GELLATLY NUT FARM REGIONAL PARK

TREE INVENTORY AND HERITAGE ORCHARD MANAGEMENT PLAN

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TD Green Streets

RDCO REGIONAL DISTRICT of CENTRAL OKANAGAN

Gellatly Nut Farm Society

REGIONAL DISTRICT OF CENTRAL OKANAGAN

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Executive Summary

The Gellatly Nut Farm Regional Park (GNFRP) represents a valuable and unique legacy created between 1905 and 1969 by D.E. (David) Gellatly and J.U. (Jack) Gellatly, and further maintained by their brother William (Bill) Gellatly from 1969 to 1984. Some of the nut tree specimens are unique in terms of their breeding and pedigree, particularly those located around the heritage home and buildings; these are now of significant age and growing in open parkland conditions. The central core of the site has largely been preserved in its original format with closely spaced trees and hazelnut (*Corylus* spp.*)* shrubs forming tree breeding and selection rows where J. U. Gellatly could prune, flood irrigate, graft and cross pollinate selected specimens in his quest to breed new genetic material for the orchard industry of North America. However, some trees, such as those located along Whitworth Road, have been heavily crown pruned to accommodate high voltage distribution lines and the root zones of trees bordering the GNFRP entrance road have been impacted to accommodate vehicles.

Traces of the flood irrigation ditches are still visible around the heritage home although the site has been re-graded (prior to Regional District of Central Okanagan (RDCO) acquisition), with a modern underground irrigation system, gravel trails, and interpretive signs installed. Additionally turf grass was established to better accommodate the general public and other parkland activities (i.e., weddings, tours and the annual nut harvest).

Subsequent to the RDCO's acquisition of the property in 2002, it was the RDCO and community's intent to establish a high quality regional park which respected both the important cultural heritage landscape and recreational values found on the site. In concert with an approved park development and management plan, the property was modified in 2004/2005 to accommodate required park infrastructure such as the primary park access road, parking lot, trails and irrigation system. It appears that intrusions into tree root systems occurred throughout the orchard property. The combination of overcrowding in the selection/nursery rows and turf grass competition for nutrients and moisture appear to have contributed to increased tree stress despite improvements in fertilization, insect control and the irrigation system. It is important to note that three independent studies commissioned prior to RDCO acquisition identified crown dieback, drought stress and the need for thinning and improved irrigation in the orchard trees (Runka, 1991; Hansen, 1997; Carlson, 2000). These historical findings confirm that the long-term tree health issues evident today at GNFRP are not a result of recent park development/recreational activities. The long-term tree health issues are more indicative of a legacy of site limitations and environmental stresses resulting from a number of factors including but not limited to: competition and overcrowding within the selection rows,

lack of sufficient irrigation prior to 2005, site grading activities to fill in the old flood irrigation ditches (date unknown) and insect infestations prior to RDCO acquisition. Without a doubt managing the site between 1905-1984 was a full time occupation for the Gellatly family, it is therefore understandable that despite the efforts, and of those who immediately followed, their efforts and resources may not have been sufficient to maintain the trees and shrubs in optimum condition, leaving a cumulative legacy of issues for the RDCO to address with increasing competition for limited funds.

Since the GNFRP opened in 2005, RDCO has made significant operational improvements in the orchard to address the tree health concerns by composting, fertilizing, changing the watering regime and minimal pruning, delicately balancing the needs of the orchard trees with the needs of the public to recreate and enjoy this unique landmark regional park.

In recent years significant progress has been made to replicate and conserve the germplasm genetic tree material in both on and offsite locations. Thanks to the efforts and foresight of Carlson *et al.,* 36 varieties of the hazelnut genus and one chestnut (*Castanea* spp.) "Layeroka" have been transferred to the National Germplasm Repository (NGR) at Corvallis, Oregon (Corvallis website accessed October 2012) and 16 hazelnut varieties are growing at the Pacific Agri-Food Research Centre (PAFRC), Agassiz, BC. Further afield, several J.U. Gellatly varieties are located at the Hamilton Royal Botanical Gardens (HRBG) arboretum in Ontario, including a Turkish tree hazel (*Corylus colurna*) with an unusual branching habit and at least three species of hickory: Shagbark (*Carya ovata*), Pignut (*Carya glabra*) and Bitternut (*Carya cordiformis*); these species are no longer represented at GNFRP. Records indicate that Morgan Arboretum near Montreal, QC has mature Japanese heartnut (*J. ailantifolia* var. *cordiformis*)[1] selections and heartnut hybrids (*Juglans* x sp.) originating from J.U. Gellatly (Gordon, 2011). Archived maps and records for the site also indicate that a broader range of genera were being selected and tested for productivity, frost hardiness and nut orchard suitability, including but not limited to soft shell Utah almond (*Prunus dulcis*) and Illinois pecan (*Carya illinoinensis*), Kentucky coffee tree (*Gymnocladus dioicus*) and maidenhair tree (*Ginkgo biloba*) (GNFS archives accessed 2012).

This site has the unique potential to form a genetic reference library of heritage nut tree varieties, hybrids and selections. It also has the potential to be a public portal to demonstrate

[1] Accepted synonymic scientific name was formerly *Juglans sieboldiana,* former common names also include Siebold walnut (USDA Germplasm Resources Information Network (GRIN) Taxonomy for Plants, accessed 2012). Former synonymic scientific names will continue to be used in the heritage orchard as they are considered period correct and accurately reflect historical records.

the art and science of tree breeding, tree care and sustainable nut harvest practices for both the homeowner and the amateur orchardist. As more of the trees and shrubs are identified it will be possible to create a living museum of nut trees for the public to enjoy with the added value of an opportunity to partake in the annual nut harvest, purchase a tree to plant at home or to establish an orchard containing J.U. Gellatly heritage varieties.

Development of a heritage nut tree arboretum at GNFRP is anticipated to be one of the most cost effective and valuable mechanisms to both conserve the unique genetic germplasm plant material which the Gellatly family have left as a living legacy and enhance visitor experience. Through a combination of preservation measures for veteran specimens and the planting of new trees from the Gellatly collection, a heritage nut tree arboretum will provide visitors with a unique opportunity to learn about the Gellatly tree breeding program, and present the relevance today in the context of sustainable tree cropping, local food security, climate change, and invasive pest and disease.

The inventory and mapping carried out under this contract highlights the layers of complexity associated with managing this site. There are 516 orchard trees and 1,179 hazelnut shrubs representing more than 12 distinct species and more than 50 known cultivars. These trees and shrubs comprise the unique J.U. Gellatly heritage orchard collection and represent a life time of commitment to nut tree breeding where a single cultivar might take 20 years to develop (Hansen, 1997). Additionally, a further 189 ornamental and native parkland trees are managed for multiple objectives within the GNFRP. Considerable effort and resources have been applied to manage this site in a manner which sensitively balances recreational interests with the significant and unique cultural heritage landscape value associated with the Gellatly legacy.

Summary of Key Recommendations

The following key recommendations were identified based on initiatives and activities that are likely to require changes to existing GNFRP operations and maintenance processes or additional resources to implement. More details on these recommendations are contained within Section 4 and throughout this report. Additional recommendations not contained in this table (non-key recommendations) can either be implemented within the existing operations and maintenance program or subsequent to the implementation of key recommendations.

#	Key Recommendations
	Cultural Landscape Value
1	Develop a detailed plan for the establishment of a heritage nut tree arboretum within the existing GNFRP boundary. The planting plan will need to be designed to minimize potential conflict with existing and planned underground services, tree root systems and allelopathic species.
2	Promote the establishment of an arboretum as an added attraction and unique visitor experience.
3	Continue with DNA testing and other methods of investigation to establish the exact pedigree of as many specimens as possible within the J.U. Gellatly collection. Replicate and plant the progeny of identified specimens in the proposed heritage nut tree arboretum.
4	Duplicate and preserve the few remaining original J.U. Gellatly tree tags, present them to the public park users in a secure location/format. Replicate the information they contain and include in archive materials.
5	Adopt a temporary moratorium on removal of live trees (except hazard trees) until the pedigree of each specimen within the J.U. Gellatly collection has been positively identified.
6	Wherever practical preserve the remaining selection/nursery rows intact, as they reflect the unique cultural heritage value and living legacy to J. U. Gellatly's lifetime achievements in nut tree selection and breeding.
7	Archive and catalogue all historical records and data associated with the J.U. Gellatly selection and tree breeding nursery, compile all information into a single database and secure a backup copy at a remote location.
8	Restore the J.U. Gellatly collection to include, where practical, the majority of genera and species that J.U.Gellatly worked with during his life time.
9	As unique and rare J.U. Gellatly specimens are located across the globe and where phyto-sanitary regulations may allow, it is recommended that unusual and unique documented specimens are re-established at GNFRP. (e.g. the Turkish tree hazelnut (*Corylus colurna*) growing at HRBG)
	Genetic Significance and Collections Management
10	Investigate methods to protect the value of the unique Gellatly heritage nut trees through copyright, name branding or similar means, to ensure that the RDCO retain royalties and all appropriate sales commission.
11	Develop a master plan for the long-term conservation of Gellatly genetic germplasm plant material, the master plan should include but not limited to: • On- and off-site genetic germplasm conservation measures • Arboretum role in genetic germplasm conservation • Satellite locations for genetic germplasm conservation (HRBG, NGR, Morgan Arboretum,

#	Key Recommendations
	PAFRC) • Canadian Plant Germplasm System
12	Develop and promote additional niche market products and merchandise associated with the J.U.Gellatly collection. (e.g. heartnut shells can be readily sold to the craft industry)
13	Continue with routine inspection of the J.U. Gellatly heritage nut tree inventory and the ornamental and native parkland trees. Regular updates of the GIS database should be performed to ensure completeness and accuracy of record keeping.
14	It is recommended that the J.U. Gellatly collection be formally recognized as part of a broader heritage nut tree collection and that attempts be made to secure sufficient resources to maintain it in perpetuity.
15	It is recommended that additional J.U. Gellatly genetic germplasm plant material be provided to secure institutions to ensure future supply of the entire collection and not just one genus such as hazelnut (*Corylus* spp.) currently stored at the National Germplasm Repository, Corvallis OR.
	Nursery Practice
16	All walnut genus (*Juglans* spp.) tree debris, including foliage, nut husks, shells and wood chips must be stored separately from other mulch materials and only used to mulch *Juglans* spp.
17	Develop a suppliers list of all known sources of cloned J.U. Gellatly collection plant material, contact the suppliers and establish a memorandum of understanding for sourcing scion material and the sale of J.U. Gellatly plant material.
18	Investigate the potential for local, national and international nursery contract growing and commission sales of the unique J.U. Gellatly heritage nut tree collection.
19	It is recommended to consult the latest research to ensure graft compatibility and thereby provide the new tree with optimum potential to reach a mature age class. DNA testing of existing grafted specimens at GNFRP will provide good benchmark data for selection of rootstock material.
	Operations and Maintenance
20	Provide wooden posts with numbered tree tags affixed at ends of each hazelnut shrub (*Corylus* spp.) row. As individual bushes are positively identified they should be given a uniquely numbered tree tag number within the row and GIS database updated.
21	Remove and replace the horse chestnut tree #440 (*Aesculus hippocastanum*) located in the traffic circle beside the information kiosk. The nuts are toxic and to the untrained eye they can be mistaken for the edible sweet chestnut (*Castanea* spp.).
22	Consult a professional agrologist (P.Ag.) to investigate the potential for use of herbaceous legumes as an alternate ground cover in the root zones of trees and shrubs.
23	It is recommended that a water balance analysis be commissioned to establish site and species specific water demand in relation to variable water consumption during essential crop development cycles. This study will provide the scientific basis for decision making around any proposed reconfiguring of the current irrigation system to optimize long-term tree health.
24	Continue to research, monitor and mitigate tree pests and disease, train RDCO staff in the recognition and prevention of chestnut blight (*Cryphonectria parasitica*), eastern filbert blight (*Anisogramma anomala*) and butternut canker (*Sirococcus clavigignenti-juglandacearum*).
25	Optimize tree friendly infrastructure design concepts throughout the park to benefit trees and protect heritage value of the entire J.U. Gellatly collection.
26	It is recommended that a feasibility study be commissioned to evaluate the use of rainwater storage

#	Key Recommendations
	tanks and grey water recycling at the public washrooms to recycle water used for hand washing for irrigation or to flush the toilets and thereby reduce overall facility water consumption.
27	It is recommended that consideration be given to testing various methods of irrigation as the orchard management plan is implemented, methods should include both landscape and localized irrigation techniques.
28	It is recommended that sections of trail which are encroaching into the critical root zones (CRZ) of high value heritage trees be realigned where practical.
39	It is recommended that turf grass which is growing in the CRZ of trees and shrubs be replaced with either herbaceous legume ground cover or composted bark mulch.
30	Investigate nutrient availability using Plant Root Simulator PRS™ probes and compare bio-available nutrient values with baseline or reference values.
32	Continue to systematically re coppice the hazelnut shrubs rows (*Corylus* spp.) to help rejuvenate them and prevent further crown dieback in older specimens.
33	Plant a beneficial overstorey of compatible tree species amongst the hazelnut shrub rows (*Corylus* spp.) to improve the growing conditions, microclimate and conserve water use.

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1 Introduction

The earliest nut trees appear to have been planted in 1905 by D.E. (David) Gellatly for the purpose of testing them for suitability for growth in Canada. During this same period J.U. (Jack) Gellatly was collecting scion material from nut trees in the United States and sending it home to Westbank[2], British Columbia (BC). In the early 1920s, J.U. Gellatly returned to Westbank to take over the work started by David (Clarke *et al*., 2003). J.U. Gellatly has since created a unique legacy for the Okanagan region and has been described as a *"plant explorer and persistent breeder of hardy productive trees which produce quality nuts"* (Gordon, 2011).

The most desirable progeny of this work would be selected, proven for nut bearing capacity and quality, named (often with the characteristic "-oka" ending to represent the Okanagan) and either shipped as scion material or grafted to compatible rootstock across North America and to Europe. Customers included other nurseries, tree breeders, commercial nut tree orchards or those who had a desire to grow tree crops for personal use. The archived nursery records, daily journals, plus the few remaining original tree tags, and letters held by customers to this-day, bear witness to the great detail that the Gellatly family invested in this nut tree breeding program (Figure 1 and Figure 2).

The Regional District of Central Okanagan (RDCO), in conjunction with the Gellatly Nut Farm Society (GNFS) and residents of the Central Okanagan, acquired the Gellatly Nut Farm as a Regional Park in 2002. In 2003, the *Gellatly Nut Farm Regional Park Concept Plan* and *Gellatly Nut Farm Regional Park Site Development Plan* were prepared, which together provide the vision and guiding principles for the planning, development and maintenance of the GNFRP. These two plans have identified the historical significance, character-defining elements, and heritage and cultural landscape values that define this unique Park.

[2] Westbank is now known as the District of West Kelowna, officially incorporated December 6, 2007

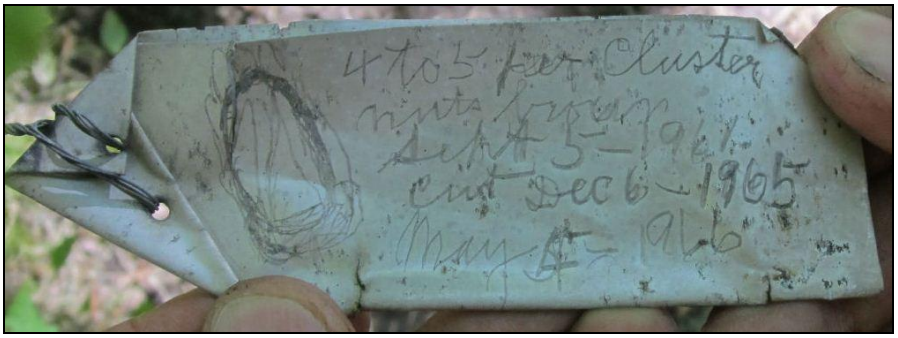
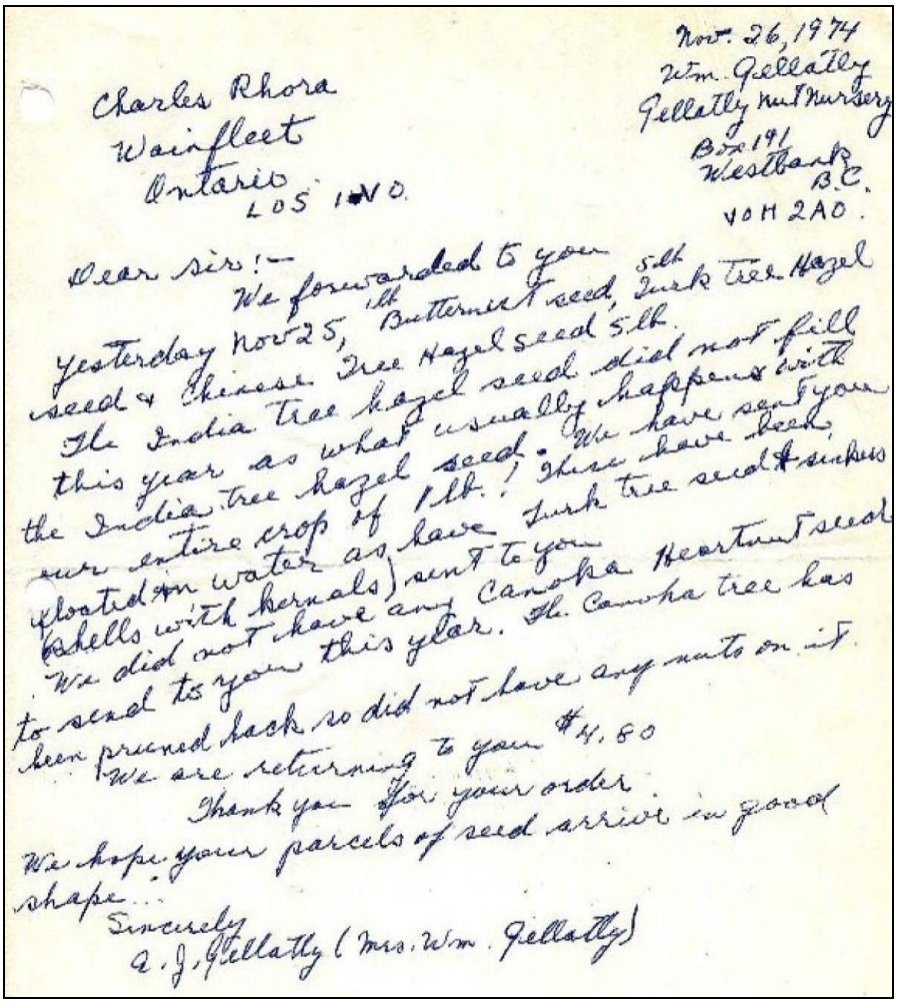


Figure 1. Example of one of the few remaining original tree tags at the Gellatly Nut Tree Farm.



Nov. 26, 1974
Wm. Gellatly
Gellatly Nut Nursery
Box 191
Westbank B.C.
V0H 2A0.

Charles Rhora
Wainfleet
Ontario
L0S 1N0.

Dear Sir!—
We forwarded to you yesterday Nov 25, 1lb Butternut seed, 5lb Turk tree Hazel seed & Chinese Tree Hazel seed 5lb.
The India tree hazel seed did not fill this year as what usually happens with the India tree hazel seed. We have sent you our entire crop of 1lb. These have been floated on water as have Turk tree seed & shells (shells with kernals) sent to you. We did not have any Canoka Heartnut seed to send to you this year. The Canoka tree has been pruned back so did not have any nuts on it.
We are returning to you $4.80
Thank you for your order.
We hope your parcels of seed arrive in good shape.
Sincerely
A. J. Gellatly (Mrs. Wm. Gellatly)

Figure 2. Letter written to Charles Rhora, an expert nut tree breeder in Ontario, from Mrs. W. Gellatly (wife of Bill Gellatly).

In 2004, site development on the GNFRP began and the Park was officially opened to the public in 2005. Since then, many of the trees and hazelnut (*Corylus* spp.) shrubs have been pruned for safety and Park use, and several have been removed to re-space the selection rows. Fertilizer, irrigation and integrated pest management (IPM) programs have been developed and implemented based on the best available information and tree care practices. The combination of these pro-active management programs has helped recover the health of the orchard trees which it appears were largely left to their own devices in the two decades prior to RDCO acquisition. In this context it is understandable that the decline in health and vigour noted by Runka, Welsh, Hansen, Carlson and McKillop in their respective professional reports would take many years of concerted efforts and significant resources to reverse.

In recent years since acquisition, RDCO staff and GNFS members have noticed the distinct decline in tree health with prominent crown dieback in the walnuts (*Juglans* spp.). Concern for the long-term health and integrity of these valuable specimens was a contributing factor in commissioning this report.

1.1 Goals and Objectives

1.1.1 Heritage Orchard Management Plan (HOMP)

The overall purpose of the Heritage Orchard Management Plan (HOMP) is to provide a guiding document that will combine heritage and cultural landscape values, nut tree genetics and historical records, to guide the gradual replication and where necessary the replacement of veteran heritage nut tree species over time. The HOMP also sets out the operational maintenance needs of a heritage selection and tree breeding nursery, which also caters to the needs of a high use regional park.

The first priority for the HOMP is to address the Park's management vision to maintain the horticultural integrity, cultural landscape, health and viability of the tree specimens, gradual nut tree replication, and where necessary replacement of veteran trees. As a second priority, the recreational values and opportunities to engage public interest in the selection, tree breeding nursery and annual nut production cycle will be considered.

Key objectives for each management theme, cultural landscape value, genetic significance and collections management, nursery practice, and operations and maintenance, are provided at the beginning of the relevant section and criteria and performance indicators have been developed to provide benchmarks to help measure successful implementation of the HOMP.

2 Nut Tree Inventory

The last comprehensive tree inventory of the Orchard was completed in 1969 by J.U. Gellatly, prior to his death. Since 1969, several partial inventories were conducted in 1991 (Runka), 1997 (Hansen) and 2000 (Carlson). The purpose of the current nut tree inventory was to build a GIS database of information on the existing heritage nut trees located within GNFRP. The GIS based tree inventory and nut tree assessments will be used in the preparation of the HOMP and to plan the establishment of a heritage nut tree arboretum. The inventory will assist in managing and preserving the historical tree records and the future heritage nut tree arboretum.

2.1 Methodology

The GNFRP is a 4.0 ha property, located at 2375 Whitworth Road, West Kelowna, BC (Lot A, District Lot 497, ODYD, Plan KAP53395).

Figure 3. Gellatly Nut Farm Regional Park Location Map

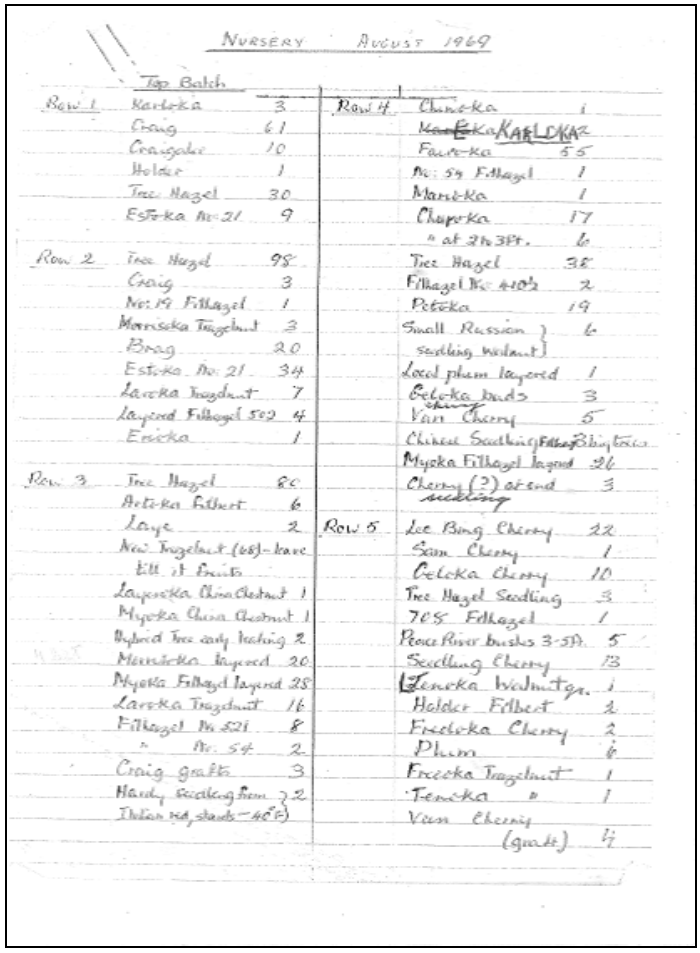


Figure 4. Example tree and shrub inventory from 1969

All nut trees, the black cottonwood (*Populus trichocarpa*) grove, wildlife snags and ornamental trees were individually tagged with a unique identification number, using round metal tree tags and aluminium nails. Tags were placed at a height of approximately 2.5 m on the northwest side (facing Whitworth Road) of each tree. Hazelnut shrub rows were tagged at the beginning and end of each row with a unique (row) number using round metal tags affixed to one stem of the shrub with an UV-resistant multi-purpose nylon cable tie. Note, this method is considered to be durable, but there is a risk that some tags may be lost; a long-term solution may be to place a treated wooden post at both ends of each row with a metal tag affixed to the posts.

