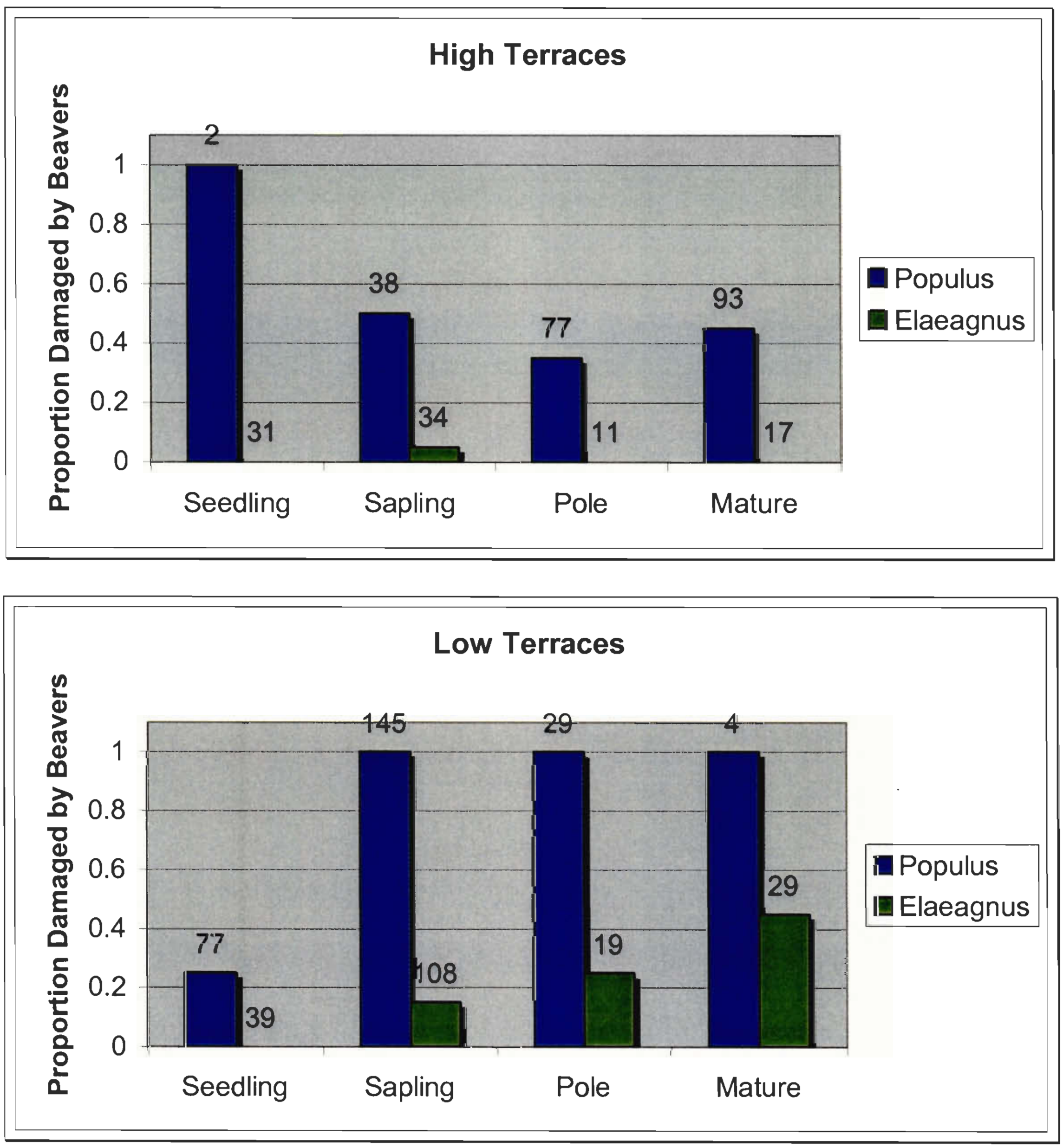

Figure 8.4. Plants Damaged by Beavers [9]

The graphs above show that no matter how many specimens of cottonwood and Russian-Olive there were, the percentage of damaged cottonwood trees was always higher. From this, it can be concluded that the population of cottonwood trees is very negatively affected by the presence of beavers. This could have long-term implications on the population of cottonwood trees on the Marias River, because as the trees get eaten away, the Russian-Olive trees get more and more sunlight and space to take over.

