Agriculture and Agri-Food Canada
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HYBRID POPLARS IN RIPARIAN AREAS:

Improving Agricultural Environments While Producing Wood

Canada

Introduction

Riparian ecosystems link terrestrial and aquatic environments. Although the area covered by riparian ecosystems is relatively small, they perform important natural functions; therefore, it is important to preserve and protect them. When a riparian area has been impacted by agriculture or land use change, the planting of hybrid poplars to create a riparian buffer can help restore ecological functions and provide potential revenue through the production of wood.

This fact sheet explains the benefits of riparian buffers in agricultural areas. It describes a riparian management model developed in southern Quebec. The riparian buffer system is 5 to 6 m wide and combines hybrid poplars and other deciduous species such as silver maple with natural herbaceous vegetation or shrubs. This combination of species can also be used in other agricultural areas in eastern Canada. The following aspects of the model are discussed:

- role of fast-growing tree species in riparian habitats;
- importance of the herb layer; and
- establishment, maintenance and management of hybrid poplar riparian buffer systems.

Finally, options are discussed to provide an overview of the multiple opportunities that exist with respect to riparian development in agricultural areas.

Role of Riparian Buffers in Agricultural Areas

Controlling non-point source pollution and reducing erosion

Non-point source pollution is water pollution affecting a water body from diffuse sources, rather than a point source which discharges to a water body at a single location. Pollutants are carried to aquatic environments indirectly, through the soil, by the hydraulic forces of precipitation and irrigation. Non-point source pollution from farming is mainly composed of nutrients (nitrogen [N] and phosphorus [P]), pesticides, suspended particles and pathogens (bacteria and viruses). The following are the main sources:

- application of pesticides and inorganic fertilizers;
- application of livestock manure;
- presence of pastures near watercourses (animal manure and disturbance of stream banks where there are no fences); and
- erosion of stream banks and cultivated land.

Non-point source pollution is accompanied by physical, chemical and bacteriological deterioration in water quality, which promotes eutrophication in aquatic environments and can lead to blue-green algae blooms. In many farming areas, riparian buffers are the last line of defence against non-point source pollution. They make it possible to restore the following ecological and biogeochemical functions:

- sequestration of N and P in the biomass;
- degradation of certain pesticides;
- establishment of an environment conducive to bacterial denitrification;
- infiltration of surface runoff;
- immobilization of sediments; and
- stabilization of stream banks and deep soil.

In spring and fall, only small amounts of nutrients accumulate in the plant biomass of riparian buffers. However, the waterlogged soil, rich in organic matter, is conducive to bacterial denitrification.

Creation of a microclimate

Tree and shrub species in riparian areas create shade, which decreases water temperature and increases levels of dissolved oxygen. Shade also reduces algal growth and the presence of certain invasive species, such as the common reed grass (Phragmites communis). In addition to providing shade for livestock during heat waves, treed riparian buffers make effective windbreaks that can reduce drought and improve crop yields in adjacent fields.

Riparian buffer created by hybrid poplars (at 5 years)

Shade created by hybrid poplars (at 4 years)

Habitats for vegetation and wildlife

Since they connect land and water and create specific microclimates, riparian areas provide crucial habitat for terrestrial and aquatic biodiversity. In Quebec, research has shown that riparian environments harbour 271 vertebrate species, 30 species of mammals, 50% of the bird species and 75% of the amphibian and reptile species (Goupil 1998). Furthermore, approximately one half of the 375 vulnerable or threatened plant species depend on wetlands or riparian areas. Finally, riparian ecosystems make it possible to protect the quality of aquatic environments. In Quebec, there are approximately 190 fish species, of which 112 are freshwater species (MDDEP 2007).

> Subsurface drainage may reduce the ability of riparian buffers to intercept non-point source pollutants. In combination with restoring vegetation along stream banks, a filtering marsh could be established into which drainage would flow.

These two photos were taken on the same day on the same watercourse. Above: aquatic environment protected by a riparian buffer of hybrid poplars (fish are present). Below: aquatic environment upstream of the riparian buffer (dominated by algae).

Influencing the hydrological cycle

By increasing the infiltration of surface runoff, reducing floodwater velocity and having a high rate of evapotranspiration, riparian vegetation may potentially reduce flooding and peak flows.