Data collected for all trees included: tree tag number, the previous tag number where present, GPS coordinates, species (and cultivar, where known), diameter at breast height, height in metres, crown spread in metres, tree health, tree defects, crown defects, crown asymmetry, tree risk assessment, hazard abatement, a detailed health notation, heritage value management recommendations and monitoring frequency. The height and crown spread in metres, health notation and the number of distinct shrubs in each hazelnut shrub row was included in the database and the width of the polygons is indicative of the average crown spread of each row at the time of assessment.

2.2 Cultivars, Selections, Varieties and Hybrids

Information such as cultivar, selection or hybrid, was transposed from signs fixed to trees and shrubs, and corrected where appropriate. For example, it was determined through DNA testing that what was formerly identified by J.U. Gellatly as the "Fioka" Buartnut (*J. ailantifolia* × *J. cinerea*) hybrid is more likely a selection of Japanese heartnut (*J. ailantifolia* var. *cordiformis*) and not a hybrid (Grimo, pers. comm. 2012).

Figure 5. Opened kernel of Japanese heartnut (*J. ailantifolia* var. *cordiformis*) revealing distinctive nut characteristics; this, along with DNA testing, will aid in the identification process.

With detailed information of 36 records of specific hazelnut varieties at the NGR (Corvallis, OR), and 16 varieties growing at the PAFRC (Agassiz, BC) it should be possible to identify a significant number of the currently unidentified selections in the tree hazelnut and hazelnut shrub breeding

rows. This exercise would likely take a number of years, given that there are 1,179 hazelnut shrubs and 112 tree hazelnuts. By recording the nut, catkin and growth characteristics of selected specimens, and comparing these with the J.U. Gellatly nut collection (located in the heritage home) and cross referencing documented records such as those that already exist and/or become available at NGR Corvallis and Agassiz, individual trees and shrubs may be identified to the cultivar. Furthermore, Charles Rhora who actively selects and sells several Gellatly varieties from his tree breeding nursery in Ontario has suggested he may remember in detail where some selections were planted having visited GNFRP on more than one occasion (Rhora pers. comm. 2012). The identification of the walnuts may prove somewhat less time-consuming where DNA reference library data is available. Analysis of more than 20 specimens is currently underway at the University of Notre Dame, Indiana. With regards to the chestnut (*Castanea* spp.) varieties it is possible that the current satellite repository for NGR Corvallis (located at the University of Missouri) may have some J.U. Gellatly varieties and information. Likewise, the USDA repository in Davis, California may also have some J.U. Gellatly walnut varieties and information.

The benefit of the newly mapped tree inventory and GIS database will be the relative ease of data management and cost effective updating. This new geodatabase provides a single source of all information for analysis, operational planning, and report generation.

Figure 4 is a scanned excerpt from the last known comprehensive inventory of the J.U. Gellatly tree breeding nursery (dated 1969), and provides the reader with an appreciation of how complex the shrub and tree inventory is within each row and across the site.

2.3 Tree and Hazelnut Shrub Inventory Observations

A number of tree assessments have occurred at GNFRP and a common theme occurring in all of them has been the observations of drought stress, crown dieback particularly in the walnuts and overcrowding of the trees and hazelnut shrubs in the selection rows. The observations contained in these legacy reports and assessments tend to suggest that long-term environmental changes such as the effects of climate change, changes in site hydrology associated with lower Lake Okanagan levels may also be affecting tree health and compounding the effects of repeated summer droughts, competition from overcrowding, insect, pests and disease factors. Significant progress has been made since 2005 in reversing the effects of these site limitations and environmental stresses; together these measures have improved the overall health and vigour of the trees and shrubs at the GNFRP. During the completion of the latest assessment drought stress still appears to be the primary plant health influence with the less drought tolerant *Juglans* genus exhibiting 15-30% crown dieback, leaf margin scorch and associated symptoms. Initial findings were summarized for each genus as follows:

2.3.1 Walnut (*Juglans* spp.)

With the exception of some young, open grown specimens (e.g., Manoka # 444, 445 & 446), the walnut all appear to be most affected by drought stress and nutrient deficiencies including Japanese heartnut (*J. Ailantifolia* var. *cordiformis*), English (*J. regia*), Japanese (*J. ailantifolia*) and black walnut (*J. nigra*) plus the hybrid "Buartnut" which is a cross between Japanese heartnut and Butternut (*J.cinerea*). Consequently they exhibit the highest percentage of crown dieback, sparse leaf canopy, limited nut yields, and leaf margin scorch, to list the most obvious symptoms. Several older specimens have fungal conks growing on stems or limbs, which indicate an advanced level of internal decay. The English walnut are currently being treated through an IPM Program for the management of: 1) codling moth (*Cydia pomonella*); and 2) walnut husk fly (*Rhagoletis completa).* Common treatment for the walnut husk fly involves several annual applications of GF-120 Naturalyte fruit fly bait; sanitation measures are also implemented during nut harvest time (Fayard, 2009). Controls in place for the codling moth include trunk banding with corrugated cardboard to trap mature larvae as they climb the tree to pupate and hanging pheromone mating disruption lure traps. It should be noted that the banding method is only effective if the banding is removed and destroyed in a timely fashion. Additionally, many larvae will pupate on the ground or find a suitable crevice in the bark before they reach the cardboard banding, therefore reducing the efficacy of this control method (Caprile, 2011). Considering the codling moth's complex life history, it is difficult to control effectively and is only considered a nut tree pest of the English walnut.

Crown dieback appeared to be most severe in areas where either excavation or grade changes were made to the site (date unknown). These effects within the critical root zone (CRZ) appear to have long-term effects on health and vigour, however it is anticipated that planned improvements to irrigation, fertilization and root zone rehabilitation measures will further help in recovering the long-term health of these valuable heritage trees.

2.3.2 Butternut-Heartnut Hybrids (*Juglans* x spp.)

Observations on the site suggest that these hybrid specimens may have inherited the short-lived characteristics of the Butternut parentage. As a result, several named specimens are now exhibiting stem and crown dieback and fungal infection. It is likely that, despite pro-active irrigation during the summer months, cumulative effects of drought and nutrient stress incurred prior to RDCO acquisition may now be manifesting itself and limiting the tree's ability to divert resources to fight disease. Given the current health profile and obvious decline, the HOMP recommends short-term measures to conserve the existing specimens as well as to reproduce them through grafted scion material at the earliest opportunity. Concurrently it is recommended that leaf samples be sent for

DNA analysis to establish the pedigree of each of these veteran selection trees. The veteran selection trees are considered to be of very high cultural heritage value to the collection and replacements should be planted in a new heritage nut tree arboretum at the earliest opportunity to conserve this unique genetic germplasm plant material.

2.3.3 Tree Hazelnut (*Corylus* spp.)

The tree hazelnuts growing in the selection rows and in open conditions generally appear to be in fair to good condition. With a few exceptions, crown dieback is considered minimal amongst this genus and foliage colour and size appears normal. The tree hazel genus is known to tolerate high pH soils, drought, and harsh winter conditions; hence it is anticipated that specimens on this site will cope better than the walnut where growing conditions may be less favourable. It is believed that there are several species of tree hazel on the site, including Turkish (*C. colurna*), Chinese (*C. chinensis)* Himalayan or Indian (*C. jaquemontii*) and possibly Tibetan (*C. tibetia* or *C. ferox).* Rhora's Nut Farm and Nursery list several Gellatly varieties for sale on their website including Gellatly Hybrids, car3, car6, car9, car12 (www.nuttrees.com).

Figure 6. Leaf scorch seen on a tree hazelnut (*Corylus* spp.) located on the shores of Lake Okanagan.

With a few exceptions the tree hazelnut seems to have coped better with the environmental constraints and limited nutrients and moisture and as a result they exhibit very limited signs or symptoms of insect infestation or disease. The only noticeable trait appears to be stem decay, which is evident in the cut stumps of larger specimens removed for stand thinning purposes. Considering the tree hazelnut appears tolerant of harsh growing conditions and site disturbance, they are expected to respond positively to improved plant health care, nutrient and irrigation regime. 'Trazel' or 'Trazelnut' are names commonly used in various texts signifying the tree form of the J.U. Gellatly hazelnut varieties. Many

Trazel varieties were developed by J.U. Gellatly. The parent genetic material included but is not limited to the following:

- India tree hazel
- Chinese tree hazel
- Turkish tree hazel

Named J.U. Gellatly varieties of Trazel also include Britoka, Chinoka, Churoka, Indoka, and Spuroka.

2.3.4 Hazelnut shrubs (*Corylus* spp.)

Many of the hazelnut shrubs in the GNFRP are growing in selection/nursery rows as they were in 1969, occupying the eastern half of the site. Across this area of the GNFRP the hazelnut shrubs are generally growing without the benefit of an overstorey tree canopy and are therefore exposed to full sun. As a result they appear to be suffering to various degrees from leaf scorch and drought stress. Hazelnut shrubs are typically grown in an understory setting where dapple shade and a more humid microclimate will prevail. By contrast, in a commercial orchard setting they are typically grown in open settings but with a rigorous irrigation regime providing up to 5 mm per day during summer months under similar climate conditions.

In addition to exposure, the hazelnut shrubs are competing with established turf grass, and are also competing with each other for growing space, nutrients and moisture. The hazelnut shrubs should be thinned to around six to eight healthy stems per bush and all of the stems cut back on a periodic basis (termed coppicing) to restore each shrub to healthy and vigorous shoot growth. Other names used to describe hybrids of tree hazel and other *Corylus* genera are likely used. For example 'Filazel' is a name developed by J.U Gellatly to describe the hybrid between Filbert which is an alternate or common name for European hazelnut (*C. avellana*) and the Canadian hazelnut (*C. cornuta*) specifically a selection from the Peace River Valley which would provide frost hardiness for the new 'Filazel'. Varieties developed by J.U Gellatly include: Manoka, Orvoka, Ureoka, Myoka hybrid, Fairoka hybrid, Eloka, Geloka and numbered varieties 500, 501, 502, 503 and 505 (Gellatly, 1965).

2.3.5 Chestnut (*Castanea* spp.)

Overall, the chestnut trees exhibit a fair to good rating for overall health and vigour, with only a small proportion appearing to be drought stressed (Figure 7). Some specimens are exhibiting basal decay where root systems have been damaged. However, wound-wood (callous) development is considered good for this genus and healing over old wounds allows the chestnut to efficiently seal out pests and disease, and retain their structural integrity. With the Gellatly "Layeroka" variety the nut bearing characteristics appear lower than what is commonly observed in commercial nut orchards. However, this is to be expected given the competition for limited resources currently available at GNFRP. The chestnut genus, similar to walnut depends on an adequate watering and nutrient regime in the spring. Adequate nutrients and moisture are important to support vigorous spring twig growth for at least five new leaves beyond last year's terminal shoot. This amount of twig growth provides the optimum number of new nut positions (spurs) along each branch. Later in the season during nut development the trees must receive adequate water and nutrients for complete nut development.

Figure 7. "Layeroka" chestnut (*Castanea* spp.) displaying healthy twig growth necessary to provide new nut positions or spurs.

2.3.6 Oak (*Quercus* spp.)

Red oak (*Q. rubra*) and English oak (*Q. robur*) occur within GNFRP. The English oak trees appear to be in fair to good condition with only minor defects and some limited growing space/overcrowding issues. The red oak tree is located by the entrance road and exhibits moderate drought stress, crown dieback and significant epicormic growth on the branches. A significant portion of the tree's CRZ has been impacted over the years by the presence of a gravel trail. Considering this, management prescription has been developed to alleviate those issues. A significant proportion of the acorns are developing without seeds. Since the nut crop from this tree is not currently harvested the issue is not considered a priority and no corrective measures have been identified.

2.3.7 Honey Locust (*Gleditsia triacanthus*)

Two honey locust (*Gleditsia triacanthus)* specimens are present on the site and without notable competition as they are occupying a dominant overstorey position in the mature tree canopy. These

specimens appear to be in good condition and without major defects at this time. This species is leguminous and will be contributing to local soil fertility. This characteristic will be to the benefit of trees and shrubs growing within the sphere of root-zone influence.

2.3.8 Black Cottonwood (*Populus trichocarpa*)

A grove of black cottonwood trees is located along the eastern edge of the GNFRP, next to the lakeshore. This site has been assessed primarily for public safety and overall condition. Generally the live trees are in fair to good condition, although several are exhibiting some crown dieback which may be associated with drought stress and other environmental factors. It appears that the presence of a trail and compaction from recreational use in the root zones may be impacting overall health and vigour. The black cottonwood grove has been assessed on more than one previous occasion. Subsequently, several of the trees located along the shoreline trail system and beach areas have been removed or modified to form wildlife snags of various heights (3 m to 8 m). Typical decay characteristics of this species appear to be prevalent where stems or root systems have sustained damage from competition or disturbance. The perimeter and the understory of the black cottonwood grove are occupied by a large number of densely spaced young volunteer trees. Management recommendations are provided for the trees in this grove. Recommendations include stand thinning to improve form, reduce competition and reduce the number of trees with stem defects arising from stand competition and phototropic tendencies.

2.3.9 Other Species

Several other species are represented on the site either as individual specimens or in small groups. These species include: two cherry (*Prunus* spp.) growing in the Whitworth roadside hedgerow; two newly planted pecan trees (*Carya* spp.); one almond (*P. dulcis*); one horse chestnut (*Aesculus hippocastanum*) tree # 440 in the traffic circle by the information kiosk; one large weeping willow (*Salix* spp.); a Norway maple (*Acer platanoides*); and one dogwood (*Cornus* spp.) located along the lakeshore beach areas. These trees have been assessed to the same standards as the rest of the tree inventory. Where appropriate, management recommendations are provided.

In reference to the horse chestnut it should be noted that it is the only nut tree at GNFRP which grows a non-edible nut, in fact the raw horse chestnut seed, leaf, bark and flower are toxic and should not be ingested due to the presence of esculin. It does not seem appropriate to retain a nut bearing tree at GNFRP which produces a toxic nut and could easily be mistaken (due to the similarity of nut characteristics) for a sweet chestnut (MacKenzie and Mah, pers. comm. 2012). Our recommendation based on the facts would be to replace this tree with a Gellatly nut tree at the earliest opportunity and certainly before it produces fruit.

2.4 Summary of Tree Inventory

Table 1. Summary of tree inventory at Gellatly Nut Farm Regional Park.

Genus/Species	Number of Trees	Age Class	*Overall Condition Rating
Orchard Trees (J.U. Gellatly collection)			
Almond	1	Sapling	good
Beech	1	Mature	good
Buartnut	27	mature and veteran	fair
Cherry	2	Mature	good
Chestnut (all) European/Chinese	131	Mature	good
Hazelnut shrubs	1179	mature	good/fair
Tree hazel	112	mature	good/fair
Japanese heartnut	9	mature	fair
Honey Locust	2	mature	good
Oak	5	mature	good
Pecan	2	sapling	good
Black walnut	54	mature	fair/good
English walnut	170	mature	poor/fair
Total (Orchard Trees)	516		
Total Hazelnut shrubs	1179		
Native and other Ornamental Parkland Trees			
Horse Chestnut	1	sapling	good
Black Cottonwood	26 13 148	mature wildlife snags juvenile	good good
Norway Maple	1	semi-mature	good
Weeping Willow	1	Mature	good
Total native and ornamental	190		

*Condition rating defined as follows:

- Good – representative crown architecture for species and less than 15% crown dieback
- Good/fair – crown architecture and branching habit indicates over-pruning or minor pest and disease symptoms with 15-25% crown dieback
- Fair – uncharacteristic crown architecture due to competition, poor pruning practice or phototropism/asymmetry and 25-40% crown dieback
- Poor – crown architecture and leaf area has been severely affected by one or more factors with 40% plus crown dieback

2.5 Tree Inventory Maps and Key

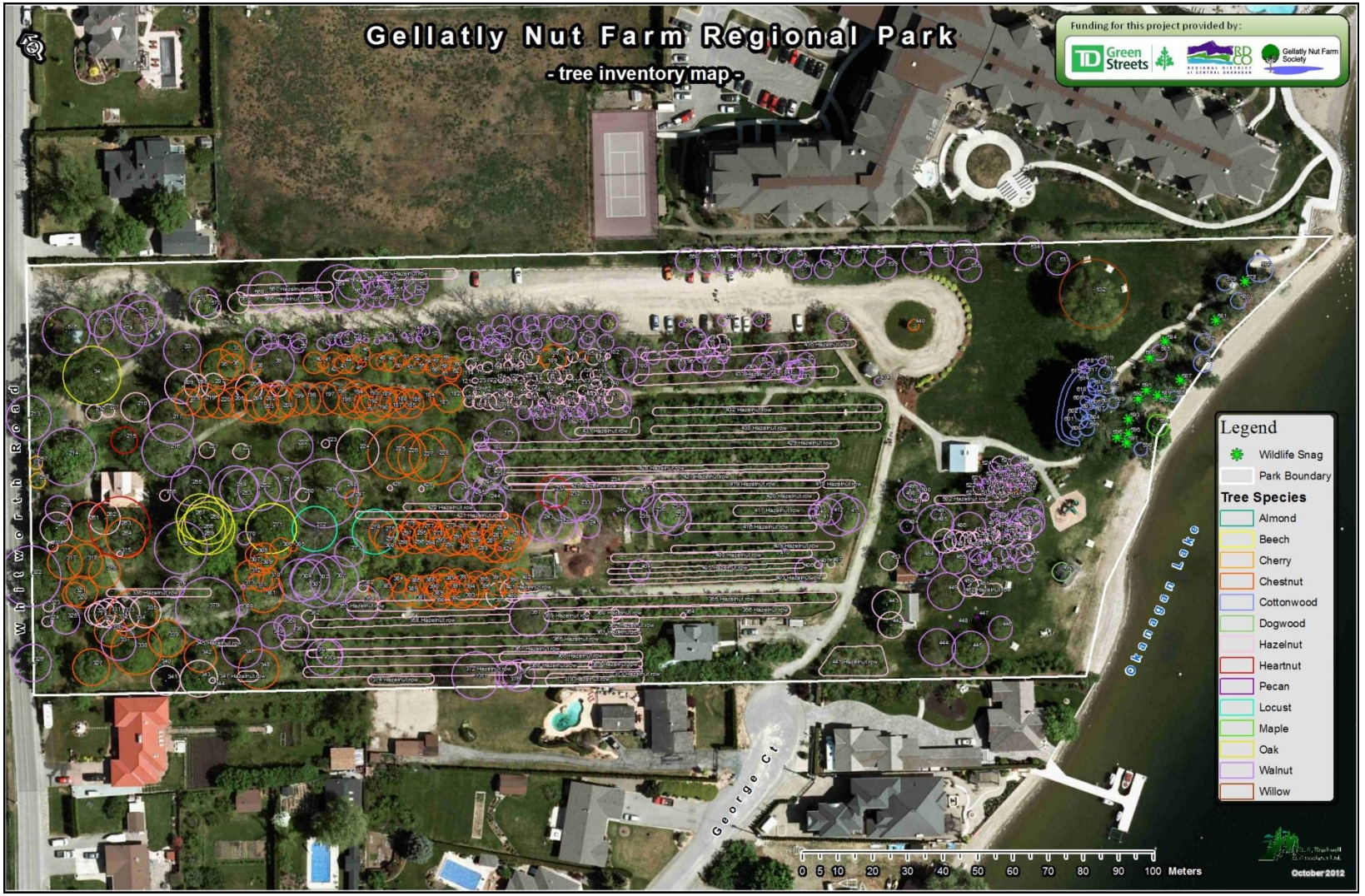


Figure 8. Tree Inventory Map with 2012 Orthophoto

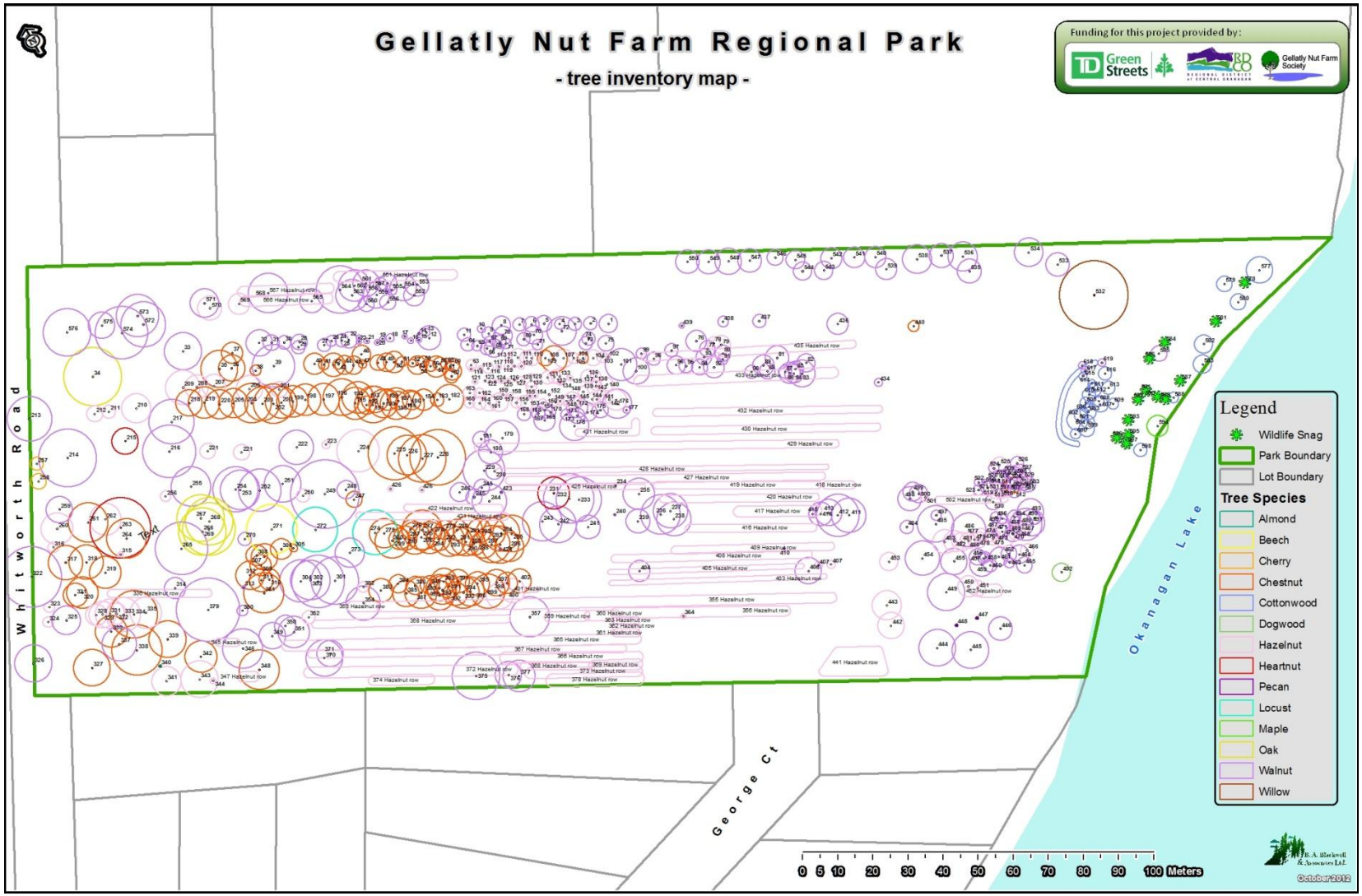
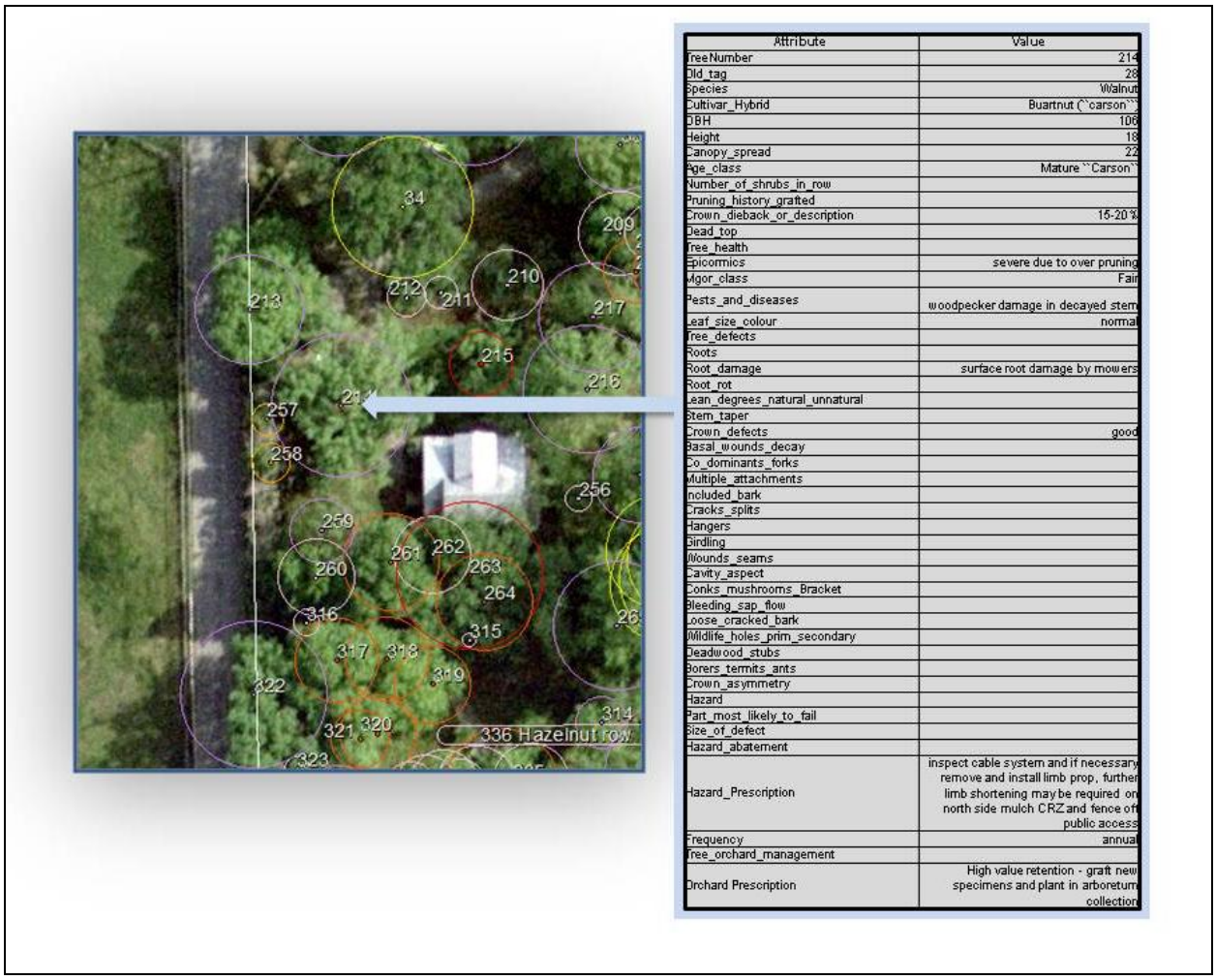


Figure 9. Tree Inventory Base Map



Attribute	Value
TreeNumber	214
Old_tag	28
Species	Walnut
Cultivar_Hybrid	Buartnut (``carson``)
DBH	106
Height	18
Canopy_spread	22
Age_class	Mature ``Carson``
Number_of_shrubs_in_row	
Pruning_history_grafted	
Crown_dieback_or_description	15-20%
Dead_top	
Tree_health	
Epicormics	severe due to over pruning
Vigor_class	Fair
Pests_and_diseases	woodpecker damage in decayed stem
Leaf_size_colour	normal
Tree_defects	
Roots	
Root_damage	surface root damage by mowers
Root_rot	
Lean_degrees_natural_unnatural	
Stem_taper	
Crown_defects	good
Basal_wounds_decay	
Co_dominants_forks	
Multiple_attachments	
Included_bark	
Cracks_splits	
Hangers	
Girdling	
Wounds_seams	
Cavity_aspect	
Conks_mushrooms_Bracket	
Bleeding_sap_flow	
Loose_cracked_bark	
Wildlife_holes_prim_secondary	
Deadwood_stubs	
Borers_termits_ants	
Crown_asymmetry	
Hazard	
Part_most_likely_to_fail	
Size_of_defect	
Hazard_abatement	
Hazard_Prescription	inspect cable system and if necessary remove and install limb prop, further limb shortening may be required on north side mulch CRZ and fence off public access
Frequency	annual
Tree_orchard_management	
Orchard Prescription	High value retention - graft new specimens and plant in arboretum collection

Figure 10. Extract from the new GIS database illustrating the detailed information recorded for each tree

The above extract from the new GIS database clearly illustrates the detailed spatial and biophysical information which is now available to the user. The live tree canopy crown spread measured in metres (diameter) is shown by the circular line surrounding each unique tree tag number. The tree canopy crown spread lines are colour coded by genus/species. The recorded attributes for each tree can be retrieved on screen by selecting the symbol for each tree or hazelnut shrub row. The attribute table has been built to ensure it is compatible with the non-spatial database provided by the Horizon Tree Service Report (2005). Additional attribute fields have been incorporated to ensure the information collected is as detailed as possible for a visual tree assessment (VTA) to afford the database manager the opportunity to perform queries and develop tree management plans based on best arboricultural practice standards.