To further compound the problem this section of the river is controlled. Cottonwood trees depend on disruption of the land by floods to germinate, and they have a very small window of time in which they germinate each year [10]. Obviously, because the river is controlled, the flooding necessary for cottonwoods is eliminated. So, the beavers kill off the trees, and they do not stand a chance of re-establishing themselves, because the natural flooding the trees need cannot occur.

The study concludes that if beavers were not present, cottonwood would dominate in this area, but since beavers are common in the area, a solution is necessary. Lesica and Miles suggests that beaver trapping and relocation to reduce the population, and "periodic large spring releases from Tiber Dam" will help to reestablish the cottonwood forests, and therefore deter the appearance of large, dominant Russian-Olive stands. This study is a prime example of how Russian-Olive could be controlled given the right conditions. It also illustrates that the sturdiness of the plant is not the only cause for the unhindered spread of Russian-Olive. Factors that humans control also affect the spread of Russian-Olive: Our dams and the innumerable other accidental effects human influence have on the land can clearly influence the balance of a delicate ecosystem. However, for the most part, the human influence is unable (or unwilling) to be removed, so other methods of control must be employed to try and tame these trees. This does not just apply to Russian-Olive; all invasive exotics need to be controlled, or they will continue to ruin valuable and unique habitats.

9. THE NEED AND THE MEANS FOR A RESOLUTION

9.1 Importance of Nuisance Weed Control in the United States

The number of nuisance plants that have been in introduced into the United States is almost inestimable. Though some plants do not pose a risk, there are also many plants that can, have, and will continue to endanger natural habitats. It is important to discuss and further the research of the control of these plants; though much has already been lost, salvaging anything that can be had is well worth the effort. As has been discussed above, the problem goes much farther than plants growing in inconvenient places. In order to fully appreciate the need for controlling these plants, it is essential to understand both the effect these plants have on the environment, and the ease with which they can spread.

Eurasian milfoil, which is a water-bound exotic that has spread rapidly in the lakes of the Northeast, can survive on the propeller of a motorboat, and hence move from lake to lake by humans, unbeknownst to them. This weed then establishes itself and grows at amazing speeds, living in the shallow water close to the shoreline, as well as on a limited basis in deeper waters. This perpetuates until it chokes out native water plants, and then affects the fish populations. The most effective way to control milfoil is to lower the level of a body of water, but this always proves difficult and usually has a very negative effect on the population of fish and native plant species. Eventually, the decline of a lake can be caused by milfoil, meaning us humans will not be able visit or enjoy the lake. Eurasian milfoil is just one example of an exotic species destroying a valuable resource.

Salt cedar, another exotic found in the western U.S. has a seemingly infinite thirst for the west's most precious resource: water. This tree has an amazing ability to ingest all of the water from the water table in riparian habitats, not only choking out every other plant in the surrounding area, but also driving off the native animals as well. Entire stands of very diverse and native species have been killed off by salt cedar, effectively destroying some of the most unique and adapted habitats this country has to offer. The growth of salt cedar is out of control, and there is no hope of eradicating it completely.

The notion that an invasive exotic species cannot be completely eradicated is not limited to salt cedar and Eurasian milfoil. This has become the case for many of the introduced species in this country, and the force of all the exotics is completely unstoppable. But, just because there is no hope of fully eradicating a non-native plant, does not mean that there is no hope of controlling the future spread and current population of the plant. That said, it is clearly necessary to discuss the type and effectiveness of current control methods for Russian-Olive.