Landscape and recreation tourism

Riparian agroforestry systems generate numerous ecological benefits for Canadians. Treed riparian buffers especially enhance the appearance of landscapes and provide valuable wildlife habitat. Each year in Quebec, approximately 800 thousand people enjoy angling and 1.2 million participate in nature study trips or outings (i.e. photography, hiking, etc.) (MRNF 2004). Riparian environments are ideal locations for relaxing, and they enhance other activities, such as canoeing and hiking. The entire community benefits from these developments.

Modification of the agricultural landscape using a hybrid poplar riparian buffer after 4 years (above) and 5 years (below)

A Riparian Development Model Using Hybrid Poplars

The riparian buffer model presented here consists of three rows of hybrid poplars and one row of silver maple that protect the stream bank directly. Implemented in 2003 at seven sites (grain corn, soybean and pasture) in southern Quebec, the model was developed by research scientists Benoît Truax (ETFRT) and Daniel Gagnon (UQAM).

Approximately 5 to 6 m wide, this type of riparian buffer can be used on both small streams and drainage ditches. The narrow width allows enough light to penetrate for a dense shrub or herb layer to develop naturally beneath the canopy. Over time, the riparian system will evolve providing a diverse mix of plant species; therefore, it is not necessary to plant shrubs or herbaceous plants, unless berry producing shrubs are desired. Only trees need to be planted, which reduces the cost of creating the riparian buffer.

Why fast growing trees in riparian areas?

The use of fast growing, flood-tolerant species, such as poplar, willow and silver maple, make it possible to optimize a number of ecological functions at the same time. Hybrid poplars are especially productive in riparian zones of farming areas and are considered to be the fastest-growing commercial species in eastern Canada. The unique physiology of poplars provides the following benefits:

- Rapid biomass accumulation of nutrients (N and P) from various soil depths;
- Efficient soil water uptake - up to 100 L/day for a five-year-old tree (Stomp et al. 1994);
- Stabilization of surface and sub-surface soil (reduces surface run-off and watercourse siltation); roots can reach depths of over 3 m after 4 years (Heilmann et al. 1994);
- Spreading fine root system supports microbial communities that can break down certain pesticides and denitrify nitrogen;
- High production of litter, the main food source for a number of aquatic organisms;
- Carbon sequestration (potential to sell carbon credits);
- Rapid improvement of landscape; and
- Creation of a microclimate that reduces water temperature and light intensity.

Above, the planting of a riparian buffer in 2003 along a stream through a pasture; below, the same riparian buffer in 2007 (fifth year of growth)

To maintain the long-term effectiveness of a poplar riparian buffer as an N and P sink, it is essential that partial harvesting of hybrid poplars and any other woody species be performed regularly. In this way, harvesting hybrid poplars after only 5 to 10 years can provide a source of biomass for energy production, while 15 to 20 years are required to produce lumber.

Importance of the herbaceous layer

While trees are important in riparian buffers, herbaceous vegetation also has a significant role. Due to the dense cover it provides, herbaceous cover slows down surface runoff containing sediments and dissolved nutrients. This promotes the infiltration of the runoff and the redistribution of nutrients in deeper layers of the soil. The nutrients can then be absorbed by trees with deeper root systems than most shrubs or herbaceous species. The growth of the herbaceous cover beneath the trees must be promoted to establish a riparian buffer system that is effective in reducing non-point source pollution.

Beneath the poplar canopy, dense and diverse vegetation develops naturally.

Establishing and Maintaining Riparian Systems

Getting started

Non-point source pollution involves more than just excess fertilizer, pesticides and sediment entering large watercourses. A significant portion originates from small watercourses, i.e., small natural or artificial streams, as well as drainage ditches, that receive significant amounts of agricultural inputs.

If a restoration plan for riparian areas is to be implemented across an entire watershed, riparian buffers are best initially developed along small streams and drainage ditches at the head of the watershed. If implementation is on a farm scale, the same strategy could be used, progressing from small streams and ditches to larger ones.

Prioritizing the restoration of small streams and ditches

Selecting poplar clones (cultivars)

In Quebec, most hybrid poplar species were created by controlled crosses involving the following species: *Populus deltoides* (D), *P. nigra* (N), *P. maximowiczii* (M), *P. balsamifera* (B) and *P. trichocarpa* (T) (MRNF 2001). In addition, a number of other clones originating from these same parental species were imported from Europe.