3 Heritage Orchard Management Plan

Each component of the HOMP was extensively researched including, but not limited to, the historical context, the significance of the J.U. Gellatly collection and best management practices. Management objectives and recommendations were developed for the short term (Table 11) (high priority, complete within 1 - 2 years), medium term (Table 12) (medium priority, complete within 2 - 5 years) and long term (Table 13) (low priority, complete within 5 - 10 years). The detailed recommendations are intended to address the broad spectrum of values identified in the terms of reference for this report. Each section of the HOMP includes a table containing criteria and performance indicators. These tables compiled at the conclusion of Section 3 are intended to help the RDCO and GNFS to gauge where current practices are in terms of meeting the goals and objectives of the HOMP and to measure success for each implemented recommendation against benchmark performance measures. Benchmark performance measures are based on industry best management practices (BMPs). As the recommendations are gradually implemented it is anticipated that reference to these tables will provide the basis of a self-assessment tool to measure the relative success of the various initiatives.

3.1 Financial Implications and Funding Opportunities

The costs and cost savings associated with implementation of the recommendations for HOMP are challenging to forecast at this early stage as further analysis of water demand linked to potential irrigation system upgrades, available nutrient status, the choice of ground cover alternatives and other management options are still to be established. However, financial expenditure trends in the form of additional funding requirements and savings can be forecast on the basis of anticipated tree growth response to proposed treatments and adjustments in resource requirements. Several initial trends, but not limited to the following can be predicted with a reasonable degree of accuracy:

1. If turf grass areas are reduced and replaced with alternate low maintenance ground cover treatments, grass maintenance and irrigation costs will be proportionally reduced.
2. Irrigation and fertilization currently intercepted by turf grass will be diverted to the benefit of the orchard trees.
3. Improving tree health will reduce pruning, maintenance and IPM requirements.
4. Improving tree health will result in increased nut yields
5. The short-term capital costs associated with establishment of a heritage nut tree arboretum and Gellatly niche marketing opportunities are likely to be offset by increased sponsorship and revenue generating opportunities.

6. Identification, propagation and marketing of unique Gellatly cultivars and hybrids will provide additional opportunities for revenue generation and enhanced visitor experience.

Defining the Financial Implications of Implementing the Heritage Orchard Management Plan

Potential cost offsets and funding partners have been identified and linked to relevant HOMP management themes. Costs and long-term savings associated with proposed management themes and how they can be balanced over the term of the Plan is outlined in Table 2.

Table 2. Financial implications and sustainable management opportunities.

HOMP Management Theme	Anticipated Cost Offsets and Potential Funding Partners	Enhanced Sustainable Management Opportunities
Identification of Cultivars Hybrids and Selections	University partnerships/Masters student projects, UBC Okanagan, Northern Nut Growers Association (NNGA)	N/A
Database & Historical Records Management	GNFS, Masters student project, UBC Okanagan, NNGA, Real Estate Foundation, Vancouver Foundation, Lottery Commission	N/A
Reduced Turf Grass Management (Mowing, Fertilizing, Aeration)	Cost savings can be used to substitute turf grass in the CRZ RDCO/UBC Okanagan research projects	Reduced Greenhouse Gas (GHG) emissions in the production and use of fertilizer Water conservation
Turf Grass Substitution (Mulching Critical Root Zones)	Funded through reduced turf management costs RDCO/UBC Okanagan research projects Okanagan Water Stewardship Council	closed loop recycling (mulch) and establishment of low maintenance perennial legumes Water conservation
Reduced Irrigation of Turf Grass	Reduced requirements for turf grass irrigation RDCO/Okanagan Water Stewardship Council	Snow melt and rain water storage and grey water recycling Water conservation
Strategic Irrigation Scheduling for Drought Intolerant Trees (*Juglans* spp.)	Strategic irrigation scheduling for walnuts and hazelnut UBC Okanagan research projects Okanagan Water Stewardship Council	Snow melt and rainwater storage and grey water recycling. Deep root watering is more water efficient

HOMP Management Theme	Anticipated Cost Offsets and Potential Funding Partners	Enhanced Sustainable Management Opportunities
Integrated Pest Management (IPM)	Improved tree health is anticipated to reduce IPM spray program expenditure UBC Okanagan research projects DOW AgroSciences[3]	Reduced GHG emissions and reliance on pesticides
Establish Heritage Nut Tree Arboretum	Initial expenditure for cloned specimens Lottery Commission, NNGA, Vancouver Foundation, Real Estate Foundation, Endowment Fund, Farm Credit Canada	Improved micro-climate conditions and reduced long-term irrigation requirements for hazelnut shrubs
Signage and Interpretive Materials for the Arboretum	Initial costs are anticipated to be offset by increased visitation and related sales of added value niche markets Rogers wireless Quick Response (QR) code self-guided walk, NNGA sponsorship, Farm Credit Canada grant	Wireless service and smartphone providers may be interested in sponsoring QR code interpretive trail signage
Pruning Costs	Improved tree health will reduce pruning program expenditure, host International Society of Arboriculture (ISA) training workshops, host ISA climbing competition	Closed loop recycling of debris Reduced GHG emissions
Propagation and Nursery Activities	Initial expenditure for cloned specimens will be gradually offset by increased sales, Commercial nursery partner, commission sales of Gellatly varieties, added value sales	Support local economy and food security Added value sales Worldwide Gellatly branding
Nut Harvest (Revenue)	Improved tree health and irrigation will result in increased nut harvest, GNFS niche market sales value added product sales commercial partner	Support local economy and create niche markets for Gellatly nut products

3.2 Cultural Landscape Value

Cultural landscape value is defined by the world heritage committee as those distinct geographical areas or properties which uniquely represent the combined works of nature and of humankind. This is particularly relevant in the GNFRP where the legacy of nearly a century of work in nut tree breeding and selection has shaped the landscape in a unique way, leaving a living museum of unique Gellatly nut trees for present and future generations to enjoy.

"Cultural landscapes represent the combined works of nature and humankind, they express a long and intimate relationship between peoples and their natural environment…cultivated terraces on lofty mountains, gardens,

[3] Dow AgroSciences Canada Inc. is a research based, agricultural sciences company with a diverse product portfolio including weed, insect and disease management for agricultural/horticultural crops and products for forestry and industrial vegetation management.

sacred places testify to the creative genius, social development and the imaginative and spiritual vitality of humanity. They are part of our collective identity." (UNESCO website accessed November 2012).

Figure 11. Tree hazelnut (*Corylus* spp.) selection rows illustrate the cultural landscape value of the Gellatly legacy at Gellatly Nut Farm Regional Park.

3.2.1 Key Objectives (Cultural Landscape Value)

To protect the cultural landscape value at GNFRP the following key objectives have been developed and used to identify criteria and performance indicators for this Section of the HOMP (Table 7):

1. Archive and catalogue all historical records and data associated with the J.U. Gellatly selection and tree breeding nursery.
2. Protect and restore the cultural landscape to accurately reflect how it was "back in the day" when it was operated as a selection and tree breeding nursery.
3. Restore the J.U. Gellatly collection to include, where practical, the majority of genera and species that J.U.Gellatly worked with during his life time.
4. Comprehensively identify all of the trees in the J.U. Gellatly collection, set up a living museum in the form of a heritage arboretum, and catalogue and share this information widely.
5. Plant and maintain a heritage arboretum to protect the genetic material of J.U. Gellatly in perpetuity.

3.2.2 The Gellatly Legacy

The J.U. Gellatly nut tree breeding and selection nursery, as represented at GNFRP, is regarded and described by experts across North America as an extremely valuable collection of heritage nut tree varieties (Welsh, 1984). Furthermore, it is recognized as a unique lifelong legacy of nut tree breeding and the selections created by J.U. Gellatly. In its day, the J.U. Gellatly tree breeding and selection nursery played a leading role in developing new and climate-appropriate cultivars and hybrids for the orchard industry. J.U. Gellatly specialized in and was successful at producing appropriate plant material for a wide spectrum of climate regimes predominantly focused on North America. In an era when nut tree breeding was not practiced widely due to the land, resource and time commitments ``*the Gellatly brothers remained open to new ideas and directions and developed one of the most broadly-based nut programs in the world*`` (Hansen, 1997).

Several J.U. Gellatly selections have found their way to Europe and are still being actively cloned and sold to the orchard industry and private growers (i.e. Orange Pippin Fruit Trees Ltd, York, UK). In essence, J.U. Gellatly provided growers with hardy, high quality, productive nut trees (Gordon, 2011). J.U. Gellatly varieties, selections and hybrids can be found to this day in commercial orchards, growing in government experimental research facilities (such as the 16 hazelnut varieties at the PAFRC), and on display at some of Canada's leading arboreta (Kempler, 2003) (Figure 12). The significance of the cultural landscape value cannot be over-emphasised; it is evident that J.U. Gellatly created a legacy that is valued across the world and his name lives on in several publications. He is remembered by experts in the field of nut culture more than four decades after he passed away (Appendix D). The following quote from the Society of Ontario Nut Growers (SONG) emphasizes the historical importance of the J.U. Gellatly collection:

> *"Jack Gellatly of West Bank, BC developed a number of largely Chinese chestnut selections. These were introduced to Ontario. One cultivar, Layeroka, stood out as an outstanding breeder tree. Layeroka has been superseded by a number of selections from its offspring as well as others. Many orchards have been planted using these seedlings and grafted trees".*

Figure 12. Hickory (*Carya* spp.) trees from the original Gellatly collection growing at Hamilton Royal Botanical Gardens Arboretum.

Figure 13. Examples of healthy "Layeroka" chestnut trees (*Castanea* spp.) growing at the McCully Chestnut Orchard in Chatham, Ontario.

The highly successful McCully Nut Farm in Chatham, Ontario is an example of the "Layeroka" chestnut legacy provided by J.U. Gellatly (Figure 13).

It is worthy to note that GNFRP represents one of the best examples of a historic nut tree breeding and selection nursery and it should not be misinterpreted as a working nut farm (as illustrated in Figure 13).

3.2.3 Heritage Tree Value versus Nut Production

J.U. Gellatly developed more than 36 varieties, selections and hybrids of hazelnut (both shrub and tree form, and at least five strains of Japanese heartnut (Calendar, Caloka, Gellatly, Canoka and Nursoka). J.U. Gellatly is believed to have developed several Buartnut which are a hybrid of the Japanese heartnut and butternut trees, several of these hybrids survive at GNFRP including Dunoka and Corsan. The "Broadview" walnut was introduced by J.U. Gellatly circa 1931, a selection from a Carpathian walnut brought to Canada from the Ukraine by a fellow immigrant in 1919. "Broadview" walnuts are still actively cloned and sold throughout the world to this day for example Orange Pippin Fruit Trees Ltd, York, UK. J.U. Gellatly developed several chestnut selections but the selections from Chinese chestnut (*Castanea mollissima)* were the most widely planted as they proved to be resistant to chestnut blight (*Cryphonectria parasitica*) these selections include Layeroka, Skioka, Manoka, Nuoka and Penoka.

This snapshot of information provides a brief glimpse into the complexity of the tree breeding and selection work J.U. Gellatly was undertaking at GNFRP. The amount of work involved in cross-pollination, observation, documentation, grafting, proving selected plant material, measuring and weighing the nuts, observing nut characteristics, naming new selections, and marketing them to prospective clients is overwhelming. Furthermore, it suggests a level of dedication and perseverance

that is evidenced only in individuals who are driven to achieve excellence in their chosen field of expertise.

It is worthy to note that as long as the trees on the site continue to be managed to optimize long-term tree health and vigour, it is also likely that annual nut production will gradually increase with improved tree-health; therefore the two management objectives are mutually beneficial.

3.2.4 Marketing the Gellatly Heritage Nut Trees (The Business Case)

There appear to be several examples of successful business models for the preservation and sale of heritage fruit trees and seed. An example from BC is Butchart Gardens in Victoria which has been actively promoting and selling (mail order) Butchart Garden seed mixes since 1920. The Butchart Gardens seed collection is now sold online and provides all visitors (virtual or in person) with an opportunity to recreate flower gardens similar to the ones they experienced when they visited the site or heard about through third parties, relatives or through any other form of media.

There is a growing demand for heritage varieties and current relevance for hardy, productive and disease resistant varieties, as developed by J.U. Gellatly. In a world of changing climate, concerns about food security and the spread of tree disease such as Eastern Filbert Blight (EFB) (*Anisogramma anomala*), it is reassuring to know that for instance, certain Gellatly "trazel" hazelnut hybrids still have relevance today due to their resistance to EFB (Chen *et al*., 2006).

Similarly it has been learned that "Broadview" walnut is the only walnut variety that will properly grow and ripen in the UK (pers. comm. Borrie, 2012). It appears that there may be an excellent opportunity to pro-actively market Gellatly heritage nut trees across the globe and thereby generate funds for the maintenance and management of the GNFRP. The first step in developing a business model for GNFRP will be to investigate copyright rules and to establish whether or not the Gellatly heritage nut tree collection can be protected in some way to ensure revenue generation opportunities are not lost to third parties. Currently, it appears that certain Gellatly varieties are being cloned and sold by third parties across the globe and therefore it is unlikely that these particular varieties of the J.U. Gellatly collection could be retrospectively copyrighted and protected. However, from preliminary investigation it appears that many Gellatly varieties within the original collection are not currently being advertised in the nut tree marketplace, therefore it may be possible to protect them through copyright rules and thereby brand, control and benefit financially from any future sales. The copyright aspect of the Gellatly heritage orchard management plan is not within the scope of this report or in the authors' field of expertise; therefore it is recommended this subject be investigated as a stand-alone project and contracted to a subject matter expert.

The second step in creating a business model would be to create a catalogue or brochure containing information about both individuals and the broad range of Gellatly heritage nut trees which are available for sale. The catalogue should include the following suggested detailed information (but not limited to) pedigree, climate hardiness zones, soil pH, nutrient, moisture and sunlight requirements, tree growth and nut characteristics and susceptibility/resistance to disease. This catalogue or brochure would provide the prospective buyer (retail or wholesale) with the information they need to make an informed decision about the suitability of Gellatly heritage nut trees for them or their customer base. Marketing scenarios for the sale of Gellatly heritage nut trees would be expected to develop in the following concepts:

1. Wholesale nursery (X) selects certain varieties from the catalogue and approaches RDCO expressing an interest in cloning and selling them to their customers or to sell them on behalf of GNFRP in the case of nursery (X) being BC based.

2. Agreement is reached to supply nursery (X) with scion material for replication and nursery (X) signs an agreement to report annually the number of clones sold and to pay ($) in royalties for each clone sold.

3. Online sales of cloned or seedling progeny of the Gellatly collection would be sold by RDCO/GNFS however the plant material could be contract grown at a local or remote nursery and shipped directly from that location to the customer. Thereby avoiding any requirement for sophisticated on site tree nursery equipment or operations and maintenance. For example Rhora's Nut Farm and Nursery currently advertises Gellatly chestnut hybrids for sale at very competitive rates ($20 for a 21-36 inch tall tree plus tax and shipping). Considering the work and resources involved in propagation it would be more cost effective to outsource this component of the sale of Gellatly heritage nut trees to one or more contract growers.

4. A supplier list may be compiled of all known worldwide sources of cloned and seedling Gellatly heritage nut trees. The consolidated suppliers list could be posted on the internet to provide a worldwide audience with a 'one stop shop' experience. Publishing the list would also encourage unknown suppliers subscribe to the list for market exposure. A fee could be charged for inclusion and service standards set for Gellatly authorized suppliers. Orange Pippin Fruit Trees Ltd have already requested inclusion on a potential suppliers list (pers. comm. Borrie, 2012)

This business model concept has the potential to quickly develop a network of contract growers and marketing agents to promote and sell the Gellatly heritage nut tree collection without major capital investment. In addition to generating a financial contribution to support the conservation efforts at

GNFRP this activity would also proactively celebrate the J.U. Gellatly name and legacy. Added value merchandise could also be incorporated into a business case master plan and would greatly enhance overall viability and branding for the Gellatly heritage nut tree collection (Appendix B).

In terms of compatibility with the continued use of the GNFRP as a public park, this business model concept is anticipated to be complimentary to public recreation and has potential to greatly enhance the user experience, by providing enhanced opportunities to take "a little piece" of the Gellatly collection home to enjoy, grow and pass on to future generations. The collection of nuts is already practiced and the only additional activity required would be the initial collection of scion material for grafting. The recent collection of scion material for DNA analysis does not appear to have created any conflict and can be scheduled to ensure they do not disrupt recreational activities. Tree climbing activities are generally very well received by onlookers and more often than not enhance the visitors experience as well as provide additional opportunity for education and outreach in HOMP activities.

3.2.5 Establishment of a Heritage Nut Tree Arboretum

An arboretum is defined as 'a place where trees, shrubs, and herbaceous plants are cultivated for scientific and educational purposes' (Merriam Webster Dictionary). Each arboretum tree and/ or shrub is carefully planted in an area large enough to permit the specimen to achieve its maximum height (in the specific climate) and width. Detailed information is collected for each specimen including: name (genus, species, variety, cultivar, etc.), place of origin, location planted, and year planted.

Some of the purposes of an arboretum are the conservation of species, the provision of early warning signals of potential diseases, the display of local growth habits of various tree species and varieties (helpful when picking out trees for orchard or private plantings), and the provision of valuable information regarding trees' abilities to adapt to potential climate change.

In many respects the existing J.U. Gellatly collection is functioning as an informal arboretum for the majority of visitors. Signs have been placed strategically across the site to inform people of the historical context, the location of named cultivars and hybrids, with some contextual information about the selection and tree breeding activities that the Gellatly family performed. To create a functional arboretum within the existing collection, it will require relatively modest resources in the first instance. Development of an arboretum is anticipated to require the following steps:

- Existing signage will need to be supplemented with additional information for each labelled specimen. To keep the costs down and to leverage modern technology the use of Quick response (QR) codes linked to website content could present a cheaper alternative to

traditional sign writing. Typically web content is cheaper to update and potentially provides more available content for the visitor with access to a smart phone or tablet. For visitors without access to tablets or smart phones it may be preferable to provide a self-guided tour brochure containing more detailed information about each specimen in the arboretum tour. Alternatively, RDCO or GNFS may conduct tours and have several tablets available for public use.

- More trees within the collection could be added to the arboretum inventory and become part of the self-guided tour as they are conclusively identified, particularly trees with unique J.U. Gellatly pedigree.

- If and when lost J.U. Gellatly trees such as ``Chinoka`` tree hazelnut are located, it is recommended they be repatriated due to their rarity, and unique qualities (Hansen, 1997). Repatriated Gellatly collection specimens should be planted in suitable locations of the new arboretum and added to the inventory.

- Tree management within the arboretum is anticipated to differ slightly between tree management for parkland and recreational activities. Arboretum trees have the same physiological requirements to other trees therefore have similar irrigation, fertilization, pruning and IPM requirements. It is anticipated that several specimens in the selection and nursery rows would be part of the arboretum collection until such time as new specimens of the same pedigree could be established elsewhere on the property. Essential differences in overall management style may be that newly planted arboretum specimens would likely be pruned for structure and form, and to respond to growth characteristics which might be exhibited in open growing conditions. Surface mulch treatments may also differ in the CRZ to allow visitors to get close to the trees to observe bark, buds, leaves and nuts although essentially it will be desirable to provide all trees with optimum growing conditions to afford long-term health and viability.

Through a combination of providing enhanced information, a self-guided arboretum trail and supplementing the existing collection with new plantings to ensure older specimens are replaced before they die, and to re-establish lost specimens, it is anticipated that a new Gellatly heritage nut tree arboretum would add considerable value to the visitor experience. Additionally, improvements will enhance conservation of the J.U. Gellatly collection.

The GNFRP is now managed for multiple objectives and the opening of the facility as a public park in 2005 created an opportunity to showcase this valuable arboreal collection of nut bearing trees to the

world. An arboretum can be regarded as a living tree museum where people can enjoy and observe trees in a natural setting and learn about all of their characteristics: growth, form, hardiness, longevity, food crops, environmental goods and services. Additionally, arboreta such as the one proposed at GNFRP will provide unique heritage values. Establishment and maintenance of an interpretive arboretum can also contribute to the conservation of valuable genetic material associated with each Gellatly selection, cultivar and hybrid represented. It is anticipated that the establishment of an arboretum at the site will also greatly enhance the visitor experience (Figure 12).

An additional benefit to the establishment of an arboretum will be the potential to study the growth characteristics of the plant material in a less restricted setting than is currently experienced by the majority of trees and shrubs. It will also provide an opportunity to plant allelopaths (trees that inhibit the growth of other species in their root zone) like the walnut genus away from susceptible genera. When other landscape plants are planted near or under black and English walnut, hickory and pecan trees they tend to yellow, wilt and die. This decline occurs because the walnut tree produces a non-toxic, colorless chemical called hydrojuglone. Hydrojuglone is found in leaves, stems, fruit hulls, inner bark and roots. When exposed to air or soil compounds, hydrojuglone is oxidized into the allelochemical juglone, which is highly toxic. Some genera of nut trees (e.g. *Corylus* and *Castanea* spp.) at GNFRP are susceptible to the allelopathic effects and therefore should be planted outside the root zone of the walnut genus to avoid these effects.

3.2.6 Gradual Tree and Shrub Replication and Replacement Schedule

The age of trees across the site ranges between < 10 year to circa 100 years plus, however the veteran specimens form the overstorey. Of all the genera, the *Juglans* genus exhibits the highest degree of crown dieback, disease and senescence. Therefore it is considered prudent to establish a program of gradual replication and replacement of the shorter lived specimens and those candidates which appear to be in a state of decline.

Table 3. Examples of the approximate natural lifespan of specimens represented at the Gellatly Nut Farm Regional Park.

