Eco-Buffers: A High Density Agroforestry Design Using Native Species

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Abstract: This study showed that Eco-Buffers are characterized by rapid establishment and superior survival when compared to single species buffers. Height of green ash (*Fraxinus pennsylvanica* Marsh. var. subintegerrima (Vahl.) Fern.) after eight growing seasons averaged 415 cm when growing in an Eco-Buffer compared to 333cm in the single species buffer. Site capture in the Eco-Buffer was 100 percent after eight years whereas the single species buffer had heavy herbaceous weed understory. In eight years plant density increased from 5000 to 35,000 plants/ha plants in the Eco-Buffer compared to a decline from 3500 to 3250 plants/ha with the single species design. This was due in large part to the development of rhizome shoots with pin cherry (*Prunus pensylvanica* L.), choke cherry (*Prunus virginiana* var. *melanocarpa* (A. Nels.) Sarg.) and Wood's rose (*Rosa woodsii* Lindl.). The study showed that Eco-buffers establish more quickly and out-compete herbaceous competition resulting in superior growth compared to single species shelterbelts.

Keywords: buffer, design, shelterbelt, establishment, hedgerow

Introduction

The predominance of large-scale agriculture and the introduction of precision farming technology have led to increased field size and a noticeable reduction in marginal habitats within, and adjacent to, agricultural fields. This has occurred mainly at the expense of naturally occurring hedgerows, woodlots, and wetlands. In some regions, where conservation tillage has reduced the threat of wind erosion, there has been removal of planted shelterbelts with the objective of increasing field size to facilitate the use of large equipment. An impact of the implementation of these production system changes is that the role of shelterbelts and hedgerows in agricultural may need to be re-defined from solely wind erosion protection to multi-purpose functions such as carbon sequestration, land and water protection, and biodiversity enhancement.

Woody hedgerows and small wooded areas present important refuge for native flora and fauna. In Canada, three types of woody field boundaries can be found: 1) planted shelterbelts, normally consisting of a single row of one species, primarily planted for wind erosion control; 2) natural woody hedgerows such as those remaining from larger cleared woodlands and left to grow naturally between agricultural fields; and 3) herbaceous fencerows with few trees and scattered shrubs. In the Canadian prairies, over 160,000 hectares of shelterbelts, predominately caragana (*Caragana arborescens* Lam.) and green ash (*Fraxinus pennsylvancia* Marsh. var. subintegerrima (Vahl.) Fern.), have been planted since the early 1900s (Schroeder and others 2008).

Eco-Buffers

The Agroforestry Development Centre (Saskatchewan, Canada) has been conducting research to develop alternative tree planting designs particularly for field boundary planting with the purpose of enhancing biodiversity, conserving soil, protecting water quality, and sequestering carbon. Multi-species, row shelterbelts have been used in the United States (Baer 1986) and Europe (Schroeder and Kort 1989) with success. These initiatives primarily concentrate on planting narrow, dense shelterbelts that establish quickly and reduce the need for long-term weed control. Considering the advantages of mixed-species shelterbelt designs used in other regions, our goal was to develop a design that resembles natural hedgerows, establishes quickly, and develops into a biologically diverse buffer. The field boundary design being researched by AAFC-AESB (Agriculture and Agri-Food Canada, Agri-Environment Services Branch) has been given the descriptive name Eco-Buffer. Eco-Buffers are multiple rows of a variety of trees and shrubs in a mixed-planting arrangement. This design can be applied where a traditional shelterbelt would be planted or a natural hedgerow may have existed. Eco-Buffers can also be used to supplement or rehabilitate existing natural hedgerows or to connect natural habitats. In addition to their ecological function of wind erosion control, microclimate modification, pollination services, wildlife habitat, and carbon sequestration, Eco-Buffers provide a source of wood and non- timber forest products (e.g. fruit and mushrooms).