9.2 Methods of Control

As with any situation, there are several options for the control of Russian-Olive; each with its own list of pros and cons. These techniques are well known and practiced throughout problem areas. Stannard, Ogle, and Holzworth [1] have compiled a concise list and description of these methods; this paper puts the information into a short tabular form.

(Table 9.1. Methods of Control, Modified from [1])

Method	Description	Advantages	Disadvantages
Mowing Saplings	Saplings easily mowed, stem material does not wind around mower blades.	-Fast -No specialized equipment required -May improve pasture quality -Repetition will reduce populations to acceptable levels	-Frequent repetition needed -Desirable species also eliminated -Accessibility limited by terrain -Cut pieces must be disposed of properly to prevent rooting and resprouting
Cutting	Relatively soft and easily cut. Cutting at base eliminates top growth for a short period. Stumps can be treated to prevent resprouting.	-Selective -Cost effective -Repetition will starve the root system -Opens up canopy, allows light to desirable understory species	-Suppression not long term -Spines hinder access to tree base -Cut pieces must be disposed of properly to prevent rooting and resprouting
Girdling	Severs phloem tissues, prevents transport of photosynthates to root system, starving the plant.	-Simple -Effective -Suited for larger trees -Selective	-May stimulate root sprouting -Dead top growth must be removed and burned (burning must occur elsewhere to insure safety of desired plants) -For multi-stem crowns, thorns on low-lying branches impede process
Flooding and Ponding	Does not withstand continual ponding.	-Can expose bare soil, improving establishment of cottonwood seedlings -Creates/improves wetland habitat -Remnant wetland plants may colonize site, reducing need to revegetate	-Artificial control of water levels required -May not be feasible in riparian areas -Costly, difficult to secure permits to alter a stream -Risk that pieces may move downstream and start a new colony

Chemical* *See below for more details.	Russian-Olive is sensitive to 2,4-D ester, triclopyr, 2,4-D + triclopyr, imazapyr, glyphosate, and others applied to various parts of the tree.	-Inexpensive -If applications targeted, desirable vegitation may be retained -Aerial, pump-up sprayers and backpack sprayers may be used where large equipment cannot go	-Most listed chemicals non-selective, requiring careful treatment -Usually requires 1-2 years follow up treatment (effective control interval is up to 3 years) -Public perception of pesticides generally negative
Shading	Shade-intolerant.	-Promoting growth and recruitment of tall cottonwoods and willows is desirable	-Shading-height cottonwood/willow trees may take several years to grow/produce -Grows two types of leaves (shade and full-sun), may adapt to shade - Limited to environments that support cottonwoods and willows
Burning	Practical when conditions support a hot fire. Saplings are most sensitive to burning. Fire must be hot enough, burn long enough to incinerate stumps of larger trees. Summer burns preferred.	-Inexpensive -Highly visual results -Effective for clearing top growth	-Rarely effective alone (can resprout from crown), so burning requires complementary treatment for effective control -Nonselective -Immediate revegetation needed -Permits may be required, difficult to obtain
Tillage	Sensitive to repeated tillage, especially saplings. Periodic renovation of pastures effective in preventing Russian-Olive from domination a site. Disks and plows are preferred over sweep cultivators.	-Reestablishing pastures usually cost effective -Tillage gear easily obtained -Multiple treatments control root sprouting and germination	-Limited to pastures and cropland -Rough terrain (steep slopes, wet soil, flooding) may eliminate tilling as an option -All existing vegetation must be