Common Name (Genus and Species)	Natural Lifespan
Black walnut (*J. nigra*)	150 years; potential to live up to 250 years in a natural setting
Butternut (*J. cinerea*)	70-100 years
Heartnut (*J. ailantifolia* var. *cordiformis*)	60-100 years
Buartnut (*J. ailantifolia* x. *J. cinerea*)	Unknown presumed similar to parent species
English walnut (*J. regia*)	150 years; longer in favourable climate
Tree hazel (*Corylus* spp.)	100 + years
Chestnut (*Castanea* spp.)	100-300 years depending on species
Hazelnut shrubs (*Corylus* spp.)	100+ years as long as they are coppiced.

Lifespans can be shortened significantly when trees are grown outside their climatic optimum and when they are grown under stressful environmental conditions. Considering life expectancy factors, the need to plan for gradual replication, and where necessary, replacement of dead or dying specimens is necessary. Particular attention to the Butternut, Japanese heartnut and Buartnut hybrids will be needed to ensure these unique specimens are successfully replicated before they die (Figure 14).

Figure 14. A high value veteran Butternut (*J. cinerea*) tree with distinct crown dieback and sparse leaf mosaic.

3.2.7 Replicating and Maintaining the Genetic Work of J.U. Gellatly

The full extent of work involved in replicating and maintaining the genetic work of J.U. Gellatly is not fully understood at this time because many tree tags and records are missing (presumed lost) or not available for analysis. It is possible that the replication of the currently documented varieties will exceed 50 and will involve considerable time and dedication. True replication will only be achieved by cloning known varieties using techniques such as grafting to compatible rootstock, layering or budding. In the case of chestnut it may be possible to perform nut grafting. Nut grafting is a technique used to clone the American chestnut (*C. dentata*). It is worthy to note that seedling replication will not conserve the true genetic pedigree of each selection, cultivar or hybrid.

Prior to cloning, an important step will be to establish the pedigree of each specimen selected for replication. Recent information has highlighted the need for DNA analysis where available. A clone of "Fioka" which was believed to be a Buartnut hybrid has been DNA tested and found to be pure Japanese heartnut (pers. comm. Grimo, 2012). DNA testing is currently being conducted by the University of Notre Dame for butternuts and Japanese walnut, Japanese heartnut cultivars, butternut-heartnut hybrids (*J. cinerea* × *J. ailantifolia* var. *cordiformia*) and butternut-Japanese walnut hybrids (*J.cinerea* × *J. ailantifolia*), but there is no test at present to detect butternut-English walnut hybrids (*J.cinerea* × *J. regia*) from English walnut (pers. comm. Severson, 2012).

There is a current seedling propagation program and some limited grafting of selected plant material, however there is insufficient detail to comment on its efficacy or potential to contribute to the replication of the genetic work of J.U. Gellatly. An important first step will be to catalogue as many of the selections, hybrids and cultivars currently on the site, and to establish a temporary moratorium on the removal of any more live trees until they have been successfully replicated and established in the heritage nut tree arboretum. An exception to this moratorium may be necessary in the case of tree removal for risk mitigation where the structural integrity of the subject tree has been assessed and documented by a certified wildlife danger tree assessor (WDTA) or tree risk assessor (CTRA) as compromised, and the defects are expected to result in imminent tree failure and present an unacceptable risk to public safety. In this instance it is recommended that every effort be made to recover suitable scion material from the upper canopy of the tree and for this material to be stored for grafting purposes at the next available opportunity.

3.2.8 Planting of Desirable Heritage Nut Tree and Hazelnut Shrub Species

The definition of "desirable" heritage tree and shrub species for planting would be interpreted as only those heritage varieties, selections and hybrids developed by J.U. Gellatly. Field research has uncovered a number of J.U. Gellatly selections that are currently growing at various sites in Ontario, including three hickories and a very unusual Turkish tree hazel which is located at the HRBG (Figure 15). With a view to reassembling the complete J.U. Gellatly collection, and since documentation exists for these four specimens, it would be highly desirable to obtain scion material and repatriate them to GNFRP. Likewise as other unique and rare J.U. Gellatly specimens are located across the globe and where phyto-sanitary regulations may allow, it is recommended that unusual and unique documented specimens are re-established at GNFRP. Currently one horse chestnut (tree #440) is planted at GNFRP in the traffic circle close to the information kiosk. Considering the nut is toxic it is strongly recommended that this tree be removed and replaced with an edible species from the Gellatly collection.

Figure 15. Gellatly tree hazelnut (*Corylus colurna*) displaying unusual branching habit (Hamilton Royal Botanical Gardens).

3.2.9 Removal of Trees and Hazelnut Shrubs

Archive records suggest that when J.U Gellatly operated the current site as a selection and tree breeding nursery he would have culled trees and shrubs that exhibited undesirable tree, or more importantly nut, characteristics and trees that were more susceptible to pests and disease (GNFS, 2012). Similarly in a commercial nut orchard setting, culling for these reasons is commonplace; however in the context of the cultural landscape value of this historic site, and the fact that the exact pedigree of so many of the trees and shrubs is unknown, it is not considered appropriate to contemplate the removal of any more trees unless they become hazardous. It is possible that a tree or hazelnut shrub with undesirable traits (with the exception of the recently planted horse chestnut) could be a unique hybrid, selection or cultivar from which J.U Gellatly was breeding to produce even better pedigree plant material. It has recently been learned that a new cultivar was selected from the "Layeroka" chestnut by Ernest Grimo in Ontario. The new cultivar was named Grimo 142Q and clones of this "son of Layeroka" were widely planted in Ontario chestnut orchards. More recently this particular cultivar has been discontinued due to graft reject and blight resistance issues (pers. comm. McCully, 2012). However, the Gellatly "Layeroka" persists and does not appear to exhibit the same issues. Therefore, to contemplate the culling of trees within an interwoven family tree of hybrids, cultivars and selections would be ill-advised at this time.

3.2.10 Planting Location, Quantity and Tree Spacing

There is limited available planting space at this 4 ha site and competing interests such as maintaining open space for public recreation activities has the potential to further constrain opportunities for additional tree planting. However, the hazelnut shrub areas will benefit from the planting of compatible overstorey tree cover. Establishing a compatible overstorey will improve the prevailing micro-climate conditions for the understory shrubs. A balanced approach is likely to be mutually beneficial and should reduce watering and fertilization demands over the long-term. Open canopy specimen tree planting (arboretum style) in this area alone could provide plantable space for an additional 80-100 overstorey trees based on a proposed minimum spacing of 10 metres across the area which is currently occupied by the hazelnut shrubs. In the central core, around and to the east of the heritage home, it appears there is potential to plant between 20-30 additional arboretum trees. These calculations are based on the assumption that open recreational space which does not currently support tree cover (predominantly occupying the eastern portion of GNFRP, north and east of the information kiosk and north of the washrooms) remains in turf grass/open space. However if there is support to plant arboretum trees in these areas (excluding the beach access and picnic areas) there will be an opportunity to plant an additional 40-50 trees at 10 metre spacing. Care will be required in the planning of all proposed heritage arboretum planting to avoid conflict with existing underground infrastructure such as irrigation water supply lines, valve boxes and sanitary sewer services. Likewise, careful planning will be required to avoid root damage to existing trees if irrigation lines need to be relocated to accommodate new plantings.

Adequate space, allelopaths, historical context and chronology, genera zones, selection rows, soil nutrient and moisture regimes, root zone protection, and quantity are principles that should be followed with all new plantings.

Adequate Space
Allow adequate above- and below-ground space for the new specimens to thrive based on mature size, soil volume requirements, tree height and natural crown spread. Poor growing conditions can result in crown asymmetry, poor stem taper, or cause critical root zones to be severely limited.

Species Compatibility
Confine the planting of allelopathic species to areas where susceptible genera will not be adversely affected. Walnut genus trees should not be planted where the allelopathic effects will detrimentally affect the long-term health and vigour of other genera. Likewise leaf, nut and tree pruning debris mulch from this genus should only be used in the CRZ of the same genus.

Historical Context and Chronology

In the arboretum and site planting plans it is considered desirable to develop a "walk through time" where visitors can walk a chronological interpretative trail and learn about the earliest available J.U. Gellatly tree selections, hybrids and cultivars through to the most recent developments created circa 1969. For example:

- The "Broadview" walnut is known to have been selected and introduced by J.U. Gellatly in 1930 and scion material was being distributed widely. The largest shipment went to Professor J.A. Neilson, first to Vineland Station, ON and later to Battle Creek, Michigan (GNFS archives Gellatly, 1964).

- Morrisoka tree hazelnut is named for Dr. R.T. Morris, an early active member of the Northern Nut Growers Association (NNGA) and author of a book on nut culture. Morrisoka has many outstanding features that include: 1) very strong-growing tree, 2) large dark-green leaves, 3) has the largest nut to date of the Trazelnuts, growing in clusters from four to six nuts that are free-falling when mature, and 4) kernels free from loose bran so common to Barcelona cultivars. Its weak point may be just that it is a shy producer of catkins. This can be solved by cross-pollinating it with some of the other heavy producers of catkins, such as Eastoka, Chinoka, Indoka, or Churoka trazelnuts (NGR, Corvallis website accessed September 2012).

Genera Zones

The arboretum and site planting plans should be designed to take the visitor through a "chapter" for each genus and species represented in the collection. This will help provide the visitor with a balanced perspective of the wide spectrum of genera that J.U. Gellatly was breeding and selecting from, as well as the complex hybridization experiments he was conducting between species within each genus. Where species are not self-fertile, planting new trees in genus/species clusters will also help improve cross-pollination, fertility and nut yields.

Critical Root-Zone (CRZ) Protection

Where trees are planted in close proximity to hardscape infrastructure such as roads, trails, seating benches and building foundations, measures should be planned and implemented to ensure that the CRZ are provided with adequate root aeration, moisture and nutrients. Root barrier panels should be installed at the time of establishment to protect roads, building foundations and concrete footings from root heaving or similar damage.

Selection Rows

Limited space and the need to replicate valuable genetic material presents an opportunity to plant new trees and shrubs in temporary locations until plantable space is made available for a long-term

location to be provided. This practice is commonplace in nut orchards and similar tree breeding facilities where plantable space is also often at a premium. This practice offers a valuable opportunity to re-create the J.U. Gellatly selection and nursery rows, and to illustrate to visitors how J.U. Gellatly managed the site "back in the day". As permanent planting locations become available, specimens can easily be transplanted from these early establishment rows to their final location using a tree spade or root pruning and hand-digging techniques.

Adopting a two-stage establishment process will also provide a ready supply of scion plant material and a safety net of extra specimens, should any of the new trees or hazelnut shrubs be lost to adverse environmental conditions, transplant shock, or pests and disease

Soil Moisture/Fertility

Site/species suitability matching will help reduce pressure on limited resources and help improve the tree health profile over the long-term. For example, the tree hazelnut selections appear to be particularly well suited to drought prone soils, therefore consideration could be given to a gradual substitution of walnut in areas such as the landscape beds bordering the parking lots, where summer drought moisture deficits and compaction may create hostile planting conditions for most other species.

Quantity

Where plantable space permits, new specimens should be planted in minimum clusters of three, this allows for the best specimen from the group to be selected for long-term retention and also provides a safety factor in the eventuality that one or more specimens is lost to graft rejection, pests or disease, or environmental factors. Tree density across the site is currently quite variable. Some trees are still growing in the original selection/nursery rows at less than 1 m spacing, whereas several veteran trees around the heritage home and buildings, and the area to the east, are growing in relatively unencumbered open canopy conditions. In the latter areas there is an opportunity to selectively under-plant the mature overstorey with arboretum trees or some of the early J.U. Gellatly specimens such as the hickory that are found at HRBG and no longer represented at GNFRP. Care will be required to avoid species incompatibility.

3.3 Genetic Significance and Collections Management

3.3.1 Key Objectives (Genetic Significance and Collections Management)

The following key objectives have been developed for protecting the genetic significance and collections management subsection. Criteria and performance indicators have been developed for

each key objective and are intended as benchmark indicators for successful implementation of the recommendations of the HOMP (Table 8):

1. To avoid erosion or permanent loss of genetic germplasm plant material resources.
2. To reduce vulnerability of the collection to catastrophic losses.
3. Genetic resource conservation of the unique J.U. Gellatly collection.
4. Protection of the collection from the risks of imported disease.

3.3.2 Historical Significance

The historical significance of the J.U. Gellatly collection appears to be far reaching with J.U. Gellatly nut trees being sold and grown to this day across North America and in several European countries (Welsh, 1984). It should be stated that because J.U. Gellatly was so successful at selecting hardy, productive and disease resistant cultivars, the collection still has widespread relevance today in an era where diseases such as EFB are no longer confined to the eastern seaboard of North America. Several Gellatly tree hazelnut varieties appear to be resistant to EFB (Chen *et al*., 2007) which suggests that orchard varieties of yesteryear are likely to be the orchard trees of tomorrow. In other genera the same theme is evidenced with the "Layeroka" chestnut hybrid proving resistant to chestnut blight (pers. comm. McCully, 2012).

J.U. Gellatly was vice president of the BC chapter of the Northern Nut Growers Association for many years and wrote numerous journals and articles for this and other publications. He is named in several publications written by nut culture experts and his work is referenced in many ways but always with a similar theme. J.U. Gellatly is recognized for the pioneering work he performed in developing hybrids and cultivars of nut trees that could both survive the harsh North American climate and produce good quality nuts (Gordon, 2011).

It is likely that if J.U. Gellatly had not engaged himself in the pursuit of nut tree breeding, there would be a significant void in the development of hardy productive nut trees. Consequently, the trees available to the North American orchard industry may not be as well developed as they are today. Several J.U. Gellatly varieties have in recent history been used as the parent material for further refinement and the progeny provide additional and successful new varieties (pers. comm. Grimo, 2012).

In addition to the J.U. Gellatly varieties still sold and in use today in commercial orchards, several very unusual J.U. Gellatly selections and hybrids have been established at arboreta across Canada.

J.U. Gellatly heartnut selections and heartnut hybrids are established at the Morgan Arboretum near Montreal, QC and one Persian-heartnut hybrid exists at McGill University, Montreal, QC (Gordon, 2011). Three Hickory (Figure 12) and a Turkish tree hazel (*C. colurna*) with unusual branching habit (Figure 15) have been located at HRBG, these four trees appear to form the remnants of a larger J.U. Gellatly nut tree consignment sent to the HRBG in the early 1970s to become part of a Ministry of Natural Resources ON. (SONG, 1978) (Appendix D).

3.3.3 Management and Consolidation of Historical Information

There appears to be a wealth of historical information on the J.U Gellatly nut cultivation trials held at both GNFS and RDCO offices. Based on a brief examination of paper records, J.U Gellatly appears to have been a meticulous record keeper, recording dates, nut sizes, shell thickness, how easily the nuts are extracted from the shell, through to catkin production, overwintering characteristics and even dates for each development stage during the growing season.

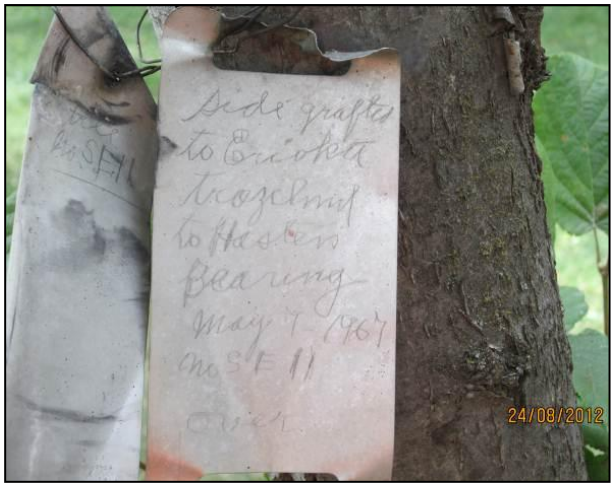


Figure 16. One of few remaining original tree tags providing insight into J.U. Gellatly's world.

It is understood that all of the available historical documents are in the process of being catalogued, scanned and archived by category and chronological order. This will be an important first step in managing this invaluable historical information and will provide a snapshot of J.U. Gellatly's day-to-day activities, and more importantly provide a glimpse into the art and science of nut tree propagation, selection and breeding.

It is recommended that the remaining period tree tags still affixed to a small number of specimens at the site be cross-referenced, catalogued and preserved for posterity. The information they contain has been transposed into the geodatabase, however it is recommended the information be transposed onto interpretive signs or replacement tree tags made from all-weather durable material to allow visitors to enjoy a unique glimpse into J.U. Gellatly's world.

3.3.4 Replication, Replacement and Propagation Records Management

As further information is made available for unknown J.U. Gellatly varieties, selections, cultivars and hybrids, the new geodatabase provided under this contract should be updated with this data. Preliminary steps have been initiated to identify more of the unknown specimens as follows:

DNA analysis

Dr. Jeanne Romero-Severson (Faculty of Biological Sciences, University of Notre Dame) has kindly offered to perform DNA analyses of the butternuts and Japanese walnut, heartnut cultivars, butternut-heartnut hybrids (*J.cinerea* x. *J. ailantifolia* var. *cordiformis*) and butternut-Japanese walnut (*J. cinerea* x. *J. ailantifolia*) hybrids. As this information is made available it will become invaluable documentation for the exact pedigree of the walnut genus at GNFRP. It should be noted that DNA analysis can only be used to identify the pedigree of specimens where a database from known J.U. Gellatly pedigree already exists. Further research will be needed in this area to establish if any other institutions possess databases that include J.U. Gellatly specimens for the other genera.

Foliage and Nut characteristics

Subject matter experts such as Charles Rhora have indicated that for the hazelnut genus a combination of leaf and nut characteristics, as well as growth form, may provide sufficient information to help identify additional specimens at GNFRP. J.U. Gellatly created a collection of nuts in jars which were used to market and promote nut tree growing back in the 1950s; the collection survives and may help identify some of the unknown specimens. To start this process GNFS President Maureen Pascuzzo has initiated a collection of nuts from unknown pedigree tree and shrub specimens. Together with the aid of available records from the J.U. Gellatly nut collection, the National Germplasm Repository (NGR) in Corvallis, OR, and the help of subject matter experts it is hoped that over the course of the next few years a more comprehensive catalogue will be assembled.

Figure 17. Digital image of "Eastoka" hazelnut nuts and husk (*Corylus* spp.). (Example of records kept at the National Germplasm Repository, Corvallis, Oregon.)

Germplasm Repository Records

At present it is known that 36 J.U. Gellatly specimens of the hazelnut genus are held at the NGR. The NGR database has been searched and no other J.U. Gellatly specimens have been found, however correspondence with Dr. Kim Hummer at NGR has indicated that the applicable repository for each genus would likely be interested in receiving new material as it is made available. Currently John Preece (University of California, Davis and NGR) is responsible for the management of the walnut genus. The University of Missouri (C/O Michele Warmund) is a satellite NGR for Corvallis, responsible for chestnut genus. The records provided by the NGR database are detailed and expected to be a significant help in the identification of specimens of the hazelnut genus (Figure 17).

Next Steps to Achieve Genetic Germplasm Conservation

A significant amount of relevant information has been uncovered during the course of authoring this report. This information will be submitted in the form of a compendium of information as it is far too voluminous to be contained in the appendices.

The collective material which is currently being compiled (sourced from RDCO and GNFS records); together with material referenced and submitted with this project represents a considerable database of both old and new information about the Gellatly collection. This information will need to be synthesised carefully into categories, chronology and relevant sections such as history versus germplasm genetic information, DNA records, location of specimens no longer represented at GNFRP, etc.

It is anticipated that once this follow up exercise is complete, a more comprehensive "state of the union" will be available for further analysis and to help guide the development of a master plan for the long-term conservation of Gellatly genetic germplasm plant material.

The master plan should include but not be limited to the following:

- On- and off-site genetic germplasm conservation measures
- Arboretum role in genetic germplasm conservation
- Satellite locations for genetic germplasm conservation (HRBG, NGR, Morgan Arboretum, PAFRC)
- Canadian germplasm repository, known as Canada's Plant Germplasm System (CPGS) although it appears that the repository is set up to receive nut tree accessions there do not currently appear to be any Gellatly accessions at this repository. There appears to be an emphasis on grain and other agricultural crops although the mandate states as follows: "Canada's Plant Germplasm System is a network of centres and people dedicated to preserving the genetic diversity of crop plants, their wild relatives and plants present and unique in the Canadian biodiversity. The system plays a significant part of Agriculture and

Agri-Food Canada's commitment to the Canadian Biodiversity Strategy in response to the Convention on Biological Diversity" (CPGS website accessed November 2012).

- Provision should be made at the earliest opportunity to submit as many known Gellatly cultivars to the Canadian Plant Germplasm System.
- Agreements with off-site repositories for the exchange of Gellatly genetic germplasm plant material.

Nursery Propagation Records Management

The historical records held at GNFS and RDCO offices indicate that J.U. Gellatly kept meticulous records of the nursery plant material that was propagated at the site; these records contribute significantly to the archive material and provide a benchmark for modern day records management. These nursery records provide important reference material for operational planning, nursery management, budgets, accounting, and to perform quantitative analysis of the business case for on-site versus off-site propagation. The nursery records also provide documentation for chain of custody and plant health tracking purposes. It is recommended that detailed nursery records are kept of all plant propagation, transplant purchase and sales, as well as operational costs associated with any onsite or off-site nursery/propagation activities. The nursery records should be held and updated in a central records management database at the RDCO offices with backup copies held at a secure offsite location.

There appears to be a wide choice of proprietary software designed for nursery management operations and retail services; however it is not anticipated that the GNFRP nursery operations will be of a sufficient scale to justify this additional investment. A Microsoft Excel spreadsheet template could be readily created to store all of the pertinent information and help calculate accumulated costs and revenues as well as provide a living document in which to store the quantity, location, source and destiny of all propagated material.

3.3.5 Protection and Distribution of the J.U. Gellatly Nut Tree Materials

The historical importance and cultural landscape value of the J.U. Gellatly nut tree materials is unique and deserves the highest level of protection from inadvertent loss or degradation. Under the ownership and management of the RDCO, the site and the trees located within GNFRP boundaries are afforded a relatively high level of protection from the majority of potentially damaging agents and activities. However it is conceivable that deliberate vandalism, fire or extreme weather events could occur and lead to the catastrophic loss of unique J.U. Gellatly genetic germplasm plant material. For these reasons and planning for the worst case scenario it is highly recommended that the collective measures outlined in Section 3.2 and applicable content found elsewhere in this report be implemented as and when budget and resources become available. This will ensure that in the

eventuality of a catastrophic loss, replacement germplasm plant material can be sourced from secure offsite locations, such as the NGR.

Furthermore, it is recommended that additional J.U. Gellatly genetic germplasm plant material be provided to secure institutions to ensure future supply of the entire collection and not just one genus such as hazelnut.

3.3.6 Creation of a Heritage Nut Tree Arboretum

The creation of a heritage nut tree arboretum is anticipated to deliver a number of the recommendations contained in this report. The benefits of establishing an arboretum are outlined as follows:

Life Expectancy Considerations

The replication and establishment of genetic replicates of the existing veteran heritage trees will help secure the conservation of unique genetic tree material on-site. Genera represented at GNFRP have differing life expectancies and therefore it will be imperative to plan for the replication of the oldest and shortest living specimens in the short-term in order to conserve the unique J.U. Gellatly genetic germplasm material and thereby protect the integrity of the overall J.U. Gellatly collection for both present and future generations (Table 3).

Repatriation of Lost Specimens

Bringing lost specimens of the J.U. Gellatly collection back to GNFRP and establishing them in a heritage nut tree arboretum will add value to the existing collection, perpetuate the cultural landscape values and recognize the incredible tree breeding that J.U Gellatly performed in the early part of the 19th century (Figure 15).

Education/Outreach

An arboretum is a unique living museum experience and will provide a unique opportunity to celebrate the cultural heritage landscape value and the historical significance of the J.U. Gellatly collection. It will also provide an education opportunity around the art and science of nut tree breeding, propagation and the potential of tree crops for both private and commercial orchard enterprise.

Collections Management

The establishment of an arboretum provides an opportunity to establish more than one of each specimen and to diversify the age structure of the J.U. Gellatly collection, in this way it will provide a safety net in case of premature loss of some of the older trees on the site. It will also provide a pool of genetic germplasm plant material for replication purposes.

Research

Establishing, growing and observing trees replicated from the J.U. Gellatly collection in a heritage arboretum setting will provide additional opportunities for research into each specimen. Many of the existing collection are growing in selection, tree breeding and nursery rows and as such their current growth characteristics are not expected to be a true representation of the natural form and crown architecture that would be displayed by a similar specimen in open grown conditions. This kind of research will provide an opportunity to record and document the natural form and characteristics of each specimen and to make this information available to prospective growers, researchers and subject matter experts.

3.3.7 Partner with Institutions, Government, Associations and Researchers to Preserve the Gellatly Collection

The international significance of the J.U Gellatly nut tree collection cannot be overstated. It is recommended that the J.U. Gellatly collection be formally recognized as part of a broader heritage nut tree collection and that attempts be made to secure sufficient resources to maintain it in perpetuity. As described in Runka (1991), the unique heritage value associated with the Gellatly collection has the potential to attract somewhat specialized funding partner opportunities, three options were explored in this early feasibility study

1. Northern Nut Growers Association
2. Vancouver Foundation
3. The Provincial Lottery Fund

In addition to these funding partner options another potential funding/preservation model is provided for consideration:

> For example, in the United Kingdom, the Brogdale National Fruit Collection is owned by a department of the British government as part of a European program to protect plant genetic resources for the future; however its care and maintenance is overseen by the University of Reading while public access to the site is managed by other partners http://www.ecpgr.cgiar.org. A similar model could be adopted in BC recognizing the international significance of the J.U. Gellatly collection.