At agricultural sites in Montérégie and Estrie, it was observed that hybrids of certain species produced a very significant volume (D X N; T X D; N X M; M X B and DN X M). After five years of growth, the hybrid poplar clones were on average10.6 m tall with a dbh of 14.2 cm in the riparian buffer established on a rich pasture (average of the following five clones: 3570, 3230, 3729, 915311 and 915508). On a site characterized as a poor pasture, the height dropped to 5.6 m and the dbh to 5.1 cm. The D X N and T X D hybrids were especially productive in rich riparian areas with moderate climate, as shown by their significant biomass production.

In colder regions or poor sites, the hybrids used should be from the parent species *P. maximowiczii* (M) and *P. balsamifera* (B). Those two species are more resistant to cold and can better tolerate poor soil.

For more information on selecting hybrid poplar clones, please contact the Eastern Townships Forest Research Trust (ETFRT).

Clone 3570 (D X N) planted in fallow land (8 years).

Leaders of three poplar clones. L to R: 915311 (M X B), 3570 (D X N) and 3230 (T X D).

Buffer width

The ETFRT-UQAM model is approximately 5 to 6 m wide, with three rows of poplars spaced 1.5 m apart, plus one row of silver maple or willow on the stream bank. The buffer should be wider in more sensitive areas (junction of an intermittent stream, steep slope, fragile soil, intensive cultivation, etc.), either by adding more rows of trees, or by widening the area colonized by indigenous vegetation.

The dotted line indicates the area in which it would be preferable to widen the riparian buffer to better control the discharge of the intermittent stream.

> It is important to **choose unrelated clone mixtures rather than a single clone. That will make the riparian buffer less vulnerable to diseases and insects.** As well, the structure of the riparian buffer will be varied, since each clone has a different crown form. Another option that is less productive, but perhaps more ecologically interesting, is to use indigenous poplar species grown at a local nursery.

Establishing a riparian buffer

To improve the establishment of seedlings, competing vegetation should be controlled. At the end of the summer before the seedlings are planted, or early during the first growing season, a non-selective herbicide (e.g., glyphosate) can be applied to control existing vegetation. If competing vegetation is controlled in the year the seedlings are planted, care must be taken not to damage the seedlings. To prevent herbicide drift damage, cardboard tubes can be used to protect the young trees.

Herbicides should not be applied on all existing vegetation. It is better to use a portable sprayer (backpack) to manually spray only those areas in which poplars will be planted (1 m^2 per seedling). The temporary, localized disruption caused by the use of an herbicide will be largely offset by the excellent vegetation cover that results over time. Plastic mulch can be used instead of a herbicide, especially in locations that are not very stony or steep. However, the cost and labour required for this technique are greater than herbicide aided establishment.

Plant hybrid poplars at least 30 cm deep.

In cases in which the use of herbicides in riparian areas is prohibited, shrub- or tree-form willows can be planted directly on the stream bank. Silver maple can also be used, but it is less tolerant of poor soil and competing vegetation.

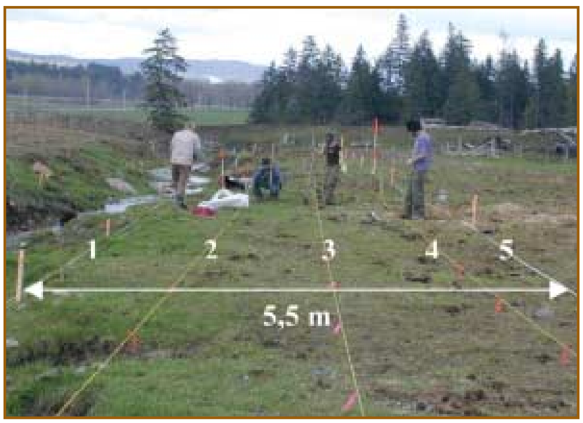
The spring following site preparation, the rooted cuttings and seedlings can be planted. Generally, the best time to plant trees is in early May, once there is no longer a risk of frost. Hybrid poplars are usually delivered as bare-root rooted cuttings approximately 1.5 to 2 m tall. To ensure good establishment the trees should be planted with a shovel, at least 30 cm deep.