		-When used with broadleaf weed control spraying, saplings effectively controlled	fully controlled -Leaves bare soil susceptible to invasion by other species -May aggravate salt accumulations at soil surface -Riparian areas vulnerable to erosion, especially following tillage (due to stream flooding events)
Biocontrol	Although originally promoted as an ornamental and/or windbreak plant because it is relatively insect and disease free, two fungal diseases cause stem dieback and death of the plants. Tubercularia canker kills entire stems, can kill diseased plants over time. Phomposis canker kills seedlings and saplings, causes dieback and cankers on larger plants.	-Cost effective (direct cost to land manager minimal) -Provides control for many years	-Development of biocontrol agents takes much time, labor, and capital investment -Agents very host-specific and will not eradicate their hosts -Efficacy inhibited by environment and climactic/cultural conditions
Chaining	Two crawlers pull an anchor chain across site, woody vegetation uprooted.	-Rapidly uproots large diameter plants -40 acres/hour can be achieved with two crawlers and a large chain. Rate depends on terrain, vegetation size, and stand density -Impact to herbaceous vegetation can be minimal	-Plants will lean over rather than be uprooted in moist soil -Not effective on saplings -Anchor chains not readily available -Indiscriminant, damaging or killing desirable species
Dozing	Eliminates top growth and stumps. Requires steel tracked crawler because spines can cause	-Very effective at removing top growth and stumps -Can smooth site and	-Skilled operator needed -Follow up treatment necessary to control

	tire damage.	make it possible for revegetation equipment to operate -Can be done during almost any season, providing proper soil conditions -Can rip to a depth of 1-3 feet, damaging roots -Other undesirable vegetation can be removed simultaneously	root sprouts -Cut pieces must be disposed of properly to prevent rooting and resprouting -Leaves bare soil prone to invasion and erosion -Can be indiscriminant, damaging or killing desirable species -Soil compaction, profile disturbance complicate site reclamation

The chemical control section deserves some expansion because each chemical is applied differently. A separate table will elaborate on this:

(Table 9.2. Chemical Control Table)

Chemical	Application Area	Application Method
12,4-D ester	Foliage	Spray
2,4-D + Triclopyr	Foliage or basal bark	Foliar or directed spray
Tricyclopyr	Basal bark	Directed spray
Imazapyr	Frill cuts	Undiluted
Glyphosate	Frill cuts	Hacked with a chemical coated hatchet

9.3 Combination treatments


Figure 9.1. Dozing a Russian-Olive Site [1]

By far, the most effective way to eliminate Russian-Olive is to combine a number of the treatments listed above. The most successful combinations will include methods that help to eradicate all aspects of the plants: top growth, well-established and old plants, saplings, re-sprouting and rooting of severed vegetation, and root growth. When the contradiction of Russian-Olive has been resolved, these combination methods will be very useful in reversing the damage that Russian-Olive has already caused. Efforts to control the trees before people stop planting them will be futile in the long run, because the plant will just spread over and over again.

9.4 The Future: Preventative Control

Currently, Russian-Olive control relies on sites that have already been infested with the plant. Many methods have been developed to control the plant's growth and spread, but hardly any methods of control address prevention of Russian-Olive infestation. If a strong enough correlation could be drawn between Carman and Brotherson's indicators, and sites being infested with Russian-Olive, there may be a way to prevent infestation of Russian-Olive in the first place. For example, Russian-Olive tends not to grow in areas rich in phosphorous. Is there a way to add enough phosphorous to a site that is vulnerable to Russian-Olive to both deter the plant from growing and avoid disruption of current plant life? Or, is there a combination of "buffer plants" that can be introduced to a site that will deter Russian-Olive from infesting? Essentially, if there was a way to modify an environment that is prone to infestation just enough to deter or retard an invasive exotic plant from infesting, then prevention could be used, instead of trying to rid an area of well established plants.

The problem with this theory lies in the need to classify each site individually, to see what the best combination of natural Russian-Olive deterrents would be. But, if a standard procedure could be developed to efficiently analyze and treat a site deemed to be in danger of Russian-Olive infestation, the results could be extremely helpful in the control of Russian-Olive. Also, if a site were already infested with Russian-Olive, and various control measures were invoked to reduce the population, could this idea be applied to the site afterward to slow the plant from re-establishing itself? This seems analogous to the idea of using an unfriendly solvent to precipitate a salt in chemistry: the salt is precipitated out of the solution, but the unfriendly solvent does little else to change the composition or characteristics of the remaining solution.