The International Treaty on Plant Genetic Resources for Food and Agriculture was adopted by the Thirty-First Session of the Conference of the Food and Agriculture Organization of the United Nations on 3 November 2001. Among other things, the Treaty aims to establish the following:

- A global system to provide farmers, plant breeders and scientists with access to plant genetic materials; and
- Ensure that recipients share benefits they derive from the use of these genetic materials with the countries where they have been originated.

The Treaty covers all plant genetic resources for food and agriculture[4].

3.3.8 Promotion of a Unique Heritage Nut Tree Arboretum

Arbor Day Farm in Nebraska partnered with Nebraska Nut Growers to establish a nut tree arboretum with the intention of providing research, education and outreach opportunities. Likewise, Cornell University established a nut tree collection in the 1960's to enhance the University arboretum and to further research and education in tree food cropping. In Canada, the Ornamental Gardens and Dominion Arboretum in Ottawa, which was founded in the 1880s, also has a limited nut tree collection. All of the arboreta listed above appear to have nut tree collections only as a component of the overall arboretum or facility. It is very difficult to locate an arboretum that is specifically focused on nut trees; therefore the establishment of a heritage nut tree arboretum at GNFRP could provide a unique attraction. J.U. Gellatly has been credited with being the first tree breeder to originate uniquely Canadian tree nut varieties, cultivars and hybrids (Gordon, 2011).

If the establishment of a unique heritage nut tree arboretum is implemented as a priority under the HOMP, it is recommended that missing varieties and cultivars be brought home to be included in the arboretum collection.

Promotion of the arboretum as an attraction and unique visitor experience is anticipated to be relatively easy to achieve, however it is recommended that a suite of attractions be developed prior to public launch or promotion. The potential suite of attractions, some of which already exist, may include:

- Historical records, society membership opportunities, regular newsletters and resources
- Heritage seed and plant material available for purchase
- Interactive web tools, visitor retention attractions, event booking, merchandising
- Schools education program, quizzes, photography competitions
- Research, funding, and sustainability components

[4] Canadian representation is provided by Mr. Felicitas Katepa-Mupondwa, Research Manager, 107 Science Place Saskatoon, Canada, Tel: 306-956-2489, Fax: 306-956-7248, Email: felicitas.katepa-mupondwa@agr.gc.ca

3.3.9 Partnerships and Networking Opportunities

Existing partnerships and cooperation with institutions, government, associations and researchers have clearly demonstrated the potential mutual benefits to developing these relationships. For example:

- The NGR has 36 J.U. Gellatly specimens in its collection, and they have the specialized staff and resources to research this valuable genetic germplasm plant material and to make this information freely available to RDCO and GNFS (pers. comm. Hummer, 2012).
- Sixteen varieties of hazelnut (are currently under trial at PAFRC and preliminary results appear to suggest these J.U. Gellatly varieties have significant potential for growing in BC (Kempler, 2003).
- In response to concerns that some of the unique J.U. Gellatly varieties might be lost to development in 1995/1996, MFLNRO Research Branch made collections of scions (grafting twigs) and seed from 58 named Gellatly cultivars of walnut, chestnut, tree hazelnut and hazelnut shrubs. Grafts were made at the Kalamalka Forestry Centre (Vernon, BC) and seedlings were grown at a local commercial nursery (Carlson, 2000)
- The University of Notre Dame has completed DNA testing on more than 20 unique J.U. Gellatly tree specimens and share the results of pedigree investigations.
- Charles Rhora, owner of Rhora's Nut Farm and Nursery has been growing and selecting from Gellatly nut trees for several decades.
- Grimo Nut Nursery (Niagara-on-the-lake, ON) has also been growing and breeding from Gellatly nut trees for a similar time period to Rhora.
- Orange Pippin Trees Ltd and other nurseries in the UK are selling the Gellatly Broadview walnut selection (pers. comm. Borrie, 2012).

Formal and informal partnerships, such as but not limited to those listed above, provide both the research institution with opportunities to obtain potentially unique genetic data, as well as providing GNFRP with enhanced knowledge of the J.U. Gellatly nut tree collection. The true value of the scientific information cannot be under-estimated and should be regarded as a valuable enhancement to GNFRP resources.

3.4 Nursery Practice

3.4.1 Key Objectives (Nursery Practice)

The following key objectives have been developed for nursery practice and are presented in Table 9 with criteria and performance indicators:

1. Provision of optimum protection for the J.U. Gellatly collection genetic resource from the effects of pests, disease and invasive species.
2. The nursery is managed to provide optimum availability of seedling and cloned genetic plant material.
3. Working with other agencies to ensure individual on-site actions are linked with broader activities beyond the GNFRP.
4. Provide optimum irrigation for all nursery plant material while conserving water usage.
5. Ensure soil is properly managed and conserved, and no soil-borne pathogens are taken on or off-site.

3.4.2 Production and Propagation for Tree Replacement

Seedling Production

Reproduction of the J.U. Gellatly collection by seedling propagation will not provide GNFRP with true genetic replicates of the selections, cultivars and hybrids that J.U. Gellatly created. It is therefore not a recommended method of reproduction where the primary objective will be to conserve the genetic material. However, where seedlings are produced by controlled cross-pollination of specimens from the same documented cultivar, the seedlings may be suitable for enthusiasts who wish to plant J.U. Gellatly heritage nut-tree seedlings. Production of seedlings using controlled pollination methods may provide the most accurate seedling replicate of a certain cultivar or selection. The time and resources involved in controlled pollination would likely outweigh any apparent advantages. Seedling production is therefore not a recommended method of replicating the J.U. Gellatly collection.

Cloning Genetic Material

To accurately replicate the genetic material of the J.U. Gellatly heritage nut tree collection it will be necessary to employ one of the following vegetative reproduction methods:

- Grafting

- Budding
- Air and soil layering
- Micro propagation

Grafting

Grafting is a horticultural practice which dates back thousands of years. It was practiced in China around 2000 BC and was common practice in ancient Greece (Mudge *et al*, 2009). There is an extensive choice of grafting methods and the method that best suits each particular genus and species should be selected. Commonly used techniques include *Approach, Budding, Cleft, Whip, Stub, Four flap, Awl and Veneer* grafting. In addition to these techniques a "nut grafting" technique has been developed specifically for the chestnut genus and may be the preferred method to replicate the chestnut selections at GNFRP. The choice of grafting technique will likely be species dependant or a preferred technique of the technician performing this task. Details of the various techniques are not reproduced in this report because there is wide range of existing reference material for grafting available, including specific material for nut tree reproduction.

Unlike budding, which can be performed before or during the growing season, most grafting is performed during winter and early spring while both scion and rootstock are still dormant. Optimum timing for grafting across the full spectrum of genera growing at GNFRP can vary quite significantly (Gordon, 2011). For example "Nut Growing Ontario Style" (Gordon, 2011,) recommends that Persian walnut scion wood should be collected early in the dormant season, whereas pecan and hickory scion wood should be collected late in the dormant season when the donor trees are full of moisture. In Ontario, the grafting of butternut onto black walnut rootstocks for the purposes of creating an archive of blight-resistant clones has had low success rates and it is currently estimated to cost $12,000 to graft and archive one tree (pers. comm. Boysen, 2012). However J.U Gellatly's success with grafting onto compatible rootstock appears to have been very satisfactory with many long-lived specimens in existence. The University of Notre Dame has offered to DNA test the rootstock to establish which species have been used so that successful rootstock matching can be achieved in the future (pers. comm. Severson, 2012).

The choice of rootstock is critical to the success of grafting and can heavily influence the life expectancy of the grafted tree. Safe practice to avoid graft rejection is to graft scion material to rootstock of the same species, therefore butternut on butternut. However, with a hybrid such as butternut-heartnut (*J. cinerea* x. *J ailantifolia* var. *cordiformis*) it may be unclear which rootstock should be used. Experience and practice suggests that some rootstocks may be universally compatible within the same genus, for example black walnut rootstock has been used extensively for grafting almost all of the walnut genus, but Persian walnut (*J. regia)* should not be grafted onto black walnut rootstock

due to 'black lining' (graft union failure) several years after an apparently successful graft (Garner, 1988). Knowledge and expertise in this area will progress with time and it is therefore recommended to consult the latest research to ensure graft compatibility and thereby provide the new tree with optimum potential to reach a mature age class. DNA testing of existing specimens at GNFRP will provide good benchmark data for selection of rootstock material.

Budding

Budding is a grafting technique in which a single bud from the desired scion is used rather than an entire scion containing many buds. Most budding is done just before or during the growing season. However, some species may be budded during the winter while they are dormant. Budding requires the same precautions as grafting - the scion and rootstock material must be compatible; the scion must have mature buds, and the cambia of the scion and rootstock must match. Care must be taken to prevent drying out or contamination of grafting materials. Research shows that the speed with which the budding process can be performed and the percentage of successful grafts for those that "take" - should equal or surpass those of other grafting techniques used on the same species (Garner, 1988).

Layering

Layering is defined as the development of roots on a stem while the stem is still attached to the parent plant. A layer is the rooted stem following detachment (removal) from the parent plant. J.U. Gellatly successfully pioneered this vegetative method of reproduction with Japanese heartnut, an exception among walnuts.

Air Layering

Air layering is a technique used to generate roots on selected scion material. Japanese heartnut and chestnut often display incompatibility issues with the graft union, and these are candidate species where air layering may be the preferred method of vegetative reproduction. The technique is generally described as follows: remove a 1 inch ring of bark from the stem; scrape the newly bared ring to remove the cambial tissue to prevent a bridge of callus tissue from forming; surround the wound with damp sphagnum moss; and wrap the moss with plastic and hold in place with twist ties or electrician's tape. Thereafter it is necessary to keep the moss moist and check regularly for root growth. Once the rooting medium is filled with roots, the stem is severed below the medium and the newly rooted scion material planted out. The new plant will require diligent care during the early establishment phase as they can be easily drought stressed (Gordon, 2011).

Soil Layering

Soil layering **s**tems that are still attached to their parent plant may form roots where they come in contact with a rooting medium. This method of vegetative propagation is generally successful

because water stress is minimized and carbohydrate and mineral nutrient levels are high because they are available through the parent plant rootstock. Some plants propagate naturally by soil layering but often the process requires assistance. Layering is enhanced by wounding the stem where the roots are to form. The rooting medium should always provide aeration and a constant supply of moisture (Gordon, 2011).

Soil layering techniques include: simple layering; tip layering; compound or serpentine layering; and mound or stool layering.

Simple Layering

Simple layering can be accomplished by bending a low growing, flexible stem to the ground, covering part of it with soil and pegging it down securely with a wire tent peg or similar device, leaving 6 to 12 inches above the soil. Finally, bend the tip into a vertical position and stake in place. The sharp bend will often induce rooting, but wounding the lower side of the bent branch may also help. Simple layering can be performed on most plants with low-growing branches. Shrub hazelnuts are well suited to this vegetative reproductive technique. Simple layering should be performed in early spring using a dormant stem or branch; alternatively it can be performed in late summer using a mature branch or stem. This technique can take up to two growing seasons before the layered stem has a well-developed root system suitable for it to be separated from the parent root stock (Evans *et al*., 1999).

Tip Layering

Tip layering is quite similar to simple layering. A hole is dug 3 to 4 inches deep, the tip of the current season's shoot is bent over and pegged in a hole 3 or 4 inches deep, and then covered with soil. The tip will likely grow downward initially, but will then bend sharply upward. With the right soil moisture regime, roots will gradually form at the bend. Once the new tip has developed adequate root mass to be self-sufficient, it can be severed from the parent plant and planted out in late fall or early spring (Evans *et al*., 1999).

Compound (Serpentine) Layering

Compound layering is similar to simple layering, but several layers can result from a single stem. The methodology is described as follows: bend the stem to the rooting medium as for simple layering, but alternately cover and expose sections of the stem (each section should have at least one bud exposed and one bud covered with soil), wound the lower side of each stem section to be covered, peg the stem down using a wire tent peg or similar device and maintain adequate soil moisture until good root mass has developed at each layer, then sever the layers and plant them out or pot them according to layering objectives (Evans *et al*., 1999).

Mound (Stool) Layering

Mound layering is useful with heavy-stemmed, closely branched shrubs, and rootstocks of nut trees. Cut the young plant back to 6 inches above the soil surface in the dormant season. Dormant buds will produce new shoots in the spring. As the dormant buds appear, mound soil over the new shoots as they grow, roots will develop at the bases of the young shoots, layers can be selectively removed from the parent rootstock in the dormant season (Evans *et al*., 1999).

Micro propagation

Micro propagation is a modern laboratory method of tissue culture used to replicate plants, in essence a small portion of sterile plant tissue (which could be sourced from stem tips, petals or other plant tissues which are free of virus or fungal infection) is placed in a plant growth medium with plant growth regulators. Successfully propagated plantlets or shoots are then multiplied to provide a large number of cloned replicates and treated to initiate root development. When the plants are taken out of laboratory culture (ideal growth conditions) they need to be acclimatized to the prevailing environmental conditions typical of where they will be grown and transferred to soil medium (pers. comm. Rowland, 2012).

Micro propagation offers the potential to produce large numbers of clones of a particular plant for relatively low cost. There are many independent and University-based micro propagation labs (including UBC Faculty of Land and Food Systems) where micro propagation research may be conducted. Success has been reported for walnut (Payghamzadeh, 2011).

3.4.3 Seedling Production for Sale and Research

For the purpose of revenue generation, and public education on nut tree crops, seedlings should continue to be produced for sale. As discussed, seedling production is not recommended as a tool for achieving the goal of genetic conservation. However, it is anticipated that few visitors to the Gellatly site will be purists and there may be considerable public demand for relatively cheap heritage variety seedling nut trees to buy and try at home. With chance seedlings, there is always a possibility of a new and improved variety, for a new locale or new climate, and that message should be conveyed when selling these seedlings. Chance seedlings are defined as the product of unintentional plant breeding, whilst seedlings may be genetically unique and display desirable characteristics. Identifying the parent plants can be problematic unless they are subjected to DNA analysis. The production of relatively unimportant seedling material to experiment with is also likely to be beneficial to many potential researchers. To protect the integrity of the Gellatly heritage the GNFS must take a robust line with any stock of seedling origin that is not sold or used and not allow it to be planted permanently on site. It is important to recognize the valuable contribution of experts in the

field, including Dr. Michael Carlson and his associates at the MFLNRO and Ministry of Agriculture who recognize the importance of the Gellatly legacy and have made significant contributions to the conservation and replication of Gellatly germplasm plant material. Sixteen hazelnut varieties are now subject of trials at PAFRC, additionally Dr. Michael Carlson submitted numerous specimens of the hazelnut varieties to NGR and he has also collected seed and propagated a significant quantity of Gellatly material for use in cloning and replicating rare specimens.

3.4.4 Preserving the Heritage Nut Tree Species and Seed Banks

Seed bank preservation is not recommended as a means to protect Gellatly genetic material, as the seed will not necessarily breed true to the parent. The larger the seed (nut), the more likely that it may be killed by desiccation (Figure 18). Most nut-bearing trees and shrubs have seeds (nuts) that are rated as 'recalcitrant' or 'intermediate', which means they are not tolerant to drying and cannot be conserved long-term in a conventional seed bank (Table 4).

Table 4. Seed storage and stratification procedures for different genera at the Gellatly Nut Farm Regional Park.

Genera	Post-Harvest	Sowing	Transplanting	COLD Stratification for Spring Sowing	Seed Treatment
Chestnut (*Castanea* spp.)	Do not allow to dry. If not planted immediately, refrigerate.	Plant 1" apart in rodent-proof cold frame in October	Transplant at end of year 1 Weak year 2 plants can be cut back hard to encourage better vigour	150 days	V, O, (C 150)
Hazel (*Corylus* spp.)	Bract should turn yellow-green before nuts are ready to harvest. Dry the fruits indoors for a few days but not more than one week. Beaked hazel has hairs that can irritate – wear gloves.	Sow densely immediately after de-husking in a rodent-proof outdoor cold frame.	Transplant by year 2 at the latest, before bud break or after leaf-fall. Protect from rodents.	150 days	O, (C 150)

Genera	Post-Harvest	Sowing	Transplanting	COLD Stratification for Spring Sowing	Seed Treatment
Heartnut, walnut, butternut and other *Juglans* spp.	Leave husked nuts in a wire-mesh-covered bucket until blackened, then spread over gravelled area and wash off husk with a hose while walking over them in rubber boots. Keep nuts moist in a refrigerator for fall planting, or stratify for spring planting.	Plant side by side in rows 8" apart, ¾ - 2" deep in soil, mulch seedbed with woodchips and enclose in a covered wire cage embedded into the soil OR Sow where you mean the tree to grow, affording it similar protection as above	Transplant to containers or final location preferably within 1 year to avoid root damage. Undercutting may be required if plants are left until year 2, however some losses due to root damage should be expected.	120 days	V, O, (C 90 -120)
Hickories (*Carya* spp.)	Place in an open bucket covered with wire mesh for one week. Husks should peel off easily; reject those that are difficult to peel even after soaking for up to one day in their husks. Do not allow to dry out. Soak the seeds for one day prior to planting. Sow immediately or stratify for spring planting.	Plant ¾ - 1" apart in fully enclosed outdoor seedbed OR Sow where you mean them to grow, with protection Bury to two times their own thickness, water thoroughly and mulch with leaf mold/leaf litter	Transplant carefully in year 1 – roots can be very long. Or undercut roots before end of year 2, ready for transplanting at year 2	Minimum 120 days cold stratification	V, O, (C 120)
V: Viability is reduced if seed dries out O: Seed is best planted in protected outdoor seedbed. An alternative in parentheses () indicates an alternative to direct seedbed sowing C: Cold stratification at 35 – 39^0 F (2-4^0 C) – not freezing; # = duration of days					

If a collected species is related to a known recalcitrant or intermediate species, the seeds should be tested before drying. This test involves viability (germination) tests before and after drying on a small sample of the collection.

European chestnut (*Castanea sativa*) has been reported to be successfully preserved by excision of embryo for cryopreservation (Pence, 1990, 1992). Cryopreservation is an expensive process that may not be sustainable for a small organization like GNFS. However, there are cryopreservation gene banks around the world that may be interested in experimenting with and preserving J.U. Gellatly seed. Such research and partnerships should be explored as a matter of priority.

For recalcitrant seeds, the only practical on-site conservation strategy for the intact seeds (nuts) involves their storage at high water contents (essentially undiminished from those characteristic of the newly shed/harvested condition), in cold storage at the minimum temperature tolerated for that species (assume 2 to 4^0 C, but experiment as low as freezing point) where viability may be preserved for months and up to about three years. It would be beneficial for GNFRP to engage with a University to conduct experimental seed bank storage aiming to achieve viable propagules for three years or longer.

Figure 18. Nuts collected from "Big Red" hazelnut shrub (*Corylus* spp.)

Available literature on this subject can be found at the following sites:

- National Tree Seed Centre http://cfs.nrcan.gc.ca/pages/331
- Kew Millennium Seed Bank http://data.kew.org/sid/storage.html
- International Plant Genetic Resources Institute http://www.bioversityinternational.org

3.4.5 Integrated Pest Management (Nursery Practice)

To develop and implement an effective IPM program for GNFRP the nursery manager/operator must possess advanced knowledge of the life cycles of the range of potential pests that are likely to affect nursery plant material. Prevention measures should be implemented as a primary element to any IPM program. Additionally the use of predators of invasive species and other bio-control methods should be employed early in program implementation and pesticides should only be used as a last resort once all other avenues of prevention and control have been exhausted. Comprehensive records should be maintained and the IPM program evaluated annually for efficacy.

3.5 Operations and Maintenance

3.5.1 Key Objectives (Operations and Maintenance)

The following key objectives have been developed for operations and maintenance section of the HOMP:

1. To maintain or enhance long-term health and vigour of all trees.
2. Adopt a balanced approach to tree health and vigour as a preventative measure in the IPM program (dealing with the cause rather than the consequence).
3. To provide optimal water requirements with minimal wastage (non-target vegetation and evapotranspiration).
4. To optimize site fertility and nutrient availability whilst minimizing the need for additional application.
5. Optimize mulching practice to suppress weed competition and improve soil moisture and nutrient regime.
6. Eliminate unnecessary and poor pruning practices which deplete the trees photosynthetic potential and nut yield.
7. Optimize tree friendly infrastructure design concepts throughout the park to benefit trees and protect heritage value of the entire J.U. Gellatly collection.

Criteria and performance indicators in Table 10 provide benchmark indicators of successful implementation of the HOMP recommendations.

3.5.2 Integrated Pest Management (Orchard Trees)

The English walnut is currently being treated through an IPM Program for the management of codling moth and walnut husk fly. Common treatment for the walnut husk fly involves several annual applications of GF-120 Naturalyte fruit fly bait; sanitation measures are also implemented during nut harvest time (Fayard *et al.*, 2009). Controls in place for the codling moth include trunk banding with corrugated cardboard to trap mature larvae as they climb to pupate. The GNFRP also uses mating disruption pheromones in lure traps. It should be noted that the trunk banding method is only effective if the banding is removed and destroyed in a timely fashion. Additionally, many larvae will pupate on the ground or find a suitable crevice in the bark before they reach the cardboard banding, therefore reducing the efficacy of this control method (Caprile, 2011). Considering the codling moth's complex life history, it is difficult to control effectively and only considered a nut tree pest of the English walnut.

Observations of the overall tree health profile at GNFRP suggest that current insect attack has more to do with the fact that stressed trees are more prone to insect attack than healthy vigorous trees of the same species. It is therefore predicted that over the course of the HOMP as overall tree health and vigour improves the trees will be in a better position to resist insect attack using natural defence mechanisms and thereby reduce the need for continued insect control measures. As demonstrated by current practice at GNFRP, preventative measures in an IPM program should focus on dealing with the cause rather than the consequence. To this end it is recommended that plant available nutrient testing is carried out at the earliest opportunity to provide the necessary baseline information to address the apparent nutrient deficiencies for each genus and species. Section 3.5.6 provides more detail in this regard, based on interpolation of historical site nutrient analyses.

It is believed that poor health and vigour associated with the current site nutrient and moisture regimes have increased the potential for insect attack by the walnut husk fly and codling moth. Walnut trees in this low rainfall climate regime require significantly more water and fertilization to build natural defences. The most influential factor is that the turf grass, established in the CRZ of trees and shrubs, is intercepting a large proportion of the current irrigation and any ground based fertilizer applications which have been applied.

Wildlife Pests

In addition to these insect control measures it is recommended that RDCO staff continue to monitor racoon, squirrel, birds, rodents and related orchard wildlife pest populations to provide the necessary baseline population data to guide appropriate prevention and control measures. The current audio scare device appears to be performing well, but it may be necessary to build additional prevention measures and adaptive management strategies into the IPM program to ensure long-term success.

3.5.3 Turf Grass Competition

To address turf grass competition the following options are provided for consideration, however the proposed conversion to the use of alternate ground cover treatments is a potentially complex issue given the current high recreational use of the GNFRP. Proposed treatments must therefore be systematically planned and phased so that they do not interfere with recreational enjoyment of the GNFRP. In appropriate proportions, and only in areas where maintenance of turf grass is considered less critical to fulfilling parkland recreation functions it may be deemed appropriate to substitute turf grass with an alternate ground cover treatment limited to the immediate area of the CRZ (within the canopy drip line of the tree):

I. composted bark mulch which will not adversely affect the soil C-N ratio

II. bare soil (clean cultivation)
III. herbaceous legumes

Option I. – Placement of composted bark mulch in the drip-line of the tree and shrub canopy will provide a low maintenance area where weeds can be easily controlled, soil moisture is retained and soil protected from erosion and extreme temperature fluctuations. The obvious disadvantage is that the mulch may impede any mechanized forms of nut harvest. The use of organic mulches has been shown to increase walnut tree growth by 89% compared to walnut tree growth in unmanaged plantings (Van Sambeek *et al*., 1986).

Option II. – Maintenance of bare, clean cultivated soil is not recommended as it can lead to higher soil compaction and erosion potential., It also provides a perfect seedbed for weeds, elevated surface evaporation rates and wider soil temperature fluctuations in the CRZ. Maintenance of bare soil is also more labour and resource intensive and tends to lead to an eventual reliance on the use of herbicides to keep the costs down.

Option III. – Establishment of leguminous grass and herb species such as Alfalfa (*Medicago sativa* L.) has the potential to provide improved soil fertility, protection of the soil from erosion and moderation of soil temperatures. Legume cover crops have shown increases in walnut tree growth by 28% compared to walnut growth in unmanaged plantings (Van Sambeek *et al*., 1986). For example, Alfalfa is relatively shade tolerant and grows a long tap root, which enables nutrient enhancement of the soil. This plant also contributes to ameliorating soil compaction over the long-term. It is believed Alfalfa would be well suited to the GNFRP site because the plant performs best on deep permeable soils which have a pH above <6.2. There may be other herbaceous legumes which are suitable for growth in the proposed capacity and since agrology is not in the author's field of expertise it is recommended that the RDCO contact a professional agrologist (P.Ag.) to further develop this theme as a way to reduce turf grass competition and improve site fertility for the growth of trees. The potential disadvantages include a need for periodic cutting and competition for soil moisture in the upper soil horizons. However, with the right choice of climate appropriate species it should be possible to minimize the negative effects and provide an overall net gain for the nut trees.