In the ETFRT-UQAM model, hybrid poplars were planted 3 m apart along the rows, in three rows spaced 1.5 m apart. However, greater spacing could be used to allow more light to penetrate the canopy. That would stimulate growth of the herb layer in addition to reducing the cost of purchasing and planting the seedlings. Care must be taken to control competing vegetation according to the spacing pattern used. For riparian buffers in pastures, a fence will prevent grazing by livestock. To completely prevent livestock problems, position the fence at least 1 m from the trees and use an electric fence, if possible.

Maintaining the system

At the end of the first growing season, the plantation should be inspected. If any trees have died, they should be replaced. However, this should be done quickly, in the first year following establishment.

During the second growing season, in June or July, trees with major defects (forking, breakage, grazing, etc.) can be pruned to maintain dominant leaders. From the third growing season until the end of the cutting cycle, lateral branches can be pruned. The poplars will have greater commercial value (peeling and sawing quality) following pruning, which furthermore will allow more light to enter through the canopy. Ideally, pruning should be done by hand with pruning shears in June so that the trees have time to heal. After pruning each tree, the blades of the shears should be dipped in alcohol to prevent the transmission of pathogens. It is best to prune small amounts, but to prune often during the rotation (every two years). Pruning is not always needed and it depends on the goals of the landowner.



Establishment of a riparian buffer in a pasture. The lines correspond to the silver maples or willows (1), the hybrid poplars (2, 3 and 4) and the fence (5).

If there are beavers in the watercourse along which the riparian buffer is established, the basal portions of the trees should be clad in wire mesh, since beavers like the tender wood of poplar trees.

Harvesting poplars in riparian buffers

To maintain the multiple ecological functions of the riparian buffer, a partial but regular harvest of the poplars must be carried out. Depending on the richness of the site, a certain portion of the trees (less than 50%) can be harvested after 5 to 10 years for biomass power. The best specimens can be kept and harvested after 15 to 20 years. Higher quality trees can yield logs for peeling or sawing - pallets, laminated veneer lumber (LVL) - as well as torrefied wood (mouldings, furniture, outdoor applications). Trees of lesser quality can be used in the oriented strand board (OSB) industry and the pulp and paper industry.

Trees should be harvested between late August and late September, to maximize the removal of nutrients from the agricultural site. At that time of year, poplars have stopped growing, but have not yet lost their leaves, which are rich in nutrients. Harvesting the trees with their leaves maximizes the amount of nutrients removed from the site. Harvesting should also be planned so that the residual cover provides sufficient shade over the watercourse after the trees have been cut.

Two options are possible after the harvest. New hybrid poplars can be planted, or the stumps can simply be left to develop shoots. In the latter case, the shoots must be thinned out so only the dominant stem is retained. Various species of trees will colonize the riparian buffer: eastern white pine, ash, oak, willow, maple, etc. However, it may be beneficial to enhance their establishment by planting them in combination with the hybrid poplars after the first cutting cycle.

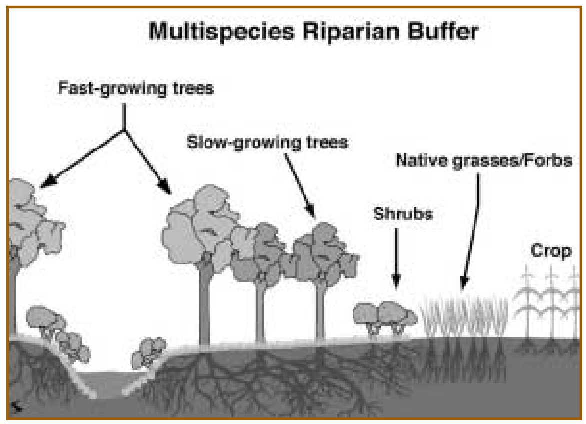


Figure 1: Multi-species riparian buffer combining tree, shrub and herbaceous layers (Schultz et al., 2004)

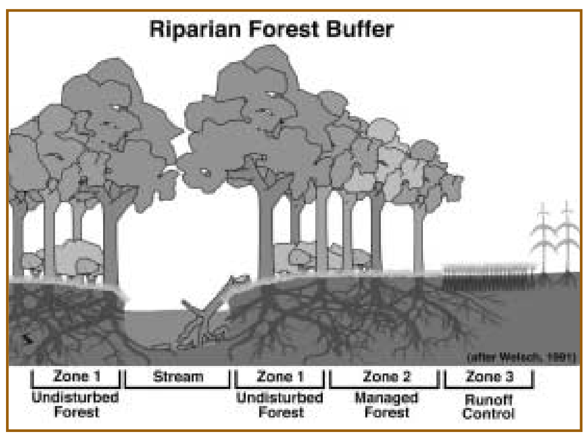


Figure 2: Riparian forest buffer combining (1) a non-harvested forest zone, (2) a managed forest zone and (3) a herbaceous zone (Schultz et al. 2004)