Eco-Buffers consist of a variety of species with variable characteristics such as thorns, spreading rhizome shoots, fast and slow growth, and varying flowering periods. Three types of woody plants are used in the design: 1) long-lived, climax-species trees every sixth plant in middle rows, e.g. ash, spruce, pine, oak; 2) fast growing, short-lived trees planted in middles rows, e.g. poplar, maple, mountain ash; 3) tall shrubs planted in middle rows with spreading rhizomes to quickly capture the site, e.g. cherry, hawthorn, elder; and 4) small and medium shrubs planted in outside rows consisting of flowering species for pollination, e.g. rose, snowberry, potentilla. The Eco-Buffer includes a minimum of four to five shrub species and every sixth plant is a long-lived tree. A range of native tree and shrub species can be used in Eco-Buffers. Species choice depends on what trees and shrubs grow naturally in the area where the Eco-Buffer will be established.

Our study objectives were to compare growth and development of tree and shrub species planted in an Eco-Buffer with those planted in a traditional shelterbelt design and to develop guidelines for species composition and arrangement in an Eco-Buffer design. Our goal is to develop a tree/shrub buffer design that increases ecological function of planted shelterbelts and hedgerows.

Methods

The study was planted at the Agriculture and Agri-Food Canada Experimental Farm near Indian Head, Saskatchewan. The two study treatments were: 1) Eco-buffer design, and 2) traditional multi-row shelterbelt design. The five-row Eco-Buffer treatment included Wood's rose (*Rosa woodsii* Lindl.), red-osier dogwood (Cornus stolonifera Michx.), green ash, round-leaf hawthorn (*Crataegus rotundifolia* Moench), choke cherry (Prunus virginiana var. melanocarpa (A. Nels.) Sarg.), pin cherry (*Prunus pensylvanica* L.), aspen (*Populus tremuloides* Michx.), and box elder (*Acer negundo* L.). The traditional design included caragana, green ash, and white spruce (*Picea glauca* (Moench.) Voss.). The species used in the study are described in Table 1 and species arrangement for the Eco-Buffer and traditional designs are illustrated in Tables 2 and 3. In-row spacing for trees and shrubs in both treatments was 1 m (3.2 feet) with between-row spacing of 3 m (9.8 feet). Each treatment plot was 36 m (118 feet) in length. The study was arranged in a randomized complete block design with four replications.

Trees were machine planted in early June, 2004. All deciduous trees and shrubs were dormant 2-0 bare root seedlings, white spruce were 2-3 bareroot seedlings. Prior to planting, a pre-emergent herbicide mixture (trifluralin + metribuzin) was applied to the site. Weeds were controlled in year one with two tillage operations (July and September). During years two and three, weeds were controlled with one tillage operation (August) and one application of glyphosate using a shrouded sprayer (September). There was no weed control after year three.

After eight growing seasons, 6-m (19.7-feet) wide transect plots were set up across each buffer design treatment plot. Height of all trees and shrubs in the plot were measured and the number of rhizome shoots with a root collar diameter greater than 7 mm (0.28 inch) was

Table 1. List of tree and shrub species used in buffer designs

Genus and Species	Common Name	Category	Eco-Buffer	Traditional
Rosa woodsii	Woods' rose	Small shrub	X	
Cornus stolonifera	Dogwood	Small shrub	X	
Crataegus rotundifolia	Hawthorn	Medium shrub	X	
Caragana arborescens	Caragana	Medium shrub		X
Prunus virginiana	Choke cherry	Medium shrub	X	
Prunus pensylvanica	Pin cherry	Tall shrub	X	
Populus tremuloides	Aspen	Short-lived tree	X	
Fraxinus pennsylvanica	Green ash	Long-lived tree		X
Acer negundo	Box-elder	Long-lived tree	X	
Picea glauca	White spruce	Long-lived tree		X

Table 2. Species arrangement in the Eco-Buffer design.

Row 1	Row 2	Row 3	Row 4	Row 5
Woods' rose	Pin cherry	Aspen	Pin cherry	Woods' rose
Woods' rose	Green ash	Choke cherry	Green ash	Woods' rose
Woods' rose	Hawthorn	Aspen	Hawthorn	Woods' rose
Dogwood	Aspen	Pin cherry	Aspen	Dogwood
Green ash	Choke cherry	Green ash	Choke cherry	Green ash
Dogwood	Aspen	Choke cherry	Aspen	Dogwood
Woods' rose	Pin cherry	Aspen	Pin cherry	Woods' rose
Woods' rose	Box-elder	Choke cherry	Box-elder	Woods' rose
Woods' rose	Choke cherry	Aspen	Choke cherry	Woods' rose
Dogwood	Aspen	Pin cherry	Aspen	Dogwood
Green ash	Pin cherry	Box-elder	Pin cherry	Green ash

Table 3. Species arrangement in the traditional buffer design.