"*The management of herbaceous legumes between trees can result in improved growth and fruit yields when compared to check treatments comprised of a mixed population of seedbank grasses and forbs"* (Haines *et al*., 1978; Van Sambeek *et al*., 1986; Van Sambeek, 2003).

In addition to the recommendation to reduce turf grass competition there is a need to improve irrigation and fertilization for the walnut genus. Both measures will reduce abiotic stresses and aid in

improved tree health and vigour. Irrigation and fertilization are addressed in more detail in Sections 3.5.8 and 3.5.6

3.5.4 Tree and Shrub Disease Mitigation

A number of minor diseases and environmental factors are affecting a small proportion of the trees and shrubs at GNFRP and specific mitigation measures are detailed in the GIS database. Field observations are outlined below:

Fungal conks have been observed on the stems and branches of some of the walnut genus and specific management recommendations have been provided for these trees to reduce partial or whole tree failure associated with branch and stem decay.

Slime flux or bacterial wetwood has also been observed on a small number of trees associated with columns of decay which have developed from old pruning wounds situated higher in the tree canopy on branches or on co-dominant stems (Figure 19).

Trees in both categories described above and listed in the geodatabase should be monitored regularly by a WDTA or CTRA to identify hazards to be mitigated in a timely manner and thereby reduce liability exposure associated with predictable tree failure. Poor pruning practice such as heading back can unnecessarily reduce the leaf area available for photosynthesis and thereby deplete the trees energy reserves and reduce its ability to compartmentalize decay and callous over pruning wounds. Cable and bracing relies on the supporting limb or stem being strong enough to support itself and the cabled limb or stem in extreme weather events.

Figure 19. Slime flux seen at the base of a veteran Buartnut (*J. ailantifolia* × *J. cinerea)* tree.

It has been demonstrated that this is not always a good support technique for use in veteran trees where the crown architecture is not well suited to the use of cabling techniques. Therefore limb propping has been recommended for a small number of the veteran high value heritage trees, as this technique is less intrusive than cable bracing and is a method used by J.U. Gellatly as early as the 1930s (Gellatly, 1964)

Cold/Winter Injury

English walnut has a tendency to be affected by cold or winter injury, and the signs and symptoms of cold injury are displayed on several trees at GNFRP. Longitudinal splitting of the bark on the lower bole of trees is often a sign, also bud killing and/or fine twig dieback. Trees with low vigour are most prone to winter injury therefore supporting the recommendation to improve overall health and vigour of the entire tree inventory at GNFRP.

Tree diseases relevant to the genera at GNFRP

At least three other tree diseases with potential to cause significant harm to the trees at GNFRP should be checked as part of an annual review by RDCO staff. These diseases are not known to be currently represented at GNFRP and therefore it would be beneficial for staff to receive some training to identify the signs and symptoms.

1. Butternut canker (*Sirococcus clavigignenti-juglandacearum*)
2. Chestnut blight
3. EFB

3.5.5 Annual Thinning, Pruning, Limb/Stem Support Systems and Tree Removal

Thinning

Thinning in GNFRP should be confined to the selective thinning of hazelnut shrub stems. The principal of thinning is intended to maintain equal optimum light conditions for each nut bearing stem and lateral branches, thereby reducing competition for moisture and nutrients and also reducing the coppice stool stress in terms of its capacity to provide all stems with adequate moisture and nutrients. Maintaining 5-8 healthy vigorous stems in each hazelnut coppice stool should provide optimum conditions as described above. As the coppice stool ages, it is good practice to re-coppice all of the stems. Coppicing within each hazelnut shrub row should be practiced on a rotational basis to provide a diversity of age classes and to minimize a significant loss of nut yield in any one year. There are 1,179 hazelnut shrubs therefore coppicing 117 shrubs each year would theoretically equate to all shrubs being re-coppiced every ten years.

Thinning of trees within the existing stand matrix does have the potential to reduce competition for nutrients and moisture resulting from the existing high stand density. This practice is not recommended at this time for the following reasons:

- There is limited knowledge on the varieties, selections, cultivars and hybrids growing in the selection rows and therefore until all specimens have been positively identified it is recommended that a moratorium on further tree removal is maintained.
- The selection rows play a significant role in reflecting the cultural heritage value of GNFRP; hence further thinning of the rows will deplete this visual reference and reduce the interpretive value of the selection and nursery rows (Figure 20).

Figure 20. Closely spaced trees in the remaining selection rows at Gellatly Nut Farm Regional Park. Close spacing can present challenges to long-term management.

Competition for nutrients and moisture resulting from current stand density can be ameliorated through a combination of:

1) Increased irrigation
2) Deep root fertilization
3) Deep root fertigation
4) Reduced turf grass competition

These measures in addition to minimizing unnecessary pruning will likely result in an overall improvement in tree health and vigour.

Pruning

The pruning of nut trees at GNFRP should be aimed primarily at building good crown architecture to support crops of nuts and resist breakage in extreme weather events. The principles are essentially the same as for training young trees in the urban environment and consist of the following:

I. Avoid the creation of narrow angles of attachment for branches or co-dominant stems.
II. Avoid the development of co-dominant stems wherever possible and where this will result in narrow angles of attachment or included bark.
III. Space scaffold branches along the main stem so that preferably no two branches arise at the same point (unless this is the natural branching habit of the tree species such as maple (*Acer* spp.)).
IV. Branches forming angles of less than 40 degrees should be avoided wherever possible.
V. Branches or co-dominant stems that form with included bark should be pruned off at an early stage in the trees development. This issue is often associated with the development of limbs or stem which are attached with a narrow angle < 40 degrees.
VI. Branches should be pruned before they attain a diameter greater than 2 inches and all pruning cuts should be made outside the branch collar to allow for effective callous or wound-wood development.
VII. Pruning should be kept to less than 25% of the leaf area in any single operation to avoid unnecessarily stressing the tree by reducing its photosynthetic potential.
VIII. Pruning practices must be sensitive to retention of nut bearing positions related to each genus/species as outlined in Table 5.

Table 5. Genus/Species pruning practice guidelines.

Genus/species	Nut bearing positions	Pruning practice
Chestnut (*Castanea* spp.)	Arise from previous year's growth	Avoid the removal of previous year's growth when pruning, phase fall season pruning to retain optimum nut positions
Walnut (*Juglans* spp.)	Nut positions form on current year's growth (female flowers)	Avoid pruning until the fall (post nut harvest)
Hazelnut (*Corylus* spp.)	Flower buds and Catkins over-winter therefore nut bearing positions are set in the previous year	Avoid the removal of viable nut positions wherever possible, prune to optimize even light through-fall in canopy and to remove sucker growth from the root crown
Japanese Heartnut (*J. ailantifolia* var. *cordiformis*)	The heartnut tree is terminal bearing, the nut flowers are housed in the tip buds of the trees. These buds are the first to open in the spring and are sensitive to cold spells in April and May. Frost injured flowers will abort and so reduce the crop.	Avoid unnecessary pruning of previous year's terminal buds.
Butternut (*J. cinerea*) Buartnut (*J. ailantifolia* × *J. cinerea*)	The decurrent branching habit of the butternut tree does not respond well to being headed back or for the installation of cable and bracing	Avoid heading back, lions tailing and the use of cable and bracing, where essential limb props should be used to support heavily weighted lateral limbs

Figure 21. Japanese heartnut (*J. ailantifolia* var. *cordiformis*) is a terminal fruit bearing species.

Limb Support Systems

As described above in Section 3.5.5 there are limitations to the effectiveness and appropriateness of cabling and bracing veteran walnut, Japanese heartnut and Buartnut trees. Crown architecture for these species is not considered compatible for the specimens assessed at GNFRP and a system of limb propping is therefore considered a better long-term solution for the veteran specimens exhibiting excessive end-weight or an inability to support heavy nut crops. Limb props will need to be sensitively designed on a case-by-case basis to avoid cambium damage and potential concerns with their use in a parkland setting. It should be noted that limb props were used by J.U. Gellatly as early as 1930 to support the limbs of the Broadview walnut when heavy cropping characteristics threatened to cause limb breakage (Gellatly, 1964). Designed and installed in a sensitive manner, it unlikely that the few limb props that may be needed on an infrequent basis are likely to detract in any way from the aesthetics of the GNFRP but instead provide another education outreach opportunity to enhance the visitor experience.

Coppicing

Coppicing is a silviculture practice performed to rapidly regenerate compatible trees and shrubs on a perpetual basis. Trees/shrubs are cut down close to ground level and the stumps are allowed to re-sprout and grow with multiple stems, before being coppiced again every 7 – 20 years or so. In Europe there is a long tradition of managing European chestnut and hazelnut shrubs as coppice. Traditionally coppicing was performed in the fall to ensure the continuous supply of small-diameter poles for various purposes including firewood, charcoal, wattle fencing, thatching, hedge laying stakes, or for juvenile plant supports. Other reasons for coppicing may include but are not limited to improved structural diversity, screening, shelter, maintaining a boundary marker (hedgerow), providing scion material, ease of maintenance, accessibility and wildlife habitat enhancement (Rackham, 1986).

Figure 22. A hazelnut shrub (*Corylus* spp.) coppice stool which has been cut too low, this practice removes dormant buds and thereby severely limits regrowth potential.

When cutting coppice, care must be taken not to cut the stump too close to ground level. Coppice shoots arise from dormant or adventitious buds located below the bark surface on the stump. If the stump is cut too low, too few or none of these dormant buds will remain and the coppice will not be successful. The first time a tree is cut to coppice, the final cut surface of the stump should be about 15 cm for smaller-diameter stumps (< 75 cm) to about 30 cm above ground level for larger-diameter stumps (> 75 cm). Where the stumps could constitute a trip hazard, precautions should be taken to exclude the public until coppice re-growth has occurred.

Partial re-coppicing may be practised with the strongest six or seven stems retained and all other stems/sucker growths removed as they occur. This may be common practice in a commercial nut orchard (pers. comm. Rhora, 2012).

Coppicing may be especially relevant as a management tool for J.U. Gellatly hazelnut cultivars when they become stressed through drought, decay or disease. The practice of coppicing has the ability to preserve the genetic resource, invigorate the plant and remove the stressed portion of the tree. Coppicing activities should be carefully planned to ensure freshly cut stools are not left in a position where they might cause a trip hazard to members of the public. Apart from a small number of shrubs which are in the beach access area, the majority of the hazelnut shrubs are growing in selection rows and not in locations where they may present a trip hazard, likewise it is proposed that shrubs are re coppiced selectively within the rows which will mean they are less accessible to members of the public and generally away from public use areas.

Tree Removal

Further removal of trees should be confined to essential removal associated with trees that have died or those that are present an unacceptable level of risk to the public and where the risk cannot be mitigated by removing the target. A moratorium on tree removal is intended to prevent the unnecessary loss of high value heritage trees and genetic germplasm plant material. There is a need for all of the trees/shrubs on the site to be positively identified, their genetic tree materials conserved and each selection, cultivar and hybrid successfully replicated to ensure the J.U. Gellatly collection survives in perpetuity.

3.5.6 Fertilization, Composting and Soil Testing

The results of recent analyses of soil and foliage samples by Bodycote Testing Group (2007), Evergro (2009) and Griffin Laboratories Corporation (2003) can be interpolated. However it is recommended that further analysis is undertaken to establish what the native soil plant available nutrient levels are now.

The collective analyses suggest the soil has a moderate to high pH (7.1), and adequate cation exchange potential typical of an illite clay soil. The walnut genus tends to prefer pH 6.4 and chestnuts prefer acidic soils in the range of pH 5.5 - 6.5, thus amending the pH may be justified.

High or low pH levels can have lock up phosphorus (P) in bio-unavailable forms (there is a narrow pH window where P is more readily bio-available). Phosphorus can be made more available by lowering the pH by adding sulphur (S) and since the soil tests indicate Sulphur (S) -deficiency this practice should be beneficial for that nutrient availability. It is important not to lower the pH too much as the P will chelate with iron and become unavailable for plant uptake; therefore pH and soil S must be monitored. The simplest method of monitoring bio-availability of plant nutrients would be to use Plant Root Simulator PRS™ probes and compare bio-available nutrient values with baseline or reference values Appendix A.

Nitrogen (N) and P uptake are linked – low availability of one impacts uptake in the other. This synopsis seems to be supported by the foliar analysis of black walnut (Bodycote Testing Group, 2007). The soil analyses suggest high calcium (Ca) values and it is understood that high Ca content in soil can also affect potassium (K) uptake. Molybdenum levels were indicated as very low and this can affect the plant's ability to take up other nutrients. By amending pH, availability and uptake of the macronutrients N, P and K may be enhanced without necessarily adding fertilizer.

Manganese is indicated as low, which will affect microbial decomposition, as it is a building block of enzymes. Organic matter is relatively abundant in the local soil. This may be recalcitrant due to suppressed decomposition and nutrient cycling in the dry, allelopathic soil, which will lead to poor overall tree vigour.

Preliminary recommendations:

- Avoid use of walnut organic matter
- Irrigate to optimum levels for the individual species then amend pH with sulphur applications. This should be done prior to deciding whether or not to add fertiliser (as it may not be necessary), preferably set up trials to assess the best approach; suggested trials are listed below:

    1. Add sulphur to amend the deficiency and the pH
    2. Add sulphur and nitrogen
    3. Add nothing (control)
    4. Add well-composted organic matter to help buffer soil against excesses.

It is likely that lowering the pH, dealing with the sulphur deficiency and adding water will result in better macronutrient uptake, and release more N through boosted decomposition of the organic matter.

3.5.7 Watering Regime

It is evident from site observations and information received from RDCO staff that there currently may be insufficient irrigation for the less drought tolerant species of tree at GNFRP during certain times of the growing season, referred to as crop development stages (**Table 6**).

Water availability during the growing season affects the trees ability to provide new fruiting positions on the tree for either the current or subsequent year. It is also critical during the flowering period and during the nut filling season (which varies by genus). Twig extension in walnut and hazelnut should be sufficient to produce at least five new buds past the previous year's terminal bud. Twig extension of this order provides the optimum number of fruiting positions for the following year. Likewise twig extension affects the number of new leaves produced in each growing season and this in turn affects the plants overall photosynthetic potential. To understand the need for water it is helpful to provide a breakdown of crop development stages and define the relative water demand during each stage as illustrated in **Table 6**.

Table 6. Example of Chico walnut water requirements in a commercial orchard setting (adapted from Goldhamer, 1998).

Crop development stage	Example water demand during crop development stages (Chico walnut 24′ spacing, clean cultivation)		
	Low	Moderate	High
Root growth (Feb/March)	(<5 gallons/tree/day)		
Bloom (March/April)	(5-40gallons/tree/day)	(40gallons/tree/day)	
Shoot growth (April/May)		(40-60 gallons/tree/day)	
Fruit sizing (May/July)		(60-111 gallons/tree/day)	(80-111 gallons/tree/day)
Kernel development (July/August)		(90-80 gallons/tree/day)	
Bud differentiation (July/August)		(80-90 gallons/tree/day)	
Root growth (August/October)	(80 declining gradually to 20 gallons/tree/day)	(80-20 gallons/tree/day)	

3.5.8 Irrigation and Water Conservation

Prior to detailing the individual water requirements for each genus at GNFRP it is important to consider the irrigation requirements for GNFRP in the context of current water availability and appropriate water conservation measures. The GNFRP obtains water supply from the District of West Kelowna's Westbank Irrigation Water system through a fixed diameter water main located off Whitworth Road. It is not known if the existing water main system is adequate to supply additional volumes for irrigation or if it is currently operating at capacity. It is therefore prudent to assume that any proposed changes to the irrigation regime at GNFRP should be formulated to fit with existing water main capacity and not exceed this to the extent that an upgraded system may be required. In the context of the HOMP it is possible to conserve water in a number of innovative ways, and implementation of these water conservation measures will help offset any increased seasonal water demand which may be necessary to help recover tree health in the walnut genus:

- It is recommended that a water balance analysis be commissioned to establish site and species specific water demand in relation to variable water consumption during essential crop development cycles. This study will provide the scientific basis for decision making around any proposed reconfiguring of the current irrigation system to optimize long-term tree health.
- Ground cover vegetation alternatives are provided (Section 3.5.3) to reduce competition for nutrients and moisture. Judiciously applied, these alternatives have the potential to increase available water for trees without increasing irrigation volumes and without detracting from the aesthetics or public recreational opportunities for the Park.
- Local irrigation such as deep root watering is a method which can be used to boost irrigation for high value specimens or small groups, and minimize unnecessary water losses through evapotranspiration.
- The use of rain water storage tanks and recycled grey water may also provide opportunities to reduce overall water consumption at GNFRP.
- The use of composted organic bark and leaf mulches has the potential to improve organic content of the soils and this will in turn improve soil moisture retention characteristics and thereby reduce water demand.
- Carefully planned overstorey plantings associated with the establishment of a heritage nut tree arboretum will help improve the micro-climate for the hazelnut shrubs and reduce overall water consumption

From observation obtained in the excavation of two soil pits in August 2012, it would appear that current irrigation during the summer months is mostly being intercepted by the established turf grass and only a small proportion of the irrigated water is reaching the tree roots. This suggests that a more strategic approach to watering is required to overcome the current shortfall at critical stages of crop development. It is important not to exceed system capacity or apply additional irrigation in a wasteful manner. To achieve these primary goals it is recommended that a water balance analysis be conducted across the site and for each individual tree genus. It is also recommended that this investigation be carried out to ensure measurements are timed to coincide with each critical crop development stage to ensure species specific watering regimes are developed.

Irrigation schedules should be developed to ensure that trees have adequate available water during critical crop development stages. Times when water demand are lower, water conservation measures may be employed without risk of detrimental effects on long-term health or nut crop yield.

It is also recommended that a feasibility study be commissioned to evaluate the use of rainwater storage tanks and grey water recycling at the public washrooms to recycle water used for hand washing for irrigation or to flush the toilets and thereby reduce overall facility water consumption.

"Irrigation based on past experience has been the traditional water management method, but increasing water costs; the fact that the municipal, industrial, and environmental sectors are competing for water; and the potential to improve orchard production and profits all call for scientific irrigation scheduling based on sound horticultural principles. Scientific irrigation scheduling techniques determine when to irrigate and how much water to apply. There are two fundamentally different approaches to scientific irrigation scheduling: (1) estimating the amount of water the orchard is using and (2) monitoring soil moisture levels by hand or with various instruments" (Goldhamer, 1998).

Walnut (*Juglans* spp.)

The genus with the highest water demands at GNFRP is the walnut. For example, Chico walnut growing at 24'x24' spacing, clean cultivated soil and in a similar climate regime, require the approximate water volumes indicated in **Table 6** during the growing season so as not to exhibit symptoms of water deficit stress (Goldhamer, 1998). This equates to 290 gallons per pound of nuts per annum in a commercial orchard setting. In contrast to a commercial nut orchard the primary objective for watering of the nut trees at GNFRP will be to optimize tree health and vigour rather than to maximize nut production. Therefore watering regimes should be designed to eliminate drought stress in the trees, with the resulting benefit of increased resistance to pests and disease.

Hazelnut Shrubs (*Corylus* spp.)

Summer season water requirements of hazelnut shrubs (growing in rows spaced at approximately 5 m and 3 m between bushes with no overstorey canopy within the rows) is estimated at 5 mm per day. This equates to approximately 360 mm/annum. Hazelnut shrubs are theoretically much closer to being climate appropriate for this region, which experiences an annual rainfall of around 300 mm. Hazelnut water demand is greatest during the critical kernel filling stage during the late summer months when the Okanagan is typically experiencing a drought. Irrigation will therefore be required to provide adequate soil moisture, which should be maintained during the active growing season at field capacity. A practical method for interpreting soil moisture across a number of soil types without using sophisticated measuring equipment is outlined in Appendix E. If the recommendation to provide a modest overstorey tree canopy is also implemented the dapple shade and improved micro-climate will help reduce summer water demand.

Care should be taken to ensure the hazelnut shrubs receive adequate watering during the crop development stages in a similar format to walnut based on peak water demand of around 5mm/day. Hazelnut yields have been described as highly sensitive to water stress during the period between fertilization and kernel filling and kernel filling takes place during a relatively short time-frame of

around one month (Mingeau *et al*., 1994). If inadequate watering takes place during this critical period the nut harvest yields will be adversely affected. Water demand drops quite rapidly in this genus once the kernels are filled.

Chestnut (*Castanea* spp.)

The chestnut genus differs from the walnut genus in that fruiting shoots arise from the previous year's growth. Therefore if irrigation and fertilization are neglected or other environmental factors affect growth in any one year, the nut yield in the following year will be adversely affected. Chinese chestnut trees are known to be drought tolerant once established, but ample water throughout the growing season promotes good tree growth and regular nut production. Maximum chestnut yields and nut size are obtained only under optimum soil water conditions, therefore irrigation is recommended. A lack of water during mid-August will result in smaller nut size, while a lack of water in September can prevent burs from opening normally, and this can create more work during the nut harvest (Hunt *et al*., 2012).

Irrigation Trials

It is recommended that consideration be given to testing various methods of irrigation as the HOMP is implemented. Methods should include both landscape and localized irrigation techniques:

- Open ditch flood irrigation (landscape)
- Micro sprinklers (localised)
- Drip systems (localised)
- Foggers (landscape)
- Deep root watering (localised)

3.5.9 Tree Risk Assessments

Tree risk assessments within GNFRP should continue to be carried out by an experienced and certified WDTA (Parks and Recreation Module). A new certification, CTRA has been developed jointly by the ISA and WorkSafe BC for the assessment of tree risk in the urban interface environment. However, at this time it is not considered necessary for the RDCO to change from its current assessment procedures with the following potential exceptions. In either case, it is strongly recommended that RDCO staff continue to conduct all tree risk assessments in-house and only rely on contracting under exceptional circumstances (for instance, following an extreme weather event) when existing staff may be required to fulfill other essential duties and are not available within a reasonable time frame to conduct assessments.

The Gellatly collection at GNFRP represents an unusual mix of species unique to BC. It is furthermore recommended that tree risk assessors have the knowledge and experience in assessing the particular species represented at GNFRP. The unusual branching habit and failure potential characteristics of some of the species are outside the range of species typically encountered during the CTRA training sessions. It would therefore be highly desirable for the RDCO to approach the local CTRA instructor and request a custom GNFRP training session as a supplement to recertification. Exceptions to conducting in-house assessments might fall into the following categories:

1. Independent investigation into tree failure when a liability claim has been cited against RDCO.
2. To provide a second independent opinion on a particularly controversial assessment, for instance where a particularly high value heritage tree is assessed as structurally compromised, warranting whole tree removal and members of the public/park users are requesting a second opinion.
3. An assessment is required by a certified tree risk assessor of a tree which is located at the perimeter of the property and overhangs a neighbouring property. Typically trees overhanging homes or public roads are not well covered by the assessment protocols provided under the WDTA certification. This can be interpreted as a 'grey' area in certification which was designed more for the rural or wilderness park locale. This 'grey' area was part of the reason for the development of the CTRA training program; however RDCO staff trained as a CTRA would still be best for assessing the tree(s) under these circumstances.

In all cases assessment findings should be well documented and the assessment records held securely at RDCO offices to ensure due diligence is fulfilled and that all inspections are defensible for a reasonable time period thereafter. It should be stated that all trees are living organisms and as such are subject to the forces of nature. It is both professionally and practically impossible to predict with absolute certainty the behaviour of any single tree or group of trees, or all their component parts, in all given circumstances. Inevitably, a standing tree will always pose some risk. Most trees have the potential for failure in the event of adverse weather conditions, and this risk can only be eliminated if the tree is removed.

3.5.10 Impacts Due to Recreational Use

Current recreational use at GNFRP appears to be contributing to limited soil compaction and minor erosion in the CRZ of some of the veteran heritage trees, in areas of high use and activity. These impacts can be readily addressed through measures such as root aeration, placing of composted bark mulch or perhaps realigning some portion of trails where they are located within the CRZ of high value heritage trees.

The more significant impacts appear to have occurred during Park development, irrigation and infrastructure installation, and ongoing damage as a result of mechanized maintenance and grass mowing activities. The impacts suffered during these phases are long-term in nature and will take more concerted efforts to alleviate.

Trails and Roads

Deep root fertilization and deep root irrigation are techniques that can be used separately or in combination (referred to as deep root fertigation) to promote root and plant recovery as well as provide soil aeration in the CRZ. In areas where compaction may have occurred, careful removal of the compacted road or trail surfacing material with hand tools or an AirSpade® is recommended. Additionally, installation of root aeration pipes, tree friendly rooting medium, geotextile fabric and re-surfacing of the trail with un-compacted gravel or a mixture of composted bark mulch and pea gravel as a preferred alternate is recommended. In the long-term it may be desirable to re-align a small proportion of the trails outside the CRZ; however it is reasonable to assume that due to site constraints and limitations this may not be possible in all cases.

3.5.11 Grass Mowing

Grass mowing activities appear to be adversely affecting the trees in a number of ways. The use of line trimmers in close proximity to the stem appears to have damaged the bark and cambium layers at the base of trees and shrubs. In most damage appears to be relatively minor, however it is cautioned that the cumulative effects are detrimental to the trees and damage increases the potential for the risk of introducing pests and disease. Installing compatible mulch in the CRZ will help alleviate these issues and reduce the grass mowing operator's temptation to use the line trimmers in close proximity to the stems.