Alternatives to Hybrid Poplar Riparian Buffers

The ETFRT-UQAM model can be modified and made more complex as desired. For example, we planted a row of silver maple directly on the stream bank because of their extensive root system. Shrub- or tree-form willows could also be used. In poor soils, alder could also be used.

If only native trees are desired in the riparian buffer, the hybrid poplars can be completely replaced by other fast-growing trees, such as eastern cottonwoods, balsam poplars and willows. Some landowners may prefer to diversify their riparian buffer using hardwoods. In that case, they can plant hybrid poplars to create a forest cover, and then plant hardwoods (e.g., oak, ash or walnut) underneath, a few years later. For example, hardwoods could be planted after the first harvest of the poplar stand (5 to 10 years), according to the model developed by Truax et al. (2000). Other landowners may wish to foster terrestrial biodiversity with a 3 zone, multi-species riparian buffer (Figure 1): (1) slow- and fast-growing trees; (2) shrubs; and (3) herbaceous vegetation (grass and forbs). That arrangement makes it possible to maximize the structural diversity of the terrestrial habitat in addition to lowering the water temperature significantly.

In agricultural landscapes that were formerly forests, which is the case throughout Quebec, riparian buffers could be created that preserve the ecological integrity of watercourses as much as possible. It would be appropriate for those riparian forest buffers to have three zones (Figure 2): (1) non-harvested forest, (2) managed forest; and (3) herbaceous vegetation to control runoff.

In this three-zone system, zone 1 (non-harvested forest) provides permanent forest cover (trees or shrubs) along the edges of the watercourse. The cover stabilizes and optimally reduces the water temperature, which benefits species such as salmonid fish. The non-harvested forest zone adds large woody debris to the aquatic environment. Debris is a significant food source for some aquatic species and adds complexity to the aquatic environment. The riparian buffer model presented here could be implemented in this fashion. The row of silver maple (or willows) and the row of hybrid poplars nearest the water would not be harvested, while the other two rows of hybrid poplars would. However, if the landowner wanted to prevent problems with logjams, the trees near the water could be harvested as well.

Conclusion

The implementation of agroforestry systems in riparian area protection strategies makes it possible to combine objectives for improving terrestrial and aquatic habitats, increasing biodiversity, reducing non-point source pollution and producing wood and energy.

In eastern Canada, most farmland was originally forested. By recreating forest cover at the water-land interface, the ecological functions of aquatic and riparian environments can be restored. By using a pioneer species such as poplar, the forest cover develops more rapidly. The riparian buffer therefore quickly becomes an active carbon, nitrogen and phosphorus sink, provided that the trees are harvested regularly.

If the following three principles are applied, the riparian buffer will fulfil a multitude of ecological and biogeochemical functions:

- **plant fast-growing, flood-tolerant trees first;**
- **promote the growth of herbaceous vegetation; and**
- **carry out a partial harvest of the trees at regular intervals.**

The management model presented in this fact sheet can be adapted according to local needs and conditions. It can be modified or used as is, depending on the landowner's economic and environmental objectives and according to the characteristics of the land.

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The authors wish to thank the Quebec Ministère des Ressources naturelles et de la Faune (MRNF) and the Conférence régionale des élus de l'Estrie, who have also provided funding for the research project, which began in 2003, and also the Quebec Ministère de l'Agriculture, des Pêcheries et de l'Alimentation. The authors also express their gratitude to the private owners and farmers who took part in the experimental project of the ETFRT, which was carried out on their properties.

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Aussi offert en français sous le titre :

PEUPLIER HYBRIDE EN ZONE RIVERAINE
Améliorer l'agrœnvironnement tout en produisant du bois

© Her Majesty the Queen in Right of Canada, 2008
Cat. No. A98-4/7-2008E-PDF
ISBN 978-1-100-10841-4
AAFC No.10631E