Row 1	Row 2	Row 3	Row 4	Row 5
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana
Caragana	Green ash	White Spruce	Green ash	Caragana

counted. In addition, ten green ash trees were measured in each treatment plot. Identity and percent cover of herbaceous species within a 1 m^2 (10.8 ft^2) area in each treatment plot were determined in early August of the eight growing season by clipping above ground vegetation, separating according to species, then drying at 70oC for 72 hours to get dry weight of the plants.

Differences between height of green ash in the two designs were subjected to analysis of variance (GLM) with MINITAB® statistical software program (Release 14, Minitab, State College, Pennsylvania). Tukey's method was used to compare means (Chew 1976).

Results

Wood's rose, choke cherry, and pin cherry showed strong development of multiple rhizome shoots in the Eco-Buffers (Table 4). There was no development of rhizome shoots for species used in the traditional design. Development of rhizome shoots in the Eco-Buffer resulted in a dense woody plant community in the understory and completely captured the buffer floor.

Tree and shrub height varied by species (Table 4). The tallest trees in the Eco-Buffer treatment were green ash followed by aspen. Green ash, which was common to both treatments, was significantly ($P=0.01$) taller in the Eco-Buffer treatment when compared with ash trees in the traditional design (Table 4).

Weed populations were significantly greater in the traditional design ($P=0.001$) than in the Eco-Buffer (Table 5). Weeds were predominantly perennial species, with brome grass making up over 50 percent of the herbaceous weed community. The principle factor influencing the structure of undergrowth is light. The open nature of the traditional design canopy allowed more light to penetrate the understory, consequently herbaceous weedy vegetation easily became dominant. The dense stratum of the Eco-Buffer design virtually eliminated opportunity for weed growth.

The main difference between the traditional design and the Eco-Buffer design was site capture and woody plant density (Table 6). This is due to extensive spreading of rhizome shoots by shrubs in the Eco-Buffer designs. After eight years, the Eco-Buffer design averaged 35,000 plants per hectare of buffer, an increase of 30,000 plants per hectare from the time of planting. On the other hand, the traditional design averaged 3250 plants per hectare, a decrease of 250 plants per hectare. The high density of plants in the Eco-Buffer did not affect growth or survival of the individual species.

Table 4. Growth characteristics of trees and shrubs in each buffer design (NP = not planted).

Species	Design Treatment			
	Eco-Buffer		Traditional	
	Height (cm)	Rhizome Shoots (no.)	Height (cm)	Rhizome Shoots (no.)
Woods' rose	136	98	NP	
Dogwood	167	0	NP	
Round-leaf hawthorn	309	0	NP	
Caragana	NP		243	0
Choke cherry	258	50	NP	
Pin cherry	305	116	NP	
Aspen	367	4	NP	
Green ash	415a	0	333b	0
Box-elder	336	0	NP	
White spruce	NP		130	0

Table 5. Herbaceous groundcover in design treatments.

Herbaceous Groundcover	Buffer Treatment	
	Eco-Buffer	Traditional
Total dry weight (g/m^2)	2.7a	550.5b
Brome grass (%)		57.1
Canada thistle (%)		26.6
Perennial sow thistle (%)		16.3

Table 6. Plant density in buffer designs.

Design Treatment	2004 -Trees/Shrubs planted (stems/ha)	2011 - Trees/ Shrubs present (stems/ha)
Eco-Buffer	5000	35000
Traditional	3500	3250

Summary

Eco-Buffers are structurally more complex than traditional, multirow shelterbelt designs (Figure 1). These buffers provide superior habitat for birds, mammals, and pollinating insects. Spreading rhizome shoots of some species resulted in quick site capture in Eco-Buffers compared to a traditional buffer design, thereby eliminating the need for long-term weed control. Furthermore, the traditional shelterbelt design had a weed higher density than Eco-Buffers resulting in reduced tree growth.

Figure 1. Eco-Buffers, consisting of long-lived and short-lived trees along with small, medium and tall shrubs are structurally complex compared to traditional, multi-row shelterbelt designs.

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