The grass mowing machines also appear to be causing minor soil erosion and compaction in high traffic. Additionally, it has been observed that surface roots are partially exposed on occasions the mower blades appear to have made contact with the roots and scalped them allowing them to become exposed to decay pathogens. As stated, placing composted bark mulch in the CRZ of trees and shrubs will alleviate these issues, aid root-zone aeration and benefit tree health and recovery.

Figure 23. Access road construction caused root damage to the adjacent trees (RDCO, 2005).

Table 7. Criteria and performance indicators for cultural landscape values.

Criteria	Performance indicators				Key objective
	Low	Moderate	Good	Optimal	
Closely associated with the lives of individuals and/or families who are considered significant to the history of the area	Anecdotal evidence (hearsay)	At least one form of documentation exists which substantiates a probable close association with a particular person(s)	Multiple documentation exists in support of a close association with a person(s)	Comprehensive records, plans, maps and other documentation to support the close association to a particular person or persons	Archive and catalogue all historical records and data associated with the J.U. Gellatly selection and tree breeding nursery
Represents the work of a recognized subject matter expert or practitioner	Vestiges of the original landscape remain but may be masked by change	Most of the original landscape remains but has been modified by others to the extent that the original landscape is no longer dominant	The majority of the original landscape remains	Virtually all of the landscape remains as originally intended	Protect and restore the cultural landscape to accurately reflect how it was "back in the day" when it was operated as a selection and tree breeding nursery.
Represents all aspects of the tree breeding and selection work undertaken by J.U.Gellatly	Only a small proportion of the full spectrum of species are identified and represented on site	More than 50% of the full spectrum of species that J.U. Gellatly was breeding during his life time are represented	More than 70% of the species are represented at the site with interpretive information available for the general public	The full spectrum of the species that J.U. Gellatly worked with during his lifetime are represented at the site	Restore the J.U. Gellatly collection to include, where practical, the majority of genera and species that J.U.Gellatly worked with during his life time

Criteria	Performance indicators				Key objective
	Low	Moderate	Good	Optimal	
Interpretive materials are available to the general public and institutions	Only a small proportion of the trees are positively identified and catalogued	More than 50% of the trees in the collection are positively identified. Labelled and catalogued	More than 70% of the trees are identified, labelled and catalogued on site and on the website in the form of a virtual tour	All of the trees have been positively identified, labelled, catalogued and all information is available in multiple formats	Comprehensively identify all of the trees in the Gellatly collection, set up a living museum in the form of a heritage arboretum and catalogue and share this information widely
Provide a means of displaying the J.U. Gellatly nut tree collection to the general public and protect the genetic material for future generations	Less than 25% of the J.U. Gellatly collection are represented in the arboretum	50% of the J.U. Gellatly collection is represented in the arboretum	70% of the J.U. Gellatly collection is represented in the arboretum	The entire J.U. Gellatly collection is represented in the arboretum	Plant and maintain a heritage arboretum to protect the genetic material of J.U. Gellatly in perpetuity

Table 8. Criteria and performance indicators for genetic significance and collections management.

Criteria	Performance indicators				Key objective
	Low	Moderate	Good	Optimal	
Plant genetic resources are protected to help achieve long term food security	No system of preservation/conservation of plant genetic resources is in place	Limited (<30%) preservation/conservation of plant genetic resources for few genera/species	More than 50% of the collection of plant genetic resource has been provided for	Comprehensive system of protection for all identified plant genetic diversity across the collection, utilising multiple repositories/methods	To avoid erosion or permanent loss of genetic germplasm plant material resources
Plant breeders can access genetic material; new varieties can be bred to respond to climate change or food security	Genetic material is not fully catalogued	Genetic material is a well-catalogued collection in a single (archive)	Diverse genetic material exists as a collection that is replicated in multiple archives	Genetic material exists as a collection across multiple archives International Plant Genetic Resources Co-operative Programme for Genetic Resources	To reduce vulnerability of the collection to catastrophic loss
Moratorium on further tree removal until the entire collection has been identified	Live trees continue to be removed	Live trees have been removed after exhausting all other alternatives	Live trees have been removed only when their genetic resource has been conserved in some form	Live trees have been removed only when their genetic resource is catalogued and cloned for replacement in the landscape (or elsewhere)	Genetic resource conservation of the unique J.U. Gellatly collection

Criteria	Performance indicators				Key objective
	Low	Moderate	Good	Optimal	
Quarantine and phyto-sanitary arrangements (Inspections can be arranged with Canadian Food Inspection Agency (CFIA) or similarly qualified plant pathologist)	Imported plant material is not certified or quarantined prior to establishment at GNFRP	All new plant material is certified as free of disease prior to receipt at GNFRP	All new plant material is quarantined upon receipt at GNFRP	Imported plant material is certified as free of disease and quarantined in an on-site test-bed facility prior to introduction to the GNFRP collection	Protection of the collection from the risks of imported disease

Table 9. Criteria and performance indicators for nursery practice.

Criteria	Performance indicators				Key objective
	Low	Moderate	Good	Optimal	
Propagation of viable replicates of the J.U. Gellatly collection for both onsite use and sale	Seed stratification practices are poor and plant propagation occurs but does not meet demand	Seed collection and stratification procedures are effective. Nursery is managed to produce 25% of requirements.	Seed collection and stratification is practiced annually and nursery produces 50% of demand	Seed collected and stratified annually. Collection of scion material, layering and coppicing are practiced to clone genetic material	The nursery is managed to provide optimum availability of seedling and cloned genetic plant material
Invasive species management	Invasive species occur frequently in unused, unmanaged or disturbed ground.	Invasive species are documented and eradicated but there are no systems in place to reduce threats.	Invasive species are detailed in an action plan. Earl detection rapid response procedures are in place.	A comprehensive plan is developed and implemented systematically for invasive species management.	Provision of optimum protection for the J.U. Gellatly collection genetic resource from the effects of invasive species
Regional co-operation and stakeholder interaction	Nursery is managed in isolation of other landowners or other groups or agencies	Nursery is managed in cooperation with regional groups	Nursery operations are consistent with nearby landowners or interest groups to achieve goals on and off site	Nursery operations are consistent with regional or higher level plans.	Working with other agencies to ensure individual on-site actions are linked with broader activities beyond the Regional Park

Criteria	Performance indicators				Key objective
	Low	Moderate	Good	Optimal	
					context
Irrigation	Water use and weather is not monitored	Weather parameters are monitored on site. Water use is measured.	Weather parameters and water use is monitored and irrigation planned and scheduled.	Weather parameters are monitored and water use is optimized to assure plant health and conserve water use	Provide optimum irrigation for all nursery plant material while conserving water usage to a sustainable level.
Integrated Pest Management	Pesticide use is not monitored	Pesticides are not applied when weather conditions are not appropriate	Crop losses to pests are reduced by the planned use of preventive measures.	Management decisions based on monitoring, and a sophisticated IPM program is implemented.	Optimized IPM practices to prevent loss of nursery plant material
Plant health and Phyto-sanitary arrangements	Imported plant material is not subject to checks for pests and disease	All new plant material is certified as free of disease prior to receipt at GNFRP	All new plant material is quarantined upon receipt at GNFRP	Imported plant material is certified as free of disease and quarantined in an on-site test-bed facility	Protection of the genetic integrity of the J.U. Gellatly collection
Disease mitigation and Soil conservation	No measures are taken to conserve soil fertility or control soil-borne pests and disease	Limited measures are in place to sterilize imported pots, and regulate soil movement on and offsite	Soil is periodically tested for pathogens. Sterilization procedures are in place	Facility is certified for the propagation and re-sale of all plant material. Soils are regularly tested for pathogens	Ensure soil is properly managed and conserved and no soil-borne pathogens are taken on or off-site

Table 10. Criteria and performance indicators for operations maintenance.

Criteria	Performance indicators				Key objective
	Low	Moderate	Good	Optimal	
Tree health profiles	Crown dieback > 15%, overall tree decline and evidence of disease	Crown dieback is halted, <10% some live crown recovery is evident	Live crown recovery < 5%, improved nut harvest	Good annual increment, minimum five leaves past terminal shoot (*Juglans*) to promote optimum nut harvest	To maintain or enhance long-term health and vigour of all trees
Integrated Pest Management	Regular pest infestations and reduced nut quality evidenced	Continued pest treatments with little or no monitoring to efficacy	Gradual reduction of pest treatments as tree health profile improves	Emphasis of management placed on prevention methods implemented to optimize tree health and vigour	Adopt a balanced approach to tree health and vigour as a preventative measure in the IPM program (*dealing with the cause rather than the consequence*)
Irrigation	Drought stress evident in all genera across the site, continued dieback and tree mortality	Drought stress and reduced nut production is evident. Tree dieback halted	Tree health recovery is evident and reduced pest control is required	Genus and species specific irrigation is provided to optimize tree health and nut yields	To provide optimal water requirements with minimal wastage (non-target vegetation and evapotranspiration)
Fertilization,	Evidence of nutrient deficiency in trees and shrubs, reducing tree health, vigour and nut harvest potential	Soil amendments and fertilization improves the health and vigour of 50% of the tree inventory	Improved health and vigour is evidenced across 75% of the tree inventory	Soil pH and moisture regimes are amended and stabilized to optimize plant available nutrients Appendix A	To optimize site fertility and nutrient availability whilst minimizing the need for additional application

Criteria	Performance indicators				Key objective
	Low	Moderate	Good	Optimal	
Mulching, mowing and weed control	Turf grass is maintained in the tree and shrub root zones, continued line trimmer and mower damage evidenced	25% of the turf grass removed and walnut mulch is used on all tree species, raw wood chips are used to mulch trees and shrubs causing an imbalance in C:N ratio	50% of the turf grass removed and replaced with composted bark mulch or herbaceous legumes	Walnut mulch is managed separately and only used in walnut (*Juglans* spp.) genus root zones. Composted bark mulch used in all CRZ	Optimize mulching practice to suppress weed competition and improve soil moisture and nutrient regime. Organic mulch should be applied to a depth of < 5cm
Pruning practices	Continued poor pruning practices are in evidence, limiting photosynthetic potential and reducing nut yields	50% of trees are target pruned for structural form but practices still limit nut yield	75% of trees are target pruned to optimize structural form and retain nut positions	Pruning practices are focused on structural form for optimum nut yields and risk mitigation	Eliminate unnecessary and poor pruning practices which depletes the trees photosynthetic potential and nut yield
Recreation, trail and road impacts	Status quo is maintained, with no improvement to trail alignment, recreation use or soil compaction issues	25% of the recommended trail re-alignments are implemented, some root-zones mulched	50% of the trail re-alignment is implemented, some root aeration systems fitted and critical root-zones mulched	All trail re-alignments completed, root aeration systems fitted and all CRZ mulched and deep root fertilized.	Optimize tree friendly infrastructure design concepts throughout the park to benefit trees and protect heritage value of the entire J.U. Gellatly collection

4 Detailed Recommendations

Detailed recommendations for GNFRP are divided into short, medium and long-term categories. Time-lines were included for guidance only, and are prioritized on the current understanding of limited resource capacity and the biophysical needs of the tree inventory; therefore medium and long-term recommendations should be prioritized as funds become available.

Table 11. Short-term recommendations for the Gellatly Nut Farm Regional Park.

Short-Term (1-2 years)				
Tree Tag Numbers and/or Site Location	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
1-11 and 64-75, 82-101	English walnut	Severe drought stress Excessive crown dieback Low nut yield	Deep root fertigation of trees # 1-6	$420.00 per application (3years)
			Increase irrigation for all trees to walnut BMP see 3.5.7	RDCO staff (1) (1 hours/day)
			No treatment trees # 7-11	N/A
			Crown reduce by 25% trees # 64-75	$3,300.00
			Remove turf-grass and mulch CRZ of trees # 82-92	RDCO staff (4) plus rental of turf cutter $400/week (40 hours)
437,438 and 439	English walnut	Drought stress Severe root and crown damage and compaction (parking lot construction)	Relocate better specimens and replace trees with tree hazel or Chestnut. Ensure new trees are installed in adequate soil volume.	Contractor $2,200.00
177	English walnut	Planted in the CRZ of mature English walnut	Hand dig in dormant season and relocate to an open location, prune off root suckers	RDCO staff (2) (3 Hours)
169 and 179	English walnut	Drought stress CRZ damaged by trail construction	Crown reduce 20%	$600.00
			Apply deep root fertigation.	$120.00 per application
			Increase irrigation	RDCO staff (1) (0.15 hour/day)

Short-Term (1-2 years)				
Tree Tag Numbers and/or Site Location	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
12-32	Buartnut (*J. ailantifolia* × *J. cinerea*)	Drought stress Construction damage to root zones when park access road and irrigation system was installed	Deep root fertigation to address compaction and root loss, increase irrigation to walnut BMP	$600.00
			Remove turf-grass and mulch CRZ.	RDCO staff (4) plus rental of turf cutter ($300) (24 hours)
			There is no option for pruning these specimens	N/A
			Replicate genetic material and plant in arboretum.	$500.00
570, 571	Trazel and heartnut	Drought stress in heartnut Severe root damage during construction of access road	Deep root fertigation	$120.00 per application
			Increase irrigation to walnut BMP	RDCO staff (1) 0.15 hours/day
572,573,574,575 and 576	Buartnut (*J. ailantifolia* × *J. cinerea*) / heartnut	Drought stress Root damage, during park entrance road construction, CRZ compaction	Deep root fertigation	$300.00 per application
			Remove turf-grass and mulch CRZ 574, 575, 576 but do not apply as deep as 572 and 573 Organic mulches should be applied to a depth of <5cm	RDCO staff (4) Turf cutter rental ($100) (8 hours)
			Increase irrigation to walnut BMP	RDCO staff (1) (0.3 hour/day)
33	"Broadview" walnut	Drought stress Compaction and root damage in CRZ	Remove turf grass and extend existing mulch bed to include CRZ of tree #33, increase irrigation to walnut BMP	RDCO staff (4) Turf cutter rental ($100) (3 hours)
34	Red Oak	Drought stress. Soil compaction and CRZ damage during road and trail construction	Remove turf-grass and mulch CRZ out to trail edge (half-moon shaped mulch bed bordering trail on two sides.	RDCO staff (4) Turf cutter rental ($100) (6 hours)
			Increase irrigation	RDCO staff (1) (0.15 hour/day)

Short-Term (1-2 years)				
Tree Tag Numbers and/or Site Location	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
214 "Corsan"	Buartnut (*J. ailantifolia* × *J. cinerea)*	CRZ compaction and drought stress	Remove turf-grass and mulch CRZ	RDCO staff (4) (4 hours)
			Increase irrigation to walnut BMP	RDCO staff (1) (0.15 hour/day)
213 "Barny"	Buartnut (*J. ailantifolia* × *J. cinerea*)	CRZ damage (public road) and compaction, building materials stacked on roots and drought stress	Remove building materials from root-zone	RDCO staff (4) (2 hours)
			Mulch CRZ between barn and root crown	RDCO staff (4) (2 hours)
			Increase irrigation to walnut BMP	RDCO staff (21) (0.15 hour/day)
263 "Calander"	Buartnut (*J. ailantifolia* × *J. cinerea*)	Root-zone compaction and drought stress	Increase flower bed to 8m in diameter,	RDCO staff (4) Turf cutter rental ($100) (2 hours)
			deep root fertigation	$80.00 per application
			increase irrigation to walnut BMP	RDCO staff (1) (0.15 hour/day)
265, 266, 267, 268, 269	English Oak, Heartnut	CRZ damage due to trail construction Drought stress and compaction damage	Remove turf-grass to edge of trail and mulch root-zone	RDCO staff (4) Turf cutter rental ($100) (6 hours)
			increase irrigation for tree # 265 to walnut BMP	RDCO staff (1) (0.2 hour/day)
255	Buartnut (*J. ailantifolia* × *J. cinerea*)	Drought stress Compaction in CRZ Crown dieback/stem canker	Prune dead limb back to live sprout	$300.00
			Deep root fertigation	$80.00 per application
			Increase irrigation	RDCO staff (1) (0.15 hour/day)
			Remove turf-grass and mulch CRZ to edge of trail	RDCO staff (4) (4 hours) Rental of turf cutter ($100)

Short-Term (1-2 years)				
Tree Tag Numbers and/or Site Location	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
			Replicate and plant in arboretum (3 grafted trees)	$150.00
216 "Fioka"	Buartnut (*J. ailantifolia* × *J.cinerea*) / heartnut	Drought stress, CRZ compaction	Remove turf-grass and mulch CRZ	RDCO staff (4) (4 hours) Rental of turf cutter ($100)
			DNA test to confirm pedigree	In progress
			Change sign if necessary	$100.00
			Increase irrigation	RDCO staff (1) (0.15 hour/day)
224	Grafted tree hazel	Root damage from trail and seating bench construction	Deep root fertigation	$80.00
			Replicate and plant in arboretum, 3 grafted trees	$150.00
			Increase irrigation	RDCO staff(1) (0.15 hour/day)
440	horse chestnut (*Aesculus hippocastanum*)	Toxic plant including the nut which is similar in appearance to sweet chestnut (*Castanea* spp.)	Remove one tree	$100
			Plant new Gellatly specimen tree in traffic circle.	$150
Black Cottonwood grove	Black Cottonwood	Heavily phototropic juvenile tree perimeter	Gradually thin and re-space to benefit trees with good stem taper and upright form	$4,000.00
			Remove trees which are shading out the walnut trees growing in the understory	$1,500.00
442 and 443	Tree hazel	Soil compaction and contamination	Remove the tractor and equipment currently stored in the CRZ.	RDCO staff (4) (2 hours)
			Deep root aeration to amend compacted soil	$160.00
			Remove turf grass and install mulch in root zones	RDCO staff (4) (2 hours) Rental of turf cutter ($100)

Short-Term (1-2 years)				
Tree Tag Numbers and/or Site Location	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
Seedling nursery	N/A	Mixed storage of all genus chips, leaf mulch and nut residues	Provide separate storage for all *Juglans* residues, do not use *Juglans* residues around other genera	RDCO staff (4) (8 hours) Labour and machinery
			Ensure all plant material brought onto site is pest/disease free	No cost Procedures manual
			Optimize irrigation and fertilization regimes	RDCO staff (1) (0.25 hour/day)
Mowing/line trimming	All trees/shrubs	Line trimmer and mowing damage to root zones	Conduct awareness and BMP training for the mowing contractor and machine operators to limit basal and surface root damage	Consultant workshop $800.00
Turf grass substitution with herbaceous legumes	All critical root zones (CRZ of trees and hazelnut shrub rows	To reduce turf grass competition for irrigation and fertilization.	Commission Professional Agrologist (P.Ag.) to conduct study into the most appropriate herbaceous legumes for use in CRZ	Consultant report estimate $5,000.00
Heritage orchard trees only	All genera	Conservation of unique germplasm genetic plant material	Impose a temporary moratorium on the removal of live trees from the Gellatly heritage orchard until the cultivar/hybrid has been positively identified, genetic germplasm material has been stored at one or more germplasm repositories and replicates have been successfully established in the proposed heritage orchard arboretum (see section 3.2.7) Also see exceptions for high risk hazard or failed trees.	N/A

Short-Term (1-2 years)				
Tree Tag Numbers and/or Site Location	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
Heritage orchard trees	All genera	Early detection rapid response to pests and disease	Continue to research, monitor and mitigate tree pests and disease, train RDCO staff in the recognition and prevention of chestnut blight (*Cryphonectria parasitica*), eastern filbert blight (*Anisogramma anomala*) and butternut canker (*Sirococcus clavigignenti-juglandacearum*)	Staff training session Forest pathologist with expertise in heritage nut tree genera present at GNFRP $1500 One day course
All trees	All genera	Tree inventory database management and tree inspections	Continue with regular inspections of all trees, mitigate hazards as they arise, address pests and disease issues and employ adaptive management strategies to optimize IPM program. Update the GIS database on a regular basis	RDCO staff time Periodic assessments

Table 12. Medium-term recommendations for the Gellatly Nut Farm Regional Park.

Medium-Term (2-5 years)				
Initiative	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
Water balance study	All genera	To determine water demand by species to optimize irrigation system	Commission water balance study to determine water demand during crop development stages and provide optimum irrigation system design parameters	Consultant project Estimate $10-15,000
Irrigation trials and system improvements	All genera	Insufficient irrigation leading to variable drought stress	Trial different methods of irrigation to determine the most efficient method for each genus	TBD
			Install or upgrade existing irrigation systems tailored to the specific water demand needs of each genus	Possible increased water usage costs? Countered by reduced area for turf grass irrigation New sprinkler heads purchased $7,000.00 (GNFS 2012) Upgrade pumping equipment? TBD based on outcome of water balance study
			Design and install historic flood irrigation system to demonstrate the historical use and application. Investigation and pre planning will be required to ensure tree root systems are not compromised	TBD

Medium-Term (2-5 years)				
Initiative	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
Soil compaction	All genera	Machinery and foot traffic causing soil compaction	Implementation of soil aeration techniques across the site (trees only) hazelnut (*Corylus* spp.) shrubs do not appear to be suffering to the same degree	All orchard trees $20,000 Estimated $40/tree cost
			Realign trails where they are located in the CRZ of trees and shrubs. An estimated 12 trees CRZ are affected across the site	Cost estimates TBD on case by case basis: Estimated $12,000 Allowing $1,000.00 per tree for installation of root aeration system in CRZ.
			Deep root aeration of trees	$80.00 per tree for small number Apply volume discounts Reduced to $40/tree for >50 trees per application
Turf grass competition	All genera	Turf-grass growing in the CRZ of trees and shrubs competing for nutrients and moisture	Gradual removal of turf-grass from the CRZ of trees and shrubs	RDCO staff time plus rental of turf cutter – turf removed should be piled and composted on-site Turf cutter = $100/day $400/week or $1,000.00/month
			Replace turf grass in CRZ with mulch and or legumes	RDCO staff time and use of composted mulch supplied by on-site debris management
			Investigate the potential to change turf care management regime to benefit trees health and vigour. (reduce turf grass irrigation in summer, increase minimum height for cutting etc.)	Based on field observations estimated 30-40% reduction in annual turf care costs

Medium-Term (2-5 years)				
Initiative	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
Soil fertility	All genera	Nutrient deficiency and soil pH incompatibility	Investigate nutrient availability using Plant Root Simulator PRS™ probes and compare bio-available nutrient values with baseline or reference values Appendix A	RDCO staff time (8 hours for 2 staff)to install PRS plant root simulator probes and dispatch them for analysis Laboratory costs for probes and analysis 100 PRS probes @ $44/probe $4,400.00
			Amend soil pH where it is adversely affecting certain genus	TBD based on results of fertility analysis
			Fertilize soils as necessary to bring them within required nutrient regime parameters for each genus/species	TBD based on results of fertility analysis
			Investigate the use of legumes to boost available nutrients to enhance tree health and vigour	Reduced mowing and fertilization costs will help offset costs of conversion to herbaceous legumes ground cover
			Apply deep root fertilization techniques to recover the health of high value heritage specimens three annual treatments are expected to be required to recover health and vigour	Cost per tree per application $40-90.00 Economy of scale discounts can be applied for treatment of large numbers of trees 30-50% reduction of costs
Pruning practices	All genera	Over-pruning and poor pruning practices	Conduct a training workshop for facility staff to teach the principals of pruning practices as they relate to GNFRP	Consultant workshop $800.00

Medium-Term (2-5 years)				
Initiative	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
			Limit pruning to essential risk mitigation and structural pruning and training of juvenile plant material	Overall cost saving expected as the plant health profile of the trees/shrubs improve
			Optimize pruning practice to conserve nut bearing capacity	RDCO and GNFS training workshop $800.00
Integrated Pest Management	All genera	Reliance on pest management to address issues caused by tree stress due to drought and fertility deficiency	Gradually improve tree health and vigour and increase use of prevention measures to reduce the need for pest management	Overall cost savings expected in reduced IPM treatment and pruning costs $10,000/annum (GNFS) proportional cost saving can be diverted to other initiatives
Conservation of genetic tree material	All genera	Poor knowledge of the pedigree of many of the trees and shrubs at GNFRP	Use all available methods to positively identify as many trees on site as possible	GNFS/RDCO staff time $20/sample DNA testing at University of Notre Dame
			Subject matter experts, nut collections, reference materials)	$1500 flight and accommodation for subject matter experts (Charles Rhora)
			Submit known specimen material to offsite germplasm repositories for conservation NGR Davis, CA (*Juglans*)	GNFS/RDCO staff time $1500.00/30 trees $50/tree
			Preserve and replicate the few remaining original tree tags	RDCO staff time plus new signs $2,000.00

Medium-Term (2-5 years)				
Initiative	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost ($) and Staff Time**
			Reintroduce unique specimens which are no longer represented at GNFRP but available through offsite collections	Partnership agreements with HRBG and others Shipping costs of scion material and grafting costs at local nursery Circa $300/specimen
			Obtain scion material and clone new specimens for each unique tree and shrub at GNFRP	$1500.00 per 30 trees $50 per tree
Nut collection	All genera	Enhance the current limited nut collection	Collect and preserve nuts from identified specimens which are currently not represented in the historic nut collection	RDCO/GNFS staff time 40 hours/annum
			Develop interpretive materials and display the nut collection at secure venues across Canada	RDCO/GNFS staff time 60 hours/annum
DNA analysis	All genera	Continue to conduct DNA analysis of unique specimens to establish and document the pedigree	Work with institutions like the University of Notre Dame to establish the pedigree of and build a comprehensive genetic database for the Gellatly collection (To date no Canadian institutions have been located with DNA databases for the Gellatly collection)	RDCO/GNFS staff time $50/tree to collect foliar samples and scion material

Table 13. Long-term recommendations for the Gellatly Nut Farm Regional Park.