10. POSITIVE ATTRIBUTES

Though the preceding portions of this paper have clearly outlined this species as a threat to the ecosystem, it must be said that Russian-Olive does not have an entirely negative impact. One of the reasons the plant has escaped is because it is planted so often, and it is only prevalent in the gardening world because of its many fruitful uses. Though the positive attributes may be outnumbered by the negative attributes, they are numerous enough to require some elaboration. This section is meant as a summary of the motivation gardeners and landscapers have for planting it so often all over the country.

The primary reason Russian-Olive has become naturalized is that it has been planted for decades as a beautiful, extremely resistant plant. In some minds, the resistance of Russian-Olive can be viewed as a negative quality. However, in other minds, a tree that is resistant to bugs, disease, bad soil conditions, and various extreme climates is generally considered to be a positive aspect of the species. As well as looking good in the backyard, the fruit is edible and nutritional for several species of animals. This will attract a variety of different animals to the backyard, which is a common desire among gardeners and landscapers. Furthermore, due to its many-sectioned trunk, the tree also provides a good home for birds and other small animals. Erosion control can be an extremely important quality in the arid environments of the west, and Russian-Olive is often planted because it prevents erosion so well. In cooler climates, Russian-Olive can be planted as a windbreak, or to prevent roving snowdrifts from building up in undesired places. From this, it can be concluded that this species became so widespread in the first place because of its positive qualities.

11. CONCLUSION

The goal of this paper has been to present the impact Russian-Olive has had on the United States since its introduction more than a hundred years ago. Though the major focus is to control the damage caused by the out-of-control spreading of the trees, the positive aspects of the tree must also be kept in mind. Many different aspects of Russian-Olive have been provided in the report to give a wide scope of information: Physical characteristics, where and how it has become established, how to control it, and its useful properties have all been discussed to give an impression to the reader that while there are reasons to have Russian-Olive, in most cases, the overall disadvantage to the environment outweighs the few advantages to the gardener, landscaper or anyone else.

Invasive exotic plants have been in this country for a very long time, and their influence on the environment is just now being explored and documented. Currently, only a relatively small number of people are aware of the potential ecological danger these plants and trees present. Add that to the lack of concise and easily available literature about how dangerous these species are and a very big problem presents itself. The solution to understanding the potential impact of exotic plants on native ecosystems is to compile and streamline the information that is available, in hopes of stimulating more interest (and therefore more control and prevention) in not only Russian-Olive, but the innumerable other exotics that have entered into the United States over the years.

The contradictions that Russian-Olive brings up must be resolved. If a simple Internet search can reveal that the entire country is in a state of confusion about how

Russian-Olive should be classified, the issue is serious. Two directly opposing viewpoints on Russian-Olive should not co-exist so easily. To resolve this, the people conducting research and setting policy on Russian-Olive must inform the consumers that this species is much more than a just a nice accent to the garden. The idea of two websites showing up consecutively in a Google search, one advertising the plant for sale, and the other describing its invasive properties is quite perplexing. These two views should be reviewed and perhaps consolidated and hopefully resolved before any truly useful measures for control are initiated.

Once people are aware of these risks, the trees are still going to be present and spreading, so the issue of control must be addressed. There are currently many methods by which Russian-Olive can be controlled, but they all focus on treating the trees after they have started to grow. If a protocol for examining an area deemed to be at risk for invasion of Russian-Olive could be developed to try to hinder or prevent the plant from invading, destroying the original habitat could be avoided. Though this method may currently be impractical, the theory of preventative management is a useful one that goes beyond physical control.

Efforts to inform the general public of all aspects of Russian-Olive is a form of preventative management. A recipe consisting of providing a lot information to the public, a proactive plan to reverse damage that has already occurred, and a fair amount of development of preventative practices will be a great start to eradicating Russian-Olive as a threat to the ecosystems of the United States. Perhaps once the public is informed, and action has been taken to control the spread, a method for planting Russian-Olive and keeping it isolated to an area may be developed. This species is beautiful and useful, but until it can be controlled and the damage it has caused can be reversed, it must be kept on the invasive exotic species list, and under close watch by informed consumers and researchers.

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