Long-term Priority (5-10 years)				
Initiative	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost $ or Staff Time**
Establish a heritage nut tree arboretum	All genera	Create a living museum of the Gellatly collection	Develop a master plan for the establishment of a heritage nut tree arboretum	Consultant $5,000.00
			Clone unique specimens as the pedigree is established and plant them in the appropriate locations in the arboretum	$50/tree 140 trees (3 trees/specimen) $21,000.00
			Develop and install arboretum signage and interpretive materials	140 signs @ $60 $8,400.00
			Periodically update mapping and inventory to reflect all changes	RDCO staff time 40 hours/annum
Develop partnerships with germplasm repository, institutions and arboreta	All genera	Improve industry networking potential and create secure offsite repository for genetic tree material	Open dialogue with germplasm institutions and arboreta across North America to establish the appetite for creating offsite satellite J.U. Gellatly collections	RDCO/GNFS staff time 40 hours
			Develop memorandum of understanding for partnership initiatives	RDCO staff time 20 hours
			Supply and exchange germplasm tree material	RDCO staff time plus scion material collection @$50/tree
Promote the unique Gellatly collection	GNFRP	Develop and expand promotional materials for this unique tree	Develop and share promotional materials with an expanded audience	RDCO/GNFS staff time plus the cost of website upgrades $5,000.00

Long-term Priority (5-10 years)				
Initiative	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost $ or Staff Time**
		breeding and selection nursery	Promote the heritage tree/seed aspect of the facility	Web based promotion, costs are assumed to be included in website upgrades
			Offer seedlings and cloned plant material for sale	Should be cost neutral or revenue generating commission sales for existing Gellatly plant material being sold by others?
			Develop workshops and educational materials for tree breeding, cross pollination, grafting, propagation, nut preparation, stratification and storage etc.)	These initiatives should become cost neutral as they are delivered on cost recovery basis Consultant costs for developing and delivering workshops $800 for one day
			Develop and promote added value merchandise for all visitors	Expected to be cost neutral and revenue generating in the long-term (Appendix B)
Selection and tree breeding	All genera	To replicate the work of J.U. Gellatly	Use archive material and research documents to develop education in the art and science of nut tree breeding and selection, emphasising the pivotal role J.U. Gellatly has played in developing the trees grown in the orchard industry today	Consultant cost to compile and compose education materials $3,000 per theme Themes include cross pollination hybridization propagation techniques
			Investigate the potential to perform some limited onsite tree breeding and selection to continue and demonstrate the work of J.U. Gellatly	Out-source contract to set up a trial breeding program $15,000.00

Long-term Priority (5-10 years)				
Initiative	**Genus/Species**	**Issue to Address**	**Recommendations**	**Estimated Cost $ or Staff Time**
			Promote the worldwide planting of Gellatly germplasm genetic plant material	Research and create a suppliers list for sourcing clones Gellatly plant material see section (3.2.2)
Coppice	Hazelnut shrubs	Rejuvenate the older hazelnut shrubs through the use of coppice techniques	Gradually coppice the older hazelnut shrubs to help restore specimens which are no longer producing nuts at their optimum potential and to reduce nutrient and moisture stress	RDCO staff time and equipment (4) 120 shrubs per annum 160 hours
Plant a beneficial overstorey tree canopy in hazelnut shrub areas	Hazelnut shrubs	To reduce the need for high levels of irrigation and to ameliorate the effects of drought stress	Plant beneficial species (not *Juglans*) to form an overstorey canopy for the hazelnut shrub rows. (The overstorey trees will also form the heritage nut tree arboretum	RDCO staff time (4)to plant trees (160 hours) 300 cloned trees at $50/tree Costs are included above in arboretum cost estimate
Allelopaths	Walnut genus	To reduce or gradually phase out the potential for detrimental allelopathic effects on susceptible genera	Develop a master plan to gradually segregate the walnut genus and the residues so that they are not exerting allelopathic effects on the other genera	RDCO/GNFS staff time and GIS mapping services 90 hours

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6 Glossary

Arboriculture is defined as the **c**ultivation of trees, shrubs, and woody plants including all aspects of growing, maintaining, and identifying plants, arranging plantings for their ornamental values.

Canadian Food Inspection Agency (CFIA) Federal agency responsible to the early detection and prevention of exotic pests and diseases entering Canada.

Canadian Plant Germplasm System (CPGS) is a network of centres and people dedicated to preserving the genetic diversity of crop plants, their wild relatives and plants present and unique in the Canadian biodiversity. The system plays a significant part of Agriculture and Agri-Food Canada's commitment to the Canadian Biodiversity Strategy in response to the Convention on Biological Diversity.

Critical Root Zone (CRZ) considered the area of a tree or shrub root system which occupies the soil matrix within the outer perimeter of the live tree canopy (Canopy drip-line).

Certified Tree Risk Assessor (CTRA) a person who has passed the certified tree risk assessor course and exam as administered by the International Society of Arboriculture.

DNA a double stranded nucleic acid DNA consists of two long chains of nucleotides twisted into a double helix and joined by hydrogen bonds. The sequence of nucleotides within the DNA determines individual hereditary characteristics.

Greenhouse Gas (GHG) emissions of gases to the atmosphere which are capable of absorbing or emitting radiation, gases which are commonly referred to include carbon monoxide, carbon dioxide, methane, nitrous oxide.

Hamilton Royal Botanical Gardens (HRBG) The Royal Botanical Gardens and Arboretum located in Hamilton, Ontario.

Included bark that has been covered by the growing together of adjacent, vertically growing stems or branches thus creating weakened attachments

Integrated Pest Management (IPM) defined as a pest management program which considers all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment.

International Society of Arboriculture (ISA) a membership society dedicated to the promotion of education in the practice of arboriculture.

National Germplasm Repository (NGR) is a cooperative effort by public (State and Federal) and private organizations to preserve the genetic diversity of plants

Northern Nut Growers Association (NNGA) The Northern Nut Growers Association, Inc. (NNGA) is a national non-profit organization with members throughout the US and 15 foreign countries founded in 1911 to share information on nut tree growing.

Pacific Agri-Food Research Centre (PAFRC) Agriculture and Agri-Food Canada's research centre located at Agassiz, British Columbia.

Society of Ontario Nut Growers (SONG) a membership society founded in 1972 dedicated to the support and promotion of nut tree breeding and growing in Ontario, Canada.

Species abbreviation sp. indicates the singular form, spp. indicates plural species, and ssp. indicates a subspecies.

Wildlife Danger Tree Assessor (WDTA) a person who has passed the course and exam currently administered by the University of Northern British Columbia (UNBC)

Visual Tree assessment (VTA) industry standard procedure for the inspection of trees for appraisal or tree risk assessment

Appendix A - Research Price List for Plant Root Simulator (PRS)™ Probes

Applying Research Solutions to Agriculture and the Environment

Research Price List 2012

Plant Root Simulator (PRS)™-Probe Price List

PRS™-probe Complete Analysis:

Analysis includes: NO_3^--N, NH_4^+-N, P, K, S, Ca, Mg, Fe, Cu, Zn, B, Mn, Al, Pb and Cd

Non-Collaborative	*Collaborative**	*Collaborative & Graduate Student Discount***
$44.00	$37.40	$33.66

PRS™-probe Anion-only Analysis:

Analysis includes: NO_3^--N, P, S, Fe, Cu, Zn, B, Mn, Al, Pb and Cd

Non-Collaborative	*Collaborative**	*Collaborative & Graduate Student Discount***
$34.00	$28.90	$26.01

PRS™-probe N-only Analysis:

Analysis includes: NO_3^-N and NH_4^+-N,

Non-Collaborative	*Collaborative**	*Collaborative & Graduate Student Discount***
$24.00	$20.40	$18.36

Note: Each PRS™-probe analysis price includes up to 4 pairs of PRS™-probes (i.e., 4 anions and 4 cations) to spread throughout the experimental unit and then combine for analyses, much like a composite soil sample. Following PRS™-probe burial and washing, labeled samples are shipped back to Western Ag for analysis.

* **Collaborative** research prices are provided to qualifying researchers that sign a Collaborative Research Agreement and include a 15% discount on the cost of analyzing PRS™-probes. We provide additional technical advice, and in return ask for a brief proposal indicating how the PRS™-probes will be used and a final report at the end of the experiment.

** **Graduate Student Discount** is an additional 10% discount applied to the first year of a study if there is a graduate student affiliated with the research.

Free Basic Shipping is included with all orders exceeding $1500 (allow two weeks for delivery). The basic shipping cost to North American destinations for orders below $1500 is $25. Please contact an R&D coordinator regarding costs for expedited delivery or international orders below $1500.

#3-411 Downey Road, Saskatoon, SK, CANADA, S7N 4L8
Phone: 306-978-1777 Fax: 306-978-4140

Appendix B - Chestnut Value-Added Products

Chestnut Value-Added Products: Unique Niche Market Opportunities

Product	*Description*
	**Fresh roasted or raw, in-shell chestnuts:** Best if sold immediately after harvest. Market opportunities include farmers' markets, local festivals, restaurants and specialty grocers. Attractive packaging – such as a fabric drawstring bag – should include preparation and storage instructions. Roasted or fresh chestnuts can sell for $4.50 to $6.50 per pound at the retail or direct customer level. Organic, locally grown chestnuts receive the highest prices.
	**Chestnut flour:** This gluten-free, finely ground product is a gourmet ingredient in pastries, pastas and desserts. Chefs may purchase chestnut flour for these purposes; consumers with gluten allergies or special diets also are increasing demand for chestnut flour. Due to the starchy consistency of chestnuts, specialized equipment may be necessary; this chestnut flour product is milled with imported equipment at Allen Creek Farm in Washington (www.chestnutsonline.com) and sells for more than $9 per pound. Other chestnut flour producers: Chestnut Growers, Inc., Michigan, http://www.chestnutgrowersinc.com/ordering.shtml; Ladd Hill Orchard, http://www.laddhillchestnuts.com/; and Empire Chestnut Company, http://www.empirechestnut.com/produce.htm#kernel
	**Mixes/gift packs:** Dried chestnuts, chestnut flour and other gourmet ingredients are featured ingredients in specialty food mixes, such as chowder, bread, scone, wild rice, pasta, cornbread and pancake mixes. These mixes are attractively packaged by Allen Creek Farm (www.chestnutsonline.com) and Ladd Hill Orchards (http://laddhillchestnuts.com/), for example.
	**Sweet chestnut puree/marron glacés:** Sweet chestnut puree is used in desserts like crepes, for example. Marron glacés are candied chestnuts that are eaten on their own or used as a garnish for other desserts. Both are common in Europe and imported here, but rarely produced in the United States and might be an interesting niche for a grower. (This Michigan-produced chestnuts in maple syrup product, left, is a twist on traditional sweet chestnuts: http://www.earthy.com/Earthy_Delights_Michigan_Chest_P892.cfm)
	**Dried chestnuts:** Dried chestnuts are excellent for long-term storage and can be rehydrated to be ground and used as a base for pasta, breading for fish or sprinkled on your potato for a sweet topping. Chestnut Growers, Inc., Michigan, has developed a freeze-dried chestnut slice that's shelf-stable for up to two years and can be rehydrated in only 15 minutes. They sell for about $20/8 oz. (8 oz. doubles when reconstituted) and can be purchased online (http://www.chestnutgrowersinc.com). Empire Chestnut Company also sells dried chestnuts – http://www.empirechestnut.com/produce.htm#kernel
	**Chestnut snack packs:** Green Valley Chestnut Ranch sells this unique Chestnut Snack Pack, a 50 gram pack of peeled, whole-roasted and ready-to-eat chestnuts – a delicious and nutritious snack. (www.chestnutranch.com)
	**Chestnut honey:** Chestnut honey is a popular and high-demand product in France, Italy and other European regions. Made from chestnut flowers, the honey is delicious in flavor and excellent in color. Many U.S. growers also are producing this gourmet product. Chestnut honey from Nutquacker Farms, pictured here, sells for approximately $10 per 12 oz. jar. (www.nutquackerfarms.com/). Ladd Hill Orchards also sells honey, in different quantities, at http://www.laddhillchestnuts.com/
	**Chestnut beers, wines and liquors** are enjoyed across Europe, with small-scale production existing in the U.S. Available chestnut beers include "Fuego del Otoño," a seasonal beer produced by Jolly Pumpkin Artisan Ales, Michigan (see http://www.jollypumpkin.com/beers.htm). In addition, Lee Williams of Trails End Chestnuts, Washington, provides roasted chestnut chips and instructions for anyone wanting to brew their own chestnut beer (http://www.chestnuttrails.com/)
	**Frozen, peeled chestnut meats:** The Australian Chestnut Company (www.cheznuts.com.au) sells frozen, peeled chestnut meats under the "Cheznuts" brand name with the tagline: "Chestnuts made easy." The product is quick and convenient for everyday cooking. Peeled Frozen Chestnuts are also available from Michigan's Chestnut Growers, Inc. See http://www.chestnutgrowersinc.com

Appendix C – Hazelnut Growing in British Columbia - Historical Background

Hazelnuts

The hazelnut *Corylus avellana* also known as filberts or cobnuts is an unusual and extremely interesting plant. The genus name *Corylus* is originated from the Greek word "Korys" meaning a helmet or hood. The name hazel has a similar origin; the angle-Saxon word for hood - "haesel." The name filbert is likely to originate from St. Philbert, whose least day is celebrated on August 22, about the time the nut matures. There are number of *Corylus* species. Just to mention few of interests- *C. americana* ranges from Main to Saskatchewan and south to Georgia, *C. avellana* ranges throughout Europe Turkey and the Middle East. *C. californica* is native in the milder areas of British Columbia, *C. rostrata* in eastern British Columbia and *C. cornuta* to the Peace River

There is much folklore associated with hazelnuts. The hazelnut term supplied the wood for the first divining rods supposedly used to find water. These were also called dowsers and witching wands, and allegedly found use in helping finds buried treasure or veins of ore. The filbert and hazel nuts were said to possess mystic powers and used in ancient rites. Temple priests burned the nuts upon altars. Herbalists and healers used the nuts in their remedies. The nuts were also used in marriage ceremonies as symbols of fertility.

At time it was the dominant vegetation of northern Europe, being the first shrubby tree to appear after the glaciers receded. However, commercial production is limited only to four areas of the world. These areas have climates influenced by large bodies of water; have cool summers and mild winters. About 75% of the world's production comes from Turkey, Italy and Spain produce about twelve and 5% of world production, respectively. The remaining 3% is produced in North America. Oregon's Willamette Valley produces about 95% of the North American hazelnut production. The bearing acreage is about 30,000 acres most of it planted to 'Barcelona' (80%), 'Ennis' accounts for 11%. In B.C., production amount to one thousand tonnes harvested off about 800 acres. The orchards are centred around Chilliwack and Agassiz. The dominating varieties are 'Barcelona', 'Ennis' and 'Duchilly' and for pollination 'Butler' and 'Daviana.' The late Henry Wigand of Agassiz deserves recognition and credit for his leadership, development and promotion of the B.C. hazelnut industry. He established the B.C. Hazelnut Growers Association a group that represents about sixty members that promote research, grower education, marketing and promotion of hazelnut and hazelnut products.

Hazelnuts are grown as single-trunk trees to facilitate mechanical harvest and other orchard practices. Tree spacing is usually 6x6 metres, although some growers plant at 3x6 and remove half the trees later. Harvest is generally in the first week of October. For harvest a sweeper is used to push the nuts into a row, and a harvester which picks up the row of nuts and places them in tote boxes. The boxes are then

taken to drying facilities where the nuts are cleaned and then dried with warm forced air. In the past the main emphasizes was production for the in-shell market, but recently the trend is shifting toward the kernel market.

Hazelnut flowering is most unusual. The tree is monoecious, which means that it has separate male and female flowers, both of which exist on the same tree. They are also self-sterile and must receive pollen from a different cultivar for nut set. Hazelnuts are wind-pollinated. In commercial planting the ratio of pollinizer tree to main crop trees is about one in twenty-five. In B.C. flowering occurs in mid-winter - January to February. The pollen grains are formed in catkins, the female flowers have no petals or sepals and in the time of pollination has no ovary. The pollen grain land on the stigma and grows to the base of the style within four to seven days of pollination. Then the pollen tube becomes quiescent for five to six months until May - June when the ovary enlarges and the ovule develops. Fertilization then can take place and the process is complete with the embryo and the kernel (seed) develops the nut mature and drop to the ground in fall.

The pests and diseases that attack hazelnuts are: leaf-rollers, aphids, scales and filbert blight (Bacterial blight). Eastern Filbert Blight (EFB) has not been seen in British Columbia although it is present in Washington and Oregon. Where the disease kills entire orchards causing severe damage. In Oregon major research effort are committed to develop resistance cultivars, study the epidemiology of EFB and how to control it. To prevent the spread of EFB to Canada quarantine on the movement of hazelnut trees from the USA to Canada has been legislated.

The Gellatly family deserves recognition for their outstanding devotion to the development of nut growing in B.C. The late J.V. (Jack) Gellatly a settler on the shores of Okanagan Lake, near Westbank, devoted most of his life experimenting with the growing breeding and propagation of number of nut crops including filberts, walnuts and chestnuts. To produce new hardier hazelnut varieties, Mr. Gellatly grew trees from nuts gathered around the world and crossed them with domestic varieties, producing new varieties that were superior in many ways. He used the hardy Peace River Hazel (*C. cornuta*) as a pistillate parent in crosses with European filbert (*C. avellana*). His objective was to incorporate the quality of the latter with the hardiness of the former. Gellatly named about thirty-five hybrids; however, none of them has received commercial acceptance. His most significant contribution lies in providing germ-plasm breeding material for other breeders as a basis for crosses involving production of rootstocks, ornamental trees, and trees with winter hardiness, large-sized nuts and early maturing nuts. In Michigan several of Gellatly's selections were back crossed with Royal to obtain hardy vigorous trees with high quality nuts. Many of the Gellatly varieties were last and no longer available. Efforts to preserve this valuable germ-plasma have not always been successful. Last year sixteen of the Gellatly varieties and selections have been planted in a hazelnut variety trail at the Pacific

Agri-Food Research Centre in Agassiz. This plant material has been obtained with the help and cooperation of Robb Bennett, MFLNRO and Mike Carlson from the Kalamalka Forestry Centre in Vernon.

There are several public misconceptions about the consumption and nutritional value of nuts creating awareness of the health risks of cholesterol and high fat diets. The facts are that nuts have essentially zero cholesterol; they do synthesize other sterols such as sitosterol that may actually reduce risks from cholesterol by blocking cholesterol uptake. Hazelnut composition is high in vitamin E (tocophenls), vitamin B6, unsaturated fatty acids (mainly oleic acid) and dietary fibre (pectines). All substances which significantly reduce risk of coronary heart disease, some types of cancer, help in the control of type II diabetes and other diseases and physiological conditions. Eating 25g of hazelnuts per day gives 100% of the recommended daily allowance for vitamin E, and 25% for vitamin B6. **As studies have shown, we should eat nuts every day for better health!**

Chaim Kempler, Small Fruit Breeder
Pacific Agri-Food Research Centre, PO Box 1000, Agassiz, BC V0M 1A0
(604) 796-2221, Ext: 224 Fax: 796-0359 Email: kemplerc@em.agr.ca
Web site: http://res.agr.ca/agassiz/biograph/kempler.htm

Appendix D - Southern Ontario Nut Growers Annual Meeting Document Excerpt

Excerpt from Fifth Annual Meeting of Southern Ontario Nut Growers (SONG) Dated 1977:

The Royal Botanical Gardens, Hamilton, hosted more than 45 SONG members for their 1977 Annual Meeting. Many of the nut growers came early to participate in the picnic lunch session. …… Lastly the R.B.G. staff with Freek Vrugtman in the lead took the SONG members for a tour of the grounds of the Gardens and in particular showed the extensive nut nursery plantings. Both well-known and rather exotic species from the **J. U. Gellatly Nursery** were studied at some length by the enthusiastic nut growers.....refer to the detailed article describing the selections of scion wood which are available for distribution to SONG members.

Special Offer - Royal Botanical Gardens

Below is a list of nut tree selections developed by **J. U. Gellatly,** and currently growing in nursery rows at the Royal Botanical Gardens, Hamilton. Freek Vrugtman, curator of collections at R.B.G., has notified SONG that until the plant-out site at R.B.G. can be brought up to a standard, suitable for growing specimen trees, the listed selections will be pruned back, and held in the R.B.G. Nursery. As a mutual aid effort R.B.G. will give out trimmed-off cuttings in mid- March, 1978. Co-operators are invited to graft selections, and be prepared to return this favour should R.B.G. lose one or more of the originals.

Direct Requests on or before February 15, 1978 to: R.R. #3, Lakeshore Road, Niagara-on-the-Lake ON LOS 1JO Ernie will prepare the mailing list for R.B.G. by the first week in March, 1978. Hopefully, requests will be flexible, so that all cuttings from each selection can be completely utilized.

Royal Botanical Gardens Hamilton, Ontario Nut Collection

Plants listed are at various locations, including the Propagating Department of the Gardens.

ID Tag #	Genus	specific epithet	English Common	Location Code	Garden Area	Location	Last Check Date	BAB notes
75015	Juglans	nigra	Black Walnut	AR-NT-S	Arboretum	Native Trees Collection - South	2002	Sep 2012; not identified
64161	Corylus	colurna	Turkish Hazel	AR-AV-2	Arboretum	Avenue of Trees #2	Jul-10	Sep 2012; located in an avenue
71226	Carya	cordiformis	Bitternut Hickory	AR-NT-S-4	Arboretum	Native Trees Collection - South	May-12	Sep 2012; not identified
75010	Carya	ovata	Shagbark Hickory	AR-NT-S-4	Arboretum	Native Trees Collection - South	May-12	Sep 2012; not identified
75073	Castanea	dentata	Sweet Chestnut	AR-NT-S-4	Arboretum	Native Trees Collection - South	May-12	Sep 2012; not identified
74601	Carya	ovata	Shagbark Hickory	AR	Arboretum	Unk	No check date	
74600	Carya	ovalis	Pignut Hickory	AR-LD-O	Arboretum	Lilac Dell, Section "O"	No check date	Sep 2012. Bottom of the lilac dell, good condition, no tag.
74005	Castanea	sativa	Sweet Chestnut	AR Trial Only - Ravine North	Arboretum	North of Entrance Road	No check date	Sep 2012. Not found.
69311	Corylus	americana	American Hazel	AR NC	Arboretum	Near Nature Interpretive Centre	No check date	Sep 2012. Not found. There is a sign indicating presence of one.
72518	Corylus	cornuta	Beaked Hazel	AR WP BED SE7	Arboretum	Weeping Trees Bed Section 7	No check date	Not checked.
XX216	Carya	ovata	Shagbark Hickory	TG-PK-NE	Teaching Garden		1995	Sep 2012. Excellent condition, tagged. Commemorative tree, memorial plaque attached.
62614	Juglans	cinerea	Butternut	TG-PK-NE	Teaching Garden		1995	Sep 2012. Missing.
71232	Juglans	cinerea	Butternut	TG-PK-NE	Teaching Garden		1995	Sep 2012. Missing.
XX224	Juglans	nigra	Black Walnut	TG-PK-NE	Teaching Garden		1995	Sep 2012. Not tagged. Good condition.

Appendix E - Guide for Practical Interpretation of Available Soil Water for Various Soil Textures

Prepared by David A. Goldhamer, Extension Irrigation Specialist.

Adapted from SCS National Engineering Handbook, Chapter 15, 1964 and Israelsen *et al*., Irrigation Principles and Practices, 1980.

Available Water (%) [1/]	Feel or Appearance of Soil			
	Sand	Sandy Loam	Loam/Silt Loam	Clay Loam/Clay
Above field capacity	Free water appears when soil is bounced in hand.	Free water is released with kneading.	Free water can be squeezed out.	Puddles; free water forms on surface.
100 (Field capacity)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand. (1.0) [2/]	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand (1.5)	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand. (2.0)	Upon squeezing no free water appears on soil but wet outline of ball is left on hand. (2.5)
75-100	Tends to stick together slightly sometimes forms a weak ball [3/] under pressure. (0.8 to 1.0)	Forms weak ball, breaks easily, will not slick. (1.2 to 1-5)	Forms a ball, is very pliable slicks readily if relatively high in clay. (1.5 to 2.0)	Easily ribbons out between fingers, has slick feeling. (1.9 to 2.5)
50-75	Appears to be dry, will not form a ball with pressure. (0.5 to 0.8)	Tends to ball under pressure but seldom holds together. (0.8 to 1.5)	Forms a ball some-what plastic, will sometimes slick slightly with pressure. (1.0 to 1.5)	Forms a ball, ribbons out between thumb and forefinger. (1.2 to 1.9)
25-50	Appears to be dry, will not form a ball with pressure. (0.2 to 0.5)	Appears to be dry, will not form a ball. (0.4 to 0.8)	Somewhat crumbly but holds together from pressure. (0.5 to 1.0)	Somewhat pliable, will ball under pressure. (0.6 to 1.2)
0-25 (0 is permanent wilting.)	Dry, loose, single-grained, flows through fingers. (0 to 0.2)	Dry, loose, flows through fingers. (0 to 0.4)	Powdery, dry, sometimes slightly crusted but easily broken down into powdery condition. (0 to 0.5)	Hard, baked, cracked, sometimes has loose crumbs on surface. (0 to 0.6)